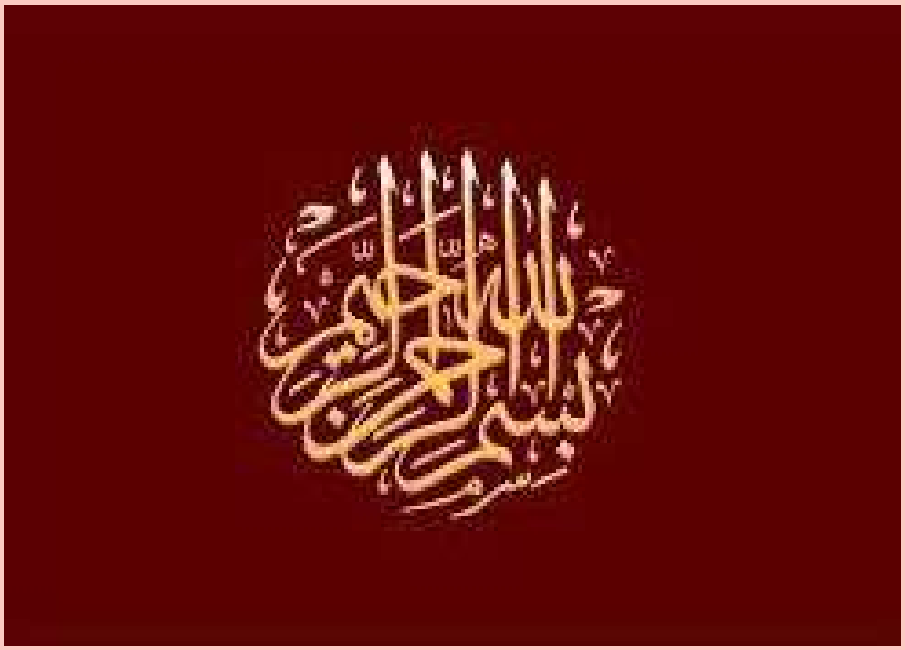
NATIONAL TEXTILE UNIVERSITY

GRADUATE PROSPECTUS 2024

www.ntu.edu.pk

Office of the Graduate Studies & Research
Email: ogsr@ntu.edu.pk

WELCOME TO NATIONAL TEXTILE UNIVERSITY



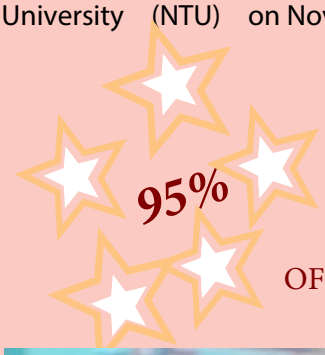
In the name of Allah, the most beneficent,
the most merciful

TABLE OF CONTENTS

About Us

The dawn of history of National Textile University (NTU) rooted back from 1954 as the Institute of Textile Technology, an excogitate effort of national industrialist prognosticators. The President of Pakistan, Field Marshall Muhammad Ayub Khan, laid the foundation stone of the Institute on 12th October 1959.

A Board of Trustees with the Minister of Industries as Chairman and nominees of the donor companies as members was constituted to manage the affairs of the Institute. In 1965, the Institute was granted affiliation by the University of Engineering & Technology, Lahore. Subsequently, the Institute was renamed as National College of Textile Engineering and it executed its functioning with Board of Governors led by Federal Minister of Industries as Chairman, seven members from Federal Government and three members from All Pakistan Textile Mills Association (APTMA). The college was granted a charter by the Government of Pakistan for establishing the National Textile University (NTU) on November 15, 2002.



EMPLOYABILITY
OF TEXTILE GRADUTES

PAKISTAN'S TEXTILE EDUCATION PREMIER INSTITUTE

#1

Since its inception in 2002, NTU has been the premier Institute of textile education in the country, meeting the technical and managerial human resource needs of entire textile industry of Pakistan by retaining crucial link between university and business world. NTU has strived to achieve the aim of imparting world class education while encouraging research and intellectual growth in the country. As a result, NTU has played a key role in setting high standards of academics and produce professionals to compete in the world.

NTU imparts extraordinary academic and social skills among students to face challenges of the time and become the next generation of leaders believing in its motto "Innovate and Lead". NTU has close collaboration with the world renowned universities to promote research and innovation. The hallmark of NTU is that within a short period of ten years, it is now among top universities of the country. On the face of fast changing and diverse world, the National Textile University stands firm to offering new programs in relevant, emerging fields for the people of Pakistan and the wider world.

MISSION

The Mission of National Textile University is to contribute towards sustainable socioeconomic development of society and welfare of humanity through pursuit of excellence in education, research and innovation in areas of National importance, with special emphasis on textile and clothing.

VISION

National Textile University aspires to have a transformative impact on the socio-economic development of the country in general and textile & clothing industry in particular, with outstanding education, research and ecofriendly innovation.

CORE VALUES

Integrity: Conducting ourselves with honesty, transparency, fairness and the highest Ethical standards in all aspects of our activities.

Merit: Maintaining rigorous procedures for undergraduate and graduate admissions & award of grades; and for faculty & staff hiring, promotions and tenure decisions.

Innovation: Fostering ingenuity, creativity and development of new ideas for the benefit of industry and society.

Excellency: Endeavoring to achieve the highest standards of scholarship, teaching, research and institutional effectiveness.

OUR CULTURE

Progressive: Striving for continual improvement in academic quality and research excellence.

Ambitious: Striving to become amongst the top National universities along with good international standing in teaching and research.

Collaborative: Striving for synergistic partnerships within university departments, with other universities and with industry.

City of Faisalabad

The National Textile University is situated in the third largest historic city of Faisalabad also known as 'Manchester of Pakistan, the world famous place for its cotton export industry and agriculture production. Indeed, a thriving hub of business and industry, the city with its old beautiful name of Lyallpur, a tribute which was given to Sir James Lyall, Lt. Governor of Punjab, for his services rendered for the lower Chenab Valley during the colonization period. The design of the city was prepared by Captain Papuan Young C.I.E, the colonization officer.Later, Lyallpur was named "Faisalabad" after the late King Faisal of Saudi Arabia to commemorate deep friendship which exists between the two great Islamic countries of the world. The famous clock tower of Faisalabad has eight streets/ bazaars leading from it and was designed in a pattern to form Union Jack, presenting a magnificent example of town planning. The city is located in the province of Punjab to the west of Lahore, the provincial capital, situated 360 kilometers south of the Federal Capital Islamabad.

Faisalabad is surrounded by major agricultural areas such as, Hafizabad and Sheikhupura towards north and northeast, Okara and Sahiwal towards east and southeast, and Jhang and Toba Tek Singh towards west and southwest. City District Faisalabad consists of eight towns, which are: Lyallpur town, Madina town, Jinnah town, Iqbal town, Samundri town, Tadianwala town, Jaranwala town, and Chak Jhumra town.

The city has two public libraries and an art council to promote art and culture and a number of cinemas to provide entertainment. A cultural museum is currently established to promote both the national and international culture. The hockey and cricket stadiums of the city host national and international matches. Moreover, international airport, dry port and industrial zone are linked with the Motorway and other national highways to facilitate this hub of industrial activities.

WELCOME
MESSAGE FROM
RECTOR

Role of University is immensely important in creating new knowledge and inventing new technologies for the benefit of humankind as well as in equipping students with suitable knowledge, skills and behavior that not only make them excel in their occupations but also in their general life, ultimately leading to the development of a peaceful and prosperous world. The purpose of education is to help mankind in the pursuit of selfactualization, in addition to the fulfillment of physiological, social and self-esteem needs. Good education includes not only the vocational development but also the cognitive, spiritual, emotional and social development of people.

National Textile University is one of the most rapidly rising University in Pakistan. Our teaching philosophy at NTU is student-oriented and our focus is to develop professional competence as well as good character in our graduates. The educational objectives of our programs not only include suitable knowledge and skills components but also the inculcation of desirable behavioral attributes in the students, such as: self-motivation, initiative and drive, passion for achieving goals, creativity, flexibility and adaptability, self-confidence, dependability, trustworthiness, fairness, empathy, politeness, integrity, conscientiousness, etc.

We offer plenty of curricular and extracurricular opportunities to enable our students to recognize and actualize their intellectual potentials and help them in acquiring key employability skills, such as effective communication, information management, critical thinking and problem solving. I am looking forward to your joining NTU to explore endless opportunities for your personal development and professional growth. I pray for your bright future and success in every walk of life.

Prof. Dr. Tanveer Hussain

WELCOME
MESSAGE FROM
Director Graduate Studies & Research

On behalf of the National Textile University community, I am pleased to extend to you the warmest of welcomes as you embark on your journey with us.

NTU is more than just an educational institution; we are a vibrant community of scholars, researchers, and innovators dedicated to pushing the boundaries of knowledge in the textile and related fields. As you step onto our campus, you will become part of this dynamic and inclusive community, where ideas flourish and dreams take shape. During your time here, you will have the opportunity to engage with world-class faculty who are at the forefront of their respective fields. You will also benefit from state-of-the-art facilities and resources that will empower you to excel in your academic pursuits.

Prof. Dr. Rashid Masood
Director, GSR

But NTU is not just about academics; it is also about personal growth, character development, and forging lifelong friendships. We encourage you to explore the numerous extracurricular activities, clubs, and organizations on campus to enhance your overall university experience. As the Director of Graduate Studies, my team and I are here to support you every step of the way.

Whether you have questions about your program, need guidance on your research, or seek assistance with any aspect of university life, our doors are always open. Remember, your journey at NTU is not just about reaching the destination; it's about the experiences, challenges, and growth you will encounter along the way. Embrace every opportunity that comes your way, and don't be afraid to reach for the stars.

Once again, We will welcome you to National Textile University. We are excited to see how you will contribute to our community and leave your mark on the textile world. Your future begins here, and the possibilities are endless.

Wishing you a good luck.

Advisor Students Office

Advisor Students Office/Office of Student's Affairs provides a broad range of services and support to NTU students, including leadership development, residential programs, public service, career exploration and community engagement through constant contact with the students.

The office performs a variety of roles for the student's community and its graduates and provides assistance in solving their day to day campus issues. The detail of the supporting services is as under:

General Services

Development and implementation of various activities and services that focus on the non-academic aspects of the student's life in the university such as the acquisition of values and skills for a lifelong learning.

Coordination and supervision of student, Discipline, Coaching, Student Sports, Hostel/ Accommodation and other Co-curricular activities.

To represent student point of view on campus issues.

Student's Co-curricular event/activity calendar, student bulletins, magazines, etc.

To handle the matters of student bodies / organizations/ Societies and helping them in arranging their functions/ extra-curricular activities.

On Campus Student Recruitment Drives/Job Placement.

Students Societies

Technical Societies

- Society of Textile Spinners
- Society of Textile Weavers
- Society of Textile Knitters
- Society of Textile Chemists
- Society of Garment Manufacturers
- Society of Textile Apparel & Merchandising
- Society of Polymer Engineers
- Society of Textile Technologists
- Society of Textile Designers
- Society of Fashion Designers
- Society of Visual Arts
- Society of Entrepreneur
- Society of Executive
- Society of Textile Management & Marketing
- Society of Computer Sciences
- Society of Software Engineering
- Society of Engineers Scholars
- Society of CS Scholars
- Society of Cloting
- Society of Physicist
- Society of Mathematician
- Society of Business Research & Development
- Society of Interpersonal & Communication Skills

Extracurricular Societies

- NTU Literary Society
- NTU Debating Club
- NTU Sports Society
- NTU Wings Society
- NTU Iqbal Society
- NTU Road Safety Club Society
- NTU Character Building Society
- NTU OSH & Blood Donation Society
- NTU Media Club & Photography Society
- NTU Society of Nature & Environmental Sustainability
- NTU Quran Society
- NTU Community Services
- NTU Kavish Magazine Society
- NTU Arts & Culture Society
- SET Counseling Club
- NTU Internship Program

Student Sports

Sports have a universal appeal and a common language spoken all across the globe. It is said "A Healthy body is a promise of healthy mind", and combination of both can do wonders for students. Besides academics, sports are one of the important co-curricular activities, included in all educational institution as a part of the curriculum. Sports attribute positively to the academic performance of our learners.

Students Sports

National Textile University gives special emphasis to arrange indoor/outdoor sports activities for the students (Male & Female) to enhance their Physical & Mental growth. For this purpose, Student Advisor Office is ꝏ ntinuously improving its sports infrastructure within campus to facilitate students in strengthening sports activities.

Two full time Sports Officers, Physical Trainee Officer (PTI) and a gym trainer are available for guidance / training of students as well as managing any type of sports activity.

Sports Facilities

- Athletics
- Bed Minton
- Table Tennis
- Hockey
- Volley Ball
- Boys Gym Club
- Cricket Football
- Girls Gym Club
- Indoor Hostel Games
- Squash Court
- A jogging track alongside the cricket ground for regular users

Sports Activities

- Continuous Sports' activities
- Intra-departmental Sports Competitions
- Inter Department Sports Competitions
- HEC Games Participation
- Friendly Matches with other Universities
- Sports Clubs of Cricket, Hockey and Badminton

Scholarship Schemes

The Advisor Students Office also performs the functions of Students Financial Aid Office (SFAO) and provides the students a central point of obtaining the information of different scholarships/ Financial Aid Schemes. The office currently handling the following scholarships:

- HEC Need Based Scholarship
- University Merit Scholarship
- PEEF Master Level Scholarship
- MORA Scholarships
- Killa Gift Fund
- National Bank of Pakistan (Interest Fee Loan)
- Ihsan Trust, Karachi Qarz-e-Hasna
- i-Textiles Research Fellowship Program
- Tanveer Mir Scholarship Program (TMSP)
- Midas Safety R&D Fellowship (MSRDF)

Graduate Employment & Career Development Services

This office also locates the jobs in market and places the employment opportunities for its graduates for all disciplines. This office manages the information regarding graduate employment opportunities, supporting students in finding employment, working with managers and acting as the liaison between graduates and prospective employers.

Students are encouraged to contact this office with questions regarding their employment issues after the completion of their study. This office organize on-campus job hunting drives. A Deputy Director is delicately working on job placment.

Facilities for Students

Health Care

A clinic supervised by a devoted medical officer has been setup on the campus to provide health care facilities to students, employees & their dependent family members.

IT Centre

Established in 2008, IT Centre is centrally air-conditioned Building having 06 computer labs, Video Conferencing Room, meeting room and Faculty/ Staff offices. Department has following infrastructure and responsibilities.

- Management of Datacentre
- Fiber Optic Sites Connectivity
- Layer 03 Networks and Virtual LANs
- Active Directory Logins and Home Drives
- Controller bases Wireless Lan to Campus and Hostels
- Secure and high speed internet access through Firewalls
- Web Apps like Faculty Profiles, Course Evaluation
- Distributed Websites and Email Management

NTU Library

NTU Library is housed in a two-story building and holds a unique collection of almost Twenty-Five Thousand information resources in textile engineering and allied disciplines. The library subscribed thirty-four national and international textile journals in print format and has bound archives of core textile and applied sciences journals, some of them starting from 1918 to date. Electronic access to more than 40,000 peer reviewed titles is also available through HEC Digital Library Program. The library acquires a variety of resources in print, audiovisual and electronic formats to support study and research in the university and has a wide range of services, including borrowing, reference, user advisory, information literacy (IL), OPAC, photocopying, indexing, TOC alert etc.

NTU library is one of the few in the country that has implemented standardized integrated software for library automation. Library World, Version 3.02 developed by CASPR Inc., USA. The library provides electronic services through an electronic services lab that has ten computers, two scanners and three printers. The library web pages provide information about its staff, rules & regulations, information services, collection, NTU student's projects, CD Roms, virtual library links, etc.

The Virtual Library contains categorized links to websites of textile and general media, product sourcing and trade associations, research centers and institutes, universities and colleges, trade directories, computer and technology for textiles, electronic resources and databases and open access journals and resources. Campus-wide access to a large number of electronic resources is available through HEC Digital Library.

Services

National Textile University Library is providing excellent knowledge resources, services and facilities to fulfill the teaching, learning and research needs of its faculty members, students, staff and a large number of users belonging to the textile community in Pakistan.

Information Literacy/Continuing Education

The library is providing information literacy services to its patrons by organizing seminars and practical workshops to enhance the learning skills of students, researchers as well as faculty members. In this regard teachers/ library community of different institutes has visited NTU library several times.

Library Hours

Library opens seven days a week according to the following schedule:

Monday Thursday	8:30 a.m. to 9:00 p.m.
Friday	8:30 a.m. to 4:40 p.m.
Saturday & Sunday	2:00 p.m. to 9:00 p.m.

There will be one-hour Prayer/Lunch break, as notified by the administration.

Borrowing Privileges

- Students/ Staff Members/ Teaching Assistant and Research Associate can borrow three books for 21 days.
- Faculty Members can borrow fifteen books for a semester or 90 days.
- Borrowing facility is not available to visiting faculty, NTU Alumni and students referred from other institution: however other library services are available accordingly.
- Some material, such as reference books, press clippings, CD-ROMs, current issue of periodicals, or any other publication marked as Reference/Reserved will not be circulated/issued.

Web OPAC

In 2011, the library has uploaded its data (books, journals, CDs, thesis and reports) on web. Now the users can search their required title/ material everywhere, even through their cell phones at library web portal. www.ntu.edu.pk/ library

HEC Digital Library

Since the year of 2008, National Textile University Library has subscribed more than 11,600 peer reviewed leading international journals and 40,000 online books available through National Digital Library Program of Higher Education Commission, Islamabad. Users can browse, search and link to find the exact information looking for, fast.

SCHOOL OF ENGINEERING & TECHNOLOGY

Introduction

School of Engineering & Technology is the largest of the four faculties of National Textile University, offering the University's flagship undergraduate and postgraduate programs in textiles and advanced materials. The school has some of the most advanced and sophisticated laboratories in the country, highly qualified faculty members, and well-trained laboratory staff.

School of Engineering and Technology offers **5** MS programs and **4** PhD programs, viz MS Textile Engineering, MS Advanced Materials Engineering, MS Textile Technology, MS Advanced Clothing & Fashion, PhD Textile Engineering, and PhD Advanced Materials.

School of Engineering & Technology has following four departments:

- **Department of Textile Engineering**
- **Department of Textile Technology**
- **Department of Materials**
- **Department of Clothing**

GRADUATE PROGRAMS

MS TEXTILE ENGINEERING

PhD TEXTILE ENGINEERING

MS TEXTILE TECHNOLOGY

PhD TEXTILE TECHNOLOGY

MS ADVANCED MATERIALS ENGINEERING

MS POLYMER SCIENCE & ENGINEERING

PhD ADVANCED MATERIALS

MS ADVANCED CLOTHING & FASHION

PhD APPAREL MANUFACTURING

MS TEXTILE & APPAREL (Karachi Campus)

Research Facilities

Our research facilities include:

Fiber Production Labs

- Comprising melt spinning, wet spinning, and electrospinning

Yarn Production Labs

- Comprising blow room, card, drawing frame, roving frame, ring frame, compact spinning, open-end spinning, and autoconer.

Weaving Labs

- Comprising single-end warping, sizing, and sample loom. Industrial-scale shuttle looms, rapier looms, projectile looms, air-jet looms, and electronic jacquard.

Knitting Labs

- Comprising circular knitting machines, flat knitting machine, gloves knitting machine, socks knitting machine, and braiding machine.

Textile Processing Labs

- Comprising IR dyeing machine, HT- dyeing machine, yarn package dyeing machine, jigger machine, jet machine, soft-flow machine, winch machine, pad-steam dyeing machine, pad-thermosol dyeing machine, stenter, calender, flat-bed printing machine, rotary printing machine, plasma treatment, autoclave and coating machine.

CAD Lab

- CAD system for pattern digitizing and plotting, 3D body scanner.

Garments Production Lab1

Basic sewing machines that include Lock stitch, Overlock, Flat lock, button attached, button hole, etc.

Garment Production Lab2

- Computer added manufacturing lab, Embroidery machines, specialized sewing machines, and garment washing machines.

Smart Lab

- Digital multimeter, DC Power supply, Digital Hygrometer, Digital microscope, Ultra sonic sewing machine, auto pattern sewing machine.

Composite Fabrication Lab

- Composite fabrication facilities including Vacuum resin infusion, Compression molding, Resin transfer molding, Filament winding, Prepreg, Thermal curing oven, UV curing oven

Composite Processing Lab

- Water jet cutter, CNC cutters, Composite Polishing machine, Ball milling machine, Hygro-thermal ageing chambers, Humidity chambers, Xenon ageing chambers, Resistance welding, Microscope **Advanced Characterization Lab**

- Differential Scanning Calorimetry, Dynamic Mechanical Analyzer, Thermo-mechanical Analyzer, Thermo-gravimetric Analyzer, Guarded Hotplate, Rheometer, Melt Flow Indexer, Universal testing machine, drop weight tester, Pendulum impact tester, Fatigue testing machine, Tribotester, Density meter, Dilatometer

Testing and Characterization Labs

- Comprising FT-IR spectrophotometer, UV-VIS-NIR spectrophotometer, atomic absorption spectrometer, UV- Visible spectrophotometer, Gel permeation chromatography, rheometer, differential scanning calorimeter, zeta-sizer, electro-kinetic potential analyzer, tensiometer, compound microscope, stereo microscope, USB microscope, scanning electron microscope, X-Ray diffractometer, sweating guarded hotplate, air permeability tester, universal fabric tensile tester, single fiber tensile strength tester, Uster yarn evenness tester, Tensorapid single yarn strength tester, fabric flammability tester, LOI indexer, pneumatic fabric stiffness tester, fabric thickness tester, fabric touch tester, hydrostatic-head tester, water repellency tester, Kawabata KES-FB2 bending tester, KES-FB3 compression tester, KES-FB4 surface tester, KES-F7 Thermolabo II.

Research Areas

Advanced Materials

- Materials for energy harvesting like Solar Cells, Batteries, and Supercapacitor; nanostructures/nanoscale materials and nanodevices; Electrospun nanostructures, smart materials, and other functional materials

Polymeric Materials

- Advanced polymers; Paints and Coatings; Elastomers; Polymer blends; Shape memory polymers; Biopolymers, Polymer rheology

Composite Materials

- Fiber-reinforced polymer composites; Nanocomposites, Functional composite materials, Particle loaded composites, Composite materials joining; Fiber Metal Laminates, Green Composites; and composite materials for high-tech applications

Engineered Textile Structures

- Linear fiber assemblies, woven fabrics, knitted fabrics, braided fabrics, nonwovens

Textile Surface Modification and Chemical Treatments

- Coloration, finishing, coating, enzyme, plasma, and other novel functional treatments of textiles

Clothing Engineering

- Tactile and thermo-physiological comfort; sizing, fit and fashion; engineering functional apparel

Technical Textiles

- Medical, protective, sports, and smart textiles

Textile Machinery and Instrument Design

- Design and development of textile sensors, machinery, instrumentation, and control systems

Modeling and Simulation

- Modeling & simulation; expert systems; image analyses; numerical analyses; computer-aided design

Energy, Environment, and Sustainability in Textiles

- Development of energy-efficient, eco-friendly, and sustainable textile products/processes

Faculty Research Interests

Prof. Dr. Tanveer Hussain, PhD (UK)

- Functional Materials including Nanofibers and Nanoparticles; Comfort & Protective Properties of Textiles;Textile Dyeing, Finishing and Coating; Modelling and Predicting Textile Behaviour; Medical Textiles

Prof. Dr. Zulfiqar Ali, PhD (Pakistan)

- Fiber Assemblies, Medical, Protective and Sports Textiles, Machinery Development and Modeling

Prof. Dr. Yasir Nawab, PhD (France)

- Advanced Materials, Engineered Textile Structures & Composites, Technical Textiles, Textile Machinery and Instrument Design, Textile Modeling and Simulation

Dr. Zafar Javed, PhD (Finland)

- Garments Manufacturing and Garments Machinery Design

Prof. Dr. Rashid Masood, PhD (UK)

- Biomaterials for Healthcare, Flame-Retardant Materials; Microencapsulation Technology, Surface Modification of Textiles; Plasma Technologies for Textiles; Medical and Healthcare Textiles

Dr. Abdur Rehman, PhD (UK)

- Textile Surface Modification and Chemical Treatments

Dr. Munir Ashraf, PhD (France)

- Nanomaterials, Surface functionalization, Synthesis and Application of Functional Dyes and Finishes

Dr. Abher Rasheed, PhD (France)

- Clothing Engineering & E-Textiles, Quality

Dr. Adul Basit, PhD (France)

- Polymer Fibers, Smart Materials, Advanced Materials, and Polymer Composites

Dr. Sheraz Ahmed, PhD (France)

- Textile Fibres, Natural Fibre reinforced composites, Technical Textiles, Textile Machine design, and Instrumentation

Dr. Talha Ali Hamdani, PhD (UK)

Technical and Smart Textiles

Dr. Muhammad Bilal Qadir, PhD (South Korea)

- Nanomaterials, Nano Composites and their application in energy devices like Solar Cells, Batteries, and Super Capacitor, Functional nanomaterials, Functional & Smart Textiles, Technical Textiles, Surface modification of Nanomaterials, Yarn Manufacturing, Functionalized Fibers, Fabric Comfort, Fancy Yarns

Dr. Khubab Shaker, PhD (Pakistan)

Fiber Reinforced Polymer Composites, Green Composites, Textile reinforcements, Resin flow, Joining of composite materials, Particle loaded composites, Thermo-mechanical characterization of materials, Finite Element Analysis, Mechanics of Materials, Sustainable Materials

Dr. Zubair Khaliq, PhD (South Korea)

- Polymer Physics, Polymer Rheology, Advanced Polymer Materials, Nanomaterials, Nanosuspensions and Processing, Technical Textiles, and Fiber Assemblies

Dr. Kahif Iqbal, PhD (UK)

- Synthesis of Micro and Nano encapsulated materials, Textile Dyeing and dye Chemistry, Surface Chemistry and modification of Textiles, Melt Spinning, Modeling, and Simulation using Finite Element, Functional Textile including smart materials, Advanced Textile Chemistry with Environmental Chemistry.

Dr. Muhammad Ali Afzal, PhD (France)

- Textiles Machinery and Instrument design, Technical Textiles, Engineered Textile Structures & Composites, Advanced Materials, Clothing Engineering, Textile Modeling and Simulation

Dr. Muhammad Babar Ramzan, PhD (South Korea)

- Mathematical Modeling and optimization, Statistical Modeling and Process Control, Quality Management Project Management, Lean Manufacturing, and Six Sigma

Dr. Hafiz Shahzad Maqsood, PhD (Czech Republic)

- To explore some greener processes for the oxidation of natural cellulose fibers from the waste of the spinning industry. Our target utility of these oxidized fibers is composites or the medical industry

Dr. Abdul Jabbar, PhD (Czech Republic)

- Textile/fiber reinforced composites, Biocomposites, Nan composites, Surface modification of natural fibers, Textiles/composites for personal protection, Nonwoven textiles, Yarn Engineering, Structure-property relationship of spun yarns

Dr. Amjed Javid, PhD (South Korea)

- Materials engineering, surface engineering of textiles, nanomaterials, biomaterials, plasma technology, polymer and carbon thin films

Dr. Hafsa Jamshaid, PhD (Czech Republic)

- Protective Textiles, Comfort Properties of Textiles, Advanced Materials, Textile Structures, Composites & Nanocomposites, Textile Machinery, and Instrument Design.

Dr. Ahsan Nazir, PhD (France)

- Electrospun Materials (Medical Applications, Energy Applications, Filteration, Protective Applications, Antimicrobial, Photocatalysis, Sensors)
- Clothing Comfort (Thermo physiological comfort, Sensorial comfort, Sensory evaluation)

Dr. Muhammad Qamar Khan, PhD (Japan)

Functional Garments, Functional Home textiles, Textile Based Filter, Technical Textiles, Smart Fashion

Dr. Muhammad Zubair, PhD (Czech Republic)

- Comfort and performance evaluation of woven fabrics, Structural Mechanics of fibrous assemblies, Mathematical modeling of fibrous assemblies, Non-woven fabrics, and their mechanics. Fabric Engineering, Structure-property relationship of woven fabrics

Dr. Zuhaib Ahmad, PhD (Czech Republic)

- Textile/Fiber-Reinforced Composites, Textile Structure and Geometry, Clothing Comfort, Fabric Structure and Design

Dr. Muhammad Usman Javaid, PhD (Czech Republic)

- Design and simulation of woven structures, image analysis for textiles, data analysis using MATLAB and Jacquard weaving for advance woven structures

Dr. Amna Siddique, PhD (China)

- Advanced Materials, Textile modeling and Simulation, Engineering Textile Structures and Composites, Textile dyeing and printing.

Dr. Muhammad Umair, PhD (Pakistan)

- Two-dimensional (2D) and three-dimensional (3D, multilayer) woven structures, 2D and 3D braided structures, Thermophysiological comfort properties of the woven fabrics, Natural and high-performance fiber-reinforced polymeric composites, Laminated and 3D woven composite structures, Ballistic protection, Statistical Modeling, Mechanical Characterization

Dr. Muhammad Irfan, PhD (Italy)

- Thin functional films, antimicrobial coatings, nanomaterials, nanotechnology in textiles, surfaces functionalization, high-performance fibers and yarns, technical textiles, nanofiber fabrication, composites

Dr. Muhammad Waqas Iqbal, PhD (South Korea)

- Textile Recycling, Sustainable Supply Chain Management, Waste Control

Dr. Madeha Jabbar, PhD (Pakistan)

- Garments production process, Garments Machinery, Garment quality assurance, Finite element analysis, Personal protective garments, Composite materials

Dr. Hafiz Affan Abid, PhD (Czech Republic)

- Surface modification and smart functionalization of the Textile based materials

Dr. Faheem Ahmad, PhD (Turkey)

- Synthesis of Fibers, Yarn Manufacturing, Clothing Comfort, Nonwovens, Aerogel Textiles

Dr. Zakariya Zubair, PhD (France)

- Shape memory polymers, Polymer Composite Materials

Dr. Asif Hafeez, PhD (Malaysia)

- Polymer membranes, Advanced polymers, Polymer synthesis, Polymer blending

Dr. Habib Awais, PhD (Malaysia)

- Smart materials, Natural fiber-based composites, Knitted structures

Dr. Muhammad Anwaar Nazeer, PhD (Turkey)

- Polymer synthesis, Biomaterials, Tissue Engineering, Functional Clothing, Sustainability

Dr. Fatima Iftikhar, PhD (Pakistan)

- Fabric comfort, Ladies apparel, Garments Manufacturing

Dr. Aqsa Imran, PhD (France)

- Ladies apparel, Garments Manufacturing, Smart Textiles

Dr. Usman Zubair, PhD (Italy)

- Energy Storage Devices (Supercapacitors, Lithium Batteries), Textronics, Sensors, Functional nanomaterials, Functional Textiles

Dr. Jawad Naeem, PhD (Czech Republic)

- Garment Manufacturing Processes and Clothing Comfort

Dr. Muzammil Hussain, PhD (France)

- Fabric Manufacturing (Knitting), Composite Materials

Dr. Muhammad Imran Khan, PhD (Pakistan)

2D and 3D reinforcements, Composites, Technical Textiles, Protective Textiles, Fabric Manufacturing

Dr. Muahmmad Tauseef Khawar, PhD (United Kingdom)

- Sustainable Clothing, Sustainable Textile Manufacturing, Nanocomposites, Nonwovens, Textile Colouration, Garment Manufacturing

- **Dr. Shahood uz Zaman, PhD (France)**
  Textile Engineering, Circularity in textiles, Yarn manufacturing process, Smart textiles, E-textiles, Reliability and standardisation issues of wearable smart textiles
- **Dr. Muhammad Haroon Rashid, PhD (Estonia)**
  Smart engineering materials for sensor application, graphene-based sensors, organic/inorganic semiconductor materials for energy harvesting applications, SiC based heterojunction devices
- **Dr. Shagufta Riaz PhD (Pakistan)**
  Functional Textiles by application of various nanomaterials, Sustainability, Upcycling of wastes to develop Technical Textiles, and Comfort properties of Functional Textiles.
- **Dr. Danish Mahmood Baitab, PhD (Malaysia)**
  Smart materials, 3D woven structures, Polymer Composites
- **Dr. Muhammad Sajid Faheem, PhD (Czech Republic)**
  Textile Functional Finishing and Coating, Advanced Sustainable Materials and Processes, Textile Flame Retardancy; New Strategies and Mechanisms involving Biobased Materials, Electrospinning and Electrospraying Technology; Fabrication of Nanofibers and Nanoparticles, Dyestuff Chemistry and Textile Dyeing, Comfort Properties of Textiles
- **Dr. Wasif Razzaq**
  Smart Polymers, Microfluidics, Functional polymers, Wet spinning, Wastewater treatment, Polymer synthesis
- **Dr. Faiza Anjum**
  Sustainable Practices, SDG

Department of Textile Engineering

The Department of Textile Engineering is the largest of all departments of National Textile University, offering the University's flagship undergraduate and postgraduate programs in textiles. The department has some of the most advanced and sophisticated textile laboratories, highly qualified faculty members, and well-trained laboratory staff.

MS TEXTILE ENGINEERING

The Master of Science in Textile Engineering is a two-year master's program offered by National Textile University in Textile Engineering. In this program, students learn about the latest developments in textile in a wide range of subjects covering advanced materials, 3D textiles, fiber-reinforced composites technology, and new processes and machines to manufacture textile products.

Program Educational Objectives (PEOs)

MS Textile Engineering program aims to create a higher learning culture that enables students to:

1. Demonstrate excellence in the application of knowledge and advanced methodological skills to conduct independent and original research in textile engineering.
2. Develop cognizance of the social, ethical, and environmental standards of society and industry.
3. Pursue continuous professional development, establish collaborations, and engage in teamwork to bring excellence in professional practice.

Program Learning Objectives (PLOs)

MS Textile Engineering program aims to create a higher learning culture that enables students to:

1. Apply acquired technical knowledge at an advanced level in their particular field to design/modify processes/products.
2. Analyze the problems, design solutions, and perform research to meet specified needs.
3. Apply knowledge to assess societal, health, safety, and legal issues and understand the impact of engineering solutions for sustainable development
4. Understand and apply ethical principles and commit to professional ethics, responsibilities, and norms.
5. Improve their knowledge, skills, and attitude continuously for pursuing lifelong learning in the broader context of innovation and technological developments

Eligibility Criteria

1. BS Textile Engineering/Mechanical Engineering/Chemical Engineering/Industrial & Manufacturing Engineering/ Product and Industrial Design/Materials Engineering/Environmental Engineering or equivalent degree from HEC recognized institution with a minimum CGPA 2.00/4.00 or 3.00/5.00 in semester system or 60% marks in annual/term system.
2. Applicants having terminal degrees as prescribed in condition no. 01, are required to qualify NTU-GAT (General) test **or** NTU-GAT (Subject) test in case of different qualification with minimum **50% score** as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit / Admission Criteria

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	
BS or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Semester-Wise Layout of Courses

Semester-I

Sr. No	Code	Course Title	Credit Hours
1	TE-5001	Textile Materials and Processes	3
2	TE-5002	Sustainability in Textiles	3
3	TE-5003	Research Methodology	3
4	TE-5004	Advance Characterization Techniques	3
5	TE-5005	Introduction to textile manufacturing and processing	Zero CR course for non-textile back ground students
		Total	**12**

Semester-II

Sr. No	Code	Course Title	Credit Hours
1	TE-50--	Elective-I	3
2	TE-50--	Elective-II	3
3	TE-50--	Elective-III	3
4	TE-50--	Elective-IV	3
		Total	**12**

Semester III & IV

Sr. No	Code	Course Title	Credit Hours
1	TE-6071	Research Thesis	6
		Total Credit Hours	**30**

List of Elective Courses

Sr. No.	Code	Course Name
1	TE-5011	Advance Textile Structures
2	TE-5012	Advanced Coloration Technologies
3	TE-5013	Textile Composites
4	TE-5014	Surface Functionalization of Textiles
5	TE-5015	Technical Textiles
6	TE-5016	Protective Textiles
7	TE-5017	Medical Textiles
8	TE-5018	Textile modeling and Simulation
9	TE-5019	Mechanics of Textile Assemblies
10	TE-5020	Nonwoven Technology
11	TE-5021	Smart Materials
12	TE-5022	Production Planning and Control
13	TE-5023	Nanomaterials
14	TE-5024	Advanced Pattern Construction Techniques
15	TE-5025	3D Textile Structures
16	TE-5026	Numerical Methods in Textile Engineering
17	TE-5027	Performance Clothing
18	TE-5028	Nanocomposites
19	TE-5029	Quality Assurance in Textiles
20	TE-5030	Denim Manufacturing and Processing
21	TE-5031	Filtration in Textiles
22	TE-5032	Electrospun materials and Applications
23	TE-5033	Textile Comfort
24	TE-5034	Advancement in Natural and Manmade Fibers
25	TE-5035	Recycling in Textiles
26	TE-5036	Chemistry of Dyes and Pigments

Rules for the selection of an elective course

1. At the end of the first semester, the list of available electives will be displayed/shared with the students.
2. The electives will be offered on the availability of relevant faculty/facilities.
3. The students will choose four electives from the given elective list within the given time limit.
4. The final elective list will be displayed/shared with the students soon after finalizing the elective subjects.
5. Students, who opted for the non-offered electives, will have to choose among the offered elective courses.

Course Specifications

Course Name	Description	Books
Textile Materials and Processes	This course aims to enable students to learn about natural fibers like cotton, silk, jute, banana, hemp, etc, and manmade fibers like polyester, nylon, polypropylene etc. All the manufacturing processes are also introduced in this course to the students. These processes include ginning, spinning, weaving, knitting, processing, and garment manufacturing.	Handbook of Natural Fibres: Volume 2: Processing and Applications By Ryszard M. Kozlowski; Handbook of Technical Textiles, A R Horrocks; Process Control in Textile Manufacturing, Abhijit Majumdar
Sustainability in Textiles	This course covers the fundamentals of sustainability and the implications of materials and processes used in the textile wet processing industry. The students study a range of sustainability principles that address lifecycle assessment, including eco-footprint analysis, embedded energy and environmental impact of textile dyeing and finishing processes. The students will also be introduced to sustainable textile fibers, enzyme biotechnologies for sustainable textile processing, key sustainability issues in textile dyeing and environmentally friendly plasma technologies for textiles. It also covers the latest technologies for sustainable textile dyeing.	Sustainability in the Textile Industry, Subramanian Senthilkannan Muthu

Research Methodology	The overall aim of this course is to enable the students to identify a research area, identify a research problem, formulate the research question, conduct literature survey, formulate research hypothesis, design research experiments, graphically present, analyze and interpret the experimental data, and draw valid conclusions. Additionally, the students will be able to write a research proposal, critically analyze research papers, and write a short literature review with proper citations and referencing. The students will practice relevant statistical tools and techniques using a statistical software package. The students will also become familiar with plagiarism and other ethical issues in research, patents, copyrights and trademarks, thesis and research paper writing styles.	Research Methods: A Practical Guide For Students And Researchers by Willie Tan (2017)
Advanced Characterizatio n Techniques	This course introduces different physical, chemical and mechanical characterization techniques, including XRD, SEM, TEM, chromatography, infrared spectroscopy, UV/Vis spectroscopy, atomic absorption spectroscopy, tensile testing, impact testing, bending, shear and hardness testing.	Advanced Techniques for Materials Characterization, By A.K. Tyagi
Advance Textile Structures	Advances in Textile Structures will present the most recent advances in the production of three-dimensional fibrous structures and how their use has resulted in the creation of novel fabrics.	Advances in 3D Textiles by X Chen, Watson's Advanced Textile Design by Z Grosicki
Advanced Coloration Technologies	This course will cover the application of different dyes on a variety of textiles substrates. The students will learn the physical aspects of dying, the properties of polymeric fibrous with respect to dyeing behavior, the theory of machines involved in the batch-wise and continuous dyeing process, union dyeing, blend dyeing containing smart and technical textiles. The course will focus on advanced dyeing and printing techniques such as supercritical fluid dyeing, nitrogen dyeing and digital printing of textile substrates and their application. The students will also gain knowledge of the thermodynamic aspect of dyeing including adsorption isotherm. During this course, students should be able to define and optimize recipes and parameters to develop the dyeing process of a particular substrate. At the end of this course, the students will be able to dye different types of textiles including fibers, yarn, knitted fabric, woven fabric and technical textiles made of different fibrous materials.	Advances in the dyeing and finishing of technical textiles by M.L. Gulrajani, Woodhead Publishers, Elsevier, 2013.
Textile Composites	Composites are the materials of 21st century. They have vast applications in sports, defence, automotive, aerospace engineering, medical sciences, building/construction material, and many other sectors. This course is designed to provide students with thorough knowledge of fundamental issues of fibers reinforced composites. Students will develop an understanding of how composites are made from different fibers and how the inherent properties and layout of fibres affect the mechanical behavior of composites. They will also learn the techniques used to characterize the structure and properties of composite materials. They will also gain the practical experience of making fiber-reinforced composites and characterize their behavior through mechanical properties.	D. ull, T. W. Clyne, An Introduction to Composite Materials, Cambridge University Press, 2nd ed. (2012) P K Mallick, "Fiber Reinforced Composite: Materials, Manufacturing and Design" CRC Press, 3rd Ed.

Surface Functionalization of Textiles	The overall objective of this course is to teach students about the surface preparation, modification, and surface treatments of textiles. The students will learn the different techniques of functionalization such as physical vapor deposition, chemical vapor deposition, surface grafting, enzymatic surface modifications etc. The students will also learn the surface functionalization using plasma treatment, nanoparticles to impart different functionality to textiles such as antibacterial, superhydrophobicity, moisture management and self-cleaning characteristics. At the end of this course, the students will be able to prepare textiles with multi-functionality in different fields of life such as activewear, sportswear, medical textile and protective textiles.	Functional Finishes for Textiles by Roshan Paul, Woodhead Publishing, 2015.
Technical Textiles	Technical textiles comprise textile materials and products which are manufactured and used primarily for their performance and functional features rather than for their aesthetics. The global technical textiles market is estimated to be worth US$150 billion. The objective of this course is to give the students a broad and detailed overview of the market size, manufacturing technologies, properties, and end uses of different categories of technical textiles, including: textiles used in agriculture, horticulture and forestry; textiles for buildings and construction;technical components of clothing; textiles used in civil engineering; household technical textiles; textiles used in filtration, cleaning and process industries; textiles used for healthcare and hygiene; textiles used in automobiles, railways and aerospace; textiles used for environmental protection; textiles used for packaging; textiles for personal and property protection; and textiles used in sports and leisure.	AR Horrocks, SC Anand, Handbook of technical textiles. Elsevier, (2000)
Protective Textiles	The focus of this course is the development and characterization of textiles for protection from fire and heat, cold, water and wind, ballistics, cuts and stabbing, microbes and odor, particulate matter, static charge, ultra-violet radiation, chemical, biological, nuclear and electrical hazards. The course deals with selecting suitable raw materials for protective textiles as well as their manufacturing and testing techniques.	Shahid-ul-Islam, Advances in functional and protective textiles, Elsevier, (2020)
Medical Textiles	This module aims to furnish students with the advanced specialized knowledge and skills required to design and develop polymer and fiber-based products for use in medicine and healthcare. It progresses students' knowledge and skills needed for designing new medical products, devices and processes. The module covers materials/tissue engineering, non-implantable materials (wound dressings, hygiene products), the healthcare environmentmaterials (surgical gowns), materials to reduce healthcare-associated infection, therapeutic drug delivery technologies as well as fundamental aspects of legal and ethical issues involved within the medical practices.	VT Bartels, Handbook of medical textiles, Woodhead Publishing, (2011)
Textile modeling and Simulation	Textile engineering involves complex processes that are not easily expressed numerically or simulated, such as fiber motion simulation, yarn to fiber formation, melt spinning technology, optimization of yarn production, textile machinery design and optimization, and modeling of textile/fabric reinforcements. This subject will cover mathematical modeling and computer simulation to improve the quality, efficiency and economic success of textile technology.	Simulation in Textile Technology by D Veit, Modelling and Predicting Textile Behaviour by X Chen

Mechanics of Textile Assemblies	This course will look at all aspects of textile structure and mechanics, including the latest technology and techniques, as well as fiber assembly for major application areas. The mechanics of materials and key mechanical concepts, such as stress, strain, bending and shear will be discussed, but also structure and mechanics will be examined in-depth, including fabric type, covering yarns, woven fabrics, knitted fabrics, nonwovens, tufted fabrics, textile composites, laminated and coated textile fabrics, and braided structures.	Structure and Mechanics of Textile Fibre Assemblies (The Textile Institute Book Series) 2nd Edition, by Peter Schwartz (2019)
Nonwoven Technology	Nonwoven materials are used worldwide in various applications, including construction, apparel, hygiene products, wet wipes, medical dressings, automotive end uses, geotextiles, home furnishings, and filtration. Hence, knowledge of how nonwoven fabrics are structured, manufactured and engineered for required end-uses is important and relevant in various industries. Nonwovens are advantageous because of their ease of manufacture, versatility, and low production cost compared to other textile manufacturing methods. The objective of this course is to introduce students to nonwoven textiles and their manufacturing processes, characterization & testing methods. The course covers various web formation, web bonding and finishing methods. An overview of product developments in key application areas is also an integral part of the course.	George Kellie, Advances in technical nonwovens, Elsevier (2016)
Smart Materials	The course is designed to discuss polymers that are used as smart materials in the areas of biotechnology, medicine, and engineering. At the end of the course, the students will be able to answer these questions: How do we distinguish 'smart materials'? and How do they work? The course will also lay the groundwork for assimilation and exploitation of this technological advancement.	Smart Materials: Integrated Design, Engineering Approaches, and Potential Applications, Edited By Anca Filimon (2018)
Production Planning and Control	Production planning and control refer to two strategies that work cohesively throughout the manufacturing process. Production planning involves what to produce, when to produce it, how much to produce, and more. A long-term view of production planning is necessary to fully optimize the production flow. Production control uses different control techniques to reach optimum performance from the production system to achieve throughput targets. In this course you will learn the basic concepts of Production, Manufacturing processes, selection of system for optimizing inventory, Product management to advanced planning and control techniques as such lot sizing, EOQ method, Order size calculation, Break-even analysis, Assembly line balancing and many more.	Production Planning and Control by D.R. Kiran
Nanomaterials	This course deals with an in-depth understanding of the relationship between the physical properties and materials dimension. It will cover the different synthesis and characterization techniques of one-dimensional and two-dimensional nanostructures. The applications of these nanomaterials with respect to their properties in various fields of advanced materials will be studied in detail.	Guozhong Gua, Nanostructures & Nanomaterials, Synthesis, Properties & Applications, Imperial College Press (2003)

Advanced Pattern Construction Techniques	This course focuses on computerized body measuring systems, creating patterns shapes by computer, construction of primary and secondary block patterns, computer pattern grading, Pattern design procedures, Pattern modification for garment size and fit, CAD technology for customization, and product data management system.	1. C mputer-aided Pattern Design and Product Development by Alison Beazley and Terry Bond (2003) 2. C ncept of Pattern Grading by Kathy K. Mullet (2015)
3D Textile Structures	This course covers 3D Textile structures, their properties, and their uses within the textiles industry. At the end of this course the students will be able to present the most recent advances in the production of three-dimensional fibrous structures and with the development of novel fabrics, including knitted, braided, and non-woven textiles, and the main uses of three-dimensional textiles.	Advances in 3D Textiles, 1st Edition, by X Chen (2015)
Numerical Methods in Textile Engineering	Familiarization with the up-to-date numerical methods in engineering and the application thereof to some typical mechanical problems in textile and clothing technology. This subject will cover new concepts, methods, and applications explain the advanced principles and techniques that can be used to solve textile.	Advances in Modeling and Simulation in Textile Engineering by Nicholus Akankwasa
Performance Clothing	This course focuses on Protective clothing (extreme weather, NBC, injuries), Medical clothing (therapeutic, biosensing), Sportswear (performance-enhancing), Vanity clothing(body sculpting, body support), cross-functional clothing (military, space suits) and special needs clothing (disabled, elderly, pregnant)	1. Designing with smart textiles. S. Kettley. 2016 2. lectronics in textiles and clothing. A. Kumar, 2016 3. Textiles. T. Dias, 2015 4. nctional Clothing Design "From Sportswear to Spacesuits". Susan Watkins, Lucy Dunne, 2015
Nanocomposites	All three classes of composite materials are included in the course: polymeric matrix composites (PMC), as well as metallic and ceramic matrix composites (MMC and CMC), though the main focus is on PMC. Dominantly, conventional (that is using micro size reinforcement) composites are discussed. Nanocomposites (that is using nanosized reinforcement) are included in the course but to a lesser extent because the industry is mainly using conventional composites. Nevertheless, nanocomposites are making great research and growing engineering impacts, following science and development in the field of nanoparticles.	Visakh P.M., Nanomaterials and Nanocomposites: Zero- to Three-Dimensional Materials and Their Composites (2016)
Quality Assurance in Textiles	Quality assurance is one of the critical departments in the textile sector that maintains the quality of the products according to the end requirements/standards. This course will focus on the quality parameters across the textile value chain, ranging from spinning to garment manufacturing. The fundamentals of quality control and assurance will be discussed alongside the standard testing methods and procedures.	The Fundamentals of Quality Assurance in the Textile Industry (2016) by Stanley Bernard Brahams

Denim Manufacturing and Processing	The objective of this course is to impart the knowledge of denim manufacturing processes emphasizing the preparation of yarn for denim, dyeing of yarn, production of fabric and garments. Various fabric treatments will be taught in detail the dyeing process and chemical washing techniques to attain the various effects for fashion articles. The student will also learn the eco-friendly denim treatment processes such as ozone fading, laser treatment to ensure the sustainable development of denim garments. Sustainability will also be addressed through the reduction of wastewater, recycling of denim garments.	Denim Manufacture, Finishing and Applications Edited by Roshan Paul, 2015
Filtration in Textiles	This course is designed to learn about the development, testing, and application of filtration and filters. Different materials and methods used for the manufacturing of filters are discussed in detail in this course. Various testing techniques to check the efficiency of filters are also discussed.	Filters and Filtration Handbook, Trevor Sparks and George Chase
Electrospun Materials and Applications	This course covers all electrospun-based materials, ways to develop different nanowebs, different electrospun technologies, and electrospun-based products. All the constraints to develop versatile electrospun products are also covered in this subject.	Electrospinning: Materials, Processing, and Applications, Joachim H. Wendorff
Textile Comfort	The course is designed to overview the role of indoor textiles and clothing as a barrier between the environment and the human body. This also explores the use of textiles as an insulation barrier, examining the relationships between textiles and the environment and textiles and the human body. It also describes a numerical investigation of the transport of air and heat through woven fabrics by means of computational fluid dynamics (CFD), and develops, applies, and verifies an original approach for simulating the woven macrostructure as a jet system, presenting proven results.	Textiles and Human Thermophysiological Comfort in the Indoor Environment (2016) By Radostina A. Angelova
Advancement in Natural and Manmade Fibers	This course gives an overview of advancements in natural fibers extraction, processing and conversion to end product. Newly developed manmade fibers with high functionality are also covered in this course.	Natural Fibres: Advances in Science and Technology Towards Industrial Applications: From Science to Market, Raul Fangueiro; Advances in Filament Yarn Spinning of Textiles and Polymers, Dong Zhang
Recycling in Textiles	This subject covers the general issues involved and the technologies concerned with the recycling of textiles. The chemical aspects of textile recycling are also discussed. This course focused on recycled textile products, including nonwovens and alternative fibers. Possible applications of recycled textiles, including using recycled products in the operating theatre, for soil stabilization and concrete reinforcement, are also part of this subject.	Youjiang Wang, Recycling in Textiles (2006)

Chemistry of Dyes and Pigments	The overall objective of this course is to give students the general description of dyes & pigments, the chemistry of dyes & pigments, and their synthesis on lab-scale as well as on an industrial scale. The students will learn the nomenclature of dyes, different chromophoric system, classification of dyes according to their chemical structure, classification of dyes with respect to their application, the physicochemical interaction between dyes and fibrous materials. The students will also learn the chemistry and synthesis of different types of organic, inorganic pigments, and advanced pigments like thermochromic and photochromic pigments. This course will also cover the synthesis and application of novel dyes with added functionality to impart UV-absorbent and antimicrobial characteristics to the textiles.	Colorants and Auxiliaries, Volume I & II by John Shore, 2002.

Career opportunities for students after Completion of the Program

The MS Textile Engineering program aims to create a higher learning culture that enables participants to work in

1. Research and development of textile industry
2. Research institute
3. Researcher and teacher in academic/research Universities
4. Companies for development and manufacturing of machines/parts/textiles

2. PhD TEXTILE ENGINEERING

The PhD Textile Engineering is a full-time program that includes 18 credit hours of course work followed by comprehensive examination and research. This is a rigorous program aimed at enabling and promoting high-quality research in textile engineering to benefit the world in general and Pakistan in particular. The program emphasizes not only depth in fundamental textile engineering but also an interdisciplinary approach to understanding technologies in which textile engineers and scientists can take a leading role.

This program attracts graduates who want to continue their careers in academia and the textile industry. The program enables the students to gain a high-quality doctoral qualification with capabilities to develop an understanding of engineering-driven business and to innovate and respond to the challenges faced during product and process development. Students must demonstrate the ability to apply scientific principles to meet engineering needs due to social and economic factors and within a reasonable time constraint.

Program Educational Objectives (PEOs)

The PhD Textile Engineering graduates will be able to:

1. Demonstrate the knowledge of textile engineering and allied disciplines to identify and investigate the technical as well as societal problems and propose a viable solution based on scientific studies
2. Conduct and manage research and development activities to address local and global challenges keeping in view sustainability.

Program Learning Objectives (PLOs)

At the time of completion of PhD Textile Engineering degree, the students will be able to:

1. Identify research problems and research gap after critical analysis of literature.
2. Apply scientific approaches to plan and conduct research to devise solution of the problem keeping in view the environmental, social, and legal aspects.
3. Design a product or process to meet the desired needs within realistic constraints and conditions.
4. Select and apply modern techniques and tools to infer the meaningful conclusions.

Eligibility Criteria

1. MS/M.Phil Textile Engineering/Mechanical Engineering/Chemical Engineering/Industrial & Manufacturing Engineering/Product and Industrial Design/Materials Engineering/Environmental Engineering/Mechatronics Engineering/Chemistry/Textile Chemistry or equivalent degree with minimum CGPA 3.00/4.00 or 3.50/5.00 in semester system or **60%** marks in annual system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test with minimum 60% score or NTU-GAT (Subject) test with minimum 50% score in case of different qualification as per HEC.
3. Applicant having MS or equivalent degree without thesis is not eligible to apply.
4. It is mandatory to pass interview in order to compete on merit.
5. Applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
6. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final MS/M.Phil or equivalent official transcript or degree.
7. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
8. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Merit / Admission Criteria

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	Weightage
B.Sc./BS/Equivalent	20% weightage
MS or Equivalent	60 % weightage
Interview	10% weightage
Publication/Relevant experience	10% weightage (05% + 05%)

Semester-Wise Layout of Course

Semester-I

Sr.No.	Code	Course Title	Credit Hours
1	TE-7001	Advanced Statistical Methods for Research	3
2	TE-7002	Recent Development in textile Engineering	2
3	TE-7003	Modern testing and Characterization Methods	3
4	TE-7004	Prototype / Review Paper	1
Total			9

Semester-II

Sr.No.	Code	Course Title	Credit Hours
1	TE-70XX	Elective – I	3
2	TE-70XX	Elective – II	3
3	TE-70XX	Elective – III	3
Total			9

Semesters III-VIII

Sr.No.	Code	Course Title	Credit Hours
1	TE-8090	Research Thesis	30
	Total Credit Hours		48

List of Elective Courses

Sr. No	Code	Course Title
1	TE-7011	Dyeing Engineering and Wet Textile Processing
2	TE-7012	Quality Management in Clothing
3	TE-7013	Fiber Reinforced Polymer Composite
4	TE-7014	Industrial Information Systems
5	TE-7015	Mechanics of Textile Machines
6	TE-7016	Clothing Engineering
7	TE-7017	Textile Machinery and Instrument Design
8	TE-7018	Medical Textiles
9	TE-7019	Textile Surface Modification and Chemical Treatments
10	TE-7020	Textile Machinery and Instrument Design
11	TE-7021	Textile Modeling and Simulation
12	TE-7022	Mechanics of Textile Assemblies
13	TE-7023	Medical Textiles
14	TE-7024	Protective Textiles
15	TE-7025	Nonwoven Technology

Sr. No	Code	Course Title
16	TE-7026	Recent Development in Textile Engineering
17	TE-7027	Engineered Textile Structures & Composites
18	TE-7028	Technical Textiles
19	TE-7029	Composite Technology
20	TE-7030	Smart Materials
21	TE-7031	Mechanics of Materials
22	TE-7032	Adv Fiber, Fabric & Yarn Manufacturing Techniques
23	TE-7033	Adv Fabric Manufacturing Techniques
24	TE-7034	Adv Textile Processing Technologies
25	TE-7035	Adv Clothing Technologies
26	TE-7036	Production, Planning and Control
27	TE-7037	Thermodynamics and Kinetics of Materials
28	TE-7038	Electronic and Mechanical Properties of Materials
29	TE-7039	Nano Materials/Structures
30	TE-7040	Smart Textiles
31	TE-7041	Nano Materials for Textiles
32	TE-7042	Nanocomposites
33	TE-7043	Electrospun materails and Applications
34	TE-7044	Filtration in Textiles
35	TE-7045	Biomaterials
36	TE-7046	Finite Element Methods
37	TE-7047	Woven Structures for Advance Engineering Applications
38	TE-7048	3D Textile Structures (Woven, Knitted, Braided, Nonwoven)
39	TE-7049	Fiber Reinforced Composite Materials
40	TE-7050	Shape Memory Materials
41	TE-7051	Surfaces and Interfaces
42	TE-7052	Flexible Electrodes
43	TE-7053	Textiles for Energy Production
44	TE-7054	Electronic and Magnetic Materials
45	TE-7055	Nanocomposites
46	TE-7056	Fracture Mechanics
47	TE-7057	Thermodynamics and Kinetics of Materials
48	TE-7058	Heat and Mass Transfer
49	TE-7059	Fluid Flow in Porous Media
50	TE-7060	Blended Textile Structures
51	TE-7061	Advanced Fibrous Structures
52	TE-7062	Advanced Industrial Marketing
53	TE-7063	Strategy and Economics Concepts of Garments Production

Sr. No	Code	Course Title
54	TE-7064	Fabric and Garment Embellishment
55	TE-7065	Clothing and Culture
56	TE-7066	Textile Merchandising
57	TE-7067	Textiles & Apparel Merchandizing Development
58	TE-7068	Apparel Design for Industry
59	TE-7069	International Textile and Apparel Sourcing
60	TE-7070	Survey Research and Experimental Designs
61	TE-7071	Fibers and Fibrous Structures
62	TE-7072	Physical Properties of Fiber Forming Polymers
63	TE-7073	Yarn Formation
64	TE-7074	Fabric Formation
65	TE-7075	Textile Processing
66	TE-7076	Garments Manufacturing
67	TE-7077	High Performance Fibers
68	TE-7078	Mechanics of Fibrous Structures
69	TE-7079	Polymer Processing Techniques
70	TE-7080	Polymer Rheology
71	TE-7081	Polymer Chemistry
72	TE-7082	Textile Calculations
73	TE-7083	Quality Assurance in Textiles
74	TE-7084	Denim Manufacturing and Processing
75	TE-7085	Air Conditioning in Textiles
76	TE-7086	Applied Statistics and Regression
77	TE-7087	Frontiers in Operations Management Research
78	TE-7088	Operations and Supply Chain Management
79	TE-7089	Organizational Behavior and Human Resource Management
80	TE-7090	Wastewater Treatment
81	TE-7091	Numerical Methods in Textile Engineering
82	TE-7092	Fundamentals of Air Quality Management
83	TE-7093	Filtration in Textiles
84	TE-7094	Production Planning and Inventory Control
85	TE-7095	Advanced Regression Techniques
Note		**Any other Course Proposed by Supervisory Committee and approved by Program Management Committee**

Course Specifications

Advanced statistical methods for research

The nature of probability and statistics; Frequency distributions and graphs; Data description; Probability and counting rules; Normal and discrete probability distributions; Confidence intervals and sample size; Hypothesis testing and testing the difference between two means/proportions/variances; Correlation/regression and Chi-Square testing; Analysis of variance; Nonparametric statistics; Sampling and simulation.

Recommended Books:

Understanding Advanced Statistical Methods by Peter Westfall, Kevin S. S. Henning, 2013.

Recent Developments in Textile Engineering

Air vortex spinning technique; MVS spinning technique; Rotor spinning technique; Advance fibers; Auxetic yarn; Recent development in fabric manufacturing (woven and knitted). Applications of enzymes in textile industry: fundamental aspects of enzymes determining catalytic properties, Basic thermodynamics and enzyme kinetics, function of textile-processing enzymes, sustainability aspects of enzyme applications. Treatment of textiles with plasma: Physics of plasma, production techniques, various applications and advancements in plasma processing. Ozone treatment of textiles: production of ozone, interaction of ozone with substrate, applications of ozone in textiles. Digital printing of textiles: Printing process, Application land scape, recent developments. Modification of textile surface for functional and performance applications: Recent developments in various functional finishes such, flame retardants, antibacterial activity, UV protection, EMI shielding etc. Recent development in textile based composite manufacturing for personal protection, automobile and aerospace applications.

Recommended Books:

1. Advances in Textile Engineering and Materials by Huawu Liu, Yongxin Yang, Shijie Shen, Zhili Zhong, Laijiu Zheng and Peng Feng, 2013.
2. Advances in Functional and Protective Textiles 1st Edition by Shahid ul-Islam Bhupendra Singh Butola, 2020.

Modern testing and Characterization Methods

Moisture management tester; Air permeability; Fabric touch tester; Water vapor permeability tester; Kawabata Evaluation system; Fourier-transform infrared spectroscopy (FTIR); Scanning Electron microscopy (SEM); X-ray diffraction (XRD).

Recommended Books:

1. Nuclear Magnetic Resonance Vol. 37 by G. A. Webb, Royal Society of Chemistry, 2008.
2. Materials Characterization Techniques. By Sam Zhang, Lin Li and Ashok Kumar, 2008.

Prototype/Review Paper

The student is required to write an in-depth, publishable review on a topic from one of the following areas of Textile Engineering & Technology: Textile Materials (Polymers, Fibers, Additives, Adhesives, etc.); Yarn Manufacturing (Production Systems, Products, Properties, End-Uses); Woven & Knitted Fabric Manufacturing (Production Systems, Products, Properties, End-Uses); Nonwovens (Production Systems, Products, Properties, End-Uses); Coloration and Finishing (Pre-treatments, Application of Color, Functional and Aesthetic Finishes); Apparel and “3-D” Product Manufacturing (Formation and Visualization of 3D Structures; Pre-production, Spreading, Cutting, Joining & Finishing of Apparels); Textile Measurement and Control (Measurement and Control of Textile Processes and Products, Property Evaluation).

Advanced Polymeric Materials

Polymers are a ubiquitous part of our everyday life. Advances in polymer synthesis, processing, and engineering have led to new applications exploiting the unique properties of polymers to realize advanced technologies far removed from their initial application. Building on a review of the fundamentals of polymer science, this unit will explore the use of polymers in a range of novel applications from biomedical applications to optoelectronic devices. Different classes of polymers will be discussed including conjugated polymers, block co-polymers, and biopolymers with a view to linking the physical properties of the polymer chain to the functionality of the technological application.

Recommended Books:
Didier Rouxel, Advanced Polymeric Materials: Synthesis and Applications (2018)

Nanocomposites

All three classes of composite materials are included in the course: polymeric matrix composites (PMC), as well as metallic and ceramic matrix composites (MMC and CMC), though the main focus is on PMC. Dominantly, conventional (that is using micro size reinforcement) composites are discussed. Nanocomposites (that is using nanosized reinforcement) are included in the course but to a lesser extent because the industry is mainly using conventional composites. Nevertheless, nanocomposites are making great research and growing engineering impacts, following science and development in the field of nanoparticles.

Recommended Books:
Visakh P.M., Nanomaterials and Nanocomposites: Zero- to Three-Dimensional Materials and Their Composites (2016)

Denim Manufacturing

The objective of this course is to impart the knowledge of denim manufacturing processes emphasizing the preparation of yarn for denim, dyeing of yarn, production of fabric and garments. Various fabric treatments will be taught in detail the dyeing process and chemical washing techniques to attain the various effects for fashion articles. The student will also learn the ecofriendly denim treatment processes such as ozone fading, laser treatment to ensure the sustainable development of denim garments. The sustainability will also be addressed through reduction of wastewater, recycling of denim garments.

Recommended Books:
Denim Manufacture, Finishing and Applications Edited by Roshan Paul (2015)

Biomaterials for Healthcare

Overview of the biomaterials and process for medical textiles and implantable biotextile devices. Review steps in the identification of healthcare needs, market size and demand, product specifications and design, prototype fabrication and sterilization, in vitro testing of mechanical, chemical, surface and biological properties, in vivo animal testing, regulatory issues, consumer and clinical trials and explant analysis. Examples of medical textiles for personal hygiene, wound care, external support, orthopedic, general surgery, dental and tissue engineering applications. The student will be introduced to the process of new product development as it applies to medical textiles and biotextiles.

Recommended Books:

1. S C Anand, Medical Textiles and Biomaterials for Healthcare (2005)
2. William R Wagner, An Introduction to Materials in Medicine (2020)

Advances in shape Memory Polymers

A broad variety of materials are actually considered as smart ones: from shape memory alloys to polymer nanosystems. With this course, specific aspects of an exciting interdisciplinary area “Smart Materials” will be introduced in such a way it can be easily understood by a broad audience. How remarkable properties of smart materials correlate with simple structural features at nanoscale and microscale, discuss various methods to characterize materials with smart properties. Inspiring trends in applications of smart materials will be highlighted.

Recommended Books:
J. arameswaranpillai, Shape Memory Polymers, Blends and Composites: Advances and Applications (2020)

Nanofibers and Nanoparticles

Importance of the surface, engineering materials, particle shape and the surface, surface, and volume, atomic structure, particle orientation, materials at the nanoscale. Diamond, fullerenes, graphene, carbon nanotubes, properties and types CNT’s, growth and applications of CNT’s, nanomaterials natural and manmade, semiconductor nanoparticles, ceramic nanoparticles, metal nano physics, polymers and composites, inorganic nanotubes, metals, oxides, quantum dots, surface-enhanced raman spectroscopy, nanocatalysis. Sources of atmospheric nanoparticles, particle size distribution, measurement of nanoparticles in roadside air, transformation and transport of ultrafine particles, measurement of particle number concentration in the atmosphere, chemical composition of atmospheric nanoparticles, indoor/ outdoor relationships of nanoparticles.

Recommended Books:

1. Maria Benelmekki, Nanomaterials (2019)
2. Andy Nieto, Nanomaterials and their Applications (2020)

Flame Retardant Materials

It discusses the basics of flame retardancy and flammability and covers various types of flame retardants and materials, including natural FRs, halogen, phosphorous, and nanomaterial-based FRs. The course also discusses methods of applications of FRs and discusses FRs and the environment.

Recommended Books:

Asim Kumar Roy Choudhury, Flame Retardants for Textile Materials (2021)

Functional Materials for Textiles

The course focuses on functional textiles for improved performance and protection, reviewing antistatic, flame retardant and infrared functional textiles, among many others. This also includes the uses of functional textiles in a medical context, including superhydrophobic materials, antibacterial textiles, and insect-repellent materials.

Recommended Books:

Abhijit Majumdar, Functional Textiles and Clothing (2019)

Microencapsulation Technology

This course is intended to provide an overview and review of the latest developments in microencapsulation processes and technologies for various applications. The general theme and purpose are to provide the reader with a current and general overview of the existing microencapsulation systems and to emphasize various methods of preparation, characterization, evaluation, and potential applications in multiple fields such as medicine, food, agricultural, and composites.

Recommended Books:

Fabien Salaün, Microencapsulation (2019)

Engineering Textiles

It covers textile product design and development, enabling the students to understand essential principles, concepts, materials, and applications. It covers design concepts and technologies, such as sustainability, nanotechnology, and wearable textiles. This course covers fiber-to-fabric engineering, product development and design of textile products, different types of fibers, yarns and fabrics, the structure, characteristics, and design of textiles, and the development of products for specific applications, including both traditional and technical textiles.

Recommended Books:

Yehia Elmogahzy, Engineering Textiles (2019)

Advances in Yarn Spinning Technology

This chapter provides an introduction to yarn fiber spinning and structure. It discussed the principles of ring spinning and the open-end spinning of yarns. Yarn structure and properties from different spinning techniques and yarn structural requirements for knitted and woven fabrics are also examined. This also covers advances in particular yarn spinning technologies. Topics range from siro spinning to compact spinning technology and air-jet spinning. How to minimize fiber damage that occurs during spinning and the use of spin finishes for textiles.

Recommended Books:

C.A. Lawrence, Advances in Yarn Spinning Technology (2010)

Design and Manufacture of Textile Composites

The term 'textile composites' is often used to describe a rather narrow range of materials, based on three-dimensional reinforcements produced using specialist equipment. In the design and manufacture of textile composites, however, the term is used to describe the broad range of polymer composite materials with textile reinforcements, from woven and non-crimp commodity fabrics to three-dimensional textiles. In this course, modeling of textile structures, composites manufacturing methods and subsequent component performance is covered broadly. It also covers applications from a broad range of areas, including transportation, sporting construction and medical applications.

Recommended Books:
A.C. Long , Design and Manufacture of Textile Composites (2005)

Mechanics of Fibrous Assemblies

Mechanics of materials is a branch of applied mechanics that deals with the behavior of solid bodies subjected to various types of loading. This course deals with stress-strain behavior of different materials, testing techniques, constitutive equations, micromechanics, modeling, and simulation techniques for structural analysis. This course develops understanding and knowledge of material response and performance under various types of forces. It helps to understand material failure behaviors and their prediction. Main concepts include stress and strain, force systems on structures, moment of inertia, and shear and bending moments etc.

Recommended Books:
Parviz Ghavami, Mechanics of Materials An Introduction to Engineering Technology, Springer, 1st Ed. (2015)

Heat and Mass Transfer in Porous Media

The course provides an insight of the governing laws for heat and mass transfer. The topics covered include one-dimensional and two-dimensional steady-state conduction, transient conduction, fundamentals and engineering treatment of convection heat transfer, external and internal heat flow and free convection. Applying the rigorous and systematic problem-solving methodology with examples and problems is discussed during this course.

Recommended Books:
1. RK Rajput, Heat and Mass Transfer, S. Chand Publishing, (2019)
2. DS Kumar, Heat and Mass Transfer, SK Kataria Publishers, (2013)

Advances in Dyeing and Finishing of Technical Textiles

The use of distinctive colourants and finishes has a significant impact on the aesthetic appeal and functionality of technical textiles. This course covers advances in dyes and colourants, including chromic materials, optical effect pigments, and microencapsulated colourants for technical textile applications. Other types of functional dyes considered include UV- absorbent, anti-microbial and water-repellent dyes. Regulations relating to the use of textile dyes are also discussed in this chapter. Advances in finishing techniques as mechanical finishing, softening treatments and the use of enzymes are also part of this course. Surfactants, Inkjet printing of technical textiles and functional finishes to improve the comfort and protection of apparel are also explored. The use of nanotechnology in producing hydrophobic, super-hydrophobic and antimicrobial finishes is dealt with alongside coating and lamination techniques.

Recommended Books:
M.L. Gulrajani, Advances in the Dyeing and Finishing of Technical Textiles (2013)

Functional Finishes for Textiles

This course focuses on the most important fabric finishes in the textile industry. It discusses finishes designed to improve the comfort and other properties of fabrics, as well as finishes that protect the fabric or the wearer. The role of a finish, the mechanisms and chemistry behind the finish, types of finish and their methods of application, application to particular textiles, testing and future trends are also covered in this course.

Recommended Books:
Roshan Paul, Functional Finishes for Textiles (2015)

Smart Textile Coatings and Laminates

This course is focused on the state-of-the-art in smart coatings for fibers, fabrics and polymers, providing fundamental knowledge and stimulus for further research and development. It includes a new range of application areas, including responsive coatings, smart coatings for medical applications, and electronics integration into textiles through coating technology.

Recommended Books:
William Smith, Smart Textile Coatings and Laminate (2018)

Surface Modification of Textiles

This course covers fundamental issues relating to textiles surfaces and their characterization. Various types of surface modification suitable for textiles, including plasma treatments and nanoparticles, are also part of this course. It discusses surface modification strategies for textile applications such as expansion into technical textile applications

Recommended Books:
Q.i, Surface Modification of Textiles (2009)

Plasma Technologies for Textiles

This course describes both the science and technology of plasma processing and its practical applications. It covers how plasma technology improves textile properties such as wettability and liquid repelling.

Recommended Books:
R.ishoo, Plasma Technologies for Textiles (2007)

Smart Clothes and Wearable Technology

This course covers an emerging area of textile research including a brief history and industry overview. This also assesses the technologies and materials available for the design and production of smart clothing. This also summarises requirements for smart textiles from both health and performance perspectives.

Recommended Books:
J. cCann and D. Bryson, Smart Clothes and Wearable Technology (2009)

Simulation in Textile Technology

This course covers principles, applications, and benefits of modeling for textile production. Neural networks and their applications before going on to explore evolutionary methods and fuzzy logic are covered. The modeling of fibrous structures and yarns, along with wound packages, woven, braided and knitted structures, are also part of this course.

Recommended Books:
D. Veit, Simulation in Textile Technology (2012)

Finite Element Analysis in Textiles

This course aims to teach the fundamentals of the finite element method for the analysis of engineering problems arising in solids and structures. The course emphasizes the solution of real-life problems using the finite element method underscoring the importance of the choice of the proper mathematical model, discretization techniques, and element selection criteria. The students learn how to judge the quality of the numerical solution and efficiently improve accuracy by optimal selection of solution variables.

Recommended Books:
Daryl Logan, A First Course in the Finite Element Method, Cengage Learning, 6th Ed. (2016)

Recycling in Textiles

This subject covers the general issues involved and the technologies concerned with the recycling of textiles. The chemical aspects of textile recycling are also discussed. This course focused on recycled textile products, including nonwovens and alternative fibers. Possible applications of recycled textiles, including using recycled products in the operating theatre, for soil stabilization and concrete reinforcement, are also part of this subject.

Recommended Books:
Youjiang Wang, Recycling in Textiles (2006)

Environmental Impact of Textiles

This course covers the effects of textile production on the environment, from growing or making fibers to discarding a product after its useful life has ended. It looks at how the physical environment is affected by textile production processes, including resource depletion, pollution, energy use and the biological environment. Covers the degradation suffered by textile materials within the environment by air pollution, wind, water and other agents.

Recommended Books:
K Slater, Environmental Impact of Textiles (2003)

Energy Harvesting Materials

This course covers all aspects of the subject, ranging from natural plant and bacterial photosystems, through their biologically inspired synthetic analogs, to other photoactive molecular materials such as dendrimers. This also establishes the theory and underlying principles across the full range of light-harvesting systems. With an authoritative, comprehensive and well-referenced content, it will appeal to all students, researchers and technologists interested or involved in solar energy, photobiology and photoactive materials science.

Recommended Books:

David L Andrews, Energy Harvesting Materials (2005)

Career opportunities for students after Completion of the Program

The PhD Textile Engineering program aims to create a higher learning culture that enables participants to work in

1. Research and development of textile industry,
2. Research institute
3. Researcher and teacher in academic/research Universities
4. Companies for development and manufacturing of machines/parts/textiles/polymer

Department of Materials

The Department of Materials was initially established as the Department of Polymer Engineering at National Textile University in 2007. It was later renamed to Department of Materials in 2021 with the enhanced scope and more programs offered. The foremost purpose of establishing this department is to provide the trained workforce to polymers, composites, and other materials-related sectors in the country. At the postgraduate level, the Department offers MS and PhD programs through a range of courses covering all areas of advanced materials. The curriculum is designed vigilantly by keeping in view the current and future needs of the industry and is fully flexible to be modified to keep pace with the rapidly changing technologies. Department of Materials has strong industrial linkages which enable the students to grab the latest trends in the industry.

1. MS ADVANCED MATERIALS ENGINEERING

The MS Advanced Materials Engineering is a two-year interdisciplinary postgraduate program offered by the Department of Materials. The program provides training opportunities for students to acquaint them with technical knowledge and skills essential for critical thinking, problem-solving, and decision making. These skills inculcate in them the ability of independent research to address multidisciplinary problems in materials engineering, making them lifelong learners.

The major areas include, but are not limited to: development of new polymers or fibers with superior properties; development of nanofibers for different applications; development and incorporation of nanoparticles in polymers; modification of current polymers or fibers for superior properties; development of polymer matrix composite structures; energy harvesting materials; advanced materials for conductive applications; advanced materials for making valuable products, etc.

Program Learning Objectives (PEOs)

MS Advanced Materials Engineering graduates will be able to:

1. Demonstrate comprehensive knowledge and research in industry and academia through engineering practices generally and advanced materials particularly.
2. Act as responsible professionals, providing solutions with due considerations to ethical and environmental impacts of their work on society.
3. Communicate effectively about scientific topics and industrial problems.

Program Learning Objectives (PLOs)

1. Acquire advanced knowledge in the advanced materials engineering industry and academia.
2. Design and conduct scientific research using acceptable methodologies and solve research problems through effective analytical skills.
3. Analyze and evaluate technical findings for better understanding of the readers in the fields of science and engineering.
4. Manage the advanced knowledge and research skills to one's work as a team member and/or leader in a multidisciplinary environment.
5. Communicate effectively, orally, and in writing, with the scientist or engineering community and society at large.

Eligibility Criteria

1. BS Polymer Engineering/Mechanical Engineering/Chemical Engineering/Industrial & Manufacturing Engineering/Product and Industrial Design/Materials Engineering/Environmental Engineering/Chemistry/Physics/Mathematics/Electrical Engineering/Electronics Engineering/Mechatronics Engineering or equivalent degree from HEC recognized institution with a minimum CGPA 2.00/4.00 or 3.00/5.00 in semester system or **60%** marks in annual/term system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.

5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit / Admission Criteria

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	
BS or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Semester-Wise Layout of Courses

Semester-I

Sr. No	Code	Course Title	Credit Hours
1	AME-5101	Advanced Materials	3
2	AME-5102	Research Methodology	3
3	AME-5103	Advanced Materials Characterization Techniques	3
4	AME-5104	Mechanics of Materials	3
	Total		12

Semester-II

Sr. No.	Code	Course Title	Credit Hours
1	AME-5111	Composite Materials	3
2	AME-5112	Advanced Materials Processing and Rheology	3
3	AME-5113	Elastomeric Materials & Processes	3
4	AME-5114	Membrane Design and Applications	3
5	AME-5115	Smart, Nano and Functional Materials	3
6	AME-5116	Additive and Subtractive Manufacturing	3
7	AME-5117	Environmental Health and Sustainable Development	3
8	AME-5118	Product Development and Innovation Management	3
	***The student will select four elective courses in 2nd semester.**		**12**

Semester-III & IV

Sr. No.	Code	Course Title	Credit Hours
1	AME-6071	Research Thesis	6
Total Credit Hours			30

Note:

- MS students will have to pass the 24 credit hours courses and 6 credit hours thesis.
- The summer semester will not be offered.
- Other details of semester activities are as follows.

Assignments	One assignment per credit is generally conducted by teachers for each subject.
Quizzes	One quiz per credit of course is conducted by each teacher.
Presentations	Teacher can ask students to present a specific topic generally once in a subject.
Projects	Teacher can allot small projects individually or in groups as per the scope of subject.
Exams	Two exams, at the mid and end of semesters, are conducted for each subject.

*Criteria for Selection of Electives

The student will have to select four elective courses in 2nd semester.

1. At the start of the second semester, the list of available electives will be displayed/shared with the students.
2. The electives will be offered on the availability of relevant faculty members.
3. The students will choose electives from the given list within the prescribed time limit.
4. An elective will be offered if a minimum of 40% of the class or at least 10 students choose to study that elective.
5. The final elective list will be displayed/shared with the students soon after finalizing the elective subjects.
6. Students, who opted for the non-offered electives, will have to choose among the offered elective courses.

Course Specifications

Advanced Materials

The objective of this course is to give the students an overview of various types of materials used for advanced engineering applications. The students will learn about the properties and applications of various polymeric, ceramic, metallic, bio- and composite materials ranging from nanoscale to macro scale. In addition to various physical and mechanical properties, various functional aspects of the materials will also be covered in the course including shape memory effect, self-healing, phase change, fire retardant behavior and energy harvesting properties. At the end of the course, the students should be able to select suitable materials for various engineering applications, particularly for making advanced technical textile products.

Reference Books

1. Advanced Materials, edited by: Theodorus van de Ven and Armand, Soldera, 2020.
2. Handbook of Advanced Materials: Enabling New Designs, Editor(s): James K. Wessel, 2004.

Research Methodology

The overall aim of this course is to enable the students to identify a research area, identify a research problem, formulate research question, conduct literature survey, formulate research hypothesis, design research experiments, graphically present, analyze and interpret the experimental data, and draw valid conclusions. Additionally, the students will be able to write a research proposal, critically analyze research papers, and write a short literature review with proper citations and referencing. The students will practice relevant statistical tools and techniques using a statistical software package. The students will also become familiar with plagiarism and other ethical issues in research, patents, copyrights and trademarks, thesis, and research paper writing styles.

Reference Books

1. Handbook Of Research Methodology, By Dr. Shanti Bhushan Mishra, Dr. Shashi Alok, 2017, ISBN: 978-1-5457-0340-
2. Research Methodology: A Step-by-Step Guide for Beginners. 5th ed. by Ranjit Kumar, SAGE Publishing, 2019. ISBN: 9781526449900
3. Higher Education Research Methodology: A Step-by-Step Guide to the Research Process, By Ben Kei Daniel, Tony Harland, Published in 2017 by Routledge

Advanced Materials Characterization Techniques

This course gives an introduction to different physical, chemical and mechanical characterization techniques, including XRD, SEM, TEM, chromatography, infrared spectroscopy, UV/Vis spectroscopy, atomic absorption spectroscopy, tensile testing, impact testing, bending, shear and hardness testing.

Reference Books

1. Advanced Techniques for Materials Characterization by Thomson Reuters BCI (WoS), 2009, ISBN: 9783038133230, DOI: 10.4028/www.scientific.net/MSFo.49-51
2. Handbook of Materials Characterization, Editors: Sharma, Surender Kumar (Ed.), Springer, 2018, ISBN 978-3-319-92955-2, DOI: 10.1007/978-3-319-92955-2

Mechanics of Materials

Mechanics of materials is a branch of applied mechanics that deals with the behavior of solid bodies subjected to various types of loading. This course deals with stress-strain behavior of different materials, testing techniques, constitutive equations, micromechanics, modelling and simulation techniques for structural analysis.

Reference Books:

1. Mechanics of Materials, An Introduction to Engineering Technology, Authors: Ghavami, Parviz, Springer, 2015, ISBN 978-3-319-07572-3
2. Handbook of Mechanics of Materials, Editors: Editor-in-chief: Hsueh, Chun-Hway, Schmauder, S., Chen, C.-S., Chawla, K.K., Chawla, N., Chen, W., Kagawa, Y. (Eds.), Springer, 2019, ISBN 978-981-10-6883-6

Composite Materials

Composites are the materials of 21st century. They have vast applications in sports, defense, automotive, aerospace engineering, medical sciences, building/construction material and many other sectors. This course is designed to provide student thorough knowledge of fundamental issues of fibres reinforced composites. Students will develop the understanding how composites are made from different fibres and how the inherent properties and layout of fibres affect the mechanical behavior of composites. They will also learn the techniques used to characterize the structure and properties of composites materials. They will also gain the practical experience of making fibre reinforced composites and characterize their behavior through mechanical properties.

Reference Books:

1. Chapter: Composite Materials Testing, Contributor(s): Khubab Shaker, Yasir Nawab, Book: Advanced Textile Testing Techniques, Ed. Sheraz Ahmad, Abher Rasheed, Ali Afzal, Faheem Ahmad, CRC Press, 2017, ISBN: 9781315155623
2. Composite Materials: Science and Applications, Second Edition by Deborah D.L. Chung, Springer 2010, ISBN 978-1-84882-830-8, DOI 10.1007/978-1-84882-831-5

Advanced Materials Processing and Rheology

The main objective of teaching this course is to give a general understanding of the primary and critical concepts of polymer solution or melt flow behavior under certain circumstances. The flow properties will be dependent on multiple polymers, solvent, solution, and physical parameters. The flow properties are studied under the title of polymer rheology. Students will be able to remember and understand the key parameters which affects the polymer solution rheology behavior. In addition, the time dependent flow behavior like Rheopexy will be considered to understand the shelf-life behavior. This course will help students understand the different viscosity requirements of polymer solutions and melt during the process, which are key elements in producing a quality product.

Reference Books:

1. Research Methodology: A Step-by-Step Guide for Beginners by Dr. Ranjit Kumar, 2nd Edition, Sage Publications (2005)
2. Doe Simplified 2E: Practical Tools for Effective Experimentation by Mark J Anderson, 2nd Edition, Productivity Press (2007)
3. RSM Simplified: Optimizing Processes Using Response Surface Methods for Design of Experiments by Mark J Anderson and Patrick J Whitcomb, Productivity Press (2005)
4. Design and Analysis of Experiments – Student Solutions Manual by Douglas C. Montgomery, 7th Edition, John Wiley & Sons (2009)

Elastomeric Materials & Processes

This course has been designed to develop students' knowledge about elastomers such as rubbers, interpretation of its thermal, chemical, and physical properties, general purpose elastomers, specialty elastomers, fillers, rubber additives, rubber equipment, vulcanization, vulcanizing agents and accelerators, plasticizers, and applications of elastomers.

Reference Books:

1. Advanced Elastomers: Technology, Properties and Applications by Anna Boczkowska, Intech Open, 2012
2. Rubber Compounding by Brendan Rogers, CRC Press, 2004
3. Handbook of Rubber Technology by J. M. Martin and W. K. Smith, 2004

Membrane Design and Applications

This course will provide an insight to the membrane technology and its uses. The course content includes background of the development of membranes followed by detail discussion on membrane materials and their properties. Various methods of membrane preparations and their characterization. The separations (transport mechanism) using membranes, principles of various membrane processes such as reverse osmosis, microfiltration, ultrafiltration, dialysis, liquid membrane, pervaporation etc. and their applications in different industries. The course will enable students to develop necessary skills to design appropriate membrane-based separation technique as per the need.

Reference Books:

M. K. Purkit, Randeep Singh, Membrane Technology in Separation Science, Taylor & Francis, 2018

Smart Nano and Functional Materials

This course has been designed to develop students' knowledge of smart materials, nano and functional materials. The mechanisms giving rise to the characteristics and beneficial properties of smart materials as well as the technological applicability and limits of smart materials.The behavior of materials at the nanometer scale and the principles of electrostatic and steric stabilization. Introduction to different types of nanoscale materials. Nucleation and growth of nanostructures. Techniques to synthesize nanostructures/nanomaterials and their characterization techniques. The applications of nanomaterials. Functional materials: relation between properties, structure and crystal symmetry, Size and interface effects on properties, electronic bands structures, Charge transport, semiconductor devices, Optical active materials: theory, examples of materials and applications, Dielectrics, piezo- and ferroelectrics: Magnetism: theory, examples of materials and applications.

Reference Books:

1. Andy Nieto, Nanomaterials and their Applications, (2020)
2. C. Prakash, S. Singh, and J. P. Davim, Functional and Smart Materials. CRC Press, (2020)

Additive and subtractive Manufacturing

Advanced/Additive manufacturing processes - extrusion, jetting, photo polymerization, powder bed fusion, direct-write, sheet lamination, directed-energy deposition and the latest state of the art. Design and fabrication processes - data sources, software tools, file formats, model repair and validation, post-processing. Designing for additive manufacturing (DfAM), Bio-printing, biomaterials, scaffolds and tissue and organ engineering, Materials: Metals, polymers, ceramics, composites, and material selection. Applications of additive manufacturing, such as in biomedical, aerospace, surgical simulation, architecture, art, and health care. The new age of distributed manufacturing, direct part production and mass customization. Processes related to AM, such as 3D scanning, mold-making, casting, and sintering.

Reference Books:

Gibson, Ian, Rosen, David, Stucker, Brent, Additive Manufacturing Technologies, 2015

Environmental Health and Sustainable Development

The main objective of teaching this course is to give engineers the knowledge and sense of social responsibility regarding environment, compliance, and sustainability.

The content if this course includes, the detail overview of Global Ecosystem, Air Pollution and its management, Water Pollution and its management, Industrial Pollution and its management, Global warming, Science of Climate Change and Impacts, Concepts of Sustainability, Sustainability Policies, Environmental Challenges & Sustainable Solutions, Instruments for implementing sustainable development

Through this course the students will become familiar with potential strategic options to perform socially responsible industrial activities in sustainable fashion while protecting environmental health.

Reference Books:

1. Environment, Health and Sustainable Development, 2nd Edition, by Hutchinson (Editor), 2015.
2. Occupational Health and Safety Management: A Practical Approach, 3rd Edition By Charles D. Reese, CRC Press 2017.

Product Development and Innovation Management

This course is designed to equip the students with management knowledge that will enable them to apply the hard skills and technical knowledge to innovate and develop new products, upscale and commercialize the prototypes and R&D work through the utilizing of innovation and product development strategies and modern practices. The content if this course is focused on overview of product development and innovation management, innovation processes, models of innovation, innovation management, innovation and industry, product development concepts, product design conceptualization, product design analysis, design test and evaluation, managing intellectual property.

Reference Books:

1. Innovation Management and New Product Development 6th Edition by Paul Trott, 2021.
2. Developing New Products and Services by G. Lawrence Sanders, Saylor Foundation 2012.

Career opportunities for Graduates after Completion of the Program

The program provides students with the knowledge and skills needed to design, fabricate, and evaluate advanced materials. The graduates would be able to get job and career opportunities in diverse areas, including:

1. Manufacturing/design engineer in manufacturing, energy, polymers/plastics, composites, textiles, defense, etc.
2. Production, planning, and quality management in public and private sector organizations.
3. Product/process development (R & D) in industry/academia
4. Engaged in the marketing and sales of different products/equipment
5. Eligible to apply for PhD program in Advanced Materials, or other disciplines

2. MS Polymer Science & Engineering

The MS Polymer Science and Engineering Program aims to provide a technology-based polymer engineering education through the specially designed courses and the extracurricular research training, students will have a good knowledge about the development and prospect of polymer science & engineering within emerging scientific intersecting fields like photonic, magnetic functional polymer materials, biomedical polymer materials, polymeric membrane for separation as well as fine polymer materials, and furthermore, develop abilities of scientific research, product development, education and technical management.

Program Learning Objectives (PEOs)

MS Advanced Materials Engineering graduates will be able to:

1. Demonstrate comprehensive advanced knowledge and research in industry and academia throughengineering practices generally and polymeric materials particularly.
2. Act as responsible professionals, providing solutions with due considerations to ethical andenvironmental impacts of their work on society.
3. Communicate effectively about scientific topics and industrial problems

Program Learning Objectives (PLOs)

1. Acquire advanced knowledge in the polymeric materials engineering industry and academia.
2. Design and conduct scientific research using acceptable methodologies and solve research problems through effective thinking skills.
3. Ability to write the analyzed and evaluated technical findings for better understanding of the readers in the fields of science and engineering.
4. The ability to manage the advanced knowledge and research skills to one's work as a member and/or leader in a team in a multidisciplinary environment.
5. An ability to communicate effectively, orally, and in writing, with the scientist or engineering community and society at large.

Eligibility Criteria

1. A candidate seeking admission in MS Polymer Science and Engineering must possess one of the following with a minimum of CGPA **2.00/4.00** or **3.00/5.00** in semester system or 60% in annual/term system from HEC recognized institute/university:
   B.Sc. /BE Engineering (Polymer/Materials/Chemical/Textile/Mechanical/Petroleum/Environmental), BS (Hons) Chemistry, Physics and Environmental Sciences, M.Sc. (Chemistry, Physics, Environmental Sciences)
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.
   Noted: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit / Admission Criteria

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	
BS or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Semester-Wise Layout of Courses

Semester-I

Sr. No	Code	Course Title	Credit Hours
1	PSE-5201	Functional Polymeric Materials	3
2	PSE-5202	Research Methodology	3
3	PSE-5203	Polymer Analysis and Characterization	3
4	PSE-5204	Mechanics of Polymers	3
	Total		**12**

Semester-II

Sr. No.	Code	Course Title	Credit Hours
1	PSE-5211	Polymer Composites	3
2	PSE-5212	Polymer Processing and Rheology	3
3	PSE-5213	Biopolymers	3
4	PSE-5214	Membrane Design and Applications	3
5	PSE-5215	Polymer Processing Simulations	3
6	PSE-5216	Polymer Coating & Adhesives	3
7	PSE-5217	Elastomeric Materials and Processes	3
8	PSE-5218	Environmental Health and Sustainable Development	3
9	PSE-5219	Product Development and Innovation Management	3
***The student will select four elective courses in 2nd semester.**			**12**

Semester-III & IV

Sr. No.	Code	Course Title	Credit Hours
1	PSE-6071	Research Thesis	6
Total Credit Hours			**30**

Note:

- Zero credit course for students with limited background knowledge of polymers

Criteria for Selection of Electives

- The student will have to select four elective courses in 2nd semester.
- At the start of the second semester, the list of available electives will be displayed/shared with the students.
- The electives will be offered on the availability of relevant faculty members.
- The students will choose electives from the given list within the prescribed time limit.
- An elective will be offered if a minimum of 40% of the class or at least 10 students choose to study that elective.
- The final elective list will be displayed/shared with the students soon after finalizing the elective subjects.
- Students, who opted for the non-offered electives, will have to choose among the offered elective courses.

Course Specifications

Functional Polymeric Materials

The objective of this course is to give the students an overview of various types of materials used for advanced engineering applications. The students will learn about the properties and applications of various polymeric, ceramic, metallic, bio- and composite materials ranging from nanoscale to macro scale. In addition to various physical and mechanical properties, various functional aspects of the materials will also be covered in the course including shape

memory effect, self-healing, phase change, fire retardant behavior and energy harvesting properties. At the end of the course, the students should be able to select suitable materials for various engineering applications, particularly for making advanced technical textile products.

Reference Books

1. Advanced Materials, edited by: Theodorus van de Ven and Armand, Soldera, 2020, DOI:10.1515/9783110537734
2. Handbook of Advanced Materials: Enabling New Designs, Editor(s): James K. Wessel, 2004,DOI:10.1002/0471465186

Research Methodology

The overall aim of this course is to enable the students to identify a research area, identify a research problem, formulate research question, conduct literature survey, formulate research hypothesis, design research experiments, graphically present, analyze and interpret the experimental data, and draw valid conclusions. Additionally, the students will be able to write a research proposal, critically analyze research papers, and write a short literature review with proper citations and referencing. The students will practice relevant statistical tools and techniques using a statistical software package. The students will also become familiar with plagiarism and other ethical issues in research, patents, copyrights and trademarks, thesis, and research paper writing styles.

Reference Books

1. Handbook Of Research Methodology, By Dr. Shanti Bhushan Mishra, Dr. Shashi Alok, 2017, ISBN: 978-1-5457-0340-
2. Research Methodology: A Step-by-Step Guide for Beginners. 5th ed. by Ranjit Kumar, SAGE Publishing, 2019. ISBN: 9781526449900
3. Higher Education Research Methodology: A Step-by-Step Guide to the Research Process, By Ben Kei Daniel, Tony Harland, Published in 2017 by Routledge

Polymer Analysis and Characterization

This course gives an introduction to different physical, chemical and mechanical characterization techniques, including XRD, SEM, TEM, chromatography, infrared spectroscopy, UV/Vis spectroscopy, atomic absorption spectroscopy, tensile testing, impact testing, bending, shear and hardness testing.

Reference Books

1. Advanced Techniques for Materials Characterization by Thomson Reuters BCI (WoS), 2009, ISBN: 9783038133230, DOI: 10.4028/www.scientific.net/MSFo.49-51
2. Handbook of Materials Characterization, Editors: Sharma, Surender Kumar (Ed.), Springer, 2018, ISBN 978-3-319-92955-2, DOI: 10.1007/978-3-319-92955-2

Mechanics of Materials

Mechanics of materials is a branch of applied mechanics that deals with the behavior of solid bodies subjected to various types of loading. This course deals with stress-strain behavior of different materials, testing techniques, constitutive equations, micromechanics, modelling and simulation techniques for structural analysis.

Reference Books:

1. Mechanics of Materials, An Introduction to Engineering Technology, Authors: Ghavami, Parviz, Springer, 2015, ISBN 978-3-319-07572-3
2. Handbook of Mechanics of Materials, Editors: Editor-in-chief: Hsueh, Chun-Hway, Schmauder, S., Chen, C.-S., Chawla, K.K., Chawla, N., Chen, W., Kagawa, Y. (Eds.), Springer, 2019, ISBN 978-981-10-6883-6

Polymer Composites

Composites are the materials of 21st century. They have vast applications in sports, defense, automotive, aerospace engineering, medical sciences, building/construction material and many other sectors. This course is designed to provide student thorough knowledge of fundamental issues of fibres reinforced composites. Students will develop the understanding how composites are made from different fibres and how the inherent properties and layout of fibres

affect the mechanical behavior of composites. They will also learn the techniques used to characterize the structure and properties of composites materials. They will also gain the practical experience of making fibre reinforced composites and characterize their behavior through mechanical properties.

Reference Books:

1. Chapter: Composite Materials Testing, Contributor(s): Khubab Shaker, Yasir Nawab, Book: Advanced Textile Testing Techniques, Ed. Sheraz Ahmad, Abher Rasheed, Ali Afzal, Faheem Ahmad, CRC Press, 2017, ISBN: 9781315155623
2. Composite Materials: Science and Applications, Second Edition by Deborah D.L. Chung, Springer 2010, ISBN 978-1-84882-830-8, DOI 10.1007/978-1-84882-831-5

Polymer Processing and Rheology

The main objective of teaching this course is to give a general understanding of the primary and critical concepts of polymer solution or melt flow behavior under certain circumstances. The flow properties will be dependent on multiple polymers, solvent, solution, and physical parameters. The flow properties are studied under the title of polymer rheology. Students will be able to remember and understand the key parameters which affects the polymer solution rheology behavior. In addition, the time dependent flow behavior like Rheopexy will be considered to understand the shelf-life behavior. This course will help students understand the different viscosity requirements of polymer solutions and melt during the process, which are key elements in producing a quality product.

Reference Books:

1. Research Methodology: A Step-by-Step Guide for Beginners by Dr. Ranjit Kumar, 2nd Edition, Sage Publications (2005)
2. Doe Simplified 2E: Practical Tools for Effective Experimentation by Mark J Anderson, 2nd Edition, Productivity Press (2007)
3. RSM Simplified: Optimizing Processes Using Response Surface Methods for Design of Experiments by Mark J Anderson and Patrick J Whitcomb, Productivity Press (2005)
4. Design and Analysis of Experiments – Student Solutions Manual by Douglas C. Montgomery, 7th Edition, John Wiley & Sons (2009)

Biopolymers

Detailed knowledge of the structure, function, and properties of biopolymers: Structure-property relationships in biological materials, biological materials: scale, heterogeneity, representative volume elements, fibers: the key building blocks for performance and versatility, design and function of structural biological materials, design for stiffness and design for strength. Case study of some biological materials: Proteins: Amino acids and their polymerization, primary structure, conformation secondary structure, structural proteins, coping with strain energy. Sugars and fillers: Fibers, structural polysaccharides in plants water, the invisible support, mucus. Bone: Composition of bone, integration and organization levels, mechanical properties of the cortical of bone. Soft tissue engineering: Structure-properties of soft tissues. Articular cartilage, structure and composition, bio-mechanics of articular cartilage, cell seeded repair systems, bio-artificial implants: design and tissue engineering. Silk fibers: Origins, nature and consequences of structure, mechanical properties of spider silks, hierarchical microstructure of silk fibers, spinning - the origins of silk fiber microstructure.

Reference Books:

1. Vincent, Structural Biomaterials, Third Edition, Princeton University Press, 2012 (ISBN: 978-1-4008-4278-0)
2. M. Elices, Structural Biological Materials, Volume 4: Design and Structure-Property Relationships, Pergamon, 2000 (ISBN-13: 978-0444552389)
3. S. Kumbar. C. T. Laurencin, M. Deng, Natural and Synthetic Biomedical Polymers, 1st Edition, 2014 (ISBN 9780123969835)
4. S. Kalia, L. Avérous, Biopolymers: Biomedical and Environmental Applications, 2011 (ISBN: 978-0-470-639238).

Membrane Design and Applications

This course will provide an insight to the membrane technology and its uses. The course content includes background of the development of membranes followed by detail discussion on membrane materials and their properties. Various methods of membrane preparations and their characterization. The separations (transport mechanism) using membranes, principles of various membrane processes such as reverse osmosis, microfiltration, ultrafiltration, dialysis, liquid membrane, pervaporation etc. and their applications in different industries. The course will enable students to develop necessary skills to design appropriate membrane-based separation technique as per the need.

Reference Books:

M. K. Purkit, Randeep Singh, Membrane Technology in Separation Science, Taylor & Francis, 2018

Polymer Processing Simulations

This course has been designed to develop students' knowledge of Single dimensional analysis and scaling: Dimensional analysis, dimensional analysis by matrix transformation, problems with non-linear material properties, scaling and similarity, balance equations, Model simplification: Reduction in dimensionality, lubrication approximation. Simple Models in Polymer Processing: Pressure driven flow of a Newtonian fluid through a slit, flow of a power law fluid in a straight circular tube (Hagen-Poiseuille equation), flow of a power law fluid in a slightly tapered tube, volumetric flow rate of a power law fluid in axial annular flow, radial flow between two parallel discs − Newtonian model, the Hele-Shaw model, cooling or heating in polymer processing, Single screw extrusion−isothermal flow problems: Newtonian flow in the metering section of a single screw extruder, cross channel flow in a single screw extruder, Newtonian isothermal screw and die characteristic curves

Extrusion dies−isothermal flow problems: End-fed sheeting die: coat hanger die, extrusion die with variable die land thicknesses, pressure flow of two immiscible fluids with different viscosities, fiber, spinning, viscoelastic fiber spinning model. Processes that involve membrane stretching: Film blowing, thermoforming. Coating processes: Wire coating die, roll coating. Injection molding − isothermal flow problems: Balancing the runner system in multi-cavity injection molds, radial flow between two parallel discs. Melting and solidification: Melting with pressure flow melt removal, melting with drag flow melt removal, melting zone in a plasticating single screw extruder.

Reference Books:

1. T. A. Osswald, J. P. Hernández-Ortiz, Polymer Processing: Modeling and Simulation, Hanser, 2006 (ISBN-13: 978-1569903988)
2. Z. Tadmor, C. G. Gogos, Principles of Polymer Processing, 2nd Edition, Wiley-Interscience, 2006 (ISBN-13: 9780471387701)
3. D. G. Baird, D. I. Collias, Polymer Processing: Principles and Design, 2nd Edition, Wiley, 2014 (ISBN-13: 9780470930588)

Polymer Coating & Adhesives

Introduction to Coatings: The importance of polymer coatings, The general constitution of Polymer coatings, Economics of coatings, The application methods of coatings, Global markets for polymeric coatings. Rheological Aspects of coatings: The importance of rheology, Rheological characterization, Hydrodynamic interactions, Rheological control of paints and powder coatings, Thickening in waterborne paints, Viscosity of paints during curing. Basic Coating Formulations: Coating compositions in general, Solvent borne formulations, Solvent borne high solids formulations, Chemistries of solvent borne high solids formulations, Waterborne formulations, Chemistries of water borne formulations, Challenges and applications of water borne formulations, Radiation curing formulations, Photo-initiators, Chemistries of radiation curing formulations, Chemistries of powder Coating Formulations, Pros and cons of radiation

curing. Additives and Particulates: Types of Additives, Thickeners, Inorganic Thickeners, Organic Thickeners, Surface Active Agents, Wetting and Dispersing Agents, Antifoaming Agents, Adhesion Promoters, Surface Modifiers. Leveling and Coalescing Agents, Catalytically Active Additives, Dryers, Special Effect Additives, Particulates.

Introduction to adhesives: Basic Definitions, Advantages and Disadvantages of Adhesive Bonding, Uses of Adhesive Bonding in Modern Industry, Economics of Adhesive Technology. The Relationship of Surface Science and Adhesion Science: Rationalizations of Adhesion Phenomena, Electrostatic Theory of Adhesion, Diffusion Theory of Adhesion, Mechanical Interlocking and Adhesion. Wettability and Adhesion, Acid-Base Interactions at Interfaces, Covalent

Bonding at Interfaces, The Relationship of Fundamental Forces of Adhesion and Practical Adhesion, The Weak Boundary Layer. The Surface Preparation of Adherends for Adhesive Bonding: Plastic Surface Preparation, Metal Surface Preparation, Anodization Treatments for Adhesive Bonding of Aluminum, General Techniques for the Surface Preparation of Metals. The Chemistry and Physical Properties of Structural Adhesives: Introduction to Structural Adhesives, Chemistry of Base Resins Used in Structural Adhesives, Formulation of Structural Adhesives for Optimum Performance Pressure-sensitive Adhesives, Rubber-Based, Contact Bond and other Elastomeric Adhesives, Hot Melt Adhesives.

Reference Books:

1. G. de With, Polymer Coatings, Wiley-VCH Verlag GmbH & Co. KGaA, Germany, 2018 (ISBN: 978-3-52734210-5)
2. V. Pocius, Adhesion and Adhesives Technology, 3rd Edition, Carl Hanser Verlag GmbH & Co. KG, Germany, 2012 (ISBN: 978-3-446-43177-5)

Environmental Health and Sustainable Development

The main objective of teaching this course is to give engineers the knowledge and sense of social responsibility regarding environment, compliance, and sustainability. The content if this course includes, the detail overview of Global Ecosystem, Air Pollution and its management, Water Pollution and its management, Industrial Pollution and its management, Global warming, Science of Climate Change and Impacts, Concepts of Sustainability, Sustainability Policies, Environmental Challenges & Sustainable Solutions, Instruments for implementing sustainable development. Through this course the students will become familiar with potential strategic options to perform socially responsible industrial activities in sustainable fashion while protecting environmental health.

Reference Books:

1. Environment, Health and Sustainable Development, 2nd Edition, by Hutchinson (Editor), 2015.
2. Occupational Health and Safety Management: A Practical Approach, 3rd Edition By Charles D. Reese, CRC Press 2017.

Product Development and Innovation Management

This course is designed to equip the students with management knowledge that will enable them to apply the hard skills and technical knowledge to innovate and develop new products, upscale and commercialize the prototypes and R&D work through the utilizing of innovation and product development strategies and modern practices. The content if this course is focused on overview of product development and innovation management, innovation processes, models of innovation, innovation management, innovation and industry, product development concepts, product design conceptualization, product design analysis, design test and evaluation, managing intellectual property.

Reference Books:

1. Innovation Management and New Product Development 6th Edition by Paul Trott, 2021.
2. Developing New Products and Services by G. Lawrence Sanders, Saylor Foundation 2012.Career opportunities for Graduates after Completion of the Program

Career opportunities for Graduates after Completion of the Program

The program provides students with the knowledge and skills needed to design, fabricate, and evaluate advanced materials. The graduates would be able to get job and career opportunities in diverse areas, including:

1. Manufacturing/design engineer in manufacturing, energy, polymers/plastics, composites, textiles, defense, etc.
2. Production, planning, and quality management in public and private sector organizations.
3. Product/process development (R & D) in industry/academia
4. Engaged in the marketing and sales of different products/equipment
5. Eligible to apply for PhD program in Polymers, or other disciplines

3. PhD ADVANCED MATERIALS

The PhD Advanced Materials program is structured to offer students a comprehensive education in Materials Science, preparing them for successful careers in Advanced Materials. The curriculum comprises a set of compulsory courses, complemented by elective courses, enabling the students to excel in the discipline of their choice. These courses help the students to address the modern-day challenges, enabling them to develop materials most suitable for the desired application. The research contributes to a broad range of fields including polymers, composites, smart materials, nanomaterials, and biomaterials.

Program Educational Objectives (PEOs)

The graduates will be able to:

1. Demonstrate a broad knowledge of materials based on research and use this to develop new knowledge following ethical standards.
2. Function as practicing materials scientists/engineers with the necessary core competencies to interface with other engineering disciplines to solve problems in other areas.
3. Develop communication skills to write and speak effectively about scientific topics, industrial problems, and research at the national and international level.

Program Learning Outcomes(PLOs)

At the completion of PhD Advanced Materials, the students will be able to:

1. Review, analyze and interpret systematically the scientific literature and innovations in the areas materials engineering
2. Develop diagnostic approaches to technological problems and shortcoming through interdisciplinary utilization of materials
3. Use the in-depth understanding of material properties and behavior in order to envisage and devise novel applications
4. Use modern engineering tools and techniques to successfully practice the engineering profession in a variety of settings.
5. Disseminate the research output effectively in research journals, conferences, seminars, thesis, and other scientific venues.

Eligibility Criteria

1. MS/M.Phil Mechanical Engineering/Chemical Engineering/Industrial & Manufacturing Engineering/Product and Industrial Design/Materials Engineering/Environmental Engineering/Chemistry/Physics/Mathematics/Electrical Engineering/Electronics Engineering/Mechatronics Engineering/Bio Chemistry/Biotechnology/Polymer Science & Engineering or equivalent degree with minimum CGPA 3.00/4.00 or 3.50/5.00 in semester system or **60%** marks in annual system from HEC recognized University /Institute.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test with minimum 60% score or NTU-GAT (Subject) test with minimum 50% score in case of different qualification as per HEC.
3. Applicant having MS or equivalent degree without thesis is not eligible to apply.
4. It is mandatory to pass interview in order to compete on merit.
5. Applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
6. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final MS/M.Phil or equivalent official transcript or degree.
7. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
8. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Merit / Admission Criteria

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	
B.Sc./BS/Equivalent	20% weightage
MS or Equivalent	60 % weightage
Interview	10% weightage
Publication/Relevant experience	10% weightage (05% + 05%)

Semester-Wise Layout of Courses

Semester-I

Sr.No.	Code	Course Title	Credit Hours
1	AM-7111	Advancements in Materials	3
2	AM-7112	Quantitative and Qualitative methods in research	3
3	AM-7113	Developments in Sustainable Materials	2
4	AM-7114	Prototype/Review paper	1
Total			9

Semester-II

Sr.No.	Code	Course Title	Credit Hours
1	AM-71XX	Elective – I	3
2	AM-71XX	Elective – II	3
3	AM-71XX	Elective – III	3
Total			9

Semesters III-VIII

Sr.No.	Code	Course Title	Credit Hours
1	AM-8090	Research Thesis	**30**
Total Credit Hours			48

List of Elective Courses

Sr. No.	Course Code	Course Title
1	AM-7120	Smart and functional materials
2	AM-7121	Nano materials
3	AM-7122	Materials for energy harvesting
4	AM-7123	Materials for biomedical application
5	AM-7124	Recycling and waste management
6	AM-7125	Sustainable biomaterials
7	AM-7126	Membrane separation technology
8	AM-7127	Advanced composites materials
9	AM-7128	Mechanics of composites
10	AM-7129	Reinforcement technology for composites
11	AM-7130	Finite element methods
12	AM-7131	Advance Characterization Techniques
13	AM-7132	Surfaces and interfaces
14	AM-7133	Mathematical methods for modelling
15	AM-7134	Smart polymers
16	AM-7135	Polymeric materials physics
17	AM-7136	Elastomeric materials and processes
18	AM-7137	Advanced polymer chemistry
19	AM-7138	Fluid flow in porous media
20	AM-7139	Heat and mass transfer
21	AM-7140	Mechanics of fibrous structures

Sr. No.	Course Code	Course Title
22	AM-7141	Woven structures for advance engineering applications
23	AM-7142	Any other subject recommended by supervisor with the consent of HoD and approved by DBOS

Course Specifications

Advancements in Materials

The objective of this course is to give the student an overview of various types of materials used for advanced engineering applications. The students will learn about the properties and applications of various polymeric, ceramic, metallic, bio-, and composite materials ranging from nanoscale to macro scale. In addition to various physical and mechanical properties, various functional aspects of the materials will also be covered in the course including: shape memory effect, self-healing, phase change, fire retardant behavior, and energy harvesting properties.

Recommended Books:

Recent Advances in Material Sciences Pujari, Satish, Srikiran, Satuluri, Subramonian, Sivarao 2018.

Quantitative and Qualitative methods in research

The overall aim of this course is to enable the students to identify a research area, identify a research problem, formulate a research question, conduct a literature survey, formulate research hypothesis, design research experiments, graphically present data, analyze and interpret the experimental data, and draw valid conclusions. Additionally, the students will be able to write a research proposal, critically analyze research papers, and write a short literature review with proper citations and referencing. The students will practice relevant statistical tools and techniques using a statistical software package. The students will also become familiar with plagiarism and other ethical issues in research, patents, copyrights and trademarks, thesis and research paper writing styles.

Recommended Books:

1. Research methodology. R. Panneerselvam, 2nd ed. PHI learning, 2014.
2. Analyzing and Interpreting Qualitative Research by Charles Vanover, Paul Mihas, Johnny Saldana

SAGE Publications, 2021

Product Development and Innovation Management

This course is designed to equip the students with management knowledge that will enable them to apply the hard skills and technical knowledge to innovate and develop new products, upscale and commercialize the prototypes and R&D work through the utilizing of innovation and product development strategies and modern practices. The overview of product development and innovation management, innovation processes, models of innovation, innovation management, innovation and industry, product development concepts, product design conceptualization, product design analysis, design test and evaluation, managing intellectual property.

Recommended Books:

Innovation Management and New Product Development, by Paul Trott, 6th Edition, Pearson Education Limited, 2021

Prototype/Review paper

The objective of this course is to introduce the concept of prototype creation and review paper write up. A review-article is also called a literature review, it involves an intensive survey of already published research work on a specific topic. It should provide an overview of current thinking on the theme and, is not like as an original research article that present new experimental results. A prototype is an early sample, model, or release of a product built to test a concept or process. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming. A prototype is generally used to evaluate a new design to enhance precision by system analysts and users.

Smart and Functional Materials

This course has been designed to develop students' knowledge of smart materials and intelligent materials. The students will gain a critical understanding of mechanisms giving rise to the characteristics and beneficial properties of smart materials, as well as the technological applicability and limits of functional materials. In addition, this course gives the recent advances in the field of piezoelectric materials, shape memory alloys (SMAs), electroactive polymers, functionally graded materials (FGMs), etc. Properties of smart materials. Innovative uses of smart materials and their systems. Medical and Military Applications of Smart Materials.

Recommended Book:

C. rakash, S. Singh, and J. P. Davim, Functional and Smart Materials. CRC Press, 2020.

Nano Materials

This course deals with an in-depth understanding of the relationship between the physical properties and materials dimension. It will cover the different synthesis and characterization techniques of one-dimensional and two-dimensional nanostructures. The applications of these nanomaterials with respect to their properties in various fields of advanced materials will be studied in detail.

Recommended book:

Guozhong Gua, Nanostructures & Nanomaterials, Synthesis, Properties & Applications, Imperial College Press (2003).

Materials for Energy Harvesting

This course covers all aspects of the subject, ranging from natural plant and bacterial photosystems, through their biologically inspired synthetic analogs, to other photoactive molecular materials such as dendrimers. This also establishes the theory and underlying principles across the full range of light harvesting systems. With an authoritative, comprehensive and well-referenced content, it will appeal to all students, researchers and technologists interested or involved in solar energy, photobiology and photoactive materials science.

Recommended Books:

Modern Piezoelectric Energy-Harvesting Materials by Christopher R. Bowen, Hyunsun Alicia Kim, and Vitaly Topolov, 2016 David L Andrews, Energy Harvesting Materials, 2005.

Materials for Biomedical Application

This module aims to furnish students with the advanced specialized knowledge and skills required to design and develop polymer and fiber-based products for use in medicine and healthcare. It progresses students' knowledge and skills required for designing new medical products, devices and processes. The module covers materials/ tissue engineering, non-implantable materials (wound dressings, hygiene products), health care environment materials (surgical gowns), materials to reduce healthcare-associated infection, therapeutic drug delivery technologies as well as fundamental aspects of legal and ethical issues involved within the medical practices.

Recommended Books:

Materials for Biomedical Engineering,Valentina, Grumezescu, Alexandru, Grumezescu, 2019

Recycling & Waste Management

This course will identify the detailed overview of recycling and waste management principles, concepts, and technologies. The global and economic impact and the evaluation of market economics of waste management, recycling, and recovery. Key concepts within solid and liquid waste management methodologies and advance technologies. Advances in incineration, composting, landfills, pyrolysis, and gasification techniques for wastes recycling, reusing, and reducing.

Recommended Books:

Zero Waste: Management Practices for Environmental Sustainability by Ashok K. Rathoure, CRC Press, 2019 Waste

management practices Book by John Pichtel, 2005.

Sustainable Biomaterials

A biomaterial is a substance that has been engineered to interact with biological systems for a medical purpose, either a therapeutic or a diagnostic one. Biomaterials include metals, ceramics, glass, and polymers. These biomaterials can be found in things such as contact lenses, pacemakers, heart valves, orthopedic devices, and much more. The utilization of biomaterials in textile applications, including heart valves, stents, and grafts; artificial joints, ligaments, and tendons; hearing loss implants; dental implants; and devices that stimulate nerves. This course highlights the applications of biomaterials in textiles, their engineering aspects, and possible modifications to meet the end requirements.

Recommended book:

Fundamentals of Biomaterials by Nesrin Hasirci and Vasif Hasirci, Springer, 2018.

Membrane Separation Technology

Overview of separation processes, Advantages and disadvantages of membranes, Application of membranes in various fields, Transport mechanism and membrane separation processes, Membrane separation processes, Membrane's contactors, Membrane Modules and process design, Membrane preparation techniques, Polymeric Membranes and Their Applications, Fouling mechanism and remedies, Membrane fouling reduction techniques, Current trends and future perspective, Advanced Materials for Membranes.

Recommended Book:

M. K. Purkit, Randeep Singh, Membrane Technology in Separation Science, Taylor & Francis, 2018

Advanced composites materials

Composites are the materials of the 21st century. They have vast applications in sports, defense, automotive, aerospace engineering, medical sciences, building/construction material, and many other sectors. This course is designed to provide students a thorough knowledge of fundamental issues of fibers reinforced composites. Students will understand how composites are made from different fibers and how the inherent properties and layout of fibers affect the mechanical behavior of composites. They will also learn the techniques used to characterize the structure and properties of composites materials. They will also gain the practical experience of making fiber-reinforced composites and characterize their behavior through mechanical properties.

Recommended Book:

1. An Introduction to Composite Materials, D. Hull, T. W. Clyne, Cambridge University Press, 2nd ed., 2012.
2. Fiber Reinforced Composite: Materials, Manufacturing and Design, by P K Mallick, CRC Press, 3rd Ed., 2014.

Mechanics of Composites

Mechanics of materials is a branch of applied mechanics that deals with the behavior of solid bodies subjected to various types of loading. This course deals with stress-strain behavior of different materials, testing techniques, constitutive equations, micromechanics, modeling, and simulation techniques for structural analysis. This course develops understanding and knowledge of material response and performance under various types of forces. It helps to understand material failure behaviors and their prediction. Main concepts include stress and strain, force systems on structures, moment of inertia, and shear and bending moments etc.

Recommended Book:

Parviz Ghavami, Mechanics of Materials: an Introduction to Engineering Technology, Springer, 1st Ed. 2015.

Reinforcement technology for composites

Historical background of composites; classification and general properties. Role of the constituent materials in composite manufacturing, i.e., matrices and reinforcements; their types, production, and properties. Polymeric matrix composites (PMCs). Metal matrix composites (MMCs). Ceramic matrix composites (CMCs). General manufacturing techniques of PMCs, MMCs and CMCs and their principles. Special purpose composites. Fiber-matrix Interface and interphase, and their role in tailoring the properties of composites.

Recommended Books:

Fiber Technology for Fiber-Reinforced Composites by M. Ozgur Seydibeyoglu, Amar K. Mohanty, Manjusri Misra, Elsevier, 2017

Finite Element Methods

The objective of this course is to teach the fundamentals of the finite element method for the analysis of engineering problems arising in solids and structures. The course emphasizes the solution of real-life problems using the finite element method underscoring the importance of the choice of the proper mathematical model, discretization techniques, and element selection criteria. The students learn how to judge the quality of the numerical solution and improve accuracy in an efficient manner by optimal selection of solution variables.

Recommended Book:

Daryl Logan, A First Course in the Finite Element Method, Cengage Learning, 6th Ed., 2016.

Advance Characterization Techniques

This course aims to introduce the concept of textile material characterization methods, interpretation of results and the importance of the compliances. The course aims at strengthening students' conceptual as well as practical knowledge in the field of testing and characterization of textile materials. This will also help the students in handling the different problems faced in the industry efficiently. They can perform preventive quality-enhancing measures rather than corrective ones. The focus will be on tools and techniques that are related to quality enhancement and proper utilization of the resources. The students will gain in-depth knowledge of conventional and advance characterization techniques. They will learn the methods to evaluate their physical and chemical properties to ensure the quality of intermediate and end products in textile processes. The students will also learn about different compliances regarding the textile industry. The requisite for these compliances and how to effectively achieve these requisites. The topics will include scanning electron microscope, transmission electron microscope, atomic force microscope, x-ray diffraction, rheometer, thermal analysis, atomic spectroscopy, chromatography, NMR, FTIR and UV Vis spectroscopy.

Recommended Books:

Handbook of Materials Characterization by Surender Kumar Sharma, Springer, 2018

Surfaces and interfaces

This course gives a descriptive account of interfacial phenomena, from simple to complex, to provide students with a strong foundation of knowledge in interfacial materials chemistry. Many case studies are provided to give real world examples of problems and their solutions, allowing students to make the connection between fundamental understanding and applications. The applications in nanomaterials and nanotechnology are also discussed during the course.

Recommended Book:

Chemistry of Functional Materials Surfaces and Interfaces by Andrei Honciuc, Elsevier, 1st Ed. 2021.

Mathematical methods for modelling

This course is an introductory course on Mathematical Modelling. It is designed for students studying mathematical

sciences (i.e. Mathematics and Statistics). It may, however, be useful to students in sciences, engineering and other related fields. It introduces students to basic concepts in mathematical modelling. It also equips the students with mathematical modelling skills with emphasis on using mathematical models to solve real- life problems. Topics to be covered in this course includes: methodology of model building, problem identification and definition, model formulation and solution, consideration of varieties of models involving equations like algebraic, ordinary differential equation, partial differential equation, difference equation, integral and functional equations, consideration of some specific applications of mathematical models to biological, social, and behavioural sciences.

Recommended Book:
Methods of Mathematical Modelling by Witelski, Thomas, Bowen, Mark, 2015.

Smart Polymers

A broad variety of materials are actually considered as smart ones(actuators): from shape memory alloys to polymer nano systems. With this course, specific aspects of an exciting interdisciplinary area “Smart Materials” will be introduced in such a way it can be easily understood by a broad audience. How remarkable properties of smart materials correlate with simple structural features at nanoscale and microscale, discuss various methods to characterize materials with smart properties. Inspiring trends in applications of smart materials will be highlighted.

Recommended Books:
Shape Memory Polymers, Blends and Composites: Advances and Applications by J. Parameswaranpillai, Springer, 2019.

Polymeric Materials Physics

Polymers are a ubiquitous part of our everyday life. Advances in polymer synthesis, processing, and engineering have led to new applications exploiting the unique properties of polymers to realize advanced technologies far removed from their initial application. Building on a review of the fundamentals of polymer science, this unit will explore the use of polymers in a range of novel applications from biomedical applications to optoelectronic devices. Different classes of polymers will be discussed including conjugated polymers, block co-polymers, and biopolymers with a view to linking the physical properties of the polymer chain to the functionality of the technological application.

Recommended Books:
Advanced Polymeric Materials: Synthesis and Applications by Didier Rouxel, Sabu Thomas, Nandakumar Kalarikkal, Sajith T.A., River Publishers, 2018

Elastomeric Materials and Processes

The course will focus on introduction to elastomeric materials, Classification of elastomers, Mastication process, Compounding ingredients for rubbers, Rubber blends, Thermoplastic elastomers, Processing, Design of elastomeric products, Comparison of Elastomer Properties. Data sources, Recycling and reuse of elastomeric materials. The course will also focus on application of elastomeric material in different industry.

Recommended Books:
Rubber Science: A Modern Approach by Atsushi Kato, Yuko Ikeda, Shinzo Kohjiya, Yukio Nakajima, Springer, Year 2017
Thermoplastic Elastomers: At a Glance by Manuela Gehringer, DeGruyter, Year 2021

Advanced Polymer Chemistry

This course explores the field of polymer chemistry. Synthetic methods for polymer preparation will be discussed, including condensation, radical, ionic, and ring-opening approaches. The solid-state structure, phase behavior, and mechanical properties of polymers will be covered, as well as current topics of interest in the literature.

Recommended Books:
Polymer Chemistry by Paul C. Hiemenz and Timothy P. Lodge, CRC Press, Year 2020.

Fluid Flow in Porous Media

Processes of flow and displacement of multiphase fluids through porous media occur in many subsurface systems and have found wide applications in many scientific, technical, and engineering fields. This course focuses on the fundamental theory of fluid flow in porous media, covering fluid flow theory in classical and complex porous media, such as fractured porous media and physicochemical fluid flow theory. Key concepts are introduced concisely, and derivations of equations are presented logically.

Recommended Book:

Liang Xue, Xiaozhe Guo, Hao Chen, Fluid Flow in Porous Media: Fundamentals and Applications. World Scientific, 1 st Ed. (2021).

Heat and Mass Transfer

The course provides an insight of the governing laws for heat and mass transfer. The topics covered include one-dimensional and two-dimensional steady-state conduction, transient conduction, fundamentals, and engineering treatment of convection heat transfer, external and internal heat flow and free convection. Applying the rigorous and systematic problem-solving methodology with examples and problems is discussed during this course.

Recommended Book:

RK Rajput, Heat and Mass Transfer, S. Chand Publishing, (2019) DS Kumar, Heat and Mass Transfer, SK Kataria Publishers, (2013)

Mechanics of fibrous structures

This subject will cover the basic theories of fiber yarn and fabric structures. The basic theories related to fibers, yarn and fabric and their geometrical parameters will be discussed. The geometrical and or mathematical relationships among different parameters will be established.

Recommended Book:

Theory of Structure and Mechanics of Fibrous Assemblies Book by Bohuslav Neckar and Dipayan Das, CRC Press, 2013.

Woven structures for Advance Engineering Applications

Understanding and predicting the structure and properties of woven textiles are important for achieving specific performance characteristics in various engineering applications. This course provides comprehensive coverage of the structure, behavior, modeling and design of woven fabrics. It covers discusses the mechanics of woven fabrics, including yarn behavior in woven, tensile, buckling, bending, and creasing behavior. The practical applications of woven fabrics for advanced engineering are also discussed.

Recommended Book:

B K Behera, P K Hari, Woven Textile Structure. Woodhead Publishing, 1st Ed., 2010.

Career opportunities for Graduates after Completion of the Program

The graduates would be able to get job and career opportunities in areas, including:

1. Technical professionals having in-depth knowledge of advanced materials and able to provide research-based solutions regarding operational problems
2. Teaching and research in the domain of advanced materials at university/post-graduate college level.
3. Research Scientist in public or private sector organizations
4. Consultancy on industrial problems to different organizations
5. Design innovative solutions/products for the industries

Department of Textile Technology

The Department of Textile Technology is committed to provide full support to the undergraduate and postgraduate students of the University for gaining in-depth knowledge of conventional and high performance textile materials, the methods to evaluate their physical and chemical properties to ensure quality of intermediate and end products in textile processes. In totality, it endeavours to make it a center of excellence for textile related research and development.

MS TEXTILE TECHNOLOGY

The MS Textile Technology program aims to provide advanced knowledge of textile technology, machine design, and quality management. It will also help in developing the skills of investigation of a research problem related to industrial operations. The MS Textile Technology program will offer each student a solid product and process-focused education in manufacturing for the large textile industry. Graduates of this program can build a successful professional career in a wide range of job functions as well as a diverse set of industries.

Program Educational Objectives (PEOs)

1. Investigate the research problem to establish the advanced knowledge of textile technology.
2. Build a successful professional career in the field of textiles and related industries on the basis of his/her product and process-oriented education/training.

Program Learning Objectives (PLOs)

At the completion of MS Textile Technology, the students will be able to

PLO	PLO Title	PLO statement
1	Knowledge	Ability to apply knowledge of advance textile technologies to enhance process efficiency and quality of various products in textile manufacturing units.
2	Design and develop	Ability to design and develop solutions for products, components or processes which fulfill the specific demands of target (textile) market.
3	Analysis	Ability to analyze problems, critical evaluation, and effective decision making to ensure improvement in quality and production using advanced tools and techniques.
4	Project Management	Ability to communicate and interface effectively with all stakeholders; sales, marketing, manufacturers and with society at large, such as being able to comprehend and write effective reports and documentation, make effective presentations, and transfer clear instructions.
5	Sustainability	Ability to design robust process, identify and provide sustainable answers for the issues in the process, and can design new products.

Eligibility Criteria

1. BS Textile Engineering Technology/M.Sc Fiber Technology/BS in any Technology program/BS in Chemistry or equivalent degree from HEC recognized institution with a minimum CGPA 2.00/4.00 or 3.00/5.00 in semester system or **60%** marks in annual/term system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit Criteria

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	
BS or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Semester-Wise Layout of Courses

Semester-I

Sr. No	Code	Course Title	Category	Credit Hours
1	TT-5061	Advanced Fiber, Filament & Yarn Manufacturing Technologies	4 Compulsory courses	3 (2-1)
2	TT-5062	Advance Fabric Manufacturing Technologies		3 (2-1)
3	TT-5063	Advanced Textile Processing Technologies		3 (2-1)
4	TT-5064	Advanced Clothing Technologies		3 (2-1)

Semester-II

Sr. No	Code	Course Title	Category	Credit Hours
1	TT-5066	Research Methodology	4 Compulsory courses	3 (3-0)
2	TT-5067	Technical Textiles		3 (3-0)
3	TT-5068	Advanced Characterization Techniques		3 (2-1)
4	TT-5065	Production, Planning and Control in Textiles		3 (3-0)

Semester-III

Sr. No	Code	Course Title	Category	Credit Hours
1	TT-6071	Research Thesis	Compulsory	3 (0-3)
2	TT-6071	Research Thesis	Compulsory	3 (0-3)

Note:

- MS students will have to pass the 24 credit hours courses and 6 credit hours thesis.
- Department can offer any course from the list of approved courses on the availability of resources.
- The summer semester will not be offered.

Other details of semester activities are as follows:

Assignments	One assignment per credit is generally conducted by teachers for each subject.
Quizzes	One quiz per credit of course is conducted by each teacher.
Presentations	Teacher can ask students to present a specific topic generally once in a subject.
Projects	Teacher can allot small projects individually or in groups as per the scope of subject.
Exams	Two exams, at the mid and end of semesters, are conducted for each subject.

Course Specifications

TT–5061: Advanced Fiber, Filament & Yarn Manufacturing Technologies

This course aims to enhance the skill in the field of advanced textile technology. The system will be the focus on the recent developments in the field of fiber technology and yarn manufacturing. The course will cover the advanced fiber manufacturing range from nano-fibers to high-performance technical fibers, conventional fibers as well as exotic fibers, conventional and recent yarn manufacturing techniques. The students will also learn about the specialty yarns.

Recommended Books:
Advances in Filament Yarn Spinning of Textiles and Polymers, Dong Zhang
Fibers to Smart Textiles, Asis Patnaik and Sweta Patnaik

TT-5062: Advanced Fabric Manufacturing Technologies

The aim of this course is to educate the students about the latest advancements in fabric manufacturing technologies introduced in the world. The course contents include conventional fabric manufacturing techniques like weaving & knitting with a focus on conventional fabrics and specialty weaving and knittings, the newest fabric manufacturing techniques like nonwoven and braiding, nonwoven manufacturing technology and multi-dimensional technical fabric technologies.

Recommended Book:
Principles of Woven Fabric Manufacturing, Abhijit Majumdar

TT– 5063: Advanced Textile Processing Technologies

This course provides knowledge about the advancements and latest technologies introduced in fabric processing and their application areas. The conventional fabric processing techniques will also be included along with state-of-the-art technologies. The topics include preparatory processes, advancements in dyes and dying processes, dying operations, processes to develop fabrics with improved aesthetic and functional properties, testing of textile performance using chemical and instrumental methods.

Recommended Book:
Guide to Wet Textile Processing Machines, J.N. Shah

TT–5064: Advanced Clothing Technologies

This course will be about the latest advancements in garment manufacturing. The ergonomic study will also be considered to be a part of this course. This course elaborates the key features and techniques used for garment manufacturing for financial growth and development of industry along with customer-based product assembly line optimization studies. The course content also includes material sourcing, preproduction operations, production planning, latest technologies and equipment for production, garment style and fit evaluation, advanced marker modes and spreading modes, and evaluation of patterns, seams, stitch types on product quality.

Recommended Book:
Textile and Clothing Design Technology, Tom Cassidy and Parikshit Goswami

TT–5065: Production, Planning and Control in Textiles

The course enables the students to design of inventory & other relevant systems, different textile production planning models & capacity requirement planning. The course includes analysis and design of inventory, Deterministic and stochastic inventory models, production, and scheduling control systems, Material Requirement Planning (MRP), Master Production Scheduling (MPS), and Aggregate Planning. It will also provide key knowledge about Warehouse, Importance of warehouse, Types of the warehouse, Layout planning of warehouse, warehouse security, safety and maintenance, Warehouse operations, introduction to the warehouse management system, functions of the warehouse management system, a step towards intelligent WMS. Introduction to Lean Manufacturing will also be included in this course.

Recommended Book:

Production Planning & Control in Apparel Manufacturing, Prasanta Sarkar

TT-5066: Research Methodology

The overall aim of this course is to enable the students to identify a research area, identify a research problem, formulate a research question, conduct a literature survey, formulate research hypothesis, design research experiments, graphical presentation, analyze and interpret the experimental data, and draw valid conclusions. Additionally, the students will be able to write a research proposal, critically analyze research papers, and write a short literature review with proper citations and referencing. The students will practice relevant statistical tools and techniques using a statistical software package. The students will also become familiar with plagiarism and other ethical issues in research, patents, copyrights and trademarks, thesis, and research paper writing styles.

Recommended Book:

New Product Development in Textiles: Innovation and Production, L. Home

TE–5067: Technical Textiles

Technical textiles comprise textile materials and products which are manufactured and used primarily for their performance and functional features rather than for their aesthetics. The global technical textiles market is estimated to be worth US$150 billion. The objective of this course is to give the students a broad and detailed overview of the market size, manufacturing technologies, properties and end-uses of different categories of technical textiles, including: textiles used in agriculture, horticulture and forestry; textiles for buildings and construction; technical components of clothing; textiles used in civil engineering; household technical textiles; textiles used in filtration, cleaning and process industries; textiles used for healthcare and hygiene; textiles used in automobiles, railways and aerospace; textiles used for environmental protection; textiles used for packaging; textiles for personal and property protection; and textiles used in sports and leisure.

Recommended Book:

Handbook of Technical Textiles: Technical Textile Applications, A. Richard Horrocks and Subhash C. Anand

TT-5068: Advanced Characterization Techniques

This course aims to introduce the concept of textile material characterization methods, interpretation of results and the importance of the compliances. The course aims at strengthening students' conceptual as well as practical knowledge in the field of testing and characterization of textile materials. This will also help the students in handling the different problems faced in the industry efficiently. They can perform preventive quality-enhancing measures rather than corrective ones. The focus will be on tools and techniques that are related to quality enhancement and proper utilization of the resources. The students will gain in-depth knowledge of conventional and advance characterization techniques. They will learn the methods to evaluate their physical and chemical properties to ensure the quality of intermediate and end products in textile processes. The students will also learn about different compliances regarding the textile industry. The requisite for these compliances and how to effectively achieve these requisites. The topics will include scanning electron microscope, transmission electron microscope, atomic force microscope, x-ray diffraction, rheometer, thermal analysis, atomic spectroscopy, chromatography, NMR, FTIR and UV-Vis spectroscopy.

Recommended Book:

Handbook of Materials Characterization, Sharma and Surender

TT- 6071: Research Thesis

The Research Project module will enable participants to bring together the knowledge and skills acquired in the earlier modules to investigate a selected topic reviewing the literature, presenting seminars and preparing material in the form of a publication. The project will demonstrate the student's capabilities to perform independently but supervised research to solve practical problems utilizing the theoretical knowledge and analytical skills attained.

The overall purpose of the module is to develop an understanding of the steps involved in the research and development process and interpretation of the findings both orally and in writing. The research projects will be allotted to the students after approval by the Research Committee.

Career opportunities for Students after Completion of the Program

The graduates of this program would be able to get job and progress opportunities in diverse areas, some of them include:

1. Technical professionals for the textile industry having in-depth knowledge of advanced textile operations and can be able to provide research-based solutions regarding operational problems
2. Teaching and research in the domain of technology at university/post-graduate college level.
3. Research and Development in public and private sector organizations.
4. Production, planning, and quality management in public and private sector organizations.
5. Higher studies and research in the field of textiles and relevant interdisciplinary fields.

PhD TEXTILE TECHNOLOGY

PhD Textile Technology is an educational program which joins the textile engineering technology with diverse disciplines of natural sciences and material science to find the novel solutions for the current problems and future challenges in the field of textiles.

Program Educational Objectives (PEOs)

The graduates will be able to:

- To develop the substantive knowledge of textile engineering technology by enhancing the intellectual level of PhD students through creativity, analytical thinking, critical analysis, and innovative problem-solving.
- To conduct the research which focuses on improvements and advancements in textile technology and associated knowledge.

Program Learning Objectives (PLOs)

At the completion of PhD Textile Technology, the students will be able to:

- Critically find out the research gap after comprehensive analysis of literature.
- Employ scientific methodologies for the strategic planning and execution of research, aiming to develop a solution for the problem while considering environmental, social, and legal aspects.
- Devise a product or process that fulfills the desired requirements, considering practical constraints and conditions.
- Make use of contemporary techniques and tools to draw meaningful conclusions from the research findings.

Eligibility Criteria

1. MS Textile Technology or equivalent with research work/thesis in the relevant disciplines from an HEC recognized University/Institute with minimum CGPA 3.00/4.00 or 3.50/5.00 in semester system, 60% marks in annual system or equivalent.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test with minimum 60% score or NTU-GAT (Subject) test with minimum 50% score in case of different qualification as per HEC.
3. Applicant having MS or equivalent degree without thesis is not eligible to apply.
4. It is mandatory to pass interview in order to compete on merit.
5. Applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
6. Result waiting applicants may apply for admission; however their merit will be finalized only on submission of final MS/M.Phil or equivalent official transcript or degree.
7. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
8. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Merit Criteria

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	Weightage
MS or Equivalent	60 % weightage
B.Sc./BE/Equivalent	20% weightage
Interview	10% weightage
Publication/Relevant experience	10% weightage (05% + 05%)

Semester-Wise Layout of Courses

Semester-1

Sr. No	Code	Course Title	Category	Credit Hours
1	-	Scientific methods for research	4 Compulsory courses	3 (0-3)
2	-	Recent development in textiles processes		2 (0-2)
3	-	Textile machinery and instrument design		3 (0-3)
4	-	Review paper/prototype		1 (0-1)

Semester-2

Sr. No	Code	Course Title	Category	Credit Hours
1	-	Elective – I	Electives	3 (3-0)
2	-	Elective – II		3 (3-0)
3	-	Elective –III		3 (3-0)

Note:

Each student will study three courses related to recent global status of textile in the world and along with scientific methods of research during the course work. The students will further study 3 elective courses, depending upon their academic background and intended area of research. The selection of the electives will be in consultation with a supervisory committee.

List of Electives

Sr. No	Code	Course Title	Credit Hours
1.	-	Advanced Materials	3
2.	-	Heat and Mass Transfer	3
3.	-	Composite Technology	3
4.	-	Technical Textiles	3
5.	-	Nonwoven Technology	3
6.	-	Medical Textiles	3
7.	-	Protective Textiles	3
8.	-	Textile Auxiliaries	3
9.	-	Advanced Analytical Techniques	3
10.	-	Functionalization of Textiles	3
11.	-	Adv Fiber, F & Y Manufacturing Tech	3
12.	-	Sustainability in Textiles	3
13.	-	Advanced Fabric Manufacturing Tech	3
14.	-	Advanced Textile Processing Technologies	3
15.	-	Advanced Characterization Techniques	3
16.	-	Production Planning control in textiles	3
17.	-	Textile surface modification and chemical treatments	3
18.	-	Clothing engineering	3
19.	-	Textile machinery and instrument design	3
20.	-	Textile modeling and simulation Energy,	3
21.	-	Environment and sustainability in textiles	3

Course Specifications

Compulsory Courses

Scientific methods for research

The major objective of this course is to develop the skills to conduct research with scientific methodology.

The course will comprise of various theories, models and scientific tools which will provide guidance to conduct various experiments and analyze the results.

Recommended Books:

1. *Mangey Ram, Om Prakash Nautiyal, Durgesh Pant., "Scientific Methods Used in Research and Writing". Taylor and Francis, 2021.*
2. *Bora Pajo, "Introduction to Research Methods". SAGE Publications, 2017.*

Recent developments in textiles processes

This course aims to provide knowledge about current developments in textile manufacturing processes which include the advancement in fiber spinning, yarn manufacturing, fabric manufacturing, textile processing and garments manufacturing.

Recommended Books:

1. *L Horne., "New Product Development in Textiles". Woodhead Publishing, 2011.*
2. *Q. Xiaoming and L. Huawu., "Advanced Textile Materials". Trans Tech Publications Ltd, 2011.*

Textile machinery and instrument design

Instrumentation and control; Applied mechatronics; Mechatronic design in textile engineering; Design of textile machines; Mechanics and calculations of textile machinery.

Recommended Books:

1. L. Ashok Kumar and M Senthil kumar "Automation in Textile Machinery" CRC Press, 2018
2. Ansel C. Ugural "Mechanical Design of Machine Components" CRC Press, 2015

Elective courses

Heat and mass transfer

The aim of this subject is to impart in depth knowledge about different heating and moisture mechanisms, theories and modeling with special emphasize on textile and clothing. This course will include basic research of heat and mass transfer phenomena, as well as related material properties and their measurements, thereby promoting applications to engineering problems.

Recommended Books:

1. *C. P. Kothandaraman., "Fundamentals of heat and mass transfer". New Age International Private Limited, 2012.*
2. T. L. Bergman and P. Frank., "Principles of heat and mass transfer". *wiley, 2013.*
3. *A.K. Haghi., S. Thomas and L. A. Pothan., "Heat and mass transfer in fibrous materials". Atlantic Publishers and Distributors Pvt Ltd. 2018.*

Advanced Materials

Advanced polymeric materials; Nano composites; Biomaterials for healthcare; Advances in shape memory polymers; Nanofibers and nanoparticles; Flame retardant materials; Functional materials for textiles; Microencapsulation technology.

Recommended Books:

1. *Theodorus van de Ven and Armand Soldera "Advanced Materials" De Gruyter Publisher, 2020*
2. Omari V. Mukbaniani, Tamara N. Tatrishvili and Marc J. M. Abadie "Science and Technology of Polymers and Advanced Materials" CRC Press, 2020

Engineered textile structures & composites

Engineering textiles; Advances in yarn spinning technology; Specialist yarn and fabric structures; 3-D Fibrous assemblies; Advances in weaving and knitting technologies; Nonwovens for technical textiles; Design and manufacture of textile composites; Mechanics of fibrous assemblies; Heat and mass transfer in porous media.

Recommended Books:

1. *Rana, Sohel, Fangueiro and Raul, "Fibrous and Textile Materials for Composite Applications" Springer, 2016.*
2. *Magdi El Messiry, Natural Fiber Textile Composite Engineering,* CRC Press, 2020

Technical textiles

Medical and healthcare textiles; Smart fibers, fabrics and clothes; Functional textiles for protection and performance; Textiles in sports; High performance textiles and their applications.

Recommended Books:

1. *A R. Horrocks and S. C. Anand., "Handbook of Technical Textiles". Woodhead Publishing, 2016.*
2. *R. A. Chapman, ed., "Applications of nonwovens in technical textiles". Woodhead Publishing, 2010.*

Textile modeling and simulation

Simulation in textile technology; Modeling and predicting textile behavior; Soft computing in textiles; Finite element analysis in textiles; Modeling, simulation and control of dyeing process; Advance CAD systems for textile and clothing; Modeling in Matlab.

Recommended Books:

1. *Nicholus Akankwasa and Dieter Veit "Advances in Modeling and Simulation in Textile Engineering" Woodhead Publishing, 2021*
2. *Tuur Stuyck "Cloth Simulation for Computer Graphics" Morgan & Claypool Publishers, 2018*

Computer simulation of cloth Production

Systems of production control (Kaizen, Kanban, Pokajoke, SixSigma, TOC, ...). Definition of simulation; system; model, types of systems and their characteristics, Generation of a computer simulation model and model testing - validation and verification of a model, analysis and result processing). Examples of software for commercial use, Pseudo-random numbers in computer simulation. Service systems. Methods of optimisation and evolutionary algorithms. Creation of a computer simulations

Recommended Books:

1. *Tuur Stuyck "Cloth Simulation for Computer Graphics" Morgan & Claypool Publishers, 2018*
2. *Nicholus Akankwasa and Dieter Veit "Advances in Modeling and Simulation in Textile Engineering" Woodhead Publishing, 2021*

Yarns and fabrics for technical applications

The aim of this course is to provide knowledge regarding different technical yarns, their production techniques and applications, technical structures of woven and knitted fabrics, their production and applications.

Recommended Books:

1. *A R. Horrocks and S. C. Anand., "Handbook of Technical Textiles". Woodhead Publishing, 2016.*
2. *R. Alagirusamy and A. Das, eds. "Technical textile yarns". Woodhead Publishing, 2010.*
3. *3. R. Paul., "High Performance Technical Textiles". John Wiley and Sons Ltd. 2019*

Advances in technical nonwovens

This course will help to familiarize the students with the developments in the fibers and manufacturing processes of technical nonwovens. The course will cover the latest trends in the use of green, recycled, biopolymer materials and nanofibers in the development of technical nonwovens. The students will also gain knowledge of structure, properties and applications of composite nonwovens.

Recommended Books:

1. *George Kellie, ed., "Advances in Technical Nonwovens". Woodhead Publishing, 2016.*
2. *R. A. Chapman, ed., "Applications of nonwovens in technical textiles". Woodhead Publishing, 2010.*
3. *D. Dipayan and B. Pourdeyhimi., "Composite nonwoven materials: structure, properties and applications". Woodhead Publishing, 2014.*

Nonwoven technology

In this course the students will be able to gain knowledge of nonwovens products and markets, raw material requirements for nonwovens and different techniques employed during dry-laid web formation including roller carding, garneting, parallel laying, cross laying, air laying. Additionally, mechanical bonding techniques especially needle punching and hydro entanglement will be covered. The students will also become familiar with wet laid web formation including bonding and drying technologies for wet laid nonwovens along with application of wet laid nonwovens, spun laid nonwovens including bonding techniques for spun laid webs, melt blown production process along with structure and properties of spun bond and melt blown fabrics. At the end, nonwovens finishing techniques, characterization and mechanics of nonwovens will be covered.

Recommended Books:

1. *Russell and J. Stephen., "Handbook of nonwovens". Woodhead Publishing, 20006.*
2. *A. Wilhelm, H. Fuchs and Walter Kittelmann., "Nonwoven fabrics: raw materials, manufacture, applications, characteristics, testing processes". John Wiley & Sons, 2006.*
3. *T. Karthik, C. Prabhakaran and R. Rathinamoorthy., "Non-woven – Process, Structure, Properties and Applications".Woodhead Publishing, 2016.*

Nanofibers and nanoparticles in textiles

This course will be focused on the fundamental principles of behavior of nanomaterials specially nanofibers and nanoparticles. Different ways to prepare/synthesize the nanofibers will be taught in depth. Electro spun based nanofibers and their applications will be discussed in detail. Different ways to prepare the nanoparticles will be covered in this subject. Nanoparticle based functional textiles will be introduced and different methods to apply these nanoparticles on the textiles will be discussed in detail.

Recommended Books:

1. *P. J. Brown and K. Stevens., "Nanofibers and Nanotechnology in Textiles". Woodhead Publishing, 2006.*
2. *R. Mishra and J. militky., "Nanotechnology in Textiles". Wooodhead Publishing, 2018.*
3. *Q. Wei., "Functional Nanofibers and their Applications". Woodhead Publishing, 2012.i*

Advance textile fibers

This course will introduce new innovative natural and manmade fibers. Different ways to prepare/synthesize the fibers will be taught in depth. Electro spun based nanofibers and their applications will be discussed in detail. Different testing methods to evaluate the performance of fibers will also be covered.

Recommended Books:

1. *R. Bunsell., "Handbook of Properties of Textile and Technical Fibres". Woodhead, 2018.*
2. *Q. Xiaoming and L. Huawu., "Advanced Textile Materials".Trans Tech Publications Ltd, 2011.*
3. *R. Mishra and J. Militky., "High-Performance and Specialty Fibers". Springer, 2016.*

3D weaving and advanced woven structures

The students will be able to learn various types of 3D fabrics including distance fabrics, multilayer fabrics, pile fabrics, tubular and complex fabrics. The course will also cover manufacturing techniques and possible applications of 3D woven structures.

Recommended Books:

1. *P. G. Unal., "woven fabrics". INTECH open access publisher, 2012.*
2. *A. E. Tayyar., "3D Weaving: Exploiting Conventional Looms to Create Dome-Shaped Fabrics and Evaluation of Dome-Shaped Fabrics". VDM Verlag, 2009.*
3. *K. Bilisik., "Multiaxis Three Dimensional (3D) Woven Fabric, Advances in Modern Woven Fabrics Technology". IntechOpen, 2011.*

Woven cloth geometry

Cloth geometry is the science of relative position and shape of elements within it. It corresponds to physical presence of fibers/yarns and their relation to fabric physical characteristics.

Recommended Books:

1. *F. T. Peirce., "The geometry of cloth structure". The Institute, 1937.*
2. *J. R. Womersley., "Cloth Geometry.* A classic textile reprint". The Textile Institute, *1978.*
3. P. K. Banerje., "Principles of Fabric Formation". CRC press, 2018.

Digital weaving/ woven cad designing

Digital weaving: is concept of easing complex job of weaving process using computers. It includes converting weaving details into computer apprehend-able format to streamline the information and let automation solve weaving problems.

Recommended Books:

1. *J. Holyoke., "Digital jacquard design". Bloomsbury academic, 2013.*
2. *F. Ng and J. Zhou., "Innovative Jacquard Textile Design Using Digital Technologies". Woodhead publishing, 2013.*

Advanced knitting techniques & practices

This course comprises of different knitting techniques, give a wide knowledge of the specialty in knitting process including special structures and their manufacturing technique. Special features added to the current knitting machines and unveiling cutting edge knitting technology has been focus of the course like 2D and 3D knitting techniques.

Recommended Books:

1. *S. Chadra., "Fundamentals and advances in knitting technology". Woodhead publishing, 2011.*
2. *K. F Au., "Advances in Knitting Technology" .Woodhead publishing, 2011.*
3. *A. R. Horrocks and S. C. Anand., "Handbook of Technical Textiles".Woodhead publishing, 2016.*

Knitwear design & production communication

This course comprises of studying the different knitting structure, the interloping process and properties of different fabrics. Use of design software's .It also comprises of knowledge of knitting calculation required for different designs.

Recommended Books:

1. *D. J. Spencer., "Knitting Technology".* Woodhead Publishing, 2011.
2. *J. Hu., "Fibrous assemblies: Properties, Applications and Modelling of Three Dimensional Textile Structures".* Woodhead Publishing, 2008.
3. K. F. Au., "Advances in Knitting Technology". Woodhead Publishing 2011.

Functional knitted textiles

This course will cover functional applications of knitted fabrics and their mechanism of development and designs.

Recommended Books:

1. *A. R. Horrocks and S. C. Anand., "Handbook of Technical Textiles".Woodhead publishing, 2016*
2. *J. Hu., "3-D Fibrous assemblies: Properties, Applications and Modelling of Three Dimensional Textile Structures". CRC Press, 2008.*
3. *D. J. Spencer., "Knitting Technology". Pergamon press, 2014.*

Advanced chemistry of colorants

The course deals with the chemistry of dyes and pigments and their interaction with the textile substrates. The students will learn the chemistry of dye intermediates, basic concept of photochemistry, energy deactivation of dyes, Electronic effect of the substituent to the conjugated system of colored organic molecules, stereoisomerism, novel chromophores, newer reactive groups and application techniques for the minimum environmental pollution. There will be emphasis on thermodynamics of dyeing, concepts of free energy and kinetics of dyeing. The mechanism of dyeing fibrous materials with various dyes will be studied. The students will be able to learn mechanism of dye sorption, diffusion and rate of dyeing. The novel dyes imparting functionality to the textile materials in addition to the colour will also be studied in this course. The photochemical transformation and degradation of dyes, analysis, ecology and toxicology of colorants will be elaborated.

Recommended Books:

1. *A. Reife and H. S. Freeman., "Enviromental Chemistry of Dyes and Pigments". Wiley-Interscience, 1995.*
2. *H. Zollinger., "Synthesis, Properties and Applications of Organic Dyes and Pigments. 3rd revised edition". Wiley-VCH, 2003.*
3. *H. Panda., "Modern Technology of Textile Dyes & Pigments 2nd Revised Edition". Niir project consultancy services, 2016.*

Chemistry of textile based biomaterials

This course describes the surface chemistry and interfacial interactions of fibrous materials for bioactivity. The outcome is to make the students able to have comprehensive knowledge of manufacturing techniques with technological advancements and modification processes on the basis of material chemistry. There will be emphasis on the mechanisms involved in the interaction of material with the living organisms and the material parameters controlling those mechanisms.

Recommended Books:

1. *S.C. Anand., J.F. Kennedy., M. Miraftab and S. Rajendran., "Medical Textiles and Biomaterials for Healthcare". Woodhead publishing, 2005.*
2. *V. Bartels., "Handbook of Medical Textiles, 1st edition".Woodhead publishing, 2011.*
3. *S. Dumitriu., "Polymeric biomaterials, 2nd edition revised and expanded". CRC press, 2001.*

Advances in textile wet processing

This course describes the advances in the preparatory processes to save time and energy and to minimize the environmental concerns. Rapid dyeing techniques, foam dyeing and other advanced dyeing techniques such as super critical fluid dyeing will be elaborated. The students will learn the recent advancements in textile printing machinery and techniques. The technology of digital printing based on the principle of static electricity, piezo electricity, thermal system and Inkjet with dry toner will be elaborated. The possibility of personalization of each particular product has been emphasized.

Recommended Books:

1. *C. Duckworth., "Engineering in Textile Coloration". Duckworth Dyers Company Publications Trust, 2018.*
2. *W. C. Miles., "Textile printing". Amer Assn of Textile, 1994.*

Colour perception and analysis

This course describes basic theoretical directions in colour theory and colour science development, colour as a basic parameter of visual experience, the effect of colour on phycho-physical reaction of observer, relation between colour and surrounding, dominant factors of visual perception, objective colour evaluation, role of colour in fashion, merits and demerits of metamerism, basic colour contrasts, colour harmony, theory of contemporary ratios, impact of lightness and chroma on colour experience, colour as message carrier and trademark, colour order system, objective evaluation of colour differences and its importance in fashion and management.

Recommended Books:

1. *W. Stiles., "*Color Science: Concepts and Methods, Quantitative Data and Formulae". Wiley-Interscience, 2000.
2. M. D. Fairchild., "Colour Appearance Models, 3rd edition". Wiley-Interscience, 2013.
3. G. A. Geischeider., "Psychophysics: The Fundamentals 3rd Edition". Psychology Press, 1997.

Advances in textile functionalization

This course defines the advanced techniques used to functionalize the textile materials for various applications (biocompatibility, antibacterial activity, fire retardant, UV and IR protection, super hydrophilicity and super hydrophobicity). It includes PVD (physical vapour deposition), CVD (chemical vapour deposition), surface treatment by plasma, deposition of thin films and modification of surfaces by wet chemicals for enhanced wettability, dyeability, surface reactivity and surface adhesion. The students will learn about the principles, chemistry and mechanisms involved in each process.

Recommended Books:

1. *Q. Wei., "Surface Modification of Textiles". Woodhead publishing, 2009.*
2. *C. W. Kan., "A Novel Green Treatment for Textiles: Plasma Treatment as a Sustainable Technology". CRC press, 2014.*
3. *R. Paul., "Functional Finishes for Textiles". Woodhead publishing, 2014.*

Advanced textile finishing

The objective of this course is to teach the students the recent developments in textile finishing such as advances in resin chemistry and applications, Poly carboxylic acids for wrinkle recovery finish, burning behaviour of textile materials and flame retardancy. New methods for superhydrophobic and super hydrophilic, antibacterial activity, surface conductivity recent developments in the coating technology would be emphasized. The students will also learn about the UV protection and IR camouflage achieved by the textiles through various chemicals, nanomaterials and application techniques.

Recommended Books:

1. *Mohammad Shahid & Ravindra Adivarekar., "Advances in Functional Finishing of Textiles, Springer. 2020.*
2. *C. Duckworth., "Engineering in Textile Coloration". Dyers Company Publications Trust, 1983.*

Clothing comfort and assessment

This course deals with physiological, physical-chemical and the psychological aspects of comfort. The human-clothing system, physical processes involved in clothing and surroundings, physiological process in human body, neurophysiological processes responsible for generation of sensory signals and microclimate characteristics between skin and clothing will be elaborated. Further, important factors and elements: moisture and water sorption and transfer, water vapour and air permeability, thermal conductivity and dynamic heat, skin contact characteristics, static electricity, fiber and fabric handle will be emphasized. The students will learn about novel textile fibers, fabric structures, multifunctional materials, comfort test methods and prediction of clothing comfort performance.

Recommended books

1. *G. Song., "Improving comfort in clothing". Woodhead publishing, 2011.*
2. A. Das and R. Alagirusamy., "Science in clothing comfort". Woodhead publishing, 2010.
3. L.E. Fourt., "Clothing; comfort and function*". Dekker (Marcel) Inc., 1971.*

Numerical modelling of textile structures

There has been a significant amount of research in the field of textile process modelling and fabric-geometrical modelling. This course will provide the students with knowledge of the domain and the existing tools like Wisetex or Texgen used for the geometric modelling. The students will understand the mechanics of the woven fabric structure.

Recommended books

1. *B. Behera and P. Hari, Eds., Woven Textile Structure, 1st ed. Cambridge: Woodhead Publishing Limited, 2010.*
2. *S. S. Bhavikatti, Finite Element Analysis. New Delhi: New Age International, 2005.*
3. *Savvas Vassiliadis, Eds., Advances in Modern Woven Fabrics Technology, IntechOpen, DOI: 10.5772/25255.*

Fabric formation, structure and properties

The course will cover different aspects of the processing of yarns to woven fabric and the interrelation between the production mechanics and structure, geometry and properties of fiber assembly. The students will be able to correlate the fabric structure with its properties and ultimately the application area.

Recommended books

1. *Y. Nawab, T. Hamdani, and K. Shaker, Eds., Structural textile design : interlacing and interlooping. Boca Raton: CRC Press, 2017.*
2. *B. C. Goswami, R. D. Anandjiwala, and D. Hall, Textile Sizing. 2004.*
3. *B. K. Behera, J. Militky, R. Mishra, and D. Kremenakova, Woven fabrics. Shanghai: InTech, 2012.*

Functional fibers and materials

This course provides knowledge about advanced textile materials and their application areas keeping in view of the requirements in desired product. This course will help the students to think and use natural products as functionalized textile materials for certain application.

Recommended Books:

1. *B. Mahltig and Y. Kyosev., "Inorganic and Composite Fibers: Production, Properties, and Applications". Elsevier Science, 2018*
2. *J. McLoughlin and T. Sabir., "High-Performance Apparel: Materials, Development, and Applications".Elsevier Science, 2017.*
3. G. Bhat., "Structure and Properties of High-Performance Fibers". Woodhead publishing ltd. 2016.

Textile material modification and processing

In this course textile material modification and processing techniques will be studied. It will help the students to structurally modify current as well as new materials and make them useable in required properties in advance form.

Recommended Books:

1. *T. L. Vigo., "Textile Processing and Properties: Preparation, Dyeing, Finishing and Performance. Elsevier, 2013*
2. *C. W. Kan., "A Novel Green Treatment for Textiles: Plasma Treatment as a Sustainable Technology". CRC Press, 2014*
3. M. Gopalakrishnan, K. Shabaridharan and D. Saravanan., "*Sustainable Innovations in Textile Chemistry and Dyes".*Springer. 2016.

Machine design

This course deals with study of theory of machine, design of machine, development and modification of machine and machine parts in accordance with improve in quality, production or new product.

Recommended Books:

1. *L.A. Kumar and M. Senthilkumar., "Automation in Textile Machinery: Instrumentation and Control System Design Principles". Taylor & Francis Group, 2018*
2. *N. Gorkaneshan., B. Varadarajan and C. B. Senthil Kumar., "Mechanics and Calculations of Textile Machinery". WPI India, 2012.*
3. A. Kumar and M. S. Kumar., "Automation in Textile Machinery: Instrumentation and Control System Design Principles". CRC Press, 2018.

Theoretical modelling

This course will help the students to theoretically evaluate the outcomes of their result results. In this course, specific mathematical forms will be studied as per requirement of research project.

Recommended Book:

1. *X. Chen., "Modelling and Predicting Textile Behaviour".* Woodhead publishing*, 2009*
2. D. Veit., "Simulation in Textile Technology: Theory and Applications". Woodhead publishing, 2012.
3. R. Shamey and X. Zhao., "Modelling, Simulation and Control of the Dyeing Process". Woodhead publishing, 2018.

Sustainable textiles

This course is designed to provide advanced knowledge in green materials and their processing. It will generate interest of students to further explore this area of high-tech emerging field of textiles.

Recommended Books:

1. *S. Kaila., "Biodegradable Green Composites". John Wiley & Sons, 2016*

2. *Shahid ul-Islam, B. S. Butola., "The Impact and Prospects of Green Chemistry for Textile Technology". Elsevier Science, 2018*
3. S. S. Muthu., "Roadmap to Sustainable Textiles and Clothing: Eco-friendly Raw Materials, Technologies, and Processing Methods". *Springer, 2014.*

Total quality management

The aim of this subject is to impart in depth knowledge about concepts, principles, practices, tools and techniques involved in total quality management with respect to the demands of dynamic industry of textile and clothing. The students will be able to identify and analyze the problems for process improvement by affective implementation of lean manufacturing, six sigma, and integration of both i.e. Lean six sigma.

Recommended Books:

1. *L. Wilson., "How to implement lean manufacturing". McGraw-Hill Professional ,2010.*
2. *T. Devane., "Integration of lean Sixsigma and high performance organizations".* John Wiley & Sons Inc*, 2004.*
3. *D. H. Besterfield., "Total Quality Management, third edition". Pearson, 2002.*

Human factor engineering

H**uman factor engineering** deals with the application of information on physical and psychological characteristics to the design of devices and systems for human use.

Recommended Books:

1. *S. J. Guastello., "Human Factors Engineering and Ergonomics". Routledg, 2013.*
2. W. Christopher., "An Introduction to Human Factors Engineering". *Bent Corners edition, 2011.*
3. N. A. Stanton**.,** P. M. Salmon**.,** L. A. Rafferty**.,** G. H. Walker**.,** C. B. Daniel and P. Jenkins.*, "Human Factor Methods"*. CRC press, 2017.

Advanced clothing design

The core of this subject is to give students a system of management based on the principle that every member of staff must be committed to maintaining high standards of work in every aspect of a company's operations.

Recommended Books:

1. *V. Koncar., "Introduction to smart textiles and their applications". Woodhead publishing, 2006.*
2. *S. Kettley., "Designing with smart textiles". Fairchild Books, 2016.*
3. *H. Mattila., "Intelligent Textiles and Clothing". Woodhead publishing, 2006.*

N.B. Any other course may also be chosen with the consent of Supervisors and Head of Department. The approval of Dean will be mandatory in such case.

Career opportunities for Students after Completion of the Program

Career opportunities for Students after Completion of the Program:

1) Research and Development
2) Manufacturing and Merchandising
3) Technical Sales
4) Quality Control
5) Production Control and Corporate Management
6) Academics

Department of Clothing

The Department of Clothing was setup with a vision to en-kindle some of the brightest technical minds of the country and equips them with all skills necessary to manage the clothing industry. The Department envisions producing successful graduates who will be capable of leading the fast faced paced changing scenarios of today's apparel industry through intellect, innovation, and values. Research and educational activities are conducted by proficient, devoted and well-qualified faculty and staff members having ample experience in various fields of garment manufacturing. An active Interaction with industry is the main feature of our Teaching Philosophy; Industrial Visits, internships, symposiums, and participation in workshops and industrial exhibitions are frequently carried out for students learning. Department of Clothing is also dynamically involved in providing consultancy services to the textile industry and other public sector organizations. Various national-level projects were carried out with success by the department during recent years.

MS ADVANCE CLOTHING & FASHION

The MS Advance Clothing & Fashion (MSACF) program will aim to integrate design, theory, problem-solving, and research in relation to the problems of sewn products industry. The Program Educational Objectives (PEOs) and Program Learning Outcomes (PLOs) of MSACF are described below:

Program Educational Objectives (PEOs)

PEOs No	PEO Description
PEO-1	Understand the research, innovation, and creativity in the context of the dynamic requirements of sewn product industry
PEO-2	Apply problem-solving techniques to develop sustainable solutions to contemporary issues related to the sewn products industry.

Program Learning Objectives (PLOs)

PLOs No	PLO Title	PLO Description
1	Knowledge	The ability to understand the clothing design and manufacturing processes
2	Analysis	The ability to evaluate the clothing quality, performance, and comfort
3	Project Management	The ability to plan, conduct and document a research proposal/project independently
4	Design &Development	The ability to design and develop an innovative clothing product/process
5	Sustainability	The ability to design and execute a sustainable framework to improve a process/product

Eligibility Criteria

1. BS Apparel Manufacturing, BS Garment Manufacturing, Textile Science, BS Textile Engineering (specialization in garments), BS Textile and Apparel Merchandising, BS Fashion Design, BS Textile Design, BS Industrial & Manufacturing Engg., BS Industrial Design, BS Apparel Technology, BS Apparel Manufacturing & Technology, BS Clothing, or equivalent/relevant degree with a minimum CGPA 2.00/4.00 or 3.00/5.00 in semester system or 60%marks in annual/term system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit Criteria

Admission merit will be calculated as per following criteria:

Merit / Admission Criteria	
BS or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Semester-Wise Layout of Courses

Semester	Course code	Course Title	Credits
Semester-I	DC-5201	Advances in Fashion Design Processes	2-0-2
	DC-5202	Advances in Sewn Product Manufacturing	2-0-2
	DC-5203	Product Development	3-0-3
	DC-5204	Data-driven Process Improvement	3-0-3
	DC-5205	Research Methodology	1-1-2
Semester-II	DC-5206	Sustainable Clothing	2-0-2
	DC-5207	Fashion branding	3-0-3
	DC-5208	Clothing CAD & Simulation	1-1-2
	DC-5209	Mathematical Modelling & Optimization	1-1-2
	DC-5210	Functional Clothing	3-0-3
Semester-III	DC-6071	Research Thesis-I	0-3-3
Semester-IV	DC-6072	Research Thesis-II	0-3-3
Grand Total			**30**

Course Specifications

Advances in Fashion Design Processes

This course aims to familiarize the students about the fashion design processes. It will focus both on the basic knowledge and recent developments related to the different stages of fashion design that will help students to understand how the elements and principals are employed by designers. This course will facilitate the students to understand the translation of creative ideas into clothing products with good understanding of design processes and materials.

Recommended books:

1. Textile and Clothing Design Technology edited by Tom Cassidy, Parikshit Goswami, 2017
2. Garment Technology for Fashion Designers by Steven Hayes, John McLoughlin, Dorothy Fairclough, 2012
3. Fairhurst, Catherine, ed. Advances in apparel production. Elsevier, 2008.

Advances in Sewn Product Manufacturing

The aim of this course is to enhance the skill of the students in the field of advanced clothing by introducing the recent advancements made in sewn product industry. The course will focus both on the basic knowledge and recent developments related to the different processes of sewn products that include fabric inspection, fabric spreading, fabric cutting, sewing, dry processes, garment washing, and garment packing. The students will learn how to convert/replace the conventional methods of manufacturing with the innovative techniques keeping in view the requirements of industry 4.0.

Recommended books:

1. Technology Evolution in Apparel Manufacturing By Dr. Prabir Jana & Helmut Jung, 2020
2. Apparel Manufacturing Technology by T. Karthik, P. Ganesan, D. Gopalakrishnan · 2020
3. Garment Manufacturing Technology by Rajiv Padhye, Rajkishore Nayak, 2015
4. Fairhurst, Catherine, ed. Advances in apparel production. Elsevier, 2008.
5. Glock, Ruth E., Grace I. Kunz, and Apparel Manufacturing. "Sewn Product Analysis." Prentice Hall published.

Product Development

This course will be about the process of New Product Development (NPD). This course covers the market opportunities, business concept to new product development, NPD trends, NPD processes, dynamics of product development, product development performance and assessment tools for NPD. The students will lean innovative techniques for product development. Further best practices in different industries will also be shared with the students.

Recommended Books:

1. Innovation management and new product development. P. Trott, 2010
2. Beyond design: the synergy of apparel product development. S. J. Keiser, 2005
3. Apparel product development. M.J. Johnson, 2000

Data-driven Process Improvement

The objective of this course is to introduce the concept, methodologies, tools and techniques to ensure the data driven process improvement in clothing industry. The course will include total quality management, learn manufacturing, Six Sigma, and integration of both i.e. lean Six Sigma along with other best practices for clothing industries like cost of quality, statistical process control, et. The course aims at strengthening students' conceptual as well as practical knowledge that will also help them in handling the different problems faced in the clothing industry efficiently. They will be able to implement different tools and techniques of above-mentioned systems to control and improve their existing system along with quality enhancement and proper utilization of the available resources.

Recommended Books:

1. How to implement lean manufacturing, Lonnie Wilson, 2010
2. Integration of lean Six Sigma and high-performance organizations, Tom Devane 2004

Research Methodology

The overall aim of this course is to enable the students to identify a research area, identify a research problem, formulate research question(s), conduct literature survey, formulate research hypothesis, design research experiments, graphically present data, analyze and interpret the experimental data, and draw valid conclusions. Additionally, the students will be able to write a research proposal and critically analyze research papers. The students will practice relevant statistical tools and techniques using a statistical software package. The students will also become familiar with plagiarism and other ethical issues in research, patents, copyrights and trademarks, thesis and research paper writing styles.

Recommended Books:

1. Research methodology. R. Panneerselvam, 2014
2. Research methodologies in the south. A. Halai, 2011
3. Research methodology: a step-by-step guide for beginners. R. Kumar, 2009

Sustainable Clothing

The objective of this course is to cover the detailed aspects of sustainability in clothing industry covering environmental, social, and economical sustainability. The course will include details regarding circular economy, waste management, recycling, upcycling, etc. The students will be familiarize how the concept of sustainability can be focused at different levels of clothing supply chain.

Recommended Books:

1. Waste Management in the Fashion and Textile Industries by Rajkishore Nayak, Asis Patnaik, 2021
2. Sustainable Technologies for Fashion and Textiles edited by Rajkishore Nayak, 2019
3. Textiles and Clothing Sustainability: Sustainable Technologies, edited by Subramanian Senthilkannan Muthu, 2017
4. Blackburn, Richard, ed. Sustainable apparel: Production, processing and recycling. Woodhead Publishing, 2015.

Fashion branding

The aim of this course is to educate students about the management of a fashion brand. Student will learn about the analysis and planning that how a fashion brand is perceived in the market. Students will be taught that how to develop good relationships with the target market and what kind of fashion product is to offer a specific group of people. Students will be demonstrated about the most up to date and complete process of fashion brand management.

Recommended Books:

1. Fast Fashion, Fashion Brands and Sustainable Consumption edited by Subramanian Senthil Kannan Muthu, 2019
2. Global Fashion management & merchandizing by Elaine Laidlaw Ritch.
3. Luxury Brand Management by Michael Chevalier.

Clothing CAD & Simulation

This course aims to introduce students with the latest application of different software in the clothing industry. The course will focus on how to develop 2D patterns, virtual avatars, virtual modeling, and its evaluation using software. The students will be able to develop personalized avatars for virtual garment design and their simulation.

Recommended Books:

1. CAD for Fashion Design and Merchandising by Stacy Stewart Smith, Bloomsbury, 2016.
2. Cloth Simulation for Computer Graphics by tuur Stuyck, 2018.
3. Research papers

Mathematical Modelling & Optimization

The objective of this course is to enable the student to solve the decision-making problems of clothing industry by developing the models of those problems like mathematical models or statistical models. The complete course will cover linear programming, integer programming, multicriteria decision making, project management, forecasting, and inventory management. The student will be able to formulate the theoretical models of their problems, graphical solutions, computer solutions, and sensitivity analysis.

Recommended Books:

1. Mathematical Modelling and Optimization of Engineering Problems edited by J. A. Tenreiro Machado, Necati Özdemir, Dumitru Baleanu, 2020
2. Handbook of Research on Applied Optimization Methodologies in Manufacturing edited by Faruk Ylmaz, Ömer, Tüfekçí, Süleyman, 2017
3. Introduction to Management Science (11th Edition) by Taylor III, BW., (2012)

Functional Clothing

This course will be focused on to design and develop the functional clothing. First of all, the course will cover different functional aspects of clothing which includes protection against clod, bacteria, fire, biological hazards etc. The course will, then, educate the students with techniques to develop products having certain functionalities using different raw materials. Smart textile and electronic textile products will also be covered in this course.

Recommended Books:

1. Functional Textiles and Clothing edited by Abhijit Majumdar, Deepti Gupta, Sanjay Gupta, 2020
2. Designing with smart textiles. S. Kettley. 2016
3. Electronics in textiles and clothing. A. Kumar, 2016
4. E Textiles. T. Dias, 2015

GM: Research Thesis

This module will enable participants to bring together the knowledge and skills acquired in the earlier modules. In the first part of the modules, the students will select a problem area, conduct a literature review, find research gaps and formulate the strategy to solve the search problem. The students will choose the raw materials, methodologies and prepare an experimental design to investigate the selected problem.

Recommended Books:

1. How to write a thesis, R. Murray, 2006
2. How to write research papers. S. Sorenson, 2002

GM-6042: Research Thesis-II

In the second part of this module, the students will conduct the designed experiments and collect data. The next step will be the data analysis and extracting meaningful conclusions from the obtained data. The research thesis will demonstrate the student's capabilities to perform independently under the guidance of his/her teacher(s) to solve practical problems utilizing the theoretical knowledge and analytical skills attained. The overall purpose of the module is to develop in the participants an understanding of the steps involved in planning and conducting a research project and in communicating the findings both orally and in writing. The topic for the research thesis will be assigned to the students after the approval from Departmental Research Committee.

Recommended Books:

1. How to write a thesis, R. Murray, 2006
2. How to write research papers. S. Sorenson, 2002

Career Opportunities for Students after Completion of the Program

The graduates of this program would be able to get job and progress opportunities in diverse areas, some of them include:

1. Technical professionals for sewn products industry (home textiles, garments, leather, shoe industry etc).
2. Research and Development in public and private sector organizations.
3. Higher studies and research in the field of clothing and relevant interdisciplinary fields.
4. Teaching and research at university/post-graduate college level.

Available Labs

1. Pattern Making Laboratory
2. Computer-Aided Designing (CAD) Laboratory
3. Computer-Aided Manufacturing Laboratory
4. Basic Sewing Laboratory
5. Advanced Sewing Laboratory
6. SMART Textile Laboratory
7. Comfort Laboratory (NTRC)
8. Textile Testing Laboratory

PhD Apparel Manufacturing

Introduction

PhD in Apparel Manufacturing is a program which brings together diverse disciplines of natural sciences, material science, textiles, fashion, design, and clothing for the development of novel solutions for the contemporary problems and future challenges in the world of Textiles.

PEOs No	PEO Description
PEO 1	To carry out research of international standard aimed at advancing the global textiles and associated knowledge in general and indigenous textiles in specific.
PEO 2	To enhance the intellectual development of PhD graduates through creativity, analytical thinking, critical analysis, and innovative problem-solving.

Admission Criteria

1. **MS / M.Phil or equivalent degree in** Clothing, Textile Design, Fashion Design, Visual Arts, Home Economics, Apparel Technology, Arts and Design, Economics, Graphic Design, Merchandizing, Interior Design, Advanced Clothing & Fashion or equivalent with minimum 3.00/4.00 or 3.50/5.00 CGPA in semester system or 60% marks in annual system or equivalent.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test with minimum 60% score or NTU-GAT (Subject) test with minimum 50% score in case of different qualification as per HEC.
3. Applicant having MS or equivalent degree without thesis is not eligible to apply.
4. It is mandatory to pass interview in order to compete on merit.
5. Applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
6. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final MS/M.Phil or equivalent official transcript or degree.
7. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
8. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Merit Criteria:

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	Weightage
MS or Equivalent	60 % weightage
B.Sc./BE/Equivalent	20% weightage
Interview	10% weightage
Publication/Relevant experience	10% weightage (05% + 05%)

Semester-Wise Layout of Course Semester-I

Sr.No.	Code	Course Title	Credit Hours
1	DC-7101	Scientific Methods for Research	3
2	DC-7102	Recent Trends in Textile Materials and Processes	3
3	DC-7103	Recent Trends in Clothing and Fashion	3
		Total	9

Semester-II

Sr.No.	Code	Course Title	Credit Hours
1	DC-7XXX	Elective – I	3
2	DC-7XXX	Elective – II	3
3	DC-7XXX	Elective – III	3
		Total	9

Semesters III-VIII

Sr.No.	Code	Course Title	Credit Hours
1	DC-8090	Research Thesis	30
		Total Credit Hours	48

Proposed elective courses

1) Clothing Product Development

This course offers an in-depth exploration of the entire lifecycle of clothing products, from initial concept to final market release. The course covers essential stages such as product planning (market research, trend forecasting etc.), Concept development (design, material selection etc.), prototyping (pattern making and production etc.). By the end of the course, students will have a solid foundation in clothing product development, equipped with the skills and knowledge needed to innovate and succeed in the fashion industry.

Recommended books

- Apparel Product Development by Maurice J. Johnson and Evelyn C. Moore, 2019
- Product Design and Development by Karl T. Ulrich and Steven D. Eppinger, 2020
- Lean Product and Process Development by Allen C. Ward and Durward K. Sobek, 2019

2) Virtual Prototyping

This course deals with the cutting-edge techniques of digital garment creation, focusing on the use of advanced software to design and simulate clothing in a virtual environment. This course covers the fundamentals of 3D modeling, digital pattern making, fabric simulation, and virtual fitting. Students will explore industry-standard tools such as CLO 3D and Gerber Blender, learning to create lifelike digital prototypes that streamline the design process and reduce the need for physical samples. The course emphasizes the benefits of virtual prototyping, including faster turnaround times, cost savings, and enhanced sustainability. By the end of the course, participants will be proficient in virtual fashion prototyping, ready to innovate and lead in the evolving landscape of digital fashion design.

Recommended books

- Digital Fashion Innovations: From 2D to 3D by Holly Fulton, 2021
- 3D Fashion Design: Technique, Design and Visualization by Thomas Makryniotis, 2020

3) Sustainable Practices in Apparel Manufacturing

This course provides a comprehensive understanding of sustainable methods and practices in the apparel industry. The course covers key concepts such as eco-friendly materials, ethical sourcing, waste reduction, and energy-efficient production techniques. Students will explore the environmental and social impacts of traditional manufacturing and learn how to implement sustainable alternatives throughout the supply chain. Topics include sustainable fabric sourcing, green manufacturing technologies, circular fashion principles, and certifications like Fair Trade and GOTS. By the end of the course, participants will be equipped with the knowledge and skills to drive sustainability initiatives in apparel manufacturing, contributing to a more ethical and environmentally friendly industry.

Recommended books

- Sustainable Fashion and Textiles: Design Journeys by Kate Fletcher, 2019
- Fashionopolis: The Price of Fast Fashion and the Future of Clothes by Dana Thomas, 2019
- Sustainable Apparel: Production, Processing, and Recycling by Richard Blackburn, 2019

4) Fashion Technology and Wearable electronics

This course explores the innovative intersection of fashion and technology, focusing on the design, development, and application of wearable electronics. This course covers fundamental concepts of smart textiles, electronic components, and integration techniques. Students will delve into the basics of circuit design, sensor technology, and microcontrollers, learning how to embed these elements seamlessly into clothing and accessories. The course also addresses issues of usability, comfort, and aesthetics, ensuring that wearable tech is both functional and stylish. By the end of the course, participants will be proficient in the principles and practices of fashion technology, ready to pioneer new developments in the rapidly evolving field of wearable electronics.

Recommended books

1. Soft Circuits: Crafting e-Fashion with DIY Electronics by Kylie Peppler, Yasmin B. Kafai, and Leah Buechley, 2021
2. Wearable Electronics: Design, prototype, and wear your own interactive garments" by Kate Hartman, 2020
3. Fashionable Technology: The Intersection of Design, Fashion, Science, and Technology by Sabine Seymour, 2019

5) Optimization of Apparel Production Processes

This course provides an in-depth exploration of strategies and methodologies for optimizing apparel production processes. In order to increase productivity, cut waste, and improve efficiency, students will learn how to apply the concepts of operations research and management. Principles of lean manufacturing, production scheduling and planning, resource allocation, workflow optimization, and performance evaluation are among the subjects addressed. The use of advanced analytical methods to solve practical issues in the clothing industry, such as mathematical modeling and simulation, will be emphasized. Students will get the practical knowledge and analytical abilities necessary to promote innovation and continuous improvement in garment manufacturing processes through case studies, practical exercises, and industry projects.

Recommended books

1. Manufacturing Excellence and Quality Management in Sustainable Fashion Apparel By Liviu Ghiuzan · 2024.
2. Productivity Improvement in Apparel Manufacturing By Paul F. Bowes 2020.
3. Research papers

6) Project management in the Apparel Industry

This course aims to educate the students about the globally recognized standards and guides of project management that could be helpful in efficient management of individual project in clothing industry. The students will be educated about the key concepts of project management including developed norms, methods, processes and practices. The course will develop project management skills in student by focusing on different areas like scope management, time management, cost management, risk management, human resource management, and quality management.

Recommended books:

1.A guide to the project management body of Knowledge (PMBOK), 5th Edition, 2013
2.Handbook of Research on Project Management Strategies and Tools for Organizational Success by Flor Nancy Diaz Piraquive, 2020
3. Project management, R. Gupta, 2014.
4. Research papers

7) Ethical Labor Practices in Apparel Manufacturing

This course aims to explore the complex issues surrounding ethical labor practices in the apparel manufacturing industry. Students will examine the social, economic, and environmental implications of labor practices throughout the apparel supply chain, with a focus on promoting fair and safe working conditions, ensuring workers' rights, and fostering sustainable production practices. Topics covered include international labor standards, corporate social responsibility (CSR), labor laws and regulations, worker empowerment, supply chain transparency, and stakeholder engagement. Through case studies, guest lectures, and interactive discussions, students will develop a deep understanding of ethical labor practices and their importance in shaping a more sustainable and socially responsible apparel industry.

Recommended books:

1.Workers' Rights and Labor Compliance in Global Supply by Jennifer Bair, Doug Miller, Marsha Dickson · 2013
2.Ethics in the Fashion Industry by V. Ann; Hillery Paulins · 2020
3. Ethical Issues in the Fashion Industry by Barbara Beltran Torres · 2021

8) Consumer Behavior and Sustainable Fashion

This course aims to explore how consumer behavior and sustainable fashion intersect with the production of clothing. Students will investigate how customer attitudes, preferences, and purchase decisions in the fashion industry are influenced by psychological, social, and cultural aspects. Furthermore, the course will examine the increasing consumer expectations for fashion that are created sustainably and ethically, as well as the tactics used by clothing brands to achieve these demands. Students will learn about the opportunities and difficulties of promoting sustainability in fashion through case studies, research projects, and group discussions. They will also explore tactics for getting customers to engage in more socially and ecologically conscious purchasing.

Recommended books:

1. A Practical Guide to Sustainable Fashion by Alison Gwilt, 2020·
2. Consumer Behaviour and Sustainable Fashion Consumption By Subramanian Senthilkannan Muthu 2019.

3. Innovation Management and Corporate Social Responsibility, Social Responsibility as Competitive Advantage by Reinhard Altenburger, 2018
4. Research Papers

9) Supply Chain Optimization in Apparel Manufacturing

This course offers a thorough analysis of supply chain optimization tactics and ideas in relation to the production of clothing. From obtaining raw materials to shipping completed goods to customers, students will investigate the complexities of the garment supply chain and discover how to use optimization strategies to boost productivity, save expenses, and increase sustainability. Inventory control, production scheduling, distribution, logistics, and working with vendors and merchants are among the subjects addressed. Students will gain the skills and knowledge necessary to design and manage flexible, adaptable, and sustainable supply chains in the apparel industry through case studies, simulations, and real-world projects.

Recommended books:

1. Supply Chain Performance Measurement in Textile Enterprises, by Pranav C. Charkha, Santosh B. Jaju, Prasenjit Chatterjee · 2024.
2. Supply Chain Risk Management in the Apparel Industry by Peter Cheng, Kin Keung Lai, Yelin Fu · 2020.
3. Optimizing Decision Making in the Apparel Supply Chain Using Artificial Intelligence (AI) From Production to Retail by W. K. Wong, Calvin Wong, Z. X. Guo, S Y S Leung · 2013

10) Entrepreneurship management in textile and apparel industry

The "Entrepreneurship Management in Textile and Apparel Industry" course equips students with essential skills for launching and managing ventures in this dynamic sector. Covering market analysis, trend forecasting, sustainable practices, and technological innovations, the course provides a comprehensive overview of the industry. Key topics include business planning, funding, supply chain management, and global sourcing. Students engage in hands-on projects and explore case studies of successful entrepreneurs, learning strategic decision-making, brand development, and ethical business practices. By the end of the course, students will be prepared to create and manage successful textile and apparel enterprises.

Recommended Books:

1. "Fashion Entrepreneurship: Retail Business Planning" by Michele M. Granger and Tina M. Sterling
2. “Entrepreneurship in the Fashion Industry" by Melissa G. Carr and Lisa Hopkins

11) Forensic and criminal investigations of textile and apparel

The "Forensic and Criminal Investigations of Textile and Apparel" course delves into the scientific methods and techniques used in examining textile and apparel evidence in criminal cases. Students learn about fiber analysis, fabric identification, and the role of textiles in crime scene investigations. The curriculum covers topics such as forensic microscopy, chemical testing, and the legal aspects of forensic evidence. Case studies and practical labs provide hands-on experience in analyzing and interpreting textile evidence, preparing students for careers in forensic science, law enforcement, and related fields.

Recommended Books:

1. "Forensic Examination of Fibres" by James Robertson, Claude Roux, and Kenneth G. Wiggins
2. "Clothing and Textile Forensics" by Nigel N. Meeks

12) Biomechanical properties of textile and clothing

The "Biomechanical Properties of Textile and Clothing" course explores the interaction between textiles and the human body, focusing on how materials respond to physical forces. Students study the mechanical behavior of fibers, yarns, and fabrics, including elasticity, strength, and durability. The curriculum covers the principles of biomechanics, material testing methods, and the design of functional clothing for various applications, such as sports, medical, and protective wear. Through laboratory experiments and case studies, students gain practical knowledge in assessing and optimizing the performance of textile products, preparing them for careers in textile engineering and design.

Recommended Books:

1. "Biomechanical Engineering of Textiles and Clothing" edited by Yan Li and Xianyi Zeng
2. "Textile-Based Biomaterials: Structures, Components, and Applications" edited by Xiaoming Tao

13) Circular Fashion

This course explores the application of circular economy principles to the fashion industry, with the goal of extending the life cycles of fashion products and creating a closed-loop system. The aim is to minimize waste and reduce the environmental impact of the fashion industry by designing, producing, using, and then recycling or repurposing clothing items in a sustainable manner. The curriculum provides a thorough examination of the traditional linear model of fashion consumption, as well as the emerging circular model. Students will delve into the comprehensive exploration of the principles, practices, and innovative solutions that are driving the transition towards a circular fashion economy. Through case studies, interactive workshops, and cutting-edge research, students will gain a deep understanding of the opportunities and challenges involved in transforming the fashion industry to become a more sustainable, circular, and equitable future.

Recommended Books:

1."Circular Fashion: A Systems Approach to Sustainable Clothing and Textile Value Chains" by Kate Fletcher and Lynda Grose (2022)
2."Circular Economy in Textiles and Apparel: Processing, Manufacturing, and Design" edited by Rajkishore Nayak and Rajiv Padhye (2019)

14) Functional Clothing

Clothing is not just about fashion and aesthetics, it serves critical functional purposes that enhance human performance, protection, and comfort in various environments and activities. This course offers a thorough analysis of specifically designed and engineered clothing having predefined performance requirements for the end user. In this course, the students will study the key protection requirement under harsh environmental conditions during work, sports, outdoor recreation, and other specialized applications. The curriculum covers

the impact of advanced knowledge and research about fibers, fabrics, finishes and apparel manufacturing techniques on the development and performance of functional clothing. Through hands-on laboratory experiments and in-depth case studies, students will gain practical experience in the key aspects of functional clothing development. This includes product design and prototyping, material characterization, and performance optimization techniques. They will be able to apply their understanding of functional fabrics, garment construction, and performance testing to enhance product development, quality assurance, and overall innovation in this dynamic field.

Recommended Books:
1."High-Performance Apparel: Materials, Development, and Applications" edited by Jinlian Hu (2017)
2."Multifunctional Clothing for Outdoor Activities" edited by Jintu Fan and Winnie Yu (2021)
3."High-Performance Sportswear" edited by Guowen Song and Jintu Fan (2020)

15) Automation/Digitalization in Apparel Manufacturing

The apparel industry is undergoing a profound digital transformation, revolutionizing the way clothing is designed, produced, and brought to market. This course provides an in-depth exploration of the emerging digital technologies, tools, and processes that are reshaping modern apparel manufacturing. The curriculum will cover the knowledge about key aspects of innovation not limited to computer-aided design (CAD), 3D virtual prototyping, digital textile printing, smart factory automation, internet of things (IOT), product lifecycle management, omnichannel retailing and personalized customer experiences. By the end of this course, students will be equipped with the knowledge and skills to leverage cutting-edge digital technologies to drive efficiency, innovation, and sustainability in the apparel industry.

Recommended Books:
1."The Digital Transformation of the Apparel and Textile Supply Chain" by Pamela Ravasio (2021)
2."Fashion Tech: Innovative Technology in Fashion" edited by Brigitte Borja de Mozota and Dominique Sciamma (2022)
3."Smart Factories in Industry 4.0: Manufacturing, Automation, and Autonomous Systems" edited by Shaukat Ali, Liu Zheng, and Mujeeb Ur Rehman (2021)

Career opportunities for students after Completion of the Program

The graduate of this program would be able to get job and progress opportunities in diverse areas, some of them include:

1. Technical professionals for sewn product industry (home textile, garment, leather, shoe industry, denim industry, etc.)
2. Research and development in public and private sector organization
3. Fashion brands, fashion and textile industry or any prestigious design insttitues.
4. Teaching and research at university/post graduate college.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MS TEXTILE & APPAREL (Karachi Campus)

The Master of Textile & Apparel is a two-year master's program offered by Karachi Campus, National Textile University. This program will aim to integrate theory, problem-solving, and research in relation to the problems of Textile & Apparel industry.

Program Objectives

Master of Textile & Apparel program aims to create a higher learning culture that enables students to:

1. Apply creative problem-solving techniques to develop sustainable solutions to issues challenging the Textile & Apparels industry.
2. Give students an exposure of modern and advanced industrial developments, research methodologies and their applications in industrial environment
3. Develop novel approaches to solve technological problems and shortcomings
4. Appreciate technological, environmental, economical and cultural factors that may influence, manufacturing & processing conditions and mode of applications
5. Strengthen the capabilities of graduates in production, quality, research and development activities in Textile products industry
6. Establish and strengthen linkage with the industry for the mutual benefits

Program Outcomes

At the time of completion of Master of Textile & Apparel program, the students will be able to:

1. Apply knowledge of advance sciences.
2. Identify, formulate and solve problems.
3. Apply acquired technical knowledge to design and modify processes for customized finished products.
4. Design a novel and advanced textile system, component, product or process to meet certain desired needs within realistic constraints and conditions such as economic, environmental, social, health and safety, manufacturability and sustainability.
5. Design and conduct experiments, as well as to analyze and interpret data.
6. Work individually as well as in a team in a diverse environment.
7. Enter industry with the techniques, skills and tools required to be able to solve real world problems in textile and apparel.

Eligibility Criteria

1. A candidate seeking admission to MS Textile & Apparel must possess a BS Textile Engineering, BS Textile Engineering Technology, BS Textile Science, BS Apparel Technology or 16 years equivalent degree from HEC recognized institution with a minimum CGPA 2.00/4.00 or 3.00/5.00 in semester system or 60% marks in annual/term system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit / Admission Criteria

Admission merit will be calculated as per the following criteria:

Merit / Admission Criteria	Weightage
BS or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Scheme of Study

Semester-I

Sr. No	Code	Course Title	Credit Hours
1	TE-5072	Technical Textiles	3(3-0)
2	TE-5074	Novwoven Technology	3(3-0)
3	ACF-5042	Clothing Comfort	3(3-0)
4	TE-5076	Protective Textiles	3(3-0)
		Total	**12**

Semester-II

Sr. No	Code	Course Title	Credit Hours
1	TE-5078	Research Methodology	3(3-0)
2	ACF-5043	Quality Management in Clothing	3(3-0)
3	TE-5071	Advanced Materials	3(3-0)
4	TT-5065	Production, Planning, Control in Textiles	3(3-0)
		Total	**12**

Semester-III

Sr. No	Code	Course Title	Credit Hours
1	-	Research Thesis	3(3-0)
		Total	**3**

Semester III & IV

Sr. No	Code	Course Title	Credit Hours
1	-	Research Thesis	3(3-0)
		Total Credit Hours	**30**

*Optional subjects for those who willn't adopt "Research thesis" and subject to the approval of AC as per new Graduate Policy

Sr. No.	Code	Course Name
1	GM-5047	Lean Six Sigma
2	AME-5071	Nano Materials

Course Specifications

TE-5072: Technical Textiles

Technical textiles comprise textile materials and products manufactured and used primarily for their performance and functional features rather than for their aesthetics. The global technical textiles market is estimated to be worth US$150 billion. The objective of this course is to give the students a broad and detailed overview of the market size, manufacturing technologies, properties, and end-uses of different categories of technical textiles, including; textiles used in agriculture, horticulture and forestry; textiles for buildings and construction; technical components of clothing; textiles used in civil engineering; household technical textiles; textiles used in filtration, cleaning and process industries; textiles used for healthcare and hygiene; textiles used in automobiles, railways and aerospace; textiles used for environmental protection; textiles used for packaging; textiles for personal and property protection; and textiles used in sports and leisure.

Recommended Book:

AR Horrocks, SC Anand, Handbook of technical textiles. Elsevier, (2000).

TE-5074: Nonwoven Technology

Nonwoven materials are used worldwide in various applications, including construction, apparel, hygiene products, wet wipes, medical dressings, automotive end uses, geotextiles, home furnishings, and filtration. Hence, knowledge of how nonwoven fabrics are structured, manufactured, and engineered for required end-uses is important and relevant in various industries. Nonwovens are advantageous because of their ease of manufacture, versatility, and low production cost compared to other textile manufacturing methods. This course aims to introduce students about nonwoven textiles and their manufacturing processes, characterization & testing methods. The course covers various web formation, web bonding and finishing methods. An overview of product developments in key application areas is also an integral part of the course.

Recommended Books:

George Kellie, Advances in technical nonwovens, Elsevier (2016).

GM-5043: Clothing Comfort

The objective of this course is to introduce the students with the science of clothing comfort. The course will start with the introduction to comfort, clothing comfort and types of comfort. The course will further elaborate the visual comfort, tactile comfort, physiological comfort and thermal comfort. In addition the students will get acquainted with the effect of body shape, body measurements and fabric properties on different types of comfort. The course also includes comfort of non-wearing products i.e. office chair, car seat etc.

Recommended Books:

1. Textiles and human thermophysiological comfort in the indoor environment. R. Angelova, 2016.
2. Improving comfort in clothing. G. Song, 2011.
3. Science in clothing comfort. A. Das, 2010.

TE-5076: Protective Textiles

The focus of this course is the development and characterization of textiles for protection from fire and heat, cold, water and wind, ballistics, cuts and stabbing, microbes and odour, particulate matter, static charge, ultra-violet radiation, chemical, biological, nuclear and electrical hazards. The course deals with the selection of suitable raw materials for protective textiles as well as their manufacturing and testing techniques.

Recommended Books:

Shahid-ul-Islam, Advances in functional and protective textiles, Elsevier, (2020).

TE-5078: Research Methodology

The overall aim of this course is to enable the students to identify a research area, identify a research problem, formulate the research question, conduct a literature survey, formulate research hypothesis, design research experiments, graphically present, analyze and interpret the experimental data, and draw valid conclusions. Additionally, the students will write a research proposal, critically analyze research papers, and write a short literature review with proper citations and referencing. The students will practice relevant statistical tools and techniques using a statistical software package. The students will also become familiar with plagiarism and other ethical issues in research, patents, copyrights and trademarks, thesis, and research paper writing styles.

Recommended Books:

Research Methods: A Practical Guide For Students And Researchers by Willie Tan (2017).

GM-5042: Quality Management in Clothing

The objective of this course is to make the students understand the philosophy of different quality management systems. This course includes an introduction to quality, quality systems, and quality management through a survey of the various philosophies, principles, techniques and procedures used by various organizations and/or managers to assure customer satisfaction of product and/or service. Some other topics are relationship between quality and competitiveness, costs of poor quality, AQL and quality culture. This course will also introduce different quality tools and techniques like brainstorming, Pareto analysis, cause and effect diagram, Kaizen, value stream mapping, decision-making, process control and process capability.

Recommended Books:

1. Effective implementation of quality management systems. B. Purushothama, 2010.
2. Acceptance sampling in quality control. E.G. Schilling, 2009.
3. Quality management in the clothing and textile industries, A. J. Chuter, 2002.

TE-5071 Advanced Materials

The objective of this course is to give the students an overview of various types of materials used for advanced engineering applications. The students will learn about the properties and applications of various polymeric, ceramic, metallic, bio- and composite materials ranging from nanoscale to macro scale. In addition to various physical and mechanical properties, various functional aspects of the materials will also be covered in the course including: shape memory effect, self healing, phase change, fire retardant behavior and energy harvesting properties. At the end of the course, the students should be able to select suitable materials for various engineering applications, particularly for making advanced technical textile products.

Recommended Books:

AR Horrocks, SC Anand, Handbook of technical textiles. Elsevier, (2000).

TE-5065: Production, Planning and Control in Textiles

The course enables the students to design of inventory & other relevant systems, different textile production planning models & capacity requirement planning. The course includes Analysis and design of inventory, Deterministic and stochastic inventory models, production, and scheduling control systems, Material Requirement Planning (MRP), Master Production Scheduling (MPS), and Aggregate Planning. It will also provide key knowledge about Warehouse, Importance of warehouse, Types of warehouse, Layout planning of warehouse, warehouse security, safety and maintenance, Warehouse operations, introduction to warehouse management system, functions of warehouse management system, a step towards intelligent WMS. Introduction to Lean Manufacturing will also be included in this course.

Recommended Book:

Production Planning & Control in Apparel Manufacturing, Prasanta Sarkar.

GM-5045: Lean Six Sigma

The objective of this course is to introduce the concept of learn manufacturing, Six Sigma, and integration of both i.e. lean Six Sigma. The course aims at strengthening students' conceptual as well as practical knowledge that will also help them in handling the different problems faced in the clothing industry efficiently. They will be able to implement different tools and techniques of above mentioned systems to control and improve their existing system along with quality enhancement and proper utilization of the available resources. The Students will gain in-depth knowledge of methodologies of lean manufacturing, and Six Sigma with both qualitative and quantitative analysis.

Recommended Books:

1. How to implement lean manufacturing, Lonnie Wilson, 2010.
2. Integration of lean SixSigma and high performance organizations, Tom Devane 2004.

AME-5071: Nanomaterials

This course introduces the fundamental principles needed to understand the behavior of materials at 18 National Textile University the nanometer scale and the principles of electrostatic and steric stabilization. It provides an introduction to different types of nanoscale materials i.e. zero dimension, one dimension and two dimension nanostructures. Homogeneous and heterogeneous nucleation and subsequent growth of nanostructures are discussed in detail. It also covers the physical and chemical techniques to synthesize nanostructures/nanomaterials and their characterization techniques like x-ray techniques, scanning probe microscopy, scanning electron microscopy, transmission electron microscopy etc. The effect of size on properties of materials like mechanical, electrical, optical, melting point etc as well as application of nanomaterials in diverse field is included in this course.

Recommended Book:

Andy Nieto, Nanomaterials and their Applications (2020).

AME-6071: Research Thesis

The Research Project module will enable the students to bring together the knowledge and skills acquired in the earlier modules to investigate a selected topic reviewing the literature, presenting seminars, and preparing material in the form of a publication. The project will demonstrate the student's capabilities to perform independently but supervised research to solve practical problems utilizing the theoretical knowledge and analytical skills attained. The overall purpose of the module is to develop in the students an understanding of the steps involved in planning and conducting a research project and in communicating the findings both oraly and in writing.

The project work can be undertaken in an industrial concern, where possible, ensuring both the relevance to the employer access to appropriate facilities, and allowing sufficient time to be spent on the practical work. Alternatively, projects could be based and carried out at the university. In case of collaboration with other national and international research institutes and universities the final semester research projects can be completed at mother and collaborated organization.

Career opportunities for students after Completion of the Program

The graduates of MS Textile & Apparel would be able to find opportunities in diverse areas such as apparel industry, textiles manufacturing industry, apparel traders, research & development industry, and product development etc. He/She may also able to get opportunities in academia as a faculty member and research officer etc.

SCHOOL OF SCIENCE

School of Science (SoS) offers specialized as well as supportive education to the core departments of the university at graduate and undergraduate level with the aim to provide a strong background in the areas of, Physics, Chemistry, Mathematics & Statistics and Computing. Faculty members of the School of Science are highly qualified who have received their degrees from renowned universities of the world, aiming to develop students into researchers, engineers, innovators as well as highly specialized professionals with broad vision and excellent skills. School of Science has state of the art research labs with excellent facilities for research activities of the graduate and undergraduate students. School of Science faculty members are actively engaged in various research projects within the institute and in collaboration with other institutes and industry.

The School of Science has two academic departments:

- Department of Applied Sciences
- Department of Computer Science

GRADUATE PROGRAMS

MS MATHEMATICS

MS PHYSICS

MS TEXTILE CHEMISTRY

PhD CHEMISTRY

DEPARTMENT OF APPLIED SCIENCES

The Department of Applied Sciences at NTU is playing an important role in developing the future scientists, engineers and professionals for industry and academia. The department offers wide range of graduate and post-graduates programs including, MS Mathematics, MS Textile Chemistry, MS Physics, PhD Physics and PhD Chemistry. The teaching methodology and learning assessment is intense comprising of lectures, laboratory work, projects, group assignments, seminars, presentations, industrial tours. Apart from its fundamental role of offering the understanding of core subjects, the department is determined to assist and promote cross-disciplinary research involving areas such as textiles, polymers, advanced materials, and Business studies. The department at NTU maintains state of the art research facilities:

1. Chemistry research lab
2. Physics research Lab
3. Organic chemistry research lab
4. Inorganic Chemistry Research lab
5. Modeling and simulation Lab
6. Electrothechnic Lab

Our faculty members are actively involved in multi-disciplinary research partnering the national and international universities as well as industries. Our faculty members are regular in competing and earning funded research projects from Higher Education Commission of Pakistan and thus offers competitive scholarships to the successful students to pursue their education.

Along with offering technical skills, the department places substantial focus on inter-personal growth of students to transpire them into productive social entities. The department assists the functioning of numerous social and academic clubs including, Society of Physicists, Society of Mathematicians, Society of Chemists.

Following degree programs are offered by Department of Applied Sciences:

1. MS Mathematics
2. MS Physics
3. MS Textile Chemistry
4. PhD Chemistry
5. PhD Physics

1. MS MATHEMATICS

Our MS Mathematics program is designed to cultivate creative thinking and critical analysis habits. We empower students to use mathematics to generalize local ideas in different disciplines, focusing on the textile industry. By developing students' ability to formulate problems using the language of mathematics, we equip them with the mathematical techniques necessary to solve the indigenous issues faced by industries, businesses, and financial organizations.

The Department of Applied Sciences offers two years of MS Mathematics, comprising twenty-six credit hours of coursework and six credit hours of research work. The department can provide any course from the list of elective courses, ensuring that students have access to a wide range of resources and guidance. The summer semester will not be offered. Internal assessments include seminars, quizzes, and assignments of every student in each subject. At least one workshop per student per subject is compulsory. At least one impact-factor journal article should be under review at the time of thesis submission.

The main objective of this program is to create self-motivated mathematicians who can fulfill the demands of current challenging fields. This program would be based on applied research to prepare students for a professional research career to facilitate academic and commercial sectors. In addition, the program will provide a unique opportunity for graduates to strengthen their knowledge and work in scientific multi-disciplines. These researchers could also have the ability to help out with different industry-related problems through knowledge of mathematical modeling and scientific computational techniques. Especially in the textile industry, problems would be modeled and solved to reduce costs, flexibility, and high quality.

Program Educational Objectives (PEOs)

1. The graduates would offer mathematical interpretation of the scientific data resulting from variety of scientific phenomena.
2. The graduates would capably employ the variety of analytical tools in support of commercial and professional research circles.
3. The graduates would competently deliver existing knowledge in academic circles.

Program Learning Objectives (PLOs)

No.	Attributes	PLOs
1	Mathematics and Knowledge	An ability to apply knowledge of Mathematics to address the industrial and everyday life problems.
2	Problem Analysis and Reasoning	An ability to survey existing literature, identification of gaps, permissible solution of problems to substantiate conclusions.
3	Investigation Tools	An ability to interact with methodological and computational advancements facilitating the permissible solutions.
4	Mathematics and Society	An ability to demonstrate the applicability of mathematical rigors in modeling of complex social and health phenomena.
5	Dissemination	An ability to communicate effectively the outcomes of Mathematical pathways.
6	Project Execution	An ability to design and execute a research project as an independent researcher in a multidisciplinary environment.

Eligibility Criteria

1. MSc/BS in Pure Mathematics/Applied Mathematics/Computational Mathematics (minimum 16-year education) or equivalent degree with minimum CGPA 2.00/4.00 in semester system or 60% in annual system/term system from an HEC recognized institute/university.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.

3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.

4. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.

5. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit/Admission Process

Admission merit will be prepared according to the following criteria:

BS/MSc or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Semester Wise Layout of Courses

Semester-I

Sr. No.	Code	Course Title	Credit Hours
1	MA-5002	Advanced Numerical Analysis	3 (3,0)
2	MA-5003	Advanced Partial Differential Equations	3 (3,0)
3	MA-5004	Fluid Mechanics	3 (3, 0)
4	MA-5025	Fractional Calculus	3 (3, 0)
	Total		12

Semester-II

Sr. No.	Code	Course Title	Credit Hours
1	MA-5006	Integral Transform	3 (3,0)
2	MA-5007	Numerical Solutions of Partial Differential Equations	3 (3,0)
3	MA-5009	Viscous Fluid Flow	3 (3, 0)
4	MA-5030	Mathematical Modeling	3 (3, 0)
5	TEX-5078	Functional Textile	2(2, 0)
	Total		14

Semester III and IV

Sr. No.	Code	Course Title	Credit Hours
1	MA-5090	Thesis	6(3+3)
	Total Credit Hours		32

LIST OF ELECTIVE COURSES

Sr. No.	Code	Course Title	Credit Hours
1	MA-5005	Advanced Graph Theory	3 (3, 0)
2	MA-5006	Integral Transform	3 (3,0)
3	MA-5007	Numerical Solutions of Partial Differential Equations	3 (3,0)
4	MA-5008	Compressible Fluid Flow	3 (3, 0)
5	MA-5009	Viscous Fluid Flow	3 (3, 0)
6	RM-5011	Research Methodology	3 (3, 0)
7	MA-5030	Mathematical Modeling	3 (3, 0)

Course Specifications

MA-5002: Advanced Numerical Analysis

Euler's method, Improved and Modified Euler's Method, Runge-Kutta Method, Milne's Method, Hamming's Methods, Initial Value Problem, Special Cases when First Derivative Missing, Boundary Value Problems, Simultaneous Algebraic Equations Method, Iterative Methods for Linear Equations, Gauss-Siedel Method, Relaxation Methods, Vector and Matrix Norms, Sequences and Series of Matrices, Graph Theory, Directed Graph of A Matrix, Strongly Connected and Irreducible Matrices, Grerschgoin Theorem, Symmetric and Positive Definite Matrices, Cyclic-Consistently Ordered Matrices, Choice of Optimum Value for Relaxation Parameter.

Recommended Books:

1. A. Iserles, A first course in the Numerical Analysis of Differential Equations, Cambridge text in Applied Mathematics.
2. J. H. Mathews and K.D. Fink, Numerical Methods using MATLAB, Prentice-Hall, Latest Edition.
3. M. K. Jain, S. R. K. I. Yengar, R.K. Jain, Numerical methods for scientific and Engineering computations, New Age International (P), Ltd., latest Edition.
4. W. Bohem and H. Prautzsch, Numerical Methods, A K Peters, Ltd., latest edition.

MA-5003: Advanced Partial Differential Equations

Cauchy's Problems for Linear Second Order Equations in N-Independent Variables, Cauchy Kowalewski Theorem, Characteristics Surfaces, Adjoint Operations, Bicharacteristics Spherical, and Cylindrical Waves, Heat Equation, Wave Equation, Laplace Equation, Maximum-Minimum Principle, Integral Transforms.

Recommended Books:

1. G .B. Whitham, Linear and Nonlinear Waves, New York, NY: Wiley, latest edition.
2. J. Kevorkian, Partial Differential Equations: Analytical Solution Techniques. Texts in Applied Mathematics, vol. 35. 2nd ed. New York, NY: Springer, latest edition.
3. E. J. Hinch, Perturbation Methods. Cambridge Texts in Applied Mathematics. Cambridge, UK: Cambridge University Press, latest edition.
4. R. B. Guenther, and W. John, Partial Differential Equations of Mathematical Physics and Integral Equations. New York, NY: Dover Publications, latest edition.

MA-5004: Fluid Mechanics

Navier-Stokes Equation and Exact Solutions, Dynamical Similarity and Reynold's Number, Turbulent Flow, Boundary-Layer Concept and Governing Equations, Laminar Flat Plate, Boundary Layer, Exact Solution, Momentum, Integral Equation, Use of Momentum Integral Equation for Flow with Zero Pressure Gradient, Pressure Gradient in Boundary-Layer Flow, Reynold's Equations of Turbulent Motion, Magnetohydrodynamics, MHD Equations, Fluid Drifts, Stability and Equilibrium Problems.

Recommended Books:

1. F. M. White. Viscous fluid flow. McGraw-Hill latest edition.
2. C. T. Crowe, D. F. Elger, B. C. Williams, and J. A. Roberson, Engineering fluid mechanics, latest edition, John Wiley & Sons.
3. Y. Munson and H. J. Okiishi, Fundamentals of fluid mechanics, J. Wiley & Sons latest edition.
4. G. K. Batchelor, An introduction to fluid dynamics. Cambridge University Press latest edition.
5. A. J. Raudkivi, R. A. Callander, Advanced fluid mechanics: An Introduction, John Wiley & Sons.
6. R. L. Daugherty, J. B. Franzini, and E. J. Finnemore, Fluid mechanics with engineering application. McGraw-Hill latest edition.

MA-5005: Advanced Graph Theory

Fundamentals of Graph Theory, Paths, Cycles, Trees, Hamilton Cycles, Euler Circuits, Planer Graphs, Flows, Connectivity, Matching Network Flows, Connectivity and Menger's theorem, External Problems, Paths, and Complete Subgraphs, Hamilton Path and Cycles, Coloring, Vertex Coloring, Edge Coloring, Graphs on Surfaces.

Recommended Books:

1. D. B. West, Introduction to Graph Theory, Prentice-Hall, latest edition.
2. J. Kleinberg and E. Tardos, Algorithm Design, Addison-Wesley, latest edition.
3. J. A. Bondy and U. S. R. Murty, Graph Theory, Springer, latest edition.
4. R. Diestel, Graph Theory, Springer latest edition.
5. F. Harary, Graph Theory, Narosa, latest edition.
6. C. Berge, Graphs and Hypergraphs, North-Holland/Elsevier, latest edition.

MA-5006: Integral Transform

Laplace Transform, Applications to Integral Equations, Fourier Transforms, Fourier Sine and Cosine Transform, Inverse Transform, Applications to Differentiation, Convolutions Theorem, Applications to Partial Differential Equations, Hankel Transform and Its Applications, Applications to Integration, Mellin Transform and its Applications.

Recommended Books:

1. S. Howison, Practical Applied Mathematics latest edition.
2. P. J. Collins, Differential and Integral Equations latest edition.
3. W. E. Boyce & R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems.
4. K. F. Riley & M. P. Hobson, Essential Mathematical Methods for the Physical Sciences, latest edition.
5. H. A. Priestley, Introduction to Complex Analysis latest edition.
6. L. Debnath & P. Mikusinski, Introduction to Hilbert Spaces with Applications, latest edition.

MA-5007: Numerical Solutions of Partial Differential Equations

Boundary and Initial Conditions, Polynomial Approximations in Higher Dimensions, Finite Element Method, Galerkin Method in One and More Dimensions, Error Bound on Galerkin Method, The Method of Collocation, Error Bounds on The Collocation Method.

Recommended Books:

1. L. Burden and J. D. Faires, Numerical Analysis, 7th ed. Brooks/Cole, latest edition.
2. U. M. Ascher and L. R. Petzold, Computer Methods for Ordinary Differential Equations and Differential Algebraic Equations, SIAM, latest edition.
3. L. F. Shampine, I. Gladwell, and S. Thompson, Solving ODEs with Matlab, Cambridge, latest edition.
4. J .D. Lambert, Numerical Methods for Ordinary Differential Systems , Wiley, latest edition.
5. R. Leveque, Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems, SIAM, latest edition.
6. J. C. Strikwerda, Finite Difference Schemes and Partial Differential Equations, SIAM, latest edition.
7. K. W. Morton and D. F. Mayers, Numerical Solution of Partial Differential Equations, Cambridge, latest edi tion.

MA-5008: Compressible Fluid Flow

Introduction to inviscid compressible flow, Concepts of thermodynamics, Types of processes, Second law of thermodynamics, Energy equation, Stream function for steady compressible flow, Velocity of sound, Mach number, Types of compressible flows, Distinction between Subsonic and Supersonic flows, Isentropic and non-isentropic inviscid compressible flow, Flow-through varying-area ducts, Normal shock waves, Prandtl relation, Fanno flow, Rayleigh flow, the Hodograph method, Introduction to viscous compressible flow, Navier-Stokes equations for a viscous compressible flow, Energy equation for a viscous compressible flow, Basic equations for three-dimensional viscous compressible flow, Exact solutions of Navier-Stokes equations for a viscous compressible flow, Boundary layer equation for two-dimensional viscous compressible flow, Momental Integral equation.

Recommended Books:

1. J. D. Anderson, Modern Compressible Flow, 3rd edition, McGraw Hill, latest edition
2. J. D. Anderson, Modern Compressible Flow with Historical Perspective, McGraw-Hill, Inc: New York, latest edition.
3. F. M. White, Viscous fluid flow, McGraw-Hill latest edition.
4. C. T. Crowe, D. F. Elger, B. C. Williams, and J. A. Roberson, Engineering fluid mechanics, latest edition, John Wiley & Sons.
5. Y. Munson and H. J. Okiishi, Fundamentals of fluid mechanics, J. Wiley & Sons latest edition.

MA-5009: Viscous Fluid Flow

Some examples of viscous flow phenomena, properties of fluids, boundary conditions, equation of continuity, the Navier-Stokes' equations, the energy equation; boundary conditions, orthogonal coordinate system, dimensionless parameters, velocity considerations, two-dimensional considerations, and the stream functions, Couette flows, Poissillee flow, unsteady duct flows, similarity solutions, some exact analytic solution from the paper, introduction to laminar boundary layers equations, similarity solutions, two-dimensional solutions, thermal boundary layer, some exposure will also be given from the recent literature appearing in the journals.

Recommended Books:

1. F. M. White, Viscous fluid flow, McGraw-Hill, latest edition.
2. P. K. Kundu, Fluid mechanics. Academic Press latest edition.
3. H. Ockendon, Viscous flow. Cambridge University Press latest edition.
4. G. K. Batchelor, An introduction to fluid dynamics Cambridge University Press, latest edition.
5. Y. Munson and H. J. Okiishi, Fundamentals of fluid mechanics, J. Wiley & Sons latest edition.

RM-5011: Research Methodology

Scientific Statements, Hypothesis, Model, Theory and Law, Types of Research, Problem Definition, Objectives of Research, Research Design, Data Collection, Data Analysis, Interpretation of Results, Validation of Results, Literature Search, Formal Research Proposal, Budgeting and Funding, Sampling, Systematic Sampling, Stratified Sampling, Cluster Sampling, Convenience Sampling, Judgment Sampling, Quota Sampling, Snow Ball Sampling, Identifying Variables of Interest and their Interactions, Operating Characteristic Curves, Power Curves, Surveys and Field Trials, Submission of a Paper, Role of Editor, Peer-Review Process, Importance of Citations, Impact Factor, Plagiarism, Protection of Research Work from Misuse.

Recommended Books:

1. Dr. R. Kumar Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, Sage Publica tions latest edition.
2. M. J. Anderson, Doe Simplified 2E: Practical Tools for Effective Experimentation, 2nd Edition, Produc tivity Press, latest edition.
3. M. J Anderson and P. J. Whitcomb, RSM Simplified: Optimizing Processes Using Response Surface Methods for Design of Experiments, Productivity Press, latest edition.

MA-5025: Fractional Calculus

Introduction to fractional calculus, historical development, motivation for studying fractional calculus, special functions, definition and properties of fractional derivatives and integrals, Grunwald-Letnikov operators, Riemann-Liouville and Caputo derivatives, basic rules and applications, introduction to fractional differential equations, linear and nonlinear fractional differential equations, initial and boundary value problems, existence and uniqueness of solutions, fractional integral equations, formulation and classification, solution techniques, numerical methods, fractional Laplace transform, definition and properties, inverse Laplace transform, applications in solving fractional differential equations, existence and uniqueness theorem for initial value problems, the Adomian decomposition method, decomposition of nonlinear equations, perturbation method, fractional systems of differential equations, linear and nonlinear systems, power series, Lane-Emden equation, Taylor series method, variational iteration method for fractional differential equations, least squares method, Galerkin method, Euler's method, Runge–Kutta methods for fractional differential equations, second-order and fourth-order Runge–Kutta methods, more general systems, vectorial Runge–Kutta algorithm, applications in various fields, and engineering applications.

Recommended Books:

1. Oldham, K. B., & Spanier, J. The *Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order.* Academic Press. Latest Edition
2. Podlubny, I. (1999). *Fractional Differential Equations.* Academic Press.
3. Kilbas, A. A., Srivastava, H. M., & Trujillo, J. J. (2006). *Theory and Applications of Fractional Differential Equations.* Elsevier.
4. Mainardi, F. (2010). *Fractional Calculus and Waves in Linear Viscoelasticity: An Introduction to Mathematical Models.* World Scientific.
5. Magin, R. L. (2006). *Fractional Calculus in Bioengineering.* Begell House.
6. Diethelm, K. (2010). *The Analysis of Fractional Differential Equations: An Application-Oriented Exposition Using Differential Operators of Caputo Type.* Springer.
7. Herrmann, R. (2014). *Fractional Calculus: An Introduction for Physicists.* World Scientific Publishing Company.

MA-5030: Mathematical Modeling

Overview of mathematical modeling concepts, importance in solving real-world problems, and interdisciplinary applications, types of models, discrete vs. continuous models, deterministic vs. stochastic models, and empirical vs. theoretical models, formulation of mathematical models, identifying key variables and parameters, making assumptions, setting up equations, and simplifying complex systems, dimensional analysis and scaling, principles of dimensional analysis, Buckingham Pi theorem, nondimensionalization, and scaling laws, model analysis and validation, analytical solutions, qualitative analysis, parameter estimation, model validation, and verification techniques, optimization techniques, linear and nonlinear optimization, constrained and unconstrained optimization, and applications in decision-making, numerical methods in modeling, finite difference methods, finite element methods, and computational techniques for solving differential equations, case studies in engineering and applied sciences, modeling fluid dynamics in composite microchannels, thermodynamics in biomedical devices, and heat transfer in oscillatory environments, stability and sensitivity analysis, stability of solutions, sensitivity to initial conditions, and impact of parameter variations, simulation and software tools, introduction to MATLAB, Mathematica, and other software for numerical simulations and data visualization, applications in physics and engineering, modeling heat conduction, fluid flow, and other physical processes; optimization in aerospace and automotive industries, advanced topics, fractional calculus in modeling complex systems, entropy production in thermodynamic systems, and multi-scale modeling techniques.

Recommended Books:

1. A. C. Fowler, *Mathematical Models in the Applied Sciences*, Cambridge University Press, 1997.
2. F. C. Hoppensteadt and C. S. Peskin, *Modeling and Simulation in Medicine and the Life Sciences*, Springer, 2002.
3. E. A. Bender, *An Introduction to Mathematical Modeling*, Dover Publications, 2000.
4. J. D. Murray, *Mathematical Biology I: An Introduction*, Springer, 2002.
5. A. Iserles, *A First Course in the Numerical Analysis of Differential Equations*, Cambridge University Press, 1996.

STAT-5031 Mathematical Statistics

Calculus of distributions, Exponential family of distribution, Moments, Moment generating functions, Characteristic functions, Marginal and Conditional distributions, Conditional expectation and Variance operators, Transformation of variable, Multivariate normal distribution, Convergence and Weak convergence in distribution, Law of large numbers and Weak law of large numbers, Central limit theorem, Hands-on training of simulation tool (MCMC).

Recommended Books:

1. R. V. Hogg, J. McKean and A. T. Craig. Introduction to Mathematical Statistics, 7th edition, Pearson. (2012).
2. J. A. Rice. Mathematical Statistics and Data Analysis, Duxbury Press (2017).
3. B. Efron. Exponential Families in Theory and Practice, Cambridge University Press. (2022).
4. D. Wackerly, W. Mendenhall and R. L. Scheaffer. Mathematical Statistics with Applications. 7th edition. Brooks/Cole CENGAGE Learning (2020).

TEX -5078: Functional Textile

Basics of textiles and raw materials, Preparatory processes of Spinning, Types of yarns and spinning, Mathematical Modeling regarding fiber and yarn properties, Woven Fabric Production, Knitted Fabric Production, Mathematical Modeling regarding fiber, yarn, and woven fabric properties, Mathematical Modeling regarding fiber, yarn, and knitted fabric properties, Nonwoven fabric formation, and operations, Introduction to textile processing, Pretreatment and dyeing of textiles, Printing, and finishing of textiles, Application of mathematical modeling in textile processing, Clothing Product design, and development, Clothing preparatory processes, Clothing manufacturing processes, Applications of mathematical modeling in clothing.

Recommended Books:

1. Y. Nawab, Textile Engineering an Introduction, 2016.
2. T. Gries, D. Veit and Burkhard, Textile Technology, latest edition.
3. B Neckar, Theory of structure and mechanics of fiber assemblies, latest edition.
4. O. Kyosev, Topology-Based Modeling of Textile Structures and Their Joint Assemblies: Principles, Al gorithms, and Limitations, 2018.

Carrier Opportunities for Students after Completion of the Program

Mathematics enhances the analytical skills that help in almost all disciplines of life. In addition, it helps in problem-solving, logical thinking, and decision-making skills. Thus, a mathematician can avail several opportunities in data sciences, artificial intelligence, and areas related to research and development in engineering and science. Jobs directly related to your degree include:

1. Research scientist in strategic organizations
2. Teaching and research
3. Data scientist
4. Data analyst
5. Artificial Intelligence
6. Technical Programmer
7. Investment analyst
8. Astronomer
9. Computational Fluid Dynamics

2. MS PHYSICS

A physics master's degree that solidifies your understanding of the core aspects of physics in both research and technical skills as you study areas of physics that support your career interests. NTU offers both research and professional options and provides advanced knowledge in core areas of physics, including advanced electrodynamics, Thin films nanoscience and deposition techniques, material physics, and magnetic materials, as well as one or more sub-areas of physics that correspond to your interests and career aspirations. The MS program in physics is designed to provide flexible options that can be tailored to the specific career goals and disciplinary interests of students seeking graduate training in fundamental and applied areas of physics. The program is suitable as either a means to further career development or as preparation for further post-graduation. Nationally, graduates of the program are in demand across all economic sectors, spanning a wide variety of exciting opportunities within the private sector, government labs, and at the university level and in higher education.

The MS Physics Program will provide students with a broad understanding of the physical principles of the universe, helping them develop critical thinking and quantitative reasoning skills, and empowering them to think creatively and critically about scientific problems and experiments. To further enhance their research capabilities, students will have access to advanced data analysis tools and methodologies, enabling them to work with large datasets, perform complex simulations, and extract meaningful insights from experimental data. The program also emphasizes the importance of data integrity and statistical rigor, ensuring that all research conducted is of the highest quality and adheres to the latest standards in scientific research.

In addition, students will gain experience in experimental and computational techniques, which are essential in modern physics research. These skills will be invaluable whether they pursue careers in academia, industry, or government, as they will be well-equipped to handle the increasingly data-driven nature of these fields. The program's comprehensive approach ensures that graduates are not only proficient in the theoretical aspects of physics but also in the practical application of data in solving real-world problems.

Program Educational Objectives (PEOs)

The educational objectives of the MS Physics program are:

1. The graduates would interpret the scientific data resulting from variety of physical phenomena.
2. The graduates would be capably utilize the variety of experimental and analytical techniques supporting the commercial and professional research circles.
3. The graduates would competently deliver existing knowledge in academic circles.

Program Learning Objectives (PLOs)

No.	Attributes	PLOs
1	Physics and Knowledge	An ability to apply knowledge of Physics to address the industrial and everyday life problems.
2	Problem Analysis and Reasoning	An ability to survey existing literature, identification of gaps, permissible solution of problems to substantiate conclusions.
3	Investigation Tools	An ability to interact with methodological, experimental and computational advancements facilitating the permissible solutions.
4	Physics and Environment	An ability to demonstrate the applicability of physical rigors in developing ecofriendly products.
5	Dissemination	An ability to communicate effectively the outcomes of Physical pathways.
6	Project Execution	An ability to design and execute a research project as an independent researcher in a multidisciplinary environment.

Eligibility Criteria

1. BS / MSc. in Physics (minimum 16 years of education) or equivalent degree with a minimum CGPA of 2.00/4.00 in semester system or 60% in annual system / Term system from an HEC recognized institute / University.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.

5. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.

6. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.

7. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.

8. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit Criteria

Admission merit will be prepared according to the following criteria:

BS/MSc. or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Semester Wise Layout of Courses

Semester-I

Sr.No	Code	Course Title	Credit Hours
1	PH-5001	Methods of Mathematical Physics	3(3-0)
2	PH-5002	Material Physics	3(3-0)
3	PH-5003	Advanced Electrodynamics	3(3-0)
4	PH-5004	Nanoscience and Techniques	3(3-0)
		Total	12

Semester-II

Sr.No	Code	Course Title	Credit Hours
1	PH-5005	Methods and Techniques of Experimental Physics	3(3-0)
2	TEX-5078	Functional Textile	2(2-0)
3	PH-XXXX	Elective-I	3(3-0)
4	PH-XXXX	Elective -II	3(3-0)
5	PH-XXXX	Elective – III	3(3-0)
		Total	14

Semester-III & IV

Sr.No	Code	Course Title	Credit Hours
1	PH-5090	MS Thesis	6
		Total Credit Hours	32

LIST OF ELECTIVE OFFERED COURSES

Sr.No	Code	Course Title	Credit Hours
1	PH-5006	Magnetism and Magnetic Materials	3(3-0)
2	PH-5007	Advanced Plasma Physics	3(3-0)
3	PH-5008	Superconductivity and its Applications	3(3-0)
4	PH-5009	Optoelectronics	3(3-0)
5	RM-5010	Research Methodology	3(3-0)

Course Specifications

PH-5001: Methods of Mathematical Physics

Fourier series: Introduction and general properties, the convergence of trigonometric series, Integral transform development of the Fourier integral, Fourier transform, inversion theorems, Fourier transform of derivatives, Laplace transforms, Laplace transform of derivatives, inverse Laplace transform. Differential equations: Separation of variables in three dimensions, Boundary value problems, Green's functions, Integral transforms, generating functions, and integral equations. Calculus of variations: dependent and independent variables, Euler-Lagrange equation and applications, several independent and dependent variables, Diffusion equation, Heat Equations, Wave equations, some nonlinear equations, Klein-Gordon equation, sine-Gordon equation Burgers equation, Backlund transformation, Tensor and vector fields, Differential geometric methods.

Recommended Books:

1. Alexander, *Mathematics for Physicists Introductory Concepts and Methods*, Cambridge University Press
2. Arfken & Weber, Mathematical Methods for Physicists, Academic Press, 6th edition.
3. Tai L. Chow, Mathematical Methods for Physicists, Cambridge University Press, latest edition.
4. G. B. Arfken and H. J. Weber, Mathematical Methods for Physicists, Academic Press, New York latest edi tion.
5. G. Stephenson and P. M. Radmore, Advanced Mathematical Methods for Engineering and Science Stu dents, Cambridge University Press latest edition.

PH-5002: Material Physics

Bonding in Elemental Materials Covalent, Metallic and van der Waals Bonding), Bonding in Multielement Materials (Ionic, Mixed Ionic-Covalent Bonding, Hydrogen Bonding), Effects of Nature of Bonding on Materials Properties. Basic Structural and Symmetry Concepts, Concept of Diffraction in a Periodic Lattice, Structural Information from X-ray Diffraction, and other Diffraction Techniques. Crystal Structures of Metals and Ceramic Materials. Point Defects (vacancies, interstitials, impurities, F-centers) and their stability Line and Extended Defects (Dislocations, Grain Boundaries, Stacking Faults, Interfacial, Surface and Volumetric Defects). Effect of Defects on the Properties of Materials.: Amorphous Materials / Glasses (Glass formation, Glass Transition, and Crystallization of Glasses, Various Glass Forming Systems). Random Closed Packing in Metallic Glasses, Continuous Random Network in Covalent Glasses. Basic Concepts, Equilibrium Phase Diagrams, Phase Transformations – Basic Concepts, Kinetics, Metastable versus Stable Transformations, Microstructure Development, Precipitation, and Dispersion Hardening, Multi-Component and Multi-Phase Systems, Alloys, Equilibrium Structures, Phase Separation.

Recommended Books:

1. WD Callister & DG Rethwisch, *Materials Science and Engineering*, latest edition.
2. J.I. Gersten and F. W. Smith, The Chemistry of Materials, publisher John Wiley& Sons Inc, latest edition.
3. M.W. Barsoum, Fundamentals of Ceramics, IOP Publishing Ltd, latest edition.
4. Richard Zallen, Theory of Amorphous Solids, publisher John Wiley & Sons Inc, latest edition.
5. D.I. Bower, An Introduction to Polymer, publisher Cambridge University Press, Cambridge latest edition.

PH-5003: Advanced Electrodynamics

Electric field due to a dipole, Electric potential due to a dipole, potential energy of a dipole in an external electric field. The mutual interaction energy of two dipoles, Force and couple on the dipole placed in an external electric field, multiple expansion of the electric field. Polarization and polarization density vector, Surface and volume charge density due to the polarization of dielectric, The electric field outside and inside of a dielectric medium. Gauss's law in dielectric and electric displacement vector, electric susceptibility, Boundary conditions on field vectors for two media. Boundary value problems involving dielectrics, Solution of Laplace equation Microscopic theory of dielectrics: Molecular field in a dielectric. Ferroelectricity, Steady current in a continuous media, approach to electrostatic equilibrium of a conductor. magnetic properties of matter, magnetization, the magnetic field produced by magnetized material, magnetic susceptibility, and permeability. Magnetic boundary conditions on field vectors, the molecular field inside matter, the origin of diamagnetism. Origin of Paramagnetism, Theory of ferromagnetism, ferromagnetic domains, ferrites. Magnetic scalar potential, magnetic vector potential, the magnetic field of a distant circuit. Electromagnetic induction, Physical significance of Maxwell's equations, Maxwell's equations, and their empirical basis. Electromagnetic field energy, the wave equation, Generalized amperes law, scalar, and vector potentials and gauge transformations, wave equations for scalar and vector potential retarded scalar, and vector potential. Boundary conditions of electromagnetic waves propagation of electromagnetic waves, plane monochromatic waves in non-conducting media, polarization, plane monochromatic waves in conducting media. Reflection and refraction at the boundary of two non-conducting media, reflection and refraction at the boundary of two conducting media. Radiation from an oscillating dipole, radiation from the half-wave antenna and their applications, Design, and Simulation of a dipole antenna, Patch antenna and horn antenna, and EMI shielding.

Recommended Books:

1. J.D. Jackson. John, Classical Electrodynamics, Wiley latest edition.
2. J.B. Marion and M.A. Heald, Classical Electromagnetic Radiation, Thomson Brooks, latest edition.
3. Reitz, Milford and Christy, Foundation of Electromagnetic theorey, latest edition.

PH-5004: Nanoscience and Techniques

Introduction to Nanoscience and Nanotechnology. Difference between bulk and nanomaterial. Nanoparticle (Origin, Chemical composition, Shape, Surface modification, aggregation state, Nanoparticles in nature. There is plenty of space at the bottom: Introduction to properties on nanoparticles (Size, Reactivity, Surface area to volume ratio, Magnetism). Nanoparticles at different size levels. Size-dependent properties of nanoparticles: Nanoparticles in different dimensions, Top-down approach, bottom-up approach. Surface to volume ratio, Quantum confinement. Magnetic properties of nanoparticles: Magnetic dipoles, Magnetic fields, Magnetic forces/units. Super para-magnetism, Magnetic moment. Thermal Properties of Nanomaterials: Melting point of nanomaterials, Cohesive energy, Cohesive energy for ideal case, Cohesive energy for bulk material, Surface area of magnetic nanoparticles, Shape factor, Cohesive energy of the metallic crystal. Calculation of Cohesive energy of solids & melting temperature of bulk matter. Optical properties of nanoparticles: Optical properties of metal, Optical properties of non-metal, Localized surface plasmonic resonance (LSPR) in metals. Mechanical properties of Nanomaterials: Strength, Yield Strength, Tensile strength, Ductility, Toughness. Elongations, Elastic Deformation, Tensile test Curve. Hall-Patch Relationship. Hall Patch strengthening limits. Synthesis of Nanomaterials: Bottom-up and top-down approaches and the synthesis methods in these two approaches. Composite materials

Recommended Books:

1. L. Wolf Edward, Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience WILEY-VCH.
2. Gabor L. Hornyak, Introduction to Nanoscience, ISBN-13: 978-1420048056.
3. Alain Nouailhat, An Introduction to Nanoscience and Nanotechnology, ISTE Ltd, latest edition.
4. Challa S, S. R. Kumar, Nanomaterial Toxicity, Health, and Environmental Issues, latest edition.
5. Daniel L. Schodek, Paulo Ferre, Nanomaterials, Nanotechnologies and Design" An Introduction for Engi neers, latest edition.

PH-5005: Methods and Techniques of Experimental Physics

Basics of X-ray diffraction, X-ray spectra, Bragg's law and importance, construction and operation of diffractometer, data analysis, Qualitative (Hanawalt method), Quantitative (matrix flushing methods). Characterization techniques, Basics of spectroscopy and importance, Lambert-Beer's law, Construction and Operation of a spectrophotometer, Radiation detection (Detectors), Data analysis. Construction and Operation of Scanning Electron Microscope, Construction, and Operation of Atomic Force Microscope, Construction and Operation of Transmission Electron Microscope and sample preparation techniques. Vacuum techniques, Production of vacuum (Vacuum pumps), Measurements of vacuum (Gauges), Leak detection.

Recommended Books:

1. B.D. Cullity, Elements of X-ray Diffraction, Published by Addison-Wesley Publ. Co. Inch. USA, latest edition.
2. B.D. Cullity, Elements of X-ray Diffraction, Published by Addison-Wesley Publ. Co. Inch. USA latest edition.
3. R.L. Horovitz and V. A. Johnson, (Latest Edition), Methods of Experimental Techniques, Acadmic press.
4. D. William, (Latest Edition), Methods of Experimental Techniques, Academic press.
5. J. Goldstein, (2003), Scanning Electron Microscopy and X-Ray Microanalysis, 3rd edition, Springer London.

PH-5006: Magnetism and Magnetic Materials

Introductory magnetism**:** Review of diamagnetism and paramagnetism, Pauli paramagnetism. Wave functions of magnetic ions (3d, 4f), spin-orbit coupling, crystal field effects. Ferro and Antiferromagnetism**:** Basic Phenomenon, Mean Field Theory, Thermodynamics of ferromagnetic systems. Quantum mechanical treatment, Exchange interactions, Indirect exchange (superexchange). Spin excitations, spin waves, magnons, application to the temperature dependences on magnetization and specific heat. Band ferromagnetism. Criteria for band ferromagnetism, examples of metallic ferromagnets. Anti-Ferromagnetism: Basic phenomenon, Mean Field treatment. Types of Antiferromagnets, Parallel and perpendicular susceptibilities, Spin flop transition. Ferrites and Applications of ferrites. Domain Structures and related properties of ferromagnets: Magnetic Anisotropy, basic phenomenology. Uniaxial, Cubic, and surface Anisotropies. Magnetization in soft and hard magnets.

Recommended Books:

1. J. M. D. Coey, Magnetism and magnetic materials, Cambridge University Press, latest edition.
2. Stephen Blundell, Magnetism in Condensed Matter, Oxford Press, latest edition.
3. Amikam Aharoni, Introduction to the theory of Ferromagnetism, Oxford Press, latest edition.
4. R. Skomski and J. M. D. Coey, Permanent Magnetism, IOP Publishing, latest edition.
5. A.Ahmed. El-Gendy, José M. Barandiarán and Ravi L. Hadimani, Magnetic *Nanostructured Materials From Lab to* Fab: Elsevier.

PH-5007: Advanced Plasma Physics

Introduction to plasma, occurrence of plasmas in nature, concept of temperature, Debye shielding, criteria for plasmas, applications of plasma. Single particle motion, motion of charged particles in uniform E and B fields, motion of charged particles in non-uniform E and B fields, motion of charged particles in time varying E and B fields, adiabatic invariants. Plasmas as fluids, relation of plasma to ordinary electromagnetic, the fluid equation of motion, equation of continuity, the complete set of fluid equations, plasma approximations. Waves in plasmas, representation of waves, group velocity, plasma oscillations, electron plasma waves, sound waves, ion waves, validity of plasma approximation, comparison of ion wave and electron wave, electrostatic electron oscillations perpendicular to B, electrostatic ion waves perpendicular to B, the lower hybrid frequency, EM waves with Bo=0, EM waves perpendicular to Bo, cutoffs and resonances, EM waves parallel to Bo, hydro-magnetic waves, magneto-sonic waves, basic nuclear fusion reaction rates and power density, radiation losses from plasmas, operational conditions, Lawson criteria, magnetic confinement fusion, inertial confinement fusion.

Recommended Books:

1. J. A. Bittoncourt, Fundamentals of Plasma, third edition, Springer-Verlag, latest edition.
2. P.M. Bellan, Fundamentals of Plasma, Cambridge University Press, latest edition.
3. Francis F. Chen, Introduction to Plasma and controlled fusion, academic Press, latest edition.

4. Peter A. Sturrock, Fundamentals of Plasma, Cambridge University Press, latest edition.
5. R. O. Dendy, Plasma Dynamics, Clarendon Press – Oxford, latest edition.

PH-5008: Superconductivity and Applications

Historical review, the state of zero resistance, Meissner effect. Electrodynamics for zero resistance metals, the critical magnetic field, the London Theory (Review of magnetic field concepts, magnetic field units). Review of thermodynamics and the thermodynamical characterization of a metal in the superconducting state, the intermediate state, concept of coherence. Type I superconductors. Current transport in superconductors, second-order phase transitions & the Ginzburg-Landau calculation for magnetic flux penetration. Microscopic theory of superconductivity, concepts of the energy gap and Cooper pairs, introduction to the BCS theory, the superconducting ground state, long range order in solids. Identification of the BCS results with experimental determination of the critical field, critical temperature and the heat capacity; quantum interference, the fluxoid. The mixed state and type-II superconductors, concept of the vortex, critical fields; critical-state models of Beam and Kim et al, flux-flow resistivity; critical currents; flux pinning, creep and flow; thin films; two-fluid model, high frequency effects and microwave surface resistance. Normal and superconductive tunneling, quasiparticle tunneling, Josephson tunneling, the Ambegaokar - Baratoff critical current, weak-links, the SQUID. Superconducting materials; the A15-type compounds; the high T c ceramic superconductors, physical properties of high Tc materials - "the good and the bad"; new topics in superconductivity; novel superconductors; safety considerations.

Recommended Books:

1. F. Kristian, S. Asle, Superconductivity: Physics and Applications,WILEY, latest edition.
2. Nekane Guarrotxena Research Methodology in Physics and Chemistry of Surfaces and Inter faces latest Edition.
3. Cardwell David, S. Ginely David, Hand book of suprcondcuting materials CRC Press.

PH-5009: Optoelectronics

Wave propagation in isotropic media, lens wave guide, fundamental Gaussian Beam in a lens like medium, propagation in media with quadratic gain profile. Optical Resonator, theory of laser oscillation, electro optic modulation, optical detection, noise in optical detection. Propagation modulation and oscillation in optical dielectric wave guide.

Recommended Books:

1. John P. Dakin, B. Robert , *Handbook of Optoelectronics: Concepts, Devices, and Techniques*: CRC Press
2. Julian Silva, Optoelectronic devices, Techniques and applications latest edition.
3. Bob Tucker, Handbook of optical sensors latest edition.

RM-5010: Research Methodology

The process of scientific research: The scientific method, research planning; the scientific explanation and demarcation criteria, characteristics of factual sciences, scientific epistemology, technology as transformational knowledge, relations between science and technology, the researcher and the structure of the research teams. Ethical aspects of the research work: Scientific ethics, axiology and ethical values of science, ethics of the researcher, personal code of conduct, internal code of conduct, conduct guidelines, ethical standards of publication, scientific fraud and malpractice; study of historical and contemporary cases. Introduction to scientific policies: Typology of research projects, strategic plans and guidelines, research products: open access publications, patents, utility models, trade secret, etc.; training of researchers, preparation of research projects, monitoring and evaluation 60025 - Research methodology in physics processes. Communication techniques: Dissemination of results, technical and scientific documents, characteristics and quality indices of journals, English usage in academic contexts, structure of scientific documents, preparation of written documents (research articles, reports), computer tools, techniques of oral presentation and defense of research works, other formats (posters, flash presentations, etc.), skills for academic writing and speaking in English, online communication technologies, evaluation procedures.

Recommended Books:

1. M.S. Shanti, A.Shashi, *HANDBOOK OF RESEARCH METHODOLOGY*: EDUCREATION PUBLISHING.
2. Dr. R. Kumar Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, Sage Publications latest edition.
3. M. J. Anderson, Doe Simplified 2E: Practical Tools for Effective Experimentation, 2nd Edition, Productivity Press, latest edition.
4. M. J Anderson and P. J. Whitcomb, RSM Simplified: Optimizing Processes Using Response Surface Methods for Design of Experiments, Productivity Press, latest edition.

TEX-5078: Functional Textile

Basics of textiles and raw materials, Preparatory processes of Spinning, Types of yams and spinning, Mathematical Modeling regarding fiber and yam properties, Woven Fabric Production, Knitted Fabric Production, Mathematical Modeling regarding fiber, yarn, and woven fabric properties, Mathematical Modeling regarding fiber, yam and knitted fabric properties, Nonwoven fabric formation and operations, Introduction to textile processing, Pretreatment and dyeing of textiles, Printing and finishing of textiles, Application of mathematical modelling in textile processing, Clothing Product design and development, Clothing preparatory processes. Clothing manufacturing processes, Applications of mathematical modeling in clothing.

Recommended Books:

1. Y. Nawab, Textile Engineering an Introduction, latest edition.
2. T. Gries, D. Veit and Burkhard, Textile Technology, latest edition.
3. B Neckar, Theory of structure and mechanics of fiber assemblies, latest edition.
4. O. Kyosev, Topology-Based Modeling of Textile Structures and Their Joint Assemblies: Principles, Algorithms and Limitations, 2018.
5. Majumdar, Abhijit, Gupta, Deepti, Gupta, Sanjay, Functional *Textiles and Clothing:* Springer

Career Opportunities for Students after Completion of the Degree Program

MS-physics degree program aims to train the professionals to design and conduct the experiments and analyze and interpret data to meet desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, sustainability, and ability to function on multi-disciplinary industry/ teams. The MS Physicist would be able to get a good job in the diverse fields, some of them include:

1. Teaching and research at university/post-graduate college level.
2. Research and Development in public and private sector organizations.
3. Product development in public and private sector organizations and industries.
4. Higher studies and research in Physics and the relevant fields.

3. MS TEXTILE CHEMISTRY

The MS Textile Chemistry is 2-years regular and extendable up to 4-years, degree program aimed to produce the graduates having the ability to understand the chemistry knowledge and literature supporting the textiles and interpret the scientific data, obtained through appropriate analytical tools, and demonstrate the learning and research outcomes in effective ways.

Program Educational Objectives (PEOs)

1 The graduates would be able to extract and interpret the scientific data from certain designed textile chemistry phenomena.

2 The graduates would be able to use various experimental and analytical techniques in strengthening the research activities in their professional circles.

3 The graduates would be able to communicate their knowledge and research in textile chemistry at appropriate forums.

Program Learning Outcomes (PLOs)

No.	Attributes	PLOs
1	Communication and Knowledge	An ability to apply knowledge of Chemistry to address industrial and everyday life problems with a prime focus on textile industry.
2	Problem Analysis and Reasoning	An ability to survey existing literature, identification of gaps, permissible solution of problems to substantiate conclusions.
3	Investigation Tools	An ability to interact with methodological, experimental and computational advancements facilitating the permissible solutions.
4	Chemistry and Environment	An ability to demonstrate the application and development of eco-friendly and economically feasible textile auxiliaries and products.
5	Dissemination	An ability to communicate effectively the outcomes of scientific pathways.
6	Project Execution	An ability to design and execute a research project as an independent researcher in a multidisciplinary environment.

Eligibility Criteria

1. BS/BE or equivalent degree in Chemistry/Applied Chemistry/Industrial Chemistry/Textile Chemistry/ Forensic Chemistry/Polymer Science and Engineering/Material Science and Engineering/Environmental Science and Engineering/Nanotechnology/Chemical Technology and Engineering/Textile Processing/ Textile Technology or equivalent degree with a minimum CGPA of 2.00/4.00 in semester system or 60% in annual system/term system from an HEC recognized institute/university.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit Criteria

Admission merit will be prepared according to the following criteria:

BS/BE or Equivalent	60% weightage
NTU-GAT (General)	30% weightage
Interview	10% weightage

Semester Wise Layout of Courses

Semester-I

Sr. No.	Code	Course Title	Credit Hours
1	TP-5001	Chemistry of Dyes and Pigments	3(2,1)
2	TP-5002	Chemistry of Fibrous Polymers	2(2,0)
3	TP-5003	Surface Chemistry	2(2,0)
4	TP-5004	Textile Auxiliaries	2(2,0)
5	TP-5005	Advanced Analytical Techniques	3(2,1)
		Total	12

Semester-II

Sr. No.	Code	Course Title	Credit Hours
1	TP-5006	Coloration of Textiles	4(3,1)
2	TP-5007	Functionalization of Textiles	4(3,1)
3	TP-5008	Sustainability in Textiles	2(2,0)
4	TP-5009	Research Methodology	2(2,0)
		Total	12

Semester-III & IV

Sr. No.	Code	Course Title	Credit Hours
1	TP-6071	Research Thesis	6
		Total Credit Hours	30

Course Specifications

TP-5001: Chemistry of Dyes and Pigments

The overall objective of this course is to give students the general description of dyes & pigments, chemistry of dyes & pigments and their synthesis on lab scale as well as on industrial scale. The students will learn the nomenclature of dyes, different chromophoric system, classification of dyes according to their chemical structure, classification of dyes based on their applications. The students will also learn the chemistry and synthesis of different types of organic, inorganic pigments and advance pigments like thermochromics and photochromic pigments. This course will also cover the synthesis and application of novel dyes with added functionality to impart UV-absorbent, antimicrobial and water repellency characteristics to the textiles.

Recommended Books:

1. The Chemistry and Application of Dyes by D. R. Waring and G. Hallas latest edition.
2. Chemistry of dyes and principles of dyeing by Shenai latest edition.
3. Colorants and Auxiliaries, Volume I & II by John Shore latest edition.
4. Handbook of Synthetic Dyes and Pigments, Volume I & II by K.M. Shah latest edition.

TP-5002: Chemistry of Fibrous Polymers

Introduction: chemical structure of natural and synthetic fibrous polymers, general polymer structures and properties (molecular size, molecular shape, intermolecular order, molecular flexibility. Fibre formation: Introduction to the types of spinning processes such as wet spinning, melt spinning, dry spinning, jet spinning. Fibre structure formation during the process of extrusion. The role of temperature, extruding speed and winding speed on the structural properties of fibres. Polyesters: Synthesis of polyesters and relation between chemical structure and properties. Polyamides: Composition and basic chemistry of polyamides, polymer chain structure, process-structure-property relationship, polyamide fibre products. Polyaramids: General characteristics of polyaramids, synthesis of ingredients for polymerization, polymerization fundamentals, fibre formation, structure-property relationship and applications, Polyolefins: Polymerization fundamentals of polyolefeins, structure-property relationship and applications, Chemical structure of carbon fibres, synthesis, polymerization, structure-properties relationship, products, applications, Monomer synthesis of polyacrylonitriles, polymerization, spinning processes, structure-properties relationship, products, applications.

Recommended Books:

1. Handbook of fibre chemistry by Menachem Lewin, 3rd Edition, CRC Press.
2. Processes of fibre formation by Zbigniew K. Walczak, Amsterdam; New York: Elsevier.
3. High performance fibres by J. W. S. Hearle, Woodhead Publishing.

TP-5003: Surface Chemistry

Introduction to surface chemistry, Capillary forces and capillarity; Laplace equation, Surface and interfacial tension phenomena and their measurement methods; Critical micelle concentration: significance and measurement; Surfactants: types, properties and applications; Adsorption and desorption on solid surfaces; Gibb's adsorption equation; Contact angle - significance and measurement; Surface wettability, Cleaning processes – detergency; Water repellency of surfaces; Young's Equation; Electrical aspects of surface chemistry: Electrical double layer; Stern's double layer phenomena; Zeta potential; Electrophoresis;, Electroosmosis; Colloids: formation, characterization and stability; Surface charge and its origin on colloidal surfaces, DLVO theory of colloidal stability; Coagulation and flocculation of colloids; Emulsification phenomena, Emulsion types: Oil-in-water emulsions, water-in-oil emulsions; Emulsion formation and stability; Hydrophilic-lyophilic balance; Orientation of molecules at oil-water interface; and Emulsion technology. Surface and colloidal phenomena taking place in textile processing.

Recommended Books:

1. Surface Chemistry Essentials by K. S. Birdi, CRC Press, latest edition
2. An Introduction to Interfaces & Colloids: The Bridge to Nanoscience, by John C. Berg, World Scientific latest edition.
3. Physical Chemistry of Surfaces by Arthur W. Adamson & Alice P. Gast, Wiley-Interscience latest edition.

TP-5004: Textile Auxiliaries

This course focuses on the chemistry and mechanism of reactions of various auxiliaries used in textile industry. These auxiliaries include sizing and desizing agents, detergents, surfactants, scouring agents, bleaching agents, dyeing auxiliaries, printing chemicals and finishing agents. The students will acquire from fundamental to advanced knowledge of these textile chemical agents and their impact on environment.

Recommended books:

1. Colorants & Auxiliaries Vol. 1 by John Shore, Society of Dyers and Colourists latest edition.
2. Colorants & Auxiliaries Vol. 2 by John Shore, Society of Dyers and Colourists latest edition.
3. Handbook on Textile Auxiliaries, Dyes and Dyes Intermediates by NPSC Board of Consultants & Engineers, Asia Pacific Business Press Inc.

TP-5005: Advanced Analytical Techniques

Introduction to different physical, chemical and mechanical characterization techniques, including XRD, SEM, TEM, NMR spectroscopy, Infrared spectroscopy, UV/Vis. spectroscopy, Mass spectroscopy, tensile testing, impact testing, bending, shear and hardness testing. The student will also learn the use of differential scanning calorimetry and zeta sizer to measure zeta potential of different textiles.

Recommended Books:

1. Materials Characterization Techniques. By Sam Zhang, Lin Li and Ashok Kumar latest edition.
2. Modern Spectroscopy, Fourth Edition. By J. Michael Hollas latest edition.
3. Modern Textile Characterization Methods. By Mastura Raheel latest edition.

TP-5006: Coloration of Textiles

This course covers the application of different dyes on variety of textiles substrates. The students will learn the physical aspects of dyeing, the properties of polymeric fibrous based on dyeing behavior, theory of machine

involved in batch-wise and continuous dyeing process, union dyeing, blend dyeing containing smart and technical textiles. The course will focus on advanced printing techniques such digital printing of textile substrates and its application. The students will also gain the knowledge of thermodynamic aspect of dyeing including adsorption isotherm. During this course, students should be able to define and optimize recipe and parameters to develop the dyeing process of particular substrate. At the end of this course the students will be able to dye different types of textiles including fibres, yarn, knitted fabric, woven fabric and technical textiles made of different fibrous materials.

Recommended Books:

1. Physico-chemical Aspects of Textile Coloration. By Stephen M. Burkinshaw and Andrew Filarowski latest edition.
2. Textile Dyeing and Coloration. By J. Richard Aspland latest edition.
3. Blends Dyeing. By John Shore latest edition.
4. Textile Printing. Revised Edition. By Leslie W C Miles latest edition.
5. Digital Printing of Textiles. By H. Ujiie latest edition.

TP-5007: Functionalization of Textiles

Softening of textiles: Types of softeners, chemistry of softeners, micro and nano-emulsions of softeners, evaluation of softening of textiles. Functionalization of textiles for repellency. Crease resistant textiles: Mechanism of creasing, formaldehyde and non- formaldehyde based easy care finishes. Functionalization of textiles for flame retardancy: Mechanisms of burning, limiting oxygen index, Chemistry of flame retardants. Functionalization of textiles for soil release: mechanism of soil release finishes, Chemistry of compounds for soil release, evaluation of treated textiles. Functionalization of textiles for moisture management: Mechanism of moisture management, chemistry of moisture management finishes. Functionalization of textiles for self-cleaning and antibacterial activity: basics of lotus effect, photocatalytic self-cleaning, nanostructures and antibacterial activity. Functionalization of textiles through plasma technology: Physics and chemistry of plasma, types of plasma, various applications in textile. Functionalization of textiles through enzymes: Chemistry of enzyme treatment, applications in textiles. Functionalization through microencapsulation. Various techniques of surface functionalization such as physical vapor deposition, chemical vapor deposition, surface grafting, sol-gel deposition and layer by layer deposition.

Recommended Books:

1. Functional Finishes for Textiles by Roshan Paul, Woodhead Publishing latest edition.
2. Surface modification of textiles by Q. Wei, CRC Press latest edition.
3. Textile Finishing by Derek Heywood, Society of Dyers and Colourists latest edition.
4. Plasma Technologies for Textiles by R. Shishoo, CRC Press latest edition.

TP-5008: Sustainability in Textiles

This course covers fundamentals of sustainability and implications of materials and processes used in textile wet processing industry. The student study a range of sustainability principles that address lifecycle assessment, including eco- footprint analysis, embedded energy and environmental impact of textile dyeing and finishing processes. The students will also be introduced to sustainable textile fibers, enzyme biotechnologies for sustainable textile processing, key sustainability issues in textile dyeing and environmentally friendly plasma technologies for textiles. It also covers latest technologies for sustainable textile dyeing.

Recommended Books:

1. Detox Fashion: Sustainable Chemistry and Wet Processing by Subramanian Senthilkannan Muthu, Springer latest edition.
2. Sustainability in the Textile Industry by Subramanian Senthilkannan Muthu, Springer latest edition.
3. Sustainable Apparel by Production, Processing and Recycling by Richard, Woodhead Publishing latest edition.
4. A Novel Green Treatment for Textiles: Plasma Treatment as a Sustainable Technology by Chi-wai Kan, CRC Press latest edition.

TP-5009: Research Methodology

The overall aim of this course is to enable the students to identify a research area, identify a research problem, formulate research question, conduct literature survey, formulate research hypothesis, design research experiments, graphically present, analyse and interpret the experimental data, and draw valid conclusions. Additionally, the students will be able to write a research proposal, critically analyse research papers, and write a short literature review with proper citations and referencing. The students will practice relevant statistical tools and techniques using a statistical software package. The students will also become familiar with plagiarism and other ethical issues in research, patents, copyrights and trademarks, thesis and research paper writing styles.

Recommended Books:

1. Research Methodology: A Step-by-Step Guide for Beginners by Dr. Ranjit Kumar, Sage Publications latest edition.
2. Doe Simplified 2E: Practical Tools for Effective Experimentation by Mark J Anderson, Productivity Press latest edition.
3. RSM Simplified: Optimizing Processes Using Response Surface Methods for Design of Experiments by Mark J Anderson and Patrick J Whitcomb, Productivity Press, latest edition
4. Design and Analysis of Experiments by Douglas C. Montgomery, John Wiley & Sons latest edition.

TP-6071: Research Thesis

The research project module will enable the students to bring together the knowledge and skills acquired in the earlier modules to investigate a selected topic reviewing the literature, presenting seminars and preparing material in the form of a publication. The project will demonstrate the student's capabilities to perform independently but supervised research to solve practical problems utilizing the theoretical knowledge and analytical skills attained. The overall purpose of the module is to develop in the students an understanding of the steps involved in planning and conducting a research project and in communicating the findings both orally and in writing. The project work can be undertaken in an industrial concern, where possible, ensuring both the relevance to the employer, access to appropriate facilities, and allowing sufficient time to be spent on the practical work. Alternatively, projects could be based and carried out at the university. In case of collaboration with other national and international research institutes and universities the final semester research projects can be completed at mother and collaborated organization. The Research Project module will enable the students to bring together the knowledge and skills acquired in the earlier modules to investigate a selected topic reviewing the literature, presenting seminars and preparing material in the form of a publication. The project will demonstrate the student's capabilities to perform independently but supervised research to solve practical problems utilizing the theoretical knowledge and analytical skills attained. The overall purpose of the module is to develop in the students an understanding of the steps involved in planning and conducting a research project and in communicating the findings both orally and in writing. The project work can be undertaken in an industrial concern, where possible, ensuring both the relevance to the employer, access. to appropriate facilities, and allowing sufficient time to be spent on the practical work. Alternatively, projects could be based and carried out at the university. In case of collaboration with other national and international research institutes and universities the final semester research projects can be completed at mother and collaborated organization.

Career Opportunities for Students after Completion of the Degree Program

The MS Textile Chemist would be able to get a good job in the diverse fields, some of them are mentioned below:

1. Teaching and research at university/post-graduate college level in the departments of Chemistry or Textile Engineering and Technology.
2. Research and development in public and private sector organizations.
3. Product development and analysis in public and private sector organizations.
4. Higher studies and research in Chemistry and Textiles and the relevant fields.

4. PhD CHEMISTRY

The National Textile University (NTU, Faisalabad is mandated to develop the scientific manpower and technical capability nationwide to achieve a speedy economic development of the country. As an academic institution, it offers and supports the programs that could bring about the effective fulfillment of its goals. As such, it is asked to help produce the critical mass of scientists in the field of Chemistry that will catalyze the development of NTU. Department of Applied Sciences being one of the basic academic divisions of NTU, has always been striving for the realization of this mandate. One manner of achieving this is to offer a Ph.D. Chemistry Program, in addition to its specific tasks of undertaking basic, applied, and mission-oriented researches.

Program Educational Objectives (PEOs)

No.	Description
1	The graduates would be able to derive, interpret and present the scientific data from certain chemistry phenomena supporting the research activities in various commercial, industrial, and academic sectors.
2	The graduates would be able to deliver sustainable solutions to the complex issues of industrial chemical phenomena by effectively employing accessible resources and scientific facilities.
3	The graduates would be able to perform quality research and disseminate that up to an international level, independently as well as a team member.

Program Learning Objectives (PLOs)

No.	Attributes	PLOs
1	Chemistry and Knowledge	An ability to apply knowledge of chemistry to address the chemical processes in industry and everyday life.
2	Problem Analysis and Design	An ability to literature survey, identify, design, and analyze chemistry problems reaching substantiated conclusions.
3	Investigation Tools	An ability to select and apply appropriate chemistry techniques, and resources to investigate the chemical substances, processes, and outcomes.
4	Chemistry and the Environment	An ability to understand the impact of chemical species on the environment and demonstrate knowledge and ways for sustainable chemical processes.
5	Dissemination	An ability to effectively communicate the outcomes of chemistry knowledge and research in the scientific community and society.
6	Project Execution	An ability to design and execute a research project as an independent researcher in a multidisciplinary environment.

Admission Criteria

1. MS/M.Phil Chemistry/Applied Chemistry/Industrial Chemistry/Textile Chemistry/ Forensic Chemistry/ Biochemistry/ Polymer Science and Engineering/ Material Science and Engineering/Environmental Science and Engineering/Nanotechnology/ Biotechnology/Chemical Technology and Engineering/ Textile Processing or equivalent degree with minimum CGPA 3.00/4.00 or 3.50/5.00 in semester system or 60% marks in annual system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test with minimum 60% score or NTU-GAT (Subject) test with minimum 50% score in case of different qualification as per HEC.
3. Applicant having MS or equivalent degree without thesis is not eligible to apply.
4. It is mandatory to pass interview in order to compete on merit.
5. Applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
6. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final MS/M.Phil or equivalent official transcript or degree.
7. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy.

Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Merit Criteria

The admission merit list will be prepared according to the following criteria:

1.	M.Sc./MS/Equivalent	60%	weightage
2.	B.Sc./BS/Equivalent	20%	weightage
3.	Interview Result	10%	weightage
4.	Publication/Relevant experience	10%	weightage (05% +5%)

Semester Wise Layout of Courses

Semester-I

Sr.No.	Code	Course Title	Credit Hours
1	CH-9007	Special Organic Materials	3 (3, 0)
2	CH-9009	Advanced Surface Chemistry	3 (3, 0)
3	CH-9012	Applied Environmental Chemistry	3 (3, 0)
		Total	9

Semester-II

Sr.No.	Code	Course Title	Credit Hours
1	CH-9001	Advanced Physical Chemistry	3 (3,0)
2	CH-9006	Advanced Polymer Chemistry	3 (3, 0)
3	CH-9011	Advanced Applied Chemistry	3 (3, 0)
		Total	9

Semesters-III-VIII

Sr.No.	Code	Course Title	Credit Hours
1	CH-9090	Research Thesis	30
		Total Credit Hours	48

LIST OF ELECTIVE COURSES

(This list is not exhaustive and new courses can be added to this category at any time depending upon the available facilities/requirements after due approval)

Sr. No	Course Code	Course Title	Credit Hours
1	CH-9001	Advanced Physical Chemistry	3 (3,0)
2	CH-9002	Inorganic Materials Chemistry	3 (3, 0)
3	CH-9003	Physical Organic Chemistry	3 (3, 0)
4	CH-9004	Nuclear Magnetic Resonance in Organic Chemistry	3 (3,0)
5	CH-9005	Advanced Mass Spectrometry	3 (3, 0)
6	CH-9006	Advanced Polymer Chemistry	3 (3, 0)
7	CH-9007	Special Organic Materials	3 (3,0)
8	CH-9008	Advanced Photochemistry	3 (3, 0)
9	CH-9009	Advanced Surface Chemistry	3 (3, 0)
10	CH-9010	Chemistry of Advanced Composite Materials	3 (3,0)
11	CH-9011	Advanced Applied Chemistry	3 (3, 0)
12	CH-9012	Applied Environmental Chemistry	3 (3, 0)
13	CH-9013	Nanochemistry	3 (3,0)
14	CH-9014	Biophysical Chemistry	3 (3, 0)
15	CH-9015	Advanced Chemical Treatment of Textiles	3 (3, 0)
16	CH-9016	Advanced Textile Chemistry	3 (3,0)
17	CH-9017	Advanced Analytical Techniques	3 (3, 0)
18	CH-9090	Research Thesis	30

Course Specifications

CH-9001: Advanced Physical Chemistry

Chemical Thermodynamics: Thermodynamic properties interrelations: Maxwell's equations; flow of fluids. Phase equilibrium: Non-ideal gas and liquid mixtures; chemical reaction equilibria. Chemical Kinetics: Reactions in solutions: Diffusion-controlled reactions; applications of transition state theory; solvent effects on polar and ionic reactions; salt effects on reactions. Chain reactions: Features of chain mechanisms; branching chain and oscillating reactions. Determination of reaction orders; Product catalyzed reactions; series reaction with reversible step; prior-equilibrium and improved steady-state approximation. Solutions: Interactions in solutions: multicomponent systems; preferential solvation. Solvents: Their characterization; microscopic structure of solvent and solvates. Molecular dynamics and microscopic structure; different techniques of molecular dynamical calculations. Theories and laws related to solutions. Macroscopic properties of solutions.

Recommended Books:

1. P.W. Atkins, Physical Chemistry, Oxford University Press, Oxford, 2018.
2. I.N. Levine Physical Chemistry, McGraw Hill, New York. Latest edition.
3. J.M. Hollas, Modern Spectroscopy, Wiley latest edition.

CH-9002: Inorganic Materials Chemistry

Introduction to inorganic materials, Application and interpretation of powder X-ray diffraction data of materials, The synthesis of inorganic materials – Solid state reactions, Precursor, solution and sol-gel methods, Solid-gas reactions, Hydrothermal method, CVD, Aerosol process, Low temperature method, Transition metal oxides, Electronic, magnetic and optical properties of inorganic materials, Nonstoichiometric compounds, Zeolites, intercalation in layer materials and solid electrolytes, Some recent developments in inorganic material chemistry.

Recommended Books:

1. A.R. West, Basic Solid State Chemistry and its Applications, John Wiley & Sons, Ltd. 2021.
2. L. Smart and E. Moore Solid State Chemistry, Chapman & Hall. Latest edition.
3. A.R. West Basic Solid State Chemistry, John Wiley & Sons, Ltd. Latest edition.

CH-9003: Physical Organic Chemistry

History and development: Evolution of a hybrid discipline, energy changes during chemical reactions, theory and principles related to kinetics and equilibrium processes. Correlation of structure and reactivity: Hammett equation and other linear free energy relationships. Huckel molecular orbital (HMO) method: Correlation of HMO parameters with molecular properties, alternant and nonalternant hydrocarbons and their properties. Correlation of structure and activity: Use of molecular descriptors, Hansch analysis, Craig plots, Topliss scheme in establishing SAR. FMO method: Concept of Frontier orbitals and its application for explaining chemical reactivity.

Recommended Books:

1. Miller, Advanced Mechanisms in Organic Chemistry, Pearson Education 2021.
2. P. Vogel and K.N. Houk. Organic Chemistry, Wiley, 2019.
3. Williams and N. Williams. Advances in Physical Organic Chemistry, Elsevier Science 2020.

CH-9004: Nuclear Magnetic Resonance in Organic Chemistry

Spin couplings: Spin coupling in different spin systems. Double resonance experiments: Spin decoupling in 1H- and C13- NMR spectroscopy, suppression of solvent signal, 1H BB decoupling, gated decoupling, 1H off-resonance decoupling. 1D NMR experiments with complex pulse sequence: The J-modulated spin echo, SPI, INEPT and DEPT experiments. 2D NMR Spectroscopy: Introduction, theory and presentation of 2D spectrum. 2D J-resolved NMR spectroscopy: Homo- and hetero-nuclear 2D J-resolved NMR spectroscopy. 2D shift-correlated NMR spectroscopy: H,H-COSY, H,C-COSY, NOESY, ROESY, HMBC, HMQC and TOCSY experiments. Applications: NMR use as a tool for structure elucidation and stereochemical assignments.

Recommended Books:

1. J.B. Lambert, E.P. Mazzola, C.D. Ridge, Nuclear Magnetic Resonance Spectroscopy: An Introduction to Prin ciples, Applications, and Experimental Methods. , John Wiley & sons Inc., USA 2018.
2. H. Friebolin Basic one-and two-dimensional NMR spectroscopy, Wiley-VCH, New York. latest edition.
3. R. M. Silverstein, F. X. Webster and D. J. Kiemle Spectrometric identification of organic compounds, John Wiley & sons Inc., USA latest edition.

CH-9005: Advanced Mass Spectrometry

Introduction: Aims and scope, theory and basic terminology. Instrumentation: Instrumental design, ionization techniques, types of analyzers and detectors. Applications: Modes of fragmentation of various organic compounds, interpretation of mass spectra of unknown organic compounds.

Recommended Books:

1. M. Smoluch, G. Grosso, P. Suder and J. Silbering. Mass Spectrometry an Applied Approach, John Wiley & Sons, New York 2019.
2. C.G. Herbert and D.P. Schulz Mass Spectrometry Basics, Taylor & Francis, New York. latest edition.
3. E. Hoffman and V. Stroobant. Mass Spectrometry, Principles & Applications, Wiley, latest edition.

CH-9006: Advanced Polymer Chemistry

Mechanism and kinetics: Step growth, free radical addition polymerization, ionic polymerization, Ziegler-Nattapolymerization. Molecular weight determination: Different methods used to determine the absolute and relative molecular weights of polymers. Structure- property relationship. Reactions of synthetic polymers. Polymer degradation and stability: Special emphasis on thermal and photo-degradation. Polymer interactions. Polymer solutions: Expansion factor in solutions; physical parameters affecting the chain dimensions; theta conditions. Theories of polymer solutions; phase separation and fractionation; solubility parameters; criteria for solubility. The polymerization processes and techniques, polymer additives (plasticizers, stabilizers and fillers). Polymers characterization.

Recommended Books:

1. H. Hemandez and K. Tauer. Heterophase Polymerization: Basic Concepts and Principles, jenny Stanford Publishing. 2021.
2. S. Koltzenberg, M. Moskos and O. Nuyken Polymer Chemistry, Springer, latest edition.
3. A. Ravve, Principles of Polymer Chemistry, Springer Science, latest edition.

CH-9007: Special Organic Materials

Organic dyes: Chromophore structure, synthesis of azodyes and cyanins, reactive vs. direct textile dyes, Chemiluminescence, photochromocs, color photography. Liquid Crystals: definition, classification: thermotropic/lyotropic, calamitic/discotic, nematic/ smectic columnar, synthesis and orientation, liquid crystal displays (LCD's), liquid crystal polymers. Electronic materials: Types of organic semi-conductors, polyacetylenes, and polyparaphenylenes, band structure, synthesis, electroluminescence and light emitting diodes (LED's).

Recommended Books:

1. K.Hunger and M.U. Schmidt, Industrial Organic Pigments: Production, Crystal Structures, Properties, Applications, Wiley-VCH; 2019.
2. K.H. Klaus. Industrial Dyes, Wiley-VCH, Verlag, GmbH & Co. latest edition.
3. P.J. Collings and J.W.G. Goodby. Introduction to Liquid Crystals: Chemistry and Physics, CRC Press, 2019.

CH-9008: Advanced Photochemistry

Principles of photochemistry: Primary and secondary chemical processes. Electron transfer in photochemistry: Collisional and coulombic modes, effect of temperature, eximers and exiplexes, the SET photochemistry, quantum yields. Kinetics and energetic of photochemical reactions: Mechanism of photochemical reactions, intersystem

crossing, flash photolysis, mass spectrometric methods. Experimental methods in photochemistry: Low, medium and high pressure mercury lamps, resonance lamps, actinometers, phototubes, sources of high intensity flashes of light, laser and synchrotron radiations. Photolytic studies: Aqueous and non-aqueous systems, effects of radiations on solids. Applications in daily life and industry: Picosecond and femtosecond flash photolysis, Supramolecular photochemistry.

Recommended Books:

1. M. Persico and G. Granucci. Photochemistry: A Modern Theoretical Perspective (Theoretical Chemistry and Computational Modelling), Springer 2018.
2. R.C. Evans, P. Douglas and H.D. Burrows. Applied Photochemistry, Springer, latest edition.
3. B. Wardle, Principles and Applications of Photochemistry, Wiley, latest edition.

CH-9009: Advanced Surface Chemistry

Solid-liquid interface: Wetting, heat of wetting, thermodynamic description of an interface, Gibbs-Duhem equation for an interphase, Gibbs adsorption isotherm, adsorption from solutions (dilute, liquid mixtures, non-electrolytes, electrolytes, etc.) at solid- liquid interface, detergency and flotation. Study of liquid interfaces: Kelvin's and Laplace equations. Technical catalysis: Catalyst preparation techniques, catalytic reactors, supported metal catalysts, industrial applications of heterogeneous catalysts. Catalysis for steam-reforming, CO- & CO2-methanation, water-gas shift, Fischer-Tropsch synthesis reactions. Catalysts for syntheses of: ammonia, nitric acid, chemical fertilizers etc.

Recommended Books:

1. B. Korenberg, K. HolmbergB. Lindman. Surface Chemistry of Surfactants and Polymers, John Wiley & Sons ,latest edition
2. K.S. Birdi, Surface Chemistry Essentials, CRC Press Taylor and Francis, latest edition.
3. G.M. Kontogeorgis and S. Kiil. Introduction to Applied Colloid and Surface Chemistry, Wiley, latest edition

CH-9010: Chemistry Advanced Composite Materials

Introduction: Definitions and classification of composite materials, natural composites, property enhancement by reinforcement and orientation, matrix interface, synthetic fibers, processing of composites. Examples: Metallic, ceramic and polymeric matrices, interface reactions. Properties: Mechanical and thermal properties of composite materials, stress relaxation and creep studies, dynamical mechanical properties, toughening mechanisms and mechanical failure in polymeric composites.

Recommended Books:

1. K.K. Chawla. Composite Materials: Science and Engineering, Springer 2021.
2. P.K. Mallick. Processing of Polymer Matrix Composites, CRC Press, latest edition
3. R.M. Wang, S.R. Zheng, Y.G. Zheng. Polymer Matrix Composites and Technology, Elsevier Science, latest edition

CH-9011: Advanced Applied Chemistry

The importance of chemical industries for the economic development of Pakistan; chemistry of ceramics and its processing; the agrochemical industry; chemistry of structural adhesives; dyes and pigments; chemistry of silicone technology; chemistry of fuel technology; corrosion; quality control (analytical and statistical). Various aspects of the energy and raw material supply, cost calculations to improve yield and to reduce pollution. Industrial techniques and quality control. Equipment for large-scale manufacturing. Conversion of a lab. process to a pilot plant and then plant procedure. Industrial catalysis. Inorganic and organic processes. Products of fermentation process. Preparation of chemical products from small molecules. Pesticides, herbicides and pharmaceuticals. The environmental impact of a process.

Recommended Books:

1. S. Kaliaguine and J-L.Dubois, Industrial Green Chemistry, de Gruyter, 2020.
2. D. Erwin. Industrial Chemical Process Design, Mc. Graw Hill Education, latest edition.
3. R.J. Farrauto, L. Dorazio and C.H. Bartholomew. Introduction to Catalysis and Industrial Catalytic Processes, Wiley, latest edition

CH-9012: Applied Environmental Chemistry

Atmospheric Chemistry: Atmospheric structure: Natural constituents, anthropogenic emissions and atmospheric pollution. Air quality criteria pollutants: Sources, dispersion models and sinks of atmosphericpollutants. Measurement and monitoring methods: Gaseous pollutants and particulate matter in the atmosphere, dry and wet depositions. Photochemical smog-formation: Types and effects. Acid rain: Causes, effects and control. Ozone Chemistry: Stratospheric ozone production and depletion, causes and significance of ozone hole, catalytic and non-catalytic processes, effects of UV on the biosphere. Global warming: Greenhouse gases, production, control and future trends of greenhouse gases, consequences of global warming. Control management: Standards and legislation regarding the atmospheric pollution. Aqueous Chemistry: Aquatic environment: hydrological cycle, water quality criteria, physical, chemical and biological characteristics of water, utilization, contamination and protection of water resources, collection and preservation of water samples. Physico-chemical analysis of water: Fresh water bodies, stratification and turn-over. Water pollution: Soap, detergents and agricultural sprays. Water management: Policies and tools. Deposition of sediments: Trace metals in the hydrocycle and sediments, quantification of environmental impact in sediments.

Recommended Books:

1. O. Lahay and I.Birmhack, Aquatic Chemistry: For Water and Wastewater Treatment Applications, de Gruyter, 2019.
2. R.M. Harrison An Introduction to Pollution Science, The Royal Society of Chemistry, UK. latest edition.
3. S.E. Manahan. Environmental Science and Technology, Lewis Publishers, New York latest edition.

CH-9013: Nanochemistry

Nanomaterials: Classification; structure and bonding; size dependent properties of mater; arrangements in 3D, 2D and.1D. Specific heats and melting points of nano-crystalline materials. Semiconductor nanocrystals: Spinels; quantum dots. Alloy semicondictors and their synthesis. Metal nanoparticles, double layers. Nanoparticle stability; charge transfer. Optical properties: Light absorption by colloids; dielectric response; size effects, electron transfer; temperature effects. Magnetism: Magnetic susceptibility and permeability: diamagnetism; paramagnetism; Langevin model; quantum effects. Ferromagnetism, Curie-Weiss law. Antiferro- magnetism: Ferri-magnetism. Magnetic anisotropy. Magnetic domains. Hysteresis. Super-paramagnetism. Nanomaterials synthesis: Chemical and catalytic aspects of nanocrystals. Nanotechnology: Synthesis techniques. Applications.

Recommended Books:

1. A.da-Silva and T.Trindade, Surface Chemistry of Colloidal Nanocrystals, RSC, UK. 2021.
2. G.A. Ozin, A.C. Arenault and L. Cademartiri. Nanochemistry: A Chemical Approach to Nanomaterials, RSC Publishing, Cambridge latest edition.
3. B.S. Vasile. Synthesis, Processing and Application of Micro and Nanostructured Materials, MDPI. 2020

CH-9014: Biophysical Chemistry

Thermodynamic aspects: Simple molecules, macromolecules, colloidal particles in solution. Bioenergetics: Association of biopolymers. Lipids and biological membranes: Membrane transport, membrane potential. Characterization of Macromolecules: Moving-boundary sedimentation,zonal sedimentation, density gradient sedimentation,viscosity measurement, electrophoresis, isoelectric focusing. Structure of proteins and nucleic acids: Folding/unfolding of proteins and nucleic acids. Enzymology: Kinetics of enzyme catalysis, mechanismsof enzyme catalysis. Experimental techniques: Protein NMR, MRI, X-ray crystallography of proteins, electron microscopy of macromolecular assemblies.

Recommended Books:

1. T.M. Nordlund and P.M. Hoffmann, Quantitative Understanding of Biosystems: An Introduction to Biophys ics, (Foundations of Biochemistry and Biophysics), CRC press 2021.
2. B. Nölting, Methods in Modern Biophysics, Springer Verlag, Berlin latest edition.
3. G.S. Rule and T.K. Hitachens. Fundamentals of Protein NMR Spectroscopy, Springer Verlag, Berlin latest edition.

CH-9015: Advanced Chemical Treatment of Textiles

This course includes the detailed study of different chemical treatments of textile materials including pre-treatments, coloration, modification along withcomprehensive study of synthetic chemistry of different chemicals used in textile processing. The course also includes the characterization of treated textile materials using advanced analytical techniques.

Recommended Books:

1. M. Raheel Modern Textile Characterization Methods, Marcel Dekker, Inc., New York, 2019.
2. W. E. Morton and J. W. S. Hearle. Physical Properties of Textile Fibres, Woodhead Publishing Limited latest edition.
3. H. Zollinger Color Chemistry: Synthesis, Properties and Applications of Organic Dyes, Wiley-VCH latest edition.

CH-9016: Advanced Textile Chemistry

Chromophore structure; synthesis and applications of azo, anthraquinones, phthalocyanines, vat, indigo polymethine and nitro dyes; Reactive vs. direct textile dyes, Chemiluminescence, photochromocs, color photography; high technology applications. Textilesurface modifications; Multifunctional finishing; Textilesurface characterization; Development of textiles fortechnical applications.

Recommended Books:

1. T.Bechtold and T. Pham Textile Chemistry de Grutyer, 2019
2. Abbott and M. Ellison. *Biologically inspired textiles*, Woodhead Publishing Limited, latest edition.
3. H. Zollinger. *Color Chemistry: Synthesis, Properties and Applications of Organic Dyes*, Wiley-VCH latest edition.

CH-9017: Advanced Analytical Techniques

Diffraction methods: Origin of X-ray spectra: Energy levels, Moseley's law. The absorption spectrum: Mass absorption coefficient. Instrumentation: X-ray generation, sources, wavelength dispersive devices, energy dispersive devices, detectors, sample preparation methods, working principle, analytical applications of X-ray absorption, X-ray fluorescence, particle induced X-ray emission, auger emission spectroscopy. Introduction, single crystal X-ray diffraction (XRD) of small molecules and macromolecules including natural systems, powder X-ray diffraction (XRD) of small molecules and macromolecules, measurement of lattice parameters, measurement of B-values, determination of space group, calculation of electron density map. Electron microscopy: Introduction, scanning electron microscopy (SEM), transmission electron microscopy (TEM), measurement of I/Q values, single particle 3-D reconstruction. Thermal Analysis: Theory and instrumentation: Thermogravimetry (TG), differential thermal analysis (DTA), differential scanning calorimetry (DSC). Quantitative interpretation: TGA, DTA and DSC curves. Kinetic and thermodynamic parameters. Applications: DTA, TGA in cements, catalysts, clays, minerals, biological materials, drugs, polymers and textiles.

Recommended Books:

1. C.S.Patil, Advanced Analytical Techniques, Oxford Book Company, latest edition
2. R. Wolstenholme, S. Jickells, S. Forbes. Analytical Techniques in Forensic Science, Wiley, 2021.
3. R. Duarte and A.C. Duarte. Multidimensional Analytical Techniques in Environmental Research, Elsevier Science, 2020.

Career opportunities for students after completion of the program

- Teaching & Research
- Textile Chemist/ Scientist
- Material Scientist
- Industrial Researcher
- Analyst
- Medicinal Chemist
- Environmental Science Specialist

5. PhD Physics

The National Textile University (NTU), Faisalabad is mandated to develop the scientific manpower and technical capability nationwide to achieve a speedy economic development of the country. As an academic institution, it offers and supports the programs that could bring about the effective fulfillment of its goals. As such, it is asked to help produce the critical mass of scientists in the field of Physics that will catalyze the development of NTU. Department of Applied Sciences being one of the basic academic divisions of NTU, has always been striving for the realization of this mandate. One manner of achieving this is to offer a Ph.D. Physics Program, in addition to its specific tasks of undertaking basic, applied, and mission-oriented researches.

Program Educational Objectives (PEOs)

1. The graduates would deliver in-depth understanding of multidisciplinary Physical happenings based on the scientific data related to Physics and related branches.
2. The graduates would deliver the feasible resolves of complex physical interlinkages by the launch of vibrant experimental and analytical techniques.
3. The graduates would perform quality research and disseminate its outputs at appropriate fora, independently and as well as in the role of a member of diverse research community.

Program Learning Objectives (PLOs)

No.	Attributes	PLOs
1	Physics Knowledge	An ability to apply knowledge of Physics to address the physical/industrial issues and everyday life.
2	Problem Analysis and Design	An ability to literature survey, identify, design, and analyze physical problems reaching substantiated conclusions.
3	Investigation Tools	An ability to select and apply appropriate physics techniques, and resources to investigate the substances and processes.
4	Physics and the Environment	An ability to understand the impact of physical species on the environment and demonstrate knowledge of and need for sustainable physical processes.
5	Dissemination	An ability to communicate effectively the outcomes of physics knowledge and research in the scientific community and society.
6	Project Execution	An ability to design and execute a research project as an independent re-searcher in a multidisciplinary environment.

Admission Criteria

1. Applicant having MS in Physics / Electronics / Advanced Materials / Nanotechnology /Applied Physics degree or equivalent degree with minimum CGPA 3.00/4.00 or 3.50/5.00 in semester system or **60%**marks in annual system is eligible to apply.
2. Applicants having terminal degrees as prescribed in condition no. 01, are required to qualify NTU-GAT (General) test with minimum 60% score while applicants having different terminal degree are required to qualify NTU-GAT (Subject) test additionally with minimum 50% score as per HEC.
3. Applicant having MS or equivalent degree without thesis is not eligible to apply.
4. It is mandatory to pass interview in order to compete on merit.
5. Applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
6. Result waiting applicants may apply for admission; however, their merit will be finalized only on submission of final MS/M.Phil. or equivalent official transcript or degree.
7. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
8. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy.

9. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.
10. The admission merit list will be prepared according to the following criteria:

M.Sc./MS/Equivalent	50%	weightage
B.Sc./BE/Equivalent	30%	weightage
Interview Result	10%	weightage
Publication/Relevant experience	10%	weightage (05%+05%)

Semester Wise Layout of Courses

Semester-I

Sr.No.	Code	Course Title	Credit Hours
1	PH-9001	Nanomaterials Growth and Characterization	3 (3,0)
2	PH-9002	Semiconductor Materials and Devices	3 (3,0)
3	PH-9003	Optical Properties of Solids	3 (3,0)
		Total	9

Semester-II

Sr.No.	Code	Course Title	Credit Hours
1	PH-XXXX	Elective Course – I	3 (3, 0)
2	PH-XXXX	Elective Course – II	3 (3, 0)
3	PH-XXXX	Elective Course – III	3 (3, 0)
		Total	9

Semesters III-VIII

Sr.No.	Code	Course Title	Credit Hours
1	PH-9090	Research Thesis	30
		Total Credit Hours	48

LIST OF ELECTIVE COURSES

(This list is not exhaustive and new courses can be added to this category at any time depending upon the available facilities/requirements after due approval)

Sr. No	Course Code	Course Title	Credit Hours
1	PH-9001	Nanomaterials Growth and Characterization	3 (3,0)
2	PH-9002	Semiconductor Materials and Devices	3 (3, 0)
3	PH-9003	Optical Properties of Solids	3 (3, 0)
4	PH-9004	Atomic and Molecular Physics	3 (3,0)
5	PH-9005	Nanotechnology and Nanoelectronics	3 (3, 0)
6	PH-9006	Environmental Physics	3 (3, 0)
7	PH-9007	Physics of superconductivity	3 (3,0)
8	PH-9008	Photovoltaic Energy and its Applications	3 (3, 0)
9	PH-9009	Computer Modeling & Simulation	3 (3, 0)
10	PH-9010	Smart Nanomaterials	3 (3,0)
11	PH-9011	Theory of Condensed Matter	3 (3, 0)
12	PH-9012	Advance Plasma Physics	3 (3, 0)
13	PH-9013	Advanced thin Film Technology	3 (3,0)
14	PH-9014	Advanced Characterization Techniques	3 (3, 0)
15	PH-9015	Physics of Surface and Interfaces	3 (3, 0)
16	PH-9016	Medical Physics	3 (3,0)
17	PH-9017	Antenna Design and Theory	3 (3, 0)
18	PH-9018	Atomic and Molecular Physics	
19	PH-9090	Research Thesis	30

Courses Outlines

PH-9001: Nanomaterials Growth and Characterization 3(3-0)

Classification of Nano materials, Size depending Quantum Mechanical aspects, Nano particle synthesis techniques (CBD, MOCVD, SPD, CSS etc.), Characterization techniques (XRD, SEM, TEM, thermal and electrical properties, optical characterizations), Nanodefects, Nanoparticles and Quantum Dots, Nanopatterned surfaces, Nanoscale porous materials and Biological nanostructures.

Recommended Books:

1. H.G. Rubahn, Basics of Nanotechnology, 3rd Edition, publisher Wiley, latest Edition.
2. S. Challa, Biomimetic and Bioinspired Nanomaterials, Publisher Wiley VCH, 2018.
3. A. Kruge, Carbon Materials and Nanotechnology, Publisher Wiley VCH, 2020.
4. M. Andriy Gusak, Diffusion controlled Solid State Reactions in Alloys, Thin-Films, and Nanosystems, publisher Wiley VCH 2021.
5. N. Andrew & C.bland, Foundations of Nanomechanics" Springer, 2019.

PH-9002: Semiconductor Materials and Devices 3(3-0)

Semiconductor Synthesis and Molecular Characterization: An Introduction to Organic Electronic Materials Synthesis of Poly (3-alkylthiophenes) (P3ATs) Synthesis of Low Bandgap Polymers Molecular and Thermal Characterization Structural and Optical Characterization, Electronic Structure: Atomic and Molecular Orbitals, The Schrodinger Equation, Application of the Schrodinger Equation, The Fermi Energy and The Density of States, Carrier Densities in Intrinsic Semiconductors, Charge Transport: Charge Transport via a Hopping Mechanism Doping in Semiconducting Materials, Multiple Trap and Release (MTR) Model, Transport in Disordered Semiconductors, Organic Field-Effect Transistors, Field-Effect Transistors and Light Emitting Devices: Overview of Organic Photovoltaic Devices, Characterizing Device Parameters in OPVs, Nano structural Impacts in OPV Devices, Interfacial Modifying Layers in OPV Devices Emerging Trends in OPV Devices, Photovoltaic and Emerging Devices:: Introduction to Organic Light-emitting Devices: Design Considerations for OLEDs, Introduction to Polymer Thermoelectric Devices, State-of-the-Art in Polymer Thermoelectric.

Recommended Books:

1. A. Rocket, The Materials Science of Semiconductors, Springer, latest Edition.
2. M. Grundmann, The Physics of Semiconductors: An Introduction Including Nanophysics and Applications, Springer, 2015.
3. D. K. Schroder, Semiconductor material and device characterization Wiley, Latest Edition.
4. W. A. Harison, Electronics structures and the properties of Solids: physics of chemical bonds, Latest Edition.
5. L. Solymar, Electrical properties of materials, Oxford Press, 2020.

PH-9003: Optical Properties of Solids 3(3-0)

Classification of optical processes, optical coefficients, optical materials, microscopic models, classical propagation of light in optical medium, atomic oscillators, vibrational oscillators, the Lorentz oscillators, Multiple resonances, the Kramer- Kroni relationships, Dispersion relations, optical anisotropy, birefringence, interband transitions, The transition rate for direct absorption, Band edge absorption in direct gap semiconductors, inter band absorption above the band edge, measurement of absorption spectra, Excitations, free excitations, excitations in external fields, Luminescence, interband luminescence, photoluminescence, electroluminescence, Semiconductor quantum wells, the quantum stark effect, Quantum dots, Plasma reflectivity, Free carrier conductivity, the Drude model, impurity absorption Plasmon, phonons, infrared active phonons, infrared reflectivity and absorption, the classical oscillator model, The Lyddance-Sachs-Teller relationship, polaritons, polarons, inelastic light scattering. Phonon life time Nonlinear optics, the nonlinear susceptibility tensor, the physical origin of optical nonlinearities, second order nonlinearities, third order nonlinear effects

Recommended Books:

1. Elliot & Gibbson, An Introduction to Solid State & its Applications, Wiley, 2019.
2. C. Kittle, Introduction to Solid State, (8th edition) Wiley, latest Edition.
3. M. Fox Properties of Solids, Oxford University Press, 2020.
4. D. Daniela, Optical Characterization of Solids, Springer, 2017.
5. F. Wooten, Optical Properties of Solids, Academic Press. 2018.

PH-9004: Atomic and Molecular Physics 3(3-0)

One Electron Atoms: Review of Bohr Model of Hydrogen Atom, Reduced Mass, Atomic Units and Wavenumbers, Energy Levels and Spectra, Schrodinger Equation for One-Electron Atoms, Quantum Angular Momentum and Spherical Harmonics, Electron Spin, Spin-Orbit interaction. Levels and Spectroscopic Notation, Lamb Shift, Hyperfine Structure and Isotopic Shifts. Rydberg Atoms. Interaction of One-Electron Atoms with Electromagnetic Radiation: Radiative Transition Rates, Dipole Approximation, Einstein Coefficients, Selection Rules, Dipole Allowed and Forbidden Transitions. Metastable Levels, Line Intensities and Lifetimes of Excited States, Shape and Width of Spectral Lines, Scattering of Radiation by Atomic Systems, Zeeman Effect, Linear and Quadratic Stark Effect. Many-Electron Atoms: Schrodinger Equation for Two-Electron Atoms, Para and Ortho States, Pauli's Principle and Periodic Table, Coupling of Angular Momenta, L-S and J-J Coupling. Ground State and Excited States of Multi-Electron Atoms, Configurations and Terms. Molecular Structure and Spectra: Structure of Molecules, Covalent and Ionic Bonds, Electronic Structure of Diatomic Molecules, Rotation and Vibration of Diatomic Molecules, Born-Oppenheimer Approximation. Electronic Spectra, Transition Probabilities and Selection Rules, Frank- Condon Principle, H2+ and H_2. Effects of Symmetry and Exchange. Bonding and Anti-bonding Orbitals. Electronic Spin and Hund's Cases, Nuclear Motion: Rotation and Vibrational Spectra (Rigid Rotation, Harmonic Vibrations). Selection Rules. Spectra of Triatomic and Polyatomic Molecules, Raman Spectroscopy, Mossbauer Spectroscopy.

Recommended Books:

1. B.H. Bransden and C.J. Joachain, Physics of Atoms and Molecules, 2nd edition, 2018.
2. R.L. Brooks, The Fundamentals of Atomic and Molecular Physics, Springer latest edition.
3. Atomic physics Oxford: Oxford University Press, xiii, ISBN: 0-19-850695-3, 2020.
4. Weinheim, Molecular physics: theoretical principles and experimental methods: Wiley-VCH: 2005, ISBN: 3-527-40566-6.

PH-9005: Nanotechnology and Nanoelectronics 3(3-0)

Nanosemiconductor: Nanowires, nanobelts, nanoribbons, nanorods. Devices, Circuits and Systems: The Ballistic Nanotransistors, scattering theory of the MOSFET. Nanowire Field-Effect Transistors. Transistors at the Molecular Scale. Focus is on the device and operation principles. Device and material options for advanced silicon: FETs at the nanoscale. Nano-circuits built using semiconductor nanowires. Non-silicon-based devices such as carbon nanotubes, semiconductor nanowires. Non-FET based devices: Molecular devices, Single electron transistors (SET), resonant tunneling diodes (RTD), and quantum dots, logic and memory devices.

Recommended Books

1. S.H. Voldman, Failure Mechanisms and Models, Wiley, 2019.
2. V. V. Mitin, V.A. Kocheleap and M.A. Strucioby, Introduction to Nanoelectronics, Cambridge University Press, 2018.
3. C. P. Poole and Frank, Introduction to Nanotechnology, John Wiley & Sons. Inc, 2013.
4. K. Goser, Nanoelectronics and Nanosystems, Springer, 2018.

PH-9006: Environmental Physics 3(3-0)

Principal layers, troposphere, stratosphere, mesosphere, thermosphere, Ideal gas model revisited, exponential variation of pressure with height, Escape velocity, Temperature structure and lapse rate. The Sun as the prime source of energy for the earth, Solar energy input, cycles daily and annual, Spectrum of solar radiation reaching the earth, Total radiation and the Stefan Boltzmann,. Thermodynamics of moist air and cloud formation, Growth of

water droplets in clouds, Rain and thunderstorms. Measuring the wind; the Beaufort scale, Origin of winds; the atmosphere as a heat engine, The principal forces acting on an air parcel, Cyclones and anticyclones, Thermal gradients and winds, Global convection and global wind patterns. Design of buildings. Atmospheric pollution; acid rain: Systems approaches to environmental issues, Acid rain as a regional problem. Sound and noise: Definition of the decibel and A-weighted sound levels, Measures of noise levels; effect of noise levels on hearing, Domestic noise; design of partitions.

Recommended Books:

1. J.H. Seinfeld, S.N. Pandi, Atmospheric Chemistry and Physics", John Wiley & sons. 2018.
2. H.B. Singh, Composition, Chemistry and Climate of the Atmosphere, 2017
3. W.C. Hinds, Aerosol Technology. Properties, behavior and measurement of airborne particles, Wiley Interscience. 2015.
4. I., Colbeck, Aerosol Science: Technology and Applications, Wiley Interscience, 2014.

PH-9007: Physics of superconductivity 3(3-0)

Discovery, zero resistance and critical temperature, magnetization, perfect diamagnetism, Meissner effect, trapped flux, type I and II behavior, superconducting elements and compounds, cuprate superconductors, structures and preparation, doing phase diagram. Qualitative Description of the Superconducting State, The pair state, effective wave function. Y(r), time-and space-dependence of the phase, Aharonov-Bohm effect, London equations, penetration depth, flux quantization, gauge invariance. Thermodynamics of Superconductors, Free energy, critical field, heat capacity, second-order phase transition, demagnetizing effects. Josephson Effects, Discovery (including single particle tunneling), principles, quantum interference, DC and rf. SQUIDS, applications of SQUIDS, AC effects, voltage standard. Ginzburg-Landau Theory and Type II behavior, Landau theory of phase transitions, Ginzburg-landau free energy and equations, type II behavior and flux lines, flux pinning, current carrying capacity, beam model, practical magnet materials, superconducting magnets and their uses.

Recommended Books:

1. J. R Waldram, Superconductivity of Metals and Cuprates, IOP Publ. 2015.
2. M. Tinkham, Introduction to Superconductivity, 2nd Edition, McGraw-Hill, 2016.
3. D.M Ginsberg, Physical Properties of High-Temperature Superconductors, World Scientific, 2017.

PH-9008: Photovoltaic Energy and its Applications 3(3-0)

Photovoltaic (PV) device, PV in the context of global energy demand and climate change, History of PV development and deployment, Overview of PV technologies, The solar resource: Spectra, insolation, diffuse vs. direct, atmospheric absorption (AM0 and. AM1.5), metrics for specifying system output, land area requirements, Review of semiconductor physics, Semiconductor equations, light absorption and charge generation, recombination, Analysis of pn junctions, depletion approximation, solution of semiconductor equations in depletion approximation, derivation of ideal diode law, solar cell performance output parameters, Ideal efficiency limits, Practical sources of loss, equivalent circuit model, characterizing solar cell performance, Improving efficiency by reducing optical losses: texturing, anti-reflection coatings, light trapping, photon recycling, concentrating PV (CPV) , Overview of commercial technologies, Commercial Technologies, Crystalline Si (c-Si), Commercial Technologies, Thin film Si (amorphous and crystalline), Commercial Technologies, CdTe and CIGS, Emerging Technologies: organic PV (OPV) perovskites, CZTS, Economics of PV; Environmental impact and benefit of PV: Life cycle analysis, energy pay back timing, resource extraction and limitations

Recommended Books:

1. G. Martin, Solar Cells: Operating Principles Technology, 2015.
2. P. Wurfel, Physics of Solar Cells: From Basic Principles to Advanced Concepts. Wiley VCH, 2019.
3. K. Mertens, Photovoltaics: Fundamentals, Technology and practice. Wiley, 2014.
4. N. Reinders, Verlinden, W. van Sark, A. Freundlich. Photovoltaic Solar Energy: From Fundamentals to Applications, Wiley & Sons. 2018.
5. Solar Electric Handbook: Photovoltaics Fundamentals and applications by solar energy international, 2017.

PH-9009: Computer Modeling & Simulation (Cr.3)

Development of Systems Simulation: Basic simulation methodology Techniques for the steady state simulation: techniques for sensitivity estimation, simulation-based optimization techniques, stochastic approximation techniques, meta-modeling and the goal seeking problems, "What-if" analysis techniques, likelihood ratio (LR) Method, exponential tangential in expectation method, interpolation techniques. Building a simulation model: The machine interference model, the generation of pseudo- random numbers, the generation of stochastic. Simulation designs: The OR approach, estimation techniques for analyzing endogenously created data, transient state vs. steady-state simulation, validation of a simulation model, variance reduction techniques and simulation projects, Quantum Monte Carlo.

Recommended Books

1. F. Neelamkavil, Computer Simulation and Modeling, John Wiley & Sons, Inc. 2012.
2. J. A. Sokolowski, C. M. Banks, Modeling and Simulation Fundamentals, Wiley Blackwell, 2015.
3. B. P. Zeigler, Theory of Modeling and simulation, Krieger Publishing Company, 2016.
4. D. Rabee, Computational materials Science, Wiley Inc. 2018.
5. A. M. Ovrutsky, A. S. Prokhoda, and M. S. Rasshchupkyna, Computational Materials Science: Surfaces, Interfaces, Elsevier, 2018.

PH-9010 Smart Nanomaterials 3(3-0)

Brief introduction of nanoparticles, its scope, magnetic nanoparticles inside and everywhere around, most extensively studied magnetic nanoparticles and their preparation, metals, nanoparticles of rare earth metals, oxidation of metallic nanoparticles, magnetic alloys, Fe–Co alloys, magnetic oxides, magnetic moments and their interactions with magnetic fields. Bohr magneton, spin and orbital magnetic moments, magnetic dipole moments in an external magnetic field, the spontaneous magnetization, anisotropy, domains, the spontaneous magnetization, temperature dependence of the magnetization in the molecular field approximation, Curie temperature in the Weiss Heisenberg model curie temperature in the stoner model, the meaning of exchange in the Weiss Heisenberg and stoner models, thermal excitations: spin waves, the magnetic anisotropy, the shape anisotropy ,the magneto-crystalline anisotropy. Magnetic microstructure: magnetic domains and domain walls, ferromagnetic domains, antiferromagnetic domains, magnetization curves and hysteresis loops

Recommended Books:

1. S. Blundell, Magnetism in condensed matter, Oxford University Press. 2012
2. R. Skomski, Simple models of magnetism, Oxford University Press. 2018
3. J.M.D. Coey, Magnetism and magnetic materials, Cambridge University Press. 2012.
4. A.P. Guimaraes, Principles of nano magnetism, Springer. 2015.
5. Z. Markus, ELECTROMAGNETIC FIELD THEORY - A PROBLEM-SOLVING APPROACH, John Wiley and Sons, Inc. 2003.

PH-9011: Theory of Condensed Matter (Cr.3)

Electronic Structure of Solids, Independent particles in periodic potential, Bolch's theorem, nearly free electron and tight binding methods, Pseudo potentials, density functional theory, Metals, Density of states, Fermi surfaces, exchange and correlation in the electron gas, screening, Insulators and Semiconductors, Ionic and covalent bonding, real and momentum space description, electronic structure of simple semiconductors. Solids in External magnetic field, Pauli-paramagnetism of conduction electrons, Landau-diamagnetism of conduction electrons, De Haas-van Alphen effect, the quantum Hall effect. Optical Processes and Excitons: optical Reflectance, Kramer-Kronig relation, exactions, Frenkel exactions, Mott-Wannier exactions, Raman effect in crystals. Collective Quantum Phenomena in Condensed Matter, Collective modes, Correlation functions and response functions, response of independent electron gas, electron-phonon interaction, Ginzburg-Landau theory of phase transition, polarons, metal-insulator transitions, Wigner crystal, superconductivity, pairing and elementary BCS theory, Josephson effect.

Recommended Books:

1. C. Kittel, Introduction to Solid State, 8th Edition, Wiley. 2015
2. J. M. Ziman, Principles of the Theory of Solids, Springer. 2012
3. Elliott S.R, The Theory of Solids, Wiley. 2010.
4. L.M. Sander, Advanced Condensed Matter, Cambridge University Press. 2019.
5. P. Phillips, Advanced solid-state Physics, Cambridge University Press. 2012.

PH-9012: Advance Plasma Physics (Cr.3)

Basic concepts of inertial and magnetic confinement fusion schemes, fusion reactor physics, thermonuclear fusion reaction criteria and driver requirements, scenario for ICF, fusion fuel burn physics. The physics of hydrodynamic compression, plasma hydrodynamic, shock wave propagation in plasmas, isentropic compression, hydrodynamic stability of the implosion process, equation of state models, and ablation driven compression. Energy transport in ICF plasmas, electron thermal conduction, thermal conduction inhibition, spontaneous magnetic field generation, supra-thermal electron transport, radiation transport models. Nonlinear mechanisms in plasmas, solitary waves and solitons, ion-acoustic solitary wave, the Korteweg-de-Vries (KdV) equation, ion-acoustic and Alfven wave solitons, Nonlinear Schrodinger equation, Nonlinear Landau damping, Bernstein-Greene-Kruskal (BGK) modes, and introduction to dusty plasmas with applications.

Recommended Books:

1. J. J. Duderstadt and G. A. Moses, Inertial Confinement Fusion, John Wiley & Sons, New York. 2012.
2. D. G. Swanson, Plasma Waves, IoP, Bristol and Philadelphia. 2013.
3. P. K. Shukla and A. A. Mamun, Introduction to Dusty Plasma Physics, IoP, Bristol and Philadelphia. 2015.
4. F. F. Chen, Introduction to Plasma Physics and controlled Fusion, Springer. 2016.
5. A. Piel, Plasma Physics: An introduction to Laboratory, Space and Fusion Plasma, Springer, 2015.

PH-9013: Advanced thin Film Technology 3(3-0)

Deposition by various PVD techniques such as evaporation, sputtering, ion-plating as well as chemical coating methods (CVD and ALD). Plasma technologies for thin films. Fundamental physical and chemical processes. Effect of the substrate on the film growth and techniques for surface modification. Models for nucleation and film growth. Morphology and texture and their impact on material properties. Applications of thin film materials and deposition technologies.

Recommended books

1. O. Milton, Materials science of thin films: deposition and structure, Elsevier, 2015.
2. K. Wasa et al., Thin films Materials Technology, Springer, 2012.
3. D. L. Smith, Thin-film deposition: principles and practice New York: McGraw-Hill, cop. 2005.
4. H. Frey, Handbook of Thin film technology, Springer, 2015.
5. A. Wagendristel, An introduction to Physics and Technology of Thin films, World Scientific, 2015

PH-9014 Advanced Characterization Techniques 3(3-0)

Importance of Rietveld refinement in XRD (fundamental), Lattice parameters, Structure analysis, Phase identification, Crystallite size analysis using Scherrer's formula, X-ray photoelectron spectroscopy (XPS), X-ray fluorescence (XRF), Energy dispersive X-ray analysis (EDAX).Crystal structure and phase identification determination by XRD (Biovia MS and phase identification by using relevant software). Field emission scanning electron microscope (FESEM), Atomic force microscopy (AFM), Scanning tunneling microscopy (STM), Transmission electron microscopy (TEM), High-resolution transmission electron microscopy (HRTEM). Ultraviolet-visible spectroscopy, Photo-luminescence spectroscopy, Fourier transform infrared (FTIR) spectroscopy, Raman spectroscopy, Nuclear magnetic resonance (NMR). Familiarization with the ultraviolet-visible absorption spectroscopy. Band gap calculation from photo-luminescence spectra. Nanomaterials Electrical and Magnetic Characterization Techniques: Measurement of resistivity by 4-probe method, Hall measurement, Measurement of magnetic of properties of nanomaterial

(Magnetic hysteresis and dielectric properties by LCR meter), Vibrating sample magnetometer. Mechanical Characterization Techniques: Elastic and plastic deformation-mechanical properties of materials, models for interpretation of nanoindentation load-displacement curves, Nanoindentation data analysis methods-Hardness testing of thin films and coatings, Mechanical properties evaluation by universal testing machine (UTM), Dynamic mechanical analysis. Physical and Optical Characterizations of Nanostructured Materials"Introduction to particle size characterization, Zeta potential measurement – Particle size analysis, specific surface area by BET analysis, Photoconductivity. Thermal and Electrochemical Characterization: Differential scanning calorimeter (DSC), Differential thermal analyzer (DTA), Thermogravimetric analysis (TGA), Electrochemical analysis (Charging-discharging cyclic voltammetry).

Recommended Books:

1. T. J. Bruno, ASM Handbook: Materials Characterization, ASM International, 2012.
2. Y. Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd., 2018.
3. R. F. Speyer, Thermal Analysis of Materials, Marcel Dekker Inc., New York, 2010.
4. K. Geoff Smith, M. Simons and B. Raguse, Nanotechnology-Basic Science and Emerging Technologies, Mick Wilson, , Overseas Press. 2015.
5. S. Zhang, Materials Characterization Techniques, Taylor & Francis, 2012.

PH-9015 Physics of Surface and Interfaces 3(3-0)

Geometrical lattice structure, surface morphology, electronic structure, surface composition, kinetics and dynamics (adsorption, vibrations, diffusion, desorption), structure and reactivity of surface molecules, catalysis and surface reactions. Surfaces of metals, oxides, semiconductors will be considered, as well as solid-solid and solid liquid interfaces, and confinement effects in 2D, 1D and 0D cases. Modern experimental methods (ultra-high vacuum based, and in air) will be discussed: theoretical bases, experimental aspects and data interpretation.

Recommended Books:

1. K. W. Kolasinski, Surface Science: Foundations of Catalysis and Nanoscience. 2nd ed.; Wiley & Sons: Chichester, England; Hoboken, NJ, 2015.
2. A. Zangwill, Physics at Surfaces. Cambridge University Press: New York, 2012.
3. D.P. Woodruff, T.A. Delchar, Modern Techniques of Surface Science. 2nd ed.; Cambridge University Press: New York, 2014.
4. J. C. Vickerman, Surface Analysis - The Principal Techniques. John Wiley: New York, 2015.
5. H. Ibach, Physics of Surfaces and Interfaces, Springer, 2016.

PH-9016 Medical Physics 3(3-0)

Interactions of lionizing Radiation with Matter: The development of radiotherapy, Radio therapeutic aims, External beam therapy, Brach therapy, unsealed source therapy, Medical Imaging: Radiation Dosimetry: The Bragg-Gray Cavity theory. Methods of Dosimetry: Health Physics: Cardinal principles of radiation protection, minimize time, Maximize distance, Maximize shielding, Time, Distance and shielding, Maximum permissible dose, whole-body occupational exposure, whole-body non-occupational exposure, partial body occupational exposure, X-ray and pregnancy, Basic radiation safety criteria, effective dose-equivalent, allowable limit on intake (ALI), inhaled radioactivity, derived air concentration, Gastrointestinal tract, Basis of radiation safety regulations

Recommended Books:

1. RIEGLER W. 2008, CERN, Academic Training Course.
2. Forty R. 2010, ICFA, Instrumentation School.
3. Armstrong P and L Martin. Diagnostic Imaging 4th Ed. Blackwell Science Ltd.
4. Bushong S C. 2019, Radiologic Science of Technologists. 5th Ed. Mosby.
5. Cember H. 2021, Introduction to Health Physics. 3rd Ed. McGraw Hill, New York.

PH – 9017 Antenna Design and Theory 3(3-0)

Theory and applications of transmission lines, Parallel plate transmission line, general transmission line equations, wave characteristics on finite transmission lines, transients on transmission lines, Smith chart transmission line

impedance matching, waveguides and cavity resonator, types of waveguides, Microwave network analysis: Impedance and equivalent voltages and currents, impedance and admittance, scattering matrix, transmission matrix, signal flow graphs, discontinuities and modal analysis, Antennas theory and radiating systems: Radiation fields of elemental dipoles, antenna patterns and antenna parameters, thin linear antennas, antenna arrays, internal impedance and directional pattern, effective area, back scattering cross section.

Recommended Books:

1. Peter A. Rizzi, *Microwave engineering: Passive circuits*, Prentice-Hall International, 2000.
2. David M. Pozar, *Microwave engineering*, 4th edition, John Wiley & Sons, 2005.
3. David K. Cheng, *Field and wave electromagnetics*, 2nd edition, Addition-Wesley, New York, 2006
4. W. M. Steen, J. Mazumder and K. G. Watkins, *Laser Material Processing*, Springer, 4th edition, 2010.

PH – 9018 Physics for renewable energy sources 3(3-0)

Promising renewable energy sources, their potential availability and present status, existing technologies and availability, solar energy: Sun-Earth relationship, solar geometry, sun path and solar irradiance, solar spectrum. Solar constant, atmospheric effects, heat transfer, transmission through glass, absorption transmission of sun energy, selective surfaces, performance, and efficiency, solar cell working, efficiencies, different types of solar cells, characteristics, (dark, under illumination), performance and applications, Wind: Global distribution, resource assessment, wind speed, height and topographic effects, power extraction for wind energy conversion, wind mills, their types, capacity, properties, wind mills for water lifting and power generation, environmental effect., Hydropower: Global resources, and their assessment, classification, micro, mini, small and large sources principles of energy conversion; turbines, their working and efficiency for micro to small power systems, environmental impact, Biogas: Biomass sources; residue, farms, forest. Solid wastes; agricultural, industrial and municipal wastes etc.; applications, Geothermal: Temperature variation in the earth, sites, potentials, availability, extraction techniques, applications; water and space heating, power generations, problems, environmental effects, nuclear: Global generations of reserves through reprocessing and breeder reactors, growth rate prospect of nuclear fusion, safety and hazards issue.

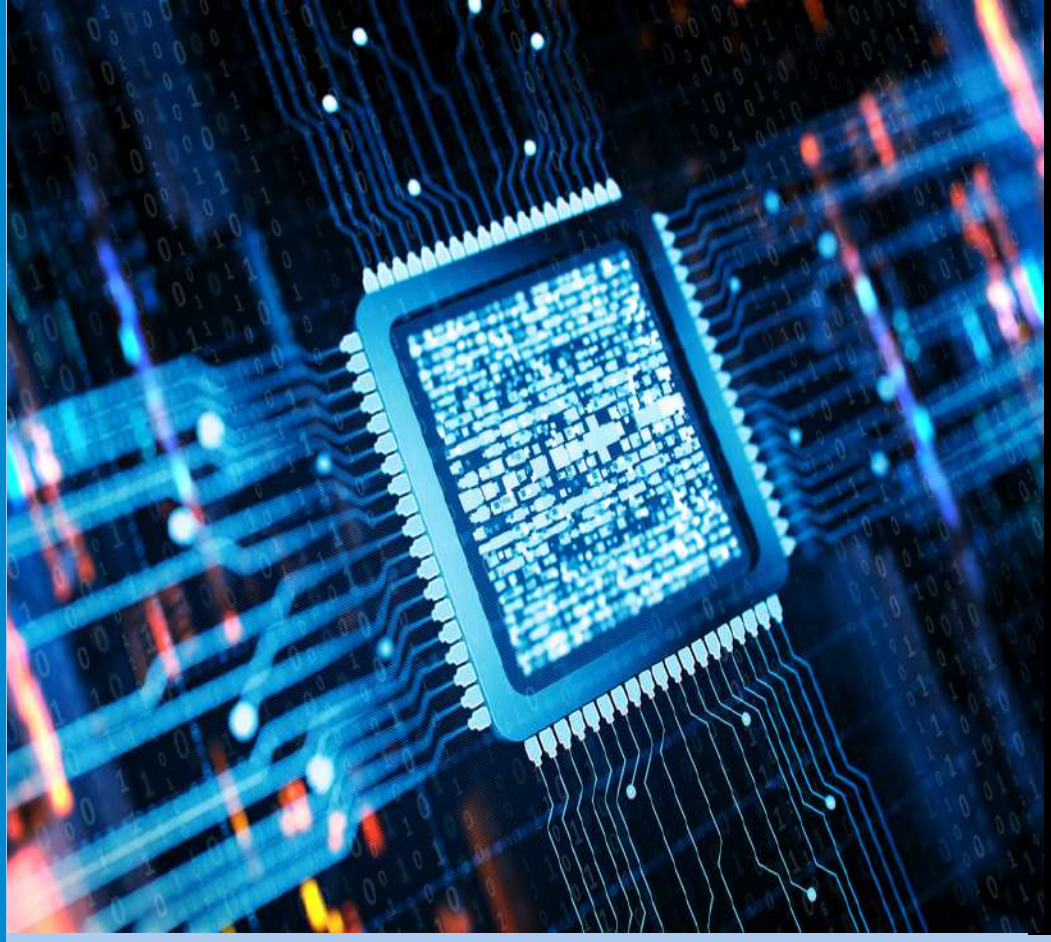
Recommended Books:

1. Manfred Grathwhol. World Energy Supply: Resources, Technologies and Prospective, Walter deGruyter-Berlin, Latest edition
2. J.W Twidell and A.D. Weir. Resources, E & F.N. Spon Ltd, London, Latest edition
3. M Iqbal. An Introduction to Solar Radiation, Academic Press, Canada, Latest edition
4. Simon Roberts. A Practical Guide to Solar Electricity, Prentice Hall, Latest edition
5. Martin A G. Solar cells: Operating Principles, Technology, & System Application, Prentice Hall, Latest edition

Career opportunities for students after completion of the program

This multidimensional academic program is designed to serve wide range of areas, significant to the socio-economic growth of the country and to produce professionals capable of contribution in latest developments at global level. The scope of services includes;

1. Atomic and space organizations
2. Forensic science
3. Meteorology
4. Electronics
5. Research laboratories
6. Health surveillance
7. Materials for alternate energy solutions
8. Radiology
9. environmental science
10. Renewable energy devices
11. Medical equipment with focus on sensory application.



GRADUATE PROGRAMS

MS COMPUTER SCIENCE

MS SOFTWARE ENGINEERING

PhD COMPUTER SCIENCE

DEPARTMENT OF COMPUTER SCIENCE

Department of Computer Science is committed to train and produce graduates who have extensive knowledge of the demanding fields that can be helpful for both the national and international industries such as in Software Design and Management, Computational Bioinformatics, Computer Networks, Database Systems, Artificial Intelligence Multimedia/Computer Graphics/ Image Processing and P arallel Computing. The Department of Computer Science offers MS Computer Science, MS Software Engineering and PhD Computer Science at postgraduate level.

Following degree programs are offered by Department of Computer Science

- MS Computer Science
- MS Software Engineering
- PhD Computer Science

1. MS COMPUTER SCIENCE

Department of Computer Science offers 2-years MS Computer Science (MSCS) program comprising 26 credit hours of course work and 6 credit hours of research work.

Program Learning Outcomes

No.	Attributes	Outcomes
PLO-1	Advanced Computing Knowledge	An ability to apply advanced knowledge of computer science and related domains for the solution of complex computing problems.
PLO-2	Problem Analysis	An ability to identify, formulate, research literature, and analyze complex computing problems reaching substantiated conclusions.
PLO-3	Design/Development of Solutions	An ability to design solutions for complex computing problems and develop systems, modules or algorithms that meet academic and industrial needs.
PLO-4	Investigation	An ability to investigate complex computing problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

Program Educational Objectives (PEOs)

1. Apply the advanced computing knowledge for solving real-world problems in general and areas of national importance in particular.
2. Adopt innovative approaches and pursue career growth by engaging in higher studies and/or conducting research in computing.

Eligibility Criteria

1. BS Computer Science / BS Information Technology / BS Software Engineering / M.Sc Computer Science / IT or 16 years equivalent degree from HEC recognized university/institute with a minimum CGPA 2.00/4.00 or first division in annual system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit Criteria

Admission merit will be prepared according to the following criteria:

BS or Equivalent	60% weightage
NTU GAT (General)	30% weightage
Interview Marks	10% weightage

Program Structure

Each MSCS student must has to complete **12** credits from **4** core courses, **14** credits from elective courses (must include Research Methodology and Functional Textiles) and **6** credits of research work to achieve the MSCS degree.

Semester-Wise Layout of Courses

Semester-I

Code	Course Title	Credit Hours
CSC-XXXX	Core Course-I	3
CSC-XXXX	Core Course -II	3
CSC-XXXX	Elective-I	3
CSC-XXXX	Elective-II	3
	Total	12

Semester-II

Code	Course Title	Credit Hours
CSC-XXXX	Core Course-III	3
CSC-XXXX	Core Course –IV	3
CSC-XXXX	Elective-III	3
CSC-5098	Elective-IV (Research Methodology)	3
	Total	12

Semester-III

Code	Course Title	Credit Hours
CSC-6072	MS Thesis-I	3
TEX-5078	Elective-V (Functional Textiles)	2
	Total	5

Semester-IV

Code	Course Title	Credit Hours
CSC-6072	MS Thesis-II	3
	Total Credit Hours	32

Registration in "MS Thesis - I" is allowed provided the student has:

a. Earned at least 18 credits
b. Passed the "Research Methodology" course; and
c. CGPA is equal to or more than 2.5

Core Courses for MS (Computer Science)

At least four courses must be taken from the following

CSC-5071 Advanced Analysis of Algorithms
CSC-5072 Advanced Operating Systems
CSC-5073 Theory of Programming Languages
CSC-5074 Advanced Computer Architecture
CSC-5076 Theory of Automata – II

List of Elective Courses

Sr. No.	Course Code	Course Title	Credit
1	CSE-5070	Advanced Computer Networks	3
2	CSE-5071	Research Methodology	3
3	CSE-5072	Data and Web Mining	3
4	CSE-5073	Intelligent User Interfaces	3
5	CSE-5074	Multimedia Database	3
6	CSE-5075	Computer Vision	3
7	CSE-5076	Knowledge Discovery in Databases	3
8	CSE-5077	Advanced Distributed Systems	3
9	CSE-5078	Advance Simulation & Modeling	3
10	CSE-5079	Rich Internet Applications	3
11	CSE-5080	Big Data Analytics	3
12	CSE-5081	Advanced Digital Image Processing	3
13	CSE-5082	Advanced Network Security	3
14	CSE-5083	Digital Signal Processing	3
15	CSE-5084	Parallel and Distributed Computing	3
16	CSE-5085	Control Systems and Robotics	3
17	CSE-5086	Real Time Operating Systems	3
18	CSE-5087	Advanced Networking	3
19	CSE-5088	Network Security	3
20	CSE-5089	Topics in Computer Networking	3
21	CSE-5090	Network Administration	3
22	CSE-5091	Advanced Artificial Intelligence	3
23	CSE-5092	Wireless Networks	3
24	CSE-5093	Complex Networks	3
25	CSE-5094	Network Performance Evaluation	3
26	CSE-5095	Web Mining	3
27	CSE-5096	Advanced Compiler Design-I	3
28	CSE-5097	Advanced Compiler Design-II	3
29	CSE-5098	Advanced Machine Learning Techniques	3
30	CSE-5099	Advanced Data Mining	3
31	TEX-5078	Functional Textile	2

(This list is not exhaustive and new courses can be added to this category at any time depending upon availability of the instructor)

MS (CS) Core Courses

Course Specifications

CSC-5071: Advanced Analysis of Algorithms

Advanced algorithm analysis including the introduction of formal techniques and the underlying mathematical theory. NP-completeness. Search Techniques. Randomized Algorithms. Heuristic and Approximation Algorithms. Topics include asymptotic analysis of upper and average complexity bounds using big-O, little-o, and theta notation. Fundamental algorithmic strategies (brute-force, greedy, divide-and-conquer, backtracking, branch-and-bound, pattern matching, and numerical approximations) are covered. Also included are standard graph and tree algorithms. Additional topics include standard complexity classes, time and space tradeoffs in algorithms, using recurrence relations to analyze recursive algorithms, non-computable functions, the halting problem, and the implications of non-computability. Algorithmic animation is used to reinforce theoretical results. Upon completion of the course, students should be able to explain the mathematical concepts used in describing the complexity of an algorithm and select and apply algorithms appropriate to a particular situation.

CSC-5072: Advanced Operating Systems

This course will cover Introduction to Characterization of Modern Operating Systems; file systems, memory management techniques, Process scheduling and resource management. In System Models architectural models, Inter process Communication, Issues of Security in Distributed Systems (Partial coverage), Distributed File System, Concurrency Control in Distributed Systems; Problems of Coordination and Agreement in Distributed Systems Replication, Advantages and requirements, Fault-tolerant services,Mobile and Ubiquitous Computing.

CSC-5073: Theory of Programming Languages

Understanding the underlying logic behind programming languages is vital for comprehending Computer Science concepts - ranging from programming to systems design. This course is designed to acquaint students with the subject matter and give them a groundwork for further study.

CSC-5074: Advanced Computer Architecture

This course forms a strong foundation for the understanding and design of modern computing systems. Building on a computer organization base, this course explores techniques that go into designing a modern microprocessor.

CSC-5076: Theory of Automata – II

Automata theory, formal languages, Turing machines, computability theory and reducibility, computational complexity, determinism, non-determinism, time hierarchy, space hierarchy, NP completeness, selected advanced topics.

MS (CS) Elective Courses

Course Specifications

CSE-5070: Advanced Computer Networks

This is a graduate level course. The emphasis will be to develop better realization and understanding of widespread Internet, diffused in our daily life as a reality. The course will introduce networking concepts and principles. It will focus on the major components of the Internet protocol suite. The course will train to be able to design and build network systems.

CSE-5071: Research Methodology

This course will provide an opportunity for participants to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. Participants will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests and determine how research findings are useful in forming their understanding of their work, social, local and global environment.

CSE-5072: Data and Web Mining

The objective of this course is to introduce basic concepts, tasks, methods, and techniques in data mining. The emphasis is on various data mining problems and their solutions with application on the web. Students will develop an understanding of the data mining process and issues, learn various techniques for data mining, and apply the techniques in solving data mining problems using data mining tools and systems. The course will also introduce major web mining techniques and develop knowledge and skills to discover useful information from data effectively. More specifically, web usage mining techniques for Web site management, user profiling, and personalization, as well as Web content and structure mining techniques, such as Web information retrieval and link analysis, aiming at supporting search engines will be explained and discussed.

CSE-5073: Intelligent User Interfaces

The increasing complexity of software and the proliferation of information makes intelligent user interfaces increasingly important. The promise of interfaces that are knowledgeable, sensitive to our needs, agile, and genuinely useful has motivated research across the world to advance the state of the art and practice in user interfaces that exhibit intelligence.The text covers the topic well.

CSE-5074: Multimedia Database

Introduction, Overview of Relational and Object- Relational Data Representations, Text/Document Databases, Multidimensional Data Structures, similarity- based search (spatial, image, audio), XML Databases, Temporal Data Models, Logical Frameworks.

CSE-5075: Computer Vision

Concepts behind computer-based recognition and extraction of features from raster images. Applications of vision systems and their limitations. Overview of early, intermediate and high-level vision, Segmentation, region splitting and merging, quad tree structures for segmentation, mean and variance pyramids, computing the first and second derivatives of images using the isotropic, Sobel and Laplacian operators, grouping edge points into straight lines by means of the Hough transform, limitations of the Hough transform, parameterization of conic sections. Perceptual grouping, failure of the Hough transform,perceptual criteria, improved Hough transform withperceptual features, grouping line segments into curves. Overview of mammalian vision, experimental results of Hubel and Weisel, analogy to edge point detection and Hough transform, Relaxation labelling of images, detection of image features, grouping ofcontours and straight lines into higher order featuressuch as vertices and facets.

CSE-5076: Knowledge Discovery in Databases

This course will introduce principles of data mining with a focus on unsupervised methods for high-dimensional and spatial data. In the first part of the course, after an overview of the course, we will study principles and selected data mining methods for clustering, classification, outlier detection, finding association rules, and spatial data mining, which will include index structures and basic query processing in spatial and multi-dimensional databases. The course will be strongly research oriented in both the lectures and the course projects.

CSE-5077: Advanced Distributed Systems

This course deals with the major recent developments in distributed systems technology. It explains the principles of distributed systems such as communication, naming, synchronization, replication, fault tolerance, and security using examples and case studies. It covers architectures in distributed systems, reflecting the progress that has been made in organizing distributed systems, and new topics such as peer-to-peer computing, sensor networks, web services, grid computing, virtualization, cloud computing and its roots in distributed systems mechanisms, and self-management of distributed systems. The course illustrates design concepts for each topic with concept-oriented assignments and a small high-level programming assignment. Students complete a term project on the design and implementation of a real distributed system.

CSE-5078: Advanced Simulation & Modeling

The course will introduce the basic concepts of computation through modeling and simulation that are increasingly being used by architects, planners, and engineers to shorten design cycles, innovate new products, and evaluate designs and simulate the impacts of alternative approaches. Students will use MATLAB to explore a range of programming and modeling concepts while acquiring those skills. They will then undertake a final project that analyzes one of a variety of scientific problems by designing a representative model, implementing the model, completing a verification and validation process of the model, reporting on the model in oral and written form, and changing the model to reflect corrections, improvements and enhancements.

CSE-5079: Rich Internet Applications

This course covers the concept and technology evolution regarding the internet applications and the

use of interface tools. Mainly, the course can focus on any one of the technologies of modern day, for example, macromedia's FLASH. However, the course will use the concepts of data structures, object oriented programming, programming languages and the software design and engineering to develop projects of medium to large magnitude.

CSE-5080: Big Data Analytics

The scope of this course is to impart the core knowledge and hands-on related to state of the art BDA technology stack and BDA infrastructures to students. Focus will be on the NoSQL database categories, i.e., document, key-value, wide columnar, and graph, along with Apache Hadoop and its strong relationship to BDA and the Lambda, Kappa, Zeta and HTAP big data architectures.

CSE-5081: Advanced Digital Image Processing

In this course, students will learn digital image processing techniques including representation, sampling and quantization, image acquisition, imaging geometry, image transforms, image enhancement, image smoothing and sharpening, and image restoration. More advanced topics include degradation models, image filtering, color image processing, and image segmentation.

CSE-5082: Advanced Network Security

This course is about the realization of IT Security on the level of network infrastructure. Usually security is implemented at single points of a network (e.g. at firewalls or on important servers). The perspective from a network infrastructure often is not taken care of. The growing complexity of Network structures brings along many risks for secure traffic and high availability. You will learn what kind of dangers there are on a network level and how efficient security measures can be implemented.

CSE-5083: Digital Signal Processing

One- and N-dimensional signals and systems, Sampling theorem, Discrete-time Fourier transform, discrete Fourier transform, fast Fourier transform, z-transforms, stability and minimum phase signals/systems, Linear filtering of signal, Time domain, Difference equations and convolution, Impulse invariance, bilinear transform, FIR filter design, 2D filter design, Statistical signal processing, Stochastic signals, correlation functions and power density spectra, Optimal filtering, Wiener filters, Adaptive filters, LMS and array processing.

CSE-5084: Parallel and Distributed Computing

Why use parallel and distributed systems? Why not use them? Speedup and Amdahl's Law, Hardware architectures, multiprocessors (shared memory), networks of workstations (distributed memory), clusters (latest variation). Software architectures, threads and shared memory, processes and message passing, distributed shared memory (DSM), distributed shared data (DSD). Possible research and project topics, Parallel Algorithms, Concurrency and synchronization, Data and work partitioning, Common parallelization strategies, Granularity, Load balancing, Examples, parallel search, parallel sorting, etc. Shared-Memory Programming, Threads, P-threads, Locks and semaphores, Distributed-Memory Programming, Message Passing, MPI, PVM. Other Parallel Programming Systems Distributed shared memory, Aurora, Scoped behavior and abstract datatypes, Enterprise, Process templates. Research Topics.

CSE-5085: Control Systems and Robotics

Review of classical control analysis methods. Nyquist stability criterion. Classical design using frequency domain methods, phase lead and lag controllers, PID controllers. Relay auto tuning. Introduction to state space methods. State space models, state transformations, solution of the state equations. Controllability and observability. Design using state feedback. LQR design, pole placement, use of observers. Introduction to robotics. Transducers, actuators and robot control.

CSE-5086: Real Time Operating Systems

The principles of real-time and embedded systems inherent in many hardware platforms and applications being developed for engineering and science as well as for ubiquitous systems, including robotics and manufacturing, interactive and multimedia, immersiveand omnipresent applications. Real-

time and quality of service system principles, understand real-time operating systems and the resource management and quality of service issues that arise, and construct sample applications on representative platforms. Platforms range from handheld and mobile computers to media and real-time server systems. Platforms may also include specialized systems used in application- specific contexts, such as autonomous robotics, smartsensors, and others.

CSE-5087: Advanced Networking

Review of basic concepts, The OSI Model, packet and circuit switching, network topology, ISDN. The TCP/ IP protocol stack, IP, ARP, TCP and UDP, DNS, ICMP, Internet Addressing, Routing, IP Multicast, RSVP, Next Generation IP – Ipng, Wireless, Radio basics, Satellite Systems, WAP, current trends, Issues with wireless over TCP. Congestion Control, Control vs. Avoidance. Algorithms, Congestion in the Internet. Mobile IP, Voice over IP (VoIP), VPNs, Network Security. Management, Quality of Service (QoS), network vs. Distributed systems management Protocols, web-based management.

CSE-5088: Network Security

Introduction, Cryptology and simple cryptosystems, Conventional encryption techniques, Stream and block ciphers, DES, More on Block Ciphers, The Advanced Encryption Standard. Confidentiality, Message authentication, Hash functions, Number theory and algorithm complexity, Public key Encryption. RSA and Discrete Logarithms, Elliptic curves, Digital signatures. Key management schemes, Identification schemes, Dial-up security. E-mail security, PGP, S-MIME, Kerberos and directory authentication. Emerging Internet security standards, SET, SSL and IPsec, VPNs, Firewalls, Viruses, Miscellaneous topics.

CSE-5089: Topics in Computer Networking

This course offers an advanced introduction and research perspectives in the areas of switch/router architectures, scheduling for best-effort and guaranteed services, QoS mechanisms and architectures, web protocols and applications, network interface design, optical networking, and network economics. The course also includes a research project in computer networking involving literature survey, critical analysis, and finally, an original and novel research contribution. Typical topics can be listed below, Overview of packet switching networks and devices. Fundamentals of Internet Protocol (IP) networking. Route lookup algorithms. Router architecture and performance. Detailed operation of Internet routing protocols such as Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP). Integrated and differentiated network service models. Traffic Engineering (TE) concepts and mechanisms including label assignment, label distribution, and constraint-based routing algorithms. Multi-protocol label switching and its generalization. Quality of service mechanisms for multimedia and real-time communications. TE-based routing and signaling protocols. Fundamentals of per-flow and aggregate scheduling algorithms. Application-level and network- level signaling protocols for data, voice, and video communications. Resource signaling and resource reservation protocols. Worst-case analysis for multimedia networking.

CSE-5090: Network Administration

Through completion of this course, students will be able to plan, install, and configure a web server, manage, monitor, and optimize a Web Server, and design and implement a Web Site on the Web Server created.

CSE-5091: Advanced Artificial Intelligence

The chief objective is to teach modern methods of probabilistic reasoning that are commonly used in many parts of computer science, including but not limited to artificial intelligence. Such methods have become extremely important and transforming the approach to a great variety of computational problems, in the field of computer science itself, and broadly across many application fields.

CSE-5092: Wireless Networks

This course covers fundamental techniques in design and operation of first, second, and third generation wireless networks, cellular systems, medium access techniques, radio propagation models, error control techniques, handoff, power control, common air protocols (AMPS, IS-95, IS-136, GSM, GPRS, EDGE, WCDMA,

cdma2000), radio resource and network management. As an example, for the third generation air interfaces, WCDMA is discussed in detail since it is expected to have a large impact on future wireless networks. This course is intended for graduate studentswho have some background on computer networks.

CSE-5093: Complex Networks

Networks are ubiquitous in our modern society, playing an increasingly larger role in everyday life. These include: Social networks such as Facebook or Twitter, infrastructure networks such as the Internet, or energy networks such as the electric grid. Network Science and Engineering is a new discipline that investigates the structure of large complex networks and their behavior and properties, and then designing technologies that control and manipulate their behaviors to bring about greater benefits to society. In this course, students will learn some of the basic tools, methods, and algorithms for analysis of networked systems, as well as practical applications of this new science.

CSE-5094: Network Performance Evaluation

This is an advanced course in networks and protocols. Analytical, simulation and experimental methods should be used to evaluate and design networks and protocols. Investigate network management tools and techniques.

CSE-5095: Web Mining

The Web is the largest collection of electronically accessible documents, which make the richest source of information in the world. The problem with the Web is that this information is not well structured and organized so that it would be easily retrieved. The search engines help in accessing web documents by keywords, but this is still far from what we need in order to effectively use the knowledge available on the Web. Machine Learning and Data Mining approaches go further and try to extract knowledge from the raw data available on the Web by organizing web pages in well-defined structures or by looking into patterns of activities of Web users. These are the challenges of the area of Web Mining. This course focuses on extracting knowledge from the web by applying Machine Learning techniques for classification and clustering of hypertext documents. Basic approaches from the area of Information Retrieval and text analysis are also discussed. The students use recent Machine Learning and Data Mining software to implement practical applications for web document retrieval, classification and clustering.

CSE-5096: Advanced Compiler Design-I

An in-depth study of compiler backend design for high-performance architectures. Topics include control-flow and data-flow analysis, classical optimization, instruction scheduling, and register allocation. Advanced topics include memory hierarchy management, optimization for instruction-level parallelism, modulo scheduling, predicated and speculative execution. The class focus is processor- specific compilation techniques, thus familiarity with both computer architecture and compilers is recommended

CSE-5097: Advanced Compiler Design-II

The course should consist of one or two major projects.Theoretical study should depend on the level of thefirst course Design I and the student needs.

CSE-5098: Advanced Machine Learning Techniques

This course provides a thorough introduction to the theoretical foundations and practical applications of Machine Learning (ML). We will learn fundamental algorithms in supervised learning and unsupervised learning. We will not only learn how to use ML methods and algorithms but will also try to explain the underlying theory building on mathematical foundations. While reviewing the several problems and algorithms to carry out classification, regression, clustering, and dimensionality reduction, we will focus on the core fundamentals which unify all the algorithms.

CSE-5099: Advanced Data Mining

The course will cover both basic and advanced data mining techniques in depth. The course will consist of a mixture of lectures by the instructor and presentations by the students. Each student is also expected to gain hands on experience by carrying out a semester long project on their topic of choice.

TEX-5078: Functional Textile

This intensive training short course is organized for the benefit of all those who are engaged in the manufacture, research and development as well as the commercial aspects of textile business. The course will cover the fibers, yarns and fabrics used in textile products for apparel, processing of fabrics, household and technical textiles applications as core modules. The different types of physical, chemical, mechanical and comfort related testing from fiber to finished product will also be covered during the course along with general understanding of the results. There will be hands-on workshops for different process for thorough understanding. The course will also cover recent trends related to environment and sustainability especially international standards and eco-innovation.

Career opportunities for students after completion of the program

1. Job in Public/Private sectors related to Computer Science
2. Provide research-oriented solutions to problems
3. Initiate a tech entrepreneurship
4. Pursue the PhD in relevant discipline
5. Provide consultancy
6. Provide advanced skills-oriented services online

2. MS SOFTWARE ENGINEERING

Department of Computer Science offers 2-years MS Software Engineering (MSSE) program comprising **26** credit hours of course work and **6** credit hours of research work.

Program Learning Outcomes (PLOs)

No.	Attributes	Outcomes
PLO-1	Advanced Computing Knowledge	An ability to demonstrate an understanding of advanced knowledge of the computer science, practice of software engineering from vision to analysis, design, validation and deployment.
PLO-2	Problem Solving	An ability to deal with complex software engineering problems and tasks by using modern software engineering principles, methodologies, and tools.
PLO-3	Investigation	An ability to identify, analyze, and ethically investigate the problems to develop solutions and strategies through reflective research processes.
PLO-4	Communication	An ability to effectively communicate both in oral and written forms.

Program Educational Objectives (PEOs)

1. Articulate their expertise in making technical contributions to design, develop, and solve problems in their practice of Software Engineering for better world.
2. Engaged in professional development or higher education to pursue flexible career paths adapting to future technological changes in Software Engineering and related fields.

Eligibility Criteria

1. BS in Computer Science/Bachelor of Computer Science/MSc in Computer Science, BSIT, BS in Software Engineering 4 year, BS Telecommunication or equivalent degree from HEC recognized university/ Institute with a minimum CGPA 2.00/4.00 or first division in annual system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit Criteria

Admission merit will be prepared according to the following criteria:

1. BS or Equivalent	60% weightage
2. NTU GAT (General)	30% weightage
3. Interview Marks	10% weightage

Semester-Wise Layout of Courses

Semester-I

Sr.No	Code	Course Title	Credit Hours
1	SEC-5071	Advanced Software System Architecture	3
2	SEC-5072	Advanced Software Requirement Engineering	3
3	SEE-XXXX	Elective-I	3
4	SEE-XXXX	Elective-II	3
		Total	12

Semester-II

Sr.No	Code	Course Title	Credit Hours
1	SEC-5073	Software Quality Assurance and Testing	3
2	SEE-XXXX	Elective-III	3
3	SEE-XXXX	Elective-IV	3
4	SEE-XXXX	Elective-V	3
		Total	12

Semester-III

Sr.No	Code	Course Title	Credit Hours
1	TE-5078	Elective-VI (Functional Textiles)	2
2	SEC-6072	MS Thesis-I	3
		Total	5

Semester-IV

Sr.No	Code	Course Title	Credit Hours
1	SEC-6072	MS Thesis-II	3
		Total Credit Hours	32

List of Elective Courses

Sr.	Code	Course Title	Credit Hours
1	SEE-5071	Research Methodology	3
2	SEE-5072	Software Risk Management	3
3	SEE-5073	Advanced Software Project Management	3
4	SEE-5074	Advanced Human Computer Interaction	3
5	SEE-5075	Agent Based Modelling and Simulation	3
6	SEE-5076	Software Measurement and Metrics	3
7	SEE-5077	Software Configuration Management	3
8	SEE-5078	Reliability Engineering	3
9	SEE-5079	Component Based Software Engineering	3
10	SEE-5080	Digital Image Processing Techniques	3
11	SEE-5081	Machine Learning Techniques	3
12	SEE-5082	Advanced Computational Intelligence	3
13	SEE-5083	Advanced Software System Architecture	3
14	SEE-5084	Design Patterns	3
15	SEE-5085	Complex Networks	3
16	SEE-5086	Formal Methods	3
17	SEE-5087	Software Engineering Ontologies	3
18	SEE-5088	Semantic Based Software Engineering	3
19	SEE-5089	Model Driven Software Development	3
20	SEE-5090	Software Process Engineering	3
21	TEX-5078	Functional Textile	2

(This list is not exhaustive and new courses can be added to this category at any time depending upon availability of the instructor)

MS (SE) Core Courses

Course Specifications

SEC-5071: Advanced Software System Architecture

Definition and overview of software architecture, the architecture business cycle, Understanding and achieving quality attributes, Attribute-driven design, Documenting software architecture, Evaluating software architecture, Architecture reuse Life-cycle view of architecture design and analysis methods, The QAW, a method for eliciting critical quality attributes, such as availability, performance, security, interoperability, and modifiability, Architecture Driven Design, Evaluating a software architecture (ATAM, CBAM, ARID), Principles of sound documentation, View types, styles, and views; Advanced concepts such as refinement, context diagrams, variability, software interfaces, and how to document interfaces; Documenting the behavior of software elements and software systems; Choosing relevant views; Building a documentation package, Future of Software Design, Architecture Description Languages, Introduction to AADL , AADL: Continued , Testing Architectures, Feature Modeling in SPLs, Testing a Family of Products.

SEC-5072: Advanced Software Requirements Engineering

Role of requirements engineering in system development, Fundamental concepts and activities of requirements engineering, Information elicitation techniques, Fundamentals of goal-oriented requirements engineering, Modeling behavioral goals, Modeling quality goals, Goal modeling heuristics, Deriving operational requirements from goals, Requirements Specification, Requirements verification and validation, Management of inconsistency and conflict, requirements engineering risks, requirement change control board and process, the role of quality goals in the requirements selection process, Techniques for requirements evaluation, selection and prioritization; Requirements management; Requirements traceability and impact analysis.

SEC-5073: Software Quality Assurance and Testing

What Is Software Quality: Quality Assurance, Quality Engineering Software Testing: Testing: Concepts, Issues, and Techniques, Test Activities, Management, and Automation, Coverage and Usage Testing Based on Checklists and Partitions, Input Domain Partitioning and Boundary Testing, Coverage and Usage Testing Based on Finite-State Machines and Markov Chains, Control Flow, Data Dependency, and Interaction Testing, Testing Techniques: Adaptation, Specialization, and Integration. Quality Assurance Beyond Testing: Defect Prevention and Process Improvement, Software Inspection, Formal Verification, Fault Tolerance and Failure Containment, Comparing Quality Assurance Techniques and Activities. Quantifiable Quality Improvement: Feedback Loop and Activities for Quantifiable Quality Improvement, Quality Models and Measurements, Defect Classification and Analysis. Risk Identification for Quantifiable Quality Improvement, Software Reliability Engineering.

MS (SE) Elective Courses

Course Specifications

SEE-5071: Research Methodology

This course will provide an opportunity for participants to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. Participants will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests and determine how research findings are useful in forming their understanding of their work, social, local and global environment.

SEE-5072: Software Risk Management

Risk-Management Discovery, Risk-Management Process, Process steps, inputs, and outputs, Methods and tools, reusable process component. Risk-Management Infrastructure, Training metrics, establishing a baseline for quantitative process improvement, infrastructure, there is no strategic plan in place to

institutionalize risk management. Senior managers, engineering managers, and change agents should benefit from these organizational building blocks. Risk-Management Implementation, standard process, Risk management activities, lifecycle planning, budgeting, scheduling, and staffing. Crisis and Control, risk-management evolution stages, Effective and ineffective practices.

SEE-5073: Advanced Software Project Management

The course provides an in depth examination of project management principles and modern software project management practices. At the end of the course the students will be able to explain principles of the project lifecycle and how to identify opportunities to work with learners on relevant and appropriate project scenarios to share this understanding. Critically evaluate and discuss the issues around project management and its application in the real world with course participants and learners. Objectives of the course includes: Understanding the five process groups and nine knowledge areas of the PMI BOK. To understand approaches for managing and optimizing the software development process. To understand efficient techniques for managing each phase of the systems development lifecycle and to use and application of tools to facilitate the software project management process (e.g. Microsoft Project). Methods for managing and optimizing the software development process are discussed along with techniques for performing each phase of the systems development lifecycle.

SSE-5074: Advanced Human Computer Interaction

The course will provide students with a theoretical framework for, and practical familiarity with, the current technologies and research directions in the field of computer user interface technologies. This course will cover the underlying software infrastructure to support modern user interface technologies and elucidate the distinctions among different approaches to user interface and their evaluation. This course will assume knowledge of traditional user interface technologies and provide a deeper understanding of state-of-the-art and future research directions for user interfaces. It will also cover types and structures of information resources; Types and structures of vocabularies; Information retrieval & Interaction in information retrieval Search engines, Digital libraries; Search techniques and effectiveness; Advanced searching Web search and the invisible web; Information seeking behavior; User modeling; Mediation between search intermediaries and users; Evaluation of search sources and results; Result Presentation to users; Keeping up: sources for life-time learning.

SEE-5075: Agent Based Modeling and Simulation

This course covers the advance topics of modeling and simulation such as developing models, executing simulations, analyzing results, calibrating models, verification and validation of models.

SEE-5076: Software Measurement and Metrics

This course is an in-depth study of software measurement and estimation with an introduction to financial measurements. The successful student will learn to measure and predict the size, complexity, and quality of software development projects by a variety of methods. Commercially available tools are used, as well as engineering rules, benchmarks, and a variety of predictive/estimation methodologies.

SEE-5077: Software Configuration Management

Source Code Management, Build Engineering, Environment Configuration, Change Control, Release Management, Deployment, Architecting Your Application for CM, Hardware Configuration Management, Rightsizing Your Processes, Overcoming Resistance to Change, Personality and CM: A Psychologist Loads at the Workplace, Learning from Mistakes, Establishing IT Controls and Compliance, Industry Standards and Framework.

SEE-5078: Reliability Engineering

Every engineer should be aware of customer needs expressed in terms of reliability requirements. A successful product/system need to translate these requirements and ensure that the reliability requirements are met. It is essential to understand terms and how they are evaluated. At present most products need to provide reliability information along with functions. This course will help students to know this important aspect and way to address these requirements.

SEE-5079: Component Based Software Engineering

Introduction to CBSE, Reuse, Basic Concepts in CBSE, Modeling components with UML, Open-COM component model, Fractal component model, Component Models and Technology, Component contracts component specification techniques, Component integration and Predictable composition, Service Oriented Computing - Key Concepts and Principles, SOA.

SEE-5080: Digital Image Processing Techniques

In this course, students will learn digital image processing techniques including representation, sampling and quantization, image acquisition, imaging geometry, image transforms, image enhancement, image smoothing and sharpening, and image restoration. More advanced topics include degradation models, image filtering, colour image processing, and image segmentation.

SEE-5081: Machine Learning Techniques

This course provides a thorough introduction to the theoretical foundations and practical applications of Machine Learning (ML). We will learn fundamental algorithms in supervised learning and unsupervised learning. We will not only learn how to use ML methods and algorithms but will also try to explain the underlying theory building on mathematical foundations. While reviewing the several problems and algorithms to carry out classification, regression, clustering, and dimensionality reduction, we will focus on the core fundamentals which unify all the algorithms.

SEE-5082: Advanced Computational Intelligence

This course covers rule-based expert systems, fuzzy expert systems, frame-based expert systems, artificial neural networks, evolutionary computation, hybrid intelligent systems and knowledge engineering. The aim of this course is to acquaint students with intelligent systems and provide them with working knowledge for building these systems.

SEE-5083: Advanced Software System Architecture

This course aims to present the most industry-relevant techniques in the area of architectural design and provide the means to document software architectures with standards like UML. It also provides the participants with the necessary knowledge to reduce the technical debt in the software development projects they work on. Moreover, the course has a hands-on approach, which translates into actionable know-how that is relevant to the professional practice of software design.

SEE-5084: Design Patterns

Overview of Object-Oriented Analysis and Design, Design Patterns (Concepts, Major issues, Reuse of ideas), Creational Patterns, Structural Patterns, Behavioral Patterns. Applications of design patterns for: Organization of Work, Access Control, Service Variation and Service Extension, Object Management and Adaptation, Architectural Patterns, Patterns for Distribution, Patterns for Interactive Systems, Adaptable Systems. Frameworks and Patterns, Idea of frameworks, Patterns for flexibility, achieving benefits of frameworks, Failures of frameworks.

SEE-5085: Complex Networks

What are networks and why networks, Erdos-Renyi random, small-world and scale-free network models, Calculation of basic measures in networks, Degree and eccentricity Centrality, Shortest path between start and end nodes, case study of calculation, Clustering coefficient, Matching index and case study, Network tools overview, Pajek, Network Workbench, Gephi, Visone, Cytoscape, Centibin, Network Simulation (Agent-based simulation of networks), Biological networks, Social Networks, Scientometric study using Networks, Modelling Communication Networks as graphs/networks, Disk Graph models such as WSNs.

SEE-5086: Formal Methods

Introduction to Formal methods, Introducing Z, Elements of Z, Logic, Using Predicates in Z, Schemas and Schema Calculus, Formal Reasoning, Case Studies in Z, Computer Graphics and Computational Geometry. Rule-Based Programming, Graphical User Interface, Safety-Critical Protection System, Modeling Large Systems, Object-Oriented Programming Model and Z, Concurrency and Real-time, Refinement, Program

Derivation and Formal Verification, Converting Z into Code.

SEE-5087: Software Engineering Ontologies

The software engineering ontology defines common sharable software engineering knowledge including particular project information. Reaching a consensus of understanding is of benefit in a distributed multi-site software development environment. Software engineering knowledge is represented in the software engineering ontology whose instantiations are undergoing evolution. Software engineering ontology instantiations signify project information which is shared and has evolved to reflect project development, changes in software requirements or in the design process, to incorporate additional functionality to systems or to allow incremental improvement, etc.

SEE-5088: Semantic Based Software Engineering

This course is a family of recently emerged technologies particularly well suited for managing and sharing large volumes of heterogeneous, rapidly evolving data. This course is an introductory course covering the Semantic Web languages RDF(S), OWL, and SPARQL. The course is a combination of lectures covering both practical and theoretic aspects of the aforementioned languages and extensive hands-on sessions on modelling and querying semantic knowledge bases.

SEE-5089: Model Driven Software Development

Model Driven Software Development (MDSD) has become a popular way of building software systems. The promise of MDSD is to improve the quality of the developed systems, including extensibility, reusability, and maintainability. The purpose of this course is to show how models can be profitably used during the development of software systems.

SEE-5090: Software Process Engineering

Engineering of the software development process including software life-cycle, maturity models, process programming, and process management. This course considers both theory and practice of engineering large, long-lived software systems, including process analysis, modeling, workflows, standards, process environments and tools, automation, and organizational context. Case studies illuminate the application of software process theory to engineering practice. Students will work in teams to analyze and develop software management plans and tools.

TEX-5078: Functional Textile

This intensive training short course is organized for the benefit of all those who are engaged in the manufacture, research and development as well as the commercial aspects of textile business. The course will cover the fibers, yarns and fabrics used in textile products for apparel, processing of fabrics, household and technical textiles applications as core modules. The different types of physical, chemical, mechanical and comfort related testing from fiber to finished product will also be covered during the course along with general understanding of the results. There will be hands-on workshops for different process for thorough understanding. The course will also cover recent trends related to environment and sustainability especially international standards and eco-innovation.

Career opportunities for students after completion of the program

1. Applications development
2. Cyber security Analyst
3. Game Developing
4. Information Systems Manager
5. IT Consultant
6. Multimedia Programmer
7. Web Developer
8. Web Designer

3. PhD COMPUTER SCIENCE

The Department of Computer Science offers **3** to **8** years PhD Program in Computer Science comprising **18** credit hours of course work and **30** credit hours of research work.

Aims and Objectives

1. To promote high achievement in theoretical and practical problems within the field of computer science and to address the burgeoning education demands for graduates and professionals with advanced Computer Science education.
2. To offer students a solid background in core areas and exposure to cutting-edge research in computer science.
3. To improve the qualifications, skills, and expertise of teachers and researchers to provide highlycompetent professionals to various public and private universities.

Eligibility Criteria

1. MS / M.Phil (Computer Science / IT / Software Engineering) or equivalent degree with minimum 3.00/4.00 or 3.50/5.00 CGPA in semester system, 60% marks in annual system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test with minimum 60% score or NTU-GAT (Subject) test with minimum 50% score in case of different qualification as per HEC.
3. Applicant having MS or equivalent degree without thesis is not eligible to apply.
4. It is mandatory to pass interview in order to compete on merit.
5. Applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
6. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final MS/M.Phil or equivalent official transcript or degree.
7. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
8. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Merit Criteria

Admission merit will be prepared according to the following criteria:

▪ M.Sc./MS/Equivalent	60 % weightage
▪ B.Sc./BS/Equivalent	20% weightage
▪ Interview result	10 % weightage
▪ Publication/Relevant experience	10% weightage (05%+05%)

Semester-Wise Layout of Courses

Semester-I

Code	Subject Title	Credit Hours
CSC-XXXX	Core-1	3
CSC-XXXX	Core-2	3
CSC-XXXX	Elective-I	3
	Total	9

Semester-II

Code	Subject Title	Credit Hours
CSC-XXXX	Elective-II	3
CSC-XXXX	Elective-III	3
CSC-XXXX	Elective-IV	3
	Total	9

Semesters-III-VIII

Code	Subject Title	Credit Hours
1	Research Thesis	30

(This list is not exhaustive, and new courses can be added to this category at any time depending upon the availability of the instructor)

List of Core Courses

Sr. No.	Code	Course Title	Credit Hours
1	CSC-7071	Advanced Research Methods	3
2	CSC-7072	Research Seminars	3
3	CSC-707X	Mathematics for Computer Science	3
4	CSC-707X	Formal Specification and Verification	3

List of Elective Courses

Sr. No.	Code	Course Title	Credit Hours
1	CSE-7001	Advanced Computer Vision	3
2	CSE-7002	Advanced Human Information Interaction	3
3	CSE-7003	Advanced Research Topics in Big Data Analytics	3
4	CSE-7004	Advanced Data Visualization Techniques	3
5	CSE-7005	Advanced Topics in Data Science	3
6	CSE-7006	Advanced Computational Intelligence	3
7	CSE-7007	Evolutionary Computation	3
8	CSE-7008	Advanced Topics in Digital Image and Video Processing with Applications	3
9	CSE-7009	Advanced Topics in Requirement Engineering	3
10	CSE-7010	Advanced Data Analytical Techniques	3
11	CSE-7011	Advanced Topics in Digital Image Processing	3
12	CSE-7012	Deep Learning and its Applications	3
13	CSE-7013	Advanced Topics in verification and validation	3
14	CSE-7014	Advanced Big Data Analytics	3
15	CSE-7015	Biomedical Image Processing	3
16	CSE-7016	Advanced Machine Learning	3
17	CSE-7017	Advanced Research Topics in Cyber Security	3
18	CSE-7018	Advanced Topics in Requirement Engineering	3
19	CSE-7019	Advanced Topics in Software Engineering	3
20	CSE-7020	Information Architecture	3
21	CSE-7021	UX Related to Mobile and Desktop Technologies	3
22	CSE-7022	Advanced Decision based Systems (Decision Science)	3
23	CSE-7023	Network Penetration Testing and Countermeasures	3
24	CSE-7024	Deep Reinforcement Learning	3
25	CSE-7025	Modeling of Web Information Systems	3
26	CSE-7026	Data Warehousing	3
27	CSE-7027	Peer-To-Peer Systems	3
28	CSE-7028	Multimedia Retrieval Techniques	3
29	CSE-7029	Metadata for Information Resources	3
30	CSE-7030	Information Privacy and Access Control	3
31	CSE-7031	Ubiquitous Information Interaction	3
32	CSE-7032	Collaborative Data Mining	3
33	CSE-7033	Communication Networks	3
34	CSE-7034	Advances in Next-Generation Networks	3
35	CSE-7035	P2P-based Information Retrieval	3
36	CSE-7036	Advanced Software Architecture	3
Sr. No.	Code	Course Title	Credit Hours
37	CSE-7037	Artificial Intelligence	3
38	CSE-7038	Advanced topics in Machine Learning	3
39	CSE-7039	Advanced Data Analytics	3

Course Specifications

CSC-7071: Advanced Research Methods

Overview of the course and a brief history; Introduction and overview of the subject. The nature of Computer Science (CS) research; what is research? Literature searches, information gathering, Reading and understanding research papers, Technical writing, referencing, bibliographies, presentation skills, written and oral. Choosing or proposing a project. Project planning, tools, and techniques for planning. Project conduct, time management, risk management, and teamwork. Commercial and economic considerations in IT research and the IT industry. Review legal, ethical, social, and professional (LSEP) issues, including data protection and standards.

CSC-7072: Research Seminar

This course offers a substantial introduction relevant to doctoral work in student's research areas. The course provides directed and supervised the investigation of selected topics. Each week Research papers related to the topic will be discussed and presented in a seminar format. This course progresses as a series of seminars, each presenting a different paper(s). It prepares students to review studies of other researchers in the field and allows them to become more knowledgeable about methods appropriate to their dissertation research.

CSC-707X: Mathematics for Computer Science

This course covers elementary discrete mathematics for computer science and engineering. It emphasizes mathematical definitions and proofs as well as applicable methods. Topics include formal logic notation, proof methods; induction, well-ordering; sets, relations; elementary graph theory; integer congruencies; asymptotic notation and growth of functions; permutations and combinations, counting principles; discrete probability. Further selected topics may also be covered, such as recursive definition and structural induction; state machines and invariants; recurrences and generating functions.

CSC-707X: Formal Specification and Verification

The course will provide an overview of the challenges of vision, the common approaches and current techniques. While specific examples and applications may be used to illustrate, the focus will be on fundamental techniques and algorithms. We assume no prior knowledge of computer vision but still aim to study many modern and state-of-art techniques.

CSE-7001: Advanced Computer Vision

Problem in Software Development, Formal Methods for the problems, Three levels of formal method, Design Process Uses, Automated Proof, Formal Languages, Validation, Precedence, Set operators, Power sets, Subjects and predicate, Symbolization Convention, Negative Quantifiers, Binary Relations, Reflexivity, Restricted Kind of Relation, Function Application, Sequences, Sequence Filtering, Theory of Equality, Set Difference, Domain Restriction Operator.

CSE-7002: Advanced Human Information Interaction

The course will provide students with a theoretical framework for, and practical familiarity with, the current technologies and research directions in the field of computer user interface technologies. This course will cover the underlying software infrastructure to support modern user interface technologies and elucidate the distinctions among different approaches to user interface and their evaluation. This course will assume knowledge of traditional user interface technologies and provide a deeper understanding of state-of-the-art and future research directions for user interfaces. It will also cover types and structures of information resources; Types and structures of vocabularies; Information retrieval & Interaction in information retrieval Search engines, Digital libraries; Search techniques and effectiveness; Advanced searching Web search

and the invisible web; Information seeking behavior; User modeling; Mediation between search intermediaries and users; Evaluation of search sources and results; Result Presentation to users; Keeping up: sources for life-time learning.

CSE-7003: Advanced Research Topics in Big Data Analytics

This course explores current research and practice in data science and analytics, extending students' knowledge and understanding of the principles and practice of obtaining data from various sources, the essential methods for pre-processing and cleaning data, data analytics and modelling.

CSE-7004: Advanced Data Visualization Techniques

In this information age, the use of visualizations is increasing every day. With the growing number of visualizations, visualization literacy, the ability to read, interpret, and create data visualizations is becoming as important as reading and writing texts. Everyone needs to have visualization literacy to avoid misuse and misinterpretation of data visualizations. Visualization literacy does not only include reading and interpreting data representations, but it also includes the ability to critically review, effectively interact, carefully design and develop data visualizations. In this course, we will go over visualization principles, showcase examples of standard visualizations, and the steps needed to design and develop a comprehensive data visualization. I will advise students on all the necessary steps from ideation to the final delivery of their project. As delivering a working data visualization is one of the main goals of this course, we do not have an examination for this course. Rather, the student evaluation throughout the term is divided into their performance in-class activities, their assignments (i.e., literature review, visualization topic presentation), and all steps of the visualization design project.

CSE-7005: Advanced Topics in Data Science

This course introduces advanced methods for data wrangling, data visualization, and statistical modeling and prediction. Topics include big data and database management, basic Bayesian methods, nonlinear statistical models, unsupervised learning, and topic models. The final module will consist of multiple deep learning subjects such as CNNs, RNNs and Autoencoders.

CSE-7006: Advanced Computational Intelligence

This course is a continuation of the Computational Intelligence course and is focused on advanced models and advanced optimization techniques to raise the performance of the developed models as well as to give broader knowledge how to construct advanced knowledge-based CI and AI solutions. It is intended to give students a deep knowledge and experience about popular solutions and efficient neural network models as well as to learn how to construct and train intelligent learning systems in order to use them in everyday life and work. During the course, we will deal with the popular and most efficient models and methods of neural networks, fuzzy systems and other learning systems that enable us to find specific highly generalizing models solving difficult tasks. We will also tackle with various CI and AI problems and work with various data and try to model their structures in such a way to optimize operations on them throughout making data available without necessity to search for them. This is a unique feature of associative structures and systems. These models and methods will allow us to form and represent knowledge in a modern and very efficient way which will enable us to mine it and automatically draw conclusions. You will be also able to understand solutions associated with various tasks of motivated learning and cognitive intelligence. We will focus on the optimization and performance of the developed models. We will also try to develop advanced and complex knowledge-based AI and CI systems, e.g. linguistic systems (chatbots), speech recognition systems, or self-adapting systems adaptable to different computational tasks.

CSE-7007: Evolutionary Computation

Evolutionary Computation can be considered as a sub-field of Artificial Intelligence. Evolutionary algorithms are inspired by the principles of natural selection and genetics. This course explores how principles from theories of evolution and natural selection can be used to construct machines that exhibit nontrivial behavior. In particular, the course covers techniques from genetic algorithms, genetic programming, and learning classifier systems for developing software agents capable of solving problems as individuals and as members of a larger community of agents.

CSE-7008: Advanced Topics in Digital Image and Video Processing with Applications

The course will expose students to all stages of the image and video processing pipeline. Starting from acquisition, the students will learn how images are captured and represented. They will learn about sampling theory, different image and video formats, and the basics of color theory. Next, the students will be introduced to various image and intensity transformations as well as filtering. The course will discuss Fourier transform and concepts such as convolution, high- and low-pass filter in both primary and frequency domains. The above topics will build the foundation for more advanced topics in image and video processing, such as restoration and enhancement. To this end, the course will also discuss different image decomposition techniques such as Gaussian, Laplacian pyramids, wavelet transform, and more advanced filtering strategies such as cross-bilateral filtering. Final lectures will introduce students to the most recent developments in image and video processing, which involve machine learning techniques. The students will learn about basic techniques which exploit neural networks in the context of image and video processing.

CSE-7009: Advanced Topics in Requirement Engineering

Requirements engineering is an integral part of every (software) development process. The specification gained during requirements engineering defines the baseline for the product and acts as a starting point for (formal) verification and testing. The process of obtaining requirements themselves, ensuring that requirements fulfil certain properties (e.g. having no inconsistencies or errors) and using requirements in formal verification and testing is an active research topic. This course will also cover requirements elicitation, analysis, specification, validation, verification, user experience design, test-driven development and continuous integration. Includes a substantial individual research project.

CSE-7010: Advanced Data Analytical Techniques

In this hands-on course, students will cover a variety of analytics tools, such as histograms, ANOVA analysis, A/B testing, Pareto analysis, clustering, box plots, scatter diagrams, partitioning, unstructured text analysis, and multivariate regression analysis. Best of all, no background in statistics or programming is required. As long as students have a basic understanding of spreadsheets, they will learn how to manipulate complex data sets so they can gain insights that are not possible with common business intelligence techniques. This course will provide students with Advanced Data Analysis skills to enable them to improve the planning, monitoring, and performance of their organization. This will strengthen their ability within the workplace, allowing you to understand, produce and evaluate data to support them in your role for the benefit of yourself and your organization.

CSE-7011: Advanced Topics in Digital Image Processing

This course teaches students advanced concepts in digital image processing, with explanations and examples that demonstrate how the topics can be applied to remotely sensed images. The course begins with a review of resolution, including spatial, spectral, temporal, and radiometric resolutions. Then the student has the option to choose between the next two modules; discrete image transforms and image quality metrics. The coverage of discrete image transforms includes theory and examples of sinusoidal, rectangular-waveform, eigen-based, and wavelet transforms. The unit on image quality metrics includes information about manual ratings, mean-square-error, signal-to-noise ratios, etc. After these two modules are completed, the student has the option of three more modules: image enhancement and restoration, image compression, and automated image analysis. For image enhancement, the student is introduced to noise models, as well as various spatial and spectral filters for noise removal. The image compression module introduces the student to transform-based compression schemes, with examples of lossy and lossless schemes. Finally, the automated image analysis module introduces the theory and practical application of 1) segmentation methods, including windowing, thresholding, edge detection, and morphological processing; 2) feature extraction methods, such as shape and texture features; and 3) feature reduction and optimization methods.

CSE-7012: Deep Learning and its Applications

Deep learning and artificial intelligence is deemed one of the most important revolutions in computer science in the past decade. It has been demonstrated to be extremely effective in learning and prediction tasks, such as computer vision, natural language processing, robotics and so on. The development in the field is so fast (with hundreds of papers in one week) that it becomes rather hard for individual researchers and students

to catch up. Therefore, a class covering recent advances in deep learning is extremely timely and important. The course aims to introduce recent important advances in deep learning models, such as deep reinforcement learning, meta-learning, Generative Adversarial Networks (GAN), Variational autoencoders, graph neural networks and interpretation of neural networks. Enrolled students should have basic knowledge in machine learning and deep learning, basic skills in conduct independent research, and programming skills. In the class, the students will have guided discussions on recent papers of advance topics in deep and conduct course project to utilize the knowledge discussed in the class. At the end of the course, the students are expected to be able to do the following: (1) understanding the mathematical formulation of different types of deep learning models; (2) apply deep learning models to real-world applications; (3) developing novel deep learning models for applications of their interest, preferably publishable in top conferences in machine learning.

CSE-7013: Advanced Topics in Verification and Validation

In this course students will learn analytical techniques and tools for verification and validation, which are two key activities in developing higher quality software systems. Conceptually, verification addresses the problem of determining if we are building the system right, and validation addresses the problem of determining if we are building the right system. The course is organized as a series of research/tool paper presentations and discussions. The selected papers will cover traditional and state-of-the-art techniques. The course content will cover some topics from specification languages and tool-sets, techniques for dynamic analysis, such as white box and black box testing, equivalence partitioning, test criteria and automation, regression testing and debugging, techniques for static analysis, such as shape analysis, techniques for systematic software testing, such as symbolic execution and model checking, including explicit-state, stateless, and bounded model checking, as well as heuristics-driven techniques, such as those that employ genetic algorithms or other artificial intelligence based heuristics. Parallel and incremental techniques may also be covered depending on the specific papers chosen.

CSE-7014: Advanced Big Data Analytics

This course teaches how to apply the growing body of ML algorithms to various Big Data sources in a business context. By the end of this course students will have a better understanding of processes, methodologies and tools used to transform the large amount of business data available into useful information and support business decision making by applying ML algorithms. The focus of the course is less on the technical aspects of ML algorithms and more on the application of ML algorithms to Big Data available in different domain. The course will use R as the primary data analysis platform and Microsoft Azure as cloud platform for execution and deployment of ML projects. Prior experience with R or Microsoft Azure is not required. Students are assumed to be familiar with basic statistics.

CSE-7015: Biomedical Image Processing

The Biomedical imaging course prepares students with a knowledge of medical imaging and gives hands on experience with ultrasound imaging, dual-energy x-ray absorptiometry (DEXA), spectral imaging, and medical image processing labs. This course covers various medical imaging modalities, such as planar xray, x-ray computed tomography (CT), DEXA, magnetic resonance imaging (MRI), nuclear medicine imaging - positron emission tomography (PET) & single-photon emission computed tomography (SPECT), ultrasound imaging, and spectral imaging. Students will also gain hands on experience with medical image processing software to import CT or MRI scans and construct 3D models of the human anatomy. The course introduces the fundamental physical and engineering principles used in medical imaging and image processing. The primary focus of this course will be on physical principles, instrumentation methods, and image processing methods. Strengths, limitations, sensitivity, and appropriate applications for each modality of imaging will be examined as well.

CSE-7016: Advanced Machine Learning

This course focuses on recent advances in machine learning and on developing skills for performing research to advance the state of knowledge in machine learning. The material integrates multiple ideas from basic machine learning and assumes familiarity with concepts such as inductive bias, the bias-variance trade-off, the curse of dimensionality, and no free lunch. Topics range from determining appropriate data

representations and models for learning, understanding different algorithms for knowledge and model discovery, and using sound theoretical and experimental techniques in assessing learning performance. Specific approaches discussed cover nonparametric and parametric learning; supervised, unsupervised, and semi-supervised learning; graphical models; ensemble methods; and reinforcement learning. Topics will be discussed in the context of research reported in the literature within the previous two years. Students will participate in seminar discussions and will present the results of a semester-long research project of their own choosing.

CSE-7017: Advanced Research Topics in Cyber Security

The course will focus on open research challenges and themes, to transmit the research methods of the field of computer security the existing threats and attack methodologies the open research challenges. The course will deal with most of the cutting edge research challenges in designing a secure system, ranging from application-level security to host and network security. However, differently from the courses offered at the M.Sc. level, we will cut short on the details of implementation, and add open research challenges and themes. Therefore, the course can be profitable even for students who already took courses on cryptography or security during the earlier levels of study.

CSE-7018: Advanced Topics in Requirements Engineering

Understanding requirements is key to successful software engineering: Building software that is fit for its purpose relies on understanding the exact problem that must be solved. The purpose of this course is to learn challenges, principles, and practices to identify, analyze and manage requirements from relevant sources, both at the start and during a software development project. The course regards these issues in specific development contexts, i.e. specific constellations of customers and suppliers as well as constraints related to the domain and development lifecycle that characterize developing a piece of software. This course is on an advanced level and takes a holistic view of the state of the art of requirements engineering as part of successful software engineering, technology, and management. Students are expected to familiarize themselves with recent, relevant research in the field, to critically reflect on the implications of new findings, and to develop their abilities and expertise as software professionals.

CSE-7019: Advanced Topics in Software Engineering

The course focuses on applying modern software engineering techniques and standards to tackle the modeling of complex evolving requirements, the architecting of secure ubiquitous responsive solutions that can mend the benefits of cloud-based, fog and edge distributed and decentralized architectural styles, the creation of quality solutions, and the management of software projects. The course will present a variety of tools, in the context of team production of publicly releasable software. The goal will be for each student to have had a hand in building complete and useful applications that could be released for real-world use. This course is a highly interactive course, in which students are expected to fully participate in class-based activities and discussions. Students will be encouraged to bring their own experiences to the discussion, as most of the topics being covered in this course are still considered open research topics. More than 50% of the course will be spend on student presentations, hands-on exercises, and practical software development as part of a team project.

CSE-7020: Information Architecture

Introduction and Overview of the course. Process of Web development; Information behavior & the Web. Content design and organization systems; Copyright issues labeling systems; Writing for the Web. Navigation design; Search systems. Page design; Multimedia. Web usability evaluation & testing. Accessibility for users with disabilities. Global audiences; Web standards & policies. Weblogs, Intranets, Websites for mobile devices; Web design software; Web Content Management Systems. Metadata; Search engines.

CSE-7021: UX Related to Mobile and Desktop Technologies

Accessibility is an important facet of user experience. Designing accessible interfaces is easier if you understand the range of disabilities, key principles of accessibility, how assistive technologies work, and how users actually use them. You will learn how to move beyond standards compliance to integrate accessibility in a way that creates equivalent, universally usable, and engaging web experiences for everyone. We'll

examine the key standards including the most recent updates of WCAG, version 2.2. We will spend time discussing how to integrate accessibility into the UX design process. Also, we will learn how to design and test for accessibility on mobile devices. We then explore user needs, validation methods, and ways to engage users with disabilities in your user experience research process. By the end of the course, you will have a firm foundation on how to design and evaluate the accessibility of systems.

CSC-7022: Advanced Decision Based Systems (Decision Science)

This course developed the understanding of foundations of decision theory and its evolution to date and understanding of the rational principles of decision making. It develops the ability of prescriptive models of choices under uncertainty and construct complex probability distributions and Bayesian revision algorithms. It also includes conjugate distributions, ability to test decomposition forms of multi-attribute utility models and to construct multi-attribute value and utility models and develops the Understanding of interplay between decision theory and game theory, the relation between descriptive and normative modeling and awareness of the possible impact of biases and heuristics for decision analysis. The major topics that will be covered are: Rational decision making; value and utility functions; distribution theory; invariance relations; copulas; value of information and control; multi-attribute utility; decision and game theory; behavioral research.

CSE-7023 Network Penetration Testing and Counter Measures

In this course, students will gain valuable insights into how hackers compromise operating systems and evade antivirus software. They will also learn to identify weaknesses in their own network using the same mindset and techniques employed by hackers. With this knowledge, students will acquire the skills to test and exploit their defenses and implement effective countermeasures to mitigate risks in their enterprise.

CSE-7024: Deep Reinforcement Learning

This course aims to present the core fundamentals behind the much talked about field of Deep Learning. We will delve into selected topics of Deep Learning, from discussing basics of neural networks, to understanding how CNN and RNN works with common examples and publicly available datasets. Special highlight of the course is the lecture on Interpretability of Neural Networks which will help students to understand how to trust a neural network's recommendation. In the final weeks of the course, we shall get an introductory exposure to Generative Adversarial Networks and Reinforcement Learning which will help build the foundation for more advanced courses in Artificial Intelligence.

CSC-7025: Modeling of Web Information Systems

Web modeling concepts; Modeling the Web applications for requirements engineering; Content modeling; Navigation modeling (Hypertext, Access structure); Modeling the presentation for the end-user; Model-driven development and model-driven architecture; Evolution of the Web, Web 1.0 (visual Web), Web 2.0 (Social Web), and Semantic Web (the Web of metadata); Hypertext patterns; Persistence of HT patterns; O&M of Web applications.

CSC-7026: Data Warehousing

Overview of the course and a brief history; Data Warehouse Architecture; Extract Transform Load; Data Cleansing Algorithms; Hot and Cold Data; Data Warehouse support for OLAP and Data Mining; Active Data warehousing; Semantic Data warehousing; Oraclesolution Teradata solution; Case Studies.

CSC-7027: Peer-To-Peer Systems

Overview of P2P Systems and brief history; Taxonomy of P2P Networks/Systems and Analysis of popular P2P Systems; Analysis of unstructured P2P Systems; Analysis of structured P2P Systems; Search Efficiency; P2P-based content delivery; Security and Reliability; Replication in peer-to-peer systems; Anonymity in peer-to-peer systems; Social, Legal and Privacy aspectsof P2P Systems.

CSC-7028: Multimedia Retrieval Techniques

Multimedia content and motivations for multimedia retrieval; Issues of multimedia Retrieval. Multimedia retrieval models; Content-based image retrieval; Content-based video retrieval; Content-based audio

retrieval: audio representations, audio feature extraction; Query modalities and similarity measures; Analysis of existing multimedia retrieval systems, retrieval evaluation criteria, relevance feedback; current trends in Multimedia Retrieval.

CSC-7029: Metadata for Information Resources

Overview of the course and Metadata; History of schemes and metadata communities; Functions and Types of metadata; Metadata Structure and Characteristics: Semantics, syntax, and structure; Metadata creation process models; Interoperability; Metadata Integration and Architecture: Warwick Framework; Resource Description Framework; Open Archives Initiative; Encoding Standards (Markup Languages): Introduction and history of markup; Metadata use of markup languages; Document TypeDefinitions (DTD); Structural metadata Data Control Standards: Resource Identifiers; Data Registries; Controlled vocabularies; Name authority control (ISAAR and FRANAR); A-Core; Encoded Archival Description (EAD), Text Encoding Initiative (TEI); Metadata Evaluation: User needs; Quality control issues; Evaluation methods; Educational Metadata: Instructional Management Systems (IMS); Learning Object Metadata (LOM); Gateway to Educational Materials (GEM); Government Information Locator Service (GILS); Visual Resources Metadata: Categories for the Description of Works of Art (CDWA); Visual Resources Association (VRA) Core; Computer Interchange of Museum Information (CIMI).

CSC-7030: Information Privacy and Access Control

Privacy, Privacy policies; Privacy enforcement; Adaptive privacy management; Access control mechanisms; Different access control models such as Mandatory, Discretionary, Role-Based and Activity-Based; Access control matrix model; Harrison-Russo-Ullman modeland undecidability of security; Confidentiality models such as Bell-LaPadula; Integrity models such as Biba and Clark-Wilson; Conflict of interest models such as the Chinese Wall.

CSC-7031: Ubiquitous Information Interaction

Information Interaction; Seminal ideas of ubiquitous computing; Tangibility and Embodiment; Social computing; Privacy; Critical and cultural perspectives; Mobility and Spatiality; Mobile Technology in the MessyNow; Infrastructure; Seams, seamlessness, seamfulness; Evaluating Interaction of Ubicomp systems.

CSC-7032: Collaborative Data Mining

Overview of the course and a brief history; Overview of Distributed Database systems; Importance and usage of collaboration; Web Data Resources; A brief introduction to overlay networks; Remote Collaboration; Collaborative Data Mining Guidelines; Parallel Data Mining; Grid-based Data Mining; Collaborative mining over social networks; Collaborative mining in P2P Networks; Collaborative data mining case studies.

CSC-7033: Communication Networks

Overview of the course & research activities in computer networks; Communication Networks & Services; Overview of network simulations; Layered architecture; Congestion Control and Traffic Management; Wireless, Mobility, and Cross-layer concepts; Switching & Routing; Quality of Service (QoS); Multicast; Peer-to-Peer (P2P) and Overlay Networks; Content Distribution in P2P Networks; Multimedia Information & Networking; Network Measurement.

CSC-7034: Advances in Next-Generation Networks

Next Generation Internet/Networks: Convergence to IP; Network Technologies and Architectures; Quality of Service; Multimedia protocols; Policy routing; Future Internet; Network traffic optimization; Next Generation Internet and broadband deployment; Advances in wireless mobile networks; Advances in sensor networks; Management of Next Generation Networks.

CSC-7035: P2P-based Information Retrieval

Overview of the Information Retrieval Systems; Multimedia & its characteristics; P2P Systems & its characteristics; Content searching/locating in P2P systems; Emerging coding standards for information; Architecture of P2P-based information retrieval; Privacy & security issues in P2P-based information retrieval;

Current research trends in P2P-based information retrieval.

CSC-7036: Advanced Software Architecture

Re-use in architectures: Software product lines, evaluation, and validation of product lines, product line testing, re-use in product lines; Service-oriented architectures (SOAs): SOA concepts, risks and challenges, quality attributes and SOAs, evaluating and testing SOAs; Architectural evaluation: Methods for architectural analysis, Comparison of methods; Architectural evolution and reconstruction: Models of software evolution, analysis, and metrics for evolution, Techniques, and tools for architecture reconstruction; Architectures in dynamic environments: Modeling and analyzing dynamic software architectures; Self-healingarchitectures: The need for self-healing, approaches for self-healing.

CSC-7037: Artificial Intelligence

This course considers ideas and techniques from Artificial Intelligence. It first introduces a range of search algorithms that are used throughout AI. It thenexamines applications and techniques of AI, includingrule-based systems for embodying human expertise, algorithms for planning and problem-solving, natural language processing, methods for machine learning, neural nets, and other computation intelligence techniques.

CSC-7038: Advanced Topics in Machine Learning

Introduction Overview of machine learning, Machine learning applications, and examples, Reinforcement learning, Elements of reinforcement learning, Model-based learning, Temporal difference learning, Generalization, Genetic Algorithms, Genetic operators, fitness function, Hypothesis space search, Genetic programming, Support Vector Machines, Optimal separating hyperplane, soft margin hyperplane, kernel functions, SVMs for regression, Combining learners, Voting, Bagging, Boosting, Assessing and Comparing Classification Algorithms, Cross-validation, and resampling, Measuring error, Assessing performance, Comparing multiple classification algorithms.

CSC-7039: Advanced Data Analytics

This course developed an understanding of the Types of Data Analysis In the first module of the course, students learn about the primary types of data analysis including, descriptive, predictive, diagnostic, and exploratory. Students will also learn about some advanced data analytic types including mechanistic, causal, and inferential. By the end of this module, you will know how to identify the different types of data analysis and their use cases. In the second module of this course, students will learn about the phases of the data analysis process including identifying data, defining scope, and level of detail. They'll learn about the data collection process, from gathering targeted information to evaluating outcomes. Students will also discover the importance of data cleaning and how removing, modifying, and formatting data is a priority, as well as the benefits of visualizing data. In the third module of this course, Students learn about the tools and skills essential for data analysis. They'll learn about using spreadsheets and databases for analyzing and managing the data, and also discover the power of query languages and multidimensional expressions. They can also describe the fundamental programming languages used in data analytics. In the fourth module of this course, Students will learn about the fundamental math and stats used for data analysis. They can also describe some advanced data analytic algorithms and their use cases, including linear regression and clustering.

FAISALABAD BUSINESS SCHOOL

Introduction

Faisalabad Business School is playing an important role in imparting quality business education in the region. The school aims to develop theoretical and practical understanding among students about core business curriculum so that the students can effectively use this knowledge in contemporary business world.

The school take pride in developing awareness among students about social and ethical considerations so that they take into account moral consequences in decision making.

One of the major goals is to produce individuals with good leadership skills with a blend of knowledge related to management, marketing, and textiles. Teaching faculty is fully committed to provide exciting, challenging and rewarding experiences to students during their studies, and to make every possible effort to help them in reaching their full potential.

MS BUSINESS ADMINISTRATION (1.5 YEAR)

MASTER OF BUSINESS ADMINISTRATION
(For Business / Non-Business Graduates)

PHD MANAGEMENT SCIENCES (Marketing)

Vision

To be a national Leader in management education and research with the special focus on the textile sector.

Mission

To contribute towards sustainable development through generating and disseminating management knowledge, develop professionals for upcoming dynamic challenges of businesses and the textile industry, and promote industry-academia linkages.

Research Facilities

The school has state of the art computer lab where students have access to a variety of academic resources e.g. research journals, case studies and latest softwares for data analysis.

Research Areas

The broader researcher areas include marketing, finance, and human resource management.

Faculty Research Interests

Dr. Sajjad Ahmad Baig, PhD (PU, Pakistan)

Quality & Operations Management, Organizational Behavior and Human Resource Management

Dr. Muhammad Hashim, PhD (Sichuan University, China)

Marketing and Supply Chain Management, Operations Management, Retail Management, Sustainable Development.

Dr. Muhammad Zia-ur-Rehman, PhD (IIU, Islamabad)

International Finance, Behavioral Corporate Finance, Microstructure of Stock Markets & Corporate Performance, Business Analytics and Efficiencies

Dr. Falik Shear, PhD (NUST, Islamabad)

Derivatives, Climate Finance and Investors Sentiments

Dr. Muhammad Ahmad Ur Rehman, PhD (UTM, Malaysia)

Export Marketing, Services Marketing, Strategic marketing

Dr. Muhammad Shahzad Iqbal, PhD (GCUF, Faisalabad)

International Business and trade, Macroeconomics, Economic Growth and Computable General Equilibrium (CGE) Modeling.

Dr. Mina Kharal, PhD (BZU, Multan)

Presentiment, Wellbeing, Gender Work Identity

Dr. Zahid Hussain (Hanyang University, South Korea)

Marketing and Supply Chain Management, Management

Dr. Beenish Qamar, PhD (GCUF, Islamabad)

Leadership, Social Influence, Organizational Politics, Self-concept and Identity.

Dr. Aima Sameen (Hanyang University South Korea)

Textile Management

Dr. Aima Sameen (Hanyang University South Korea)

Textile Management.

Dr. Muhammad Usman (UAF, Pakistan)

International Economics, Financial Economics, Circular Businesses, Sustainable Development Goals (SDGs)

Dr. Muhammad Navid Iqbal (Superior University Lahore)

Mutual funds, Investments, and Sustainable Finance

Dr. Iram Bashir (GC Faisalabad)

Employee wellbeing, decision making skills and leadership, Green HRM practices

1. MS BUSINESS ADMINISTRATION (Marketing, HRM and Finance)

Eligibility Criteria

1. A candidate must have 16 Years relevant Business Education BBA-BSTMM-MBA-M.Com or 16-years relevant equivalent degree from HEC recognized University / Institute with minimum 2.00/4.00 CGPA in semester system or 50% in annual system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
6. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Note: *The student will submit his/her publication from his/her thesis research work to his/her supervisor. Final thesis defense of student will be held after the submission of publication to a relevant HEC recognized journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.*

Merit Criteria

BBA (4 Years), BSTMM (4-Years) BBS, M.Com or 16 year equivalent	60% weightage
degree NTU-GAT (General) Test	30% weightage
Interview	10% weightage

Program Educational Objectives (PEOs)

1. To provide students with the opportunity to learn the latest academic theories, concepts, techniques and applications with emphasis on teaching, research, practice in the field of concentration, and consulting.
2. Strengthen the capabilities of graduates to carry out independent research at an advanced level, and enhance their ability to deliver their ideas, research methodology and findings by means of formal presentations with critiques of their analytical, written, oral and media presentation skills in business, professional, and educational environments.

Program Learning Outcomes (PLOs)

Sr.No.	Attributes	Outcomes
1	**Core Business Education**	An ability to understand and apply theoretical knowledge related to core business subjects at a level expected from graduates with MSBA degree.
2	**Research Skills**	An ability to do research to understand, analyze and contribute in the academic discussions at a level expected from graduates with MSBA degree.
3	**Critical Thinking**	An ability to demonstrate critical thinking approach to research at a level expected from graduates with MSBA degree.
4	**Teaching Skills**	An ability to communicate and disseminate knowledge at higher education level.

Program Structure for MS Business Administration

Sr.No	Code	Course Title	Credit Hours
1	MGT-6091	Advance Research Methods	(3-0-3)
2	MGT-6092	Strategic Finance	(3-0-3)
3	MGT-6093	Strategic Marketing	(3-0-3)
4	MGT-6094	Organization Theory & Design	(3-0-3)
5	MGT-6095	Project Management	(3-0-3)

6	MGT-6096	Leadership and Organizational Behavior	(3-0-3)
7	-	Elective-I	(3-0-3)
8	-	Elective-II	(3-0-3)
9	-	Elective-III	(3-0-3)
10	-	Elective-IV (Functional Textiles)	(2-0-2)
11	-	Thesis / Dissertation	(6-0-6)
		Total	35

Note: Institute may Change / shuffle or substitute the sequence of courses during the program as per requirement.

Course Specifications

MGT-6091: Advance Research Methods

This course emphasis is on the research design, instrument development, data collection techniques and methods of evaluation in applied settings. Additionally, to business research methodology contents, students also become of familiar with the policy implications of business research outcomes. It is intended to introduce students' ways of conceptualizing problems, designing research, collecting data, and interpreting those data. It also examines implications and consequences of choices among alternative approaches. On the successful completion of this course students should be able to acquaint with research processes and assumptions and they can introduce alternative methods and logics of inquiry which will make students more discriminating consumers of other's research and promote the development of their research. They will develop research skills which will be required for planning and executing research projects, including conducting literature review, articulating research questions, justifying a research approach and methodology, designing a study and selecting specific methods and techniques appropriate for answering the questions and conducting data collection, analyzing data and presenting research results. The key topics includes, research methods in management sciences, research problems and how to explore them and how to conduct literature search, research paradigms and approaches-assumptions of positivist, interpretive and critical approach, quantitative research methods, survey based research, statistical modeling techniques, selecting statistical packages tutorials (SPSS etc), qualitative research methods, ethnographic research, cross-paradigm and multi method research, writing the research proposal and structure, from research question to research design- justifying the methodology and writing strategies.

Recommended book:

Research Methods for Business (seventh edition) by Uma Sekaran and Roger Bougie Saunders, M. N., Lewis, P., & Thornhill, A. (2016). Research Methods for Business Students (5th ed.): Pearson Education. Cooper, D.R. & Schindler, P.S. (2018) Business Research Methods, Thirteen Edition. McGraw-Hill Education.

MGT-6092: Strategic Finance

The aim of this course is to examine the theoretical underpinnings of corporate finance. The material is a continuation of what was taught in the first year Financial Management course. In this course, methodological issues for development of value-based management systems will be discussed. A special attention is devoted to measures and approaches of the corporate strategies. There are two perspectives of corporate finance, management context and investor's context; both perspectives will be covered in this subject. Financial decisions can be categorized into investment, financial and operational, at strategic level the focus of this course will remain on investment and financing decisions. Although theoretical framework of Strategic Finance is derived from Financial Management but it deals with more practical and complex scenarios.

Recommended book:

Executive Finance and Strategy : How to Understand and Use Financial Information to Set Strategic Goals by Ralph Tiffin, Corporate Financial Strategy by Ruth Bender and Keith Ward, Guide to CFO Success : Leadership Strategies for Corporate Financial Professionals by Samuel Dergel.

MGT-6093: Strategic Marketing

Strategic Marketing Management is an advance level Marketing course. The aim of the course is to develop a strategic thinking approach to marketing. It aims to help students understand how companies compete using marketing strategy and its correlates focusing on achieving a competitive advantage for the firm by creating customer value and leveraging the firm's marketing resources in the most efficient and effective manners.

It builds upon the basic concepts of Marketing, which the students have learned in their previous marketing courses and to prepare students to grasp the complex issues of specialized courses like Business policy, etc. In this course students are exposed to a dynamic world of marketing activities using a number of approaches and to enable the students to understand the practical issues that are critical to develop performance orientation. Principles, concepts, and analytical tools are taught employing real- l i f e examples from both Pakistan's and international corporate world. This will enable the students to develop skills and competency to apply analytical tools and develop appropriate strategic marketing plans and manage its implementations. After taking this course student are better equipped, both mentally and academically; they understand various terms and concepts and understand how and when toapply them. It prepares them to take on the real-l i f e challenges and to add value to the organization forwhich they will work.

Recommended book:

Parsons, E., Maclaran, P., & Chatzidakis, A. (2017). Contemporary issues in marketing and consumer behaviour, second edition, Routledge.

MGT-6094: Organization Theory & Design

Business is changing at break-neck speed so managers must be increasingly active in reorganizing their firms to gain a competitive edge. Organizational Theory, Design, and Change continue to provide students with the most up-to-date and contemporary treatment of the way managers attempt to increase organizational effectiveness. Organization theory and design gives us the tools to evaluate and understand how a huge, powerful firm like Lehman Brothers can die and a company like Bank of America can emerge almost overnight as a giant in the industry. It enables us to comprehend how a band like the Rolling Stones, which operates like a highly sophisticated global business organization, can enjoy phenomenal success for nearly half a century, while others with equal or superior talent don't survive. Organization theory helps us explain what happened in the past, as well aswhat may happen in the future, so that we can manageorganizations more effectively.

Recommended book:

Organization Theory & Design, Richard L. Daft 13th Edition, (2020)

MGT-6095: Project Management

Projects have been part of the human scene since civilization started, yet the practice of project management is quite recent. The concepts and tools required to plan, organize, implement, and evaluate a project are equally applicable to such diverse ventures as launching of a space shuttle, developing curriculum in primary education, or organizing a trekking tripto the K-2 base camp. The purpose of this course is to expose students to the real-life issues in project management and equip them with necessary tools toresolve these issues. Use of quantitative techniques is supplemented by softer skills of leadership and humanresource management.

Recommended book:

The Managerial Process (McGraw-Hill Series Operations and Decision Sciences) 7th Edition.2020 for Project management

MGT-6096: Leadership and Organizational Behavior

Leadership and Organizational behavior is an interdisciplinary field drawing from numerous disciplines including psychology, sociology, anthropology, economics, organization theory, statistics, and many others. Effective management of human resources within organizations require an understanding of various behavior and leadership. This course provides an opportunity for students to focus on leadership and employee behavior from both theoretical and practical perspectives. The course employs theoretical concepts and models, coupled with case studies based on the experiences of leaders within the profession to understand how to develop leadership potential in oneself and others. Leaders need to know why people behave as they do in relation to their jobs, their workgroups and their organizations. This knowledge of individuals' perceptions, motivational attitudes and behavior will enable students to understand the individual, group and organizational levels of behavior. Theory and practice will be explored together throughout the course.

Recommended book:

The Leadership Challenge: How to Make Extraordinary Things Happen in Organizations, 6th Edition
James M. Kouzes, Barry Z. Posner

2. MBA (Marketing, HRM, Finance, Fashion & Luxury Business)

Program Educational Objectives (PEOs)

1. Augmentation of higher levels of managerial proficiency in functional areas of business for progressive careers.
2. Understanding of modern era managerial challenges and their innovation-oriented solutions in the field of business.
3. Solve industrial problems by applying analytical, leadership, managerial and entrepreneurial skills.

Program Learning Outcomes (PLOs)

No.	Attributes	Outcomes
1	**Core Business Education**	An ability to understand and apply theoretical knowledge related to core business subjects to solve business problems at a level expected from graduates with MBA degree.
2	**Textile Management and Marketing with Global Prospectus**	An ability to understand technical knowledge, working environment, managerial issues, and opportunities of Pakistan's Textile Industry to enable the students to contribute positively towards textile sector.
3	**Analytical Thinking and Decision-Making Skills**	An ability to organize and analyze data for effective decision making to reach an appropriate and sustainable solution at a level expected from graduates with MBA degree.
4	**Leadership and Entrepreneurial Spirits**	An ability to understand and apply theoretical knowledge on leadership and implementing entrepreneurial skills to achieve organizational goals.

Eligibility Criteria

1. A candidate must have 16 years or equivalent relevant (business graduates)/non-relevant education from HEC recognized University / Institute with minimum 2.00/4.00 CGPA in semester system or 50% in annual system.
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test or NTU-GAT (Subject) test in case of different qualification with minimum 50% score as per HEC.
3. The applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
4. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final BS/M.Sc or equivalent official transcript or degree.
5. The student will submit his/her publication from his/her thesis research work and submit to his/her supervisor. Final defense will be held after the submitted publication of student will be notified as "Under Review" or "Under Consideration" by a journal. It will be compulsory for graduate student to include his/her Supervisor's name in his/her publication.
6. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
7. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Merit Criteria

16 year relevant/ non-relevant degree	60% weightage
NTU-GAT (General) Test	30% weightage
Interview	10% weightage

Program Structure for MBA

MBA program is comprised over **30** Credit Hours **for business graduates** and **60** Credit Hours **for non-business graduates.**

	Structure for Non-Business Graduates	Cr. Hr.	Structure for Business Graduates		
Fall-1	BUS-5081: Applied Statistics for Business	3	Exempted		
	ACCT-5081: Accounting for Managers	3			
	ECON-5081: Business Economics	3			
	MGT-5081: Management and Organizational Behavior	3			
	MKT-5081: Marketing Management	3			
	Total Semester Credit Hours	**15**			
Spring-1	FIN-5081: Finance for Managers	3	Exempted		
	ECON-5082: Managerial Economics	3			
	FIN-5083: Introduction to Fintech	3			
	BUS-5082: Business Analytics	3			
	MGT-5082: Managing Human Resource	3			
	Total Semester Credit Hours	**15**			
Fall-2	MGT-6081: Cases in Management	3	Cases In Management	3	Fall-1
	MGT-6083: Strategic Marketing	3	Strategic Marketing	3	
	MGT-6082: Operations & Supply Chain Management	3	Operations & Supply Chain Management	3	
	MGT-6084: Strategic HR and Leadership	3	Strategic HR and Leadership	3	
	Elective –I	3			
	Total Semester Credit Hours	**15**	**Total Semester Credit Hours**	**12**	
Spring-2	MGT-6085: Financial Statement Analysis	3	Financial Statement Analysis	3	Spring-1
	Elective-II	3	Elective-I	3	
	Elective-III	3	Elective-II	3	
	TEX-5078: Functional Textile	3	Functional textile	3	
	FYP (03 Credit Hours)	3			
	Total Semester Credit Hours	**15**	**Total Semester Credit Hours**	**12**	
			Elective-III	3	Fall-2
			FYP (03 Credit Hours)	3	
			Total Semester Credit Hours	**6**	
Total Courses 19 + FYP (3Cr.Hr)			**9 + FYP (3Cr.Hr)**		
Program Credit Hours 60			**30**		

Course Specifications

BUS-5081: Applied Statistics for Business

Applied Statistics for Business is an important course in the MBA degree and provides opportunities to students to integrate and apply current statistical methods and inquiries to problems in the modern business environment. Topics include probability, sampling techniques, confidence intervals, hypothesis testing, representation of data, Classification and Tabulation, Measures of Central Values, Measures of Dispersion, Simple Correlation, Method of least square and curve fitting, Kinds of Index numbers with special emphasis to consumer price, Discrete and Continuous Random variables. Students analyze real data sets using standard statistical software, interpret the output, and write extensively about the results in business and Commerce.

Recommended book:

Applied Statistics in Business and Economics, Latest edition, Doane and Seward, McGraw-Hill.

ACCT-5081: Accounting for Managers

Accounting for Managers is a basic course in MBA which acquaint the students with the fundamental principles of financial, cost and management accounting and enable them to prepare, analyze and interpret financial statements and to take decisions using management accounting tools. It imparts knowledge and skills that are considered essential for managers to operate successfully in the dynamic world. Topics include Accounting Principles, Basic Accounting terms, Journalizing Transactions, Ledger Posting and Trial Balance, Sub-division of Journal , Final Accounts, Preparation of Cost Sheet, Elements of cost, Classification of cost, cost ascertainment, Financial Statement analysis and Interpretations, Ratio Analysis, Classification of Ratios, Fund Flow Statement, Cash Flow Statement, Budgetary Controls, Program Budgeting, Performance Budgeting, Responsibility Accounting, Zero Based Budgeting, Standard costing as a management tool, Standard Cost sheet, Cost variance, Direct Material Cost Variance, Direct Labor Cost Variance, Overhead Cost Variance, Absorption Costing, Marginal Costing and direct costing, Differential costing, Cost-volume profit Analysis, Break Even Analysis.

Recommended book:

1. Accounting for Managers: A Business Decision Guide by Steven M. Bragg, Accounting Tools, Latest Edition
2. Accounting For Managers by Jelsy Josheph Kuppapally, PHI, Delhi, Latest Edition

ECON-5081: Business Economics:

Business Economics is the study of the financial issues and challenges faced by corporations. It deals with issues such as business organization, management, expansion, and strategy. It will expose students to basic Microeconomics Concepts and inculcate an analytical approach to explain various basic economic theories. The course will stimulate the student's interest by showing the relievable economic theories and enable them to apply reasoning to problems of business. Topics include Economic rationale of optimization, Nature and scope of business economics, Macro and Microeconomics, Basic problems of an economy, Marginalism, Equimarginalism, Opportunity cost principle, Discounting principle, Risk and uncertainty, Theory of utility, cardinal and ordinal utility theory, law of diminishing marginal utility, law of Equimarginal utility, indifference curves, consumer equilibrium, consumer surplus, Theory of Consumer Behavior The indifference curve approach, Different concepts of demand, demand curve, Determinants of demand, Law of demand, Demand forecasting methods, Market equilibrium, Concepts of elasticity, Concept of supply curve, Conditions of supply, Elasticity of supply, Economies of scale and scope, The production function, Short-run and Long-run production function, law of diminishing returns and returns to scale, Fixed, variable and other cost concepts, least cost-input combination, Relationship between production and cost, Pricing in different Market Structures, Price determination (long run and short run) in Perfect Competition, Monopoly, Monopolistic and Oligopoly markets, pricing strategies.

Recommended book:

Economics by Paul Samuelson and William D. Nordhans Latest Edition, McGraw Hills.

MGT-5081: Management and Organizational Behavior

This course approaches management as a process of reaching organizational goals by working with and through people and other resources. Organizations are treated as dynamic entities affected by individual and group behavior as well as structural and environmental factors. International as well as domestic situations will be examined. This will provide Students a basic theoretical and practical framework for understanding the fields of management and organizational behavior with relevant organizational examples so that even students without "real life" organizational experience can recognize the relevance and provide exposure to career preparation in field of management.

Recommended book:

Essentials of Contemporary Management by Jones & George, Connect, Latest Edition

MKT-5081: Marketing Management

The course is an introduction to the language and issues of marketing with an emphasis on learning to develop responsive marketing strategies that meet customer needs. The course focuses on basic marketing concepts, the role of marketing in the organization, and the role of marketing in society. Topics include market segmentation, product development, promotion, distribution, and pricing. Other topics, which will be incorporated into the course, are external environment (which will focus on integrative topics with marketing, such as economics, politics, government, and nature), marketing research, international/global marketing with relevance to cultural diversity, ethics, the impact of technology on marketing, and careers in marketing.

Recommended book:

Marketing Management by Philip Kotler, Kevin Lane Keller, Pearson International edition Pearson one series Pearson Prentice Hall, Latest Edition

FIN-5082: Finance for Managers

Finance for Managers equips students with essential concepts to understand and predict the financial implications of managerial decision making. It provides framework to help interpret and analyze financial statements and understand how business decisions are reflected in financial reports. Students will be equipped with analytical techniques for project analysis, they will learn to allocate resources more optimally and understand financial markets and their role in capital raising and monitoring. Topics include Introduction to finance and the time value of money (TVM), interest rates, Risk and return, Capital investment analysis, cash flow estimation, risk and the cost of capital, Capital structure and payout policies.

Recommended book:

Finance for Nonfinancial Managers, by Gene Siciliano, 2nd Edition, McGraw-Hill, Latest Edition

ECON-5082: Managerial Economics

Managerial Economics is the use of economic tools and analytic approaches in order to examine how a firm can make optimal managerial decisions given the constraints it faces. The main objective of this course is to equip students with the necessary theory and techniques and the ability to apply them in order to inform and enhance managerial decision making and to develop an economic perspective that is appropriate for managing business units or entire companies in a wide variety of industries. Topics include goals of the firm, optimization techniques, demand theory and estimation, forecasting and measurement, theory of production and estimation, cost theory and estimation, pricing and output determination under different market structures, game theory, and pricing in practice.

Recommended book:

Managerial Economics, by Keat, P., Young, P.K. and Erfle, S., Latest Edition, Prentice Hall, Managerial Economics & Business Strategy by Michael R. Baye, Latest Edition, McGraw-Hill

FIN-5083: Introduction to Fintech

This course introduces students to the dynamic and evolving field of Financial Technology (FinTech). The course covers the fundamentals of FinTech, its impact on the global financial services industry, and explores the latest trends and innovations in the field.

Recommended Books

1. Global Fintech: Financial Innovation in the Connected World, by Shrier., David L., and Pentland, Alex., latest edition, MIT Press

2. FinTech: Finance, Technology and Regulation by Ross P. Buckley., Douglas W. Arner., and Dirk A. Zetzsche, latest edition, Cambridge University Press.

BUS-5082: Business Analytics

Business Analytics is a modern course that uses data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions. It is more than just analytical methodologies or techniques used in logical analysis. It is a process of transforming data into actions through analysis and insights in the context of organizational decision making and problem solving. Topics include a range of activities that consists of business intelligence, standard and ad hoc reports, queries, alerts and quantitative methods, statistical analysis, forecasting/ extrapolation, predictive modeling (such as data mining), optimization and simulation.

Recommended book

Business Analytics: Data Analysis and Decision Making by. S. Christian Albright, Wayne L. Winston, Latest Edition, Cengage Learning Asia

MGT-5082: Managing Human Resource

Human Resource Management links people-related activities to business strategy. The course develops a critical understanding of the role and functions of the various human resource activities in an organisation, providing students with a comprehensive review of key HRM concepts, techniques and issues. Topics include job analysis and design, recruitment and selection, evaluation, performance management, occupational health and safety, and the strategic contribution of HRM to organisational performance and evaluating HRM effectiveness. Working with contemporary case studies, students not only engage in collaborative and individual work processes but use communication and discourse characteristic of the HRM context and environment.

Recommended book

Managing human resources, by Gomez-Mejia, Luis R. | David B. Balkin | Robert L. Cardy, PHI Learning Private Limited (New Delhi)

MGT-6081: Cases in Management

Cases in Management is one of the most important courses in the MBA degree and provides opportunities to students to integrate and apply business education to solve important problems. This course will require students to work in groups to come up in classes after proper case preparation to contribute in making discussion in case classes richer.

Recommended book:

The Case Study Handbook, Revised Edition: A Student's Guide by William Ellet 2nd edition (2018), Harvard Business Review Press

MGT-6081: Operations and Supply Chain Management

Operations and Supply Chain Management is concerned with the design, planning and management of all facilities, processes and activities required to transform resources into goods and services within and between organizations. It is applicable to all types of organizations including manufacturers, retailers, hospitals, tourism sector, banks and even many clubs and non-profit organizations.

This course is designed to provide the student with an understanding of the foundations of the operations function in both manufacturing and services. The course will analyze operations from both the strategic and operational perspectives and highlight the competitive advantages that operations can provide for the organization. The goal of the course is to help students become effective managers in today's competitive, global environment. The course will examine operations as a competitive weapon, demand forecasting, supply-chain management, aggregate planning, inventory systems, just in-time systems, material requirements planning and lean systems.

Recommended book:

Operations and Supply Chain Management by F. Robert Jacobs and Richard Chase, 15th Edition, McGraw-Hill Education

MGT-6084: Strategic HR & Leadership

The purpose of this course is to help students acquire the specific knowledge, skills, and abilities associated with human resource management and strategic decision making in the organization. Students are prepared to perform the essential functions that human resource professionals are expected to perform at strategic level. The second part of the course will introduce leadership theories using case studies to explore the characteristics of each theory. The last part deals with the understanding of organizational contexts and patterns of leadership behavior through application of theories. For students, a better appreciation of the complexity of managerial leadership the importance of having theoretical knowledge about leadership, and the need to be flexible and pragmatic in applying this knowledge.

Recommended book:

Strategic Human Resource Management: An HR Professional's Toolkit 1st Edition by Karen Beavan, Kogan Page

MGT-6085: Financial Statement Analysis

Financial statement analysis is the process of analyzing a company's financial statements for decision-making purposes. External stakeholders use it to understand the overall health of an organization as well as to evaluate financial performance and business value. Internal constituents use it as a monitoring tool for managing the finances. This course introduces students to the complex world of commerce.

It emphasizes the practical and functional nature of business decisions from the perspective of financial analysis, and financing of business operations. Students in this course will gain skills in reading, interpreting, analyzing, and applying accounting standards. The course is essential for all individuals exposed to financial information in the workplace including accountants, auditors, financial analysts, managers, bankers, and oversight bodies involved in the preparation or use of company financial statements.

Recommended book:

Financial Statement Analysis and Valuation by Peter D. Easton 4th edition, Cambridge Business.

TEX-5078: Functional Textile

The overall aim of the course is to introduce students about the textile industry. The students will get knowledge about the different steps involved during the conversion of textile fiber to finish product.

Recommended book:

Functional Textiles and Clothing by Abhijit Majumdar, 1st edition, springer publishers

PhD Management Sciences

Program Educational Objectives (PEOs)

1. To develop conversant graduates through management sciences research to meet local and global needs of the Academia & Industry
2. To equip graduates with scientific, critical, innovative thinking, and practical skills that will help to generate novel ideas and solutions for basic & applied real-world management problems
3. To improve the quantitative and qualitative problem-solving proficiencies of teachers and professionals

Program Learning Outcomes (PLOs)

1. Demonstrate an in-depth knowledge of leadership and management sciences research. (PEO 1, PEO2)
2. Ability to systematically review, analyze, and interpret the scientific literature and innovations in the areas of management sciences. (PEO1, PEO 2)
3. Ability to conduct high-quality basic & applied research and effectively disseminate the research outputs in international research journals of repute, conferences, seminars, patents, research proposals, and other scientific venues. (PEO 2, PEO 3)
4. Contribute to original research to broaden the boundary of knowledge through dissertations.(PEO2, PEO 3)

Eligibility Criteria

1. MS / M.Phil business degree or equivalent degree with minimum 3.00/4.00 CGPA in semester system or 1st division in the annual system from HEC approved Pakistani or foreign recognized Universities. Applicants with MBA or MS degree without project/thesis can apply for admission to the PhD Management Sciences program***. However, preference will be given to students who have completed MBA/MS degree with project/thesis as per HEC business education roadmap.***
2. Applicants having terminal degrees as prescribed in condition no.01, are required to qualify NTU-GAT (General) test with minimum 60% score or NTU-GAT (Subject) test with minimum 50% score in case of different qualification as per HEC.
3. It is mandatory to pass interview in order to compete on merit.
4. Applicant must not be already registered as a student in any other academic program in Pakistan or abroad.
5. Result waiting applicants may apply for admission, however their merit will be finalized only on submission of final MS/M.Phil or equivalent official transcript or degree.
6. Relevant Admission Committee will determine relevancy of terminal degree and decide deficiency course/s (if any) at the time of admission interview, the detail of which will be provided to the student in his/her admission letter/email.
7. Deficiency course/s will be treated as non-credit and qualifying course/s for which student will also pay extra dues as per fee policy. Those course/s will neither be mentioned in student's final transcript nor will be included for calculation of CGPA. However, the student may obtain his/her a separate transcript for completion of deficiency course/s.

Merit / Admission Criteria

Following criteria will be followed to calculate admission merit:

MS/Equivalent	60 %
BS/Equivalent	20%
Interview	10%
Publication & Relevant experience	10 % (05% +5%)

Scheme of Studies (semester-wise, including credit hours)

Students will complete **18** Cr.Hrs before starting their synopsis/research work.

Scheme of Studies:

1st Semester			Cr.Hrs
1	MGT-7084	Academic Writing & Design	3
2	MGT-7081	Philosophy in Management Sciences	3
3	-	Elective-I	3
4	-	Elective-II	3
Total			**12**

2nd Semester			Cr.Hrs
1	MGT-7082	Advanced Quantitative Tools and Techniques	3
2	MGT-7083	Advanced Qualitative Tools and Techniques	3
3	-	Elective-III	3
4	-	Elective-IV	3
	Total		**12**
3rd Semester	Comprehensive Exam		
4th–6th Semester	Thesis		30
Total Credit Hours			**54**

Course outlines

1. Academic Writing and Research Design

The course offers an overview of the important research design concepts, data collection, statistical and interpretative analysis, and final report presentation. It will help scholars conduct rigorous academic research and express their ideas in a coherent academic format. The course contents will familiarise scholars with the language of research, ethical principles and challenges, and the research process elements within the quantitative, qualitative, and mixed methods approach. Moreover, they will understand the dos and don'ts of writing important sections of a dissertation and journal papers. They will learn to present their ideas clearly and develop a proper structure and discourse for academic research design and writing. Students will use these theoretical underpinnings to critically review the literature relevant to their field of interest and determine how research findings are useful in forming their understanding of their local and global environment.

Recommended books:

1. Abbott, M. L., & McKinney, J. (2013). Understanding and applying research design. John Wiley & Sons.
2. Jogulu, U. D., & Pansiri, J. (2011). Mixed methods: A research design for management doctoral dissertations.
3. Management research review. Oshima, A., & Hogue, A. (2007). Introduction to academic writing (p. 3). Pearson/Longman.

2. Philosophy in Management Sciences

This course focuses on philosophical approaches to understanding organizations and their management. The module will consist of three interrelated themes. The first will comprise the attempt to familiarize students with the essential problems at the heart of the philosophical debate and expose them to different ways of dealing with them. The second theme will be organized around contemporary schools of thought and thinkers (e.g., logical positivism and Foucault), and founding intellectual fathers of economic thought (e.g., Marx). During these sessions, students will be utilizing various philosophical lenses to make sense of organizational phenomena, gain a better grasp of the intellectual origins of our extant understandings, and critically reflect upon taken-for-granted views about managing. The final theme will concentrate more sharply on organizational settings by studying how advances in organizational theory have afforded important philosophical insights into organizations and (the possibility of) their management.

Recommended Books:

1. Wren, D. A., & Bedeian, A. G. (2020). The evolution of management thought. John Wiley & Sons.
2. Lounsbury, M. (2011). Philosophy and organization theory. Emerald Group Publishing.

3. Advanced Quantitative Tools and Techniques

This course focuses on developing students' technical skills and knowledge in quantitative research and prepares them to be proficient researchers and consumers of empirical research. It will guide students on critically assessing primary quantitative research methods, making the right decision to use the most appropriate statistical analysis methods for research questions of interest, and carrying out practical research activities. The course will introduce students to various advanced quantitative statistical techniques along with the appropriate statistical software packages. The course will focus on the processes, methods, and tools of conducting quantitative research, how to present the findings of quantitative research, and how to deal with the challenges of doing quantitative research.

Recommended books:

1. Stacey, R. D. (2012). Tools and techniques of leadership and management: Meeting the challenge of complexity. Routledge.
2. Anderson, D. R., Sweeney, D. J., Williams, T. A., Camm, J. D., & Cochran, J. J. (2012). Quantitative Methods for Business (Book Only). Cengage Learning.
3. David R. Anderson, Dennis J. Sweeney, Thomas A. Williams, Jeffrey D. Camm, James J. Cochran (2016). Quantitative Methods for Business. Cengage Learning.

4. Advanced Qualitative Tools and Techniques

This course aims to offer students a broader and deeper knowledge of qualitative research: Philosophy, Design, and Analysis. Qualitative research relies on diligent observations, individual interviews, focus groups, and action research to collect data to gain a rich understanding of a specific phenomenon under investigation. It is interested in the participants' perspective and their meaning to their experience of events and examines how those experiences are framed. It focuses on applying qualitative research methods in organizational contexts, emphasising qualitative methodology. The course will focus on the process, methods, and tools of conducting qualitative research, how to present the results of qualitative research, and how to deal with the challenges of doing qualitative research.

Recommended books:

1. Symon, G., & Cassell, C. (Eds.). (2012). Qualitative organizational research: core methods and current challenges. Sage.

2. Myers, M. D. (2019). Qualitative research in business and management. Sage.

Marketing (Elective Courses)

1. Strategic Services Marketing

This course will help students learn the fundamentals of services marketing from a practical perspective. This course will focus on customer needs, which are the most important factors to consider while making business decisions. To keep happy and delightful long-term relationships with customers, students must understand services marketing from multiple perspectives. This course will also be useful if students wish to establish a new service business or manage an existing one. Moreover, the course will focus on theoretical paradigms, methods, tools, and challenges of conducting Strategic Services Marketing research.

Recommended Books:

1. Adhikari, A., & Roy, S. K. (Eds.). (2017). Strategic marketing cases in emerging markets. Springer.

2. Zeithaml, V. A., Bitner, M. J., & Gremler, D. D. (2018). Services marketing: Integrating customer focus across the firm. McGraw-Hill Education,

3. Dixit, S. K. (Ed.). (2017). The *Routledge handbook of consumer behaviour in hospitality and tourism. Taylor & Francis.*

2. Seminar in Marketing

This course covers contemporary research in the marketing management area, including topics such as consumer and industrial product development and management, advertising and sales promotion management, pricing, distribution, and retail issues, sales management, and personal selling, as well as the philosophies and methods relevant to applied managerial research. This course aims to develop a high level of understanding and a critical analytic perspective across a diverse range of marketing scholarship by focusing on conceptual, theoretical, and substantive research findings found in the academic research literature in marketing. The course will emphasise theory construction and theory development in several substantive marketing domains, focusing on selected managerial marketing topics.

Recommended Books:

Szmigin, I., & Piacentini, M. (2018). Consumer behaviour. Oxford University Press.

3. Marketing Research

This course will introduce scholars to the realm of marketing intelligence and the significance of data to marketers as well as to companies as an important foundation for planning marketing activities towards the creation of value for the firm. The course offers a comprehensive approach to contemporary marketing research principles and practices towards gathering, acquiring, appraising, and applying evidence for appropriate decision making. It will provide students with a background in research methods, procedures, and issues related to extracting marketing insights. It helps students understand commonly used research methods and experience in interpreting multiple research information sources and extracting actionable insights. Students will become equipped with a knowledge of the principles of sampling and basic data analysis for marketing research.

Recommended Books:

Malhotra, N. K., Nunan, D., & Birks, D. F. (2017). Marketing research: An applied approach. Pearson Education Limited.

4. Research in Retail Supply Chain Management

This course's focus is the underlying principles, theories, and debates in retail supply chain management. As retailers have become more powerful members of their supply chains, retail-specific supply chain management research has become more prevalent in the literature. Subject topics may include but will not be restricted to retail sales and order forecasting, inventory management, and store execution issues. The course will help students develop the ability to understand essential concepts and apply that understanding were applicable. This will help students develop a high understanding and a critical analytic perspective across a diverse range of conceptual, theoretical, and substantive research findings. The course will emphasise theory testing and development, focusing on Retail Supply Chain Management.

Recommended Books:

Leeman, J. J. (2020). Supply Chain Management: Fast, Flexible Supply Chain in Manufacturing and Retailing-. BoD–Books on Demand.

5. Current Issues in Retailing

This course will introduce and problematise current issues in retailing and provide insights and concrete tools to handle those issues. It aims to make students familiar with and interested in contemporary marketing challenges that retail companies face when doing business in the local or international marketplace. It will help students conceptualise frameworks and practical experiences to analyze and understand global retailing issues. After studying this course, students will be able to describe and explain the theories, concepts, and models used in retailing as well as understand the complexities involved in managing retailing across nations. They will be able to apply these theories, concepts, and models to analyze and suggest solutions to problems arising from operating a retailing firm in an international arena.

Recommended Books:

Foglieni, F., Villari, B., & Maffei, S. (2017). Designing better services: a strategic approach from design to evaluation. Springer.

6. Behavioral Research in Marketing

This course covers contemporary research in Marketing that draws on fundamental research from social and cognitive psychology or other relevant source disciplines. The course's alternate offerings cover either research on consumer attitudes and information processing or research on consumer choice and behavioural decision-making, among other related topics. Publications from academic journals will be discussed and critiqued by participants, paying attention to theoretical and methodological issues. It will help students understand the underlying research and paradigms and apply them to real-world research problems.

Recommended Books:

Gravetter, F. J., & Forzano, L. A. B. (2018). Research methods for the behavioral sciences. Cengage Learning.

7. Quantitative Research in Marketing: Empirical Methods

This course will focus on the main empirical research methods in marketing and will cover both theory and practice. It will help students understand the application of theoretical concepts for practical issues. After the course, students should be able to apply all methods covered in the course. This course will also focus on software tutorials. At the end of the course, the students will be able to demonstrate an understanding and application of quantitative techniques to a range of problems in Finance.

Recommended Books:

Malhotra, N. K., Nunan, D., & Birks, D. F. (2017). Marketing research: An applied approach. Pearson Education Limited.

8. Advertising Research

The design and implementation of effective advertising and media strategies require careful evaluation. The course Advertising Research provides students with an overview of the methods and techniques used to evaluate advertising effectiveness and research consumer responses to advertising more generally. Employment in advertising research requires particular expertise and is an area of growing employment demand. This course expands and introduces core concepts in advertising research and understands quantitative and qualitative research techniques employed in advertising research.

Recommended Books:

De Mooij, M. (2018). Global marketing and advertising: Understanding cultural paradoxes. Sage.

9. Industrial Marketing and International Business

The course is focused on students with a particular interest in international business marketing and development. There are two main parts of the course. The first part deals with industrial marketing, which involves corporate purchasing behaviour and business channel management. The second section offers and introduces significant theories and developments in international business. The course will address the key challenges that companies face as they grow their business globally, and after studying this course, students will be able to apply these fundamental concepts to contemporary research issues in industrial marketing and international business.

Recommended Books:

Rizomyliotis, I., Konstantoulaki, K., & Kostopoulos, I. (2017). Business-to-business marketing communications: Value and efficiency considerations in recessionary times. Springer.

Human Resource Management (Elective Courses)

1. Contemporary HRM Issues in the 21st Century

This course aims to give a broad overview and knowledge of the contemporary issues that exist within the Human Resource Management (HRM) context across a global workplace. It will help students recognize the key emerging issues associated with Human Resource Management and evaluating what challenges these issues pose to our existing understanding of the literature and theory. It will help them examine individual and organizational strategies and approaches in coping with contemporary and emerging HR issues as well as critically analyzing their practical implications for organizations and employees. Topics may include psychological contracts, career management, HRM and the service sector, mental health and wellbeing at work, drug and genetic testing, work designs, and ethical practices.

Recommended Books:

1. Holland, P. J. (Ed.). (2019). *Contemporary HRM Issues in the 21st Century*. Emerald Publishing Limited.
2. Turkmenoglu, M. A., & Cicek, B. (Eds.). (2020). Contemporary Global Issues in Human Resource Management. Business Science Reference

2. Contemporary Issues in Leadership and Organizational Development

This course addresses leadership and leadership development as processes directed towards organizational development, professional development, group development, personal development, identity formation, and how to manage and support such processes. Leadership development will be analyzed and discussed from different perspectives of the most prominent leadership theories and research. The readings will include a mixture of classic and contemporary papers that are both theoretical and empirical. Through the readings, students would gain an understanding of the major theories and research in contemporary issues of Leadership and Organizational development and obtain knowledge and skills to conceptualize and conduct research.

Recommended Books:

1. Harrison, C. (2017). Leadership theory and research: A critical approach to new and existing paradigms.
2. Springer. Storey, J. (2016). Leadership in Organizations: Current issues and key trends.

3. Negotiation and Conflict Management

Negotiation and conflict management are common occurrences in workplaces and our personal lives because people see things from different perspectives and do not always agree with one another. Research indicates that conflict, contrary to general belief, is not always dysfunctional. Where properly managed, conflicts can lead to positive outcomes, such as improved understanding, better alternatives, and increased satisfaction. Thus, this course presents negotiation theory as well as the strategies and styles within an employment context. In addition to the theory and exercises presented in class, students will cover a range of topics, including challenging situations such as cross-cultural mentoring, first and third-party conflict negotiations, and investigations to assist the systematic change because of a dispute. Students will be introduced to theoretical paradigms and underpinnings used in negotiations and conflict management research at the workplace.

Recommended Books:

1. Menkel-Meadow, C., Schneider, A. K., & Love, L. P. (2020). *Negotiation: processes for problem solving*. Wolters Kluwer.
2. Budjac Corvette, B. A., Glasgow, H., Fisher, R., & Ury, W. (2007). *Conflict management: A practical guide to developing negotiation strategies*. Upper Saddle River^ eNJ NJ: Pearson Education, Inc..
3. Olekalns, M., & Adair, W. L. (Eds.). (2013). *Handbook of research on negotiation*. Edward Elgar Publishing.

4. Recruitment and Selection

In a highly competitive business world, an organization's staff can determine whether a company profits or perishes. This course presents recruitment and selection (R&S) as an essential component in recruitment planning. The role of recruitment and selection is examined in relation to an organization's overall profitability or viability. Through a blend of theory and application, the course introduces students to a wide range of issues, principles, practices, and trends in recruitment and selection. This course is intended to provide students with an understanding of recruitment and selection methods and processes as well as allow them to develop a critical approach to R&S and HRM. Students will be introduced to theoretical paradigms and underpinnings used in investigating the recent recruitment and selection workplace challenges.

Recommended Books:

1. Carrie A. Picardi (2019). Recruitment and Selection. Strategies for Workforce Planning & Assessment. Sage Publishing.
2. Compton, R. L. (2009). Effective recruitment and selection practices. CCH Australia Limited. Roberts, G. (1997). Recruitment and selection. CIPD publishing.

5. Contemporary issues in Compensation Management

Compensation and reward systems are key contributors to organizational effectiveness. In this course, students will learn how such systems operate to attract, retain and motivate a competent workforce. Further students will gain an understanding of how to assess reward systems in terms of the criteria of equity and cost-effectiveness and how to assess and diagnose compensation management issues and problems and develop appropriate solutions. Moreover, emphasis will be given to the theoretical and practical implications of this function for organizations. Students will be introduced to a wide range of issues, practices, and trends in compensation management which will help students develop a critical approach to remuneration and benefits management in organizations.

Recommended Books:

BERGER, L. A., & BERGGER, D. R. (2020). *The compensation handbook. A state-of-the-art guide to compensation strategy and design*.

Upadhyay, S. S. (2009). *Compensation management: Rewarding performance*. Global India Publications. Bhattacharyya, D. K. (2009). *Compensation management*. Oxford University Press.

6. Theory and Research in Strategic Management

This course focuses on helping scholars develop an understanding of the theoretical underpinnings of strategic decision-making for business organizations. It further explores other areas of academic interest and their interactions with the strategic management of the organization. A natural outcome of the content of this course is to help students understand how pivotal links are created in managing an overall organization through external adaptation and internal integration. This course will highlight the dynamics of industry forces and focus on fostering growth and sustaining competitive advantage by aligning resources and strategies in a coordinated, synergistic, and integrated manner.

Recommended Books:

Lasserre, P. (2017). *Global strategic management*. Macmillan International Higher Education.

David, F. R., David, F. R., & David, M. E. (2013). *Strategic management: Concepts and cases: A competitive advantage approach*. Upper Saddle River: Pearson.

7. Micro Topics in Organizational Behavior

Micro Topics in Organizational Behavior is a Ph.D. seminar course exploring current and seminal research on individual, dyadic, small group, and intra-organizational behavior. The readings will include a mixture of classic and contemporary papers that are both theoretical and empirical. Through the readings and course requirements, students would gain an understanding of the major theories and research in Organizational Behavior and obtain knowledge and skills to conceptualize and conduct research in Organizational Behavior.

Examples of topics at the individual level include emotions, cognition, and behavioral decision-making. Examples at the dyadic level include social perception and bias. Group-level topics include teams and multiparty decision making. Topics at the intra-organizational level include culture and gender.

Recommended Books:

1. Baykal, E. (Ed.). (2019). *Handbook of research on positive organizational behavior for improved workplace performance*. IGI Global.
2. Nahavandi, A., Denhardt, R. B., Denhardt, J. V., & Aristigueta, M. P. (2013). *Organizational behavior*. Sage Publications.
3. Miner, J. B. (2005). *Organizational Behavior: Essential theories of motivation and leadership. one* (Vol. 1). ME Sharpe.

8. Macro Topics in Organizational Behavior

This course covers classical and key contemporary works in organization theory and surveys the main paradigms that are now active in the field. It draws on disciplinary roots in (alphabetically) economics, political science, psychology, and sociology to explain the origins, persistence, and disappearance of the institutional structures that order economic life (organizations, firms, networks, markets, and others). Students will read some of the classic statements of the major approaches and trace the history of ideas as the field has developed up to the present. Examples of topics include contingency theory, resource dependence, network approaches, institutional theory, social movements, and organizations, etc.

Recommended Books:

1. Van Wormer, K., & Besthorn, F. H. (2017). *Human behavior and the social environment, macro level: Groups, communities, and organizations*. Oxford University Press.
2. Smith, W. K., Jarzabkowski, P., Lewis, M. W., & Langley, A. (Eds.). (2017). *The Oxford handbook of organizational paradox*. Oxford University Press.
3. Nahavandi, A., Denhardt, R. B., Denhardt, J. V., & Aristigueta, M. P. (2013). *Organizational behavior*. Sage Publications.
4. Wagner III, J. A., & Hollenbeck, J. R. (2014). *Organizational behavior: Securing competitive advantage*. Routledge.

9. Meso Organizational Behavior

This course will introduce research scholars to the simultaneous study of multiple levels of organizational behavior. This class intends to build their scholarly abilities by exposing them to a wide range of topics related to meso research. Their ability to understand, develop, and extend theory will be enhanced by an enriched understanding of the mechanisms that connect variables, particularly mechanisms that bridge levels of analyses. This class surveys many different types of mechanisms, collective constructs, and areas of crosslevel research by design. The class topics will first introduce students to mechanisms and meso-level theorizing and then explore these in the context of basic mechanisms related to meaning, emotion, and action, teams, identity, culture, climate, and learning in organizations.

Recommended Books:

Champoux, J. E. (2020). *Organizational behavior: Integrating individuals, groups, and organizations*. Routledge.

Finance (Elective Courses)

1. Derivative Pricing and Theory

This course focuses on helping students understand the derivate pricing and underlying theory by introducing students to a wide range of issues, principles, practices, and trends of these mechanisms. They will develop an understanding of the Black-Scholes model's application to the

range of derivative securities encountered in the market and the term structure of interest rates. Links between derivative prices and underlying theory will be examined as well, as the discrepancies between the Black-Scholes model and market data will be described and analyzed along with other alternative models. This course is tailored for research students with quantitative and Finance backgrounds, and the goal of this course is to help students understand the valuation of a derivative option in financial markets. After this course, students will derive analytical solutions for some basic options and be expected to grasp essential numerical tools for derivatives pricing, such as the Monte-Carlo method, finite difference method, etc.

Recommended books:

John C. HullO (2017). Options, futures and other derivatives, Pearson

2. Advanced Behavioral Finance

This course is designed to provide an overview of an exciting new and fast-growing area in Finance. This course is intended to complement other finance courses that are primarily based on the traditional paradigm, which assumes that investors and managers are generally rational. Specifically, this course has three key objectives. First, it aims to examine how behavioural finance theories' insights shed light on individual investors and finance professionals' behaviour in investment decision-making and corporate financial decision-making. Second, it explores the possibility to improve investment performance and corporate performance by recognising the cognitive biases and applying appropriate debasing techniques. Finally, it investigates the implications of behavioural Finance for the construction of good corporate governance mechanisms and theory.

Recommended books:

Statman, M. (2019). Behavioral Finance: The Second Generation. CFA Institute Research Foundation.

3. Quantitative Methods in Finance

The course aims to provide students with current and advanced quantitative methods being applied in financial research. This course is focused on providing students with an understanding of quantitative methods, processes, and trends in Finance. The course will cover linear and non-linear methods, focusing on regression analysis, panel data analysis, GARCH-family, and Markov regime-switching models. At the end of the course, the students will be able to demonstrate an understanding and application of quantitative techniques to a range of problems in Finance.

Recommended books:

1. Asteriou & Hall (2011). Applied Econometrics, Macmillan International Higher Education
2. Anokye Mohammed Adam, Peterson Owusu (2018). Financial Econometrics: An Example-based Handbook, Nova science

4. International Finance

This course aims at providing a solid understanding of international Finance within complex capital markets and corporate governance context. It emphasises finance's managerial perspective for a multinational corporation (MNC). It will focus on two key areas, firstly, the introduction and critical evaluation of the main relevant economic theories, models, and empirical works in key areas of International Finance and secondly, the application of these analytical tools to build an understanding of relevant economic developments and policy issues in the global markets and MNCs. The basic tenets of international Finance are presented through a core textbook, assigned readings, and lectures.

Recommended books:

Jeff Madura (2020). International Financial Management, Cengage Learning, Inc

5. Advances in Islamic Banking and Finance

This course aims to introduce the basic concepts of Islamic banking and finance applied locally and globally. The course will simplify and explain the underlying theories and concepts of the Islamic financial instruments used in the Islamic finance industry and how these concepts are practically implemented. It includes the concepts of finance theories and concepts in the light of Islamic philosophy/ Islamic Sharia'h and the mechanism involved in developing financial products. It will also spotlight the efforts undertaken in Pakistan and other Islamic countries at the state level and the private sector to revamp the overall economy on the universal principles of Shariah and the challenges in the transformation of the economy from the socalled interest-based modes to interest-free transactions.

Recommended books:

Dilip Mutum, Mohammad Mohsin Butt, Mamunur Rashid (2017). Advances in Islamic Finance, Marketing, and Management: An Asian Perspective, Emeralds

6. Finance Theory

This course focuses on the main developments in finance theory over the past 60 years, investigates gaps in current finance practices, and investigates the need for future developments. The course develops the main theoretical foundations of Finance, including investment decision making, utility theory, portfolio theory, equilibrium asset pricing, arbitrage asset pricing, the term structure of interest rates, option pricing theory, agency theory, performance measurement, corporate governance, and corporate Finance. The course provides the theoretical foundations for subsequent finance research and is intended to provide students with an understanding of the relevant methods, processes, and finance research trends.

Recommended books:

1. Doron Peleg (2014). Fundamental Models in Financial Theory, MIT press
2. Pierre Vernimmen, Pascal Quiry, Maurizio Dallocchio, Yann Le Fur, Antonio Salvi (2020), Corporate Finance: Theory and Practice, Wiley

7. Advanced Financial Risk Management

Derivative securities are the most rapidly growing area in the global financial market. The purpose of this course is to provide a comprehensive analysis of the properties of options and futures and to offer a theoretical framework within which all derivatives can be valued and hedged. This course provides both theory and a working knowledge of financial derivatives. The theory component covers fundamental pricing principles that apply to various derivative contracts in financial markets. The working knowledge component will cover the main types of derivatives contracts and valuation techniques. The course emphasises the use of derivatives in financial risk management.

Recommended books:

Donald R. Van Deventer, Kenji Imai, et al. (2013). Advanced Financial Risk Management: Tools and Techniques for Integrated Credit Risk and Interest Rate Risk Management, Wiley John C. Hull (2018). Risk Management and Financial Institutions, Wiley

8. Advanced Empirical Finance

This course provides a concise synthesis of the recent available literature on empirical studies in corporate finance, investments, and asset pricing within a logical and analytical structure. The

course will focus on the discussion of estimation methods that can be used to analyze financial models, followed by a description of the time series properties of various financial data. The Scholars will be able to apply such techniques to address practical financial problems. The most important theoretical models in Finance are then presented and accompanied by an explanation of the available methods for testing theoretical hypotheses.

Recommended books:

Bali, T. G., Engle, R. F., & Murray, S. (2016). Empirical asset pricing: The cross section of stock returns. John Wiley & Sons.

9. Advanced Portfolio Management Theory

This course will introduce the scholar to the main theories and practice of investments and portfolio management. The scholars will learn about various investment opportunities, including real and financial assets; the investment environment includes the money and capital markets; the investment process includes identifying goals, data gathering, analysis, etc.; and decision-making under a changing market environment. The material covered will include a selection of assets with special emphasis on securities selection through technical analysis and fundamental analysis, computation of risk and 21return of individual assets, asset allocation and portfolio formation, computation of risk and return of portfolios, measurement of portfolio performance, and rebalancing of portfolios. Also included in the material will be topics such as the "pyramid" approach, forecasting and the use of indicators and, market and industry indexes, models such as the CAPM, bond and stock valuation, mutual funds, domestic versus global investment, etc. To understand the theory and practice aspects of portfolio construction and management, advanced investment topics will be covered throughout the course.

Recommended books:

Giuseppe A. Paleologo (2020). Advanced Portfolio Management: A Quant's Guide for Fundamental Investors, Wiley

10. Emerging Issues in Finance

The introduction of new financial products (e.g., cryptocurrencies), the surge in new investment vehicles (e.g., exchange-traded funds), and the focus on environment-friendly project financing and investment (i.e., green Finance) have brought forth new challenges and issues in Finance. Moreover, the recent COVID crisis has provided new research challenges in Finance. This course will accentuate these issues and their impact on existing financial products. This course will help students understand the contemporary issues in finance and understand their implications to critically analyze current finance practices.

Recommended books:

Chishti, S., & Barberis, J. (2016). The Fintech book: The financial technology handbook for investors, entrepreneurs and visionaries. John Wiley & Sons.

11. Contemporary Issues in Financial Markets

The course aims to cover recent trends and issues in financial markets. The focus will be on money markets, capital markets, and derivative markets. The course will encompass new advances in these markets and their subsequent impact on the field of Finance. The students will be able to identify new research areas in financial markets. Through a blend of theory and application, the course will introduce students to a wide range of issues, principles, practices, and trends in financial markets so that students can understand and apply this knowledge to contemporary research issues.

Recommended books:

Madura, J. (2020). Financial markets & institutions. Cengage learning.

Career Opportunities for students after completion of the program

This program is suitable for those who want to pursue a research or teaching career in the future. The program is designed to provide a welcoming learning atmosphere where students will have many opportunities to engage with business leaders, professors, and other students. Students can be very competitive in the industry and play a strategic role in decision-making based on their particular expertise and training, and they can also play an essential role in improving the quality of education in their field as teachers.

Academic Rules (MS & PhD)

All MS/PhD admissions (Fall-2024) will be made based on Graduate Education Policy-2023 of HEC (As approved by Advanced Studies & Research Board and adopted by Academic Council of NTU. However, updated version of said policy /academic rules will be uploaded on NTU website for information of students. University has right to modify partially or wholly, any clause of said policy/academic rules from minimum level any time. Students will be required to follow update guidelines.

Fee Structure for Postgraduate Programs (Fall-2024)

Programs	Total One Time Dues at Admission (Rupees)	Tuition Fee (1st Semester) (Rupees)	Total Other Charges (Per Semester) (Rupees)	Total 1st Semester Dues (Rupees)
M.S. Mathematics	32,400	37,630	11,000	**81,030**
M.S. Physics	32,400	37,630	11,000	**81,030**
M.S. Textile Chemistry	32,400	37,630	11,000	**81,030**
M.S. Computer Sciences	32,400	37,630	11,000	**81,030**
M.S. Software Engineering	32,400	37,630	11,000	**81,030**
M.S. Business Administration (1.5Y)	32,400	48,920	11,000	**92,320**
Master of Business Administration (1.5Y)	32,400	48,920	11,000	**92,320**
Master of Business Administration (2Y)	32,400	60,210	11,000	**103,610**
M.S. Textile Engineering	32,400	37,630	11,000	**81,030**
M.S. Advance Materials Engineering	32,400	37,630	11,000	**81,030**
M.S. Advance Clothing & Fashion	32,400	37,630	11,000	**81,030**
M.S. Textile Technology	32,400	37,630	11,000	**81,030**
Ph.D. Textile Engineering	32,400	37,630	8,000	**78,030**
Ph.D. Advance Materials	32,400	37,630	8,000	**78,030**
Ph.D. Textile Technology	32,400	37,630	8,000	**78,030**
Ph.D. Apparel Manufacturing	32,400	37,630	8,000	**78,030**
Ph.D. Computer Science	32,400	37,630	8,000	**78,030**
Ph.D. Chemistry	32,400	37,630	8,000	**78,030**
Ph.D. Management Sciences	32,400	37,630	8,000	**78,030**

Detail of One Time Admission Dues and Other Charges

Particulars	Rupees
Admission Fee (Once at admission)	25,000
Certificate Verification Fee (Once at admision)	2,000
University Security (Refundable)	5,000
Red Crescent Donation (Once at admision)	100
University Card Fee (Once at admision)	300
Library Fee (Per Semester)	3,000
Examination Fee (Per Semester)	3,000
Medical Fee (Per Semester)	2,000
Student Activity Fund (Per Semester) for MS/MBA only	2,000
Endowment Fund (Per Semester) for MS/MBA only	1,000
Degree Fee (Once in the Last Semester)	5,000

Hostel Dues

Particulars	Rupees	
Hostel Charges (Per Semester)	25,000	
Hostel Security (Refundable)	5,000	**30,000**

(ii) The security deposit is against breakage and/or any other damage caused by the students.

(iii) The security deposit is refundable within two year after the completion of degree or leaving the University without completion or expulsion from the University. After Two years all the unclaimed securities will be forfeited.

(iv) If any student fails to submit semester dues till sixth week from the commencement of semester then the student's admission will be cancelled. Student may sit in mid exam after the payment of re-admission fee of **Rs.15,000/-** along with semester dues.

Note: (i) Tuition Fee will increase **@ 2.5% Per Annum** in Subsequent Years.

Thesis Delay Fine Policy for All MS Programs

1. If a MS student submits his/her thesis after minimum duration of degree period / submitting all regular semester dues following thesis delay fine will be charged:

i. Rs. 5,000/- only will be charged as thesis delay fine in 4th semester* (for MS Business Administration students only)

All Other MS Programs:

ii. Rs. 5,000/- only will be charged as thesis delay fine in 5th semester*

iii. Rs. 6,000/- only will be charged as thesis delay fine in 6th semester*

**Examination Fee will be charged separately*

2. While if a student who will register / repeat any previous subject/s along with thesis, 1/3rd of tuition fee of last regular semester will also be charged other than above fine.

Late Fee Fine Policy

The fine for late deposit of fee charges shall be **Rs. 5,000/-** up to two weeks after expiry of the due date and **Rs. 10,000/-** from 3rd week to 6th week, **after that the student's admission will be canceled.** Student may sit in mid exam after payment of re-admission fee of **Rs. 15,000/-** along with semester dues.

Thesis Delay Fine Policy for PhD Programs

i. One year (02 semesters) as extra period after regular / minimum period of PhD program (3 Years / 6 Semesters) to encounter unforeseen conditions (whatsoever) in the way of thesis completion without dues.

ii. After expiry of one-year grace period, Rs. 12,000/- each semester will be charged as thesis delay fine (double to MS fine) and Rs. 3,000/- as examination charges (Total Rs. 15,000/- each semester).

iii. PhD student who have submitted his/her final thesis in Graduate Office for internal / external evaluation, will not be charged any dues.

Refund Policy

Students who desire to leave their studies from the university will be refunded the dues as per existing refund policy of HEC, Islamabad according to the following rules:

1. If any student applies for the refund of university dues paid by him/her up to 7th day of commencement of classes, he/she will be refunded full (100 %) deposited dues except the admission fee of **Rs.25,000/-** (Subject to clearance from all the departments).
2. If any student applies for the refund of deposited university dues from 8th to 15th day of commencement of classes, then he/she will be refunded security deposited and half (50%) fee (Subject to clearance from all the departments).
3. If any student applies for the refund of paid university dues from 16th day of the commencement of classes, only his/ her amount of security will be refunded (Subject to clearance from all the departments).

Note:

% age of fee shall be applicable on all components of fee, except for security and admission charges.

Time line shall be calculated continuously, covering both weekdays and weekend.

Security Refund:

1. The above fee structure is subject to change from time to time
2. The security deposit is against brakeage and / any other damage caused by the student
3. All the securities are payable only once at the time of admission.

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Disclaimer:

Whilst the University endeavours to ensure that the information provided in this booklet is accurate at the time of publication and is shared for general guidance of graduate applicants taking admission in the programme.

The University intends to offer the courses and facilities described in the booklet but it reserves the right to withdraw or make alterations in course, and facility if deemed necessary without prior notice including acadmic/administrative guidelines on recommendation of Advanced Studies & Research Board/Academic Council, NTU

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