Graduate Prospectus 2014

Institute of Space Technology

HELP YOU ACHIEVE YOUR AMBITIONS
To foster intellectual and economic vitality through teaching, research and outreach in the field of Space Science & Technology with a view to improve quality of life.
INSTITUTE OF SPACE TECHNOLOGY
1, ISLAMABAD HIGHWAY, ISLAMABAD
PAKISTAN

Bureau Veritas Certification certify that the Management System of the above organisation has been audited and found to be in accordance with the requirements of the management system standards detailed below.

Standards

ISO 9001:2008

Scope of certification

PROVISION OF EDUCATIONAL SERVICES IN TEACHING & LEARNING, WHICH CONSIST OF PROGRAM REGISTRATION, EXAMINATION, MONITORING OF STUDENTS' EFFECTIVENESS, RESEARCH & DEVELOPMENT, TEACHING EVALUATION, INDUSTRIAL TRAINING, GRADUATION OF:
- AERONAUTICS & ASTRONAUTICS ENGINEERING
- ELECTRICAL ENGINEERING
- MATERIALS SCIENCE ENGINEERING

Certification cycle start date: 20th October 2012
Subject to the continued satisfactory operation of the organisation’s Management System, this certificate expires on: 11th January 2015

Original certification date: 12th January 2013
After monitoring the performance of the organisation’s management system in Surveillance Audits the certificate validity will be renewed after every year subject to maximum of 36 months from the date of approval.

Certificate No. PAK000903-U

Mohammed Shahab Saqib
Signature

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Welcome Message
Vice Chancellor

The Institute of Space Technology welcomes the ever increasing number of students who aspire to enhance their knowledge and specialize in technologies that are shaping the 21st century world.

Selecting a Graduate study program is a vital career choice. Many of the prospective graduate students may be holding professional positions where they are keen to enhance their career. Others may wish to continue their studies having recently completed an undergraduate program or may have an interest in a particular area in which they are keen to contribute through research.

Whatever one’s ambitions are, choosing Institute of Space Technology’s linked or local PhD / MS programs would enhance one’s future prospects through an advanced program that is underpinned by an outstanding, dedicated and qualified faculty.

The underlying objective of the linked programs is to offer a cost effective opportunity of earning a Graduate degree in a specialized field from a reputed foreign university. Similarly, the Local PhD / MS programs present an opportunity to study and carry out research at the Graduate level at one of the most prestigious institution of higher learning in Pakistan quite inexpensively. The program is fully based on HEC guidelines, and endeavors to meet the highest standards of Graduate study.

We look forward to see you at the Institute of Space Technology.

Imran Rahman
Location

**Islamabad: The Heart of Pakistan**

Pakistan's capital ISLAMABAD nestles against the backdrop of Margalla Hills at the northern end of the Potohar Plateau. It symbolizes the aspirations of a young and dynamic nation that looks forward to a glorious future for its people. Islamabad is a city which welcomes modern ideas but, at the same time recognizes and cherishes traditional values and the past history of its people.

Modern, spacious and carefully planned, is a city of wide, tree-lined streets, large houses, elegant public buildings and well organized bazaars. From shopping centers to eateries, you will find it all here.

Apart from all the modern amenities, Islamabad is a neighbor to quite a few historical sites. Among them are:

**Rawalpindi**

Rawalpindi is a city in the Potohar Plateau near Pakistan's capital city of Islamabad, in the province of Punjab. It is also known as the twin city of Islamabad. It is the military headquarters of the Pakistan Armed Forces and also served as the nation's capital while Islamabad was being constructed in the 1960s. The city is home to many industries and factories. With historical buildings and bazaars, vast parks, chilling winters and hot summers, Rawalpindi has proven its status as a MUST visit place.
Location

Margallah Pass
To the North of Islamabad, Margallah lies between the ancient capital of Gandhara (Taxila), and Islamabad. There is an obelisk right on the top of the Pass, built in 1890 in memory of Brig Gen of the British army, by his colleagues. A small part of the ancient Shahi (Royal) Road built by Chandar Gupta and later developed by the Afghan King Sher Shah Suri in 1540s, can also be seen.

Taxila
Most of the archaeological sites of Taxila (600 BC to 500 AD) are located around Taxila Museum. For over one thousand years, Taxila remained famous as a centre of learning Gandhara art of sculpture, architecture, education and Buddhism in the days of Buddhist glory. There are over 50 archaeological sites scattered in a radius of 30 kms around Taxila. Also, a museum comprising various sections with rich archaeological finds of Taxila has been established close to the site. It is a popular destination with tourist visiting from all over Pakistan as well as abroad.
Location

Wah Gardens
Once a major campsite of Mughal rulers, Wah Gardens is located 12 km west of Taxila on the G.T. Road. The gardens were developed with magnificent trees and water channels by successive Mughal emperors. It is a place that must be visited.

Gurudwara Panja Sahib in Hasan Abdal
The town of Hasan Abdal has a particular association with Mughals and Sikhs. It was mentioned by Emperor Jahangir in his memoirs and frequently visited by successive Mughal Kings, on their way to Kashmir. It has a Sikh Gurdwara (temple) known as Panja Sahib and is visited biannually by Sikh pilgrims from all over the world.

Murree Hills
To the further east at about 45 miles away are the green top Murree Hills. Murree is a place for all seasons; in summers it is an ideal place to beat the sizzling heat of the twin cities and a romantic hideout to catch some snowflakes during winters.


Saidpur Village
Saidpur, a little quaint village, famous for its pottery, is part of Islamabad today. It is located off the Hill Road to the east of Daman-e-Koh. Saidpur was founded by Sultan Said Khan, son of Sultan Sarang Khan. He gave his daughter in marriage to Mughal Prince Saleem who later became Emperor Jahangir. Saidpur was a garden resort and a perpetual spring provided water for drinking and for watering gardens. An attractive destination, where cultural exhibitions and restaurants provided a great ambiance among the hills during the Mughal period. It has recently been renovated into an attractive tourist destination, where exhibits and restaurants provide a great view among the hills.

Rawal Lake
To the east of Islamabad and at the foothills of Murree, lies a scenic & spectacular lake aptly named as Rawal Lake. This lake is host to many of the sporting events like, rowing, sailing and recreations like boating, fishing, sightseeing etc. Rawal Lake's primary role is to provide a water reservoir for the twin cities. Nevertheless, it is an attractive place for the visitors.
Introduction

Science is a methodical study of the world, an attempt to comprehend the puzzles of our universe, testing hypotheses with experiments, and then sharing what is discovered with the rest of mankind. The present era of technological advancements provided stimulus for realizing our dream: to set on a journey to explore the Universe and try to find the answers to the questions in our mind: (1) how the Universe was created, (2) how life started on planet earth, and (3) does life exist on any other planet than earth. The space exploration has created an ecosystem where cutting edge technologies were conceived, researched and eventually developed.

There has been an exponential increase in scientific discoveries in the past century and we have to be on the leading edge of that vast wave. In this milieu, Institute of Space Technology (IST), Islamabad, was established in September, 2002. Being the only institute of its kind in Pakistan, it strives to impart specialized education in space and related science. At IST we offer undergraduate degrees in Aerospace, Electrical, Mechanical, Materials Science & Engineering and Space Science. Currently, besides offering indigenous PhD/ MS Programs, the Institute is also collaborating with Beihang University (BUAA), China, University of Surrey (UniS), UK & Northwestern Polytechnical University (NPU).

China to offer linked programs in more than a dozen specialized areas.

The institute has a remarkable number of foreign trained specialized faculty who are not only dedicated but have brought home with them years of experience from abroad.

The institute aims at offering state-of-the-art learning environment that will inculcate in students a desire to generate knowledge through innovation and research. Quality research demands advanced Labs where real world experiments are conducted; therefore, the Institute focuses on providing world class research labs. Equipments like Subsonic and Supersonic Wind Tunnel have been provided. IT facilities have been further enhanced with the addition of computers and Wi-Fi facility.

The Institute aspires to instill “critical thinking skills” in students through intellectual challenges posed to them that facilitate and inculcate innovative ideas. With the focus on ushering you towards the path of success in the scientific world, IST looks forward to be a mentor and conduit for you.
The Institute

Campus
Away from congestion, noise and pollution of the city, at 20 minutes drive from Islamabad and Rawalpindi, having multiple access through Islamabad Highway and GT Road, IST is located in the Capital Territory of Pakistan. This advantageous location offers round the clock accessibility through public and private transportation. Spanning over 577 kanals of picturesque expanse of greenery adjacent to DHA, the campus features wide lawns, ample parking spaces and playgrounds. This tranquil environment makes it ideal for situating a seat of higher learning and research.

Academic Block I
Amidst the green spaces a spacious purpose-built, double storied, centrally air conditioned building with a covered area of 5384 sqm, houses administrative and faculty offices, class rooms, lecture theatres, teaching and research laboratories, Information Technology Center, library, conference room, auditorium, faculty lounge and exhibition area.

Academic Blocks II to VI
Academic Blocks II & VI are also available to house additional classes and laboratories. The Blocks are air-conditioned to support a conducive learning environment.

Video Conferencing Facility
A state-of-the-art video conferencing facility is available in the Academic block I. The facility is useful for distance learning and telecasting lectures to and from other universities with similar facilities.

Auditorium
Aesthetically designed, fully air-conditioned auditorium with a capacity of 230 persons is located adjacent to the entrance lobby of the Academic Block-I. An ideal venue for holding national and international conferences, seminars, and workshops, it is equipped with modern audio-visual systems.
Lecture Theatres
All lecture theatres and classrooms are centrally air-conditioned, well-lit and equipped with training aids and multimedia facilities. Lecture theatres can accommodate 60 students, whereas classrooms have a seating capacity of 30 students.

Computer Theatres
Classrooms with individual computers for each student are available for computer based training. The computers are networked to a server and an overhead multimedia projector to enable interactive, hands-on training on computational and professional software learning skills. A computer laboratory housing powerful computers is available for assignments and projects. Also, internet facility is available to students at all times of the day.

Specialized Laboratories
The academic program is supported by laboratories equipped with state-of-the-art equipment. Multiple equipment and instruments are available to ensure hands-on training of each student in the following laboratories:
- Aerospace Materials
- Electronics
- Finite Element Methods
- Communication Systems
- Computational Fluid Dynamics
- Computer Networks
- Aerospace Instrumentation
- Electrical Circuits
- Information Technology
- Embedded Systems
- Computer Aided Design
- Digital Signal Processing
- UAV Design Lab
- Digital Communications
- Workshop
- Mobile Communications

Library
The library is integrated with digital technology and electronic information resources. There is an active and continuous development program for the IST library. It has a dynamic collection of books, journals and magazines related to all disciplines which is supplemented by a Xeroxing facility. The core design, furniture and general decor contribute to the formation of an intellectual environment that enables students to study with concentration.

General Collection: IST library has a collection of more than 6,300 books on all subjects relevant to the courses taught at the institute. Moreover, books on general knowledge, Islam, history, geography and fiction etc are also available.

Reference Section: The reference section has over 600 reference books, handbooks, encyclopedia and dictionaries etc.

Periodicals: IST library is currently subscribing to 47 periodicals to meet the requirements of researchers, faculty and students.

Audio Visual Collection: Audio-visual material is considered an essential medium of instruction. Library has a good collection of educational videos and related audio/visual devices.

Online Resources: To enrich the library collection with the latest online resources available through Internet, professional publications from AIAA, IEEE, ACM and ASME are accessible. More than 23,000 journals and 45,000 e-books are available (full text) through HEC Digital Library Program.

Equal Opportunity Institution
IST is an equal opportunity institution and prohibits discrimination on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, marital or family status in all its programs and activities.

Timings
Evening Classes

Medium of Instruction
The medium of instruction at IST is English.
Facilities

Hostel
Hostel accommodation is available for both male and female students outside campus. IST provides pick & drop facility from hostels to campus & shuttle service for markets. Dining facility is available and the boarders enjoy the tranquility and fine meals of the mess. Hostels are equipped with backup generator to provide continuous supply of electricity. All the hostels are furnished with free internet facility. Hostels have a conducive environment for boarding & lodging of students.

Computing
A large number of computers are available at convenient locations for students to do their assignments and projects. Moreover, wireless internet facility is also available to students to connect to the internet from anywhere in the campus.

Sports & Games
Students can avail spare time to enjoy a game of table tennis in the table tennis room or perfect their shooting in the basketball court. Also, there are numerous indoor games that students can enjoy at their leisure time.

Fitness
For the fitness conscious, a fitness room with multiple fitness and exercising equipment is available.

Mosque
The mosque, adjacent to the academic block and dormitory hosts regular prayers. Namaz-e-taraveeh is also held during the month of Ramadhan.

Lost & Found
A lost and found office is available for depositing the found and retrieving the lost items on providing sufficient proof of ownership to incharge student affairs.

Extra Curricular Activities:

IST Societies & Clubs
IST has a wide range of student societies to convene the recreational and vocational needs of the students, who also bring along a rich blend of extramural interests. IST student societies have the distinction of winning many inter-university competitions. Following Societies and clubs are currently active with students as their office bearers as well as members.

Departmental Societies
Aero Society
Aero Society is a promising platform that creates awareness and provides incentive for students to participate practically in the area of aerospace technology. The society also serves as a platform for beginners and intermediate level students to share their skills and experience that builds the crucial ability of team work. The main objectives of Aero Society comprise of following:

- To arrange a Aero specific National level competition every year
To organize, independently or jointly with other institutions, seminars/symposia/workshops related to aerospace

To assist the students in collaborating with the relevant industry and publish their research works at national and international level

**Electrical Society**
It aims to provide a platform for the dissemination of knowledge on both theoretical and applied research in electrical technologies and software computing. This society triggers and develops the intelligence quotient of the students to write new codes, algorithms and software. It promotes research activities by encouraging students to come up with new ideas and host discussions, assisting them in writing formal research papers. The Society includes following clubs:
- Software and Robotics
- Communication Research

**Materials Science Society**
This society provides an opportunity for the young learners to discover their skills and explore new horizons in Materials Science. In order to incorporate these qualities in the students, the society arranges multiple activities through its club named as:
- Materials Research

**Space Society**
Space society aims to create awareness amongst the students of IST and other academic institutions of Pakistan about the informatics of space, astronomy, aeronautics, space communications and environment through practical & engaging activities.

**Society of Mechanical Engineering IST (SSOME-IST)**
The mission of the society is to introduce the undergraduate Mechanical Engineering Department of IST in the form of an interesting engineering community. The mission is supported by offering undergrads a multitude of social events, exposure to the applications of the courses they are taking, industrial tours, inter & intra universities competitions, seminars and exhibition regarding engineering technologies.

**IST Research Society**
This society works to boost the knowledge and skills of IST students eventually leading them to research and innovation. The aim of the society is to inculcate research motivation and learning in the students at IST.

**IST Entrepreneurial Society**
IST Entrepreneurial society is striving to create success in uncertainty blaze, a path of innovation and secure a future for all members of IST Entrepreneurial society. Initiating new entrepreneurial ideas and producing employers rather than employees is the core aspect of this society.

**Philanthropy Societies and Clubs**

Universities and Colleges are in a strategic position to shape the thinking and values of future leaders: to shape them into responsible citizens with a commitment to pay back to their communities and work for social change. Social investments are used to leverage systematic change with the aim to solve important problems, not only by ameliorating their immediate short term effects, but by targeting their cause. Finding ways to enhance and promote philanthropy in its traditional form, and deepen its impact on society, by focusing on education and research so as to enable youngsters to take charge. Following Societies and Clubs work under this society.
- Umeed Society
- Blood Donors Club
- Planteers Society

**Arts and Publication Society**
An exciting part of the co-curricular scene at IST is the Arts and Entertainment Society. The objective is to inculcate the literary and professional aptitude among the students, through various linguistic and literary activities. Students are given an outlet to display their hidden potential through the following clubs:
- Publications Club
- ART-IST “The Arts Society”

**GHOONJ “The Music Society”**
The society promotes music activities and provides quality
entertainment to the students of IST. The society arranges music performances in the institute to promote singing talent among the students.

AOUJ “Dramatics Society”
Dramas, short plays and skits have always been regular features of the AOUJ Dramatics Society repertoire at Welcome Parties, concerts and other occasions. The Society is set up to help the student's exhibit and enhance their dramatic skills. Through this platform, students gain confidence, improve their public speaking skills and learn to express themselves. This society aims to contribute to personality and character-building through the performing arts. Those looking for fun, excitement and productive teamwork can join the AOUJ Dramatic Society.

Cinematic Society
This society arranges movies for the students, especially for those living in hostels to lighten them up from their busy study schedule. Thought provoking, science fiction and animated movies are played by the society to provide healthy entertainment to the students.

IST Media Club
This club do all the media oriented coverage of all co-curricular events at IST. It includes photography, generating report, video graphics and social media coverage and publicity of the events at IST.

Fidens “Adventure Club”
Fidens Adventure Club plan and arrange adventurous and hiking trips to hilly areas. The basic concept to establish this Club is to promote healthy adventure activities, especially camping, trek and climbing etc. The Club organizes several trips for the interest of students.

IST Language Society

Chinese Language Club
Knowledge of Chinese language is becoming increasingly important in the global economy. Many businesses rely on contacts and connections with Chinese manufacturers and facilities. Hiring employees with Chinese-language skills is a benefit to employers. Seeing its growing importance, more and more schools and universities across the world have started to offer Chinese language as one of their options alongside Spanish and French.

IST initiated Chinese language classes on 1st Feb 2011. Peoples' Republic of China, currently the fastest growing economy in the world, is widely regarded as the potentially biggest global market in the twenty-first century. Proficient speakers of Mandarin Chinese will find jobs in various fields such as Business, Government, International Relations, Information Technology, Tourism, Education, Translation etc. Of all foreign languages at worldwide universities and colleges, Chinese shows the highest proportional increase in enrollment.

Arabic Language Club
The Arabic Language Club is to create awareness and to promote Arabic language among students/employees of IST by providing a platform for holding formal classes and organized activities.

French Club
IST started a French Club in IST with a purpose to know a bit about the Francophone cultures as well as to learn the French language. The IST French Club seeks to expand the knowledge and awareness of Francophone cultures and encourages the practice of the French language. Club members have the advantage of being able to participate in all activities and events. These include:

- Monthly reunions
- French language classes
- Festivals and cultural events
- French movie nights
- French-themed parties
- Educational lectures, presentations & demonstrations
- Excursion trips and French cuisine
- French chocolate tasting
- French cheese tasting

Sports at IST
To relieve the academic pressure, sports are an integral part of the extracurricular activities at IST. A series of inter-departmental tournaments are held periodically throughout the year to provide participation of the maximum number of students. Outstanding
Sportsmen/sportswomen are encouraged to take part in the inter-university tournaments and national level competitions. IST students have given excellent performance in various competitions by achieving top positions. Following sports activities are available to the students:

- Badminton
- Basketball
- Cricket
- Table tennis
- Volleyball
- Football
- Tennis
- Marathon
- Tug of War
- E-Gaming

Sports Facilities
IST provides students with the facilities of indoor and outdoor games. Students are encouraged to play in their spare time.

Coaches and Trainers
IST has a full time sports coach and a physical fitness trainer. In addition, the external sports coaches are also invited to train students and enable them to improve their skills in specialized sports.

Awards
IST has five departments namely Aeronautics and Astronautics, Electrical Engineering, Materials Science & Engineering, Mechanical Engineering and Space Science. All the departments compete for the supremacy in sports and the winning teams of the pool matches compete in the final for the title. The winner team is awarded with the Departmental Trophy. The best players (Male/Female) of the respective sports categories are awarded Gold Medals during the Annual Prize Distribution Ceremony in which parents of the winning students are also invited.

Events

**Job Fair**
Job fairs are becoming a popular method for doing preliminary assessment of different skills set needed by potential employers. Day-long Job Fair is organized at Institute of Space Technology every year. All major public and private sector organizations including our elite R&D organizations are invited to participate in the event thus providing an opportunity to the IST students to meet their potential employers. Many IST students have been able to secure good career jobs at the IST job fair.

**IST Youth Carnival**
IST organizes this event every year. This event was recognized as Twin City Inter University challenge in the earlier years of IST. In year 2011, the spectrum of this event was broadened to the national level and hence it was renamed as IST Youth Carnival. The event consists of entertaining competitions like arts contest, video shooting, Photography, essay and story writing, singing competition/Clash of the Clans, poetry and drama competitions etc.

**World Space Week**
World Space Week is celebrated in accordance with the United Nation’s General Assembly’s declaration of 1999. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) suggested the celebration of the World Space Week.
The objective of World Space Week is to increase awareness among decision-makers and the general public, of the benefits of peaceful uses of outer space. This week is coordinated by the United Nations with the support of Space Week International Association and local coordinators in many countries with a unique theme every year. Hence every year from 4th to 10th of October this week is celebrated by the Institute of Space Technology in coordination with our National Space Agency.

IST has always played a leading role in implementing the UN’s charter by celebrating the World Space Week with vigor and enthusiasm.
Academic Programs

Local and Linked MS Programs

Institute of Space Technology offers Indigenous MS Programs and linked MS programs in collaboration with Beihang University (BUAA), and Northwestern Polytechnical University (NPU), China and University of Surrey (UniS), UK. These programs lead students to earn their MS degrees economically in the cutting edge technologies from the foreign universities that are leading the trends in the respective disciplines.

The Institute of Space Technology offers the following MS degree programs:

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<tr>
<th>University</th>
<th>Programs</th>
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<tbody>
<tr>
<td>IST (Local MS Program)</td>
<td>Aerospace Engineering with following specializations:</td>
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<td></td>
<td>Aerodynamics/Computational Fluid Dynamics</td>
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<td></td>
<td>Propulsion</td>
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<td></td>
<td>Structural Design &amp; Analysis</td>
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<td></td>
<td>Aerospace Vehicle Design</td>
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<td>Guidance, Navigation and Control</td>
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<td></td>
<td>Global Navigation Satellite Systems</td>
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<td></td>
<td>Electrical Engineering with following specializations:</td>
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<td></td>
<td>Wireless Communication</td>
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<td></td>
<td>Signal and Image Processing</td>
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<td>Information and Cyber Security</td>
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<td></td>
<td>Materials Science &amp; Engineering</td>
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<td></td>
<td>Mechanical Engineering with following specializations:</td>
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<td></td>
<td>Fluid &amp; Thermal Systems</td>
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<td></td>
<td>Mechanical Design &amp; Analysis</td>
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<td></td>
<td>Manufacturing Systems</td>
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<td></td>
<td>Automobile</td>
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<td></td>
<td>Remote Sensing &amp; Geo-Information Science (RS&amp;GIsc) with following specializations:</td>
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<td></td>
<td>RS&amp;GIsc</td>
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<tr>
<td></td>
<td>Geo-informatics</td>
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<td>Spatial Information Technology</td>
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<tr>
<td></td>
<td>Astrophysics and Astronomy</td>
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<td></td>
<td>Atmospheric &amp; Environmental Science</td>
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<tr>
<td></td>
<td>Remote Sensing &amp; Geo-Information Science</td>
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</tbody>
</table>
The programs are structured in a manner to prepare the engineering students for a career with wide ranging opportunities in research, design, development, production, management and solutions development related to aerospace and communication technologies in the fast growing aerospace and telecommunication, wireless and satellite industry. The Linked MS programs are comprised of two segments. The first segment of each program formulates the basis of the program, consists mainly of course work and is conducted at IST. Whereas, the subsequent segment is based on course work and practical research and is completed at Beihang University (formerly Beijing University of Aeronautics and Astronautics, BUAA) and Northwestern Polytechnical University (NPU) in China for aerospace and University of Surrey (UniS) in the United Kingdom for communication related programs. After admission, the students undergo a rigorous preparatory session of ten weeks duration, known as ‘zero semester’ during which some of the required basic subjects and skills are reviewed. The first semester for Aerospace students is of Eighteen weeks duration and is conducted at IST. Thereafter, the students proceed to BUAA, where they pursue the subsequent three semesters over a period of eighteen months. The students who are selected for NPU, they spend one year (two semesters) at IST and remaining two semesters (one year) at NPU. Similarly, for Communication Systems’ students, the first semester is of 18 weeks duration at IST before proceeding to UniS, where they complete the remaining two semesters in nine months. On completion of the degree requirements, students are conferred degrees by their respective foreign universities.

<table>
<thead>
<tr>
<th>Aerospace Engineering with following specializations:</th>
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<tbody>
<tr>
<td>Aerodynamics/ CFD</td>
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<td>Rocket Propulsion</td>
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<td>Guidance Navigation &amp; Control</td>
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<td>Structural Design &amp; Analysis</td>
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<tr>
<td>Aerospace Vehicle Design</td>
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<tr>
<td>Satellite Engineering with following specializations:</td>
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<tr>
<td>Guidance, Navigation and Control</td>
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<tr>
<td>Spacecraft Design &amp; Applications</td>
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<tr>
<td>Materials Science and Engineering with following specialization:</td>
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<tr>
<td>Manufacturing Engineering</td>
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<td>Welding Engineering</td>
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<tr>
<td>Aerospace Engineering</td>
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<tr>
<td>Satellite Communications Engineering</td>
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<tr>
<td>Electronics Engineering</td>
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<tr>
<td>Mobile Communication Systems</td>
<td></td>
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<tr>
<td>Mobile &amp; Satellite Communication</td>
<td></td>
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<tr>
<td>Space Technology &amp; Planetary Exploration</td>
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</table>
Linked PhD program
Institute of Space Technology also offers linked PhD programs in the field of Aeronautics and Astronautics in collaboration with Beihang University of Aeronautics and Astronautics (BUAA) and Northwest Polytechnical University (NPU), China. After admission in the linked PhD program, the students are sent to these universities for an initial period of 12 months, where they study the courses relevant to their proposed field of study, in consultation with their PhD supervisor, and prepare a research proposal. Next 18 months are spent at IST, where they continue their research work. They will also undertake courses at IST if their advisor proposes the same. After that the students go back to their respective university in China and complete the rest of their research work and submit the thesis. The time duration for this third phase is 12 months at NPU and 15 months at BUAA. On completion of degree requirements, the doctoral degree is awarded by the respective Chinese university.

Future in Aerospace
The field of aerospace technology offers a wide range of employment opportunities to those with the proper educational background. An aerospace team is made up of engineers, scientists, and technicians. Positions are available through the private sector as well as within the government sector. Examples of major engineering roles in the aerospace industry include:
- Analysis
- Design
- Materials and Processes
- Systems Engineering
- Software Development
- Manufacturing
- Flight Research

Future in Astronomy and Astrophysics
Astronomy is the oldest branch of natural science that deals with heavenly objects. The field of astronomy and astrophysics is currently gaining importance worldwide. A new generation of advanced ground-based and spaceborne telescopes and enormous increases in computing power are enabling a golden age of astrophysics. The MS program in Astronomy and Astrophysics focuses on underlying physics of phenomena beyond the Earth, data analysis and modeling techniques, which will undoubtedly play a prominent role in international basic research. The main objectives of the program are initiation in scientific research and training in Astronomy and Astrophysics. The graduates can get PhD positions in Physics/Astronomy in local and foreign universities and get scholarships from agencies like, International Max Planck Research School (IMPRS), German Academic Exchange Service (DAAD), Albert Einstein Institute (AEI), Erasmus Mundus, and Higher Education Commission of Pakistan (HEC). The graduates having MS Astronomy and Astrophysics degree have tremendous opportunities for jobs in national space agency of Pakistan SUPARCO as well as in all public/private sector universities of Pakistan offering teaching and research in natural sciences.

Future in Atmospheric and Environmental Science
The Atmospheric and Environmental Science Group offers an internationally recognized postgraduate program at the Department of Space Science. The group currently focuses on both experimental and theoretical aspects of ground and satellite based observations related to cutting edge meteorological and atmospheric pollution research. The Group has a dedicated “Atmospheric and Meteorology Lab” which hosts state-of-the-art meteorological and environmental pollution monitoring equipment geared towards both learning and research purposes. The curriculum of the program is designed to provide a solid background in Atmospheric and Environmental Sciences, Remote Sensing for the Environment and Mathematical Physics towards developing world class research and problem-solving
experts for incoming graduate students. The range of electives allows a focused pursuit of sub-areas such as Ground and Satellite meteorology, Atmospheric Chemistry, Atmospheric Dynamics, Cloud and Aerosol Physics, Numerical Weather Prediction, Climate Change Modeling and associated areas, both in local and international contexts.

**Future in Communication Engineering**

MS Communication Engineering is an indigenous MS program started by IST. This will provide students with an opportunity to gain deeper understanding of the principles of communication systems and networks and will prepare the students for a successful career in this expanding and dynamic field. The versatility of this program gives extensive knowledge of terrestrial and space communication. With the changing trends of the market, this course will enhance the capability of candidates accordingly. On successful completion of the course, the students will be able to work in companies that work in the area of telecommunications, data communications, broadcasting and the Internet, with interests ranging from overall system design to the more detailed development of radio frequency and data subsystems. The domain of communication engineering is ever expanding and now includes the following areas (though not limited to them):

- Telecommunications
- Communication Networks
- Satellite Communications
- Mobile Communications

**Future in Remote Sensing & GISc**

The MS program in Remote Sensing and Geographical Information Science is designed for imparting expertise in the science, methods, and applications of these rapidly growing fields. The job market is vast and varied, with the growing need for experts in these fields in both the government and commercial sector. The nature of possible careers is spread over a wide canvas: research, planning and development, advising the decision-makers, or the application and service providing sector. Some of the options include:

- Agriculture (crop planning, crop health monitoring, yield forecasting)
- Natural Resource Management
- Geology (mineral exploration, earthquake prediction and mapping)
- Water Resources: (snow melt monitoring and melt-water estimation, flood mapping, monitoring and prediction, irrigation planning and monitoring)
- Urban Planning and Monitoring (city planning, transportation & utility network planning)
- Revenue and Tax Collection

**Future in Materials Science and Engineering**

Materials Science and Engineering (MS&E) has played a pivotal role in the technological evolution of our society, from structural steels to optoelectronics and information processing. The field of MS&E is currently evolving at a more rapid pace than at any other point in its history. The evolution of the field, and its social impact, continuously occurs through collaborations between materials scientists/engineers and a researcher from fields such as biology, medicine, physics, chemistry and other areas of engineering and manufacturing. Most fields in science and engineering are concerned in some way with materials, but only the field of materials science and engineering focuses directly on them. Further, the materials play an important role to provide solutions to the major challenges in fabricating nanotechnology based devices. So a wide variety of opportunities await the materials
science and engineering graduate in research, development, design, production and management in almost every industry.

**Future in Manufacturing Engineering**
The MS in manufacturing engineering provides deep understanding of manufacturing process like machining, casting, molding, shaping, forging etc. The manufacturing industry is also rapidly expanding in the country and an acute shortage of manufacturing engineers exist in the country. The potential career opportunities are in Aero, Automotive, Textile, Agriculture and machinery manufacturing etc.

**Future in Mechanical Engineering**
Department of Mechanical Engineering offers studies leading to the degree of Master in Mechanical Engineering, preparing young engineers for a wide range of exciting opportunities including aerospace, manufacturing, automotive, chemical, biomedical, nuclear power, robotics, textiles, R&D, administration and management. The curriculum includes the methodical tools, innovative thought, communication skills, management tools, and provide young engineers the opportunities to work efficiently as individuals and in teams. The structure and sequence of courses is designed to ensure that every graduate has the knowledge, ability and understanding required for value education. The main focus of this degree program is on the following specialized areas:
- Fluid and Thermal Systems
- Mechanical Design and Analysis
- Manufacturing Systems
- Automobile

**Future in Welding Engineering**
The welding and joining technology plays very important role in the manufacturing industry. The understanding of the joining process and its effects on base material is very important to produce high quality and durable products. Welding engineering experts have a wide scope in a number of industries like aero, automotive, agriculture and other machinery etc. The country is also facing an acute shortage of welding technologist and therefore the job market of welding engineers is high both in public and private sector industries.

**Future in Information & Cyber Security**
In today’s world Information alone has emerged as the most important asset for many organizations. It is considered as important an asset as capital or work. Many experts believe that the threat of Information warfare is to 21st century, what the threat of nuclear warfare was to the 20th century. The three primary methods by which information systems are protected are authorization, message filtration, and ensuring the integrity of core processes. However, the fact that information can be generated world-wide and can be accessed over the internet has spawned new challenges in the field of Information & Cyber security. The challenge is even more pressing since the hacker/cyber-terrorist need not to physically intrude into the organization's premises; rather the security breach attacks can be launched with the mere availability of an internet connection, while sitting on the opposite side of the globe. On one hand the world is becoming more and more dependent on automation, for instances, in terms of online-banking, payroll, air-craft control systems etc, while on the other hand, organizations are finding it more difficult to deny unauthorized access, secure information and protect against malicious activities. As computers become smarter, more sophisticated, and more flexible, they will become more like humans. They will acquire the reliable information security provisions that and will begin to ingest information at the semantic level from outside sources, and will thus be heir to more subtle but no less problematic forms of information warfare.
The Department of Aeronautics and Astronautics maintains an internationally recognized academic program in aerospace engineering by engaging all stakeholders through an open dialogue. The major stakeholders are: students, faculty, industry and aerospace professionals. The result of this consultative process is reflected in continuously improving the academic improvement to provide the best possible education to our students.

The aerospace engineer is primarily concerned with the design, analysis, testing and overall operation of aerial vehicles. The curriculum is designed to educate the students in the fundamental principles of aerodynamics, flight dynamics, propulsion, structural mechanics, flight controls, design, testing and space technologies. A wide variety of opportunities await the aerospace engineering graduate in research, development, design, production, sales and management in the aerospace industry and in many related industries where fluid flow, control and transportation problems play major roles.

Mission Statement
The mission of the Aerospace Engineering Program is to prepare the engineering student for a career with wide-ranging opportunities in research, development, design, production, sales and management in the aerospace industry and related industries which are involved with the solution of multi-disciplinary, advanced technical problems.

Programs Educational Objectives
- Produce Aerospace Engineers with a strong practical and theoretical exposure in the relevant disciplines, who are able to contribute to society through innovation, enterprise and leadership
- Nurture engineer with a global outlook and to provide technological leadership through necessary technological tools
- Produce engineers with teamwork, communication and interpersonal skills
- Enable them to be productive members of interdisciplinary engineering teams and are further capable to adopt to changing environments of engineering, technology and society
- Produce engineers with high moral and ethical values
- Inculcate critical thinking among students and develop initiatives and innovative ideas

Aerospace Engineering
Aerospace engineering is a field where state-of-the-art technologies are applied everyday. It is an exciting profession with outstanding career opportunities in which physical sciences, mathematics and computers are combined in the design of air and space vehicle systems and components to achieve high performance with limited size and weight. This requires aerospace engineers to constantly develop and apply the most advanced technologies. Aerospace technology has grown out of the problems of design, construction and operation of vehicles that orbit above the Earth's surface (vehicles ranging from ground-effect machines to aircraft and spacecraft).

Design of such vehicles has always been challenging, not only because of the requirement that they operate in a hostile environment, but also the high premium placed on light weight, high efficiency and great reliability. These requirements are not only relevant to future spacecraft and high performance aircraft, but also to the next generation of ground transport vehicles.
Local MS Programs

Aerospace Engineering (Local)
Specialization: Aerodynamics/Computational Fluid Dynamics

Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
Valid NTS GAT-General test score with minimum 50 marks.

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<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MAT721</td>
<td>Numerical Analysis (3-0)</td>
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<tr>
<td></td>
<td>AAE 751</td>
<td>Aerodynamics (supersonic) (3-0)</td>
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<tr>
<td></td>
<td>AAE752</td>
<td>Computational Fluid Dynamics (3-0)</td>
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<td></td>
<td>AAE753</td>
<td>Viscous Flow (3-0)</td>
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<tr>
<td>4</td>
<td>Thesis</td>
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</tbody>
</table>

Mandatory Courses
Minimum 9 credit hours

Elective Courses
The elective courses will be offered from the following list; subject to the availability of specialized faculty and the number of students interested in each course.

Electives
- AAE754 Turbulent Fluid Flow (3-0)
- AAE755 Advanced Computational Fluid Dynamics (3-0)
- AAE657 Measurement Techniques in Fluid and Thermal Engineering (2-1)
- AAE756 Multi-phase Fluid Dynamics (3-0)
- AAE758 Hypersonic/High Temperature Gas Dynamics (3-0)
- MGT631 Industrial Management & System Engineering (3-0)
- MAT611 Partial Differential Equations (3-0)
- AAE716 Methods of Optimization (3-0)
- AAE759 Unsteady Aerodynamics (3-0)
- AAE7510 Flight Dynamics (3-0)
- AAE7315 Multidisciplinary Optimization (3-0)

Note: Duration of program is four semesters including thesis/dissertation; students must complete a minimum of 30 credit hours including 6 Credit hours of Thesis to fulfill degree requirements.
Aerospace Engineering (Local)

Specialization: Propulsion

Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
- Chemical

Valid NTS GAT-General test score with minimum 50 marks.

Mandatory Courses
Minimum 9 credit hours

Elective Courses
The elective courses will be offered from the following list; subject to the availability of specialized faculty and the number of students interested in each course.

Electives
- AAE724 Advanced Heat Transfer (3-0)
- AAE725 Advanced Energy Conversion for Aerospace Systems (3-0)
- AAE726 Advanced Combustion (3-0)
- AAE727 Space Propulsion and Power Systems (3-0)
- AAE728 Electric Propulsion (3-0)
- AAE729 Aero thermo chemistry of Advanced Propulsion Systems (3-0)
- AAE621 Combustion & Flow in Rocket Engines (3-0)
- AAE7210 Liquid Propellant Rocket Engine System Engineering (3-0)
- AAE622 Process Simulation and CAD of Rocket Engine (3-0)
- AAE758 Hypersonic/High Temperature Gas Dynamic (3-0)
- AAE657 Experimental Techniques in Fluid & Thermal Engineering (2-1)
- AAE7317 Advanced Stress Analysis & Thermal Strength of Structures (3-0)
- MSE611 Advanced Materials in Engineering (3-0)
- AAE622 Heating, Ventilating, Air Conditioning and Refrigeration (3-0)
- MGT631 Industrial Management & System Engineering (3-0)
- AAE623 Turbo Machinery (3-0)
- AAE7315 Multidisciplinary Optimization (3-0)

Note: Duration of program is four semesters including thesis/dissertation; students must complete a minimum of 30 credit hours including 6 Credit hours of Thesis to fulfill degree requirements.
Aerospace Engineering (Local)
Specialization: Structural Design & Analysis
Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
- Manufacturing
Valid NTS GAT-General test score with minimum 50 marks.

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<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Courses</th>
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<tbody>
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<td>1</td>
<td>MAT721</td>
<td>Numerical Analysis (3-0)</td>
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<tr>
<td></td>
<td>AAE731</td>
<td>Mechanical Behavior of Materials *(3-0)</td>
</tr>
<tr>
<td></td>
<td>AAE732</td>
<td>Finite Element Methods *(3-0)</td>
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<tr>
<td>2</td>
<td>AAE733</td>
<td>Aerospace Structural Analysis *(3-0)</td>
</tr>
<tr>
<td></td>
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<td>Elective 1</td>
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<tr>
<td></td>
<td></td>
<td>Elective 2</td>
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<td></td>
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<td>Elective 4</td>
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<td>4</td>
<td></td>
<td>Thesis</td>
</tr>
</tbody>
</table>

Mandatory Courses
Minimum 9 credit hours

Elective Courses
The elective courses will be offered from the following list; subject to the availability of specialized faculty and the number of students interested in each course.

Electives
- AAE734 Advanced Structural Dynamics (3-0)
- AAE735 Aero Elasticity Theory (3-0)
- AAE736 Theory of Plasticity (3-0)
- AAE737 Engineering Mechanics of Composite Material (3-0)
- AAE738 Fracture Mechanics (3-0)
- AAE631 Advanced Mechanics of Materials (3-0)
- AAE739 Theory of Elasticity (3-0)
- AAE617 Mathematical modeling and Simulation (3-0)
- AAE7310 Experimental Stress Analysis (2-1)
- AAE7311 Experimental Methods in Structural Dynamics (2-1)
- AAE7312 Nondestructive Evaluation of Structures and Materials (3-0)
- AAE7313 Smart Structures (3-0)
- AAE7314 Structural Design of Launch Vehicle & Reentry Vehicles (3-0)
- AAE7315 Optimization Techniques in Structural Design (3-0)
- AAE7316 Non-linear Dynamics and Chaos (3-0)
- MGT632 Corporate Management (3-0)
- AAE7315 Multidisciplinary Optimization (3-0)

Note: Duration of program is four semesters including thesis/dissertation; students must complete a minimum of 30 credit hours including 6 Credit hours of Thesis to fulfill degree requirements.
Aerospace Engineering (Local)
Specialization: Aerospace Vehicle Design

Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
Valid NTS GAT-General test score with minimum 50 marks.

Electives

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>AAE651</td>
<td>Aircraft Preliminary Design and Performance</td>
<td>(3-0)</td>
</tr>
<tr>
<td>AAE7412</td>
<td>Flight Vehicle Guidance, Control &amp; Navigation</td>
<td>(3-0)</td>
</tr>
<tr>
<td>AAE7512</td>
<td>Advanced Aerodynamics</td>
<td>(3-0)</td>
</tr>
<tr>
<td>AAE614</td>
<td>Computer Aided Design</td>
<td>(3-0)</td>
</tr>
<tr>
<td>AAE657</td>
<td>Experimental Techniques in Fluid &amp; Thermal Engine</td>
<td>(2-1)</td>
</tr>
<tr>
<td>AAE758</td>
<td>Hypersonic/High Temperature Gas Dynamic</td>
<td>(3-0)</td>
</tr>
<tr>
<td>AAE642</td>
<td>Digital Control Systems</td>
<td>(3-0)</td>
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<tr>
<td>AAE7416</td>
<td>Optimal Control</td>
<td>(3-0)</td>
</tr>
<tr>
<td>MSE611</td>
<td>Advanced Materials in Engineering</td>
<td>(3-0)</td>
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<tr>
<td>AAE715</td>
<td>Systems Engineering and Analysis</td>
<td>(3-0)</td>
</tr>
<tr>
<td>AAE7513</td>
<td>Aerospace System Design and Management</td>
<td>(3-0)</td>
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<tr>
<td>AAE714</td>
<td>Reliability Engineering</td>
<td>(3-0)</td>
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<tr>
<td>MAT721</td>
<td>Numerical Analysis</td>
<td>(3-0)</td>
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</tbody>
</table>

Mandatory Courses
Minimum 9 credit hours

Elective Courses
The elective courses will be offered from the following list; subject to the availability of specialized faculty and the number of students interested in each course.

Note: Duration of program is four semesters including thesis/dissertation; students must complete a minimum of 30 credit hours including 6 Credit hours of Thesis to fulfill degree requirements.
Aerospace Engineering (Local)
Specialization: Guidance, Navigation and Control

Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
- Electrical
- Mechatronics
- Computer Science

Valid NTS GAT-General test score with minimum 50 marks.

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<tr>
<th>Semester</th>
<th>Code</th>
<th>Courses</th>
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<tbody>
<tr>
<td>1</td>
<td>MAT721</td>
<td>Numerical Analysis (3-0)</td>
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<tr>
<td></td>
<td>AAE741</td>
<td>Spacecraft Dynamics and Control *(3-0)</td>
</tr>
<tr>
<td></td>
<td>AAE742</td>
<td>Modern Control Theory *(3-0)</td>
</tr>
<tr>
<td>2</td>
<td>AAE743</td>
<td>Guidance and Navigation of Aerospace Vehicles (3-0)</td>
</tr>
<tr>
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<td>Elective 1</td>
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<td>Thesis</td>
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</tbody>
</table>

Mandatory Courses
Minimum 9 credit hours

Elective Courses
The elective courses will be offered from the following list; subject to the availability of specialized faculty and the number of students interested in each course.

Electives
- AAE643 Automatic Control of Flight Vehicles (3-0)
- AAE744 GPS and its Applications (3-0)
- AAE745 Applied Nonlinear Control of Aerospace Vehicles (3-0)
- AAE746 Interplanetary Navigation and Guidance (3-0)
- AAE644 Spacecraft Navigation (3-0)
- AAE748 Flight and Trajectory Optimization (3-0)
- AAE645 Atmospheric Flight Control (3-0)
- AAE749 Computer Applications in Guidance and Control (3-0)
- AAE7410 Intelligent and Adaptive Control System (3-0)
- AAE7411 Inertial & Integrated Navigation System (3-0)
- AAE7412 Flight Vehicle Guidance, Control & Navigation (3-0)
- AAE7413 Orbit and Attitude Control of Spacecraft (3-0)
- AAE646 Orbital Mechanics (3-0)
- AAE7414 Linear Feedback Control Systems (3-0)
- AAE7415 Multivariable Controls (3-0)
- AAE7315 Multidisciplinary Optimization (3-0)
- AAE7416 Space Missions Analysis & Design (3-0)
- AAE7510 Flights Dynamics (3-0)

Note: Duration of program is four semesters including thesis/dissertation; students must complete a minimum of 30 credit hours including 6 Credit hours of Thesis to fulfill degree requirements.
Aerospace Engineering (Local)
Specialization: Global Navigation Satellite Systems (Local)

Prerequisites
BE/BS in any one of the following disciplines
- Electronics and Communications Engineering
- Civil Engineering
- Mechatronics Engineering
- Aerospace / Avionics Engineering
- Software and Computer Engineering
- Environmental Engineering
- MSc Electronics / Communication / Physics/ Space Sciences

Valid NTS GAT-General test score with minimum 50 marks.

Introduction:
The Masters of Science in Global Navigation Satellite Systems (MS GNSS) at Institute of Space Technology, Islamabad is a specialized Master Program structured according to the GNSS curriculum proposed and designed by the United Nations Office for Outer Space Affairs (UNOOSA) and offered for the very first time in Pakistan. The MS GNSS course work consists of eight three credit hours subjects covering specific areas of GNSS (theory, technology and applications) followed by a six credit hours Thesis. These courses will also be part of PhD curriculum for registered PhD students in GNSS. The requirement of PhD degree is successful completion of six graduate courses of 3 credit hours each and 30 credit hours doctoral thesis.

Global Navigation Satellite Systems (GNSS) include constellations of Earth-orbiting satellites that broadcast their locations in space and time, of networks of ground control stations, and of receivers that calculate ground positions by trilateration. GNSS are used in all forms of transportation: space stations, aviation, maritime, rail, road and mass transit. Positioning, navigation and timing play a critical role in telecommunications, land surveying, law enforcement, emergency response, precision agriculture, mining, finance, scientific research and so on. They are used to control computer networks, air traffic, power grids and more. Thus the specific objectives of the implementation of the MS GNSS degree program are the demonstration and understanding of GNSS signals, codes, biases and practical applications, and the implications of prospective modernization.

At present GNSS include two fully operational global systems, the United States’ Global Positioning System (GPS) and the Russian Federation’s GLObal NAvigation Satellite System (GLONASS), as well as the developing global and regional systems, namely Europe's European Satellite Navigation System (GALILEO) and China's

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<tr>
<th>Semester</th>
<th>Courses</th>
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<tr>
<td>1</td>
<td>AAE 561 Fundamentals of GNSS (3-0)</td>
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<tr>
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<td>MAT 551 GNSS Mathematics and Position</td>
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<td></td>
<td>Determination Techniques (3-0)</td>
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<td>AAE 562 GNSS INS Integration (3-0)</td>
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<td>2</td>
<td>AAE 663 GNSS Receivers (3-0)</td>
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<td>SS 654 Space weather and GNSS (3-0)</td>
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<tr>
<td></td>
<td>AAE 664 Sensors and Embedded System Design</td>
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<td></td>
<td>(3-0)</td>
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<td>3</td>
<td>AAE 765 GNSS Applications (3-0)</td>
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<td>AAE 766 GNSS Augmentation systems (3-0)</td>
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<td>AAE 793 Thesis (6-0)</td>
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<td>Total MS Credit Hours (course work + Thesis) (30-0)</td>
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</table>
COMPASS/BeiDou, India's Regional Navigation Satellite System (IRNSS) and Japan's Quasi-Zenith Satellite System (QZSS). Once all these global and regional systems become fully operational, the user will have access to positioning, navigation and timing signals from more than 100 satellites. In addition to these, there are satellite-based augmentation systems, such as the United States' Wide-area Augmentation System (WAAS), the European Geostationary Navigation Overlay Service (EGNOS), the Russian System of Differential Correction and Monitoring (SDCM), the Indian GPS Aided Geo Augmented Navigation (GAGAN) and Japanese Multi-functional Transport Satellite (MTSAT) Satellite-based Augmentation Systems (MSAS). Combining them with proven terrestrial technologies such as inertial navigation, will open the door to new applications for socio-economic benefits. The latter are applications that require not just accuracy, but in particular reliability or integrity. Safety-critical transportation applications, such as the landing of civilian aircraft, have stringent accuracy and integrity requirements. For developing countries, GNSS applications offer a cost-effective way of pursuing sustainable economic growth while protecting the environment. Satellite navigation and positioning data are now used in a wide range of areas that include mapping and surveying, monitoring of the environment, precision agriculture and natural resources management, disaster warning and emergency response, aviation, maritime and land transportation and research areas such as climate change and ionospheric studies. In conclusion, as we move forward in the 21st century, governments and business in developing and industrialized countries are exploring potential growth areas for their national economies. Almost without exception, the most promising option seems to be outer space, and in particular satellite positioning, navigation and timing, and its potential and future almost universal applications.

**Course 1**

**Fundamentals of GNSS**

1.1 I introductions to GNSS: Conventional navigation, background, concepts and evolutions of global navigation satellite systems (GPS, GLONASS, Galileo, BeiDou/COMPASS) and regional navigations satellite systems (IRNSS, QZSS). Comparison of GNSS with other navigation systems;

1.2 Reference systems: Terrestrial, celestial and orbit coordinate reference system. Height Systems. Geoid. Time systems, synchronization and data conversion. Transformations between coordinate reference systems. Contribution of the International GNSS Service (IGS) to providing access to the International Terrestrial Reference Frame (ITRF);

1.3 Satellite orbits: Orbital parameters. Orbital motion, representation (Keplerian elements, etc.) Determination of satellite position, visibility and ground tracks;


**Course 2**

**GNSS Mathematics and Position determination techniques**

2.1 GNSS measurements: pseudo-ranges, carrier phase and Doppler;

2.2 Position determination techniques (general);

2.3 Single point position technique: models and estimation methods;
Course 3  |  GNSS INS Integration  
---|---
2.4 | Satellite constellation and dilution of precision: satellite geometry, bounds and calculations on dilution of precision (DOP).

<table>
<thead>
<tr>
<th>Course 3</th>
<th>GNSS INS Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Inertial navigation systems. Accelerometer, Gyroscopes, Inertial platforms, Navigation equation, Integration of modelling equations in e-frame;</td>
</tr>
<tr>
<td>3.2</td>
<td>INS error dynamics: Simplified analysis, Error dynamics equations in e-frame, INS initialization and alignment;</td>
</tr>
<tr>
<td>3.3</td>
<td>GNSS/INS integration: Integration mode, Mathematical model of supported INS navigation, Observation procedures for inertial surveying; 6.4. General sensor fusion concepts.</td>
</tr>
</tbody>
</table>

Course 4  |  GNSS receivers  
---|---
4.1 | Receiver architecture: Technology, radio-frequency front end, signal processing system hardware and software techniques, software defined radio; |
| 4.2 | Signal tracking: Maximum likelihood estimate of delay and position, delay lock tracking of signal, coherent and non-coherent delay lock tracking of pseudo noise sequences, mean square error estimation, vector delay lock loop, receiver noise performance, maximum likelihood estimate, early late gating; |
| 4.3 | Navigation algorithm: Measurement of pseudo range, Doppler, decoding and using of navigation data, single point solution, precise point positioning, dynamics of user, Kalman filter, least-squares adjustment, and other alternatives |

Course 5  |  Space weather and GNSS  
---|---
5.1 | Sources of space weather and related background physics: Sun, galactic cosmic rays, magnetosphere, thermosphere, ionosphere coupling; |
| 5.2 | Impact of space weather events on GNSS; |
| 5.3 | Satellites, interference with solar radio emission, radio wave propagation; |
| 5.4 | Different view in precise (geodesy, DGPS) and safety of life (aviation) applications; |
| 5.5 | Ionospheric scintillations and their impact, monitoring and modeling; |
| 5.6 | GNSS-based monitoring of the ionosphere by ground and space based measurements; |
| 5.7 | Ionospheric correction and threat models. |

Course 6  |  Sensors and embedded system design  
---|---
6.1 | Sensors and transducers: Introduction, Sensor classification, characteristics and compensation, classification of transducers. Transducer descriptions, parameters, definitions and terminology; |
| 6.2 | Embedded systems: Cell phones, pagers, PDAs, answering machines, microwave ovens, televisions, VCRs, CD/DVD players, video game consoles, GNSS devices, network routers, fax machines, cameras, music synthesizers, planes, spacecraft, boats, and cars all contain embedded processors. |

Course 7  |  GNSS applications  
---|---
7.1 | Geospatial databases: Geo extensions for Open Source Databases, POSTGRES, MySQL etc. |
7.2 GNSS navigation: Professional and personal, GIS/mapping, Surveying, Natural Hazards management, Earth sciences, Natural resources, Infrastructure;

7.3 Navigation and communication: Integrated application;

7.4 Communication, navigation and surveillance: Integrated application;

7.5 GNSS applications for remote sensing of the atmosphere and space weather: Radio occultation technique for monitoring terrestrial weather (temperature and water vapour) and monitoring ionospheric weather (electron density and total electron content);

7.6 Revenue model for value added services;

7.7 Management, team work, intellectual property, business in GNSS.

**Course 8**

**GNSS augmentation systems**

8.1 Errors in GNSS measurements: functional model and fundamental error equation, effect of GDO, classes of ranging errors and biases;

8.2 Error budget, user equivalent range error, position accuracy with one sigma and three sigma errors;

8.3 Error mitigation techniques: real time kinematic (RTK), differential GNSS (DGNSS), local area DGNSS, wide area DGNSS;

8.4 Augmented systems: Wide Area Augmentation System (WAAS), European Geostationary Navigation Overlay Service (EGNOS), System of Differential Correction and Monitoring (SDCM), Multi-functional Transport Satellite (MTSAT) Satellite based Augmentation System (MSAS), GPS Aided Geo Augmented Navigation (GAGAN), etc;

8.5 GNSS networks: Global, regional and local GNSS Permanent Networks and geodetic infrastructure for real positioning services;

8.6 GNSS impact factors and mitigation techniques: Orbit errors, clock errors, multipath, troposphere, ionosphere including higher order ionospheric refraction effects, vulnerability against space weather, jamming;

**Laboratory experiments, field visits, project work**

- Coordinate and time conversion, and reference system transformations
- GNSS/INS equipment
- GNSS data formats: Receiver Independent Exchange Format (RINEX), Real-Time GNSS Data Transmission Standard (RTCM), United States National Marine Electronics Association (NMEA)
- Single point positioning solution
- High precision post processed GNSS
- Experiment with DGPS
- Experiment with RTK receivers
- Experiment to demonstrate accuracy improvement using satellite-based augmentation system (SBAS);
- Design aspects of software for integrating location-based services with position, for example, Smartphone applications
- Design of application: Combining satellite navigation with satellite communication (Fleet monitoring)
- Design of application: Combining satellite navigation with satellite communication (Disaster management)
- Design of computer simulated receiver based on software defined radio
Linked Programs with Beihang University

Beihang University

Beihang University (formerly Beijing University of Aeronautics & Astronautics) or BUAA for short, was founded on October 25, 1952. It is situated in the center of Zhongguancun Science Park, next to China’s National Olympic Center, with an area of over 100 hectares; in capital city of P.R. China BUAA is China’s first university of aeronautical and astronautical engineering.

Since its inception, BUAA has been one of the key universities given priority for development. At present, the university comprises 17 schools and 6 departments, covering such diverse fields as science, technology, liberal arts, law, economy, management, philosophy, foreign languages and education.

There are more than 3,300 faculty and staff members including 10 academicians of either the Chinese Academy of Sciences or the Chinese Academy of Engineering Sciences, over 1400 full or associate professors and 290 supervisors of doctorate programs. BUAA has a total enrolment of over 26,000, including more than 1300 doctorate candidates, over 5000 master candidates, more than 14,000 undergraduate candidates and about 300 overseas students. It has 42 research institutes or interdisciplinary research centers, 11 key disciplines of the national level and 89 laboratories (including 4 national key laboratories, 5 national specialized laboratories and 12 provincial or ministerial-level key laboratories).

In recent years BUAA is ranked among the top schools in China in terms of its research budget and expenditure. The university is equipped with all ancillary facilities. The library, with an area of over 24,000 square meters, has a collection of over 1.2 million books. BUAA’s sports facilities include a modern gymnasium and a sports ground with sophisticated equipment. BUAA has become one of China’s important incubators for scientific and technological innovation that is driven by qualified and trained workforce.

Institute of Space Technology offers linked programs with Beihang University. After completion of the program, the MS degree will be conferred by the Beihang University, China.
Aerospace Engineering
Specialization: Aerodynamics/CFD
Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
Valid NTS GAT-General test score with minimum 50 marks.

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Electives
- Mechanics of Continuous Media
- Advanced Fluid Dynamics
- Mechanics of Viscous Fluid Flows
- Experimental Fluid Mechanics
- Finite Element Method in Fluid Mechanics
- Hypersonic Aerodynamics
- Theory of Transonic Flows
- Theories of Complex Flows
- Unsteady Aerodynamics
- Theory of Flow Visualization and Numerical Image Processing
- Plasma Dynamics
- Rarefied Gas Dynamics
- Multi-phase Fluid Dynamics
- Singular Perturbation Theory
Aerospace Engineering

Specialization: Guidance Navigation and Control

Prerequisites

BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
- Electrical
- Mechatronics
- Computer Science

Valid NTS GAT-General test score with minimum 50 marks.

Electives

Flight Vehicle Guidance Control & Navigation
Inertial & Integrated Navigation System
Inertial Component Design
Modern Controls Theory & Applications
Intelligent and Adaptive Control System
System Identification & Estimation
Robust and Fault Tolerant Control System
Digital Control Systems
Computer Application in Guidance & Control
GPS and its Applications

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Aerospace Engineering
Specialization: Structural Design & Analysis
Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
- Manufacturing
Valid NTS GAT-General test score with minimum 50 marks.

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Electives
Usage of FEM Software (NASTRAN) & Structural Optimization
Structural Dynamics
Composite Mechanics & Applications
Thermal Strength of Structures
Structural Design of Launch Vehicle & Reentry Vehicles
Experimental Solid Mechanics
Plasticity Mechanics
Advanced Stress Analysis
Structural Analysis & Optimization
Aero-elasticity
Aerospace Engineering
Specialization: Rocket Propulsion
Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
- Chemical
Valid NTS GAT-General test score with minimum 50 marks.

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Electives
- Combustion Theory
- Liquid Propellant Rocket Engine System Engineering
- Liquid Rocket Engine Design
- Solid Rocket Motor Design
- Structural Design and Thermal Protection
- Combustion & Flow in Rocket Engines
- Process Simulation and CAD of Rocket Engine
Aerospace Engineering
Specialization: Aerospace Vehicle Design
Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
Valid NTS GAT-General test score with minimum 50 marks.

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Electives
- The Conceptual Design & Preliminary Design of Launch Vehicles
- Structural Optimization
- Re-entry Body Design of Warheads & Recoverable Orbiters
- Launch Vehicle Trajectories
- Advanced Flight Mechanics
- Modern Design Methods for Launch Vehicles
- Launch Vehicle Structural Design
- Guidance, Navigation & Control
- Integrated Navigation Systems
- Rocket Propulsion
Satellite Engineering
Specialization: Navigation, Guidance and Control
Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Mechanical
- Electronics/Industrial Electronics
- Communication/Telecommunication
Valid NTS GAT-General test score with minimum 50 marks.

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Electives
- Advanced Flight Control, Navigation and Guidance
- Computer Control and Simulation Technology
- Intelligent Control and Decision
- Virtual Technology and its Application
- Computer System Reliability and Information Security
- Air Traffic Management
- Spacecraft Navigation, Guidance and Control
- Spacecraft Active Orientation Technology
- Spacecraft Measuring and Control Technology
Satellite Engineering
Specialization: Spacecraft Design & Applications
Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Mechanical
- Electronics/Industrial Electronics
- Communication/Telecommunication
- Mechatronics
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Electives
- Spacecraft Guidance, Navigation & Control
- Methodology of Spacecraft Design
- Propulsion Systems
- Theory and Methods of Structure Optimization
- Spacecraft Navigation
- Theory and Application of Gyros
- Conceptual Design of Advanced Spacecraft
- Spacecraft Advanced Design Method
- Flight Dynamics, Guidance, Navigation and Control
- Spacecraft Structural Dynamics, Control and Optimization

www.ist.edu.pk
Welding Engineering
Specialization: Welding Engineering
Prerequisites
BE/BS in any one of the following disciplines
- Manufacturing
- Mechanical
- Materials
- Industrial
Valid NTS GAT-General test score with minimum 50 marks.

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Electives
Aerospace Materials/Engineering Materials
Metallography
Principles of Fusion Welding
Metal Arc Welding Technology and Equipment
Advanced Welding and Fabrication Technique
Material Molding and Structure Manufacturing
Science of Materials Processing
Electron Beam and Laser Beam Welding
Joining of Aerospace Materials
Joining of dissimilar Materials
Post-Weld Analysis and Treatment
Numerical Simulation of Materials Processing
**Materials Science & Engineering**

**Specialization:** Materials Science & Engineering

**Prerequisites**
- BE/BS in any one of the following disciplines
  - Aerospace
  - Aeronautical
  - Mechanical
  - Materials
  - Industrial

Valid NTS GAT-General test score with minimum 50 marks.

<table>
<thead>
<tr>
<th>Campus</th>
<th>Semester</th>
<th>Code</th>
<th>Courses</th>
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<tbody>
<tr>
<td>IST</td>
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<td>MAT721</td>
<td>Numerical Analysis (3-0)</td>
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<td>Theory of Matrices (3-0)</td>
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<td>AAE731</td>
<td>Mechanical Behavior of Materials (3-0)</td>
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**Electives**
- Electron Microscopy
- Solid State Phase Transformation
- Fatigue and Fracture of Metals
- Dislocation Theory
- Solid Mechanics in Materials Science
- Alloy Thermodynamics
- Purpose Built Materials
- Fracture Mechanism of Metallic Materials
- Progress of Advanced Materials
- Principles of Designing Advanced Materials
- Processing of Ceramics
- CAD in Materials Processing
Manufacturing Engineering

Specialization: Manufacturing Engineering

Prerequisites
BE/BS in any one of the following disciplines
- Aerospace
- Aeronautical
- Mechanical
- Materials
- Industrial

Valid NTS GAT-General test score with minimum 50 marks.

<table>
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Course Description (Split MS) (First semester only)

MAT621 Engineering Mathematics (R)

MAT721 Numerical Analysis (3-0)
Solution of the Linear equations set, Matrix characteristic value and computation of characteristic vector, Non-linear equations and iterative decomposition solving method of non-linear equations set, Interpolation and approximation, Numerical integration, Numerical solution of the initial value problems of the common differential equation

MAT722 Theory of Matrices (3-0)
Elementary theory of the matrix, Linear algebraic foundation, Some important decomposition of the matrix, Generalized inverse of the matrix, Matrix analysis

EE611 Matlab/Simulink (R)
Matlab fundamentals, matrix and array operations, plotting, M files, scripts and functions, program control statements and introduction to simulink

EE612 Programming Language (R)
Design an object oriented solution to a problem, concepts of encapsulation, inheritance, polymorphism and overloading, parameter-passing mechanisms for C++ functions, mechanisms for programming tasks, looping and selection structures, structures for the steps of algorithm, write programs which perform sequential input and output using either keyboard and screen or files, use one-and two-dimensional arrays

ENG621 Communication Skills (R)
Introduction, listening and speaking skills, types of communication, communication strategies, technical report writing, research documentation, speech and pronunciation, presentation environment, presentation configuration, presentation strategies, illustrations, designing of effective visual aids

AAE731 Mechanical Behavior of Materials (3-0)
Types of stresses and strains, elastic and plastic deformation, defects and imperfections in single and polycrystalline materials, classification of defects, tensile, compression, torsion, bend, impact and fracture, toughness testing of materials. Effect of strain rate on flow properties of materials, fracture mechanics, fatigue, creep and stress rupture of materials, Griffith and Orwan theory of fracture of materials, factors affecting fatigue, stress rupture test, Nabaroo-Herring and cable creep, embrittlement and its types, materials’ selection and failure analysis, case studies

AAE732 Finite Element Methods (3-0)
Introduction to Finite Element Method (FEM), mathematics preliminaries, truss analysis, variational and weighted residual formulations, general approach to structural analysis, on continuous shape function, stress analysis for one & two-dimensional problems of structures, beam analysis and ANSYS software for FEA analysis

AAE751 Aerodynamics (supersonic) (3-0)
Theory of supersonic flow, formation of bow shock and oblique shock wave, aerofoil shapes for high speed flight, aerodynamic shapes of bodies for high speed flight, concept of lifting bodies, compressibility effect, aircraft handling requirements at supersonic speeds

AAE752 Computational Fluid Dynamics (3-0)
Classification, implicit & explicit methods, iterative & time/space marching schemes, grids, boundary conditions, aerospace applications,
Finite-difference; finite volume methods for solution of Navier-Stokes & Euler equations, Classification of partial differential equations and solution techniques. Truncation errors, stability, conservation and monotonicity, Differencing strategies. Advanced solution algorithms, Grid generation, Construction of complex CFD algorithms, Current applications, Use of CFD codes

AAE741 Spacecraft Dynamics and Control (3-0)
Six degree of freedom motion of aerospace vehicle, ascent and re-entry of launch vehicle and spacecraft, transfer of orbit, types of spacecraft orbits, Methods of Coordinate Transformation, Equation of Motion for Flight over Flat Earth, Equation of Motion for Flight over Spherical Earth, Equation of Motion for Flight over Ellipsoidal Earth, Flight Dynamics of launch vehicle and spacecraft

AAE7510 Flight Dynamics (3-0)
Dynamics and control of aircraft, Linear systems theory, state equations, transfer functions, stability, time and frequency response, Aircraft longitudinal and lateral flight dynamics

AAE742 Modern Control Theory (3-0)

AAE721 Heat Transfer and Mass Transfer (3-0)

AAE722 Rocket Propulsion (3-0)
Analysis of liquid and solid propellant rocket power plants, propellant thermochemistry, heat transfer, system considerations. Low-thrust rockets, multi-stage rockets, trajectories in powered flight, electric propulsion, Space Propulsion and Power Systems, Analysis and performance of chemical and nuclear rockets, electric propulsion systems, Introduction to solar, chemical, thermoelectric and nuclear power sources, Aerothermochemistry of Advanced Propulsion Systems, Physics and chemistry needed to analyze high performance rocket propulsion systems including reacting high temperature radiating gas and plasma flows

MSE712 Joining Technology for Modern Materials (3-0)
Introduction, special challenges and requirements of joining of advanced materials, mechanical fastening, conventional and non-conventional welding and joining techniques, active metal brazing and diffusion bonding of metals, alloys and inter-metallic and adhesive bonding. Joining of dissimilar materials, wet-ability, need for joining dissimilar materials, logical and illogical combinations, metallizing, glass-to-metal bonding, glass-to-ceramic bonding, ceramic-to-metal bonding, bonding of metallic materials to polymers and composites. Evaluation of joints and their structural integrity

AAE716 Methods of Optimization (3-0)
Applications of unconstrained and constrained parameter optimization, dynamic programming, and optimal control theory to problems in aerodynamics, aerospace structures, flight dynamics and control, and aerospace design, numerical methods of optimization
MAT621 Engineering Mathematics (R)

MAT271 Numerical Analysis (3-0)
Solution of the Linear equations set, Matrix characteristic value and computation of characteristic vector, Non-linear equations and iterative decomposition solving method of non-linear equations set, Interpolation and approximation, Numerical integration, Numerical solution of the initial value problems of the common differential equation

MATB21 Engineering Mathematics (R)

EE611 Matlab/Simulink (R)
Matlab fundamentals, matrix and array operations, plotting, M files, scripts and functions, program control statements and introduction to simulink

EE612 Programming Language (R)
Design an object oriented solution to a problem, concepts of encapsulation, inheritance, polymorphism, and overloading, parameter-passing mechanisms for C++ functions, mechanisms for programming tasks, looping and selection structures, structures for the steps of algorithm, write programs which perform sequential input and output using either keyboard and screen or files, use one-and two-dimensional arrays

ENG621 Communication Skills (R)
Introduction, listening and speaking skills, types of communication, communication strategies, technical report writing, research documentation, speech and pronunciation, presentation environment, presentation configuration, presentation strategies, illustrations, designing of effective visual aids

functions, stability, time and frequency response, Aircraft longitudinal and lateral flight dynamics

AAE752 Computational Fluid Dynamics (3-0)
Classification, implicit & explicit methods, iterative & time/space marching schemes, grids, boundary conditions, aerospace applications, Finite-difference; finite volume methods for solution of Nervier-Stokes & Euler equations, Classification of partial differential equations and solution techniques. Truncation errors, stability, conservation and monotonicity, Differencing strategies. Advanced solution algorithms, Grid generation, Construction of complex CFD algorithms, Current applications, Use of CFD codes

AAE753 Viscous Flow (3-0)
Laminar boundary-layer theory, three-dimensional and compressible boundary layers, Laminar-flow instability theory, transition, Introduction to the mechanics of turbulence, turbulent free shear flows and boundary layers, Computational and general solution methods, Stability of laminar flows, transition and turbulent flow

AAE754 Turbulent Fluid Flow (3-0)
Description of turbulent flow, Flow equations, vorticity dynamics,
Reynolds-averaged equations, engineering turbulence models, Theory of homogeneous turbulence, spectral dynamics, Shear flow turbulence, mean and fluctuating structure of free and wall-bounded turbulent flows Qualitative features of turbulence, Statistical and spectral representation of turbulent velocity fields, averages, moments, correlations, length and time scales and the energy cascade, Averaged equations of motion, closure requirements, Reynolds stress, dissipation rate. Isotropic turbulence, homogeneous shear flows, free shear flows, wall bounded flows. Scalar transport, particulate transport

AAE7511 Aerospace Vehicle Design (3-0)
Multidisciplinary integration of aerodynamics, performance, stability and control, propulsion, structures and aeroelasticity in a system approach aimed at designing aerospace vehicles for a set of specifications. Includes weight estimates, configuration and power plant selection, maneuver and gust diagrams, wing loading and numerical analysis

AAE7512 Advanced Aerodynamics (3-0)
Two- and three-dimensional potential flow about wings and bodies; Unsteady aerodynamics, slender-body theory, Viscous effects, airfoil stall, high-lift systems, boundary-layer control, Wings and bodies at transonic and supersonic speeds, numerical methods

AAE723 Advanced Aerothermodynamics (3-0)
Aerothermodynamics of Aerospace vehicles,(missiles, space planes, airbreathers), flight dynamics (trajectory, range, stability), aerothermodynamics (fluid dynamics, thermodynamics, aerodynamics, heating) and propulsion systems (scramjets, combined cycles)

AAE724 Advanced Heat Transfer (3-0)
Different modes of heat transfer, i.e. Conduction, Convection and Radiation 2-D steady and 1-D unsteady problems in conduction, Forced and free convection and the equations of motion, energy and mass conservation

AAE726 Advanced Combustion (3-0)
Fundamentals of combustion systems, fire and explosion phenomena, Thermochemistry, chemical kinetics, laminar flame propagation, detonations and explosions, flammability and ignition, spray combustion and the use of computer techniques in combustion problems, Thermodynamics of gas mixtures, chemical kinetics, conservation equations for multi-component reacting gas mixtures, deflagration and detonation waves. Nozzle flows and boundary layers with reaction and diffusion

AAE722 Rocket Propulsion (3-0)
Analysis of liquid and solid propellant rocket power plants, propellant thermo chemistry, heat transfer, system considerations. Low-thrust rockets, multi-stage rockets, trajectories in powered flight, electric propulsion, Space Propulsion and Power Systems, Analysis and performance of chemical and nuclear rockets, electric propulsion systems, Introduction to solar, chemical, thermo electric and nuclear power sources, Aerothermochemistry of Advanced Propulsion Systems, Physics and chemistry needed to analyze high performance rocket propulsion systems including reacting high temperature radiating gas and plasma flows

AAE731 Mechanical Behavior of Materials (3-0)
Types of stresses and strains, elastic and plastic deformation, defects and imperfections in single and polycrystalline materials, classification of defects, tensile, compression, torsion, bend, impact and fracture, toughness testing of materials. Effect of strain rate on flow properties of materials, fracture mechanics, fatigue, creep and stress rupture of materials, Griffith and Orhan theory of fracture of materials, factors affecting fatigue, stress rupture test,
Nabaroo-Herring and coble creep, embrittlement and its types, materials' selection and failure analysis, case studies

**AAE732 Finite Element Methods (3-0)**
Introduction to Finite Element Method (FEM), mathematics preliminaries, truss analysis, variational and weighted residual formulations, general approach to structural analysis, cn continuous shape function, stress analysis for one & two-dimensional problems of structures, beam analysis, and ANSYS software for FEA analysis

**AAE733 Aerospace Structural Analysis (3-0)**
Stress analysis of elastic structures for aerospace application under different loading conditions, Shear flow distribution in thin-wall structures, Bending and torsion analysis of thin walled structure, Buckling of thin plates, columns, shear panels, compression panels and thin walled circular and conical cylinder

**AAE734 Advanced Structural Dynamics (3-0)**
Free and forced vibration of single-degree-of-freedom, two-degree-of-freedom and multiple-degree-of-freedom, determination of natural frequencies and mode shapes, continuous systems, vibration control

**AAE735 Aero Elasticity Theory (3-0)**
Equations of the theory of elasticity in different co-ordinate system, solution to plane stress and plane strain problems, Fourier transformation method and St. Venant's principle, Solution to plates of various profiles and end conditions along with the most commonly used numerical energy methods

**AAE736 Theory of Plasticity (3-0)**
Foundations of plasticity, elastoplastic bending and torsion, plastic analysis of beams and frames, further solutions of elastoplastic problems, theory of the Slipline field, steady problems in plane strain

**AAE738 Fracture Mechanics (3-0)**
Fundamental concepts, elastic-plastic fracture mechanics, dynamic and time-dependent fracture, fracture mechanisms in metals and nonmetals, fracture toughness testing of metals, fracture testing on nonmetals, fatigue crack propagation, environmentally assisted cracking in metals, computational fracture mechanics

**AAE631 Advanced Mechanics of Materials (3-0)**
Elasticity, shear center and unsymmetrical bending, curved flexible members and stresses in flat plates, torsion of non-circular sections, stresses in rotary sections and contact stresses

**AAE739 Theory of Elasticity (3-0)**
Basic definitions of strain and stress tensors, derive strain-deformation relationships for finite and small deformations, derive compatibility conditions for strain tensors, equilibrium equations and formulate constitutive properties of orthotropic and isotropic elastic materials. Introduce the Airy stress functions for 2-D plane stress and plane strain problems in Cartesian and Cylindrical coordinate systems

**AAE617 Mathematical Modeling and Simulation (3-0)**
Introduction to a Dynamic systems and control, modeling and analysis techniques, the fundamentals and...
applications of control systems, transfer functions, sensitivity and robust control and digital control. Case studies related to motion control system design, electromechanical system design, vehicle suspension design and aircraft response modes

AAE7310 Experimental Stress Analysis (2-1)
Elementary elasticity and fracture mechanics, strain-measurement methods and related instrumentation, optical methods of stress analysis, coating methods and application of statistics

AAE7311 Experimental Methods in Structural Dynamics (2-1)
Vibration analysis Overview, experimental methods in vibration analysis, vibration measuring instruments, selection of sensors, accelerometer mountings, vibration exciters-mechanical, hydraulic, electromagnetic and electrodynamics, frequency measuring instruments, system identification from frequency response, testing for resonance and mode shapes

AAE7313 Smart Structures (3-0)
Analysis, design and implementation of smart structures and systems, modeling of beams and plates with induced strain actuation, shape memory alloys, electro-rheological fluids, magnetostrictor and electrostricter actuators and fiber optic sensors

AAE7315 Optimization Techniques in Structural Design (3-0)
Unconstrained and constrained optimization techniques, advanced optimization techniques, static and dynamic applications

AAE7316 Nonlinear Dynamics and Chaos (3-0)
Modeling of Duffing-type Mathieu systems, sources of geometrical and material non-linearity, non-dimensionalisation of equation of motion, methods of harmonic balance and simple perturbation, review of Floquet theory, basics of stability analysis, chaotic dynamics, how to identify chaotic vibrations, point attractors and limit cycles in autonomous systems, periodic and chaotic attractors, bifurcations and Lyapunov exponent, applications in the physical sciences

AAE742 Modern Control Theory (3-0)
Applications of modern control theory to flight control, Controller design based on optimal control techniques. Nonlinear system theory applications, typical aerospace control methods such as model following, load alleviation, and flutter suppression, recent advances in aerospace vehicle control

AAE743 Guidance and Navigation of Aerospace Vehicles (3-0)
Principles of guidance systems for spacecraft, launch vehicles, homing and ballistic missiles. Optimal guidance, Interplanetary transfer guidance with low thrust, Principles of inertial navigation, theory and applications of the Global Positioning System, Celestial navigation procedures, application of Kalman filtering to recursive navigation theory

AAE643 Automatic Control of Flight Vehicles (3-0)
Application of classical and modern linear control theory to automatic control of flight vehicles. Spacecraft attitude control, control of flexible vehicles, Linear-quadratic regulator and pole-placement design applications

AAE7416 Optimal Control (3-0)
The optimal control problem, Variational approach, Pontryagin's principle, Hamilton-Jacobi equation, Dynamic programming, Time-optimal, minimum fuel, minimum energy control systems, the regulator problem, Structures and properties of optimal controls

AAE646 Orbital Mechanics (3-0)
Review of 2-body problem, Orbit perturbation analysis, Gravity field expansions and effects on orbiters, 3-body problem with applications

AAE716 Methods of Optimization (3-0)
Applications of unconstrained and constrained parameter optimization, dynamic programming and optimal control theory to problems in
aerodynamics, aerospace structures, flight dynamics and control and aerospace design, numerical methods of optimization.

AAE715 Systems Engineering and Analysis (3-0)
Introduction to organized multidisciplinary approach to designing and developing systems. Concepts, principles and practice of systems engineering as applied to large integrated systems. Life-cycle costing, scheduling, risk management, functional analysis, conceptual and detail design, test evaluation and systems engineering planning and organization.

AAE7513 Aerospace System Design and Management (3-0)
The course will offer a comprehensive introduction to modern design and management methods. The course will concentrate on successful management examples of complex aerospace projects.

AAE714 Reliability Engineering (3-0)
Introduction to reliability engineering, basic concepts from statistics, the quantification of reliability and its related functions, analysis of reliability data, load-strength, interference, reliability in design and testing.

AAE614 Computer Aided Design (3-0)
Computer generation of geometric models, calculation of design parameters, trade-off diagrams and finite-element modeling and analysis.

Split PhD Program with BUAA China

Eligibility
- Master of Engineering in discipline relevant to the proposed field of study at PhD
- Valid NTS GAT-General test score with minimum 50 marks.

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<th>Month No.</th>
<th>Duration</th>
<th>Campus</th>
<th>Activities</th>
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</table>
| 1-12      | 12 Months | BUAA   | • Initial course work to be decided mutually
|           |          |        | • Chinese language
|           |          |        | • Initial Literature survey
|           |          |        | • Selection of main research area
|           |          |        | • Preparation of research proposal |

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<th>Campus</th>
<th>Activities</th>
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</table>
| 13-30     | 18 Months | IST    | • Literature survey
|           |          |        | • Course work
|           |          |        | • Work on main research area |
| 31-45     | 15 Months | BUAA   | • Submission and defense of research proposal for doctoral dissertation
|           |          |        | • Additional course work
|           |          |        | • International Publication of research
|           |          |        | • Submission and defense of doctoral dissertation |
Located in the metropolitan city of Xi'an which enjoys her name as “Oriental Rome”, NPU is a unique university in the People's Republic of China which develops aeronautics, astronomy and marine science simultaneously. The university now has about 25,000 students, including 3,100 PhDs, 6,100 Masters, 15,200 undergraduates and 290 overseas students. So far, this university holds the prestige of graduating the first PhD student in China in 6 disciplines. Totally, 34 PhDs or teachers of this university have received prestigious Humboldt Research Fellowships by Alexander von Humboldt Foundation. Among it alumni are: 30 academicians of the Institute of Science or the Institute of Engineering of China, more than 30 generals and 6 students have reached to the top echelons of Chinese society.

As a multidisciplinary and research-oriented university, it offers 47 bachelor programs, 55 master degree programs and 28 Ph.D. programs, and 6 national key laboratories, 4 national specialized laboratories, 2 engineering research centers and 26 provincial key laboratories have been established. Xi'an, historically known as Chang'an in the ancient China, was the seat of capital for 13 feudal dynasties of the Zhou (11th century B.C. – 256 B.C.), Qin (221 B.C. – 206 B.C.), Han (206 B.C. – 220 A.D.), Tang (618 – 907), etc. Rich historical heritages highlight Xi'an as an internationally renowned tourist city, which attracts millions of foreign tourists on sightseeing tours every year. The city marks the point of departure for the Silk Road in the ancient times and has Qin Shi Huang Museum of Terra-cotta Warriors and Horses – “eighth wonder of the world”, the Big Wild Goose Pagoda constructed in the Tang Dynasty, Xi'an Museum of Steles that is home to treasured calligraphic works of China, and the cultural theme park of Tang Paradisiacal Garden. Xi'an lies where the central and western parts of China join, with advantageous location and moderate climate. Xi'an is the provincial capital of Shaanxi Province and has a population of 6.70 million people, who acquire higher level of education on the average and communicate mostly in Chinese. Xi'an has the tradition of accepting international students. As early as in the Tang Dynasty over 1,000 years ago, Xi'an, the capital of the dynasty, began to admit students from Japan, Korea and other nations of Asia. In recent years, with growing worldwide interest in acquisition of Chinese, Xi'an has become a major city for international students that are eager to learn Chinese.
Split MS with NPU

Eligibility
- BSc / BE in a discipline related to the proposed field of study at MS Level
- Valid NTS GAT-General test score with minimum 50 marks.

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<th>Activities</th>
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<td>2nd Year (12 Months)</td>
<td>NPU</td>
<td>Course Work &amp; Thesis</td>
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Split PhD with NPU, China

Eligibility
- MS in a discipline related to the proposed field of study at PhD level
- Valid NTS GAT-General test score with minimum 50 marks.

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<th>Month No.</th>
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<td>• Course work</td>
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<td>• Work on main research area</td>
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<td>31-45</td>
<td>12 Months</td>
<td>NPU</td>
<td>• Additional course work</td>
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<td>• Submission and defense of research plan for doctoral dissertation</td>
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<td>• International publication of research</td>
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<td>• Submission and defense of doctoral dissertation</td>
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DEPARTMENT OF

Electrical Engineering
Department of Electrical Engineering

The Department of Electrical Engineering (EE) runs an internationally recognized academic program in Communication Engineering with specializations in “Wireless Communications” and “Signal and Image Processing”. The department consists of experienced faculty, well-equipped classrooms and state-of-the-art lab facilities. The department provides continuous academic improvement through consultation with faculty, industry, communication engineering professionals and students.

The focus of this course is on the design, analysis, development and testing of communication systems; encompassing both wired and wireless communications technologies and along with in depth knowledge of signal and image processing techniques. The curriculum is designed to provide students with advanced principles and application of modulation and demodulation methods, digital communications, digital signal processing, coding techniques, image processing, video sequence analysis, computer vision & 3D, wireless technologies, fiber-optics and satellite systems.

Mission Statement
Mission of the department is to offer an open and thinking environment that spurs interest in research; emphasizes teaching excellence; meet the educational and personal needs of students; incorporate collaborative research with other universities and relevant industry; effective teaching; academic advising; counseling; and through university-sponsored cultural, recreational, and extracurricular programs.

Program Educational Objectives
- Coordinate the electrical engineering program’s educational objectives, and learning outcomes with the objectives of National Telecommunication Policy, National Space Policy and vision of the President of Pakistan.
- To produce engineers who can develop engineering solutions that are well-conceived and carefully implemented to meet public and private sector needs.
- To produce graduate engineers who would be thoroughly equipped with necessary tools and skills set to carry out research in pursuit of developing cost effective and innovative solutions.
- To produce graduate engineers who will contribute effectively by solving complex engineering problems, as leader and/or team members.
- To act responsibly within society in light of the obligations that engineers have to design and develop effective products that are of positive value to the society, and will practice leadership in advising society on the wisdom of specific developments, and will act with honesty and integrity, with courage and compassion.
- To practice professional ethics under all circumstances.
- To foster personal and organizational success in a dynamic, globalized professional environment. Driven to continuous lifelong learning by an inherent desire of discovery and societal improvement.
Local MS Programs

MS Electrical Engineering with specialization in Signal & Image Processing

Prerequisites
Sixteen years of education with strong background in the following areas
- Electrical
- Electronics
- Telecommunications
- Communications
- Industrial Electronics
- Computer Engineering
- Computer Science
- Other - subject to approval by the department
Valid NTS GAT- General test score with minimum 50 marks.

Mandatory Courses

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<td>EE-771</td>
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<td>EE-724</td>
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<td>EE-725</td>
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<td>EE-726</td>
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<td>EE-727</td>
<td>Computer Vision &amp; 3D Elective 2</td>
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<td>EE800</td>
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Electives

EE 772 Simulation and Modeling
EE 601 Research Methodology
EE 623 Adaptive Filters
EE 773 Signal Estimation & Detection Theory
EE 774 Video Sequence Analysis
EE 728 Document Image Analysis

Note: Duration of this program is four semesters including thesis/dissertation; students must complete a minimum of 30 credit hours to complete their MS degree requirements, including 6 Credit hours of Thesis.
MS Electrical Engineering with Specialization in Wireless Communications

Prerequisites
Sixteen years of education with strong background in the following areas
- Electrical
- Electronics
- Telecommunications
- Communications
- Industrial Electronics
- Computer Engineering
- Other - Subject to approval by the Department

Valid NTS GAT-General test score with minimum 50 marks.

**Mandatory Courses**

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<td>EE-746</td>
<td>Advanced Wireless Communication</td>
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<td>EE-747</td>
<td>Advanced Mobile Communication</td>
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<td>EE-748</td>
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**Electives**

|        | EE 772   | Simulation and Modeling                     |
|        | EE 601   | Research Methodology                        |
|        | EE 623   | Adaptive Filters                            |
|        | EE 773   | Signal Estimation & Detection Theory        |
|        | EE 774   | Telecommunication Systems & Networks        |
|        | EE 728   | Wireless Sensor Networks                    |

**Note:** Duration of this program is four semesters including thesis/dissertation; students must complete a minimum of 30 credit hours to complete their MS degree requirements, including 6 Credit hours of Thesis.
Linked Programs with University of Surrey

University of Surrey

University of Surrey's core disciplines of Computing, Electronic Engineering, Mathematics and Physics enjoy a reputation for excellence in research and teaching, allied to a strong enterprise culture and an unrivalled record of graduate employment. UniS is home to some 110 academic staff, 90 support staff, 130 researchers, 1,000 undergraduates and 600 postgraduates, a thriving international community located less than 40km from the center of London, in one of the most attractive counties in England. With its pleasant campus atmosphere located above the bustling historic market town of Guildford, just on the edge of the Downs, and yet just 30 km from the centre of London, the University of Surrey provides a lively and friendly cosmopolitan learning environment within easy reach of the cultural centers of the South East London.

As a student in the school of Electronics and Physical Sciences, you will be studying alongside fellow students from diverse backgrounds who come to Surrey to gain a world-class education in the subject areas at the height of 21st century life- Computing, Electronics, Mathematics and Physics.

Institute of Space Technology offers linked programs with University of Surrey (UniS). After completion of the program, MS degree will be conferred by the University of Surrey, UK.
Satellite Communications Engineering

Prerequisites
Sixteen years of education with strong background in the following areas
- Electrical
- Electronics
- Telecommunications
- Communications
- Industrial Electronics
- Computer Engineering
- Other-subject to the approval of the Department
- Valid NTS GAT-General test score with minimum 50 marks.

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<td>EE-764</td>
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<td>Satellite Communications B</td>
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</table>

Electives-IST
- EE-744 Digital Communication
- EE-724 Mathematics of Signal Processing
- EE-745 Principles of Telecom & Packet Networks
- EE-753 Antennas & Propagation

Electives-UniS
- Launch Vehicles & Propulsion
- Data and Internet Networking
- Network Services, Management & Control
- Space Robotics
- Advanced Guidance, Navigation & Control
- Dynamics and Control of Spacecraft
- RF Systems and Circuit Design
- Network Service Management and Control
**Mobile & Satellite Communications**

**Prerequisites**
Sixteen years of education with strong background in the following areas
- Electrical
- Electronics
- Telecommunications
- Communications
- Industrial Electronics
- Computer Engineering
- Other - subject to approval by the Department

Valid NTS GAT-General test score with minimum 50 marks.

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<td>Thesis/ Dissertation</td>
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**Electives-IST**
- EE 724  Mathematics of Signal Processing
- EE 745  Principles of Telecom & Packet Networks

**Electives-UniS**
- Operating System for Mobile Systems Programming
- Data and Internet Networking
- Advanced Signal Processing
- Network Services, Management & Control
- Mobile Applications & Web Services
Mobile Communications Systems

Prerequisites
Sixteen years of education with strong background in the following areas
- Electrical
- Electronics
- Telecommunications
- Communications
- Industrial Electronics
- Computer Engineering
- Other - subject to approval by the Department

Valid NTS GAT-General test score with minimum 50 marks.

Electives-IST
- EE 724 Mathematics of Signal Processing
- EE 748 Satellite Communication A

Electives-UniS
- Operating System for Mobile System Programming
- Advanced Signal Processing
- Networks Service Management and Control
- Mobile Applications and Web Services

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<td>EE-745</td>
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www.ist.edu.pk
Electronics Engineering
Prerequisites
Sixteen years of education with strong background in the following areas
- Electrical
- Electronics
- Telecommunications
- Communications
- Industrial Electronics
- Computer Engineering
- Other - subject to approval by the Department
Valid NTS GAT-General test score with minimum 50 marks.

Electives-IST
- EE 724 Mathematics of Signal Processing
- EE 753 Antenna & Propagation
- EE 764 Spacecraft Systems Design
- EE 748 Satellite Communication A
- EE 745 Principles of Telecom & Packet Networks
- EE 747 Mobile Communications A
- EE 744 Digital Communications

Electives-UniS
- Advanced Signal Processing
- Microwave Engineering Principles
- Launch Vehicles & Propulsion
- RF & MMIC Design Technology
- Adv. Guidance, Navigation & Control
- Operating Sys for Mobile Systems Programming
- Speaker and Speech Recognition
- AI & AI Programming
- Spacecraft Bus Subsystems
- Mobile Communications B
- Nanophotonics
- Data & Internet Networking
- Frontiers of Nanotechnology
- Optoelectronics
- Image & Video Compression
- Nanoelectronics & Devices
- Satellite Communications B
- Network & Services, Management & Control
Space Technology and Planetary Exploration
Prerequisites
Sixteen years of education with strong background in the following areas
- Electrical
- Electronics
- Telecommunications
- Communications
- Industrial Electronics
Valid NTS GAT-General test score with minimum 50 marks.

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<td>Satellite Remote Sensing</td>
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Electives-IST
- EE 724 Mathematics of Signal Processing
- EE 753 Antenna & Propagation

Electives-UniS
- Advanced Signal Processing
- Microwave Engineering Principles
- Launch Vehicles & Propulsion
- RF & MMIC Design Technology
- Satellite Communications B
- Space Missions
- Spacecraft Bus Subsystems Design
Course Description (Programs offered at IST only)

EE-745 Principles of Telecommunication & Packet Networks

EE-748 Satellite Communications/A

EE-746 Principles of Telecommunication & Packet Networks

EE-747 Mobile Communications A

EE-748 Satellite Communications/A

EE-764 Spacecraft Systems Design
Geocentric Orbits & Orbital Maneuvers, Basic Orbits, Real Orbits, Orbital Maneuvres. Attitude Dynamics & Attitude Control Systems, Rigid Body Dynamics, Attitude control Systems, Attitude Determination, Getting to Orbit, Propulsion Technology, Launch Vehicles

EE-771 Stochastic Processes
Review of probability and random variables, random walk, Stochastic Processes —definition, methods of description, time averaging and ergodicity, continuity, integration
and differentiation, autocorrelation, power spectral density, response of linear systems to stochastic inputs, classes of stochastic processes, Shot noise, thermal noise, point processes, Markov processes, Gaussian processes, Mean square error filtering, orthogonality, smoothing, prediction, stochastic gradient algorithm, innovations, Weiner filter, Kalman filter, queuing theory, Poisson arrivals

EE-746 Advanced Wireless Communications
Wireless Channel Models, Performance of Wireless Channels, Noise and Interference, Pathloss and Shadowing, Equalization, Diversity and Space-Time Coding, Diversity Multiplexing Tradeoffs, Wireless Networks and Resource Management, Wireless Networks for fixed mobile systems, MIMO, Digital Modulation over Wireless Channels

EE-745 Telecommunication Systems and Networks

EE-753 Antennas & Wave Propagation

EE-772 Simulation and Modeling
Brief Mathematical Review, Background on Search and Optimization, Direct Search Techniques, Least-Squares-Type Methods, Stochastic Approximation for Linear and Nonlinear Systems, Search Methods Motivated by
Physical Processes, Model Building, Simulation-Based Optimization, Markov Chain Monte Carlo, Input Selection and Experimental Design

EE-724 Advanced Digital Signal Processing

EE-725 Advanced Digital Image Processing
Image analysis, Preprocessing, Image enhancement, Discrete transforms, Fourier analysis, discrete cosine, filtering, wavelet analysis, Freq. filters, Morphological image processing, point, line and edge detection, geometric transforms, image compression: system model, lossy and lossless methods

EE-726 Pattern Recognitions
Introduction to Pattern Recognition, Features, Statistical Decision Methods, Bayesian Decision Theory, Structural and Hybrid Methods, Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA), Hidden Markov Models, String matching algorithms, Dynamic Time Warping, Linear Discriminant Functions, Support Vector Machines

EE-727 Computer Vision and 3D
Color image processing, multi-sensor images, and extraction of structural features from images, recognition methods for computer vision, 3D modeling, stereoscopy, 3D image reconstruction, Video Analysis and compression
MS in Information and Cyber Security (Local) Prerequisites
Sixteen years of education with strong background in the following areas
- BE/BS in Communications, Computer Engg
- Electrical
- Electronics
- Telecommunication
- Software Engg
- Computer Science
- Information Technology
Valid NTS GAT-General test score with minimum 50 marks.

**Core Courses**
- CSY-5501 Computer and Network Security
- CSY-5502 Applied Probability and Stochastic Processes
- CSY-5503 Information Theory
- TCSY-5504 Cryptography
- CSY-5505 Secure Operating System Design and Implementation

**Electives Courses:**

1. **Major in Information Security**
   - CSY-5501 Computer and Network Security
   - CSY-5502 Applied Probability and Stochastic Processes
   - CSY-5503 Information Theory
   - TCSY-5504 Cryptography
   - CSY-5505 Secure Operating System Design and Implementation

2. **Major in Cyber Security**
   a. **General Courses**
      - CSY-5541 Mobile Computing
      - CSY-5542 Distributed & Cloud Computing
      - CSY-5543 Wireless Network Security
   b. **Secure Operating and Application System Design**
      - CSY-5521 Secure Architecture Design and Models
      - CSY-5522 Secure Systems and Application Software Design and Development
      - CSY-5523 Wireless Network Security
   c. **Intrusion Detection & Malware Analysis**
      - CSY-5524 Trust Networks
      - CSY-5525 Privacy Aware Computing
      - CSY-5526 Smart phone security
      - CSY-5527 Visualization and Image Processing for Cyber Security
   d. **Digital Forensics**
      - CSY-5528 Malicious Software Detection
      - CSY-5529 Web Security
      - CSY-5530 Statistical Methods for Intrusion Detection
      - CSY-5531 Forensic Profiling of the Cyber Terrorist
   e. **Cyber law policy**
      - CSY-5532 Security Management
      - CSY-5533 Ethics and Law of Cyber Security
Core Courses

Computer and Network Security CSY-5501 (3-0)

Applied Probability And Stochastic Process ESCSY-5502 (3-0)
Basic laws of probability, conditioning, and Bayes rule. Random variables and their functions; PDF, PMF, and CDF notions; statistical averages; moments and characteristic functions; multiple random variables; joint and conditional PDF and PMF; multiple functions of random variables; correlation and covariance; mean squared estimation of random variables; Markov, Chebychev, and Chernov inequalities; various notions of convergence of random variable sequences; laws of large numbers; central limit theorem; and large deviation theory. Basic notions of estimation and properties of estimators, unbiased and minimum variance estimation, CRLB, sufficient statistics, consistency of estimators, basic notions of discrete and continuous-time random processes, mean and autocorrelation function, WSS and cyclo-stationary processes, ergodicity of random processes.

Information Theory CSY-5503 (3-0)
Entropy and its properties, Conditional entropy, relative entropy, mutual information, Chain rules, data processing inequality, Fano's inequality, Compression : codes and decodability, Kraft's inequality, bounds on optimal codes, block coding, Huffman codes, Markov chains, entropy rate of stochastic processes, Asymptotic Equipartition Property (AEP) and its consequences, Lempel-Ziv, universal source coding, Arithmetic codes, Fibonacci codes, Elias Omega codes, Large deviation theory, Maximum entropy method, Channel coding

Introduction To Cryptography CSY-5504 (3-0)
Stream ciphers, Semantic security, Block ciphers and pseudorandom functions, Chosen plaintext security and modes of operation, The DES and AES block ciphers, Message integrity. CBC-MAC, HMAC, PMAC, and CWMAC, Collision resistant hashing, Authenticated encryption. CCM, GCM, TLS, and IPsec. Key derivation functions, Odds and ends: deterministic encryption, non-expanding encryption, and format preserving encryption, Basic key exchange: Diffie-Hellman, RSA, and Merkle puzzles, Computational number theory, Number theoretic hardness assumptions, Public key encryption, Trapdoor permutations and RSA, The ElGamal system and variants.

Secure Operating System Design And Implementation CSY-5505 (3-0)
(QEMU/VirtualBox/Xen/KVM), Symbolic Execution and Whitebox Fuzzing, Vulnerability Analysis, Exploits: Buffer Overflows, Heap Overflow, Integer Overflow, Robust Exploits: ROP shellcode, Heap Spray, Fighting for Malware: Unpack, Disassemble, Decompile. Understanding the Threats such as Viruses and Worms, Logging, Auditing and Recovery. Malware Capture and Analysis (Honeypots and Honeyfarm).

Elective Courses

Information Security

Advanced Cryptography CSY-5511 (3-0)
Digital signatures and certificates, Identification protocols, Authenticated key exchange and TLS key exchange, Zero knowledge protocols and proofs of knowledge, Privacy mechanisms: group signatures and credential systems, Private information retrieval and oblivious transfer, Two party computation; Yao’s protocol and applications, Elliptic curve cryptography, Quantum computing, Pairing-based cryptography, Lattice-based cryptography, Fully homomorphic encryption

Number Theory CSY-5512 (3-0)

Mathematical Basis for Cryptography CSY-5513 (3-0)
Mathematical preliminaries: probability theory, algebra, computational complexity, and number theory. Foundations of cryptography, public key cryptography, probabilistic proof systems, pseudorandom generators, elliptic curve cryptography, and fundamental limits to information operations.

Public Key Infrastructure and Managing E-Security CSY-5514 (3-0)
Public Key Infrastructure (PKI) components, Role of digital certificates, essential aspects of key-management, Capabilities of PKI and digital certificates in the context of business environment, law and regulations, PKI planning, rollout and interoperability issues.

Advanced Algorithm Analysis and Design CSY-5515 (3-0)
NP-completeness, Search Techniques, Randomized Algorithms, Heuristic and Approximation Algorithms, Asymptotic analysis of upper and average complexity bounds, Fundamental algorithmic strategies: brute-force, greedy, divide-and-conquer, backtracking, branch-and-bound, pattern matching, numerical approximations, Standard graph and tree algorithms, 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. Network flows (max flow and min-cost flow/circulation), Data structures (fibonacci heaps, splay trees, dynamic trees), Linear programming (structural
results, algorithms), Dealing with intractability: approximation algorithms (techniques for design and analysis), Dealing with large data sets (compression, streaming algorithms, compressed sensing), Computational geometry

Secure Operating and Application System Design
Secure Architecture Design and Models CSY-5521 (3-0)

Secure Systems and Application Software Design and Development CSY-5522 (3-0)

Principles of Software and Hardware Reverse Engineering CSY-5523 (3-0)

Intrusion Detection & Malware Analysis

Malicious Software Detection CSY-5531 (3-0)
Malicious Software, Botnets detection and Rootkits, Static analysis and its limitations, Reverse engineering, Polymorphism, code obfuscation, Dynamic analysis and its limitations, AccessMiner — system-centric models, Mobile malware, Dynamic analysis of Android malware

Web Security CSY-5532 (3-0)
Client-side (browser) vulnerabilities associated with browsing the web, system penetration, information breach and identity threat. Encrypting data stream using SSL, Confidentiality and Integrity of data using third party transaction protocols e.g. SET, PCI DSS Standard, Server-side security: CGI security, server configuration, access control, operating system security, malicious e-mails, web scripts, cookies, web bugs spyware, rogue AV etc.

Statistical Methods for Intrusion Detection CSY-5533 (3-0)
Introduction to the data and methodologies of computer intrusion detection, Statistical and machine learning approaches to detection of attacks on computers, Network monitoring and analysis, Estimating the number and severity of attacks; network-based attacks: probes and denial of service attacks; host-based attacks: buffer overflows and race conditions; and malicious code: viruses and worms, Statistical pattern recognition for detection and classification of attacks. Visualization of network data

Machine Learning for Computer Security CSY-5534 (3-0)

Secure Software & Protocol Engineering CSY-5535 (3-0)
Designing secure systems, Analyzing and verifying program correctness, Examining existing protocols, Limits of techniques for software protection such as code obfuscation, tamper-proofing and watermarking, Analysis of software-based attacks (and defenses), timing attacks and leakage of information, type safety, and capability systems.
Cyber security

Mobile Computing CSY-5541 (3-0)
Existing wireless technologies, Impact of mobility on networks, computing systems and security design, Decomposition of protocol stack to layers and analysis of interaction and co-operation between wireless protocol layers, Design and configuration 802.11 and Bluetooth wireless networks, Design and analysis of reliable and secure data communication protocols over wireless links, Design and analysis of wireless MAC protocols, Design and analyze mobile IP, Design and analyze ad-hoc routing protocols for the 4th generation wireless networks, Design of systems and applications using wireless technologies, Design of systems and applications in mobile platforms

Distributed Computing CSY-5542 (3-0)
Characterization and Models of Distributed Systems, Networking and Inter-process Communication, Distributed Objects and Remote Invocation, Network Operating System, Security of Distributed Systems, Distributed File Systems, Name and Directory Services, Time and Global States, Coordination and Agreement of Distributed Processes, Distributed Transaction Control and Management, Replica Control of Distributed Objects, Web Services

Cloud Computing
Cloud and data center file systems, Map reduce programming, High-level parallel processing, Distributed data management systems, Virtualization, Amazon web services, Interactive Web Apps and Google app engine, Security and privacy, Resource management in the cloud

Wireless Network Security CSY-5543 (3-0)

Trust Networks CSY-5544 (3-0)

Privacy Aware Computing CSY-5545 (3-0)
Data perturbation, Data anonymization, Random Responses, Privacy Measures, Cryptographic methods or data privacy, Privacy preserving data mining, Private information retrieval, Secure data outsourcing, Privacy in social networks

Smart Phone Security CSY-5546 (3-0)
Android’s application architecture, Android system programming, Security policy of Android, Interfaces used to define policy, Best practices for using those interfaces, Pitfalls leading to insecure applications, Design and implementation of selected software attacks (ethical hacking), Design and implementation of security extensions to the Android framework (e.g., access control policy enforcement)
Visualization and Image Processing for Cyber Security CSY-5547 (3-0)
The Visualization Pipeline, Data Representations, Scalar Visualization, Information Visualization, Camera Models and Calibration, Image Processing and Segmentation, Tracking and Motion

Digital Forensics
Computer and Network Forensics CSY-5551 (3-0)

Forensics CSY-5552 (3-0)
Incident handling/incident response, Manage incidents; understand common attack techniques and tools; and defend against and/or respond to attacks when they occur, Understand current threats to systems and networks and effective countermeasures, The spectrum of computer forensics tools and the Forensics Toolkit, Core forensics procedures necessary for performing thorough investigations on all computer systems and file types. Proven investigative strategies and define proper evidence-handling procedures, Skills to track an offender on the Internet, Coordination with law enforcement and how to design an incident response strategy
Vulnerability Assessment and Ethical Hacking
CSY-5553 (3-0)
Definitions, Concepts, and Phases of Vulnerability Assessments and Ethical Hacking, Legal Statutes and Issues of Vulnerability Research and Ethical Hacking, Exploring the way of thinking for an industrial spy, a competitor, or a hacker, Network Surveying, Port Scanning, System Identification / OS Fingerprinting, Vulnerability assessment and ethical hacking methodologies, technologies, and techniques and from a defensive and offensive perspective, Examining an organization for weaknesses and exploiting vulnerabilities remotely, Vulnerability Research and Verification, Service Identification, Internet Application Testing, Implementing appropriate countermeasures to thwart malicious hacking, Employing tools & exploits; BackTrack, Core Impact, DDOS, Sniffers, Spoofing, Session Hijacking, Buffer Overflows, Hacking Web Servers and Applications, Google Hacking, Network and host monitoring and traffic analysis, Configuring and monitoring intrusion detection systems and honeypots and honeynets, Reading, interpreting, and analyzing network traffic and log files, Footprinting, scanning, enumeration and escalation

Forensic Profiling of the Cyber Terrorist
CSY-5554 (3-0)
Psychological Impacts and Consequences of Terrorism, Critical Infrastructure Protection in Today’s Climate and facing Today’s Challenges, Motivation for Terrorism and Hacking, Profile of a Terrorist and Hacker, Ways terrorists can use the Internet to communicate covertly with each other right under the nose of US law enforcement, How Internet Cafes, Wi-Fi “hotspots” and library Internet terminals provide ways to anonymize terrorists over the Internet, How global networks (ATM terminals, airline reservations, etc.) are used for covert channels through the Internet, Understanding what makes the mind of the terrorist work

Cyber law policy

Security Management CSY-5561 (3-0)

Ethics and Law of Cyber Security
CSY-5562 (3-0)
The Ethics of Cyber Terrorism, Cyber Security & the Law, Can governments shut down privately owned Internet Cafes or e-mail servers?, International law and cyber security, The rights of the individual vs. public safety and cyber law & ethics
DEPARTMENT OF

Materials Science & Engineering
Materials Science & Engineering is a broad, versatile and ever evolving discipline. It deals with structure, properties, applications of metals, alloys, ceramics, polymers and composites. They are studied in terms of their structural as well as functional properties and applications. In modern times as the need for smaller and lighter materials grows, the desire for new materials, their design, fabrication and characterization becomes imperative.

Institute of Space Technology offers Indigenous MS Program in Materials Science & Engineering with areas of specialization in metals, ceramics, polymers, composites, aerospace materials and nano-engineering. The program aims to provide specialized education/training in modern materials science and engineering. It would enable students to attain a deep understanding of the theoretical and practical aspects of materials engineering. The students will be pleasantly surprised to discover that the program is attractive because of its rapidly expanding importance in both academic and industrial sectors.

Mission
The MS program at the Institute of Space Technology is designed to provide an opportunity for higher education and research in the area of Materials Science and Engineering. This will enable the students to gain in-depth knowledge, training and skills in the subject area necessary for their career goals. The students will be awarded a Masters (MS) degree upon successful completion of the course.

Prerequisites
BE/BS in any one of the following or relevant discipline:
- Materials Science
- Metallurgy
- Physics
- Chemistry/Chemical engineering,
- Electrical and Mechanical Engineering
Valid NTS GAT-General test score with minimum 50 marks.

Local MS Program: Materials Science & Engineering
Specialization: Aerospace Materials

<table>
<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MSE 711</td>
<td>Aerospace Materials Structure and Properties of Materials</td>
<td>3-0</td>
</tr>
<tr>
<td>1</td>
<td>MSE 621</td>
<td>Thermodynamics of Materials</td>
<td>3-0</td>
</tr>
<tr>
<td>2</td>
<td>MSE 631</td>
<td>Advanced Characterization Techniques</td>
<td>3-0</td>
</tr>
<tr>
<td>2</td>
<td>CSE 601</td>
<td>Research Methodology</td>
<td>3-0</td>
</tr>
<tr>
<td>2</td>
<td>MSE 735</td>
<td>Composites for Aerospace Applications</td>
<td>3-0</td>
</tr>
<tr>
<td>3</td>
<td>MSE 742</td>
<td>Processing of Materials</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td>Elective 1</td>
<td></td>
<td>3-0</td>
</tr>
<tr>
<td>4</td>
<td>Thesis</td>
<td></td>
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</tr>
</tbody>
</table>

Note: Students will undertake the research project (Thesis) in the same specialized area of Materials Science & Engineering awarded a Masters (MS) degree upon successful completion of the course.

Elective Course
The elective course will be offered from the list; subject to the availability of specialized faculty and the number of students interested in the course.
### Local MS Program: Materials Science & Engineering

**Specialization: Nano-Engineering Materials**

<table>
<thead>
<tr>
<th>Semester</th>
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<th>Credit Hours</th>
</tr>
</thead>
<tbody>
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<td>3-0</td>
</tr>
<tr>
<td></td>
<td>MSE 622</td>
<td>Thermodynamics of Materials</td>
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<td>MSE 631</td>
<td>Advanced Characterization Techniques</td>
<td>3-0</td>
</tr>
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<td></td>
<td>CSE 601</td>
<td>Research Methodology</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td>MSE 735</td>
<td>Nanotechnology</td>
<td>3-0</td>
</tr>
<tr>
<td>3</td>
<td>MSE 744</td>
<td>Nano-Materials Engineering</td>
<td>3-0</td>
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<tr>
<td></td>
<td></td>
<td>Elective 1</td>
<td>3-0</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Thesis</td>
<td>0-6</td>
</tr>
</tbody>
</table>

**Note:** Students will undertake the research project (Thesis) in the same specialized area of Materials Science & Engineering. The elective course will be offered from the list; subject to the availability of specialized faculty and the number of students interested in the course.

### Local MS Program: Materials Science & Engineering

**Specialization: Composite Materials**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MSE 711</td>
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<td>3-0</td>
</tr>
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<td></td>
<td>MSE 621</td>
<td>Structure and Properties of Materials</td>
<td>3-0</td>
</tr>
<tr>
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<td>MSE 622</td>
<td>Thermodynamics of Materials</td>
<td>3-0</td>
</tr>
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<td>MSE 631</td>
<td>Advanced Characterization Techniques</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td>CSE 601</td>
<td>Research Methodology</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td>MSE 612</td>
<td>Metals and Alloys</td>
<td>3-0</td>
</tr>
<tr>
<td>3</td>
<td>MSE 742</td>
<td>Processing of Materials</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective 1</td>
<td>3-0</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Thesis</td>
<td>0-6</td>
</tr>
</tbody>
</table>
Note: Students will undertake the research project (Thesis) in the same specialized area of Materials Science & Engineering.

Elective Course
The elective course will be offered from the list; subject to the availability of specialized faculty and the number of students interested in the course.

Local MS Program: Materials Science & Engineering
Specialization: Ceramics and Glasses

<table>
<thead>
<tr>
<th>Semester</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>3-0</td>
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<tr>
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<tr>
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<td>MSE 622</td>
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<td>3-0</td>
</tr>
<tr>
<td>2</td>
<td>MSE 631</td>
<td>Advanced Characterization Techniques</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td>CSE 601</td>
<td>Research Methodology</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td>MSE 613</td>
<td>Ceramics and Glasses</td>
<td>3-0</td>
</tr>
<tr>
<td>3</td>
<td>MSE 723</td>
<td>Functional Materials</td>
<td>3-0</td>
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<tr>
<td></td>
<td>Elective 1</td>
<td></td>
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</tr>
<tr>
<td>4</td>
<td>Thesis</td>
<td></td>
<td>0-6</td>
</tr>
</tbody>
</table>

Note: Students will undertake the research project (Thesis) in the same specialized area of Materials Science & Engineering.

Elective Course
The elective course will be offered from the list; subject to the availability of specialized faculty and the number of students interested in the course.

Local MS Program: Materials Science & Engineering
Specialization: Polymer Engineering

<table>
<thead>
<tr>
<th>Semester</th>
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</tr>
<tr>
<td></td>
<td>MSE 622</td>
<td>Thermodynamics of Materials</td>
<td>3-0</td>
</tr>
</tbody>
</table>
Course Description

Mandatory Courses

Aerospace Materials (MSE 711)

Structure and Properties of Materials (MSE 621)

Thermodynamics of Materials (MSE 622)
Thermodynamics review. Laws of thermodynamics; property relation; free energies; Maxwell relations; chemical potential; thermodynamic activity. Statistical thermodynamics. Defects in solids, Surfaces and interfaces. Solidification, metallic glasses, diffusion, atomic mechanisms of diffusion, high-diffusivity paths; diffusion in multi phase binary systems; diffusional transformations in solids, diffusion less transformations.

Advanced Characterization Techniques (MSE 631)

Research Methodology (CSE 601)

Elective Courses

Composites for Aerospace Applications (MSE 735)
Failure analysis of composites.
Recycling and disposal of composites.

**Processing of Materials (MSE 742)**
Introduction to materials processing science with emphasis on heat transfer, chemical diffusion and fluid flow. Synthesis and production of materials with engineered microstructures for desired properties. High temperature, aqueous, and electrochemical processing; thermal and mechanical processing of metals and alloys; casting and solidification; diffusion, microstructural evolution, and phase transformations; modification and processing of surfaces and interfaces; deposition of thin films; solid state shape forming; powder consolidation; joining of materials.

**Nanotechnology (MSE 712)**
Introduction. Moore's Law. Richard Feynman prediction. Size dependent properties at nano scale. Molecular nano technology, Top-down and bottom-up approach; size dependence on properties; materials and processes; silicon technology; semiconductor grade Silicon; silicon single crystal growth and wafer production; photolithography; Soft-lithography; clean room; impact of nano technology; impact of nano technology on information technology, materials and manufacturing, health and medicine, energy, environment, transportation, security and space exploration. Quantum mechanics and nano technology. Thin film technology. Bio-Inspired nano technology. Impact of nano materials. Ethics and dangers of Nano technology.

**Nano-Materials Engineering (MSE 744)**
Synthesis and characterization of nano particles, nano composites and other materials with nano scale features. Nano fabrication techniques. Zero-dimensional nano particles. One-dimensional nano structures e.g. nano tubes, nano rods, nano wires and nano fibers. Two dimensional thin films. Design and properties of devices based on nano technology. Importance of nano structured materials. Structure-property-processing relationship in nano materials and uses in electronics, photonics, magnetic applications.

**Composites (MSE 615)**
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. Hybrid composites. The emerging field of nano composites. Composite materials as surface coatings. Fiber-matrix Interface and inter phase, and their role in tailoring the properties of composites. Interface mechanics and toughness. Design and analysis of composites. Elastic, thermal and physical properties. Thermal stresses in composites. Applications of composites.

**Preform Technology for Composites (MSE 745)**
Introduction to composites reinforcements, One-dimensional preforms, Two-dimensional preforms, Random fibre preforms, Preforms based on uni-directional layers, Woven reinforcements, braided reinforcements, Knotted reinforcements, Solid three-dimensional preforms, Sandwich preforms, Preform architecture and mechanical behavior of reinforcements/preforms, General approach to modeling of mechanical properties of reinforced composites, Representative volume element (unit cell) of composites, description of the unit cell geometry as a starting point for prediction of mechanical properties.

**Metals and Alloys (MSE 612)**
Different methods of classification of steels, various phases and reactions in steel: ferrite reaction,

Ceramics and Glasses (MSE 613)
Bonding in ceramics; structure of ceramics; effect of chemical forces on physical properties; thermodynamics and kinetic considerations; defects in ceramics; diffusion and electrical conductivity; phase equilibria; formation, structure and properties of glasses, sintering and mechanical properties. Fracture, creep and fatigue. Thermal properties.

Functional Materials (MSE 723)
Ferro electric, para electric and pyroelectric materials, piezoelectric materials, Polarization mechanisms; magnetic materials and properties; optical materials and properties, sensor/actuator materials.

Polymer Engineering (MSE 614)

Smart Polymers (MSE 734)
Introduction to smart polymers, Chemical responding polymers, Thermo responsive polymers, pH sensitive polymers, Electroactive polymers, Light responding polymers, Magnetic responsive polymers, Selfhealing polymers, Multiple stimuli polymers, Smart polymer hydrogels. Polymers for drug release, Shape memory polymers, Conductive polymers, Fire retardant polymers, their design, structure, properties and characterization. Outlook for the future.

Materials for Energy and Environment (MSE 643)
Environment catastrophes; sustainability, time scales, length-scales and units. Energy. Solar energy. Energy balance of the earth and the greenhouse effect. The earth system. Global warming; steam engines; electric engines; combustion engines and the electric car; nuclear energy; fusion and nuclear fuels; biomass and biofuels; consumption; thermal energy and heating; hydrogen and energy storage; energy and food; energy and water; geothermal energy; tide and wave energy; ozone layer.

Materials for Solar Energy (MSE 642)
The energy problem: causes, scope and scale. Solar Cells. Solar spectrum. Basic semiconductor physics: electron and hole energy bands; p-n junctions; photovoltaic effect, solar cell operation and characteristics; fill factor, efficiency; materials issues in solar cells; emerging solar cell technology; photovoltaic systems; grid tied versus battery backup; assessing energy resources.

Mechanical Behaviour of Materials (MSE 731)
conditions; stress intensity factor, failure and fracture modes. Griffith
and Orowan theory of fracture. Fatigue, creep and stress rupture.
Nobaroo-Herring and Coble creep. Super-plasticity, radiation damage
and embrittlement.

Electronic and Magnetic Properties of Materials (MSE 724)
Semiconductors; binary and tertiary semiconductor materials; single
crystal growth techniques; doping profiles; VLSI technology; magnetic
moment; classification of magnetic materials; magnetization curves;
domain theory; soft and hard magnetic materials; magnetic
materials processing; cast and sintered magnets;
magnetostriction; metallic and ceramic magnets.

Thin Film Technology (MSE 641)
Review of vacuum science and technology. Methods of preparation
of thin films: electrolytic deposition; cathodic and anodic films, physical
vapor deposition. The physics and chemistry of thermal evaporation.
Film thicknesses; uniformity and purity, Evaporation hardware and
techniques, Glow discharges and Plasmas; sputtering, sputtering
processes; laser ablation hybrid and modified PVD processes; chemical
vapor deposition: reaction types, thermodynamics of CVD, gas
transport, growth kinetics, CVD processes and system. Growth and
structure of films; atomistic nucleation processes; post-
ucleation growth; film structures; structural aspects of epitaxial films;
lattice misfit and imperfection in epitaxial films; Epitaxial Film growth
and characterization; amorphous thin films.

Electrochemistry and Corrosion (MSE 625)
Electrochemical Concept of Corrosion, Faradaic and Non-
Faradaic Processes, Electrical Double Layer, Corrosion Cells,
Corrosion Processes, Corrosion circuit, Cathodic and Anodic
Reactions, Formation of Solid Products and their importance.
Electrochemical Thermodynamics and Kinetics including charge
transfer, polarization and mixed electrodes, Interface Potential
Difference and Half-Cell, Nernst-Equation, Pourbaix Diagrams. Types
of corrosion and their mechanisms, Galvanic Coupling, Corrosion of
Active-Passive Metals and Alloys, Anodic Polarization and Passivity,
Influence of Environmental Variables. Corrosion Rate
Measurements, Tafel Analysis, Polarization Resistance,
Electrochemical Impedance Spectroscopy, Cyclic Polarization
Scans. Corrosion of welded
structures and Micro-Biological Corrosion with case studies.

Fracture Mechanics (MSE 733)
Fundamental concepts of fracture mechanics and their applications, concepts of elastic-plastic fracture mechanics, dynamic and time-dependent fracture aspects, fracture mechanisms in metals, fracture toughness testing of metals, fatigue crack propagation, environmentally assisted cracking in metals and computational fracture mechanics.

Fractography and Fracture Analysis (MSE 743)
Engineering aspects of fracture and failure analysis, mechanical and metallurgical causes of failure, failure modes, characterization of fractured surface, macroscopic and microscopic features of fracture, fatigue, creep and corrosion assisted / induced failures, fractography, selected case histories and failure prevention methods.

Semiconductors (MSE 713)
Energy band and carrier concentration in thermal equilibrium, carrier transport phenomenon, semiconductor devices: PN junction, Bipolar transistor and related devices, MOSFET and related devices, MESFET and related devices, Microwave diodes, quantum-effect and hot-electron devices, photonic devices.

Solid State Physics (MSE 623)
Crystal vibrations, thermal properties, free electron Fermi gas, energy bands, Fermi surface and metals, superconductivity, diamagnetic and paramagnetism, ferromagnetism and antiferromagnetism, Magnetic resonances, Plasmons, Polaritons and Polarons, Optical Processes and Excitons, Dielectrics and Ferroelectrics, Surface and Interface Physics, Non crystalline solids, point defects, Dislocations, alloys.

Advanced Engineering Mathematics (MAT 715)
Vector Calculus, Coordinate system transformation, Power series solution, Special functions, Bessel functions, Legendre polynomials, Laplace and inverse transforms, Solution of linear differential equations by the Laplace transform method, Introduction to PDE’s, Functions of many variables and their geometries.

Finite Element Methods (AAE 732)
Introduction to Finite Element Methods (FEM), mathematics preliminaries, truss analysis, variational and weighted residual formulations, general approach to structural analysis, efficient representation of computational meshes, efficient computation of the element tensor (element stiffness matrix), tensor representation of multilinear forms, Stress analysis for one and two dimensional problems of structures, beam analysis, and ANSYS software for FEA analysis.
The graduate program at the Department of Mechanical Engineering (ME) is designed to edify young engineers who will be at the forefront of engineering profession leading a way to improve engineering systems with specialization in areas of Fluid & Thermal Systems, Mechanical Design & Analysis, Manufacturing Systems and Automobile. These specialized areas bring together the faculty and young engineers into a group of intellectuals with a common interest in research and innovation and give them the opportunity for advanced studies. Research turns money to knowledge whereas innovation converts knowledge to money. It is practiced here by strong linkage with industry and dedicated research teams of the ME and allied departments.

Mechanical Engineering is concerned with the design, development, manufacturing, and operation of a wide variety of energy conversion and machine systems. The program, although rooted in mechanical engineering, may be significantly interdisciplinary. Generally, the graduate programs are designed to encourage students to develop an understanding and capability to use engineering analysis tools in solving a broad spectrum of problems faced in industry. Coursework is supplemented through collaborative work of faculty with their ongoing research and industry of repute for their assenting feedback, so as to prepare young engineers for career involving technical innovation and leadership and to be in a place where one stands second to none.

With our experienced faculty and dedicated staff, the department of ME is well equipped for the challenges of this competitive world. Innovation and excellence can't be achieved until one works and strives for improvement unremittingly, the future comes on its own, but progress does not. We invite you to face these challenges with us.

Mission Statement
The mission of Mechanical Engineering program is to serve engineering profession by providing high quality education and contribute to the development of innovative solutions through research in mechanical and allied disciplines.

Program Educational Objectives
The program aims to:
- Provide students with an in-depth understanding of the knowledge required for the practice of, or for further advanced study, including the engineering and scientific principles, analysis techniques and design methodologies.

- Nurture engineers with a global outlook and to provide technological leadership through necessary technological tools.
- Produce engineers with teamwork, communication and interpersonal skills.
- Enable them to be productive members of interdisciplinary engineering teams and the ability to adapt to changing environments of engineering, technology and society.
- Produce engineers with high moral and ethical values.
- Provide students with broad-based advanced education necessary for productive careers in the industry, academia, R&D, management & administration etc.
- Inculcate critical thinking among students and develop initiatives and innovative ideas.
Program Educational Outcomes

The department of Mechanical Engineering has adopted ABET Criterion 3 educational outcomes that is supported by our defined educational objectives listed above. These educational outcomes relate to the aptitude, awareness and performance that students acquire as the program progress.

- An ability to apply knowledge of mathematics, science and engineering.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design system, component or process to meet desired needs with realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- The broad education necessary to understand the impact of engineering solutions in global, economic, environmental and social context.
- A recognition of the need for, and an ability to engage in life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.
- An ability to work effectively and professionally in all areas of mechanical engineering.
MS PROGRAMS
Mechanical Engineering with following specializations:
- Fluid & Thermal Systems
- Mechanical Design & Analysis
- Manufacturing Systems
- Automobile

Prerequisites
BE/BSc in one of the following disciplines:
- Mechanical
- Aerospace
- Industrial
- Manufacturing
- Mechatronics
- Chemical (for specialization in Fluid & Thermal Systems only)
- Materials Science & Engineering (for specialization in Mechanical Design & Analysis and Manufacturing Systems)

Valid NTS GAT-General test score with minimum 50 marks.

Mandatory Courses
Minimum 9 credit hours

Elective Courses
The elective courses will be offered from the following list; subject to the availability of specialized faculty and the number of students interested in each course.

Elective Mathematics

<table>
<thead>
<tr>
<th>Code</th>
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<tbody>
<tr>
<td>MAT 721</td>
<td>Numerical Techniques</td>
</tr>
<tr>
<td>MAT 725</td>
<td>Partial Differential Equations</td>
</tr>
<tr>
<td>MAT 726</td>
<td>Advanced Engineering Mathematics</td>
</tr>
<tr>
<td>MAT 727</td>
<td>Probability and Random Variables</td>
</tr>
<tr>
<td>MAT 728</td>
<td>Differential Equations &amp; Dynamical Systems</td>
</tr>
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</table>

<table>
<thead>
<tr>
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<tr>
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<td></td>
<td>Elective Maths</td>
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</tbody>
</table>
Specialization in Fluid & Thermal Systems (FTS)

Specialization in fluid and thermal systems aims at imparting understanding of intensely practical, design-oriented engineering problems pertaining to the technical challenges of the country facing nowadays. We aim to germinate and evoke rational skills which will help in understanding multi-disciplinary engineering problems. FTS combines the field of thermal systems & stresses, advanced combustion, fluid mechanics, heat transfer, and computational fluid dynamics, etc. to create innovative products and solutions to real world problems. This field of specialization is quite diverse with experimental, analytical, and numerical investigations in the following areas:

- Advanced Fluid Mechanics & Computational Fluid Dynamics
- HVAC and Refrigeration
- Thermal Systems
- Fluid Structure Interactions
- Advanced Heat Transfer & Combustion

This program enables the graduates to implement their knowledge and skills towards the development of effectual and environmental friendly systems.

### Core Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 721</td>
<td>Advanced Heat &amp; Mass Transfer (3-0)</td>
</tr>
<tr>
<td>ME 722</td>
<td>Advanced Fluid Mechanics (3-0)</td>
</tr>
<tr>
<td>ME 723</td>
<td>Computational Fluid Dynamics (3-0)</td>
</tr>
<tr>
<td>ME 724</td>
<td>Internal Combustion Engines (3-0)</td>
</tr>
<tr>
<td>ME 725</td>
<td>Design of Thermal Systems (3-0)</td>
</tr>
</tbody>
</table>

### Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
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</tr>
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<tbody>
<tr>
<td>ME 726</td>
<td>Theory of Thermal Stresses (3-0)</td>
</tr>
<tr>
<td>ME 727</td>
<td>Advanced Thermodynamics (3-0)</td>
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<tr>
<td>ME 728</td>
<td>Advanced Combustion (3-0)</td>
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<tr>
<td>ME 729</td>
<td>Aircraft Engines (3-0)</td>
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<tr>
<td>ME 7210</td>
<td>Thermal Design of Heat Exchanger (3-0)</td>
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<tr>
<td>ME 7211</td>
<td>HVAC &amp; Refrigeration (3-0)</td>
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<tr>
<td>ME 7212</td>
<td>Nuclear Engineering (3-0)</td>
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<tr>
<td>ME 7213</td>
<td>Energy Conversion &amp; Prime Movers (3-0)</td>
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<tr>
<td>ME 7214</td>
<td>Turbo Machinery (3-0)</td>
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<tr>
<td>ME 7215</td>
<td>Gas Dynamics (3-0)</td>
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<tr>
<td>ME 7216</td>
<td>Alternate Energy Resources (3-0)</td>
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<tr>
<td>ME 7217</td>
<td>Fluid Structure Interactions (3-0)</td>
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<tr>
<td>ME 7218</td>
<td>Vacuum Science &amp; Technology (3-0)</td>
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<tr>
<td>ME 7219</td>
<td>Fluid Dynamics Measurements (3-0)</td>
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<tr>
<td>ME 7410</td>
<td>Total Quality Management (3-0)</td>
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<td>ME 7411</td>
<td>Production &amp; Operations Management (3-0)</td>
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<tr>
<td>ME 7415</td>
<td>Engineering Management &amp; Economics (3-0)</td>
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</table>
Specialization in Mechanical Design & Analysis (MDA)

Specialization in Mechanical Design and Analysis includes new methodologies for design, analysis, simulation and experimentation of the behavior of mechanical systems and components. MDA covers a number of areas such as engineering design & analysis, product development, strength and dynamics of structures, modeling, simulation and mechanics of systems with the aid of advanced mathematical tools and management techniques. Key research areas for this field of specialization are:
- Linear and Nonlinear Behavior of Mechanical Structures
- Modeling and Simulation of Mechanical Systems
- Product Design and Analysis
- Vibrations, Chaos, and Machine Condition Monitoring etc.

MDA is a most valuable and pragmatic program that develop a strong technical, analytical, and problem solving skills essential for a range of exciting careers in the challenging field of perfunctory engineering. This program enables the graduates to contribute in the development of new and better solutions for mechanical components & systems, production equipment and industrial plants etc.

Core Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
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<tbody>
<tr>
<td>ME 731</td>
<td>Mechanical Behavior of Materials (3-0)</td>
</tr>
<tr>
<td>ME 732</td>
<td>Finite Element Methods (3-0)</td>
</tr>
<tr>
<td>ME 733</td>
<td>Advanced Mechanics of Materials (3-0)</td>
</tr>
<tr>
<td>ME 734</td>
<td>Advanced Mechanical Vibrations (3-0)</td>
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<tr>
<td>ME 735</td>
<td>Fracture Mechanics (3-0)</td>
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Elective Courses

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<tr>
<th>Code</th>
<th>Course</th>
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<tbody>
<tr>
<td>ME 721</td>
<td>Advanced Heat Transfer (3-0)</td>
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<tr>
<td>ME 723</td>
<td>Computational Fluid Dynamics (3-0)</td>
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<tr>
<td>ME 736</td>
<td>Theory of Plates and Shells (3-0)</td>
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<tr>
<td>ME 737</td>
<td>Product Design Fundamentals (3-0)</td>
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<tr>
<td>ME 738</td>
<td>Renewable Energy - Fuel Cell Systems (3-0)</td>
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<tr>
<td>ME 739</td>
<td>Theory of Plasticity (3-0)</td>
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<tr>
<td>ME 7310</td>
<td>Theory of Elasticity (3-0)</td>
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<tr>
<td>ME 7311</td>
<td>Modeling and Simulation of Systems (3-0)</td>
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<tr>
<td>ME 7312</td>
<td>Mechanics of Composite Materials (3-0)</td>
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<tr>
<td>ME 7313</td>
<td>Non Destructive Evolution of Structures and Materials (3-0)</td>
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<tr>
<td>ME 7314</td>
<td>Smart Structures (3-0)</td>
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<tr>
<td>ME 7315</td>
<td>Non Linear Dynamics and Chaos (3-0)</td>
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<tr>
<td>ME 7316</td>
<td>Rapid Prototyping (3-0)</td>
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<tr>
<td>ME 7317</td>
<td>Theory of Aero-elasticity (3-0)</td>
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<tr>
<td>ME 7318</td>
<td>Experimental Stress Analysis (3-0)</td>
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<tr>
<td>ME 7319</td>
<td>Condition Monitoring of Rotating Machines (3-0)</td>
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<tr>
<td>ME 7320</td>
<td>Introduction to MEMS (3-0)</td>
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<tr>
<td>ME 7321</td>
<td>Fatigue in Metals &amp; Composites</td>
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<tr>
<td>ME 7322</td>
<td>Multidisciplinary Design Optimizations</td>
</tr>
<tr>
<td>ME 7323</td>
<td>Vibrations of Shells &amp; Plates</td>
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<tr>
<td>ME 7410</td>
<td>Total Quality Management</td>
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<td>ME 7411</td>
<td>Production &amp; Operations Management (3-0)</td>
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<tr>
<td>ME 7415</td>
<td>Engineering Management &amp; Economics (3-0)</td>
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</tbody>
</table>
Specialization in Manufacturing Systems

Specialization in manufacturing systems combines the field of factory planning and scheduling, inventory control and queuing models, material flow and storage, optimization of production systems, forecasting, and linear & dynamic behavior of production systems for analyzing the manufacturing systems to improve the quality of products. This program allows the young engineers to assimilate systems perspectives with interdisciplinary education, combining the engineering study with hands-on training, and topical research activities.

The program covers not only the important aspects of manufacturing but also the business planning and management which are an essential part for the growth of industry and business. It also aims at producing quality products throughout the design process, thus focusing on integrated manufacturing and total quality management by keeping the design and production processes in parallel increasing responsiveness. Key research areas in this specialization are as follows:

- Production Planning and Design
- Ergonomics
- Production & Operational Management
- Advanced Manufacturing Techniques
- Leadership & Entrepreneurship

Manufacturing systems program enables the graduates to implement effective manufacturing systems. Reducing high costs and improving usability, maintainability and manufacturability are few important areas where department focuses on contributing and leading the ever changing definition and role of industrial and manufacturing systems engineering.

Core Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
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</thead>
<tbody>
<tr>
<td>ME 732</td>
<td>Finite Element Methods (3-0)</td>
</tr>
<tr>
<td>ME 741</td>
<td>Advanced Manufacturing Systems &amp; Design (3-0)</td>
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<tr>
<td>ME 742</td>
<td>Advanced Manufacturing Processes (3-0)</td>
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<tr>
<td>ME 743</td>
<td>Applied Optimization Techniques (3-0)</td>
</tr>
<tr>
<td>ME 744</td>
<td>Computer Integrated Manufacturing (3-0)</td>
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Elective Courses

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<tr>
<th>Code</th>
<th>Course</th>
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<tbody>
<tr>
<td>ME 733</td>
<td>Advanced Mechanics of Materials (3-0)</td>
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<tr>
<td>ME 745</td>
<td>Supply Chain Management (3-0)</td>
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<tr>
<td>ME 746</td>
<td>Leadership &amp; Entrepreneurship (3-0)</td>
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<tr>
<td>ME 747</td>
<td>Manufacturing Strategies &amp; Technology (3-0)</td>
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<tr>
<td>ME 748</td>
<td>Modeling &amp; Simulation (3-0)</td>
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<tr>
<td>ME 749</td>
<td>Product Development (3-0)</td>
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<td>ME 7410</td>
<td>Total Quality Management (3-0)</td>
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<tr>
<td>ME 7411</td>
<td>Production &amp; Operations Management (3-0)</td>
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<tr>
<td>ME 7412</td>
<td>Industrial Ergonomics (3-0)</td>
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<tr>
<td>ME 7413</td>
<td>Concurrent Engineering (3-0)</td>
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<tr>
<td>ME 7414</td>
<td>Systems and Reliability Engineering (3-0)</td>
</tr>
<tr>
<td>ME 7415</td>
<td>Engineering Management &amp; Economics (3-0)</td>
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</tbody>
</table>
Specialization in Automotive

Specialization in Automotive deals with design and manufacturing of new vehicle and their component parts, repairing and servicing of vehicles, integration of components into an automotive system and the study of their sub-sections. Rapid development in the modern and innovative automotive technology, young engineers broaden a comprehensive understanding of the complex field of Automotive Engineering. The future engineers of the automobile can select one field of study out of more in the following areas:

- Vehicle Dynamics & Vibrations
- Fuel and Emission Systems
- Chassis and Power Train Systems
- Crash Safety
- Design, Manufacturing and Assembling

This specialization provides hands-on education based on the latest scientific results and methods, that enables the young engineers to work independently and with confidence. In addition, graduate students improve social and methodical skills. The program also enables them to face ever-increasing challenges and standards of international markets.

Core Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ME 732</td>
<td>Finite Element Methods (3-0)</td>
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<tr>
<td>ME 751</td>
<td>Introduction to Automotive Design (3-0)</td>
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<tr>
<td>ME 752</td>
<td>Advanced CAD (3-0)</td>
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<tr>
<td>ME 753</td>
<td>Powertrain and Brake Design (3-0)</td>
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<tr>
<td>ME 754</td>
<td>Chassis and Suspension Design (3-0)</td>
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Elective Courses

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<th>Code</th>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ME 724</td>
<td>Internal Combustion Engines (3-0)</td>
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<td>ME 728</td>
<td>Advanced Combustion (3-0)</td>
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<tr>
<td>ME 755</td>
<td>Road Vehicle Aerodynamics (3-0)</td>
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<tr>
<td>ME 756</td>
<td>Noise Vibrations and Harshness (3-0)</td>
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<tr>
<td>ME 757</td>
<td>Hybrid Vehicle Design (3-0)</td>
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<tr>
<td>ME 758</td>
<td>Vehicle and Traffic Safety (3-0)</td>
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<tr>
<td>ME 759</td>
<td>Vehicle Dynamics (3-0)</td>
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<tr>
<td>ME 7510</td>
<td>Vehicle Acoustics (3-0)</td>
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<tr>
<td>ME 7511</td>
<td>Dynamics and Controls of Automatic Transmission (3-0)</td>
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<tr>
<td>ME 7512</td>
<td>Tribology (3-0)</td>
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<td>ME 7410</td>
<td>Total Quality Management (3-0)</td>
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<tr>
<td>ME 7415</td>
<td>Engineering Management &amp; Economics (3-0)</td>
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</tbody>
</table>
Courses Description

MAT 721 Numerical Techniques (3-0)
Introduction to Numerical Analysis, Error Propagation and Stability, Solution Systems of Linear Equations, Numerical Interpolation, Differentiation and Integration, Error and Convergence Analysis, Cholesky's Method, Pivoting, Lagrange Interpolation

MAT 725 Partial Differential Equations (3-0)

MAT 726 Advanced Engineering Mathematics (3-0)

MAT 728 Differential Equations and Dynamical Systems (3-0)
ME 721 Advanced Heat and Mass Transfer (3-0)
Principles of conduction, Analysis of one-dimensional and multidimensional steady and transient, Phase change and moving heat source, Numerical and Analytical methods for solving heat conduction problems, Principles of convection, Analysis of heat transfer for internal and external flows; laminar and turbulent boundary layer theories, forced and natural convection, Analysis using similarity transformations, Integral solutions and numerical methods, Introduction to thermal radiation, Radiative exchange in semitransparent mediums, The electromagnetic spectrum; the blackbody, wave phenomena versus geometric optics, polarization, diffraction & refraction effects; emission, reflection, absorption, and transmission of thermal radiation by surfaces

ME 722 Advanced Fluid Mechanics (3-0)
Basic review of fluid properties and basic flow equations, laminar flows, Partial differential equations governing the conservation of mass, Momentum and energy of Newtonian fluids, Dimensional analysis for simplification of governing equations, low Reynolds number flow, strokes flow, high Reynolds number laminar flow, Boundary layer separation phenomena and approximations to the governing equations, laminar stability and transition to turbulent boundary layer conditions

ME 723 Computational Fluid Dynamics (3-0)
Numerical methods or the basic equations of fluid dynamics, Navier-Stokes equations, Euler and Reynolds Averaged equations governing the flow of gases and liquids, Turbulence models, Basics of finite approximations for partial differential equations, Mathematical properties of hyperbolic systems, Finite volume and finite element methods, Boundary conditions, Grid generation Classification, implicit & explicit methods, iterative & time/space marching schemes, grids, boundary conditions, Classification of partial differential equations and solution techniques. Truncation errors, stability, conservation, differencing strategies. Advanced solution algorithms, Grid generation and Practical algorithms for compressible and incompressible flow, Introduction to verification, Validation and uncertainty quantification for computational fluid dynamics predictions, Practicing modules on commercial software ANSYS / COMSOL MULTIPHYSICS

ME 724 Internal Combustion (IC) Engines (3-0)
Thermodynamic Analysis of IC Engine Cycles, Effect of design and operating parameters on cycle efficiency, Modified fuel-air cycle considering heat losses and valve timing, Engine dynamics and torque analysis, Use of Combustion chart, Thermodynamic cycle with supercharging both SI and CI

ME 725 Design of Thermal Systems (3-0)
Modeling of Thermal Systems: types of models, Mathematical modeling, Curve fitting, Linear algebraic systems, Numerical model for a system, System simulation, Methods for numerical simulation Acceptable Design of a Thermal System: initial design, design strategies, design of systems for different applications, additional considerations for large practical systems; Economic Considerations: calculation of interest, worth of money as a function of time, series of payments, raising capital, taxes, economic factor in design, application to thermal systems. Problem Formulation for
optimization, optimization methods, optimization of thermal systems, practical aspects in optimal design, Lagrange multipliers, Optimization of constrained and unconstrained problems, Applicability to thermal systems; search methods: single-variable problem, multivariable constrained optimization, examples of thermal systems, geometric, linear, and dynamic programming and other methods for optimization, knowledge-based design and additional considerations

ME 726 Theory of Thermal Stresses (3-0)
Effects of thermal environment on people and the means of assessing and controlling risks associated with thermal stress, thermal spectrum, Principles, Effects of temperature extremes, Thermal comfort, Evaluation of hot environments, Control of hot environments, Thermal surveys, Evaluation of cold environments, Control of cold environments and Approaches to Risk Assessment

ME 727 Advanced Thermodynamics (3-0)
Introduction to basic Thermodynamics, Statistical Thermodynamics, Dynamics of Non-equilibrium Processes, Flux Equations, Entropy Production Minimization Theory, Fluid Equations, Simple Kinetic Theoretical Estimates, Distribution Functions & the Transport Equation, Collisional Processes, Moments of the Transport Equation, Chapman-Enskog Method

ME 728 Advanced Combustion (3-0)
Fuels and types, combustion process, combustion mechanism, adiabatic flame temperature, flame propagation, stability, kinetics, combustion aerodynamics, gaseous detonations, flame ignition and extinction and condensed phase combustion, combustion in SI and CI engines, ignition and burning rate analysis. Solid burning equipment, stokers, pulverized coal burning systems, cyclone combustors, emissions, types of fluidized beds, fluidized bed combustion, fundamentals bubbling bed, gas and liquid burners types, gas turbine combustion systems, combustion modeling. Design of combustion systems for boilers, furnaces, gas turbines and IC engines, combustion chamber performance. Propellants Types, theory of combustion, energy balance calculations

ME 729 Aircraft Engines (3-0)
Introduction to modern aircraft engines, Classification of aircraft engines, Brayton Cycle and its applications, Component of Jet engines, Parametric Cycle Analysis (turbosjets, turbofans, turboprops and ramjet engines), Component Performance, Irreversibility of each component and Engine Performance Analysis

ME 7210 Thermal Design of Heat Exchanger (3-0)

ME 7211 HVAC & Refrigeration (3-0)
Introduction to air conditioning systems and refrigeration applications, heat pumps, air handling units, air conditioning systems, applied psychrometrics, design principles, and comfort in the built environment, Cooling load calculations, heating load calculations, introduction and use of computer-based load estimation packages software, air distribution, fans, ducts, air conditioning controls, advanced refrigeration cycles, evaporators, condensers, cooling towers, compressors, pumps, throttling devices, piping, refrigerants, control, refrigeration equipment, simulation of refrigeration systems, refrigeration and industrial applications

ME 7212 Nuclear Power Plants (3-0)
Basic concepts of reactor physics, radioactivity, Neutron Scattering, Thermal and fast reactors, Nuclear cross-sections, Neutron flux and reaction rates, Moderator criteria. Reactor core design, Conversion breeding and Types of reactors, Operations of Nuclear Power Plants,
Characteristics of boiling water, Pressurized water, Pressurized heavy water, Gas cooled and liquid metal cooled reactors, Future trends in reactor design and operation, Thermal-hydraulics of reactors, Heavy water management, Containment system for nuclear reactor, Reactor safety radiation shields, Waste management and Pakistan nuclear power program

ME 7213 Energy Conversion & Prime Movers (3-0)
Understanding of the theory, technology and practice of converting energy into useful forms, Different type of prime movers, Steam turbine, Steam Turbine Modeling, Speed Governors for Steam Turbines, Diesel Engines, Stirling Engines, Hydraulic Turbines, Wind turbine

ME 7214 Turbo Machinery (3-0)
Introduction and overview of the design and performance of all types of Turbo machines, The essential elements of axial & radial turbo machinery design and performance, Fundamental principles of fluid mechanics, thermo-dynamics, and structural mechanics, all of the essential turbo machinery concepts, Sound understanding of the basic principles which govern the flow through any turbine, Pump, compressor, or fan together with failure mechanisms and life prediction methods

ME 7215 Gas Dynamics (3-0)

ME 7216 Alternate Energy Resources (3-0)

ME 7217 Fluid Structure Interactions (3-0)
The course will focus on the fundamental concepts and advanced topics in computational fluid-structure interaction (FSI). Introduction to important techniques to solve fluid-structure interaction problems, the stabilized formulations, Arbitrary Lagrangian-Eulerian (ALE) method, space-time (ST) method, mesh update methods for flows with moving interfaces, iterative solution techniques and parallel computing concepts, and iso-geometric analysis. ST computational FSI techniques and FSI coupling techniques. The core technologies and the special techniques targeting specific classes of problems, solution techniques to tackle common difficulties in fluid-structure interaction simulations

ME 7218 Vacuum Science & Technology (3-0)
Theory and practice of high vacuum systems, Introduction to Vacuum, Units of Measurement and Altitude, Vacuum Pumps, Main Vacuum Pump Types, Oil-Sealed Rotary-Vane Pump, Mechanical Booster Pump, Dry Pump, Turbo Molecular Pump, On-Tool Pumping, Vacuum gauges, Piping system for vacuum technology, Degassing, Outgassing, Knudsen number, Chambers used for vacuum and Vacuum Applications
ME 7219 Fluid Dynamics Measurements (3-0)
Dimensional analysis and similitude, Uncertainty analysis, pressure measurement techniques, Flow visualization techniques, Flow measurement, Force measurement, Digital data acquisition and time series analysis

ME 731 Mechanical Behavior of Materials (3-0)
Types of stresses & strains, elastic & plastic deformation, Defects & Imperfections in single polycrystalline materials, Classification of defects, Tensile, Compressive, Torsion, Impact & Fracture, Effect of strain rate on flow properties of materials, fracture mechanics, fatigue, creep and stress rupture of materials, Griffith & Orwan theory of fracture of materials, Nabaroo-Herring and coble creep, materials selection and failure analysis, Case studies

ME 732 Finite Element Methods (3-0)
Introduction to Finite Element Methods (FEM), Mathematical preliminaries, Strong and weak form of FEM, Truss Analysis, Variational approaches & weighted residual formulations to FEM, General approach to structure analysis, cn continuous shape functions, Stress analysis for one & two-dimensional problems of structures, problem formulation and solution for 1D, 2D, 3D, in-Plane and Eigen value problems, beam analysis, introduction to coupled problems in FEM, Dynamical Structural Analysis and ANSYS / COMSO MULTIPHYSICS for analysis

ME 733 Advanced Mechanics of Materials (3-0)

ME 734 Advanced Mechanical Vibrations (3-0)

ME 735 Fracture Mechanics (3-0)
Basic concepts, Toughness, elastic & plastic fracture mechanics, Fatigue, creep and Impact fracture behavior, fracture mechanism in metals and non-metals, crack propagation, thermal fatigue

ME 736 Theory of Plates 7 Shells (3-0)
Free and forced vibration of single-degree-of-freedom, two-degree-of-freedom and multiple-degree-of-freedom systems, determination of natural frequencies, experimental modal analysis, and mode shapes Transient vibrations, Analytical methods to solve dynamic systems, Eigen problems, continuous systems and their modeling, damping, vibration design and control

ME 737 Product Design Fundamentals (3-0)
Optimization methods, nonlinear optimization under constraints, multi-objective optimization, multidisciplinary design, incorporating different disciplines simultaneously, single and multi-objective optimization under constraints, Different approaches to Multidisciplinary Design

ME 738 Renewable Energy - Fuel Cell Systems (3-0)
Fuel cell systems for transportation, buildings, utility and portable power energy conversion applications, Overview of fuel cell technology, Thermodynamics of direct energy
conversion and fuel cell efficiency, Electrochemistry, equilibrium and reaction kinetics. Temperature and pressure effects on polarization curves, Proton exchange membrane fuel cell performance modeling. Fuel cell system components: heat exchangers, humidifiers, air compressors, electric power processing and management, overall system integration, modeling, and control, Fuel cells for transportation, vehicle performance and efficiency characteristics, Fuel processing and reformers, Fuel cell system design, economics and optimization

**ME 7311 Modeling and Simulation of Systems (3-0)**
Basic mathematical tools for kinematics and dynamics modeling of planar and spatial rigid multi body dynamic systems. Absolute and relative kinematic constraints and driving constraints, virtual work and the generalized force concepts, equations of motion for constrained rigid multi body systems, inverse dynamics of kinematically driven systems, equilibrium conditions, and constant reaction forces, Euler parameters for the orientation of rigid bodies in space, numerical considerations in solving spatial differential-algebraic equations of motion, Methods of coordinate transformations with the help of Euler angles, Direction cosines and Quaternions, Attitude dynamics (dynamics of angular motion), Failure mode analysis, Robustness analysis, Monte Carlo Simulations, ANSYS / COMSOL MULTIPHYSICS for analysis

**ME 7312 Mechanics of Composite Materials (3-0)**
Types of Composites, manufacturing, mathematical modeling for composites, laminated – unidirectional composites under various loading conditions, lamination theory, effective stiffness properties, laminated plate theory, edge effects in laminates, nonlinear theory of composites, failure theories of composites, behavior of composites under fatigue, creep, bending and impact

**ME 7313 Non Destructive Evolution of Structures and Materials (3-0)**
Realization of the full potential of structures, The course aims to introduce the full range of NDE techniques currently available, including ultrasonic's, low-frequency methods, X-radiography, acoustic emission, shear graph and thermograph

**ME 7314 Smart Structures (3-0)**
Adaptive structures theory and design, actuation system, shape memory alloys, piezoelectric materials, composite skins and elastic sheets, anemometer, thermocouple, pitot tube, magnetostrictor, electrostriction, fiber optic sensors, Feedback smart structures

**ME 7315 Non Linear Dynamics and Chaos (3-0)**
Modeling of Duffing type Mathieu systems, sources of geometrically non-linearity, kinematics and rigid body dynamics, non dimensionalization of equation of motion, methods of harmonic balance, simple perturbations, review of Floquet theory, chaotic dynamics, chaotic vibrations

**ME 7316 Theory of Aeroelasticity (3-0)**
Theory of Elasticity, Basic Aerodynamics and Aerodynamic analysis tools, structural dynamics Single and Multi degree of freedom
systems), Complex Analysis, derivation of equations of elasticity, Problems in Plane stress and plane strain, Fourier transformation, basic review of control systems, steady and unsteady aerodynamics, Static Aero elasticity phenomena (Divergence, loss of lift effectiveness and control reversal, Aero-elastic trim), St. Venant's Principle, various solutions for different plate profiles, numerical energy method, unsteady aerodynamics, dynamic aero-elasticity (Flutter, Dynamic response (gust)), roto-dynamics (wind turbines, hydropower turbines and jet engines)

ME 7319 Condition Monitoring of Rotating Machines (3-0)
Introduction to vibration analysis, maintenance in modern industry, machine condition indicators, use of vibration of mechanical components on machine condition indicators, common causes of vibrations in mechanical system, vibration characteristics, spectrum analysis, vibration orbits or LISSAJOUS figure, statistical distribution of the common causes of vibration, Lubricant analysis, spectral changes, signature analysis

ME 7320 Introduction to MEMS (3-0)
Introduction to Microsystems, overview and trends, MEMS materials, Lithography & thin film processes, Bulk silicon micromachining, Surface micromachining, MEMS design, Electrostatics, Electromagnetic, thermal actuation, Inertial sensors; Accelerometer, Gyroscope, pressure transducers, Optical transducers, Microfluidic basics, Microfluidic devices, bio-MEMS, MEMS packaging, Application of MEMS in space satellites

ME 7321 Fatigue in Metals & Composites (3-0)
Intro to fatigue in metals & composites, Fatigue crack growth, Structural integrity of Metals, Structural Integrity Polymeric matrix composite laminates, Biomaterials and its applications

ME 7323 Vibrations of shells & Plates (3-0)
Intro to Vibrations of Shells and Plates, Deep shell Equations, Equation of Motions for commonly occurring geometries, Non shell structures, natural frequencies & Modes, vibrations of shells and Membranes under the influence of initial stresses, Combination of Structures and its applications

ME 741 Advanced Manufacturing Systems & Design (3-0)

ME 742 Advanced Manufacturing Processes (3-0)
### ME 743 Applied Optimization Techniques (3-0)
Optimization Areas & Introduction, Direct and indirect approach, Gradient based methods, Global and local methods, Lagrangian approach, Convexity, KKT conditions, Region elimination methods, Linear Programming, Conjugate gradient methods, Advanced Optimization Techniques, Evolutionary Approach Genetic Algorithms, Application areas and Modeling Methods

### ME 744 Computer Integrated Manufacturing (CIM) (3-0)
Introduction to CIM, CIM Wheel & Jigsaw, PLC & CNC programming as automated inspection and transportation systems, Open Systems & Standardization, Open Networks, IDEF Modeling Methods, House of Quality tool, Lean Manufacturing and other artificial intelligence technologies, Training on CAD/CAM software like Pro-E / Creo2 / Master CAM Mill 8+ / DELCAM / Part Maker etc

### ME 745 Supply Chain Management (3-0)

### ME 746 Leadership & Entrepreneurship (3-0)
Introduction, Entrepreneurship, Entrepreneur Forum, Entrepreneurial Traits, Small & Medium scale industries, Entrepreneurial Ethics, Business Plans, Marketing for small business, Franchising, Case Studies

### ME 747 Manufacturing Strategies & Technology (3-0)
Methodologies used in the synthesis and analysis of product design to optimize manufacturability, Relationship of design to production processes, product material, material handling, quality costs, and CAD/CAM, Introduction to cloud Manufacturing, Rapid Prototyping, CNC programming

### ME 748 Modeling & Simulation (3-0)
Stochastic processes applied to control of various types of systems: Markov chains, Queuing theory, Bifurcations, Perturbation Methods, non-homogeneous Equations, Modeling and Simulation of Dynamic systems based on Bond graph theory, Training on Lab View software

### ME 749 Product Development (3-0)

### ME 7410 Total Quality Management (3-0)
Management of Quality Assurance, Operational and Statistical Principles of Acceptance Sampling and Process Control, Quality problems in production lines, Introduction to Total Quality Management concepts, Taguchi Methods, Quality Function Deployment, ISO 9000 & Baldridge Award

### ME 7411 Production & Operations Management (3-0)
Methods of Planning and Control of Manufacturing Organization, Processes and Facilities including Demand forecasting, Product Development, Capacity Planning, Inventory Control, Site selection, Finance Development, Decision Processes, Personnel Development and Training, Manufacturing Policy Formulation, Sequencing & Scheduling

### ME 7412 Industrial Ergonomics (3-0)
Functional Anatomy of the Human body, Work physiology and body Energy Expenditure, Biomechanics for people at work, Analytical tools for Ergonomics, Introduction of the fundamentals and applications of industrial ergonomics for improving equipment & tools, workplace & job design, Design principles for human operators and current issues in
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 7413</td>
<td>Concurrent Engineering (3-0)</td>
<td>Concurrent/simultaneous engineering methods and tools such as system analysis, modeling and Integration, Market Oriented, Integrated Design for Manufacturing, Assembly, Quality and Maintenance, Product Design Analysis, Integrated Product Design and Manufacturing innovation methods, QFD (Quality Function Deployment) applied to concurrent engineering, FMEA (Failure Mode and Effect Analysis), POKA-YOKE, KANZEI, waste reduction, quality circles, Rapid Prototyping of designed objects</td>
</tr>
<tr>
<td>ME 7415</td>
<td>Management &amp; Economics (3-0)</td>
<td>Organization Structure, Project Delivery Systems, Planning &amp; Scheduling, Cost Control, Uncertainty Analysis in Engineering, Random Signals, Time Value of Money, Interest Equivalence, Evaluation of Projects, Inflation, Depreciation, Taxation</td>
</tr>
<tr>
<td>ME 751</td>
<td>Introduction to Automotive</td>
<td>Vehicle mechanics, Introduction to automotive layout configurations, modeling philosophy, Automotive design elements: Powertrain, Braking, Suspension, Styling, Chassis, interior design and ergonomics, Road surfaces and tyre-ground interaction Axle loads, Road loads: Aerodynamically induced forces and moments Aerodynamic vehicle design Quasi-static cornering behavior, Acceleration behavior: Powertrain elements and their characteristics, Traction and power limited performance Fuel economy, Deceleration behavior: Brake system components and their characteristics, Brake proportioning, efficiency and adhesion utilization, Governing standards and legislation. Handling behavior, handling performance criteria, mathematical modeling of vehicle handling, straight line stability and cornering behavior, Practical suspension system design</td>
</tr>
<tr>
<td>ME 752</td>
<td>Advanced Computer Aided</td>
<td>CAD philosophy, Part Modeling through constructive solid geometry, engineering drawings, and interfacing with CNC machines, assembly drawing, mechanical joints and fasteners modeling, surfacing and styling. In-depth knowledge and be well-versed in at least one CAD system used in industry. This course is intended to broaden the student's knowledge in other popular CAD packages by studying similarities and differences of the various commands and techniques, interfacing in between different CAD and FE software</td>
</tr>
<tr>
<td>ME 754</td>
<td>Chassis and Suspension</td>
<td>Suspension systems and components: Introduction to vehicle suspensions, suspension types, suspension components and their characteristics, design and selection—springs, anti-roll bars, dampers, bushes, kinematic and force analysis, anti-squat and anti-jounce geometries, vehicle ride quality analysis. Steering systems: review of designs, system geometry and kinematics, bump, roll and compliance steer, forces-stationary and moving vehicles, four wheel</td>
</tr>
</tbody>
</table>

ME 755 Road Vehicle Aerodynamics (3-0)
Numerical methods or the basic equations of fluid dynamics, Navier-Stokes equations, Euler and Reynolds Averaged equations, Turbulence models, Basics of finite approximations for partial differential equations, Mathematical properties of hyperbolic systems, Finite volume and finite element methods, Boundary conditions, Grid generation and Practical algorithms for compressible and incompressible flow

ME 756 Noise Vibrations and Harshness (3-0)
The application of engineering tools and specifications for noise vibrations, and harshness, Sources, Mitigation methods, Complexity and influences on other vehicle functions, Design, simulation and validation methods

ME 757 Hybrid Vehicle Design (3-0)
The course focuses on techniques and tools to build Hardware-in-the-Loop (HIL) Simulation for evaluating hybrid powertrains components and architectures using programmable power supplies, electrical loads, dynamometers, and rapid control prototyping tools. Special emphasis is given to the use of such tools for component characterization, safely and efficiently interfacing electric machines and their controllers within the hybrid powertrain, accommodating accessory loads (disturbances) in hybrid powertrains and conducting system diagnostics

ME 758 Vehicle and Traffic Safety (3-0)
History of crash safety, Active and Passive safety, Road design for safety, restraint and supplemental restraint systems, crumple zones and structural design, fire and post-crash safety, Crash legislation and testing in various parts of the world, evolution of crash safety protocols, application of crash safety practices in Pakistan, Statistical data collection and interpretation, Design constraints for crash, Computational methods to analyze the mechanical response of automotive structure, Systems and components to dynamic impact loading such as in crash situations, Crash characteristics, Structural collapse and their influence on safety, Social and economic aspects of safety

Vehicle ride, Quarter/half/full car model, Suspension design optimization, Design guidelines/conflicts, Wheelbase effects and left/right track inputs, Front/Rear suspension results, Ride measurements, Human response to vibration, ISO standards, Springs, nonlinear effects, bump stops, Damper properties, nonlinear properties, mono-tube, twin-tube.

Vehicle handling: Development of 2 D.O.F model, Understeer/Oversteer, Steady state cornering, stability, frequency response, Transient, limiting manoeuvres, Standard tests, steering pad, J turn, Lane change manoeuvres, Straight running, stability, aerodynamics effects, neutral steer point, Effects of braking, traction, Effect of vehicle/suspension design properties, c.g. position, tyre size, load transfer, camber, compliances, Effects of braking, traction, Extended model including roll, steering system, suspension derivatives. Tyres: Mechanism of force generation, Study of typical force/moment data, Review of tyre models. Suspension kinematics and compliances: Role of the suspension, Kinematics, wheel motion control, Forces transmitted, Roll centres, anti-dive and anti-squat properties, Suspension design, Review of typical designs, Current design trends, Practical implications
ME 7510 Vehicle Acoustics (3-0)
Review of current methods for the noise, vibration and harshness (NVH) design of passenger vehicles. Load cases, analysis types and CAE (Computer Aided Engineering) optimization processes. NVH analysis with relationship to other vehicle function CAE processes, Modeling, analysis procedures and accuracy of results in “virtual” vehicle development process. Variability in actual vehicle structures, Materials, modeling and design, for NVH treatment, Sound quality, Source identification

ME 7511 Dynamics and Controls of Automatic Transmissions (3-0)

ME 7512 Tribology (3-0)
Surface topography and contact mechanics, Hydrodynamic, Elasto-Hydrodynamic and Boundary lubrication, Rheology and lubricant chemistry, Wear and friction of metals, Ceramics and Polymers, Surface Engineering, Delamination theory, Test methods in Tribology

ME 791 Thesis
Individual project carried out under the supervision of one or more members of academia. It requires literature review, investigating problem, testing, data gathering and analysis, modeling and development, experimentation, and evaluation of results. These various aspects vary from studies to studies; however the maximum components must be a part of the studies
Department of Remote Sensing & Geo-information Sciences

A well equipped Department of (RS&GISc) has been established at Karachi to serve as a Centre of Excellence in Remote Sensing and Geo-informatics Sciences (RS&GISc). The Department will run under the Institute of Space Technology (IST), Islamabad. It has a mandate to offer a wide range of educational programmes such as short training courses, Certificate, PGD, Masters and PhD programmes as well as research in varied disciplines of RS and GIS in a phased manner. While it has already initiated some of the envisaged academic activities through short training on different themes of Remote Sensing and GIS, it has Master degree in RS/GISc in Fall 2009 followed by PhD program in 2013. The Masters degree in RS&GISc is an intensive program for students who are interested in exploring the emerging space technologies and its applications in different disciplines. Realizing the fact that many of the developed countries are already drawing tangible benefits of these technologies in a variety of discipline areas, while the developing countries like Pakistan are merely a user of these technologies and its applications, the Centre of excellence in RS and GIS is mandated to fill in this technological and skill development gap and to draw optimum benefits through these technologies in various national programmes. Department of (RS&GISc) will provide a powerful platform for scholars, professionals, students, public and private sector organizations to broaden their vision in space-related technologies and applications.

Master of Science in (RS & GISc)

NCRG has the advantage of having worked with the industry for more than 2 decades in a variety of related disciplines and user community. NCRG therefore finds itself in a much better and comfortable position to look thoughtfully in different phases of curriculum development process in the backdrop of knowledge growth, real market demands, future trends as well as constraints and limitations in practically adapting and implementing RS/GIS based technological solutions. With these experiences, center has also attained an insight into the real problems and the knowledge/skill gaps that demand further research work without being involved in re-inventing the wheel. Department of (RS&GISc) is also fortunate to have the curricula of various renowned international and national universities and institutes; as a consequence, it is able to find the strengths and weaknesses of the programmes of these institutions. The HEC curriculum gives a good guideline and starting point for this activity. While going through the program structure of different universities, like AIT, ITC, Stuttgart, MASTA and some of the UK based Universities, it was felt that to maintain an international standard and to offer a career oriented program, there is a room for improvement, not only from the theoretical and conceptual point of view but also from the perspective of industry and its emerging requirements. With such improvement and add-ons, a passing out student would feel more comfortable with the value of degree awarded to him.
Local MS Programs with the following specializations:
MS in RS&GISc with specialization in:
- RS&GISc
- Geo-informatics
- Spatial information Technology

Prerequisite
- 4 years BS (RS & GIS) degree or Minimum of 16 years of education in the field of Engineering / Science
- Valid NTS GAT-General test score with minimum 50 marks.

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<th>Course Code</th>
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<tr>
<td>0</td>
<td>RSGS 611</td>
<td>RSGS 621</td>
<td>Introduction to Remote Sensing &amp; Digital Image Processing</td>
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<td></td>
<td>RSGS 631</td>
<td>RSGS 632</td>
<td>Introduction to Geographical Information Science</td>
</tr>
<tr>
<td></td>
<td>RSGS 633</td>
<td>RSGS 632</td>
<td>Remote Sensing and GIS Multidisciplinary Applications</td>
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<tr>
<td>1</td>
<td>RSGS 711</td>
<td>RSGS 721</td>
<td>Advanced Remote Sensing and Digital Image Processing</td>
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<tr>
<td></td>
<td>RSGS 73XX</td>
<td>RSGS 7311</td>
<td>Advanced Geographics information science</td>
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<tr>
<td></td>
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<td>(i) RSGS 7311</td>
<td>Advance Database, Programming and</td>
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<td>(ii) RSGS 7311</td>
<td>Customizing GIS</td>
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<td>2</td>
<td>RSGS 7313</td>
<td>RSGS 7314</td>
<td>Advanced Research Methods</td>
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<td>RSGS 7315</td>
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<td>Urban and Regional Planning</td>
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<tr>
<td></td>
<td></td>
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<td>Environmental Science</td>
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</table>

Mandatory Courses
Minimum 9 credit hours

Elective Courses
The elective courses will be offered from the following list; subject to the availability of specialized faculty and the number of students interested in each course.

Elective Courses
Environmental Sciences
- Agriculture
- Fundamentals of Geology
- Hydrology and Water Resources
- Urban and Regional Planning
- Coastal Zone Management
- Geostatistics
- Programming Languages and environment for RS/GIS
- Hazards and Disaster Management
- Land information System WebGIS
- Spatial Decision Support System (SDSS)
- Satellite Navigational System
- Space Laws

Note: Duration of this program is four semesters including thesis/dissertation; students must complete a minimum of 30 credit hours to complete their MS degree requirements, including 6 Credit hours of Thesis.
Course Description

Introduction to Remote Sensing & Digital Image Processing
Introduction to Remote Sensing & Digital Image Processing

Introduction to Geographical Information Science
Introduction, Coordinate Systems, Data Acquisition & Capturing Techniques, Data Visualization and Cartography, GIS Application Platforms, Spatial Data Development and Manipulation, Attribute Data Input and Management, Georelational Vector Data Model, ObjectVector Data Model, Raster Data Model, Querying Spatial Data, Geometric Transformation Satellite based Navigation, labs

Introduction to Database and Programming
Introduction to databases, Database Environment, The Relational Model, Data Manipulation, Data Definition, Entity-Relationship Modeling, Normalization Computer Programming/Languages, Application Types, Programming Paradigms, Programming Environment, Variables and Expressions, Data Types, Control Structures, Connecting to Databases, Labs

Remote Sensing and GIS Multidisciplinary Applications
Remote Sensing Applications Land use / Landover, Agriculture, Water Resources, Natural Resources, Natural Hazards and disaster Management, Soil, Geology, Geography, Urban Planning and Management, Space laws, Labs, Projects/studies on different thematic applications

Introduction to Mathematics/Statistics

Advanced Remote Sensing and Digital Image Processing(2-1)

Advanced Geographical Information Science (2-1)
Spatial Data Analysis, Spatial Interpolation, Vector Data Analysis, Raster Data Analysis, Terrain Mapping and 3-D Analysis, Voronoi Methods & TIN Algorithms, 3-D GIS for City Modeling, Viewsheds and Watersheds, Geocoding, Network Analysis, Spatial Data Quality & Uncertainties, GIS Project Design, GIS Models and Modeling, GIS Applications & Case studies 3-D data Visualization, Labs

Advanced Database, Programming and Customizing GIS (2-1)

Advanced Research Methods (3)
Introduction, Information Acquisition, Assessment Of Short Comings and Reliabilities Of
<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
</tr>
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<tbody>
<tr>
<td>Measurement, Study Designs and Measurement, Sampling, Data Collection Methods</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>Data Analysis And Interpretation, Anticipated Out Puts, Presentation Skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban and Regional Planning (2-1)</td>
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<td></td>
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<tr>
<td>Environmental Sciences (2-1)</td>
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<tr>
<td>Coastal Zone Management (2-1)</td>
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<tr>
<td>Introduction, The scope of coastal zone management, Ecosystems/Coastal processes, Coastal Environment, The role of marine reserves in coastal zone management, Integrated approaches to coastal zone management, Detailed case studies of CZM in Pakistan, Labs, Field visit to different Coastal areas</td>
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<tr>
<td>Fundamentals of Geology (2-1)</td>
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<tr>
<td>Hazards and Disaster Management (2-1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Disaster Management, Earth Structure, Materials, Systems, and Cycles, Hazards Classification, Disaster Management &amp; Planning, Natural Hazards: Earthquake, Tsunami, Cyclones, Floods, Droughts and Landslides, Remote Sensing and GIS applications in Disaster Management, Labs</td>
<td></td>
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<tr>
<td>Programming Languages and Environment for RS/GIS (2-1)</td>
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<tr>
<td>Land Information System (2-1)</td>
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<tr>
<td>Land information, Location of land Registration and Cadastre in LIS, Relation Land Registration and Cadastre, General Role of land registration and cadastre, Land Registration process, Boundaries, Fiscal Cadastre, Multipurpose Cadastre, Institutional arrangement and technical matters, Procedures for introducing a land administration system, Role of State of the art RS and GIS Techniques in Land administration, Labs</td>
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<tr>
<td>Hydrology and water resources (2-1)</td>
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<tr>
<td>Introduction, Precipitation, Abstractions from Precipitation, Streamflow Measurement &amp; Hydrological Analysis, Hydrographs, Floods, Flood Routing, Flood Control, Groundwater, Runoff, Labs, Project design and development</td>
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</tbody>
</table>
Agriculture (2-1)
Agronomy, Soil Science, Horticulture, Entomology, Plant Pathology, Agricultural Practices in Irrigated and Rain fed Areas, Main techniques for image enhancement for identification of different crops, Mapping and monitoring agricultural fields- Case studies, RS and GIS integration for agricultural applications, Advanced methods, Crop monitoring, Crop Area estimation, Crop condition assessment, Crop yield estimation, Field visit

Web based Geographic Information System (2-1)

Spatial Decision Support System (SDSS) (2-1)

Geostatistics (2-1)
Introduction, Measures of Central Tendency or Averages, Measures of Dispersion, Correlation and Simple Regression, Geo-Statistical Analyst: Powerful Exploration and Data Interpretation Solutions Labs

Satellite Navigational System (2-1)
Fundamentals of Reference Systems and Frames, Basic Principles of GPS Operations, Basic Types of GPS Observable, GPS Error Sources and Error Handling

Space Laws
Introduction to International Law, Nature and development of Space Law, Exploitation and Use of Outer Space, Issuance of use of Outer Space
Department of Space Science

Space Science is the study and research of issues specifically related to space flight/travel and space exploration. It comprises of interdisciplinary fields e.g. Stellar, Solar, Galactic and Extragalactic astronomy, Planetary Science and Physical Cosmology, Astrobiology, Astrochemistry, Astrophysics, Space plasma physics, Orbital mechanics/ Astrodynamics, Atmospheric/Environmental Science, Satellite and Space Communications, Aerospace engineering, Control engineering, Space environment and Space medicine. Rapidly growing subjects of Space Science in the present era of information technology are in process of evolution from the state of infancy to the advanced levels at academic and research institutions. The significant subjects falling under the umbrella of Space Science comprise Remote Sensing, Satellite Applications, Space Physics, Astrodynamics, Atmospheric Science etc. The courses offered in the department are the main building blocks of Space Science. Emphasis has also been given to research and applications oriented areas such as Flight Dynamics and Control, Space Mission Design and Analysis, Space Data Processing and Geoinformatics. The Space Science uses new space-age technologies like satellite positioning, space data visualizations, analysis tools and space data interpretation to greatly advance scientific understanding of Earth and its systems. With the launch of Earth resources satellites such as micro & nano satellites in Low Earth Orbit and Communication Satellites in Geostationary orbits around the Earth, the last decade has witnessed a wide spectrum of applications in diverse fields subject to the need and quality of imagery datasets acquired from the Earth orbiting satellites. The advances in computing technology & techniques have also contributed a lot in the development of more sophisticated than ever sensors capable of observing the Earth with specialized and dedicated on-board sensors with the help of satellite constellations. The Space Science department at IST is a truly multidisciplinary department within a multidisciplinary university. As society looks towards the future, we continue the pursuit of further understanding the Earth system and beyond with our focus on Space Communications, Remote Sensing, Astrodynamics, Atmospheric Science, Meteorology and Earth Sciences. The department also conducts public awareness programs like Sky-watch/Star-gazing shows and World Space Week (UN) for scientific outreach.

Mission:
The department mission is to develop scientists with sound theoretical and applied backgrounds in space sciences and major allied disciplines. This will help uplift their socio-economic contributions and allow them to compete in various educational and R&D industry arenas.
Program Educational Objectives

- Produce scientists with advanced knowledge of mathematics, science, and applied sciences within specializations related to the field of Space Science.
- Produce scientists with an ability to engage both theoretical and experimental design towards addressing and solving leading research questions in respective fields.
- To develop an advanced ability to formulate or design a system, process, or program to meet desired needs within multidisciplinary teams.
- Cultivate the talent to function in multidisciplinary and interdisciplinary research teams towards publishing at top-notch impact factor peer-reviewed journals.
- Nurture scientists by cultivating a systematic research approach towards identifying and solving applied science problems at national and international levels.
- Develop understanding of professional and ethical responsibility.
- Develop effective communication ability and ability to write for research journals.
- Provide broad education necessary to understand the impact of solutions in a global and societal context.
- Recognition of the need for ability to engage in life-long learning.
- Produce scientists with an ability to use the techniques, skills, and modern scientific and technical tools necessary for professional practice and related research.
- To impart quality education through up-to-date curriculum and state-of-the-art laboratory facilities.
- To strengthen the research skill of the students.
- To expose the students to real-world problems and their solutions through regular field work campaigns.
- To expose students to international research through linkages with international universities and research centers.
- To provide opportunities to the students to interact with national and international peers through regular conferences, workshops, guest lectures and short courses.
- To foster linkage between academia and industry.
- To maintain student-teacher ratio at par with the international standards.
- To provide a platform to scientists working in various national universities and R&D organizations for higher learning.
Astronomy & Astrophysics - Field of Study

Introduction
Astronomy is the oldest branch of natural science that deals with heavenly objects. Night sky observations of prehistoric cultures helped them to learn about seasons, phases of moon, eclipses and celestial navigation. Galileo Galilei first pointed telescope towards the heavens and realized that heavenly body are not unchanging spherical objects, rather evolving entities with variety of shapes and sizes. By applying laws of physics, astrophysicists try to understand the origin, structure, and evolution of planets, stars, galaxies, and the universe. Fuelled by technological developments, the field of astronomy and astrophysics is currently gaining importance worldwide. A new generation of spaceborne telescopes such as Hubble Space Telescope, Chandra X-ray observatory and the Spitzer Infrared Space Telescope together with advanced ground-based telescopes and enormous increases in computing power are enabling a golden age of astrophysics. Important discoveries have been made within our own solar system through explorations of robotic spacecraft and landers. Precise observations of centers of galaxies including our own Milky Way Galaxy revealed that most galaxies, if not all, harbor central supermassive black hole responsible for extremely energetic and exotic phenomena associated with quasars and radio galaxies. We also discovered that universe is expanding with ever increasing rate suggesting that we are living in an epoch of dark energy dominated universe. With CMB data from WMAP and PLANCK, we understand a great deal about large scale structure formation. The MS program in Astronomy and Astrophysics focuses on underlying physics of phenomena beyond the Earth, theory, data analysis and modeling techniques, which will undoubtedly play a prominent role in international basic research. The key areas of focus include Gravitational, Physics, Galaxy Evolution, Dynamics and Evolution of Supermassive Black Holes in Galaxy Centers, Modeling of Galaxy Mergers, Gravitational Waves Data Analysis, Solar Plasma Physics.

Employment Prospects
The graduates having MS Astronomy and Astrophysics degree have tremendous opportunities for jobs in national space agency of Pakistan SUPARCO as well as in all public/private sector universities of Pakistan offering teaching and research in natural sciences.

Higher Education (PhD)
The graduates can get PhD positions in Physics/Astrophysics/Astronomy in local and foreign universities and get scholarships from agencies like, International Max Planck Research School (IMPRS), German Academic Exchange Service (DAAD), Albert Einstein Institute (AEI), Erasmus Mundus, and Higher Education Commission of Pakistan (HEC).
MS in Astronomy & Astrophysics

Duration: 2-years (4-semesters)

Prerequisites
- M. Sc. Physics/Math from a recognized university
- B. S. Physics/Math
- B. S. (Space Science) from a recognized university
- M. Sc. (Space Sciences).

Valid NTS GAT-General test score with minimum 50 marks.

Credit Hours: 30(24 + 6)

Research Areas:
- Galaxy Dynamics
- Supermassive Black Holes Evolution
- Gravitational Physics
- Space Plasma Physics

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<thead>
<tr>
<th>Semester</th>
<th>Subject</th>
<th>Credit Hours</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Astronomy &amp; Astrophysics</td>
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<td>Mathematical Physics</td>
<td>3</td>
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<tr>
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<td>Theoretical Plasma and Astrophysics</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Universe of Galaxies</td>
<td>3</td>
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<td>Computational Astrophysics</td>
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<tr>
<td>4</td>
<td>Thesis</td>
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</tbody>
</table>
Compulsory Courses

Fundamentals of Astronomy
Historical overview, coordinate systems, celestial mechanics, virial theorem, solar system

Telescopes
Light gathering, angular resolution, image formation, refracting telescopes, reacting telescopes, adaptive and active optics, ultra violet and infrared Astronomy, radio Astronomy, high energy Astronomy, space telescopes

Star Formation and Properties of Stars
Gravitational binding, molecular clouds and star formation, magnetic effects and star formation, luminosity of collapsing clouds, brightness of star light, continuous radiations from stars, stellar colors, stellar distances, apparent and absolute magnitude, spectral lines, spectral types of stars, HR-diagram, The Sun: a typical star, basic structure, temperature distribution, chromosphere, corona, solar activity, solar neutrinos

Stellar Evolution and the Fate of High Mass Stars
Stellar energy sources, gravitational potential energy and life time of stars, nuclear energy for stars, stellar structure, stellar models, evolution of the high mass stars, evolution of low mass stars, Cepheid variables, white dwarfs, core evolution, supernova remnants, neutron stars, neutron degeneracy pressure, pulsars, stellar mass black holes

Galaxies and the Large Scale Structure of the Universe:
The Milky Way galaxy, kinematics of the Milky Way, Hubble sequence, spiral galaxies, elliptical galaxies, galaxy clusters, expansion of the universe, active galactic nuclei, cosmology, Hubble's law, cosmic wave back ground, origin of the structures

Literature

Mathematical Physics

Recommended Textbooks:
- Szekeres, P. A course in Modern Mathematical Physics: Groups, Hilbert Space and Differential Geometry, Cambridge Press, 2004

Universe of Galaxies
Tools of Astronomy, Stars, galaxy classification, galaxy evolution, galaxies in expanding universe, pre-galactic era, The Milky Way: Stellar populations, stellar luminosity function, mass to light ratio, initial luminosity function, thick and thin disk, star clusters and spiral
Galactic rotation curve, Galactic bulge, bar and Galactic center, stellar halo, globular clusters, Milky Way formation scenarios, *Spiral and Elliptical Galaxies*: Main characteristics of spiral galaxies, surface photometry, cold gas, molecular gas, Schimdt law, rotation curves, Tulley-Fischer relation, spiral structure and density waves, Shapes of elliptical galaxies, photometry and structure, stellar motions, Faber-Jakson relation, fundamental plane, gas contents, central black hole, Mbh - sigma relation, luminosity function, *Active Galaxies*: Types of active galaxies, quasars, radio galaxies, AGN supermassive black hole connection, unified scheme, *Dark Matter*: Visible matter, dark matter in galaxies, dark matter in clusters, gravitational lensing, dark matter candidates, dark matter observations, *Cosmology*: Fundamental observations, Hubble’s Law, Cosmic Microwave Background (CMB), observing nucleosynthesis and early universe, formation of structures, expansion of the universe, large scale structures

**Literature**
- Barbara Ryden, *Introduction to Cosmology*, 2006, Addison-Wesely

**Theoretical Plasma & Astrophysics**

**Hydrodynamics**: derivation of equations of hydrodynamics; virial theorem; ideal and viscous fluids; hydrostatic equilibria; sound waves; supersonic flows and shocks; hydrodynamic instabilities; convection and turbulence.

**Plasma Physics**: Plasma fourth state of matter, Single particle motion, Plasma as fluids, Waves in Plasma, Diffusion and resistivity, equations of ideal magnetohydrodynamics; ambipolar diffusion (non-ideal MHD); Alfvén waves; collisionless plasma; dispersion relations; longitudinal waves and Landau damping.

**Stellar Dynamics**: timescales; relaxation processes; Jeans equation; virial theorem for N-body systems; equilibria and stability of self-gravitating systems; dynamical friction; Fokker Planck approximation.

**Elective Courses**
- Theoretical Plasma & Astrophysics
- Computational Astrophysics
- General Relativity


**Recommended Textbooks**
Goals
In this course the students will learn about the necessary statistical concepts, methods and their applications to analyze data in statistical manner. Particularly, it will help to prepare them to learn the analysis of gravitational waves data coming from gravitational wave detectors operating in different parts of the world.

Recommended Literature:
- Modern Mathematical Statistics with Applications (Springer Texts in Statistics)
- By Jay L. Devore, Kenneth N. Berk
- An Introduction to Statistical Methods And Data Analysis
- By Lyman R. Ott, Micheal T. Longnecker
- Markov Chain Monte Carlo in Practice (Chapman & Hall/CRC Interdisciplinary Statistics) By W.R. Gilks, S. Richardson, David Spiegelhalter
- By DaniGamerman and Hedibert F. Lopes

Statistics and Probability
Probability, Types of Random variables (discrete, continuous, univariate, bivariate…), Probability Distributions of Random Variables (general/special) General Probability Distributions, Special Probability Distributions, Inferential Statistics, Testing of Hypothesis, Regression and Correlation analysis, Monte Carlo Integration

Experimental Techniques in Plasmas
Plasma types, Parameter ranges (time, space, density, temperature, spectra), Implications on diagnostics needed, Plasma discharges, Laser produced plasmas Fusion reactors, Vacuum regimes, Types of pumps and performances, Pressure gauges, Emission spectroscopy, Interferometry, Thomson scattering, Laser induced fluorescence, Langmuir probes, Thompson parabolas, Mass spectroscopy, Electrical and magnetic probes, Impedance measurements, Laser-plasma Interactions, Space Plasmas, Thermonuclear Fusion, Technological Plasmas

Learning outcomes
On successful completion of the module students will have
- A knowledge of the operating principles of the most significant types of
- Experimental plasma devices
- A knowledge of the operating principles behind widely-used plasma physics
- Diagnostic techniques

Typical Reference Texts
- Laser Aided Diagnostics of Gases and Plasmas
- K Muraoka and M Maeda Institute of Physics Publishing
Space Plasmas
Quasilinear Theory, Non-linear wave interaction, MHD turbulence, Landau Damping, Schocks, Chaos, Vortices, Plasma Diagnostic Techniques

Stellar Dynamics
Potential Theory: Spherical systems, potential density pairs, potentials of spheroidal, ellipsoidal and disk systems, Potential of our galaxy.
N-body Codes: Direct summation, tree-codes, particle mesh codes.
The Orbits of Stars: Orbits in spherical potential, orbits in axisymmetric potential, orbits in triaxial potential, orbits in elliptical galaxies, numerical orbit integration.
Equilibria of Collisionless Systems: Boltzmann equation, Jeans theorems, distribution functions, Jeans and virial equation.
Kinetic Theory: Relaxation processes, Fokker Planck approximation, the evolution of spherical stellar systems.
Dynamical Friction: Chandrasekhar’s formula, applications of dynamical friction, decay of black hole orbits, formation and evolution of binary black holes.

Literature

Galactic Nuclei and Supermassive Black Holes
Observations of Galactic Nuclei and Supermassive Black Holes: Structure of galaxies and galactic nuclei, Techniques for weighing black holes, Evidence for binary and multiple supermassive black holes (SMBHs), Gravitational Waves.
Motion Near Supermassive Black Holes: Keplerian orbits, perturbed orbits, The post Newtonian approximation, Relativistic orbits, stellar motion at the center of the Milky Way.
Loss Cone Dynamics: Spherical symmetry, non spherical nuclei, binary and hyper velocity stars, relativistic loss cones, extreme mass ratio inspirals.
Collisional Evolution of Nuclei: Evolution of stellar distribution around SMBH, cusp (re)generation, black hole driven expansion, massive perturbers, Evolution of nuclei lacking SMBH. Binary Multiple Supermassive Black Holes: Interaction of massive binary with field stars, massive binary at the center of a galaxy-early and late evolution, simulations of galaxy mergers, triple supermassive black holes and final parsec problem.

Literature:

Gravitational Waves Data Analysis
Modeling / parameter estimation in general: Prior, likelihood, posterior, MAP, ML.
Source Models: Starting from simple examples of single and multiple sinusoid and chirp mass signals.
Noise (white/colored) and its spectrum: auto-covariance/-correlation, spectrum, white noise, coloured noise, spectrum estimation, Fourier methods, windowing.
Estimation methods (Bayesian MCMC): Common posterior computations, pseudo random number generation, inverse method; Gibbs sampler, Metropolis sampler, Metropolis-Hastings sampler, simulated annealing, parallel tempering, nested sampling.

Goals
The purpose of this course is to produce potential researchers to tackle the greater challenge of gravitational wave detection. In this course the students will gain knowledge and skills that are needed for this area of research thus making it easier for them to collaborate with or join a gravitational wave data analysis group in NASA, ESA and other international organizations.

Potential references
* GW in general
* Bayesian methods, computational methods:
  * Gaussian non-white noise modelling, "Whittle" likelihood etc.:

Industrial Plasmas
Electrical breakdown, DC discharges, RF-driven plasma sources, Low Pressure Plasmas, Capacitive coupling, Inductive coupling, Microwave driven, Magnetically enhancement, High Pressure Plasmas, Arcs, Corona, Dielectric Barrier Discharges, Jets, Microplasmas, Plasma Chemistry, Collision physics Plasma-surface interactions, Sheaths, Sputtering, Adsorption, Desorption, Electron emission, Industrial Use of Plasmas, Lighting, Microelectronics, Surface modification, Nanoscale fabrication,

Modeling, parameter estimation &c
* general (mostly frequentist) statistics:
* Bayesian methods, computational methods:
  * Gaussian non-white noise modelling, "Whittle" likelihood etc.:

Biomedicine

Learning outcomes
- On successful completion of the module students will have a knowledge of the operating principles of important low temperature plasma devices and their electrical, physical and chemical properties
- A knowledge of existing and potential applications of low temperature plasmas
- An insight into research at the frontiers of the field

Typical Reference Texts:
Atmospheric & Environmental Science
Field of Study

MS in Atmospheric & Environmental Science

Prerequisites
- BS/ BSc (16 years of education): Environmental Science/ Environmental Engg/ Chemical Engg/ Mechanical Engg/ Aerospace Engg/ Physics/ Chemistry/ Space Science/ Life Sciences from a recognized university
- MSc (16 years of education): Environmental Science/ Environmental Engg/ Chemical Engg/ Mechanical Engg/ Physics/ Chemistry/ Aerospace Engg/ Space Science /Life Sciences from an HEC recognized university
- Others with permission of the departments

Valid NTS GAT-General test score with minimum 50 marks.

Introduction:
The advent of atmospheric sciences dates as far back as Aristotle who in his classical treatise, Meteorologica laid some of the foundations of this expanding field. With the advent of ground instruments, computers and more recently observations from space, a new and exciting era of atmospheric and environmental sciences is unfolding. In the local context, Pakistan is heavily challenged due to extreme weather events and climate change including major massive flooding in the past four years. A major focus of the MS program is towards developing better understanding of these major issues and working towards providing solutions that are sustainable. The group at IST is focused on both physics and chemistry aspects of these issues and approaches complex environmental problems in a multidisciplinary and interdisciplinary manner. Further, both local and international collaborations are involved, which includes joint partnerships with Pakistan Meteorological Department and Environment Canada. The MS program in Atmospheric and Environmental Science thus focuses on underlying physics and chemistry of processes related to Earth which involve direct observation, data analysis and modeling approaches. Key focus areas include Atmospheric Physics and Chemistry, Cloud and Aerosol dynamics, Satellite and Ground Meteorology, Hydrology and Climate Change. Students in the MS program are trained at local and international standards for scientific scholarship and research. This is expected to open many arenas of professional opportunities towards meaningful contributions to their scientific communities.

<table>
<thead>
<tr>
<th>Semester</th>
<th>Subject</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>Core Course: Advanced Research Methods</td>
<td>3</td>
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<tr>
<td></td>
<td>Core Course: Advanced Environmental Science</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Core Course: Advanced Atmospheric Science</td>
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</tr>
<tr>
<td>2</td>
<td>Core Course: RS/GIS for Environment</td>
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<td>Thesis</td>
<td>3</td>
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<td>4</td>
<td>Thesis</td>
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</tbody>
</table>
Core Courses

Advanced Atmospheric Science

Advanced Environmental Science
Environmental pollution; Air, water, soil, marine, thermal, nuclear pollution, Solid waste management, Disaster management, Introduction to Environmental Management System; principles and elements of the process of EMS, Application of environmental management principles and tools of environmental management, Introduction of ISO14000 series of standards and its role in environmental management. Environmental Analytical Techniques; Introduction; Principles of physical, chemical and microbiological analysis of environmental pollutants, Sampling Procedure for the examination of Water, Wastewater, Air and Solid Waste; sampling rules, sample collection and preservation. Laboratory Techniques and Field Monitoring for parameters of importance causing environmental pollution. Environmental Chemical Analysis; role and importance, classical methods: volumetric and gravimetric analysis. Instrumental Techniques using Atomic Absorption and Emission Analysis Spectrophotometry, Gas Chromatography etc. Assessment and Interpretation of Results using Statistical Tools. Use of GIS RS for environmental monitoring and sensing Climate Change; Introduction, Green House Gases, Effects of climate change on atmosphere and terrestrial and aquatic ecosystems, Climate change and food production, climate change and its effects on Pakistan's agriculture, water resources, forests etc. Energy and Environment; Energy and its forms, energy resources, types, uses; merits and demerits of development and use of energy resources (coal, gas, petroleum, nuclear) local, regional and global impacts of the use of different energy resources, energy resources of Pakistan, non-renewable and renewable, patterns of energy consumption in Pakistan, Future energy scenario of world and Pakistan, sustainable energy management for agriculture, transport, industry and domestic sectors, alternate energy resources, merits and demerits of wind, solar, hydropower, bio-energy resources

Advanced Research Methods
Introduction to Research, Research Problem, Review of Related Literature, Research Hypothesis or Questions, Sampling, Research Instruments, Research Types (Detail Description), Skills and knowledge required to pursue any research/scientific study/investigation, collection and analysis of data, qualitative and quantitative measurement techniques, surveys and sampling procedures, data interpretation and analysis, writing Research Proposals and Reports, Evaluation Criteria. Standards methods and steps followed in any research activity right from the evolution of idea, validation of results and accuracy
assessment. Focus on the research undertakings in the field of Space Science

**Atmospheric Dynamics**
- Momentum Equation, Scale Analysis of Equation of Motion, Continuity Equation, Thermodynamics Energy Equation, Basic Equation in Isobaric Coordinates, Vertical Motion, Circulation and Vorticity, Planetary Boundary Layer, Quasi Geostrophic Analysis, Atmospheric Waves, Baroclinic Instability, Mesoscale Circulation and General Circulation

**Ground/Satellite Radar Meteorology**
- Brief history of radar and satellite meteorology; Solar and thermal infrared radiation and relevance to remote sensing, Properties of radiation: wave, frequency, and energy; Flux and intensity; EM spectrum; Emission; Planck function, Wien's law, Stefan-Boltzmann law, Rayleigh-Jeans approximation; Absorption; Kirchhoff's law, Lambert's law; Scattering; Basic radiative transfer equation; No-scattering and no-emission equations; Reflection; Refraction; Rayleigh and Mie scattering
- Radar hardware; Doppler dilemma, pulsing rate (PRF) and Nyquist velocity; the relationship between pulse width and radar range resolution; Curvature, super, sub-, and standard refraction; Radar equation for point targets; Distributed targets; concept of reflectivity and \( D^{-6} \) relationship with size for Rayleigh scattering, Doppler velocity; Interpreting Doppler Velocity Patterns. Cloud and rain drop size distribution (Marshall Palmer distribution), Z-R relationship, Snow, bright band, and hail; Attenuation and TRMM radar; Introduction to satellite meteorology and orbits; Operational remote sensing in visible and IR; Operational remote sensing in microwave and UV; Retrievals of temperature and clouds; Wind retrieval; Precipitation retrieval; Identifying clouds; Identifying dynamic features; Identifying surface and visibility phenomena

**Advanced Atmospheric Chemistry**
- Atmospheric Radiation and photochemistry: Basic principles, Radiation (solar & Terrestrial), Radiative Flux in Atmosphere, Beer-Lambert law, Atmospheric photochemistry, absorption of radiation by atmospheric gases, photodissociation
- Chemistry of the Stratosphere; Overview of the stratospheric chemistry, Chapman mechanism, Nitrogen Oxides Cycles (Stratospheric sources of NOx from N2O, NOx Cycles) HOx Cycles, Halogen Cycles, Stratospheric ozone depletion, Ozone depletion potentials
- Chemistry of troposphere; Production of OH radical in the troposphere, photochemical cycle of NO2, NO, and O3, Atmospheric Chemistry of CO, Atmospheric chemistry of methane, Role of VOC and NOx in ozone formation, Chemistry of nonmethane organic compounds, Chemistry of biogenic hydrocarbons, Chemistry of Sulfur compounds
- Chemistry of the atmospheric in aqueous phase; Water in the atmosphere, Henry law, aqueous phase chemical equilibria
- Properties of atmospheric Aerosol; Size Distribution Function, Ambient aerosol size distribution, Aerosol chemical composition, Spatial and Temporal Variation, Gaseous inorganic air pollutants, organic air pollutants, photochemical smog
- Nucleation, Atmospheric Diffusion; infrared radiation and relevance to Dry deposition, wet deposition. Indoor Air pollution; sources, types of pollutants, health effects

**Cloud and Aerosol Physics**
- Properties of the Atmospheric Aerosol; The Size Distribution Function; The Number Distribution; Properties of Size Distributions; Ambient Aerosol Size Distributions; Aerosol Chemical Composition; Spatial and Temporal Variation; Vertical Variation; Dynamics of Single Aerosol Particle; Continuum and Noncontinuum Dynamics; Stokes' Law; Corrections to Stokes' Law; The Drag Coefficient; Gravitational Settling of an Aerosol Particle; Particle Diffusion; Aerosol and Fluid Motion; Thermodynamics
of aerosols
Interaction of Aerosols with Radiation; Scattering and Absorption of Light by Small Particles; Rayleigh Scattering Regime; Geometric Scattering Regime; Scattering Phase Function, Extinction by an Ensemble of Particles; Scattering, Absorption, and Extinction Coefficients from Mie Theory. Dynamics of Aerosol Populations; The Condensation Equation; Nucleation theory; Cloud Physics; Properties of Water and Water Solutions; Water Equilibrium in the Atmosphere; Equilibrium of Water in various phases and conditions; Cloud and Fog Formation; Mathematical Description of Cloud Formation; Growth Rate of Individual Cloud Droplets; Growth of a Droplet Population; Cloud Condensation Nuclei; Cloud Processing of Aerosols; Nucleation Scavenging of Aerosols by Clouds; Chemical Composition of Cloud Droplets; No Raining Cloud Effects on Aerosol Concentrations; Aerosol Nucleation Near Clouds; Other Forms of Water in the Atmosphere; Ice Clouds; Extended Köhler Theory; Parameterization of clouds in weather and climate models

Numerical Weather Modeling and Forecasting
Meteorology of the tropics; seasons and circulations; the Asian monsoon; solar radiation and characteristics of terrestrial radiation; absorption and transmission of radiation, Simpson's computation of terrestrial radiation transfer, heat balance; development and analysis of weather chart, t-Phi-GRAM, weather forecasting Numerical Weather Prediction (NWP); governing systems of equations; Reynolds' equations and related approximations; numerical solutions; finite-difference methods; effects of the numerical approximations; boundary conditions; physical-process parameterizations; Cloud microphysics parameterizations; convective parameterizations; radiation parameterizations; boundary-layer parameterizations; stochastic parameterizations; cloud-cover parameterizations; surface processes modeling Model initialization; choice of observations; ensemble methods; sources of uncertainty and definition of ensembles; benefits of ensemble forecasting; predictability with model and initial condition error considerations; verification approaches; experimental design in model-based research; analyzing model output; operational NWP; Post-processing using statistical methods; Computational Fluid Dynamics (CFD) approaches; climate modeling and downscaling models

Climate Change Modeling Climate variability and climate science; dynamics, change and climate prediction; El Niño: an example of natural climate variability; basics of global climate; Components and phenomena in the climate system, time and space scales; interactions among scales and the parameterization problem; radiative forcing; Ocean circulation; the ocean vertical structure; thermohaline circulation; the carbon cycle; Physical processes in the climate system; conservation of momentum; coriolis force; pressure gradient force; velocity equations; ocean and air temperature equation; continuity equation; oceanic continuity equation; atmospheric continuity equation; Conservation of mass; moisture equation for the atmosphere and surface; sources and sinks of moisture, and latent heat; salinity equation for the ocean; moist processes; wave processes in the atmosphere and ocean; gravity waves; kelvin waves; rossby waves. Climate models; different types of models; building a climate model; sub-grid-scale processes; resolution and computational cost; downscaling models; numerical representation of atmospheric and oceanic equations; finite-difference versus spectral models; time-stepping and numerical stability; generation of different grids; parameterization of small-scale processes; hierarchy of climate models; climate sensitivity and feedbacks; climate model scenarios for global warming; greenhouse gases, aerosols and other forcings used in models; EdGCM as a teaching tool and RegGCM3 and...
Selected Topics in Atmospheric & Environmental Science

Natural Disasters: Disasters due to natural phenomena such as climate change, hurricanes, tornadoes, earthquakes, tsunamis, volcanic eruptions, asteroid/comet impacts, and mass extinctions are examined from an environmental perspective; each type of event will be characterized in terms of its origin, evolution, warning potential, range of significant environmental impacts and possible mitigation strategies.

Climate Variability and Change: seasonal to multi-decadal natural variability of the global climate system; the El Nino Southern Oscillation (ENSO); monsoons, droughts and their causes; variability of high impact weather such as hurricanes; the fundamental physics of the coupled atmosphere-land-ocean system and our ability to predict it. Anthropogenic climate change, including an objective assessment of observed trends in the past century and the anthropogenic contribution; theory of climate change linked to increased greenhouse gases; climate change predictions and the IPCC process.

Hydrology

Hydrology from science and engineering viewpoints; hydrological cycle and hydrometeorology; precipitation; storage and runoff; water quality. Fluid Mechanics; Physical properties of water; Fluid at rest; Hydrostatic pressure and forces; Mass conversion; Continuity equation; Energy and Momentum conservation; Friction, shear stress and energy gradients; Open channel applications of the energy and momentum equations; Specific energy; Critical flow controls; Equation of steady gradually varied flow and flow profiles.

Engineering aspects; Laminar/turbulent flows; Energy losses; Pipe networks; Pressure surges/Surge tanks; Flows in Porous Media; Porosity; Hydraulic head and Darcy’s law; Aquifer types and behavior.

Environmental Management; Unsteady flow; approximate methods; Numerical methods; Flood routing; Sediment transport; stream flow analysis and modeling; water resource management in the context of Pakistan and climate change.
Remote Sensing & Geo-Information Science

Field of Study

MS in RS&GISc

Prerequisites
- MSc (16 years of education): Space Science/Physics/Maths from an HEC recognized university
- BS (16 years of education): Space Science/Physics/Maths from an HEC recognized university

Vision: Eligibility:
- Valid NTS GAT- General test score with minimum 50 marks.

Introduction:
In order to bring Pakistan at par with developed nations, education and research in emerging fields of science and technologies is of fundamental importance. Geospatial science and technologies including GISc, RS and associated disciplines have emerged as “enabling discipline” having applications in almost every domain.

Institute of Space Technology (IST) started MS in RS & GISc in 2009 at National Center for Remote Sensing and Geoinformatics at Karachi. In view of the growing importance of the discipline and scarcity of universities offering degree programs nationally, IST has taken yet another step forward and started MS in RS & GISc at Space Science (SS) Department at IST Islamabad Campus. The SS department gathers best foreign qualified faculty and ensures to create top quality RS & GISc human resource.

Mission:
The mission of MS in RS & GISc program at SS department is to provide;
- Conductive environment for education and research that meets international standards.
- Students with best resources for learning under the guidance of top ranked foreign qualified faculty.
- Create human resource in RS and GISc that fits well in national and international market

Objectives:
At the successful completion of the program the students must have;
- Sufficient GIS and RS skills to be capable of competing nationally and internationally.
- The ability to do research by inculcating in them the ability to do creative and innovative thinking

Eligibility:
1. 4 years BS degree or 16 years of education (from HEC Recognized Institutes / Universities) preferably in RS & GIS, Geoinformatics, GIScience, Surveying, Space Science, Geography, Computer Science, Information Systems, Electrical/Environmental/Civil Engineering. Specific cases can be considered upon application
2. Minimum 2.5 CGPA out of 4 or 60% marks in BS
3. Valid NTS GAT test or GRE (General) with minimum 50% marks Recommendation by faculty interview panel

Duration and Structure:
1. 2 years spread over 4 semesters (2 semesters per year)
2. Students will be required pass all courses (4 core courses and 4 electives, Cr. Hrs. 24) and defend thesis (6 Cr. hrs) for earning MS degree.
Remote Sensing & Geo-Information Science

Semester-I:

<table>
<thead>
<tr>
<th>No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Type</th>
<th>Credit Hrs</th>
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<tbody>
<tr>
<td>1</td>
<td>Rg711</td>
<td>Remote Sensing and Digital Image</td>
<td>Core</td>
<td>3 (2-1)</td>
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<tr>
<td>2</td>
<td>Rg721</td>
<td>Processing Geographical Information Science</td>
<td>Core</td>
<td>(2-1)3</td>
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TOTAL Credit Hours (minimum) 9

Semester-II:

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<th>No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Type</th>
<th>Credit Hrs</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Rg723</td>
<td>Spatial Databases</td>
<td>Core</td>
<td>3 (2-1)</td>
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<tr>
<td>2</td>
<td>RG701</td>
<td>Research Methods</td>
<td>Core</td>
<td>(2-1)3</td>
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<td>Elective</td>
<td>Elective (3-0 or 2-1)</td>
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TOTAL Credit Hours (minimum) 9

Semester-III:

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<tr>
<th>No.</th>
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<tr>
<td>1</td>
<td>Thesis -II</td>
<td>Thesis</td>
<td>3-0</td>
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</tbody>
</table>

TOTAL Credit Hours (minimum) 3

Electives define field of specialization. Currently we are offering specialization in four broad areas list below. Elective courses will be offered on the basis of faculty expertise and availability.

**Elective:**

**GIScience**
1. GIS Customization and Programming
2. GIS Theory I
3. GIS Theory II
4. Web GIS
5. Mobile GIS
6. Spatial Decision Support Systems
Special Topics in GIS

**Remote Sensing**
1. Radar Remote Sensing
2. Satellite Oceanography

**Geospatial Computing**
1. Functional Programming-I
2. Functional Programming-II
3. Geospatial Programming with Python
4. Geospatial Data Structures and Algorithms
5. Geospatial Datamining and Warehousing
6. Object Oriented Programming with Java
7. Geospatial Development with C# and .NET

**Interdisciplinary – Applied Courses**
1. Land Information Systems
2. Geostatistics
3. Meteorology
4. Environmental Science
DEPARTMENT OF

Applied Mathematics & Statistics
Department of Applied Mathematics & Statistics

Mathematics & Statistics form the backbone of knowledge development not only for scientists but also for engineers. An engineer cannot excel in the field of engineering without sound knowledge in science and particularly in mathematics. In this era of emerging technologies, it has been observed that only those nations progress who have prominent research skills and strong bond between scientists and engineers.

In Pakistan, we have skilled people, but unfortunately, linkage between scientists and engineers for qualitative and applied research is still missing. Institute of Space Technology (IST) has taken several steps to bridge this gap. We, at IST, have modeled the department of Mathematics & Statistics in such a way that research performed by our faculty and graduate students is a joint venture undertaken by mathematicians and engineers as well. The curriculum for MS/PhD students is designed with the collaboration of mathematicians and engineers. Students undertaking research in this department will have a chance to learn not only the fundamental courses of engineering but also advanced courses related to their area of specialization and interest. Emerging specializations in the domain of engineering, like Nonlinear Dynamics and Cryptography, will be offered for the first time as area of research for graduate students at this department. After graduation, our students will be equipped not only with advanced mathematical tools but also have strong and applicable understanding towards engineering problems.

The department of Applied Mathematics & Statistics will be a unique department of its nature. IST has already set an example for other local universities by sending the first student satellite “iCube” into space, which shows our commitment towards making significant contributing towards the vision of IST. The establishment of department of Mathematics & Statistics will be another quantum leap towards achieving our targets and fulfilling our mission.

Mission Statement

The mission of Department of Applied Mathematics & Statistics is to provide firm foundation to the engineers & scientists working for space science related technologies in fulfilling the demands of their profession and create a bridge of knowledge and understanding between mathematicians and engineers.

Programs Educational Objectives

After graduation, our students will be equipped not only with advanced mathematical tools but also have strong and applicable understanding towards engineering problems. Our graduates will be able to

- Collaborate with Engineers and scientists from industry and academia in research/projects to promote the culture of interdisciplinary research and produce quality research in Pakistan
- Explore the new emerging areas of science and engineering, like, nonlinear dynamics, computational mathematics and cryptography
Local MS Programs

MS-Mathematics (Local)
Specialization: Nonlinear Dynamics
Prerequisites
- The applicant must have completed 4-years BS in Mathematics/ Applied Physics/ Space Science or BE in any engineering discipline or MA/ MSc. in Mathematics/ Applied Physics/ Space Science (having BSc. with Mathematics I & II)
- Valid NTS GAT-General with minimum 50 score

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<th>Semester</th>
<th>Code</th>
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<tr>
<td>1</td>
<td>MAT611</td>
<td>Advanced Partial Differential Equations (3-0)</td>
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<td></td>
<td>MAT721</td>
<td>Advanced Numerical Techniques (3-0)</td>
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<tr>
<td>2</td>
<td>MAT731</td>
<td>Nonlinear Dynamics-I (3-0)</td>
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<td>MAT722</td>
<td>Numerical Solutions to PDEs-I (3-0)</td>
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<td>Elective-II (3-0)</td>
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<tr>
<td>3</td>
<td>MAT732</td>
<td>Nonlinear Dynamics-II (3-0)</td>
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<td>Thesis-II (6-0)</td>
</tr>
</tbody>
</table>

Electives
- Stellar Dynamics
- General Relativity
- Mathematical Modeling & Simulation
- Modern Control Theory
- Introduction to Cryptography
- Acoustics
- Advanced Probability & Statistics
- Bayesian Theory
- Topics on Nonlinear Dynamics

MS-Mathematics (Local)
Specialization: Computational Mathematics
Prerequisites
- The applicant must have completed 4-years BS in Mathematics/ Applied Physics/ Space Science or BE in any engineering discipline or MA/ MSc. in Mathematics/ Applied Physics/ Space Science (having BSc. with Mathematics I & II)
- Valid NTS GAT-General with minimum 50 score

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<td>MAT723</td>
<td>Numerical Linear Algebra (3-0)</td>
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</table>

Electives
- Mathematical Modeling & Simulation
- Computational Fluid Dynamics
- Heat Transfer and Mass Transfer
- General Relativity
- Gravitational Wave Data Analysis
- Acoustics
- Operations Research
- Magnetohydrodynamics
Local MS Programs

MS-Mathematics (Local)
Specialization: Fluid Mechanics
Prerequisites
- The applicant must have completed 4-years BS in Mathematics/ Applied Physics/ Space Science or BE in any engineering discipline or MA/ MSc. in Mathematics/ Applied Physics/ Space Science (having BSc. with Mathematics I & II)
- Valid NTS GAT-General with minimum 50 score

<table>
<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Courses</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>MAT611</td>
<td>Advanced Partial Differential Equations (3-0)</td>
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<tr>
<td></td>
<td>MAT711</td>
<td>Newtonian Fluid Mechanics (3-0)</td>
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<tr>
<td></td>
<td></td>
<td>Elective-I (3-0)</td>
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<td>2</td>
<td>MAT712</td>
<td>Non-Newtonian Fluid Mechanics (3-0)</td>
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<tr>
<td></td>
<td>MAT612</td>
<td>Initial and boundary value problems (3-0)</td>
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<td></td>
<td></td>
<td>Elective-II (3-0)</td>
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<tr>
<td>3</td>
<td>MAT713</td>
<td>Magnetohydrodynamics (3-0)</td>
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<tr>
<td></td>
<td></td>
<td>Elective-III (3-0)</td>
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<tr>
<td></td>
<td></td>
<td>Thesis-I (6-0)</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Thesis-II (6-0)</td>
</tr>
</tbody>
</table>

Electives
Mathematical Modeling & Simulation
Computational Fluid Dynamics
Heat Transfer and Mass Transfer
Acoustics
Advanced Numerical Techniques
Numerical Solutions to Partial Differential Equations-I
Bayesian Theory
Advanced Probability & Statistics

Semester Code Courses

Electives
Mathematical Modeling & Simulation
Mathematics of Cryptography
Cryptanalysis
Nonlinear Dynamics-II
Gravitational Wave Data Analysis
Elliptic Curves
Operational Research
Information Theory

MS-Mathematics (Local)
Specialization: Cryptography
Prerequisites
- The applicant must have completed 4-years BS in Mathematics/ Applied Physics/ Space Science or BE in any engineering discipline or MA/ MSc. in Mathematics/ Applied Physics/ Space Science (having BSc. with Mathematics I & II)
- Valid NTS GAT-General with minimum 50 score

<table>
<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Courses</th>
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<tbody>
<tr>
<td>1</td>
<td>MAT621</td>
<td>Advanced Number Theory (3-0)</td>
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<tr>
<td></td>
<td>PRB721</td>
<td>Advanced Probability &amp; Statistics (3-0)</td>
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<td></td>
<td></td>
<td>Elective-I (3-0)</td>
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<tr>
<td>2</td>
<td>MAT731</td>
<td>Nonlinear Dynamics-I (3-0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introduction to Cryptography (3-0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective-II (3-0)</td>
</tr>
<tr>
<td>3</td>
<td>PRB722</td>
<td>Stochastic Processes (3-0)</td>
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<tr>
<td></td>
<td></td>
<td>Elective-III (3-0)</td>
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<td></td>
<td>Thesis-I (6-0)</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Thesis-II (6-0)</td>
</tr>
</tbody>
</table>
Course Description

Stellar Dynamics
Potential Theory: Spherical systems, potential density pairs, potentials of spheroidal, ellipsoidal and disk systems, Potential of our galaxy, N-body Codes: Direct summation, tree-codes, particle mesh codes, The Orbits of Stars: Orbits in spherical potential, orbits in axisymmetric potential, orbits in triaxial potential, orbits in elliptical galaxies, numerical orbit integration, Equilibria of Collisionless Systems: Boltzmann equation, Jeans theorems, distribution functions, Jeans and virial equation, Kinetic Theory: Relaxation processes, Fokker Planck approximation, the evolution of spherical stellar systems, Dynamical Friction: Chandrasekhar’s formula, applications of dynamical friction, decay of black hole orbits, formation and evolution of binary black holes.

Mathematics Modeling And Simulation
Introduction to a Dynamic systems and control, modeling and analysis techniques, the fundamentals and applications of control systems, Modeling and Simulation of Dynamic systems based on Bond graph theory, transfer functions, sensitivity and robust control and digital control. Case studies related to motion control system design, electromechanical system design, Stochastic processes applied to control of various types of systems, Markov chains, Queuing theory, Bifurcations, Perturbation Methods, non-homogeneous Equations, Training on Lab View software.

Computational Fluid Dynamics

Heat Transfer And Mass Transfer

Non-Newtonian Fluid Mechanics
Basic review of fluid properties and basic flow equations, (Navier-Stokes’ equations etc.), laminar flows, Turbulent flows, Compressible and Incompressible flows, Partial differential equations governing the conservation of mass, Momentum and energy of Newtonian fluids, Derivation of dimensional analysis used to simplify the governing equations, low Reynolds number flow, strokes flow, high Reynolds number laminar flow, Boundary layer separation phenomena and approximations to the governing equations, laminar stability and transition to turbulent boundary layer conditions.

Advanced Partial Differential Equations
Definition of PDE, Solution of PDEs and principle of superposition, Boundary conditions and their types, Homogeneous PDEs with constant coefficients and separation of variables, Holomorphic functions, Classification of second order linear PDEs, The Heat equation and diffusion equation, Wave equation and vibrating string, Initial and boundary conditions for heat and wave equations, Orthogonal

**Magnetohydrodynamics**

Equations of electrodynamics, Equations of Fluid Dynamics, Ohm's law equations of magnetohydrodynamics, Motion of a viscous electrically conducting fluid with linear current flow, steady state motion along a magnetic field, wave motion of an ideal fluid, Effects of molecular structure, Currents in a fully ionized gas, partially ionized gases, interstellar fields, dissipation in hot and cool clouds, Kinematics of MHD: Advection and Diffusion of a Magnetic field, Low-Magnetic Reynold's number.

**Newtonian Fluid Mechanics**

Fluids and flows, Viscosity, Newton's law of viscosity, Classification of fluids, Types of flows, Static equation, Euler's equation, Conservation laws, Flux, Fourier law of conduction, Fick's laws, Bernoulli Equation, Navier-Stokes equation and exact solutions, Dimensional analysis and Similitude, Boundary layer approximations and governing equations.

**Initial And Boundary Value Problems**

Green's function method with applications to wave-propagation, regular and singular perturbation techniques with applications, Variational methods. A survey of transform techniques; Wiener-Hopf technique with applications to diffraction problems, Asymptotic expansion integrals and properties, Methods of averaging, Convergence of mathematical solutions.

**Non-newtonian Fluid Mechanics**

**General Relativity**

**Gravitational Waves And Data Analysis**
Prior, likelihood, posterior, MAP, ML, Starting from simple examples of single and multiple sinusoid and chirp mass signals, autocovariance correlation, spectrum, white noise, coloured noise, spectrum estimation, Fourier methods, windowing, Marginal likelihood, evidence, Bayes factor, likelihood ratio test, Neyman-Pearson Lemma, generalized likelihood ratio test, multiple testing, trials factor, "look-elsewhere-effect", Lindley's paradox, detection/false-alarm probabilities sensitivity/specificity), ROC curve, non-detection limits, Common posterior computations, pseudo random number generation, inverse method Gibbs sampler, Metropolis sampler, Metropolis-Hastings sampler, simulated, annealing, parallel tempering, nested sampling.

**Modern Control Theory**
Introduction To Cryptography
Background and overview, One-time encryption using stream ciphers, Semantic security, Block ciphers and pseudorandom functions, Chosen plaintext security and modes of operation, The DES and AES block ciphers, Message integrity. CBC-MAC, HMAC, PMAC, and CW-MAC, Collision resistant hashing, Authenticated encryption. CCM, GCM, TLS, and IPsec. Key derivation functions, Odds and ends: deterministic encryption, non-expanding encryption, and format preserving encryption, Basic key exchange: Diffie-Hellman, RSA and Merkle puzzles, A crash course in computational number theory, Number theoretic hardness assumptions, Public key encryption, Trapdoor permutations and RSA, The ElGamal system and variants, Digital signatures and certificates, Identification protocols, Authenticated key exchange and TLS key exchange, Zero knowledge protocols and proofs of knowledge, Privacy mechanisms: group signatures and credential systems, Private information retrieval and oblivious transfer, Two party computation: Yao’s protocol and applications, Elliptic curve cryptography, Quantum computing, Pairing-based cryptography, Lattice-based cryptography, Fully homomorphic encryption

Advanced Number Theory
Divisors; Bezout’s identity; LCM, Linear Diophantine equations, Prime numbers and prime-power factorizations; Distribution of primes; Primality-testing and factorization, Modular arithmetic; Linear congruences; An extension of chinese Remainder Theorem; The arithmetic’s of Z; Solving congruence’s mod, Units; Euler’s function. The group U; Primitive roots; The group U, n is power of odd prime and n is power of 2. Quadratic congruences; The group of quadratic residues; The Legendre symbol, Quadratic reciprocity, Definition and examples; perfect numbers; The Modius Inversion formula., Random integers, Dirichlet series, Euler products, Sums of two Squares; The Gaussian integers; Sums of three Squares; Sums of four Squares, The problem; Pythagorean Theorem; Pythagorean triples; The case n=4; Odd prime exponents.

Mathematics Of Cryptography
Historic background Cryptographic algorithms Types of attacks used to break cryptosystems, Modular arithmetic Greatest common divisors Congruences Chinese Remainder Theorem Primitive roots Finite fields, Substitution ciphers Polyalphabetic ciphers Permutation ciphers, One-way hash functions and properties Secure Hash Algorithm Birthday attacks, Applications to information assurance and cyber security
Cryptanalysis
Introduction to cryptanalysis, Monographic substitution systems, Monoalphabetic unilateral substitution systems using standard cipher alphabets, Monoalphabetic unilateral substitution systems using mixed cipher alphabets, Monoalphabetic multilateral substitution systems part three - polygraphic substitution systems, Characteristics of polygraphic substitution systems, Solution of polygraphic substitution systems polyalphabetic substitution systems, Periodic polyalphabetic substitution systems, Solution of periodic polyalphabetic systems, A periodic polyalphabetic ciphers, part five - transposition systems, Types of transposition systems, Solution of numerically-keyed columnar transposition ciphers, Transposition special solutions part six - analysis of code systems, Types of code systems, Analysis of syllabary spelling, Frequency distributions of English digraphs, Frequency distributions of English trigraphs, Frequency distributions of English tetragraphs.

Advanced Probability & Statistics

Bayesian Theory
Nonlinear Dynamics-I

Nonlinear Dynamics-II


Operations Research
Introduction to Operations Research (OR): Introduction to Foundation mathematics and statistics, Linear Programming (LP), LP and allocation of resources, LP definition, Linearity requirement, Maximization Then Minimization problems., Graphical LP Minimization solution, Introduction, Simplex method definition, formulating the, Simplex model, Linear Programming – Simplex Method for Maximizing, Simplex maximizing example for similar limitations, Mixed limitations, Example containing mixed constraints, Minimization example for similar limitations,
Numerical Linear Algebra

Acoustics

Advance Numerical Techniques
Numerical Solution Of PDE-I

Numerical Solution Of PDE-II
First-order nonlinear equations, quasi-linear and conservation forms, Characteristics, shock waves and contact discontinuities, Finite volume methods, Godunov methods and Riemann solvers, high resolution schemes, Dirichlet and Neumann problems, solvability, Direct vs. iterative methods of solution, line by line implementation of thomas algorithm, Relaxation and multigrid methods, Multistep schemes, stability of general multistep schemes, Dispersion and dissipation of numerical schemes, Group velocity and wavepackets in numerical schemes, Numerical solution of systems of hyperbolic PDEs; multilevel schemes; stability and convergence. Introduction to finite element method, finite element method for elliptic and parabolic equations, Recent development in numerical methods

Elliptic Curves
Cryptography basics, Public-key cryptography, Finite Field Arithmetic, Binary field arithmetic, Elliptic Curve Arithmetic, Introduction to Elliptic Curves, Point representation and the group law, Curves with efficiently computable endomorphism, Point multiplication using halving, Cryptographic Protocols, The elliptic curve discrete logarithm problem, Types of Attacks of Elliptic Curves, Domain parameters, Key pairs, Signature schemes, Public-key encryption, Key establishment

Stochastic Processes
Review of probability and random variables, random walk, Stochastic Processes – definition, methods of description, time averaging and ergodicity, continuity, integration and differentiation, autocorrelation, power spectral density, response of linear systems to stochastic inputs, classes of stochastic processes, Shot noise, thermal noise, point processes, Markov processes, Gaussian processes, Mean square error filtering, orthogonality, smoothing, prediction, stochastic gradient algorithm, innovations, Weiner filter, Kalman filter, queuing theory, Poisson arrivals
Office of Research, Innovation and Commercialization (ORIC)

An Office of Research, Innovation and Commercialization (ORIC) has been established to promote value added innovation in basic and applied research. ORIC has been very actively functioning to promote research, commercialization and collaboration since its inception in June 2011.

This office is responsible for commercialization of research and knowledge developed by IST’s researchers, faculty, staff and students. Our focus is to foster and develop collaborative work environment among researchers, industrial partners and funding agencies.

Our vision is to become the hub for innovative ideas and we aim at to ignite ingenuity, creativity and innovation in hearts of our researchers to explore their inner soul and make their dreams a reality.

As a team, we are committed to extend all possible facilitation and assistance to solicit your research plan and to encourage each and every single innovation which stimulates the country’s economy.

Research Operations
We are facilitating our faculty and researchers to provide funding opportunities for R&D initiatives and ventures through national/ international sources.

Apart from external funding sources for R&D initiatives, IST has also established a R&D Fund to further strengthen and broaden the research and innovation base. Within a very short span of formation, more than 10 research projects have so far been funded through IST R&D Fund. ORIC has signed MoUs with several globally recognized R&D entities to foster value added innovation and, hence nurturing national economy.

University Industry Collaboration
ORIC primarily focuses on to bridge the gap between Academia and Industry. The office is striving to outreach and give maximum possible support to the industry. In continuation of the same, several projects have been initiated with engineering industries and chambers of commerce.

www.ist.edu.pk
IST has been endeavoring to raise the quality of research in Pakistan to international level. In order to augment this cause, a series of seminars and workshops have been planned by ORIC. In connection with, the office has engaged specialized trainers and consultants to impart trainings on latest cutting edge research domains. Intra-disciplinary participation of faculty, engineers, researchers and professionals from public and private sector will help in augmenting the cause of academic industry linkages and establishing partnerships.

Business Incubation Center - BIC
Business Incubation Center (BIC) IST has been established in partnership with the Higher Education Commission (HEC). BIC will provide a supportive entrepreneurial environment to IST graduates / staff to nurture and commercialize their innovative ideas by providing adequate resources and services.

The BIC at IST seeks entrepreneurs with innovative ideas to create new products and services. It provides comprehensive technical and commercial assistance to help startup businesses to flourish to influence socially and economically. To develop the entrepreneurial mindset and to inculcate entrepreneurial skills among the students and researcher of IST, various initiatives have been launched at IST. These initiatives include interaction with successful entrepreneurs, seminars / workshops and participation in Business Plan competitions. Some of the partners to this initiative are International Finance Corporation (IFC), TiE Islamabad, Islamabad Chamber of Commerce & Industries and MIT Enterprise Forum. In collaboration with TiE Islamabad, Youth Entrepreneurial Society (YES) is also working at IST. YES business club is being managed by IST students and has successfully arranged several events.
Admissions

Eligibility for MS Programs
A candidate seeking admissions to a MS program at IST must meet the following criteria:

- Sixteen years of education with a strong background in areas listed with each program, completed in 1st division or more than 2.00 CGPA from a Higher Education Commission (HEC)/Pakistan Engineering Council (PEC) recognized institution of Pakistan or from Foreign University of good repute

- Graduate Assessment Test Valid NTS GAT-General test score with minimum 50 marks.

Eligibility for PhD Programs
A candidate seeking admission to a PhD Program, must meet the following eligibility criteria:

- MS with a strong background in areas listed with each program with 1st division / CGPA 3 from a recognized institution of Higher Education (HEC)/Pakistan Engineering Council (PEC) or from Foreign institution of good repute

- Graduate Assessment Test (GAT)-Subject taken by NTS after May 01, 2011 with minimum 60 marks

Application
Application forms can be submitted online at IST's website: www.ist.edu.pk

The following documents must reach the Admissions Office by the date specified in the press announcement:

- Copy of online duly filled Application Forms
- Certificate of GAT-General / Subject score (one copy)
- Rs 1,000/- through Demand Draft or Postal Certificate payable to “Institute of Space Technology”
- Computerized National Identity Card (one copy)
- BSc / BE / MSc / MS Engineering Degree (one copy)
- BSc / BE / MSc / MS Engineering Transcript (one copy)
- HSSC / A-Levels / Equivalent Certificate (one copy)
- SSC / O-Levels / Equivalent Certificate (one copy)
- Equivalence Certificate from Inter Board Committee of Chairman (IBCC), Islamabad (required only for applicants with A-Levels / Equivalent Certificate)
- Recent passport-sized colored photographs (four copies)
- Two reference letters

Note
- Applications received by the Admissions Office will be acknowledged through IST's website www.ist.edu.pk
- The merit and waiting lists will also be posted on the website and admission letters to the successful applicants will be issued

Selection
Admission shall be granted strictly on merit which will be determined on the basis of the recommendations of the Graduate Assessment Committee

Important
- Applicants are required to submit score of GAT-General / Subject taken by the NTS after May 01, 2011
- Applications should either be sent through registered post or courier service. The student may also directly submit applications to the Admissions Office at IST
- An application for admission shall not be considered unless submitted on the prescribed form and completed as required
- Applicants who fail to report for registration on the specified date shall be considered to have forfeited their chance for admission.

- Original certificates of all examination must be produced at the time of registration.

- If any document received is later found to be false/forged admission shall be cancelled and will be considered ab initio void.

- In case of cancellation of admission/suspension, admission fee and other dues shall not be refunded.

- The Institute shall not be liable to refund the tuition fee and other dues in case candidate is refused visa for studying in the linked universities by the Embassy of the concerned country.

- The programs mentioned in this prospectus are expression of intent only. The institute reserves the right to discontinue, or make amendments in any of its program or its portion depending on the availability of human and other necessary resources.

- The Institute has right to have a visa cancelled on the basis of academic or disciplinary grounds.

- The students are required to return back to Pakistan after completion of his/her studies in the relevant countries.

- The Institute and linked universities reserve the right to cancel or refuse admission to any applicant without assigning any reason.

- Applicant is not eligible to claim for any refund or document without submission of duly signed No Demand Certificate.

**Visa for Linked University**

Acquiring visa for respective foreign country is the sole responsibility of the candidate. However, the Institute will extend all possible assistance in submission of the visa application.

**Registration**

Before the commencement of classes in each semester, students are required to register themselves. Registration encompasses approval of courses from respective academic department/advisor and payment of all dues. A student shall not be considered to have been registered for the semester unless all dues have been paid.
### MS/PhD Programs

#### One Time Charges

<table>
<thead>
<tr>
<th></th>
<th>(Pak Rs)</th>
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</thead>
<tbody>
<tr>
<td>Registration</td>
<td>20,000/-</td>
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<tr>
<td>Security Deposit</td>
<td>10,000/-</td>
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#### Zero Semester Dues (For MS Only)

<table>
<thead>
<tr>
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<th>(Pak Rs)</th>
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</thead>
<tbody>
<tr>
<td>Tuition Fee</td>
<td>15,000/-</td>
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<tr>
<td>Sports Fee</td>
<td>170/-</td>
</tr>
<tr>
<td>Service Charges</td>
<td>700/-</td>
</tr>
<tr>
<td>Library Fee</td>
<td>170/-</td>
</tr>
<tr>
<td>Laboratory Fee</td>
<td>350/-</td>
</tr>
<tr>
<td><strong>Total of Per Semester Dues</strong></td>
<td><strong>16,390/-</strong></td>
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</table>

#### Regular Semester Dues

<table>
<thead>
<tr>
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<th>(Pak Rs)</th>
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</thead>
<tbody>
<tr>
<td>Tuition Fee</td>
<td>5,000/-</td>
</tr>
<tr>
<td>Sports Fee</td>
<td>500/-</td>
</tr>
<tr>
<td>Service Charges</td>
<td>2,000/-</td>
</tr>
<tr>
<td>Library Fee</td>
<td>500/-</td>
</tr>
<tr>
<td>Laboratory Fee</td>
<td>1,000/-</td>
</tr>
</tbody>
</table>

#### Optional Charges Per Semester

<table>
<thead>
<tr>
<th></th>
<th>Zero Semester (For MS Only) (Pak Rs)</th>
<th>Regular Semester (Pak Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory Charges</td>
<td>8,500/-</td>
<td>35,000/-</td>
</tr>
<tr>
<td>Shuttle Service Charges</td>
<td>700/-</td>
<td>3,000/-</td>
</tr>
<tr>
<td>Washing Charges</td>
<td>600/-</td>
<td>3,000/-</td>
</tr>
<tr>
<td>*Transport Charges</td>
<td>5,500/-</td>
<td>20,000/-</td>
</tr>
</tbody>
</table>

*Hostel Charges*

Health Insurance for student if arranged by the Institute, the charges / Premium will be charged as per actual.

### Note:

(a) Repeat/Add Course Fee @ Rs 5,000/- per credit hour will be charged.
(b) Fee/Charges are subject to change from time to time.
(c) Charges are applicable only if services are offered by IST.
(d) All Gov. Taxes will be applicable as notified by FBR.
(e) Students for Linked Universities will pay their dues as per respective University Fee Structure.
(f) A student obtaining scholarship/ sponsorship from any source will not be considered for merit or any other scholarship offered/ announced by IST.
# Fee Schedule (for International Students)

## MS/PhD Programs

<table>
<thead>
<tr>
<th><strong>One Time Charges</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration</td>
<td>1,250/-</td>
<td></td>
</tr>
<tr>
<td>Security Deposit</td>
<td>500/-</td>
<td></td>
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</table>

### Per Semester Dues

<table>
<thead>
<tr>
<th><strong>Dues</strong></th>
<th><strong>Zero Semester (For MS Only)</strong> (US $)</th>
<th><strong>Regular Semester (US $)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition Fee</td>
<td>900/-</td>
<td>300/- Per credit Hour</td>
</tr>
<tr>
<td>Sports Fee</td>
<td>15/-</td>
<td>50/-</td>
</tr>
<tr>
<td>Service Charges</td>
<td>15/-</td>
<td>50/-</td>
</tr>
<tr>
<td>Library Fee</td>
<td>15/-</td>
<td>50/-</td>
</tr>
<tr>
<td>Laboratory Fee</td>
<td>30/-</td>
<td>100/-</td>
</tr>
</tbody>
</table>

**Total of Per Semester Dues:** 975/-

## Optional Charges Per Semester

<table>
<thead>
<tr>
<th><strong>Hostel Charges</strong></th>
<th><strong>Zero Semester (For MS Only)</strong></th>
<th><strong>Regular Semester</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory Charges</td>
<td>US $190</td>
<td>Pak Rs. 35,000/-</td>
</tr>
<tr>
<td>Shuttle Service Charges</td>
<td>Pak Rs. 700/-</td>
<td>Pak Rs. 3,000/-</td>
</tr>
<tr>
<td>Washing Charges</td>
<td>Pak Rs. 600/-</td>
<td>Pak Rs. 3,000/-</td>
</tr>
<tr>
<td>*Transport Charges</td>
<td>Pak Rs. 5,500/-</td>
<td>Pak Rs. 20,000/-</td>
</tr>
</tbody>
</table>

Health Insurance for student if arranged by the Institute, the charges / Premium will be charged as per actual.

### Note:

1. Repeat/Add Course Fee @ US $300/- per credit hour will be charged.
2. Fee/Charges are subject to change from time to time.
3. Charges are applicable only if services are offered by IST.
4. All Gov. Taxes will be applicable as notified by FBR.
5. Students for Linked Universities will pay their dues as per respective University Fee Structure.
6. A student obtaining scholarship/ sponsorship from any source will not be considered for merit or any other scholarship offered/ announced by IST.
Fine for late payment

The following fine will be levied for payment of fee after due date:
- For first fifteen days after the due date, 5% of the total payable amount
- After fifteen days and up to one month after due date, 10% of the total payable amount
- Thereafter, registration of the student will be suspended and he/she will not be allowed to attend the classes and exams etc. Registration of the student will be restored only after deposit of outstanding dues along with fine

Mode of Payment

Payment of fees can be made through online Transfer/Bank Draft/Pay order against the fee challan issued at any online branch of HBL (Nationwide).
Note: Cheques and Cash are not acceptable.

Fee Refund Policy

- The time of request/application for fee installments, fine waivers, refund claims etc will be considered from the date of receipt.
- Registration and Service Charges are non-refundable.
- Security Deposit is refundable after deduction of all outstanding dues at the time of leaving the Institute and no adjustment against security will be entertained during stay in the institute. For claim of security refund, submission of NDC is a must.
- Only Tuition Fee, Sports Fee, Library Fee and Laboratory Fee are refundable within 15 days of convene of classes on a pro rata basis as given below.
- No refund shall be admissible after 15 days of convene of classes either one joins IST/avails facilities or not.

Transport Charges and Hostel Charges (Dormitory Charges, Shuttle Service Charges and Washing Charges) are refundable within 30 days of registration on a pro rata basis as given below. No refund shall be admissible after 30 days of registration either one joins IST/avails facilities or not.

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**Timeline for Refund of Compulsory Fees**

<table>
<thead>
<tr>
<th>%age of Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 7th day of convene of classes</td>
</tr>
<tr>
<td>From 8th – 15th day of convene of classes</td>
</tr>
<tr>
<td>From 16th day of convene of classes</td>
</tr>
</tbody>
</table>

**Timeline for Refund of Optical Dues**

<table>
<thead>
<tr>
<th>%age of Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 1st to 7th day of Registration</td>
</tr>
<tr>
<td>From 8th to 15th day of Registration</td>
</tr>
<tr>
<td>From 16th to 21st day of Registration</td>
</tr>
<tr>
<td>From 22nd to 30th day of Registration</td>
</tr>
<tr>
<td>From 31st day of Registration</td>
</tr>
</tbody>
</table>
ACADEMIC REGULATIONS: (MS-LOCAL)

The Academic Program
The Master of Science in Engineering is a two year program. There are two semesters in each academic year, with a total of four semesters. Each semester is of 18 weeks duration. There are 16 weeks of classes. After attending classes for 16 weeks, students are to take final examination which is carried out in the 17th and 18th week.

Degree Requirement
- The requirement to earn a degree of Master of Science is completion of the number of credit hours mentioned against each discipline, with a Cumulative Grade Point Average (CGPA) of 3.00 or more, with a minimum of 'B' grade in thesis (6 credit hours).
- There shall be no unresolved failing 'F' grade, or 'W' grade or 'I' grade left during the program.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace Engineering</td>
<td>30</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>30</td>
</tr>
<tr>
<td>Materials Science &amp; Engineering</td>
<td>30</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>30</td>
</tr>
<tr>
<td>Remote Sensing &amp; Geo-informatics</td>
<td>30</td>
</tr>
<tr>
<td>Space Science</td>
<td>30</td>
</tr>
</tbody>
</table>

- This requirement is to be completed in a maximum duration of four years.
- A student shall be registered continuously for the entire duration

ACADEMIC EVALUATION: (MS-LOCAL)
A student's academic progress/standing is determined and monitored through the following modes of evaluation.

Assignments
These are the problem sets or projects to be completed independently.

Quizzes
At least two unannounced quizzes per credit hour of up to 5 to 10 minutes duration.

Reports/Projects
These are reports to be prepared on the basis of assignments/projects.

One Hour Tests (OHT)
These are announced tests of 50 minutes duration. At least one OHT per credit hour is taken for each course in a semester.

Finals
These are announced tests of a maximum of three hours duration for each course of a semester during the 17th and 18th week.

Conduct of Examination
- There is no choice of questions in quizzes, OHTs and finals
- There shall be no make-ups for any of the evaluation modes
- The award of course grade and semester grade point average (SGPA) is governed by the grading regulations
- Maximum of two courses can be repeated, including mandatory repeats for 'F' grade courses
- The student may repeat a course only once to improve his/her course grade; remember that the second grade achieved will replace the first in the calculation of SGPA / CGPA
- The Grades on Transcript will reflect that the student has repeated the course

Monitoring and Performance: (MS-local)
SGPA / CGPA will be the primary measure of academic performance and standing:
Grading System

Absolute Grading System

If the total number of students is less than 20 absolute grading is used according to cutoff levels decided before the start of the course. The following table shows thresholds for all grades:

<table>
<thead>
<tr>
<th>Interpretation</th>
<th>Grades</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>A</td>
<td>85 ≤ marks ≤ 100</td>
</tr>
<tr>
<td></td>
<td>A-</td>
<td>81 ≤ marks &lt; 85</td>
</tr>
<tr>
<td>Very Good</td>
<td>B+</td>
<td>77 ≤ marks &lt; 81</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>73 ≤ marks &lt; 77</td>
</tr>
<tr>
<td>Good</td>
<td>B-</td>
<td>69 ≤ marks &lt; 73</td>
</tr>
<tr>
<td></td>
<td>C+</td>
<td>65 ≤ marks &lt; 69</td>
</tr>
<tr>
<td>Average</td>
<td>C</td>
<td>61 ≤ marks &lt; 65</td>
</tr>
<tr>
<td></td>
<td>C-</td>
<td>57 ≤ marks &lt; 61</td>
</tr>
<tr>
<td>Poor</td>
<td>D+</td>
<td>52 ≤ marks &lt; 57</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>50 ≤ marks &lt; 52</td>
</tr>
<tr>
<td>Fail</td>
<td>F</td>
<td>marks &lt; 50</td>
</tr>
<tr>
<td>Voluntary Withdrawal</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>Withdrawal due to short attendance</td>
<td>WSA</td>
<td></td>
</tr>
<tr>
<td>Withdrawal due to medical illness</td>
<td>WMI</td>
<td></td>
</tr>
</tbody>
</table>

In addition:
- The Labs, however, will be graded with the above-mentioned system.
- The BS/MS/PhD classes, having less than 20 students, will be graded using the absolute grading system.
- In case of the Final Year Project, the minimum pass grade is C and after it "F" will be awarded.
- In case of an MS course, the minimum pass grade is C and after it “F” will be awarded.
- If the total number of students in a class is more than 20, relative marking system is used. Relative grading allows for screening students according to their performance relative to their peers. The ranges for assigning grades are based on upper limit of percentage of students in a course that can have a particular grade. It also establishes minimum achievement standards.

Grade Point Average (GPA)

Semester GPA is calculated by multiplying the grade points earned in a course with the number of credit hours of that course, taking the sum of such products for each course of the semester and dividing the result by the total number of credits of the semester. GPA is rounded off to two decimal points. The second decimal point is rounded up to next higher digit if the third decimal point is 5 or higher, otherwise second decimal point remains unchanged.

\[
GPA = \frac{\text{Sum of (Credit hours x grade points)}}{\text{Sum of Credit hours}}
\]

Similarly, cumulative GPA is calculated for all the courses in all semesters attended and rounded off accordingly.

Grade “F”: Fail

Grade “F” is awarded to a student in a course for not demonstrating adequate performance. Any such course
is required to be repeated by the student when offered the very next time.

Grade “I”: Incomplete
Grade “I” is awarded to a student who is unable to take the final examination of a course due to extreme circumstances. Any such student is required to take the final examination of that course within six weeks of the final examination, provided all the other requirements of the course are completed. Grade “I” will be converted to grade “F” otherwise.

Repeat Course
- Course repetition is allowed for students seeking to improve grades including “F” grades which is mandatory. However, only one attempt per course and a total of three repeats are permissible in the academic program. The latest grade earned shall be considered for computation of cumulative GPA. A letter “R” will be affixed against the course attempted the first time, and symbol # will be affixed with the grade earned on the repeat attempt on the transcript
- The students will only be allowed to repeat a course if the seats are available in a classroom after admitting the students of a regular batch. The preference will be given to the students who have lower grades over the students who have higher grades, if the number of students exceeds the capacity of a classroom
- The students, who have repeated any course, are ineligible to get academic medals and merit certificates

Grade “W”: Withdrawn
Students may withdraw courses in a semester according to the dates mentioned in academic calendar. The request for withdrawn courses shall be made with the approval of the academic advisor on the prescribed form. Fee paid for these courses will not be reimbursed. The course will be required to be repeated by the students whenever offered the very next time.

Add/ Drop Course
Students may add or drop courses in a semester according to the dates mentioned in academic calendar. The request for add or drop courses shall be made with the approval of the academic advisor on the prescribed form

Attendance
Students are required to be regular and punctual. A student with less than 80% attendance in a course shall not be allowed to sit in the final exam of that course and a “WSA” grade will be awarded. Minimum 80% attendance is mandatory in a repeat course as well

Readmission
A student dropped-out on academic basis, may apply for readmission through the regular admission process with the subsequent intake

Academic Integrity
Academic integrity is maintained strictly. A zero-tolerance policy is enforced for academic dishonesty. Any such case is referred to the Disciplinary Committee. The student has the right to appeal against the decision to VC (IST), within 15 days of serving of warning letter by the mentioning the penalty. The decision taken by the VC (IST) will be final and binding.

Conduct and Discipline
Good conduct and discipline is expected of all students of the Institute. Any case of misbehavior or indiscipline is dealt strictly. If a student's registration is ever cancelled on disciplinary grounds, the student shall be ineligible for readmission to the Institute.
Faculty

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Dr Muddassar Farooq  Dean
Engr Ishaat Saboor  Registrar
Dr Abid Ali Khan  Head - Aeronautics & Astronautics
Dr Qamar ul Islam  Head - Electrical Engineering
Dr Ibrahim Qazi  Head - Materials Science & Engineering
Dr B. M. K. Ghauri  Head - National Centre for Remote Sensing & Geo-Informatics Science
Dr Asif Asrar  Head - Mechanical Engineering
Dr. Farrukh Ahmed Chishtie  Head - Space Science
Dr. Muhammad Fahim Hashmi  Head - Failure Analysis Center
Ahmed Jamal Gilani  Director Administration
Tariq Javid Malik  Director Establishment
Arbab Mehmood Ahmed  Head - Quality Enhancement Cell
Muhammad Zia Sarwar  Chief Finance Officer
Khurram Humaiyun  Dy Director Administration
Umar Saleem Butt  Controller of Examinations
Vaqar Ehsan-i-Haque  Dy Director Admissions
Muhammad Hafeez  Dy Director Facilities & Services
Dr Najam Abbas Naqvi  Head - Student Affairs
Mirza Muhammad Naseer  Head - Library
Tahir Abbas  In charge-Hostel
LOCATION MAP OF IST KARACHI CAMPUS
Location Map
Institute of Space Technology
1, Islamabad Highway
Near CDA Toll Plaza
Islamabad
Disclaimer
The contents as stated in this prospectus are expression of intent only. The institute reserves the right to discontinue any portion or make amendments at any time without notice.