COURSE INFORMATION BOOKLET
2018-19
(A Guide to Courses at IIT BOMBAY)
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DISCLAIMER

The information written in the booklet is only a guideline to the students to help them with their choices in the courses they make and also in the various important features of the institute academic system. It may happen that the actual details of courses or rules mentioned in the booklet may face an amendment or change any time. Please confirm the rules/details from relevant authorities before making any decisions. The Academic Council members can be contacted for this purpose (details shared on the last page of the booklet).
PREFACE

Dear Students,

This information booklet has specially been made for you! Through this booklet we aim to open doors for your way ahead with academics in IIT Bombay, this booklet will help you make a choice beyond what you would learn in your core curriculum, pursue courses by keeping in mind your true interests and future aspirations. This booklet will tell you about the various options available to you for pursuing your true passion and hopefully make learning more enjoyable and wonderful for you. This booklet will tell you about the various categories of courses, the advantages of doing a minor and how you should go about finding a minor program which suits you in all respect! If you have missed out what you exactly wanted to learn because of your JEE rank this is the time to cover up for it! A minor program will help you far beyond than what you think and in this world of cutting edge interdisciplinary research will help you mold yourself into a good engineer or scientist. We are open to suggestions and ideas from your side to improve this booklet.

Wishing you a good stay at IIT Bombay and a bright future!

Best Wishes,

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We would like to thank all the DAMP Teams of the UG departments for reviewing the course descriptions and also to all the people whom we might have missed above for their contribution in providing the updated information.
1. **Category of Courses**

1.1. **Core Courses:**
Core courses are those courses which you have to do compulsorily for obtaining your degree. These courses count towards your final degree in all respects and count in your core CPI (Cumulative Performance Index). These courses are **NOT** optional and have to be completed within the stipulated duration of your coursework (4 or 5 years). They give you a lot of exposure to your own departmental subjects and research; They also have an elective component, details regarding which are explained in the section on electives.

1.2. **Minor Courses:**
A Minor is an additional credential, a student will earn if he/ she does minimum 30 credits worth of additional learning in a discipline other than his/ her major discipline. Most of the academic units in the Institute offer minors in their disciplines, and prescribe a specific set of courses and/ or other activities like projects for earning a minor in that discipline. Note that, courses equivalent in content to any of these specified courses from the same dept. can be taken as a minor course with the approval of the concerned HOD. After the completion of credits under the stipulated time period, a minor degree is awarded to the student. It is mentioned in the Degree Certificate as "Bachelor of Technology in xxx with Minor in yyy." The fact will also be reflected in the transcript along with the list of courses taken.

Minor courses are allocated to students through a pre-registration process before the starting of every semester and the allocation for every minor course is done on the basis of CPI of the student as the seats are limited in every minor course. If you miss out on the allocation of a minor course due to CPI constraints you can avail a position in the waitlist for a course so that if some student drops the course you can take up the seat (Wait list allocation would be first come first serve though, and depends on the time that you enrolled in the waitlist at the time of registration).

Dual degree students are allowed to register for a minor only if they have a CPI above 8.0. Back loggers will not be allowed to take up minor courses until they clear them. Minor courses do not count in your core CPI.

1.3. **Honor Courses:**
Honour is an additional credential a student will earn if he/ she opts for the extra 24 credits (in some cases, 30) needed for this in his/ her own discipline. The concerned department specifies the course requirements for earning the Honors. An Honor is like a specialisation in your own discipline.
Honor courses are either advanced level courses in your discipline, or are courses designed to give you more exposure to different areas of your discipline. On successful accumulation of credits at the end of the programme, this will be mentioned in the Degree Certificate as “Bachelor of Technology in xxx, with honours.” The fact will also be reflected in the transcript, along with the list of courses, etc. taken. Dual Degree students have to do the Honors courses by default. They are considered as their core courses. Honor courses do not count in your CPI other than for dual degree students. You can register for an Honor and minor both together if you have a CPI>8 with no backlogs.

1.4. Electives:
Every programme (B.Tech/ M.Tech/ Int. M.Sc.) in IIT Bombay will have its own curriculum defined, which will define your core courses and the total credit requirement for the award of the degree. According to your curriculum your course completion may require doing courses of your own choice, wish and interest from:

1. **Dept. of Humanities and Social Sciences- Humanities Elective**
   All undergraduates are required to do a Humanities elective from HSS department in their third year and you have to choose this elective from the following set: HS 301 - Philosophy, HS 303 - Psychology, HS 307 - Sociology, and HS 309 - Introduction to the Study of Language.

2. **Your own department- Department Elective**
   As per your curriculum you may be required to choose a few courses (Number varying across programmes) of higher level (Say 4xx or 5xx) from your department across a pool of courses put forward by your department.

3. **A department other than yours- Institute Elective**
   As per your curriculum you may be required to choose a few courses (Number varying across programmes) from a foreign department. Generally you are free to choose any course out of your department (Except 1xx courses and some of the IDC courses, you ask the concerned faculty and HOD to ask if they will allow a particular IDC course to be tagged as institute elective) as Institute electives. Instructor/ Departmental based restrictions may be there.

All these electives are a part of the core curriculum and will count in your CPI.
1.5. Additional Learning Courses:
All students with a CPI > 8 (Category 1 standing) are permitted to overload beyond Honors and Minors and take up extra courses to tailor their profile as per interest. A student may also take up additional learning courses instead of Minors or Honors even to do courses of his/ her interest. Additional learning courses can be credited or audited. These ALC courses don’t constitute the core CPI/SPI of a student. The tag of such a course can be changed during the retagging period which is explained later.
2. Why minor? And which minor to select?

A minor degree adds value to your major degree and will enable you to get opportunities in the field you have completed your minor or even help you to shift to the field in which you have done your minors in future. Your minor degree will give you sufficient knowledge to enable you to do research in an interdisciplinary field and even pursue your higher studies in the same, abroad at elite institutions. You should go about selecting your minor degree in such a way that it either suits your major degree in a research oriented interdisciplinary aspect or in a generic way to any engineer or scientist.

Before you select a minor, try to find what you are truly interested in. There would definitely be something that would generate a spark in you, and it’s your job to find it out, and you do that by simply searching for it. Once you are done with this, you will definitely enjoy learning and become what you aim for.

You can select any minor course from any department but to draw the complete benefit out of it you should look for overlap between them and your discipline so that it supplements your learning, however there is no harm in learning something different and new and you may always try out something different. Minor courses don’t count in your CPI, so you should select a minor based on your interest.

Listed on the next page is a suggested set of minor programme which may suit each branch. This matching is done by looking at how much overlap each discipline has with respect to other fields, so that the minor programmes can support interdisciplinary learning of each student depending on his career plans:
<table>
<thead>
<tr>
<th>Minor Programme</th>
<th>Suitable Branches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace Engineering</td>
<td>Mechanical, Electrical, Civil</td>
</tr>
<tr>
<td>Biosciences and Bioengineering</td>
<td>Chemistry, Engineering Physics, Chemical, Electrical, Metallurgical Engineering and Material Sciences, Energy</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Engineering Physics, MEMS, Electrical, Chemical, Energy</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>Chemistry, Mechanical, Electrical, Energy</td>
</tr>
<tr>
<td>Centre of Studies in Resources Engineering (CSRE)</td>
<td>Electrical, Computer Science, Engineering Physics</td>
</tr>
<tr>
<td>Computer Science and Engineering</td>
<td>Suits all!</td>
</tr>
<tr>
<td>CTARA</td>
<td>Suits all!</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>Engineering Physics, Chemistry, Chemical, Mechanical, MEMS, Energy, Aerospace, CSE</td>
</tr>
<tr>
<td>Energy</td>
<td>Mechanical, Chemical, Aerospace</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>Suits all!</td>
</tr>
<tr>
<td>Environmental Sciences and Engineering</td>
<td>Chemistry, Chemical, Civil</td>
</tr>
<tr>
<td>Humanities and Social Sciences</td>
<td>Suits all!</td>
</tr>
<tr>
<td>Industrial Design Centre</td>
<td>Suits all!</td>
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<tr>
<td>IEOR</td>
<td>Suits all!</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Suits all!</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>Civil, Electrical, Aerospace</td>
</tr>
<tr>
<td>Management</td>
<td>Suits all!</td>
</tr>
<tr>
<td>Physics</td>
<td>Chemistry, Chemical, Electrical, Mechanical, MEMS</td>
</tr>
<tr>
<td>Statistics and Informatics</td>
<td>Suits all!</td>
</tr>
<tr>
<td>Systems and Control Engineering</td>
<td>Engineering Physics, Electrical, Mechanical, Civil, Chemical, Aerospace</td>
</tr>
</tbody>
</table>
3. **Why Honours?**

Honor courses are either advanced level courses in your discipline, or are courses designed to give you more exposure to different areas of your discipline. They help you get focused knowledge in your department to take a job in a certain specialized area, so that you can compete with, say, an M.Tech who has specialized in the same area. You are likely to develop strong subject skills by completing an honor successfully. Undergraduate classes have introduced you to a wide range of topics and problems, and an Honors project enables you to explore one in much greater depth. Honors research topics are various and negotiable – if you are really interested in a topic and want to find answers, you’ll be encouraged and supported.

From a potential employer’s perspective, whatever your department, it looks very good to have demonstrated ability in achieving a complex goal and having a more focused knowledge in your department. If you’re in for the learning experience, by all means, it is.

Honor courses help you a lot if you want to go for potential research opportunities in the future. Since, you have more dedicated knowledge in your specialization, your resume getting shortlisted for an MS program in an elite university has much higher chances. Honor courses don’t count in your CPI. You have a separate Honors CPI so taking a course or two and not being able to complete your Honors also won't harm you much as it will give you some detailed idea about your department in any case.
4. Tagging Rules

Every course that you do in the institute falls under one of the categories of courses as described in the section 1 and hence a tag is given to the course that you have done, in order to classify them. The tags of electives can be changed as per the rules that follow.

This facility allows students to do additional courses and finally make select courses count towards 'Core CPI' (the CPI of prescribed curriculum credits; Core CPI is used for placement purposes).

Rules: Re-tagging will be available to students ONLY TWICE in their entire program duration, first time before placements (Second Last Semester Starting) and second time post curriculum completion (Last Semester). The courses that have been re-tagged during the opportunity given during the previous window will be debarred from the re-tagging process.

NOTE: From year 2017 onwards, the tagging window for Category I DD Students will also be the same as the re-tagging window of their B.Tech counterparts (those who are graduating). For them (Category I DD students), the second window for re-tagging will be made available at the time of graduation. This has been done to ensure a fair process of selection for the institute medals.

For the rest of the categories’ DD students, first tagging window will be opened in the Autumn Semester before placements and the second one at the time of their graduation.

Tags of courses:
(i) Core - C
(ii) Department Elective - D
(iii) Institute Elective - I
(iv) Additional Learning Minors- M
(v) Additional Learning Others- T
(vi) Additional Learning Honors - O/ E (Honors core/ elective)

An approved change of tag will result in fresh calculation of SPI/ CPI from the semester the tag change has been made effective due to the fact that additional learning course(s) do NOT constitute the core SPI/ CPI of a student.

On the next page is given a table specifying the current rules about the changing of tags from one to another and the restrictions put on the same:
<table>
<thead>
<tr>
<th>TAG CODE</th>
<th>TAG DESCRIPTION</th>
<th>CHANGEABLE INTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Additional Learning</td>
<td>D,I,O,E</td>
</tr>
<tr>
<td>C</td>
<td>Core Course</td>
<td>Not Changeable</td>
</tr>
<tr>
<td>D</td>
<td>Department Elective</td>
<td>O,T,E</td>
</tr>
<tr>
<td>O</td>
<td>Honours Course</td>
<td>D,E,T</td>
</tr>
<tr>
<td>E</td>
<td>Honours Elective</td>
<td>D,O,T</td>
</tr>
<tr>
<td>H</td>
<td>Humanities Elective</td>
<td>T</td>
</tr>
<tr>
<td>I</td>
<td>Institute Elective</td>
<td>T</td>
</tr>
<tr>
<td>M</td>
<td>Minor Course</td>
<td>I,T</td>
</tr>
</tbody>
</table>

**Note:**
For any special requests i.e. a change, which cannot be implemented on the tagging interface, the student has to get an approval from his/her Faculty Advisor and HOD of concerned department (other department in case of minors).
5. Minor Courses of Different departments

This section gives a comprehensive description of the minor, and the course contents and the major topics covered in the minor courses of various departments.

5.1 AEROSPACE ENGINEERING

PREFACE:
The Aerospace Engineering minor develops the engineering-analysis and design skills necessary for creating and understanding aerospace vehicles and their subsystems. The minor includes diverse topics relevant to applications both in the Earth’s atmosphere (e.g. aerodynamics) and in space (e.g. spacecraft thermal systems or orbital mechanics). Aerospace Engineering is broadly divided in four sub-groups: Structures, Aerodynamics, Propulsion and Control & Navigation.

COURSES:
Minor in aerospace engineering is composed of two components; a compulsory part containing the following two courses and a minor basket for choosing the remaining three courses.

AE 153 – Introduction to Aerospace Engineering (Offered in III Semester)
This is the Department Introductory Course (DIC) for aerospace engineering and introduces students to the fundamentals of fluid mechanics and basic aerodynamic phenomenon.
Basic Aerodynamics: Streamlines, steady fluid motion, incompressible flow, Bernoulli’s equation, Mach number, Pressure and airspeed measurement, Boundary Layer, Reynolds number, Laminar and Turbulent flow.
Aerofoils and wings: pressure coefficient and lift calculation, Critical Mach number, Wave drag, Finite wings, induced drag and swept wings.
Aircraft performance: steady level flight, Altitude effects, Absolute ceiling, steady climbing flight, Energy methods, Range and Endurance, Sustained level turn, pull-up maneuver, V-n diagram, Take-off and landing.
Re-entry vehicles: Ballistic and Glide Reentry, Blunt body concept.

AE 415M – Spaceflight Mechanics (Offered in IV Semester, Prerequisite: AE 153)
Both these courses are to be offered in slot 5 with applicable semester restriction. Students desirous of minor in aerospace must complete these two courses, in the specified sequence, before choosing courses from basket.

Minor Basket:
In addition to the above two courses, students pursuing minor in aerospace engineering are required to complete three more courses over remaining four semesters (V, VI, VII & VIII), by
choosing courses from minor basket below. As a rule, they are required to do any three courses from the two sets, but can do a maximum of two from any one set).

**First set: Autumn Semester:**

**AE 227M – Solid Mechanics (Not available to students of CE, ME, EN)**
This course falls under the Structures sub-group of Aerospace Engineering and deals with the basics of Solid Mechanics. Contents of this course are generic to Mechanical, Civil and Energy Engineering. Topics include: Euler-Bernoulli Beam Theory, Truss Structures, Cauchy Stress Tensor, Buckling of Columns, Mohr’s Circle.

**AE 225M – Incompressible Fluid Mechanics (Not Available to students of CE, ME, EN, CL)**
This course falls under the Aerodynamics sub-group of Aerospace Engineering. It is the first part of the module of Fluid Mechanics and focuses on the elementary physics of Fluids. Course contents: Definition of Fluids and parameters associated with them, Pascal’s Pressure Law, Reynolds Number, Bernoulli’s Principle, Euler Equation, Potential Flow Theory, Viscosity in Fluids, Navier-Stokes Equation.

**AE 223M – Thermodynamics and Propulsion (Not Available to students of CE, ME, EN, CL)**
This course falls under the Propulsion sub-group of Aerospace Engineering. It deals with the basics of Thermodynamics and briefly focuses on the aspects which are specific to Aircraft and Rocket Engines. Topics include: Laws of Thermodynamics, Types of thermodynamic processes, Carnot Engine, Carnot Cycle, Otto Cycle, Diesel Cycle, Brayton Cycle, Outline of an Aircraft Engine, Heat Transfer.

**AE 234M – Aircraft Propulsion (To run with AE 711, prerequisite: AE 223M or equivalent)**
This course falls under the Propulsion sub-group of Aerospace Engineering. It deals in detail with the different parts of an Aircraft Engine and their analysis. Topics include: Brayton Cycle, Brayton Cycle with Reheating, Regeneration and Intercooling, Aircraft Engine Intake, Axial and Centrifugal Compressors, Turbines, Nozzles and Afterburners.

**AE 236M – Compressible Fluid Mechanics (To run with AE 616, prerequisite: AE 225M or equivalent)**
This course falls under the Aerodynamics sub-group of Aerospace Engineering. It is the second part of the module of Fluid Mechanics and focuses on the physics of Compressible Fluids. Topics include: Compressibility, Mach Number, Adiabatic Compressible Flow Relations, Shock Waves, Expansion Waves, Shock Tube Experiment.

**AE 238M – Aerospace Structural Mechanics (To run with AE 709, prerequisite: AE 227M or equivalent)**
This course falls under the Structures sub-group of Aerospace Engineering and deals with the
aspects of Solid Mechanics relevant to Aircraft flight. Topics include: Flight Envelope, Torsion, Membrane Analogy, Thin Walled Beam Theory, Warping, Torsional Buckling, Shear Flow, Structural Instability Analysis.

**AE 305M – Flight Mechanics (To run with AE 305)**
This course jointly falls under the Control & Navigation and Aerodynamics sub-groups of Aerospace Engineering. It emphasizes on the dynamic behaviour of an aircraft in flight and its associated phenomena. Topics include: Equilibrium, Static Stability and Control, Longitudinal Stability and Control, Trim Condition, Hinge moments, Neutral Point, Lateral Stability, Equations of Motion, Euler Angles, Body-fixed axis, wind axis, stability axis, Phugoid Mode, Short-Period Oscillations, Dutch Roll.

**AE 4xxM – Modelling and Simulation (To run with AE 4xx)**
This course falls under the Control & Navigation sub-group of Aerospace Engineering. It deals with the concepts of Modelling a System and performing Simulations. Course contents: Modelling techniques, Types of Simulations, Mechanical Systems, Electrical Systems, Hydraulic Systems.

**AE 333M – Aerodynamics (run with AE 333, prerequisite: AE 225M, AE 236M or equivalent)**

**AE 3xxM – Vibrations and Structural Dynamics (To run with AE 3xx, prerequisite: AE227M or equivalent)**
This course falls under the Structures sub-group of Aerospace Engineering. It deals with the Dynamics of structures and the associated phenomenon. Topics include: Modal Analysis, Analysis of Multiple-DOF Systems, Dynamic Instabilities in Structures, Effects of Damping and Stiffness, Energy Methods.

**Second Set: Spring Semester:**

**AE 234M – Aircraft Propulsion (To run with AE 234)**
This course falls under the Propulsion sub-group of Aerospace Engineering. It deals in detail with the different parts of an Aircraft Engine and their analysis. Topics include: Brayton Cycle, Brayton Cycle with Reheating, Regeneration and Intercooling, Aircraft Engine Intake, Axial and Centrifugal Compressors, Turbines, Nozzles and Afterburners.

**AE 236M – Compressible Fluid Mechanics (To run with AE 236, prerequisite: AE 225M or equivalent)**
This course falls under the Aerodynamics sub-group of Aerospace Engineering. It is the second part of the module of Fluid Mechanics and focuses on the physics of Compressible Fluids.
Topics include: Compressibility, Mach Number, Adiabatic Compressible Flow Relations, Shock Waves, Expansion Waves, Shock Tube Experiment.

**AE 238M – Aerospace Structural Mechanics (To run with AE 238, prerequisite: AE 227M or equivalent)**
This course falls under the Structures sub-group of Aerospace Engineering and deals with the aspects of Solid Mechanics relevant to Aircraft flight. Topics include: Flight Envelope, Torsion, Membrane Analogy, Thin Walled Beam Theory, Warping, Torsional Buckling, Shear Flow, Structural Instability Analysis.

**AE 3xxM – Aerospace Propulsion (To run with AE 3xx, prerequisite: AE 225M, AE 236M or equivalent)**
This course falls under the Propulsion sub-group of Aerospace Engineering. It is complementary to the Aircraft Propulsion Course and deals with the thermodynamic analysis of Rocket Engines and the phenomenon associated with them. Topics include: Types of Rocket Engines, Parts of a Rocket Engine, Fuel Analysis of Rocket Engines, Flight Trajectory of a Rocket Engine.

**AE 332M – Aircraft Design** (To run with AE 332, prerequisite: AE 305M or equivalent)
This course is specific to the design of an aircraft and deals with the aspects of Aircraft Performance. Topics include: Types of Civil and Military Aircrafts, Design Process of an Aircraft, Sizing of an Aircraft, Weight estimation, Rubber Engine Sizing, Range-Payload Diagrams, V-n diagrams, Aircraft Rules and Regulations, Comparison of various Aircraft Configurations.

**AE 308M – Control Theory** (To run with AE 308)
This course falls under the Control & Navigation sub-group of Aerospace Engineering. It is an elementary course dealing with the basics of Classical Control Theory. Course contains: Laplace Transforms, Open Loop and Closed Loop Systems, Root Locus, Pole-Zero Placement, PID Control, Bode Plot, Nyquist Plot.

**AE 4xxM – Navigation and Guidance** (To run with AE4xx)
This course falls under the Control & Navigation sub-group of Aerospace Engineering. It describes the basic theory behind Navigation and Guidance of Aircrafts, Rockets and Missiles. Topics include: Working of RADARs, Continuous Wave RADARs, Navigation Theory, Observability, Kalman Filter Design, EKF, Guidance Laws for Missiles.

All minor registrations will be carried out in consultation with minor coordinator Prof. Viren Menezes.
5.2 BIOSCIENCES AND BIOENGINEERING

PREFACE:
The minor elective courses from this Department include courses from both the Biosciences and Biomedical fields, providing a short introduction to each so that students can pursue whichever of them catches their attention. The Biosciences courses will be useful for the Chemical Engineering, Chemistry and Physics branches. The Biomedical courses will be useful for the above, in addition to Electrical Engineering and MEMS students.

COURSES:

**BB 400 – Molecular Biophysics:**
Molecular structure; Torsion angles; Steric effect: Contact distances; Homomorphous sugars; Cis & trans peptide bonds; Ramachandran map: for amino acids and as a general conformational analysis tool. Non-covalent interactions; hydrogen bond; stacking; Entropy: Entropy/enthalpy compensation; A=T vs. GºC. Effective conc. Enthalpic and entropic cooperativity. Oligopeptide conformation. Conformationally constrained amino acids; Hydrophobic effect; Affinity and specificity in intermolecular interactions; Stability of protein structure; Folding / unfolding; m values; Models of protein folding; Folding funnel; Contact order; F value analysis; Denatured state; Intrinsically unfolded proteins; Protein and RNA folding; In vivo folding; Kinetically stable proteins; Lipids: Assemblies; Volume, surface area, length relationship; X-ray studies; Phase transitions of anhydrous and hydrated lipid bilayers.

**BB 404 – Metabolism and Bioenergetics:**
Overview of metabolism; concept of flow of matter and energy; thermodynamics of coupled systems and non-equilibrium reactions; biological energy currencies: high energy bond, reducing power and interconversions of energy forms; carbon, nitrogen cycles in biosphere; classification of living system based on carbon and energy requirements; methods to study metabolism; carbohydrate and lipid catabolism; glycolysis; TCA cycle; fatty acid oxidation, other metabolic routes of carbon; oxidative phosphorylation; biosynthesis of carbohydrates and lipids photosynthesis; photosynthetic electron transport; Calvin cycle and other avenues of harvesting light energy; gluconeogenesis; Cori cycle; glycogen metabolism; biogenesis of fatty acids and sterols; nitrogen metabolism: sources of organic nitrogen; flow of nitrogen into biosynthesis and catabolism of amino acids; central role of glutamine; purines and pyrimidines; the metabolism of nucleotides; urea cycle and excretion of nitrogen; integration of metabolism and concepts of metabolic regulation.

**BB 405 - Molecular Biology:**
Nucleic acids, DNA structure, central dogma; Replication: eukaryotic and prokaryotic replication, mechanism and control, replication of double stranded and single stranded circular DNA, the end-replication problem and telomerase; Nucleosomes: eukaryotic and prokaryotic genome packing, heterochromatin, euchromatin; Transcription: mechanism of RNA transcription in prokaryotes and eukaryotes; model systems of transcriptional control: lac operon, lambda phage; promoters, enhancers, repressors; RNA processing: processing of
heterogeneous nuclear RNA: splicing, capping, polyadenylation; Translation: universal genetic code, degeneracy of codons, mechanisms of initiation, elongation and termination of translation, wobble hypothesis, genetic code in mitochondria; Mutations: nonsense, missense, frameshift and point mutations; intragenic and intergenic suppression; DNA repair: photoreactivation, excision, mismatch and SOS repair; Recombination: mechanism of homologous recombination in prokaryotes, site specific recombination, insertion sequences, Transposons.

**BB 411 – Introduction to Molecular Cell Biology:**

**BB 503 – Genetic Engineering:**
Concept of recombinant DNA technology and purpose, basic methodology, use of plasmids, Type I, II and III restriction modification systems, type II restriction endonucleases, nomenclature and sequence recognition, mcr and mrr genotypes, linkers, adaptors, blunt end ligation, homopolymeric tailing, Transformation, methods in screening recombinant DNA. Radioactive and nonradioactive methods for labeling DNA: Nick translation, random priming, use of Klenow enzyme, T4 DNA polymerase, bacterial alkaline phosphatase, polynucleotide kinase, hybridization techniques, northern, Southern and colony hybridization. Restriction maps and mapping techniques. PCR technology, enzymes in PCR, hot-start, touchdown PCR, primer design, introduction of restriction sites etc. Construction of cDNA libraries in plasmids, hybrid select translation, RT-PCR and quantitative RT-PCR. Strategies for maximizing gene expression, prokaryotic expression vectors; pMal, GST fusion vectors, pET vectors and their applications in expression, quantitation, purification. Inclusion bodies, approaches to solubilization, Intein based expression and purification vectors. Cloning in M13 mp vectors, application to DNA sequencing, site-directed mutagenesis; PCR-based mutations. Transcription vectors. Lambda vectors; insertion and replacement vectors, selection and screening recombinant phage, in vitro packaging, genomic libraries and cDNA cloning, application of lgt 10, lgt 11, IZAP vectors. Cosmid vectors. Yeast transformation, yeast cloning vectors, specialized vectors such as gap and retrievers, principles and application of dihybrid systems. Cloning and expression in mammalian cells, methods of selection and screening, application of reporter genes. Basic principles of transcriptomics and proteomics.

**BB 507 – Molecular Enzymology:**
Rate accelerations in biological systems; Catalysis and historical perspective on enzymes; Overview of applied enzymology and enzyme technology; Enzyme nomenclature; Origins of enzyme catalytic power; Structural basis of enzyme action and characterization of active site
residues; Kinetic approaches to understand enzyme action; Michaelis-Menten kinetics; Evaluation of Km, kcat and enzyme inhibition analysis; Concept of an efficient catalyst; Elucidation of kinetic mechanism through initial velocity, product inhibition, pH and isotopic analysis; Role of metal ions in enzyme catalysis; Integration of kinetic, chemical and structural data to describe enzyme action; Control of enzyme activity and its role in regulating metabolism – in vivo enzymology; Frontiers in enzymology: Rational design of an enzyme catalyst, directed evolution, abzymes, non-protein catalysts.

**BB 603 – Physiology for Engineers:**
Basic cell physiology; Biochemical cycles. Systemic physiology: Neuromuscular system; Blood and lymph; Circulatory system; Respiratory and Cardiovascular system, Gastrointestinal system; Kidney and excretory system; Sensory systems- visual, auditory, vestibular; Endocrine- pituitary, adrenal, pancreas, Clinical and technological implications.

**BB 605 – Genetics and Evolution of Biological Circuits:**

**BB 610 – Biomedical Microsystems:**
Introduction; photolithography; mask design; wet and dry etching; thin film deposition and growth, electroplating, molding, LIGA, bonding and sacrificial processes, polymer processing and rapid prototyping, biomaterials and biocompatibility issues, micro total analysis system (μTAS): Fluid control components, μ-TAS: sample handling, μ-TAS: separation components, μ-TAS: detection, cell handling and characterization systems, systems for biotechnology and PCR, polynucleotide arrays and genetic screening, miniature biosensors, biosensors arrays and implantable devices, neural interfaces, microsurgical tools, microneedles, and drug delivery, miniature bioreactors and Microsystems for tissue engineering, tissue scaffolds, optical biosensors, MEMS metrology, MEMS packaging.

Detailed course contents can be found on the departmental website: www.bio.iitb.ac.in/academics/minor-courses

5.3 CHEMISTRY
PREFACE:
Chemistry, a branch of physical science, is the study of the composition, structure, properties and change of matter. Chemistry is chiefly concerned with atoms and their interactions with other atoms - for example, the properties of the chemical bonds formed between atoms to create chemical compounds. Whatever you touch and see in chemistry and it plays a major role in every field. A Chemistry minor is ideal for Physics, Material science and Electrical engineering (In Nanoelectronics) students as they need the direct applications of chemistry in their core research fields.

COURSES:

CH 104 – Chemistry 2:
This is the department introductory course for the 4 year BS students and has two portions, Organic and Inorganic.
Inorganic Chemistry: Organometallic compounds - their synthesis, term symbols for d-block elements.
Organic Chemistry: Recap of various Organic reactions and mechanisms which students have learnt in JEE.

CH 227 – Introduction to Transition Metal Chemistry:
This course starts off with a basic recap of the d block transition metal complexes, their properties and spectra interpretation and then onto inorganic photochemistry. The inorganic photochemistry deals with basics of fluorescence (excitation and emission), Jablonski diagram, and interpretation of spectra.

CH 229 – Chemical Thermodynamics:
The initial part of the course discusses basic definitions and laws of thermodynamics, which the students study during their JEE preparations. The later part of the course discusses advanced topics such as reversible cycles, irreversible cycles and fugacity to deal with real systems. An advanced version of solutions and colligative properties is also taught. The last part deals with phase transformations, phase diagrams, and binary and ternary systems.

CH 223 – Structure and Stereochemistry:
This course gives the students a good exposure onto frontier molecular orbital theory and various chemical reactions are understood using this theory. Pericyclic reactions are mainly taught for giving a good insight in understanding MOT based interpretation. The second half introduces students to the powerful tool of spectroscopy and how it’s used in understanding molecular structure. Interpretation of NMR spectroscopy, Mass spectrometry, IR spectroscopy etc are taught in details.

For the fifth course for completing the 30 credit requirements of a minor you are free to choose any 4 level course (CH 4XX).
5.4 CHEMICAL ENGINEERING

PREFACE:
Chemical Engineering is a field of engineering which uses physical or life sciences like physics, chemistry, and biology and combines them with intensive use of mathematics and economics to process raw materials into substances which are useful, valuable or desired. It involves the scaling up the reactions performed in a chemistry laboratory to produce the desired chemical on an industrial scale.

Chemical engineers deal with the transformation of raw materials into useful products that have an impact on virtually every facet of human life. However, this requires an understanding of principles of micro, meso and macro scale processes which are dealt with while doing the courses.

Within Chemical Engineering, there are two broad subgroups. One of them deals with the design, manufacture, and operation of plants and machinery in industrial chemical and related processes ("chemical process engineers") while the other deals with the development of new or adapted substances for products ranging from foods and beverages to cosmetics to cleaners to pharmaceutical ingredients, among many other products ("chemical product engineers").

Chemical engineers work in a diverse range of responsibilities- manufacturing, supply chain, R&D, consulting, etc. Pursuing a minor in Chemical would equip you with knowledge that is necessary while designing plants/equipment. FMCG industries would value such skill the most since most of their work is an amalgamation of different engineering fields. The Chemical Engineering Minor would give a student an advantage in R&D the topics covered here expose you to a lot of different areas.

COURSES:
CL 152 – Introduction to Chemical Engineering:
Basic Stoichiometry, Analysis of systems with recycle, purge and bypass, Energy and Material Balances at Steady State, Single/Multicomponent system analysis, Psychometry, Chemical Processes Analysis.

CL 255 and CL 250 (Split over two 6 credit courses):
Chemical Engineering Thermodynamics: Equations of State and Generalized Correlations, Closed and Open Systems, First Law of Thermodynamics, Second Law and Entropy, Reversible Heat Engines, Power and Refrigeration Cycle, Solutions- Partial molar quantities; Gibbs-Duhem Equation; Phase-Rule; Phase Equilibrium Criteria, Non-ideal solutions; Residual and Excess Properties; Fugacity and Activity Coefficient models; Vapour-liquid equilibria (VLE) at low to moderate pressures, Raoult’s Law, Henry’s law, Chemical Reaction Equilibrium, Homogeneous and Heterogeneous Reactions, Combined Phase and Reaction Equilibria.
**CL 203 – Transport Phenomena:**
Vectors and Tensors, Equations of Change for isothermal systems, Substantial derivatives
Equations of change for Isothermal, Non-isothermal and multicomponent systems
Unidirectional flows and unsteady flows, Thermal conductivity and mechanism of energy
transport, Shell energy balances, Diffusivity and the mechanisms of mass transport

**CL 324 – Chemical Reaction Engineering:**
Kinetics, Reaction rate, order, rate constant, Batch reactors design and Kinetic Constants
Mass and Energy balances, Catalysts and Catalytic Rates and Transport, Reactor design for
ideal flow reactors, Yield and Selectivity, Residence Time Distribution, Segregation and
Maximum Mixedness models.

**CL 302 – Process Control:**
First Principles, Process dynamics for first, second and higher order systems, Linearization and
Transfer function models, Empirical models from data, Control system instrumentation,
Introduction to feedback control, Analysis of closed loop system, Frequency response using
Bode and Nyquist plots, Control design techniques, Time and frequency domain techniques,
Advanced control strategies, Cascade and feedforward, Introduction to multivariable control,
Controller implementation through discretisation.

**NOTE:** Students pursuing a minor in Chemical Engineering have to complete the courses
while they are running in core course slots in the department, and not the default slot for
minor (Slot 5).

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### 5.5 CENTRE FOR STUDIES IN RESOURCES ENGINEERING

**PREFACE:**
Modern technologies like Geographic Information System (GIS), Global Positioning System
(GPS), Satellite image processing and Remote Sensing, are extensively used in the Centre's in
teaching, research, consultancy and continuing education programmes. CSRE has been
active in contributing significantly towards the needs of developing and demonstrating the
technology of satellite data utilization and development of Geographic Information System.
The Centre has successfully demonstrated the application potential of remote sensing
technology in the programs of disaster mitigation like drought and flood along with national
agencies such as ISRO and NRSA.

**COURSES:**

**GNR 401 – Remote sensing and Image processing:**
Remote sensing is the acquisition of information about an object or phenomenon without
making physical contact with the object. In modern usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on Earth (both on the surface, and in the atmosphere and oceans) by means of propagated signals (e.g. electromagnetic radiation). In imaging science, image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

**GNR 403 – Geo-informatics Lab:**
Tutorial on Spatial data generation, management, modeling, analysis and applications; on satellite image georeferencing, enhancement and filtering, transformations, classification and accuracy assessment and applications Laboratory sessions involving use of state-of-the-art GIS and image processing software to get familiarized with handling and analyzing spatial datasets including satellite images Reading and discussing papers/reports on image processing / GIS / applications.

**GNR 405 – Mini Project:**
This involves a small independent study on a problem identified by the student and the faculty member supervising it. The mini-project may focus on a problem involving application of geo-informatics tools and techniques.

**GNR 407 – Natural hazards and Disaster management:**
Classification of disasters, natural, man-made, technological; scale, intensity and frequency of disasters, hazard zone mapping, risk assessment, vulnerability mapping, extreme event analysis; Forecasting, early warning systems, disaster preparedness, monitoring techniques, response and disaster management, rehabilitation and reconstruction strategies; Case studies on flood, droughts, snow avalanches, landslides, earthquakes.

**GNR 409 – Terrain Evaluation and Land use planning:**
Terrain unit, generalization of terrain, terrain classification: conventional and geomorphological approach, groundtruth collection, sampling schemes, integrated land survey methods, conventional approach to terrain evaluation systems, Quantitative terrain evaluation, drainage analysis, soil mapping, applications of remote sensing and GIS in civil engineering projects: geotechnical appraisal, site selection, route alignment, irrigation projects, urban planning and development and case studies. Resource-informatics for decision making; land use/cover and its dynamics; land degradation, conservation and rehabilitation; land use planning, case studies.

**GNR 411 – Integrated Coastal Management: Coastal and ocean scenario:**
coastal geomorphological processes and land cover, biological, physical and chemical aspects of oceans, marine pollution, causes and impacts Coastal hazards- cyclones, storm surges, tsunami, shoreline change and sea level changes, saltwater intrusion, wetlands and their role in marine ecological systems, carbon cycle, ocean atmosphere interactions and global warming, El Nino La Nina, Need and basic concepts of ICM, ICM history, prevalent legislations, case studies Use of Remote Sensing and GIS in ICM.
Preface:
Discrete mathematics lies at the core of CSE, more than the mathematics that students learn in the first year. Ability to write programs, reason about programs, modelling real life situations in programs - some level of fondness for all this will be very useful.

Other Benefits:
CSE minor will equip one with coding skills which will be useful in developing computational research methods in different fields. CSE minor will be relevant for the students interested in working in Quant companies and banks which have relevant profiles. CSE minor students are also allowed to sit for tests in companies like Google etc. during placements.

COURSES:
CS 207(M) – Discrete Structures:
Propositions and predicates, proofs and proof techniques. Sets, relations and functions, cardinality, basic counting. Posets and lattices: Dilworth’s theorem, inversion and distributive lattices. Graph theory : paths, cycles, trees, connectivity. Group theory : Lagrange’s theorem, homomorphisms, applications.

CS 213(M) – Data Structures and Algorithms:

CS 224(M) – Computer Networks

CS 347(M) – Operating Systems:

CS 416(M) – Foundations of Network Security and Cryptography:
Vulnerabilities, risks, attacks, defences, forensics. Examples and applications of Public Key

**CS 419(M) - Introduction to Machine Learning:**
This course will provide a broad overview of Machine Learning with a stress on applications. Supervised learning: Decision trees, Nearest neighbor classifiers, Generative classifiers like naive Bayes, Support vector Machines Unsupervised learning: K-Means clustering, Hierarchical clustering, EM, Itemset mining Applications: image recognition, speech recognition, text and web data retrieval, bioinformatics, commercial data mining.

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**5.7 ELECTRICAL ENGINEERING**

**PREFACE:**
Electrical engineering is a field of engineering that generally deals with the study and application of electricity, electronics, and electromagnetism. The department is actively engaged in research areas ranging from practical implementation to theoretical investigations. A rough classification of the research areas in the department are as: Communications and Signal Processing, Control and Computing, Power Electronics and Power Systems, Microelectronics and VLSI, Electronic Systems. The aim of the minor courses offered by the Electrical Engineering department is to give an overview of the basic subjects in the field:

(1) Communication and Signal Processing  
(2) Control and Computing  
(3) Analog and Digital Circuit design  
(4) Device Physics.

The idea of memory elements of ROM and PLA are required as these are the basic building blocks of storage of many computational devices. In this age where processing is autonomous, the elementary knowledge of finite state machines is useful for a logical approach to programming. For any engineering system, the measured quantity is generally a signal in some form; however this signal is distorted with noise. Therefore, to obtain measurements, it is necessary to process a clean signal for precision. This is particularly useful in the process control and instrumentation sector. Chips are designed for various applications in every field of engineering, also BJT and power diodes are used for various small or high voltage applications, as a result to find definite results for point of operation, stability etc. modelling of devices is required to put them in a form which can be solved by a computer or such like. The knowledge of the characteristics of these devices helps to place them in a familiar form, thus optimizing calculations. Together these courses aim to cater to the multifarious and ever-growing needs of the industry.

**COURSES:** (All of the following are 6 credit courses)
EE 210 – Signals & System:

EE 221 – Digital Electronics:
Review of basic combinational and sequential logic, Review of digital electronics, Digital Logic Families: TTL, CMOS etc., Number systems and basic digital arithmetic, Finite State Machine Design, Analysis and Synthesis, Introduction to Hardware Description Language, Array based logic elements (Memory, PLA, FPGA), Special Topics (such as processor design, testing and verification, special digital systems, asynchronous state machines etc.)

EE 204 – Analog Electronics:

EE 207 – Electronic Devices:
Modeling devices: Static characteristics of ideal two terminal and three terminal devices; Small signal models of nonlinear devices. Introduction to semiconductor equations and carrier statistics: poisson’s and continuity equations, Fermi-Dirac statistics and Boltzmann approximation to the Fermi-Dirac statistics. Semiconductor Diodes: Barrier formation in metal-semiconductor junctions, PN homo- and hetero- junctions; CV characteristics and dopant profiling; IV characteristics; Small signal models of diodes; Some Applications of diodes. Field Effect Devices: JFET/HFET, MIS structures and MOSFET operation; JFET characteristics and small signal models; MOS capacitor CV and concept of accumulation, depletion and inversion; MOSFET characteristics and small signal models. Bipolar transistors: IV characteristics and elers-Moll model; small signal models; Charge storage and transient response.

EE 325 – Probability and Random Processes:
Sets and set operations; Probability space, Conditional probability and Bayes theorem, Combinatorial probability and sampling models, Discrete random variables, probability mass function, probability distribution function, example random variables and distributions, Continuous random variables, probability density function, probability
distribution function, example distributions, Joint distributions, functions of one and two random variables, moments of random variables, Conditional distribution, densities and moments, Characteristic functions of a random variable, Markov, Chebyshev and Chernoff bounds; Random sequences and modes of convergence (everywhere, almost everywhere, probability, distribution and mean square), Limit theorems, Strong and weak laws of large numbers, central limit theorem.Random process. Stationary processes. Mean and covariance functions. Ergodicity. Transmission of random process through LTI. Power spectral density.

**EE 342 – Control and Communications:**

**5.8 ENERGY ENGINEERING**

In view of the problem of climate change and scarcity of fossil fuels, the field of energy engineering offers significant challenges and opportunities. The Department of Energy Science and Engineering offers a minor in Energy Engineering to enable undergraduate students with different backgrounds to understand the different aspects of energy engineering. Students will be exposed to the status of energy resources, its interaction with environment, the fundamentals of energy economics, different technologies associated with renewable energy sources, conventional power generation technologies and power generation capacity enhancement, and different techniques & technologies for energy management and energy conservation. An additional elective may be selected based on the interest from the list of electives (fuel cells, wind energy, solar thermal, solar PV, nuclear...). This provides an opportunity to explore possible options in energy efficiency and clean energy to develop sustainable energy systems.

**COURSES:**

**EN 301 – Introduction to Renewable Energy:**
Introduction to world energy scenario, Renewable energy resources, Radiation, Solar Geometry, radiation models; Solar Thermal, Optical efficiency, thermal efficiency, concentrators, testing procedures, introduction to thermal systems (flat plate collector), solar architecture, solar still, air heater, panel systems; Photovoltaic; Introduction to semiconductor physics, doping, P-N junction, Solar cell and its I-V characteristics, PV systems components, design of a solar PV systems. Biomass, Biomass resources, wood composition, pyrolysis, gasifier, biogas, biodiesel, ethanol; Wind, Introduction, types of wind machines, Cp-I curve & betz limits, wind resource analysis; Systems, stand alone, grid connected, hybrid, system design; Hydro systems, Hydro resources, types of hydro turbine, small hydro systems; Other systems, Geothermal, wave energy, ocean energy
EN 302 – Power Generation and Systems Planning:

EN 402 – Energy Management:

EN 403 – Energy Resources, Economics and Environment:
You can choose any courses from this Elective list to complete your last minor course:
1. EN 613 - Nuclear reactor theory
2. EN 615 - Wind Energy Conversion system
3. EN 616 - Direct Energy conversion
4. EN 617 - Thermodynamic analysis of Industrial Systems
5. EN 619 - Solar Energy for Industrial Process heat
6. EN 624 - Conversion of energy in buildings
7. EN 628 - Materials and for energy conversion devices
8. EN 630 - Utilisation of solar thermal energy
9. EN 632 - Waste to Energy
10. EN 634 - Nuclear reactor thermal Hydraulics and safety
11. EN 640 - Solar photovoltaics - Fundamentals, technology and application
12. EN 645 - Process Integration
13. EN 646 - Energy and climate

5.9 ENTREPRENEURSHIP

PREFACE:
Desai Centre for Entrepreneurship aims to provide all the necessary inputs to students at IITB including: A wide range of courses covering all the aspects of entrepreneurship; Facilities for prototyping, Proof of Concept, Exposure to Start-ups under development, mentoring support; and Internships at startups.

The courses would be based on the principles of experiential learning and immersion. Thus, students will get an opportunity to learn from entrepreneurs through class interaction, mentoring and internship. The courses offered by the Centre have been designed in line with this ideology. In addition, students will also be encouraged to take courses being offered by other Departments/Centres which can enhance inputs for innovation and development of new products and services.

CORE COURSES:

ENT 201 – Introduction to Entrepreneurship:
This is an introductory course in entrepreneurship and is designed to acquaint students with the evolution and impact of entrepreneurship on business and society. It introduces the students to the importance and application of techniques of innovation and creativity to the generation of new ideas. The course helps the students to understand the process of transformation of ideas into business opportunities.

ENT 202 – Business Skills for Entrepreneurs:
This course is designed to inculcate team building skills in students and help them appreciate the issues in establishing a new venture. This course introduces the student to building and managing an effective board of directors, different selling skills and sales strategies vital to the survival of a startup. In addition, topics related to viral marketing, executing a global market strategy, negotiating VC deals, sales deals and business deals are also discussed. The students are taught about customer care before, during and after a sale. The students are also groomed on presentation skills for communicating effectively with customers, employees and partners.
ENT 203 - Identifying and Exploiting Opportunities:
The course begins with a discourse on defining an entrepreneurial opportunity and seeing change as an opportunity. The course gradually shifts to introducing the participants to the different types of change, issues in emerging technology becoming technically and economically feasible, technological trajectories and technology drivers for new age entrepreneurs. There is also an emphasis on understanding how and why improvements occur in some technology domains more than in other and market mapping exercises to identify entrepreneurial whitespace in the new course.

ENT 204 - Developing a Proof-of-Concept (Basic):
The course is designed to enable students in converting their ideas with commercial potential into a tangible product/service. In addition to helping them understand the new product development process, it helps the students in learning to integrate the needs of the end-consumer into the new product development process. In this course the students are expected to use the new product development process to conceive their own new product or service. At this stage they are not expected to build a startup around this product or service.

ENT 205 - Intellectual Property for Entrepreneurs:
In this course students are introduced to the discipline of Intellectual Property. They are also taught the fundamentals of the Patenting process. The other topics covered in this course are Patent Informatics, Copyrights and Designs (including graphic and interaction design), Trademarks, Service, Dress Branding, Trade Secrets and other forms of IP. It is ensured that students receive ample exposure to Industry specific IP issues through representative case studies. The students are also taught IP Management and IP Issues in Agreements.

ENT 206 - Developing a Proof-of-Concept (Advanced)(pre requisite-ENT 204):
This advance course in developing a proof-of-concept for a product idea is an extension of the basic course ENT 204, which must be taken first before a student can enrol for this course. The students in this course are expected to enhance, improve and extend the features of the products developed in the basic course ENT 204 in the previous semester. Now they are expected to obtain customer feedback and perform a customer validation exercise. The students are expected to explore the possibility of commercializing the technology product ideas. The performance of the students is evaluated on the working models developed for product testing, learnings in iterations and skills imbibed during the prototype building process.

ENT 208 - Technology Venture Creation:
This course is designed to take the participating student teams through all the stages of a new venture creation with critical inputs from mentors leading to business proposals which are assessed at the end of the semester by faculty, experts and venture capitalists. This course focuses on converting technology ideas into business opportunities through important topics such as opportunity assessment and assessing technology ideas in terms of market opportunity and market validation of the product idea. The students are also exposed to the process of fundraising and IP management in the early and later stages of the development of a startup.

ENT 210 - Marketing for Entrepreneurs:
This course is designed for the unique marketing needs of entrepreneurs. The course starts with an introduction to the evolution of the discipline of marketing management. The students learn to appreciate the role of marketing within the startup framework through techniques of problem identification and market research. They learn to segment customers and develop focus for launch. They develop the customer value proposition and techniques for accelerated product/solution design. They undergo modules in lean marketing strategy for new ventures and early stage positioning, branding and communication. The student teams are taught pricing and commercial strategies during new product introductions. Due to the course's focus on entrepreneurship the students are taught techniques for managing marketing spend and measuring RoI. They also learn techniques of test marketing a new product/solution, competitive defense/differentiation and scaling up for profitability.

In addition to the instructors, visit by successful entrepreneurs, guest lectures and visits to startups are organized to enhance learning.

Credit Distribution (for B.Tech. Minor): ENT 205/210 are 3 credit courses, all others are 6 credit courses.

Key Deliverables spread across different semesters: Team details, Plan of action, Customer response and validation, Product development timeline, Product development plan.

**5.10 ENVIRONMENTAL SCIENCE AND ENGINEERING**

**PREFACE:**
The Centre for Environmental Science and Engineering (CESE) offers wide professional expertise and actively pursues sponsored research, consultancy and technical services. CESE is also very active in manpower development and regularly organizes tailor-made workshops and training programmes. It also offers opportunities for research in environmental protection through pollution control and prevention. Air, Water and Solid Waste issues are related with Chemical Engineering, Mechanical Engineering, Metallurgical Engineering and Material Sciences, Chemistry, Civil Engineering, Energy and Biosciences. This course prepares individuals for careers as engineers and scientists in Environmental Quality & Pollution Control. This program offers coursework and research opportunities leading to the masters and doctoral degrees and ultimately enable our graduates to contribute to the solution of current and future environmental problems.

**COURSES:**
**ES 203 – Water and Wastewater Engineering:**
Introduction to water and wastewater technology; water quality and effluent standards; Water demand forecasting; Determination of reservoir capacity; Water pollution; Environmental hydraulics; Water distribution systems; Wastewater collection; Water and Wastewater treatment: physical, chemical and biological unit operations; Sludge disposal.

**ES 204 – Environmental Chemistry:**
Aquatic Chemistry, Chemical equilibria and kinetics fundamentals, Acids and bases,

**ES 303 – Municipal Solid and Biomedical Waste Management:**
Solid waste management: Sources, Composition and Properties of Municipal Solid Waste, Engineering principles; Generation of solid waste; On Site handling, storage and processing including segregation; Collection of solid waste; Transfer and transport; Processing technique and equipment; Recovery of resources; Conversion products and energy; Composting; Recycling; Incineration and pyrolysis; Disposal of solid waste including sanitary landfill, planning, siting, design, closure and post closure monitoring; Regional/Integrated solid waste management related issues. Biomedical waste: Regulatory framework, categorization; generation, collection, transport, treatment and disposal.

**ES 306 – Environmental Systems Modelling:**
Definition; Classification; Examples of models for environmental systems. Introduction to air quality models; Meteorology; Atmospheric stability and turbulence; Gaussian plume model and modifications; Numerical models, Urban diffusion models, Calibration and sensitivity analysis; Applications of public domain models and software, Global radiation balance and climatic changes. Transport and fate of pollutant in aquatic systems; Introduction to river, estuarine and lake hydrodynamics; Stratification and eutrophication of lakes; Dissolved oxygen model for streams; Temperature models. Transport and fate of pollutants in soil and groundwater; Utility of environmental models for forecasting. Computational methods in environmental modelling.

**ES 401 – Environmental Management:**
Environmental regulations and policies; Environmental protection laws and acts; Corporate and international charters and protocols; Environment Risk assessment; Industrial ecology, Pollution prevention and Waste minimization; Sustainable development; Life cycle assessment; Environmental auditing; Eco-labelling of products; Performance indicators. Environmental management systems particularly IS 14000 series. Successful Case Studies.

**ES 444 – Industrial Pollution Prevention and Clean Technologies:**
Principles and techniques for industrial pollution prevention and waste minimization; Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Source reduction tools and techniques: raw material substitution, toxic use reduction and elimination, process modification and procedural changes; Recycling and reuse;
Opportunities and barriers to cleaner technologies; Pollution prevention economics. Waste audits, emission inventories and waste management hierarchy for process industries; Material balance approach; Material and process mapping approach; Emission sources; Estimation of fugitive emissions; Environmental impact of VOCs; Energy and resource (material and water) audits for efficient usage and conservation. Unit operations in separation technology; Pollution prevention for unit operations: Boilers and Heat Exchangers; Storage tanks; Distillation columns; Application of separation technologies for pollution prevention; Process optimization for cleaner industrial processes: Flow Sheet analysis—qualitative and quantitative approaches using mass exchange networks; Thermodynamic constraints to waste minimization; Holistic and critical technology assessment; Environmental performance indicators; Concept of industrial ecology and symbiosis of eco-parks. Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp and paper, textile, electroplating, leather, dairy, cement and other industries.

**ES 458 - Environmental Change and Sustainable Development:**
Issues of sustainability : food, materials and energy resources, demands, policies, ethics; Paradigms of agricultural/industrial age, population, limits to growth; Current debates on the issues of sustainability; Relationships of ecological, economic and social systems; Engineering tools for assessment and design for environment and sustainability; Relevance of traditional paradigms for rural India.

**NOTE:** ES 444 and ES 458 is offered in alternate year

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### 5.11 HUMANITIES AND SOCIAL SCIENCES

**PREFACE:**
The Department of Humanities and Social Sciences plays a unique and distinctive role in an institute where the ethos of science and technology prevails. It is believed that engineering and science are, by their very nature, humanistic and socially derived enterprises. Hence a complete science and technology education must include liberal arts, economics, social and behavioural sciences where the students unites application of scientific principles along with human, moral and social understanding. The undergraduate courses taught by the Department faculty aim at making the science and technology students aware of the various issues concerning man and society. They are meant to sensitize students to the broader social, cultural, economic, ethical and humane issues involved in social change.

The course content of HSS minor courses are highly instructor dependant for many courses and they generally run a subset of courses from the following pool:

**HS 208:** An approach to Literatures  
**HS 215:** Quantitative methods for Economic analysis  
**HS 417:** Philosophy of Life  
**HS 419:** Methodological foundations of Indian scientific tradition
HS 213: Language and Literature
HS 219: Applying Psychology in modern life
HS 207: Social Psychology
HS 217: Sociological Theory
HS 411: Indian Economy
HS 457: Managerial Economics
HS 448: Professional Ethics
HS 490: Organisational behaviour and Implications for Management

You can find sample course contents for the above: asc.iitb.ac.in or http://www.hss.iitb.ac.in/en/btech

5.12 INDUSTRIAL DESIGN CENTRE

PREFACE:
Design at IDC is all encompassing, coexists in an active triadic relationship with design education, design research and design practice. Design education - to train and propagate; design research - to seek, analyse, experiment, integrate; and design practice to apply, implement and realize. IDC strives towards creating an excellent pedagogical environment with foundations in these areas to prepare professionals and visionaries of tomorrow. The following courses are run by the department towards the award of a minor degree. Only a few courses of these run each semester.

ID 401 – Introduction to Design:
History of industrial design, The significance and value of industrial design, Basic characteristics of industrial design, The wide spectrum of design practice and terminology, Industrial design methodology, Creation of a product, Factors concerning the product in use, Capturing insights of users, Creative idea generation, From generation of products, Design for manufacture, Appearance of the product, Case studies on wide variety of products to showcase the above.

ID 403 – Basics of Animation:
The concept of animation, Persistence of vision, Broad methods in traditional animation, Computer animation, Effects and integration with live action, Stop motion animation, Other methods in animation, pixilation, animatronics, the principles of animation. From story to script to screen, pre-production, production and post-production, the process applications if animations of films, episodes, commercials, visualisation, simulation, online, education, gaming and mobile technology.

ID 404 – Basics of Visual Communications:
Visual communication is communication through visual aid and is described as the conveyance of ideas and information in forms that can be read or looked upon. Visual communication in part or whole relies on vision, and is primarily presented or expressed with two dimensional images, it includes: signs, typography, drawing, graphic design, illustration, Industrial Design, Advertising, Animation colour and electronic resources. It also explores the idea that a visual message accompanying text has a greater power to inform, educate or persuade a person or audience.
**ID 405 - Human Computer Interaction Design:**
This is an introductory course about user-centered design of interactive products and systems. The course will introduce some basic theoretical elements of HCI such as Garrett. Layers of user experience, human cognitive processes such as memory, affordances, mappings, conceptual models and heuristics and principles of good design. The course will try to communicate that there are bad designs everywhere. Why interaction designers go wrong. It will then provide an introduction to the HCI design process, including how to understand users through contextual interviews, how to analyze interviews to identify problems and opportunities, how to define usability goals and user experience goals, how to model users with techniques such as stages of use model and personas, how to explore solutions through scenarios, how to prototype explorations and how to evaluate prototypes for usability. Depending on the interest of the students, the course may cover some related topics such as user experience metrics, integrating HCI in software development and HCI in India.

**ID 406 Studio Project I:**
The studio project is offered for students who already have exceptional skills in the area of design and are able to contribute to the specialisation of the faculty. The student will have to undertake a topic in guidance with the guide from IDC and would have to complete the project within the semester.

**ID 407 Studio Project II:**
The studio project is offered for students who already have exceptional skills in the area of design and are able to contribute to the specialisation of the faculty. The student will have to undertake a topic in guidance with the guide from IDC and would have to complete the project within one semester.

**ID 408 Technology and Animation:**
The course is an eye opener to how various technologies have influenced the methods and workflow in animation & how use of animation has affected technology. This includes A historical perspective of technology in animation. Digital Image & Video Input technologies Digital Image Processing Visual Database creation & Management for animation Virtual 3D world creation & Rendering Expressions, Relationships computation and solving and their applications Mechanical Rigs and Gizmos for animation & effects. Motion Capture & Motion Control Convergence and combination of different sources for animation & effects creation Use of Animation in Technology & Science. New frontiers with the combination of Science, Technology & Animation Interactivity, optimisation, real-time animation. Massive parallel processing & distributed rendering.

**ID 409 Introduction to Scriptwriting:**
Script and story structure, plot and scenario building, character development, dialogue writing, visual treatment, scripting formats, writing for animation and live-action.

**ID 410 – Sound and Music Design:**
Defining music in sound, Concept of Anhad and Naad, Concept of Shad, The scale system and the raga time and space theory in music, music for visual medium, History of sound recording, Analog and digital sound recording principles, Elements of a recording studio and recording softwares.
**ID 411 Introduction to Ergonomics:**

**ID 627 Elements of Design I:**
- An introduction to basic elements: Line, texture, colour, form, symmetry, balance, scale, mass, unity and variety.
- Concept of visual language and visual design.
- Introduction to Gestalt laws, composition and figure and ground relationships. Introduction to concept of negative space.
- Introduction to typography and fonts.
- Use of grids in graphic composition.
- Colour circle, colour combinations and its dimensions: hue, value and chroma.
- Colour meanings in traditions and psychological use of colours.
- For detailed course contents contact the IDC departmental office or the instructor taking it in that semester.

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**5.13 INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH**

For the newly launched minor programme from the IEOR department, **you need to complete IE 501 and 502 and one of IE 503 or 504.** The remaining two courses should be IE labelled Electives. It is suggested that the students complete IE501, IE502 and IE503 or IE504 before choosing any other IE labelled Electives. IE labelled electives can be any two IE labelled theory courses (subject to satisfaction of pre-requisite requirements, as applicable), but excluding IE 505, IE 507, IE 605, IE 614, IE 684.

**COURSES (TENTATIVE) IN AUTUMN SEMESTER (JUL-NOV 2018):**

**IE 501 - Optimization Models:**
**Prerequisite:** Instructor’s permission
IE 503 - Operations Analysis:
Prerequisite: Instructor's permission
The aim of the course is to familiarize students with supply chain system and issues therein; and equip with techniques to model some specific operational issues in such systems.


IE 601- Optimization Techniques: (8 CREDITS)
Prerequisite: Exposure to relevant concepts at undergraduate level and instructor consent
The aim of this course is to have some basic understanding of provably convergent computational schemes for $\mathbb{R}^n$ constrained optimization problems. Some examples, mainly from decision making viewpoint. A brisk look at linear programming: Fundamental theorem of linear programming, Degenerate solutions, Simplex based methods, Cycling, Duality, Complementary slackness conditions.


Constrained optimization problems: Lagrange variables, Karush-Kuhn-Tucker conditions, Regular points, Sensitivity analysis. Quadratic programming, Convex problems. Optional Topics: Mixed integer models; Interior point methods; Iterative schemes for constrained problems; Sequential quadratic programming methods; Barrier methods; Trust-region methods, etc.

IE 611- Introduction to Stochastic Models: (8 CREDITS)
Prerequisite: Exposure to relevant concepts at undergraduate level and instructor consent
Apart from their intrinsic role in the theory of stochastic processes, Markov chains and regenerative processes form an important set of tools for analysis and optimization problems arising in many decision models.


Jump processes; jump chain and sojourn time construction of continuous time MCs, Poisson processes, birth-death processes. Forward and backward equations. Class structure, recurrence and transience, invariant distributions, convergence to equilibrium. Uniformization and time reversed chains.

Optional topics: Conditional expectation and conditional measures, Markov processes, Brownian motion, diffusions, Martingales, etc.

**IE 603- Discrete Event System Simulation:**
Concepts in discrete event system simulation; approaches based on event scheduling, process interaction and activity scanning. Examples of systems such as job shop scheduling & extensions, queuing systems, inventory systems. Use of linked lists in implementing some common data structures encountered in simulation. Simulation in C. Concepts of object oriented simulation. Simulation packages.

Overview of basic concepts from probability and statistics concerning random variables, correlation, estimation, confidence intervals, hypothesis testing. Generation and testing of random numbers. Generation of random variates, random vectors, correlated random variates and stochastic processes. Input modeling; useful probability distributions; hypothesizing families of distributions, estimation of parameters, testing goodness of fit. Simulation Output data analysis for a single system; statistical analyses for transient systems and systems in statistical equilibrium. Comparing alternative system configurations; confidence intervals, ranking and selection. Variance reduction techniques. Experimental design, sensitivity analysis and optimization.

Simulation of manufacturing systems.

**IE 612- Introduction to Financial Engineering:**
Prerequisite: Exposure to relevant concepts at undergraduate level and instructor consent.

The only requirement for this course is that either you are doing IE 611 (or equivalent) along with course or have already done such a course. Probability background is not required in the first half, but you require it for the second half of the course.

The aim of this course is to cover some basic concepts of financial engineering: the issues that arise in modeling, analysis and decision making involving financial instruments. Discrete time models and computational tools will be the focus.

Portfolio optimization: Markowitz model; Two and one fund theorems; mutual funds. Capital Asset Pricing model; Security market line.

Arbitrage; Hedging; Pricing. Contingent claims; Forward and futures contracts. European and American options; Asian and other path dependent options. One and multi-period binomial models; Finite state models. Equivalent martingale measures; Completeness of markets; Fundamental asset pricing theorems; Option pricing. Black-Scholes option pricing formula.

**IE 714: Quantitative models for supply chain management**

**Prerequisite: IE 601 and IE 611, or equivalent or Instructor's permission**

Supply chain management involves a number of decisions that benefit by quantitative techniques of analysis and design. The course will take up a few of these to explore modeling, computation and IT-enabled implementation of solutions in some areas of Supply Chain Management. The application areas include material flow management across the supply chain, value management and analysis of total supply chain costs, robust design of supply chains, coordination of supply chain decisions and handling of uncertainties in supply chain management. The emphasis will be on modeling, analysis and implementation issues, including a few case studies, but the relevant techniques will be covered as required.

**COURSES IN SPRING SEMESTER (JAN-MAY 2019):**

**IE 502 - Probabilistic Models:**

**Prerequisite: Instructor's permission**
Models and techniques to deal with randomness that underlie many industrial and social systems. It includes discussions on models, their properties and their applications. Review of basic probability concepts: conditional probability and random variables. Stochastic processes, sample paths, finite dimensional distribution functions. Time averages and Laws of large numbers. Finite state Markov chains, Chapman-Kolmogorov equations, limiting state probabilities, Stationary distributions. Memory-less property of exponential random variables.
and related models & examples. Poisson process and its applications. Renewal processes with examples.
Elementary Queueing theory: steady state probabilities, Little's Law. Exponential models with examples. Applications of open and closed queueing systems. Applications in reliability theory, systems with parallel and series of components, component life vs. system life, expected system life. Applications in inventory, random demand and stockouts, notions of service levels.
Performance measures of above models in terms of relevant transient and steady state Distributions.

IE 504 - Service & Infrastructure Systems:
Prerequisite: Instructor's permission
This course aims to familiarize students with service & infrastructure systems, and related issues of allocation and deployment of various resources and to introduce techniques to model some planning and operational issues in such systems.
Planning of infrastructure systems. Fixed costs, sunk costs and variable costs of infrastructure. Break even analysis. Introduction to financing and operating of infrastructure systems.

TENTATIVE LIST OF REST OF THE SPRING SEMESTER COURSES WILL BE RELEASED IN AUGUST

ADDITIONAL COURSES THAT WERE THERE IN LAST SPRING SEMESTER:

IE 613 Online Learning
IE 616 Decision Analysis and Game Theory
IE 645 Industrial Scheduling
IE 708 Markov Decision Processes
IE 709 IEOR for Health Care
IE 710 OR Applications in Infrastructural and Service Sectors
5.14 MATHEMATICS

The minor programme in Mathematics is designed to allow engineering and science students to pursue a more rigorous education in mathematics. The minor courses have been selected to represent the different basic areas of mathematics. A student completing these courses will achieve a better understanding of the mathematical techniques used in the sciences and engineering disciplines and will also be well equipped for further advanced mathematical education.

Other benefits:
Having a good understanding of Maths Concepts helps you develop a more analytical approach in general. The exercises of so many different concepts are like exercises for your mental health. Maths Minor helps you develop a better attitude of questioning why things are the way they are? It helps you not to take things easily for granted. You start thinking and analysing what other possibilities made sense in a given situation and how to support your intuition via rigorous arguments. These habits that develop along with some serious understanding of mathematics provide you a heads up in comparison to others. You can read and understand any maths related research paper or papers that need some related concepts. Besides this, certain companies appreciate someone who has a good understanding of Maths during placements.

MA 403 – Real Analysis:

MA 419 – Basic Algebra:
Review of basics: Equivalence relations and partitions, Division algorithm for integers, primes, unique factorization, congruences, Chinese Remainder Theorem, Euler φ-function. Permutations, sign of a permutation, inversions, cycles and transpositions. Rudiments of rings and fields, elementary properties, polynomials in one and several variables, divisibility, irreducible polynomials, Division algorithm, Remainder Theorem, Factor Theorem, Rational Zeros Theorem, Relation between the roots and coefficients, Newton's Theorem on symmetric functions, Newton's identities, Fundamental Theorem of Algebra, Rational functions, partial fraction decomposition, unique factorization of polynomials in several variables, Resultants and discriminants. Groups, subgroups and factor groups, Lagrange’s Theorem, homomorphisms, normal subgroups. Quotients of groups, Basic examples of groups: symmetric groups, matrix groups, group of rigid motions of the plane and finite
groups of motions. Cyclic groups, generators and relations, Cayley's Theorem, group actions, Sylow Theorems. Direct products, Structure Theorem for finite abelian groups. Simple groups and solvable groups, nilpotent groups, simplicity of alternating groups, composition series, Jordan-Hölder Theorem. Semidirect products. Free groups, free abelian groups. Rings. Examples (including polynomial rings, formal power series rings, matrix rings and group rings), ideals, prime and maximal ideals, rings of fractions, Chinese Remainder Theorem for pairwise comaximal ideals. Euclidean Domains, Principal Ideal Domains and Unique Factorization Domains. Polynomial rings over UFD’s

**MA 406 – General Topology:**

**MA 412 – Complex Analysis:**

**MA 522 – Fourier Analysis and Applications:**

**5.15 MECHANICAL ENGINEERING**

**PREFACE:**
The minor in mechanical engineering complement studies in a major field closely allied to mechanical engineering, such as materials science and engineering, aerospace engineering,
electrical engineering, civil engineering, chemical engineering and a number of other possibilities. A student can be awarded a minor in mechanical engineering provided he/she completes courses worth 30 credits (typically 5 courses) out of the following courses:

**COURSES:**

**ME 201 – Solid Mechanics (6 credits):**
Fundamentals of mechanics of deformable solids – Introduction, analysis of axial and shear loaded components, Castigliano’s theorem, Beams – shear force and bending moment diagrams, Stress, strain, and their relationships, Thermal stress, fatigue and creep, Mohr’s circle, Stresses in beams, Torsion, Thick cylinders and rotating discs.

**ME 209 – Thermodynamics (6 credits):**

**ME 219 – Fluid Mechanics (8 credits):**
Fluid Mechanics will give you a very broad idea of fluid statics and dynamics and equip you with a first-hand analysis to compute basic flow parameters. Introduction: fluid characteristics, continuum concept and properties of fluids, Fluid statics and kinematics, Flow analysis using the Control Volume approach, Navier-Stokes equations and solutions to some special cases, Boundary layer theory, Dimensional analysis.

**ME 316 – Kinematics and Dynamics of Machines (6 credits):**
The course is divided into two major sections. One involves study of the kinematics of mechanisms, and the other involves study of dynamics of machinery. The kinematics part involves: Degrees of freedom, types of joints and motions, Different types of linkages, their uses and inversions, 4 bar linkage: displacement, velocity and acceleration (analytical technique), Graphical techniques for kinematics, Cam motions: Principle, standard cam-follower motion design. The dynamics part involves: Dynamic (force) analysis of 4 bar linkage, slider crank mechanism, Primary and Secondary unbalanced forces and their balancing for crankshafts of different engine designs, Optimal cylinder firing order, Introduction to vibration theory and resonance of structures.

**ME 333 – Manufacturing Processes I (6 credits):**
Manufacturing Introduction: Materials, processes, Metal Casting: Types, tooling design, solidification, feeder design, mold filling, gating design, simulation, defects, Welding and
Brazing: Types, analysis and defects, Metal Forming Processes: Rolling, forging, bending, drawing, extrusion, Miscellaneous: Powder metallurgy, plastic injection molding, free form fabrication (rapid prototyping).

**ME 338 – Manufacturing Processes II (6 credits):**

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**5.16 MANAGEMENT**

**PREFACE:**
Management comprises of diverse set of fields where every field aims to take a step in the direction such that it will help the individual in controlling business organisations so that they can perform at their efficient levels and constantly develop in their field.

**Other Benefits:**
The Management minor plays a very important role for a person who aims at a career in general management industry or government. It gives a basic taste of management to a person in case he or she opts for an MBA.

**COURSES:**

**MG 401 – Marketing Management:**

**MG 402 – Human Resource Management:**
Recruitment & Training. Performance Management & Appraisal

**MG 403 – Basics of Accounting and Financial Management:**
Principles of Accounting, Double Entry System, Assets, Liabilities, Reserves, Shareholding patterns, discounted cash flows, Net present value of money, financial case studies, Tax Savings.

**MG 405 – Project Management:**

**MG 406 – Operations Management:**

5.17 PHYSICS

**Preface:**
The minor elective courses include courses needed for a basic understanding of physics as it is taught in a Master’s programme today. In addition, there are also courses that are designed to expose students to modern areas of research in physics, and to equip them with the theoretical knowledge required to further appreciate the application of physics in their own fields.

**COURSES:**

**EP 252 – Introduction to Quantum Mechanics:**
This course puts forward a comprehensive mathematical background and detailed overview to the basic concepts involved in quantum physics. Course contents: Linear Vector Spaces, Concept of Inner Product, Dual Space, Dirac Notation, Linear Operators and their matrix representation, Brief Discussion of orthogonal, Hermitian and unitary matrices, eigenvalue problem, square integrable functions, Postulates of Quantum Mechanics, meaning of wave function (Copenhagen Interpretation), Uncertainty principle, Heisenberg microscope, space representation of Schrodinger’s equation. One dimensional problems.1-d Harmonic Oscillator, Hermite polynomials. Symmetries and their generators, linear momentum, angular momentum, spin-1/2 representation and interaction of spin with magnetic field. Solution of Schrodinger’s equation for central potentials, Hydrogen atom problem (Laguerre polynomials), non-degenerate and degenerate states.

**EP 332 – Thermal and Statistical Physics:**
A brief recap of thermodynamics followed by the statistical approach to it and the explanation of its applications and resulting phenomena. Course contents: Review of thermodynamics:
notion of equilibrium, equation of state, first and second laws of thermodynamics, thermodynamic potentials and Maxwell’s relations. Phase space, ergodicity, Liouville’s theorem, microcanonical, canonical and grand canonical ensembles, Boltzmann statistics and its applications to ideal gas. Bose-Einstein and Fermi-Dirac statistics, and their applications.

**PH 432 – Condensed Matter Physics:**
It deals with the physical properties of condensed phases of matter. Condensed matter physicists seek to understand the behaviour of these phases by using physical laws. Course contents: Crystal structures, reciprocal lattice, X-ray and electron diffraction. Lattice vibrations, Einstein and Debye models, phonons, Drude and Sommerfeld models, Block theorem, Empty lattice and nearly free electron model, tight-binding model, Density of states and Fermi surfaces. Semi classical model of electron dynamics. Concept of Effective mass.

**EP 454 – Light Matter Interactions:**
The aim of this course is to give the student advanced knowledge on the quantum-mechanical interaction between light and matter and its application in different research fields. The course also involves a small experiment to be completed in 2-3 labs. Course contents: Interaction between atoms and light, Laser cooling and trapping, Radiation forces, Atoms in strong fields, Application to extreme optics, attosecond pulses, manipulation of atoms, molecules and larger systems with light, atom optics, quantum computers and quantum communication.

**PH 401 – Classical Mechanics:**

5.18 STATISTICS AND INFORMATICS

**PREFACE:**
As statistical data analysis, modelling and inference are required in almost all areas of the natural and social sciences, technology and industrial research. The skills taught in the SI minor are extremely useful in almost all branches of engineering, as well as in certain non-technical careers. For example, in quality control in mechanical, chemical, metallurgical or electrical engineering, the regression techniques learnt are extremely useful. Stochastic processes are useful in Chemical Engineering and in Physics, while derivative pricing is useful in future financial careers. All in all, this minor increases the analytical skills of the student taking it, which can only be an asset.

**SI 417 – Introduction to Probability Theory:**
random variables, Expectation, moment generating functions, Modes of convergence, Weak and strong law of numbers, central limit theorem.

**SI 402 – Statistical Inference:**

**SI 404 – Applied Stochastic Processes:**

**SI 422 – Regression Analysis:**
Simple and multiple linear regression models estimation, tests and confidence regions. Check for normality assumption. Likelihood ratio test, confidence intervals and hypothesis tests; tests for distributional assumptions. Collinearity, outliers; analysis of residuals, Selecting the Best regression equation, transformation of response variables. Ridge’s regression.

**SI 527 – Introduction to Derivative Pricing:**

**5.19 SYSTEMS AND CONTROL ENGINEERING**

**PREFACE:**
Control engineering has an essential role in a wide range of control systems, from simple household washing machines to high-performance F-16 fighter aircraft. It seeks to understand physical systems, using mathematical modelling, in terms of inputs, outputs and various components with different behaviors; use control systems design tools to develop controllers for those systems; and implement controllers in physical systems employing available technology. Students enthusiastic in robotics would find this minor useful in modelling robots.
and control systems. Systems and Control Engineering is very multidisciplinary in nature with applications in finance, robotics (from self driving cars to military drones), aerospace, mechanical, electrical and chemical engineering.

3 compulsory core courses:
**SC 201 – Mathematical structures for systems and control:**
Groups (definition, matrix groups - GL(n,R), SO(3), SE(3), the commutator, the Lie algebras so(3) and se(3), applications: robotics, aerospace problems), vector spaces (definition, linear dependence, basis, subspaces, dual spaces, linear transformations, matrix representations, similarity transformations, eigenvalues, applications: control and signal processing) and, elements of differential geometry (n-surfaces in Euclidean space, tangent vectors, vector fields, co-vector elds, geodesics, covariant derivative, applications: robotics, dynamical systems and control.)

**SC 202 – Signals and feedback systems:**
Signals and systems and their interconnections, convolution, differential and difference equations, state variable models, Fourier, Laplace and z-transforms, regions of convergence, the transfer function, linear feedback systems, the stability problem, the Routh-Hurwitz and root locus method.

**SC 301 – Linear and nonlinear systems:**
Linear state-space models, solutions, controllability, observability, state-feedback (both continuous and discrete domain.) Nonlinear state-space models, phase plane diagrams, existence and uniqueness of solutions, Lyapunov stability.

Rest are electives, you may choose any two from the list below:
1. **SC 627 - Motion Planning and Coordination of Autonomous Vehicles**
2. **SC 624 - Differential Geometric Methods in Control**
3. **SC 613 - Multivariable Control Systems**
4. **SC 700 - Embedded Control Systems**
5. **SC 602 - Control of Nonlinear Dynamical Systems**
6. **SC 605 - Optimization-based Control of Stochastic Systems**
7. **SC 607 - Optimization**
8. **SC 612 - Introduction to Linear Filtering and Beyond**
9. **SC 616 - Large Scale Systems**
10. **SC 617 - Adaptive Control Theory**
11. **SC 623 - Optimal and Robust Control**
12. **CL 692 - Digital Control**
13. **CL 686 - Advanced Process Control**
14. **EE 640 - Multivariable Control Systems**
15. **EE 636 - Matrix Computations**
The Centre for Technology Alternatives for Rural Areas (CTARA) Department does not offer a minor as such for the undergraduates but instead has a Technology and Development Supervised Learning (TDSL) program for them. These courses offer the students an opportunity to work on a live project, urban or rural, which involves direct interaction and interface with the larger society and stakeholders.

All the projects offered through TDSL fall under 3 broad categories- Study, Analysis and Design. The output of the project could be in the form of policy recommendations and studies, protocols or design solutions. Projects are floated by the faculty members and student interested in a particular topic may directly approach to work with the faculty member on the project.
6. MINOR REVIEWS

Deciding which minor to take is always a confusing task - students often find themselves in a dilemma as to whether they should go for the “popular” minors or something based on their interest. To help ease out the confusion, here’re some reviews on some specific minors by the seniors who took them:

6.1 Parth Kothari - Computer Science

The Computer Science minor comprises of completing five 6-credit courses of the CS Department. Most of the times, one to two minor courses are run every semester which can be found in the CS Department timetable of the respective semesters. The prerequisite for getting admitted into a particular CS Minor course is mostly having an 8-8.5 CPI.

I’ve have personally completed five “M” courses and have a mixed opinion. In general, you will find most of the courses really good but you may not like a couple of them depending on your liking for particular domains. (I would like to point out that sometimes you are forced to undertake a course because no other course is offered or the one being offer has already been completed by you. This is the case with every minor though). Coming to the course content, it is really good and important to know if you want to identify yourself as someone who knows basic CS. Some of the courses involved only theory and no labs or assignments. It might seem good if you only want to just complete a minor but if you are looking for a good practical understanding of the topic, you might not enjoy it and want to explore more on your own. A couple of courses did involve really interesting assignments which I thoroughly enjoyed and helped me keep my coding skills up to date. One advantage of the CS Minor is that it might help you change your branch to CS in future (but not too much of an advantage) and also help you crack good internships if you happen to understand the corresponding topic really well.

In reality, I have observed that most of the students slack off and only complete the minor for the sake of getting that tag in their transcript. If you are genuinely interested in getting a better understanding, I suggest you to read something apart from the classroom theory and be assured that the instructors are ALWAYS there to help you if you are ready to put in the extra efforts.

6.2 Kaustubh Sridhar - Systems and Control

The systems and control engineering minor requires you to first do 3 compulsory courses and then pick 2 out of a basket of choices. The first of the 3 (and first course in the minor) deals with all the math (and only the math) that you would need to work on any system or control problem. The second introduces signals and teaches classical control theory (here is where it
gets very interesting. From every machine in any industry to aircraft and rockets, all of them heavily using classical control theory. Further, the next course deals with modern control theory which involves the control of linear and nonlinear systems. This course introduces everything from state space representations to Lyapunov Functions --- all of which form an essential part of robotics and any kind of automation today (from industrial robots to self driving cars and drones in the air or in the sea)

After completing the 3 compulsory courses that basically introduce you to the wonderfully interesting world of control theory, you get to choose among various courses that range from a more robotics side (SC627: motion planning for autonomous vehicles, SC700: embedded systems, etc) to delving deeper into advanced control techniques (SC617: Adaptive Control, SC623: Optimal and Robust Control, SC624: Geometric Control, etc)

Although a Systems and Control (fondly called syscon) minor would be a helpful addition for anyone in any department wanting to explore robotics, automation and real world machine workings, it would be particularly helpful to those Majoring in Aerospace, Electrical, Mechanical, Chemical, Metallurgical Engineering because of the heavy correlation between their subjects. (Think controlling aircraft, rockets, robots, industrial machines, etc.)

Also, the syscon minor opens up lots of opportunities to do research in robotics and related fields. The minor has also been instrumental in helping me get research internships in India and abroad. :P

6.3 Priyanka Poonia - Management

I don’t want to right away conclude whether you should or shouldn’t go for this, I would just answer the basic questions you may have. Hopefully, it will help you to decide.

Why should you? Doesn’t matter whether you are interested in core or non-core sector, it’s always helps to know the business side of the things, how do companies operate and make money! Well, this minor would help you get a good insight.

How’s the content? Under the umbrella of management minor SOM offers 6 courses on Strategy, Marketing, Accounts & finance, HR, Project, and Operations Management. These courses are basically an overview of the concepts you will be using during your work as consultant, manager, strategist or founder of a startup. Although you can’t expect in-depth knowledge, but it would familiarize you with the terms generally used in the business world. Even if you can’t complete the minor, try to do Strategy Management, it’s an amalgam of all other courses.

How are the classes? Most of the professors are super awesome, you won’t even feel as if some class is going on, feels more like storytelling. Classes are less theoretical and talk more about real life examples, good to get a break from your core courses. Additionally, all the courses are full of class discussions, everyone is encouraged to speak, so if you are the one
who hesitates in asking doubts in the class or public, this would be the best place for you to start.
Are you eligible? There is no strict CPI cut off but generally seats fill in real quick, so getting it at CPI less than 8 is bit dicey. Register as soon as portal opens to be on the top of the waitlist. Attend all the classes for at least first two weeks, either your waitlist will be cleared itself or if the professor feels you are sincere enough, he/she may directly enroll you for the course. Don’t go for this minor just because people say it lifts your resume up, go for it because of the content it offers.

6.4 Arkya Chatterjee - Mathematics

The mathematics minor is aimed at covering topics that are central to almost all of contemporary mathematics. At present, there are four courses in the minor program - real analysis (RA), complex analysis (CA), general topology (GT), and basic algebra (BA). Among these, BA and RA, which are typically run in odd semesters, don't have prerequisites, whereas RA itself is a prerequisite for both CA and GT, typically run in even semesters. All of the courses are worth 8 credits, with 3 lecture hours and one 1-1.5 hour tutorial per week.

I have taken three of the four minor courses - RA, GT and BA in my 3rd, 4th and 5th semesters respectively. RA deals with topics like sequences, power series, convergence of functions, point-set topology (in the context of the real numbers), and a little bit of differentiation and integration. Although some of these are also discussed in the freshman calculus course, the spirit of mathematical rigour and the importance of proofs is emphasized to a much greater extent in this particular course. GT is the most abstract of all the minor courses. It constitutes a study of sets endowed with a very basic structure, namely “openness”. As a result, it gives rise to very deep and widely applicable theorems, and opens up various avenues for the motivated student to explore as follow-up to this course. BA exposes the student to algebraic structures such as groups and rings. Algebra, being a very classical topic in mathematics, constitutes an immense body of knowledge. Keeping that in mind, this particular course, justifiably called “basic”, has a very modest goal - that of introducing the student to the field of abstract algebra.

There are a few personal comments that I should make here. First, it is highly advisable to take RA as the first math minor course, since it helps the student develop a sense of how to think about rigorously proving mathematical statements - a skill that would be indispensable in all math courses. Second, since the lectures are 1.5 hour-long, a typical lecture covers quite a lot of material. Therefore, being irregular in class can turn out to be detrimental to your understanding of the topic(s) being taught, not the least because the instructor often tends to rely on concepts built up in a previous lecture. Third, don’t worry if you are not able to clear the CPI cutoff during pre-registration; most math professors are more than willing to let motivated students take up courses even if they don’t have a high enough CPI. Lastly, especially since the current list of courses allows no freedom in terms of choice of courses, taking up math
courses as electives could be a less-restrictive way of doing courses that you like rather than opting for a minor and being forced to do a course that you might not like.

Like with any other minor, doing a mathematics minor won’t make you an expert in any of the topics mentioned above, but it will allow you an opportunity to get a taste of how to think like a mathematician, relying on logic and the ability of abstract and creative thinking, which are valuable skills in any STEM field.

6.5 Yashraj Gurumukhi - Electrical

Elec minor gives you a broad overview of different "subdivisions" of electrical, such as logic (digital electronics), device physics (electronic devices), communication and signal processing (signals and systems, probability), Power (power electronics), and circuit design (analog electronics). It is more application focussed and more of electronics than electrical. None of the courses have prerequisites. And all courses have equivalent core courses. However, the minor courses are significantly diluted compared to their core equivalent. On one hand, this means that these courses have very little load but on the other, these courses also don't teach you a LOT. Also, given the aim of the minor, you'll learn a number of disjointed things but collectively they don't build up to something, except for a taste of the different subdivisions of electronics engineering.

Hence, as in introduction course it serves well for branches disconnected from electrical engineering, such as mechanical engineering, aerospace engineering, metallurgy, chemical engineering etc. However, for engineering physics this will not serve to add significantly to what they have learnt. Though, having some sort of a formal degree in electrical will be of immense help for those looking to change their branch in their masters or their jobs.

6.6 Varun Mittal - Industrial Engineering and Operations Research (IEOR)

IEOR minor is a relatively new opportunity the institute offers when compared to other mainstream minors offered. There is tagline which goes with all the IEOR courses (I personally had come across this, written on the office door of one of the department professors!) that while other engineering departments make things, IEOR department deals with making things better. So, if you are a person who likes formulating & modeling problems and solving optimization problems, IEOR minor would be a great choice for you.

The minor consists of five 6-credit courses, three of them are mandatory and the other two are electives. The three mandatory courses are Optimization Models, Probabilistic Models and any one between Operation Analysis & Services and Infrastructure Systems. All the three are introductory level courses and are prerequisites for quite a few other courses the department offers. Since the other two courses are electives, students have a lot of choice and can take courses suited to their interests. Every course in the minor has an upper cap of 20 students making the pre-registrations a little competitive. The courses are very interesting and intuitive. Most of them have a very simple structure (as in most freshman year courses, you may have come across): two quizzes, mid-sem and an end-sem.
The course content is intuitive (more often than not) which makes it easy to score in these courses and students usually sail through given they have a decent attendance, to know what has been taught in the class. If you have any inclination towards topics like probability, forecasting, planning, scheduling, optimization, etc. you should opt for a minor in IEOR.

6.7 Anand Dhoot - Statistics

One would think Statistics as a tool which would help them in data analysis - like, if you go to a finance company then given the data, you will learn how to make certain conclusions based on the data and stuff like that. But statistics minor is way different than that. There are three 8 credit courses and one 6 credit course. Most of the 8 credit courses require 3 hours of lecture and one tutorial hour, except one, which has 1 hour of practicals. The minor is mathematics oriented, but not as abstract as the maths minor. There is quite a lot of overlap of these courses with CS core courses, and have wide applications in computer science and finance. They also help in internships and placements. The CPI cut off for doing this minor is high because there are only 20 seats for this minor. But, the prof might easily allow you to take the course up if you show some interest. Also, the minor courses run only in alternate years, just like the maths minor.

6.8 Shievani Upadhyay - Industrial Design Center

The general perception about IDC courses are that you can easily get a 9 or 10. That’s true for only some courses. More often than not, you will have to religiously attend lectures and do assignments. Still, IDC courses are relatively easier to score in and hence a popular choice for Institute Electives. Most IDC courses will not have a strict attendance policy. But attendance will be recorded and given a pretty high weightage in the final marks. So make sure you attend classes regularly. As mentioned above, grading is relatively chill, but all assignments given will count. Examination pattern varies from course to course. Most courses don’t have quizzes or mid sem examinations (some even end sem). Instead they have course assignments. This gives you a very hands on experience in the subject and doesn’t add up to another course in your mid sem schedule. IDC courses cover a vast range of topics - for example: animation, film appreciation, product design, data visualization, etc. More often than not, you’ll probably have no experience in these fields. So, ask seniors who have previously done courses in IDC. As a piece of advice, please try and actually learn what is taught in the course. You might end up loving it. Being in IIT Bombay, we are really lucky to have the option to explore Design courses. Utilize this opportunity to learn something different. The IDC faculty is very approachable and will help you out if you just show some interest. They really love what they are teaching and will even let you do projects under them during the vacations.

6.9 Yashraj Gurumukhi - Mechanical

It consists of six courses from the core mechanical courses itself. The basic courses include fluid dynamics, solid dynamics, thermodynamics, manufacturing processes 1, manufacturing
processes 2, kinematics and dynamics of machines. These are pretty popular courses and cover the basics you need for mech and also these courses do not go much into details, they just provide an overview. It’s a pretty interesting field and a mechanical minor makes a lot of sense if you are really interested in robotics as well.

6.10 Archit Bhatnagar - Biosciences

Taking a minor in an usually hated subject for fresh IITians must seem bizarre and incomprehensible to many. After all, who wants to take a subject which they gave up before with joy? But those who are thinking on this line of thought are in for a shock, for this minor is not just about courses in biology; it is about hard core engineering, but with way more cooler tools. This minor starts slow; the first course is usually not that interesting, since it’s mostly a repeat of BB101. But after that one sees concepts learned in chemistry and physics playing a very central role in biology. One can have two branches in this topic: Genetic & molecular biology and biomedical engineering. The former exposes to the learner the application of conventional fields like Thermodynamics, electrochemistry, and quantum mechanics to the complicated structures of the biological world work and then showing the use and power of the tools that can be developed from these. The latter focuses more on healthcare devices, explaining how they function, why they are used the way they are and how can they be built. This branch is much more similar to conventional engineering approaches; just has biological overtones added to it. Instead of diving into core biology, this branch takes a cursory view and then extracts portions required for developing applications. This minor does not require much math, but does require a razor sharp mind, ready to accept extraordinary cases and to think out of the box. This minor does not demand from you much to get good grades (in fact the professors usually give a good grade for a fair amount of work), but it does offer unconventional methods of thinking and testing (these will probably be the only exams where you would have to think for much more time than to write the answers), and good springboard to explore other courses offered by Biosciences and Bioengineering department. So, if you wish to take this minor, go ahead and take it, for professors usually won’t refuse entry to the course although it might be useful to keep the lost diadem of ravenclaw handy (just in case).

6.11 Sheetal Jain - Aerospace

It is a slightly different minor, compared to other Minors offered at IIT-B. There are one compulsory course (AE153 – Introduction to Flight). It runs in the Autumn semester. Other than this course, one is required to do 4 other courses (all 6 credit courses) by choosing from minor baskets defined for Autumn and Spring semesters, respectively. Note that some prerequisites have equivalents in other depts. (like Mech.) so clarify, with the prof. taking the course if you have already done the equivalent required courses or not. As for the pros and cons about the minor: Pros – Basic Physics Content and simple Math required Courses very well taught, and attending lectures highly beneficial and fun Well defined course content covered rigorously Medium time demand of courses, so don’t interfere with core curriculum Cons – Dedication and compulsory attendance strictly demanded and enforced Most courses not offered in slot 5 (advantageous for those targeting dual minors) Project work and weekly assignments which are instrumental for performing well Linked topics, so flow between classes must be maintained Challenging Quizzes and Exams
6.12 Harsh Ranjan - Entrepreneurship

To become an entrepreneur you don’t need to have a great idea to begin with. It is a skill which can be learnt. Entrepreneurship in itself is an iterative process and something which cannot be taught theoretically. Thus the ENT minor is more about the pragmatic aspects of entrepreneurship. This is one of the major reasons why I personally like the ENT courses. ENT courses are very different from your core theory courses, the exams also mainly comprise of case studies and applications to real life problems. In a few courses (eg Marketing for entrepreneurs) there were no exams, only assignments and project submission. Even the proof of concept courses require major work only on your projects. The lectures sometimes are quite monotonous due to the style of a few professors, but some professors are really nice. Another good thing about ENT courses is that there are many lectures by guest speakers and thus they expect you to attend these lectures, otherwise attendance is pretty chill (but that will again depend on the prof). CPI cut off is not really an issue. The minor is not really a ‘must’ if you want to become an entrepreneur but you’ll definitely find it interesting.
7. HSS ELECTIVES - COURSE CONTENT

7.1 HS 301- Introduction to Philosophy

Course Content:

This course covers Branches of Philosophy namely Plato's Cave Allegory, Indian Philosophy, Plato's Reality as Idea, Aristotle Reality as matter and form, Democratic Philosophy, Marxist Philosophy, Foucault Philosophy, Feminist Philosophy; Rationalism and Empiricism. Theories by Immanuel Kant Transcendental Idealism, Hegel on Absolute Idealism, Wittgenstein on Logical Atomism and Anti-Reductionism

Topics:

1) Philosophy and History of Science:

Growth of scientific knowledge: Factors leading to the emergence of modern science; Conceptual evolution: Internal and external history; Methodology of science: Induction, falsificationism, confirmation and probability; Nature of scientific laws and theories: Realism, instrumentalism and underdetermination; Relationship between scientific observation, experiment and scientific theory; Nature of scientific explanation: Teleological explanations and the covering law model.; Selected case studies on scientific theories.

2) Logic and the nature of mathematical reasoning:

Inductive and deductive forms of reasoning; Nature of axioms: Formal axiomatic systems; Concept of consistency, independence and completeness; Nature of rules of inference and proof; Selected examples of axiomatic systems and proof procedures

3) Cognition:

Current approaches to the understanding of mind and mental processes: Empiricist, rationalist, behaviourist and cognitivist.

4) Ethics:

Impact of science and technology on man and society: elements of environmental

7.2 HS 303 - Introduction to Psychology

Topics:

1) Understanding human experience and behaviour:

Definition, schools, methods, branches and application of psychology for engineers

2) Measuring human abilities:

Intelligence, Personnel testing
3) **The individual working life:**
   Personality - definition, approaches and theories

4) **Psychological problems of everyday life:**
   Stress and coping, Psychological disorders, Work and mental health, Human learning

5) **Motivation:**
   The concept and theoretical framework, motivating people at work, attitude and work behaviour, group dynamics Intergroup relations, conflict resolutions, leadership and management.

### 7.3 HS 307 - Introduction to Sociology

**Topics:**

1) What is sociology, some sociological concepts: social structure, status, role, norms, values etc. Socialization, and culture and change.

2) Social stratification - various approaches and concept of social mobility.


4) Major social institutions - Family and marriage, caste and tribe and organizations:
   a) Formal organization (bureaucracy)
   b) Informal organization.

5) Processes of social change - Modernization (including Sanskritization), industrialization, environmental/ecological changes and development.

6) Social movements - protest movements, reformist movement and radical movements in India.

### 7.4 HS 309 - Introduction to the Study of Language

**Course Content:**

This course looks at ‘language’ itself as an object of study which helps us answer several questions about ourselves and our communities, including of course literary expression. We looked at the history, psychology, sociology and structure of language – all languages. Some of the questions we were asked and addressed include:

1) Is language a learned behaviour or an instinct? Is it special to us humans, or found in other animals?
2) What are the special organizational features of language? And how can we describe them?
3) Are human languages different from one another and in what ways? Are some languages more advanced than others? More complicated?
4) How and why do speakers of a given language speak differently? Are human brains special with respect to language?
5) What is the origin of language? What are the politics of language across nations, across sexes, across cultures?
6) Why do computers have trouble understanding/producing human languages?
7) How do we read literary and other texts? How is language crafted in literature? What makes poetry or prose?
8) How do we describe the uses of language such as metaphor? What about humour?
9) Why is second language learning so difficult? What is an ‘accent’?
10) How are mother and other tongues learned by children and adults? What is language death or revival?

Topics:

1) **Nature of Literature**:
   Literature as a Humanistic Experience.
2) **Definitions**:
   (i) Humanities: concern with culture, values, ideologies;
   (ii) Literature: concepts of imitation, expression, intuition & imagination.
3) **Major Themes of Literature**:
4) **The Language of Literature**:
   Modes of literary and non-literary expression.
   The concepts of Figurative language, imagery, symbolism, style.
5) **The Forms of Literature**:
   Prose Narratives (short stories & novels) Poetry, Drama and Essays. [Note: 1. Suitable texts are to be chosen by the instructors from the Texts and References listed below as well as from other sources.
6) Use of a Learner Dictionary (Oxford Advanced Learner's Dictionary is prescribed for language work.)]
8. HSS ELECTIVES - COURSE REVIEWS

8.1 Mukesh Pareek - HS 301 Introduction to Philosophy

The offering of the course I attended was given by Prof. Amrita Banerjee. This was an introductory course on Philosophy. The actual course content might be instructor dependent.

The course content was quite interesting and the ideas discussed were thought-provoking. It begins with Plato's text "The Apology of Socrates" and discusses the ideas in Greek Philosophy. It further covers texts from Chinese Dao philosophy, Buddhism and Upanishads. Going forward we studied modern philosophers including Kant, Descartes, Bentham, Hume etc. It touched broadly upon concepts like Epistemology, Metaphysics, Consequentialism, Morality, Ethics moving towards contemporary philosophers like Butler and Beauvoir introducing the theme of existentialism. The course provides an insight to the thought process of philosophers and the art to analyse and understand philosophical theories.

The examination pattern was objective and the questions were memory based. There were no quizzes. Reading the texts and slides was enough to score good marks. The slides were concise. Texts were lengthy but interesting and important to score. There was an assignment(10% of the course) which tested our understanding of the concepts covered in class and the ability to apply them in real life scenarios. The first half of the course was quite intuitive and not so difficult to understand. The theories got complicated as we moved towards modern philosophers and required more effort. Overall the course was good but lectures could be made more interesting and interactive.

8.2 Aniket Shirke & Snehal Chandan - HS 303 Introduction to Psychology

The offering of the course I attended was given by Prof. Azizuddin Khan. This was an introductory course on Psychology. Although the course content might be instructor dependent, the topics covered were Sensation and Perception, Learning, Memory, Motivation and Emotion, Language and Thought, and Personality.

The course content was absolutely amazing. It started with a basic introduction to Psychology where the instructor discussed about the applications of psychology in real life and the many branches of it (which contradict each other!). Many people get bored in the initial lectures, but it forms the basis for the theories coming ahead. Sensation and Perception was about sensory receptors in human body and how human mind perceives it. Learning is where it starts getting more interesting; you will get to know about famous psychologists and their theories on how a mind learns. The theory about Memory is exactly what it sounds like. Motivation and Emotion is very thought-provoking and the title is exciting in itself; why people do some things and don't do some other. Language and Thought touches upon the basics of HS 309, the linguistics course.
Personality is a vast area in Psychology, and the instructor did a pretty good job to summarise it. You will get to know about Sigmund Freud, the father of psychoanalysis, in this section and his theories were very twisted and controversial (trust me, you will enjoy it!).

The slides just had bullet points and were not complete, but the course textbook “Understanding Psychology” was interesting and lucid. The examination pattern was objective and tested the concepts heavily. The quizzes and mid sem were MCQs. But it was not that simple as there was negative marking involved, and the number of questions in a quiz was 20 and that in the mid sem was 60! End Sem had 20% subjective questions, but the rest were MCQs. The instructor kept the second quiz a surprise, but he kept a makeup quiz for people who missed it (which was extremely tough!). The instructor was quite strict about the usage of phones and laptops in class and attempted to make the lectures more interactive. The course was not-so-intuitive but super-amazing (if one attends all the lectures regularly) as it is all about how human mind works and the case studies will blow your mind too. I was quite hesitant to take this course initially, but I don’t regret a bit taking it as it was a very good learning experience and I am able to appreciate awesome Psychology memes.

8.3 Ashwin Dravid - HS 307 Introduction to sociology

The sociology course is quite interesting in the matter that it covers, though you have to pretty much do the course yourself by reading up on the handouts given. These can be pretty long, and unless you’re good at reading a lot of material quickly, I’d suggest you not pick it up. I took the course under Partha Sarathi Sharma. 4 marks had been allotted specifically for attendance and one can choose to ditch them. The material, though, when read on your own is quite interesting, and gives you a beginner level of insight on why various peoples develop the way they do and hold specific beliefs. That’s useful in life.

Exams in the course are a test of English more than sociology and be careful of double negative usage in the options for MCQs. You’ll find it to be tiresome and might not put in efforts as it is easy to pass by learning nearly nothing. If you’re good at English, the course is a cakewalk and you’ll at least get a 9 even if you study only for 4-5 hours the day before. Unfortunately, as it is a social sciences course, familiarity or proficiency in the language of instruction is the biggest factor.

8.4 Toshi Parmar - HS 309 Introduction to the Study of Language

Out of the four options offered at the start of the fifth semester, Languages requires the least amount of rote learning, and is fairly intuitive. It is an extensively logical course in linguistics with objective question papers and thought-provoking insight into the development of English, Hindi and a couple of major regional languages. The last time (session 2017-18) the course was administered by Prof. Vaijayanthi Sarma of HSS dept., and saw the maximum enrollment
of students because of a relatively lenient grading by the previous professor (session 2016-17), which is an objectively stupid criteria to take up this course because of the following reasons -

1. There are no official prerequisites for this course, but it presumes a fairly above average level of proficiency in English grammar to begin with.
2. The course doesn’t require additional learning but to get a decent grade >80% attendance is required, along with presence of mind, since the instructors often do not mention a lot of details in the slides and ask questions in every exam from the said part.
3. 10 weekly tests with a total of 30% weightage have to be taken by every student, the tests are easy but are more often than not are based on content that is not in the slides but was discussed in class.

The course is a relatively easy and interesting one, majorly divided into - Morphology, Syntax, Phonetics, Phonology, Language Acquisition and change, and Writing. There are excellent references for the course which match the instructor’s course plan and content very well. If, say, you are interested in Computational linguistics or Natural language processing, both interdisciplinary fields between CS, EE, and linguistics, this is a good course to build fundamentals in the latter. If you are not interested in any of these but are fascinated by the development, similarities, dissimilarities, and vagaries of language, this is a course that holds answers. If none of the above things apply to you but you’re looking for an HS course that is mildly-interesting, would not require much rote learning, and would fetch good grades if you just pay the minimum required attention in class, this one is still a safe bet.
9. Equivalent Courses for clearing backlogs

For the purpose of clearing backlogs, a list of equivalent courses which can be done has been given below:

It is to be noted that these courses are not equivalent by default but due to the similarity in the course structure, they have been allowed to be taken in lieu of the corresponding backlog courses subject to approval from the Faculty Advisor and HOD of the concerned HOD's. Approval needs to be taken from the DUGC for tagging two courses as equivalent that are not given in this list.

<table>
<thead>
<tr>
<th>Backlog</th>
<th>Equivalent Course</th>
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<tbody>
<tr>
<td>ME 346- Heat Transfer II</td>
<td>CL 246- Heat Transfer</td>
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<tr>
<td>MM 152- Materials &amp; technology</td>
<td>CL 346- Material Science</td>
</tr>
<tr>
<td>CE 201- Solid Mechanics</td>
<td>CL 231- Solid Mechanics</td>
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<tr>
<td>CE 201- Solid Mechanics</td>
<td>ME 201- Solid Mechanics</td>
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<tr>
<td>CE 205- Fluid Mechanics</td>
<td>ME 203- Fluid Mechanics</td>
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<tr>
<td>CE 221-Solid Mechanics</td>
<td>ME 201- Solid Mechanics</td>
</tr>
<tr>
<td>AE 460-Heat Transfer - Aerospace Applications</td>
<td>ME 346, Heat Transfer II</td>
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<tr>
<td>AE 102-Data Analysis and Interpretation</td>
<td>MM 217-Data Analysis and Interpretation</td>
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<tr>
<td>CL 202-Introduction to Data Analysis</td>
<td>EP 219-Data Analysis and Interpretation</td>
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<td>AE 102-Data Analysis and Interpretation</td>
<td>ME 102-Data Analysis and Interpretation</td>
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<tr>
<td>AE 209-Solid Mechanics</td>
<td>ME 201-Solid Mechanics</td>
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<tr>
<td>AE 102-Data Analysis and Interpretation</td>
<td>CS 215-Data Analysis and Interpretation</td>
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<tr>
<td>EN 206-Power Electronics and Machine</td>
<td>EE 222-Electrical Machines and Power Electronics</td>
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<tr>
<td>AE 308-Control Theory</td>
<td>EE 302-Control Systems</td>
</tr>
<tr>
<td>ME 346-Heat Transfer II</td>
<td>AE 460-Heat Transfer - Aerospace Applications</td>
</tr>
<tr>
<td>EN 201-Basic Electrical Engineering</td>
<td>EE 111-Introduction to Electrical Systems</td>
</tr>
<tr>
<td>MA 214-Introduction to Numerical Analysis</td>
<td>CL 244-Introduction to Numerical Analysis</td>
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The statistics courses of various departments are: AE 102, CS 215, EE 223, EP 219, ME 102, EN 207, MM 217, and CL 202 (8 credits).

10. Contact Information

In case of any queries please feel free to contact the UG academic council members, their contact details are as follows:

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THE END