COURSES AHEAD @ IITB

(A freshmen Guide to COURSES at IIT BOMBAY)

COURSE INFORMATION BOOKLET
2015-2016

Student Support Services
UG Academic council
IIT Bombay

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Disclaimer

The information written in the booklet is only a guideline to the fresher's. 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 higher authorities before making any decisions.

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 programme 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 programme will help you far beyond than what you think and in this world of cutting edge inter- disciplinary research will help you mould 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,
Vishnu Nair
Institute Secretary of Academic Affairs

Head – Student Support Services (2013-2014)

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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 course work (4 or 5 years). Core courses give you a major exposure to your own departmental subjects and research; they make you an expert in your major subject. Core courses also have an elective component, details regarding which is 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 will offer minors in their disciplines, and will **prescribe a specific set of courses** and/ or other activities like projects which is necessary for earning a minor in that discipline. **Note that, courses equal 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 wait list 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). 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:

Honor/ Honour is an additional credential a student will earn if he/ she opts for the extra 30 credits (Credit requirements subjected to change from the batch of 2014) needed for this in his/ her own discipline. The concerned department specifies the course requirements for earning the Honor's. An honor is exactly like a minor except that all courses are of the same dept. 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 s."** 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 305 - Reading Literature, HS 307 - Sociology. One more course (HS 3XX - Introduction to the Study of Language) is to be added to this list, refer ASC for the updated info.
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.
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 (An audit is a sit through course where you just receive a pass grade if you satisfy the criterion of audit as decided by the instructor in that course. There are no credits for the audit course, but it will reflect on your transcript) and do not count in your core CPI.

2. Why Minor ? & How to select a Minor ?

To become a successful engineer or scientist, you need supplements other than your own core courses in this competitive world, which is what your minor courses are. Minor courses enable you to learn something that you are passionate about and something out of the box. 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. If you are looking for a research topic of interest then browse through the departmental webpages of each department and search on internet as to what each of it is and during this process you will definitely stumble across your actual interest, once you are confident about your interest then you should probably look for a minor that best fuels your interest and go ahead with 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 below 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:

1. Aerospace Engineering:

Mechanical, Electrical, Civil Engg

2. Bio-sciences and Bio-engineering:
Chemistry, Engg. Physics, Chemical Engg, Electrical Engg, MEMS
3. Civil Engineering:
Mechanical and Aerospace Engg
4. Chemistry:
Engg. Physics, MEMS, Electrical Engg, Chemical Engg, Energy Engg
5. Chemical Engineering:
Chemistry, Mechanical Engg, Electrical Engg.
6. Centre of Studies in Resources Engineering (CSRE):
Electrical Engg., Computer Science, Engg. Physics
7. Computer Science and Engineering:
Suits All !
8. Electrical Engineering:
Engg. Physics, Chemistry, Chemical Engg, Mechanical Engg, MEMS, Energy Engg., Aerospace Engg.
9. Energy:
Mechanical Engg, Chemical Engg, Aerospace Engg.
10. Entrepreneurship:
Suits All !
11. Environmental Sciences and Engineering:
Chemistry, Chemical Engg, Civil Engg.
12. Humanities and Social Sciences:
Suits All !
13. Industrial Design Centre:
Suits All !
14. Mathematics:
Suits All !
15. Mechanical Engineering:
Civil Engg., Electrical Engg., Aerospace Engg
16. Material Sciences and Engineering:
Chemistry, Engg. Physics, Chemical Engg, Energy Engg.
17. Management:
Suits All !
18. Physics:
Chemistry, Chemical Engg., Electrical Engg., Mechanical Engg.,MEMS.
19. Statistics and Informatics:
Suits All !
20. Systems and Control Engineering:
Engg. Physics, Electrical Engg., Mechanical Engg., Civil Engg., Chemical Engg., Aeropsace Engg.

3. 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 tenure, 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 have been debarred from the re-tagging process.

Tags of courses:

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

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.

Tag code	Tag description	Changeable-to
T	Additional Learning	{D, I, O, E}
C	Core Course	
D	Departmental Elective	{O, T, E}
O	Honors Course	{D, E, T}
E	Honors Elective	{D, O, T}
H	Humanities Elective	{T}
I	Institute Elective	{T}
M	Minor Course	{I, T}

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).

4. Minor Courses:

4.1. Aerospace Engineering:

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).

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. Course contents: Nomenclature of aircraft components. Standard atmosphere. 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, V-n diagram, Take-off and landing. Re-entry vehicles: Ballistic and Glide Re-entry, Blunt body concept.

AE 415M – Spaceflight Mechanics (Offered in IV Semester, Pre-requisite: 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 (any three courses from two sets, also maximum of two from any one set)
In addition to the above, 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.

Autumn Semester 2015-2016:

AE 227M – Solid Mechanics (Not available to students of CE, ME, EN)
AE 225M – Incompressible Fluid Mechanics (Not Available to students of CE, ME, EN, CL)
AE 223M – Thermodynamics and Propulsion (Not Available to students of CE, ME, EN, CL)
AE 234M – Aircraft Propulsion (To run with AE 711, prerequisite: AE 223M or equivalent)
AE 236M – Compressible Fluid Mechanics (To run with AE 616, prerequisite: AE 225M or equivalent)
AE 238M – Aerospace Structural Mechanics (To run with AE 709, prerequisite: AE 227M or equivalent)
AE 305M – Flight Mechanics (To run with AE305)
AE 4xxM – Modelling and Simulation (To run with AE 4xx)
AE 333M – Aerodynamics (run with AE333, prerequisite: AE 225M, AE 236M or equivalent)
AE 3xxM – Vibrations and Structural Dynamics (To run with AE 3xx, prerequisite: AE227M or equivalent)

Spring Semester 2015-2016:

AE 234M – Aircraft Propulsion (To run with AE 234)
AE 236M – Compressible Fluid Mechanics (To run with AE 236, prerequisite: AE 225M or equivalent)
AE 238M – Aerospace Structural Mechanics (To run with AE 238, prerequisite: AE 227M or equivalent)
AE 3xxM – Aerospace Propulsion (To run with AE 3xx, prerequisite: AE 225M, AE 236M or equivalent)
AE 332M – Aircraft Design (To run with AE 332, prerequisite: AE 305M or equivalent)
AE 308M – Control Theory (To run with AE 308)
AE 4xxM – Navigation and Guidance (To run with AE4xx)
All minor registrations will be carried out in consultation with minor coordinator Prof. Viren Menezes.

4.2. Bio- Sciences and Bio- Engineering

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:

BS 400 – Molecular Biophysics : Molecular biophysics is a rapidly evolving interdisciplinary area of research that combines concepts in physics, chemistry, engineering, mathematics and biology. It seeks to understand bio-molecular systems and explain biological function in terms of molecular structure, structural organization, and dynamic behaviour at various levels of complexity (from single molecules to supramolecular structures, viruses and small living systems). The technical challenges are formidable, and the discipline has required development of specialized equipment and procedures capable of imaging and manipulating minute living structures, as well as novel experimental approaches. This course will basically teach you about the conformations that various biomolecules like proteins etc. would attain in a particular medium or conditions inside a cell and the physics behind protein folding and dynamics.

BS 403 – Molecular Biology/ BS 409 – Introduction to Molecular Cell Biology:
Molecular biology is the branch of biology that deals with the molecular basis of biological activity. This field overlaps with other areas of biology and chemistry, particularly genetics and biochemistry. Molecular biology chiefly concerns itself with understanding the interactions between the various systems of a cell, including the interactions between the different types of DNA, RNA and protein biosynthesis as well as learning how these interactions are regulated. BS 409 is a lighter and basic version of the BS 403 course for those who are from Non– Biology background.

BS 404 – Metabolism and Bio-energetics: Metabolism is the set of life-sustaining chemical transformations within the cells of living organisms. These enzyme- catalysed reactions allow organisms to grow and reproduce, maintain their structures, and respond to their environments. The word metabolism can also refer to all chemical reactions that occur in living organisms, including digestion and the transport of substances into and between different cells, in which case the set of reactions within the cells is called **intermediary metabolism** or **intermediate metabolism**. **Bioenergetics** is the subject of a field of biochemistry that concerns energy flow through living systems. This is an active area of biological research that includes the study of thousands of different cellular processes such as cellular respiration and the many other metabolic processes that can lead to production and utilization of energy in forms such as ATP molecules.

BS 501 – Molecular Enzymology: Enzymes are large biological molecules responsible for the thousands of metabolic processes that sustain life. Molecular Enzymology deals with the study of these chemical reactions, their reaction pathways, thermodynamics and kinetics.
Usually the department runs all the above courses every year across the two semesters and the application based courses below are run periodically so that students get to choose over their interests.

BS 503 – Genetic Engineering
BS 605 – Genetics and Evolution of Biological Circuits
BS 658 – Biomedical Microsystems
BM 600 – Introduction to Biomedical Engineering
BM 603 – Physiology for Engineers

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

4.3. Civil Engineering:

The Civil Engineering minor is designed to give an introduction to the Civil Engineering Department for those who have an interest in it. As such, students of Mechanical Engineering who would like to learn about Civil Engineering could find the courses to their interest, though students from other departments with an interest will find it equally rewarding

Future Benefits:

Civil engineers work in a diverse range of responsibilities- management, planning, designing, safety, R&D, consulting, etc. Pursuing a minor in Civil Engineering would not only equip you with knowledge that is necessary while designing plants, industries but will also give you an exposure of how basic elements in a city function like transportation, construction of bridges, dams, sewerage disposals, controlling floods, disaster management etc. The Civil Engineering Minor would give a student an advantage in R&D the topics covered here expose you to a lot of different areas.

COURSES:

CE 102 – Engineering Mechanics: Equivalent Force Systems, Planar and parallel force systems, Distributed force systems, Equations of Statics and its Applications: Virtual Work and Potential Energy Principles Vibrations, Equations of motion for single degree-of-freedom systems and rigid body assemblies, Free vibration (simple harmonic oscillator): Damped free vibration: equations of motion for harmonic excitation: transient and steady-state vibrations.

CE 201 – Solid Mechanics I: Rigid and deformable solids, Method of sections for evaluating internal forces in bodies - review of free body diagrams, Concept of stress - normal and shear stresses, Concept of strain - normal and shear strains, Hooke's law and Constitutive relations, Axially loaded members, force and deflections, Indeterminate systems and compatibility conditions, Simple indeterminate systems and lack of fit problems, Stress in cylindrical and spherical shells.

Torsion of circular shafts, Elastic theory of bending of beams, Shear force and bending moment diagrams, Bending and shearing stresses in beams of symmetrical cross-section

Concept of shear flow and shear centre, Principle of superposition and its limitations

Mohr's circle, bending deflection of beams by direct integration method, Application of direct integration method to simple indeterminate systems, Elastic buckling of compression members.

CE 205 – Fluid Mechanics: Fundamental definitions, Flow characteristics, Classification of fluids, Fluid properties, Fluid Statics: Fluid pressure, Forces on solid surfaces, Buoyant forces, Kinematics of Fluid Flow: Equations for acceleration, Continuity equation, Ir-rotational and rotational flow, Potential and stream functions, Dynamics of Fluid Flow: Finite control volume analysis, Euler and Bernoulli's theorems, Impulse momentum theory, Laminar and Turbulent Flows: Types of flow, Reynolds experiment, Laminar flow between parallel plates, Laminar flow in pipes, Turbulent flow in pipes., Introduction to Navier-Stokes equations, Exact solutions for simple cases of flow, Plane Poiseuille flow, Coute flow, Stokes flow and porous media flow, Boundary Layer Theory and Applications: Concepts of boundary layer, Flow separation, Circulation, Drag and lift on immersed bodies.

CE 303 – Soil Mechanics I: Origin of soils, Properties of soil aggregate, soil structure, soil classification, Soil compaction, laboratory compaction, Field compaction, Soil-water statics, Effective stress, Capillarity phenomenon in soils, Flow through soils, Quick sand condition, Permeability and methods for its determination, Flownets, stresses in soil from surface loads, Boussinesq theory, Westergaards theory, Newmarks chart.

CE 310 – Transport Engineering: Introduction to transportation systems engineering, Transportation system characteristics, Planning of highway, railway and airport systems, Highway/railway route selection, Airport site selection, Geometric design of highway, railway and airfield elements, Pavement/track materials and testing, Material characterization for design, Design of highway and airfield pavements, Structural design of the railway track, Highway construction, maintenance and rehabilitation.

4.4. Chemistry:

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 Nano-electronics) 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 5yr Integrated M.Sc. students and it has got three portions in the course- Physical Chemistry: Introduction to Chemical thermodynamics– here you are taught about the deviation from ideal to real behaviour of chemical systems and how you understand those using thermodynamic properties. Chemical Kinetics: Revision of JEE concepts, Collision theory and Transition state theory, Introduction to Molecular Dynamics. Inorganic Chemistry: Organometallic compounds- their synthesis and spectra properties, Magneto-chemistry, Introduction to Electronic Spectroscopy. Organic Chemistry: Recap of various Organic reaction and mechanisms which you have learnt in JEE.

CH 210 – Inorganic Chemistry – 1: 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 and its application in designing novel materials like Dye sensitised solar cells, Photonic nanowire and Anionic and cationic sensors etc. (This is an application oriented course – no mugging required!)

CH 211 – Physical Chemistry – 1: This course mainly deals with Chemical thermodynamics, Solution thermodynamics and Phase transformation and the second half deals with the Electrochemistry of Ions which forms an important concept in designing of many electrochemical sensors and biosensors.

CH 221 – Organic Chemistry – 1: This course gives you a good exposure onto frontier molecular orbital theory and the occurrence of chemical reactions is understood using this theory. Pericyclic reactions are mainly taught for giving a good insight in understanding MOT based interpretation. The later part introduces you to the powerful tool of spectroscopy and how it's used in understanding molecular structure, reactions and detecting them.

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

4.5. Chemical Engineering:

Overview of the Department: 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. Chemical engineering is a service-oriented field which serves to provide raw materials to other industries like FMCGs, while other fields Mechanical, Aerospace, Electrical and Computer Science Engineering are product oriented.

Future Benefits:

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 254 – Chemical Energy 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, Homogenous and Heterogeneous Reactions, Combined Phase and Reaction Equilibria.

CL 203 – Transport Phenomenon: 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 Concentration distributions in solids and laminar flow, Heat and Mass Transfer coefficients.

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, Segregation and Maximum Mixedness models.

CL 457 – 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 feed forward, Introduction to multivariable control**,** Controller implementation through discretisation.

4.6. Centre for Studies in Resources Engineering: (CSRE)

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 402 – Introduction to Geographic Information Systems: A geographic information system (GIS) is a system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data. The acronym *GIS* is sometimes used for geographical information science or geospatial information studies to refer to the academic discipline or career of working with geographic information systems and is a large domain within the broader academic discipline of Geo-informatics.

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.

Other courses run by the department are as follows:

GNR 403 – Geo-informatics Lab

GNR 407 – Natural hazards and Disaster management

GNR 409 – Terrain Evaluation and Land use planning

GNR 410 – Digital Photogrammetry and GPS

GNR 411 – Integrated Coastal Management
GNR 412 – Fundamentals of Natural Resources Engineering

You can find the complete course contents at:
http://www.csre.iitb.ac.in/csrewebsite/academics/minor-course

4.7. Computer Science and Engineering:

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 213 – Data Structures and Algorithms: Introduction to data structures. Abstract data types. Analysis of algorithms. Creation and manipulation of data structures: arrays, lists, stacks, queues, trees, heaps, hash tables, balanced trees, tries, graphs. Algorithms sorting and searching, order statistics, depth-first and breadth-first search, shortest paths and minimum spanning tree. Special topics from problems in computational geometry and string matching

CS 218 – Design And Analysis of Algorithms: Models of computation, algorithm analysis, time and space complexity, average and worst case analysis, lower bounds. Algorithm design techniques: divide and conquer, greedy, dynamic programming, amortization, randomization. Problem classes P, NP, PSPACE; reducibility, NP-hard and NP-complete problems. Approximation algorithms for some NP-hard problems.

CS 228 – Logic for Computer Science: Propositional logic, Derived rules, Provable equivalence, Semantics of propositional logic, Semantic equivalence, Conjunctive normal forms and validity, Horn clauses and satisfiability, SAT solvers. Predicate logic: Predicate log ic as a formal language, Terms, Formulas, Free and bound variables, Substitution, Proof theory of predicate logic, Natural deduction rules, Quantifier equivalences, Semantics of predicate logic, Expressiveness of predicate logic. Program correctness, Notion of program correctness, Hoare triples, Proof calculus for partial correctness, Proof tableaux, Proof calculus for total correctness, Programming by contract, Other Applications such as Logic in databases, Logic programming, Puzzle solving, Practice with Verification tools

CS 317 – Database and Information systems: Database principles-designing databases. Database Management System. Structured Query Language (SQL); Relational models; Entity Relationship Models. Storage and file structures; indexing and hashing of storage structures. Query processing and query optimization. Database transactions.

CS 348 – Computer Networks (Pre-requisite– CS 213): Design of Computer Networking protocols at all layers. Transmission media, data link protocols. Media access control, routing and congestion control, admission control, traffic shaping and policing. Internet working (IP) and transport layer protocols (TCP). Performance analysis of networks.

CS 416 – Computer and Network Security: Overview of vulnerabilities, risks, security incidents and forensics for computers and networks. Operating Systems security and Secure Programming. Cryptography: secret-key, public-key and digital signatures. Authentication and authorization. Network security including VPNs. Firewalls and intrusion detection. Security of Web services, E-commerce and payment protocols. Formal Models of Security and Cryptographic protocols.

4.8. Electrical Engineering:

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:

EE 210 – Signals & System: The field studies input and output signals, and the mathematical representations between them known as systems, in four domains: Time, Frequency, *s* and *z*. Since signals and systems are both studied in these four domains, there are 8 major divisions of study. As an example, when working with continuous time signals (*t*), one might transform from the time domain to a frequency or *s* domain; or from discrete time (*n*) to frequency or *z* domains. Systems also can be transformed between these domains like signals, with continuous to *s* and discrete to *z*.

EE 221 – Digital Electronics: Digital electronics, or digital (electronic) circuits, represent signals by discrete bands of analog levels, rather than by a continuous range. All levels within a band represent the same signal state. In most cases the number of these states is two, and they are represented by two voltage bands: one near a reference value (typically termed as "ground" or zero volts) and a value near the supply voltage, corresponding to the "false" ("0") and "true" ("1") values of the Boolean domain respectively. Digital techniques are useful because it is easier to get an electronic device to switch into one of a number of

known states than to accurately reproduce a continuous range of values. Digital electronic circuits are usually made from large assemblies of logic gates, simple electronic representations of Boolean logic functions.

EE 232/ EE 204 – Analog Electronics: Biasing of discrete devices and integrated circuits, Low frequency amplifiers, Feedback amplifiers, Frequency response of amplifiers and high frequency effects, Internal stages of OPAMP Difference amplifier, Intermediate stage amplifier, Level shifter, Output buffer, Linear applications of OPAMP, Non-Linear applications of OPAMPS, Wave generation with OPAMP, Active filters, Oscillators, Regulators, Power amplifiers.

EE 203/EE 207 – Electronic Devices: Band Theory of solids and devices, modelling of semiconductor devices, PN junction diodes, discrete transistor amplifier, BJT and MOS transistors.

EE 325 – Probability and Random Processes: The goal of the course is to provide the student with a background in applied probability, statistics and random processes that is necessary to undertake courses in communication theory, radar, signal processing and similar areas. In probability theory, a stochastic process or sometimes random process (widely used) is a collection of random variables; this is often used to represent the evolution of some random value, or system, over time. This is the probabilistic counterpart to a deterministic process (or deterministic system).

EE 342 – Control and Communications: Review of Signals and System. Fourier Transforms. Linear Feedback System- frequency and time domain analysis. Transfer function. Ruth Hurwitz and Nyquist Stability Criteria. Analog Communications System- AM, FM and receiver structures. Frequency and Time Divison Multiplexing. Sampling and Pulse Code Modulation (PCM). Pulse Amplitude Modulation.

4.9. Energy:

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, gasifies, biogas, biodiesel, ethanol; Wind, Introduction, types of wind machines, Cp-l curve & betz limits, wind recourse 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: Overview of the Indian power sector, Thermodynamic analysis of Conventional Power Plants. Advanced Power Cycles, Kalina (Cheng) Cycle, IGCC, AFBC/PFBC, Steam Turbine - Superheated, reheater and partial condenser vacuum. Combined Feed heating and Reheating. Regenerative Heat Exchangers, Reheaters and Intercoolers in Gas Turbine power plants. Hydro power plants - turbine characteristics. Auxiliaries - Water Treatment Systems, Electrostatic Precipitator / Flue gas Desulphurisation, Coal crushing / Preparation - Ball mills / Pulverisers, ID/FD Fans, Chimney, Cooling Towers. Power plant control systems- Review of control principles, Combustion control, pulveriser control, control of air flow, Furnace pressure and feed water, steam temperature control, Safety provisions / Interlocks Analysis of System load curve -plant load factor, availability, Loss of load Probability calculations for a power system, Maintenance Scheduling Pricing of Power - Project cost components, Analysis of Power Purchase Agreements (PPA), Debt/Equity Ratio and effect on Return on Investment, Environmental Legislations/Government Policies Optimal Dispatch - Scheduling of Hydro-Thermal plants. Load Forecasting - Time series, Econometric, end use techniques. Least Cost Power Planning - Integration of DSM, Renewable into supply.

EN 402 – Energy Management: 1. Importance of energy management. Energy auditing: methodology, analysis of past trends plant data), closing the energy balance, laws of thermodynamics, measurements, portable and on line instruments. 2. Energy economics - discount rate, payback period, internal rate of return, life cycle costing. Steam Systems: Boiler -efficiency testing, excess air control, Steam distribution & use- steam traps, condensate recovery, flash steam utilisation. Thermal Insulation. 3. Electrical Systems: Demand control, power factor correction, load scheduling/shifting, Motor drives- motor efficiency testing, energy efficient motors, motor speed control.4. Lighting- lighting levels, efficient options, fixtures, daylighting, timers, Energy efficient windows.5. Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration & air conditioning systems. Waste heat recovery: recuperators, heat wheels, heat pipes, heat pumps.6. Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy. Heat exchanger networking- concept of pinch, target setting, problem table approach, composite curves. Demand side management. Financing energy conservation

EN 403 – Energy Resources, Economics and Environment: Overview of World Energy Scenario, Dis-aggregation by end-use, by supply Fossil Fuel Reserves - Estimates, Duration Overview of India`s Energy Scenario - Dis-aggregation by end-use, by supply, reserves Country Energy Balance Construction - Examples Trends in energy use patterns, energy and development linkage. Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy , Cost of Energy generated, Examples from energy generation and conservation, Energy Chain, Primary energy analysis Life Cycle Assessment, Net Energy Analysis Environmental Impacts of energy use - Air Pollution - SOx, NOx, CO, particulates Solid and Water Pollution, Formation of pollutants, measurement and controls; sources of emissions, effect of operating and design parameters on emission,

control methods, Exhaust emission test, procedures, standards and legislation; environmental audits; Emission factors and inventories Global Warming, CO2 Emissions, Impacts, Mitigation Sustainability, Externalities, Future Energy Systems.

You can choose any courses from this Elective list to complete you minor:

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

4.10. Entrepreneurship:

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 start-ups.
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:

Innovation and Entrepreneurship, Idea to Opportunity, Business Model Canvas, New Product Development, Commercializing Technology, Basics of Finance, Customer Discovery and Validation, Feasibility Study

ENT 202 – Business Skills for Entrepreneurs: Intended for students to develop an in-depth understanding of how to manage a start-up. Advanced entrepreneurship course for those who have already completed ENT 201 Introduction to Entrepreneurship
Scope and Coverage: Setting Up an Organization, Building a Team, Selling Skills and Sales Strategy, Sales Deals and Business Deals, Customer Relationship, Angel and VC Deals, Board of Advisors and Directors, Presentation Skills, Skills to build a winning team, win business with early and strategic customers, develop a viral marketing strategy, establish a global sales strategy, learn the basic principles of business negotiations, From opportunity to setting up the new venture, Organizing for results, financial planning & control

The course also allows students to start a new project or continue to develop their concept started in ENT 201.

Other courses by Centre for Entrepreneurship:

- **Identifying and Exploiting Opportunities**
- **Resource Planning for New Ventures**
- **Management of Intellectual Property**

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

Courses offered by Other Academic Units

- **Introduction to Design (IDC)**
- **Innovation and Creativity (IDC)**
- **Entrepreneurship in Materials Science (MEMS)**
- **Collaborative Engineering (ME)**
- **Industrial Marketing (SJMSOM)**
- **Basics of Accounting and Finance (SJMSOM)**
- **Managing with New Business Models in Knowledge Economy (SJMSOM)**

Apart from these courses Centre for Entrepreneurship has also introduced,

Ignition Lab

Objectives: To develop a Proof-of-Concept and appropriate prototype for ideas with high business potential.

Steps: Team formation, Commercial potential assessment, Demonstration of proof-of-concept, Creation of Prototype, Pitching to Investors

Selection Criteria: Commercial potential, Customer feedback, Technology intensity, Capacity of the team to take the idea to a logical conclusion, approximate time, resources, funds and mentoring needed.

Credit Distribution (for B.Tech. Minor): 3+6 across two semesters.

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

4.11. Environmental Science and Engineering:

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 course work 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, Titrations, Acidity, Alkalinity, Buffers and buffer intensity, Chemical equilibrium calculations, pC-pH diagram. Precipitation and dissolution, Water softening and water conditioning, Langelier index, Solubility diagram, Coexistence of phases in equilibrium, Complexation of metal ions and organic complexes in natural water. Oxidation and reduction reactions stoichiometry, Redox couples, pE-pH diagrams, Redox control in natural systems, Basic concepts of organic and colloid chemistry. Soil Chemistry, Weathering reactions, Structure and surface reactions of clays and oxides, Forces at soil-water interfaces. Atmospheric Chemistry, Chemical equilibria and kinetics, Photo-dissociation and free radical reactions, Chemistry of precipitation, Acid rain.

ES 303 – Municipal Solid and Biomedical Waste Management: 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 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 ground water, 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 644 – 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.

4.12. Humanities and Social Sciences:

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/courses/BTech/ugcoursecontents.htm

4.13. Industrial Design Centre:

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

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, Form 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 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.

Other Courses offered by Industrial Design Centre to complete the minor are:

ID 405 – Human Computer Interaction Design

ID 406 – Studio Project-1

ID 407 – Studio Project-2

ID 408 – Technology and Animation

ID 411 – Introduction to Ergonomics

ID 627 – Elements of Design-1

For detailed course contents contact the IDC departmental office or the instructor taking it in that semester.

4.14. 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: Metric spaces, compactness, connectedness, completeness. Continuity, Monotonic functions. Differentiation of vector-valued functions. Functions of bounded variation and absolutely continuous functions. Riemann- Stieltjes integral and its properties. Fundamental theorem of integral calculus. Sequences and series of functions, uniform convergence and its relation to continuity, differentiation and integration. Equi-continuous families of functions, Ascoli-Arzela theorem. Weierstrass approximation theorem. Fourier series, Fejer"s theorem, point wise convergence.

MA 419 – Basic Algebra: Equivalence relations and partition. Division algorithm for integers. Chinese Remainder Theorem, Euler φ-function. Permutations. Polynomials in one and several variables. Newton's identities. Fundamental Theorem of Algebra. Rational functions. Lagrange's Theorem. Jordan-Holder Theorem. Unique Factorizations Domains. Polynomial rings over UFD's.

MA 406 – General Topology: Topologies through open sets, bases, sub-bases, closure, interior, boundary, subspaces. Continuity, open functions, homeomorphisms, embeddings, strong and weak topologies generated by families of functions. Quotient spaces. First and Second countable, separable, Lindeloff, compact spaces. Separation axioms, Urysohn"s lemma. Products, embeddings into products, Urysohn metrisation theorem. Convergence of nets and filters. Filters and compactness, ultra-filters. Tychonoff compactness theorem, Local compactness, Alexandroff compactification. Function spaces, compact-open topology. Connectedness, components, local connectedness, paths, loops. Homotopy, fundamental group. Computation of the fundamental group of the circle.

MA 412 – Complex Analysis: Complex numbers and the point at infinity. Analytic functions. Cauchy-Riemann conditions. Mappings by elementary functions. Riemann surfaces. Conformal mappings. Contour integrals. Cauchy-Goursat Theorem. Uniform convergence of sequences and series. Taylor and Laurent series. Isolated singularities and residues. Evaluation of real integrals. Zeroes and poles, Maximum Modulus Principle, Argument Principle. Rouche's theorem.

MA 5022 – Fourier Analysis and Applications: Properties and Uniqueness of Fourier Series. Convolutions, Cesaro and Abel Summability. Fejer`s theorem, Poisson Kernel and Dirichlet problem in the unit disc. Mean square Convergence, example of Continuous functions with divergent Fourier series. Distributions and Fourier Transforms. Calculus of Distributions, Schwartz class of rapidly decreasing functions**.** Fourier transforms of rapidly decreasing functions. Riemann Lebesgue lemma, Fourier Inversion Theorem, Fourier transforms of Gaussians. Tempered Distributions. Applications to PDEs (Laplace, Heat and Wave Equations). Schrodinger-Equation and Uncertainty principle. Paley-Wienner Theorems, Poisson Summation Formula: Radial Fourier transforms and Bessel`s functions. Hermite functions.

4.15. Mechanical Engineering:

The minor in mechanical engineering complements studies in a major field closely allied to mechanical engineering, such as materials science and engineering, aeronautics and astronautics, electrical engineering, management, and a number of other possibilities. A student can be awarded a minor in mechanical engineering provided he completes any five of the following courses:

COURSES:

ME 201 – Solid Mechanics: Detailed analysis of stress strain relations in simply supported beams. Study of torsion of circular shafts and introduction to bending of beams. Introduction to Mohr's circle and Castigliano's Theorem. Analysis of Shear Loaded Components. Beams; Shear Force and Bending Moment Diagrams. Thick Cylinder; Interference Fit; Rotating Disc.

ME 316 – Kinematics and Dynamics of Machines: As the course name suggests, it involves study of mechanisms of machines and its kinematics. It includes- Introduction to Mechanisms of machines. Position, velocity and acceleration analysis. Analysis of gear tooth profiles, spur gears and helical gears. Balancing. Analysis and Applications of Discrete and Continuous System Vibration.

ME 209 – Thermodynamics: Begins from the very basics of thermodynamics covered during JEE and studies its laws in detail. It involves: zeroth law, first law, second law. Maxwell equations, Property relations, Properties of steam, Introduction to steam tables, Other equations of state, Van-der-Waals gas, Kelvin-Planck and Clausius statements, Equivalence of statements, Carnot theorem, Clausius inequality, Definition of entropy, Evaluation of entropy, Availability and energy, Lost work.

ME 203 – Fluid Mechanics: Detailed study of fluids, their behaviour and mathematics involved. Includes: Introduction, fluid characteristics, continuum concept, properties of fluids, fluid statics, flow kinematics, control volume equations, flow analysis, solution of Navier-Stokes equations for some special cases, boundary layer theory and dimensional analysis.

ME 333 – Manufacturing Processes I: This course involves the study of basic concepts of how to produce manufactured items. It includes: Casting processes: dispensable and permanent mould processes; analysis of melting, pouring and solidification phenomena; design of pattern, core, feeder and gating system; casting defects and inspection. Joining processes: fusion and solid-state welding; brazing and soldering; weld joint design, cooling rate, and joint properties; welding defects and inspection. Bulk and Sheet Forming processes: rolling, forging, extrusion and drawing; sheet metal working; forming limit diagram; loads, friction and lubrication; forming defects and inspection. Powder processing: Powder manufacture, characterization and compaction and sintering; metal injection moulding; hot and cold isostatic pressing. Polymers and Composites: Thermoplastics, thermosets, elastomers and composites; related processes; injection mould design; moulding defects and inspection. Advanced processes: Free form fabrication (rapid prototyping), and net shape manufacturing.

ME 338 – Manufacturing Processes II: Continues on the previous course. Involves: Material Removal Processes: Mechanics of Machining, tool geometry and materials, chip formation, tool temperature, tool wear, tool life, surface finish, machinability. Optimization of machining processes. Machine Tools: Generation of surfaces by machining, basic operations on shaping, slotting and planning machines, lathe, drilling and boring machines and grinding machines. Process Parameters and setups. Production Machines: Capstan and turret lathes, automats, broaching machines, centreless grinding machines. Special purpose machines for thread cutting and gear cutting (hobbing and shaping). Finishing processes honing, laping burnishing and deburring. Introduction to modern machining processes: EDM, ECM, LASER, Jigs and fixtures, principles of location and clamping, synthesis of simple jigs and fixtures.

Principles of assembly engineering, theory of dimensional chains, fully interchangeable and selective assembly. Introduction to Numerical Control.

4.16. Metallurgical and Material Science Engineering:

Metallurgical Engineering and Materials Science is one of the most basic branch of engineering and finds its application in each and every branches of engineering. It is valued even in chemical (Thermodynamics of Materials, Phase transformation), electrical (Electronic properties of materials, Phase transformations), mechanical (Thermodynamics, Phase transformations) industries for various purposes. So companies would prefer students who have some basic knowledge about Metallurgical Engineering and Materials Science. MEMS is a field that focusses on everything that has to do with materials. MEMS engineers study a wide range of properties of materials and their extraction, along with getting introduced to many exciting and novel materials and their syntheses, in order to ultimately employ them suitably in many diverse applications that serve the betterment of human life. Every possible field would require the use of materials and we help in that choice of apt materials to cater to an application. The minor thus, introduces the students to properties of materials that are usually taken into consideration when they are employed in some use.

MM 201 – Structure of Materials: Classification of materials. Geometry of crystals, symmetry and point groups, Bravais lattice, unit cells. Atomic packing factor and theoretical density. Fractional coordinates, Crystallographic directions and planes. Inter-planar spacing and angles, zone axis. Diffraction of X-Rays, Braggs Law, structure factor and intensity calculations. Applications of XRD: Identification of phases, lattice parameter determination, solvus line, crystallite size, super lattice lines. Amorphous materials and glasses. Polymeric structures. Defects in crystals. Point defects, dislocations, Burgers vector and its representation. Planar defects: stacking faults, twins, grain boundaries. -Equilibrium phase diagrams, cooling curves, phase rule, lever rule and invariant reactions. Introduction to important binary phase diagrams. Some examples: Fe-Fe3C, Cu-Zn, Al-Cu. Concept of microstructure. Optical microscopy. Microstructures in steels and cast iron.

MM 202 – Thermodynamics of Materials : Laws of thermodynamics, concepts of reversibility, internal energy, enthalpy, entropy, maximum work, free energy, fugacity, activity and chemical potential, homogeneous and heterogeneous equilibria, phase rule, properties of solutions and concepts of partial molal properties, alternative standard states and interaction parameters, statistical concepts of entropy. Basic kinetic laws, order of reactions, rate constant, elementary and complex reactions, rate limiting steps and Arrhenius equations, theories of reaction rates - simple collision theory, activated complex theory.

MM 318 – Electronic Properties of Materials: Geometry of crystals. Reciprocal lattice, reflection condition and Bragg's law. Free electron theory of metals. Kronig-Penney model. Brillouin zones, Energy bands, energy- wavevector diagrams. Conductivity in metals and Hall Effect. Semiconductors: intrinsic and extrinsic. Carrier concentration, effective mass, Fermi energy determination. Dielectric and Optical properties- polarization, types and mechanisms, macroscopic and local fields, polarizability. Dispersion and complex dielectric constant. Complex refractive index, Transmission, Reflection, Absorption and Plasma resonance. Magnetic properties: Paramagnetism, Curie-Weiss law, Pauli paramagnetism, molecular field theory, exchange interactions, ferro, anti-ferro and ferri-magnetism. Soft and hard magnetic materials. Magnetization, Introduction to superconductivity.

MM 404 – Engineering Polymers: Classification of polymers. Polymerization reactions. Polymer characterization, Thermal, Mechanical and electrical properties, Polymer Crystallinity, Structure Property correlations in polymers. Hybrid polymers; Polymer Degradation and Stabilization. Polymer Engineering: Raw materials for production, Industrial Polymer production, Polymer processing techniques; Fabrication of special polymer products; polymer matrix composites; Recycling of Plastics.

MM 453 – Engg. Polymers and Composite of Materials: Recap of above course along with Introduction and classification of composite materials, strengthening mechanisms in composites, Reinforcing materials: fibres, whiskers and particles. Manufacture of glass fibres, fabrication of fibre reinforced plastics and metal matrix composites. Properties and application of composites.

4.17. Management:

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: Principles of Marketing (4 P's and 5 C's). Sales and Demand Forecasting. Marketing Strategy and tactics. Marketing analysis. Organization`s system for planning the marketing effort. Implementation of marketing strategies. Analysis of practical marketing problems

MG 402 – Human Resource Management: Personnel Management vs Human Resource Management. Principles of HRM. Who is a Manager and his responsibilities? What is Human Resource Planning and Staffing? Organisational Structure and Culture. Leadership. Stakeholders, Managers and Ethics 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: Project management Process and role of Project Manage. Project screening and Selection Techniques Structuring concepts and Tools (WBS, OBS, and LRC). Project Planning Tools (Bar charts, LOB, CPM, and PERT). Cost Estimates and Estimating Methods, Project Budgeting. Project Planning and Scheduling, Project Scheduling with Resource. Constraints, Resource Levelling and Allocation. Case studies on managing special projects (Software projects /New Product Development projects/ R&D projects /Mega Projects).

MG 406 – Operations Management: Principles of Operations Management. Practices in Operations Management. Inventory Management. Supply Chain Design. Planning and Controlling Supply Chain Scheduling. Continuous and Batch Processes. Quality Management.

4.18. Physics:

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, micro canonical, 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 State 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, atto second pulses, manipulation of atoms, molecules and larger systems with light, atom optics, quantum computers and quantum communication.

PH 401 – Classical Mechanics: As the course name suggests, it covers classical mechanics which is nothing but Newtonian mechanics but in a mathematically rigorous way, in detail. Course contents: Review of Newton`s laws of motion. Hamilton`s principle, variational method and Lagrange`s equations with and without constraints. Central force, Kepler`s laws. Hamilton`s equations, canonical transformation, Poisson brackets. Periodic motion, small oscillations, normal coordinates. Rigid body dynamics, moment of inertia tensor, Euler

equations, motion of a symmetric top. Frames of reference, rotating frames, centrifugal and Coriolis forces.

4.19. Statistics and Informatics

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: The basics of probability. Pre-requisite for SI 402, SI 404, SI 527. It includes: Axioms of Probability, Conditional Probability and Independence, Random variables and joint distributions, Functions of random vectors. Expectation, moment generating functions and characteristic functions, Conditional expectation and distribution functions. Functions of random variables, Expectation, moment generating functions, Modes of convergence, Weak and strong law of numbers, central limit theorem.

SI 402 – Statistical Inference: Statistical inference is the process of drawing conclusions from data that are subject to random variation, for example, observational errors or sampling variation. It includes: Polynomial interpolation. Piecewise polynomial and cubic spline interpolation. Least square approximation. Numerical integration: various rules and their composite versions. Numerical differentiation. Methods for single non-linear equation. Bisection and secant methods. Newton's method: convergence and rate of convergence. System of equations. Numerical solution of ordinary differential equations. Euler method. Runge-Kutta and multi-step methods. Predictor-corrector method. Exposure to software packages like Mathematica, Matlab and IMSL Subroutines.

SI 404 – Applied Stochastic Processes: This course deals with stochastic processes (a collection of random variable; often used to represent the evolution of some random value, or system, over time).The course includes: Linear Programming: Problem formulation, simplex and revised simplex methods. Duality and sensitivity. Case studies. Interior point methods. Nonlinear Programming: Problem formulation. Basic concepts from calculus of several variables, linear algebra and convex analysis. Iterative methods for unconstrained optimization. Least square optimization. Convex programming and Karush-Kuhn-Tucker theory. Penalty methods. Optimization with equality constraints.

SI 422 – Regression Analysis: Regression analysis is a statistical process for estimating the relationships among variables. It helps us understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. It includes: Simple Linear Regression Model in Matrix Terms, Multiple Linear Regression and General linear Regression Model in matrix terms, qualitative predictor variables, ANOVA Table, Inference. Diagnostics and remedial measures, Multicollinearity, Polynomial Regression Model. Qualitative Predictors. Model Selection, Criteria for model selection, Search procedure.

SI 527 – Introduction to Derivative Pricing: In derivative pricing, the price of a security is dependent upon or derived from one or more underlying assets. It includes: Basic notions, Cash flow, present value of a cash flow, securities, fixed income securities, types of markets. Forward and futures contracts, options, properties of stock option prices, trading strategies involving options, option pricing using Binomial trees, Scholes model, Scholes formula, Risk-Neutral measure.

4.20. Systems and Control Engineering:

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 behaviour's; 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.

3 compulsory core courses:

SC 201 – Mathematical structures for systems and control: Introduction to basic mathematics involved in control engineering and understanding of mathematical models in systems and control. Course contents: 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, eigen values, applications: control and signal processing) and, elements of differential geometry (n-surfaces in Euclidean space, tangent vectors, vector fields, co-vector fields, geodesics, covariant derivative, applications: robotics, dynamical systems and control.)

SC 202 – Signals and feedback systems: Understanding the concept and importance of feedback in control engineering. Course contents: 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: The course studies the linear systems in detail with focus on variables involved. It also studies how the linear systems can be extended to non-linear systems as well. Course contents: 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

4.21. Centre for Technology Alternatives for Rural Areas (CTARA):

It has been proposed and will be presented in the upcoming senate meeting for approval. The programme is designed to retain strong technical education centred on betterment of disadvantaged sections of the society. This also aims to expose and equip students to take up a career in the field of development. The Technology and Development minor is comprised of 5 courses (a minimum of 30 credits).

New Academic Courses proposed for the minor are as follows:

1) Structure of Society: Perspectives on Development and Research Methodology.
2) Structure of Technology: Appropriate Technology and Design of Intervention.

You should check your ASC or contact CTARA HOD for further information.

Minor Cut-off 2014

Note: *Some of the Cut-offs at lower end of CPI spectrum are actually CPI of the last registered student instead of branch cut-off as the course didn't reach its registration limit.*

CPI-Wise Cut-off List

Course Code	CPI Cutoff
SI 417	9.53
MA 403	9.17
MA 419	8.85
CS 228	8.73
MG 403	8.59
MG 401	8.52
SI 402	8.36
SC 618	8.24
BS 501	8.23
CS 317	8.19
MGT671	8.17
SC 633	7.87
EE 221	7.71
GNR 407	7.69
CS 218	7.56
SC 201	7.55
EE 204	7.16
BS 603	7.16
EE 210	7.07
SC 620	6.96
ID 408	6.9
ME 338	6.8

Course-wise Cut-off List

Course Code	CPI Cutoff
AE 332	6.38
BS 403	6.39
BS 409	5.13
BS 501	8.23
BS 603	7.16
BS 605	5.52
CE 102	5.65
CE 303	5.69
CE 310	6.22
CS 218	7.56
CS 228	8.73
CS 317	8.19
EE 204	7.16
EE 210	7.07
EE 221	7.71
EN 301	6.32
EN 645	6.12
EN 647	6.04
EN 649	5.81
EN 703	5.73
EP 332	6.01
ES 203	5.02

GNR 409	6.67	ES 303	6.25
ID 401	6.39	ES 401	6.19
BS 403	6.39	GNR 07	7.69
ID 404	6.38	GNR 409	6.67
AE 332	6.38	GNR401	5.96
SC 625	6.32	HS 207	5.93
EN 301	6.32	HS 213	5.86
MM 202	6.25	HS 217	5.09
ES 303	6.25	HS 219	5.02
CE 310	6.22	ID 401	6.39
ES 401	6.19	ID 404	6.38
ID 407	6.16	ID 406	5.68
SC 629	6.13	ID 407	6.16
EN 645	6.12	ID 408	6.9
EN 647	6.04	ID 411	5.66
SC 631	6.02	MA 403	9.17
EP 332	6.01	MA 419	8.85
GNR401	5.96	ME 201	5.3
HS 207	5.93	ME 203	4.96
SC 301	5.9	ME 338	6.8
HS 213	5.86	MG 401	8.52
EN 649	5.81	MG 403	8.59
EN 703	5.73	MGT671	8.17
CE 303	5.69	MM 202	6.25
ID 406	5.68	PH 401	5.05
ID 411	5.66	SC 201	7.55
CE 102	5.65	SC 301	5.9
BS 605	5.52	SC 601	5.43
SC 601	5.43	SC 607	5.3
SC 607	5.3	SC 618	8.24
ME 201	5.3	SC 620	6.96
BS 409	5.13	SC 625	6.32
HS 217	5.09	SC 629	6.13
PH 401	5.05	SC 631	6.02
HS 219	5.02	SC 633	7.87
ES 203	5.02	SI 402	8.36
ME 203	4.96	SI 417	9.53

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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Other useful Links:

UG Acads Wiki:

http://gymkhana.iitb.ac.in/~ugacademics/wiki/index.php/Main_Page

Academic Divisions, Dept. links:

http://www.iitb.ac.in/en/education/academic-divisions

UG Academics Website:

http://gymkhana.iitb.ac.in/~ugacademics/app/#/ugacads

Courserank Portal (Online Course Reviews):

http://gymkhana.iitb.ac.in/~ugacademics/courserank/