As approved by the Academic Committee in its 2nd meeting held on 16th July 2009.

Undergraduate Academic Programmes

at

Indian Institute of Technology Ropar

Report

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1. Introduction

The undergraduate academic programmes of the IITs are known for their rigour, intensity and the demands made on the students. There is stress on providing students a strong base in sciences and engineering science. There is conscious attempt to keep the courses current and to expose students to the state of the art and current thinking in all the courses that the students do. The focus is to graduate an as complete an engineer as possible, an engineer who is trained in all sub branches of a discipline.

A consequence of all these requirements is that the programmes are loaded with course work. A student routinely does up to six courses theory a semester. In the pressure to keep up with the classes, students often orient their focus on completing the requirements for the courses they have registered at the expense of understanding the material deeply and experiencing the excitement of following a line of investigation to its logical conclusion. The learning process has tended to become examination driven. Also, because of the packed schedule any shortfall/deterioration in performance increases stress on the students because making up is difficult as the curriculum schedule is already very packed.

The above is from the perspective of the student. From the perspective of curriculum developers and planners also there are aspects of current processes that hinder flexibility and inhibit natural evolutionary pressures. Much of it is due to over specification done with the objective to facilitate uniformity in rules, interpretation and implementation. Some of it is due to well meaning turf wars fought to ensure that changes in curriculum in the name of innovation do not happen at the expense of diluting the share of existing interest groups. Accumulation of compromise solutions over the years result in practices that do not encourage holistic perspective, stress conformity and make the process of bringing change so daunting and sapping that planners lower expectations from themselves in the name of pragmatism and realism.

The Committee has deliberated the above issues at length. The curricular recommendations that follow are, therefore, driven by the following guiding objectives:

(a) Overall curricular structure should be simple with delineation of categories that encourage interdisciplinary work/interdependencies rather than compartmentalization.

(b) The quantum specified should be such that it brings out the philosophical underpinnings of the over all objectives.

(c) The structural framework should be such that it enables planners of individual academic programs to find particular solutions without necessarily feeling the pressures to conform.

(d) The curriculum should emphasize the stand out qualities of strong science and engineering science base for which the IIT system is known.

(e) The curriculum should enable a student to have time to explore ideas, and encourage self study.

(f) The learning process should emphasize projects done both individually and in groups and not be just examination oriented.

(g) The curriculum should emphasize learning through design and development.

(h) The laboratory experience should include opportunities to plan, select equipment, assemble the set up and find solutions to structured but open ended problem definitions, working both individually and in groups.

(i) The curriculum should encourage instructors to use different forms of evaluation ranging from oral presentations, structured in-class examinations to take home submissions.

(j) The curriculum should provide freedom to a student to orient his/her academic programme along areas and expertise which cut across departmental boundaries with even greater flexibility than currently available through minor area initiatives.

(h) The curriculum be based on the credit structure in use at IIT Delhi.

2. Broad Overall Recommendations

As at most other institutions that follow the credit structure the Committee recommends that the over all requirements for a four year degree programme of Bachelor of Technology be structured into a few broad categories. For the programmes at IIT Punjab the categories recommended are Sciences, General Engineering, Humanities and Social Sciences, Programme requirements, Core Project, and Industry Internship.

2.1 Sciences

Sciences include Physics, Chemistry, Biology, and Mathematics. The issue of what should be the objectives of teaching courses in sciences was debated. Should the content of courses in this category be designed keeping in view the requirements of later (discipline) courses or should the courses focus on teaching the subjects as they would be taught to students majoring in that discipline? It was recognized that courses taught with the first objective in mind tend to be packed with information and often have quite unrelated material in them. This utilitarian view comes in the way of students developing and understanding of the nature of thought processes that lead to the development of new concepts and ideas. Instructors feel the pressure to complete the syllabus at the expense of developing capability of critical thinking. Students' learning also becomes formula driven and there are reasons to believe that such courses lead to reduction in motivation levels among the students. The Committee, therefore, recommends that courses be organized around well defined conceptual themes with titles that reflect their content. Courses with titles such as Mathematics 101 or Physics 101 should be avoided.

Curriculum designers for undergraduate engineering programmes should be encouraged to define core science requirements for students in terms of number of credits/courses that they feel all students should do rather than by listing out specific courses. It is felt that training of the mind to conceptualize, handle abstractions, and solve problems is more important in the long run and gets done equally well in all foundational science courses. Further it is more valuable when students do what they are interested in rather than the faculty worrying whether the student has come prepared with specific concepts over which engineering courses are supposed to build upon. It is the general experience that specific tools and techniques invariably get re-introduced in engineering courses regardless of whether they were taught as a part of basic science courses simply because what now gets emphasized is modeling rather than the technique in abstraction. Moreover, retention levels are such that repetition is a necessity in practice. This plan also provides students the experience of making choices and become responsible for their academic programme which adds to the over all enthusiasm levels exhibited by students towards the material they are working with.

Notwithstanding the above the Committee is fully aware that the dynamics of curriculum planning of undergraduate engineering education is such that the utilitarian view towards the role of science education starts influencing even the scientists in their approach to course formulation and syllabus development. To limit its influence the Committee feels that as a matter of principle it is necessary that syllabus contents of science courses be decided by the scientists as they see fit.

2.2 General Engineering

What makes a person an engineer? The Oxford English dictionary defines an engineer as one who contrives, designs, or invents. More than any professional knowledge of an engineering discipline, there is this cultural aspect to the persona of an engineer which distinguishes him from other professionals. Engineering education is based on the premise that designing and inventing can be taught or rather learned. All good engineering education is nothing but a continuous process of teaching designing, modeling, and building with more and more sophisticated tools, techniques, and knowledge. General Engineering constitutes in the Committee's view the basic foundation on which all engineering education is based. By definition and premise what constitutes General Engineering has to be a part of all engineering curriculum and also its content must reflect the curriculum planners perspective on what are today's essential tools, techniques, and processes that shape what an engineer does and how he does it.

It is the Committee's view that today's engineering is driven by the use of computer as the basic designing tool; that the primary energy form is electrical and advances in electronics are making the use of embedded devices to control and monitor function ubiquitous; and that advances in materials are revolutionizing not only the shape, form, and function of today's inventions, but also the processes by which engineered artifacts are designed, realized and ultimately manufactured. Understanding of computing, electrical technology and electronics, modern materials and manufacturing defines what an engineer does aspect of General Engineering.

It is the Committee's view that how he does it has gone through a major revolution in the last twenty years. Manufacturing is now driven by the use of automated tools, and the skills necessary to operate on the floor shop of a factory today are entirely different from those that were required twenty years ago. The design process has also undergone a revolutionary change. Not only design tools enable an engineer to conceptualize, build simulation models, simulate performance, and develop drawings that realize the concept on a computer, it is the current engineering practice to also build prototypes by realizing designs using computer driven rapid prototyping machines. This technology is transforming the practice of engineering and it is possible to now teach the practice aspects of engineering in an integrated environment where design and its realization are integrated. The Committee proposes that the General Engineering category include a course which can be called Product Realization which introduces students to design principles, enables them design using software tools, and then provides them the experience of realizing the design in a manufacturing environment using modern prototyping machines and tools. The emphasis would be on building working models integrated with the use of embedded devices like motors and electronic controllers as necessary. This design course will be in place of traditional courses on engineering drawing and workshop practices. Team work, central to all engineering activity, will be the mode of work in this course.

General Engineering is, therefore, viewed as a category consisting of four courses that every engineering student does as a part of the degree requirements. While the syllabus and how these courses are taught will go through the traditional process of periodic review, a change of the addition and deletion of courses type is expected to happen only as a reaction to the recognition of some transformational change in the practice of engineering. To emphasize that these courses are jointly owned by the faculty at large and are not simply proprietary to some department it is recommended that they do not have department numbers rather their number should reflect that they are foundational and belong to General Engineering.

2.3 Humanities and Social Sciences

The role of Humanities and Social Sciences in undergraduate engineering education cannot be over emphasized. Here, also, the utilitarian view that such education improves communication skills, introduces students to concepts that they may find useful in their later careers as managers, etc. is narrow and self defeating. It has been our experience that such objectives do not challenge students and receptivity if not hostile, is at best grudging. On the other hand courses that expose students to alternative analytical frameworks, widen their world view, and introduce the importance of the role of societal and human factors in the success and failure of engineering solutions should excite and attract them. This is done best when humanities and social sciences faculty are teaching courses that draw on their research and other professional activities, as in any other area.

An important issue that arises is whether there be a possibility of streams which will require a series of courses to be floated which students could do in some sort of (partial) order as opposed to having courses that do not necessarily build on each other. The attraction of streams is that it allows a student the option of going deep into a subject if he/she so desires by taking a planned sequence of courses (with pre-requisites so that they are offered at an appropriate level); this also opens the possibility of minor in disciplines (say economics) which likely would be attractive to many students. Students may even opt to do projects required as a part of their degree requirement around a stream specialization provided they have done enough preliminary course work for establishing their competency to take on such tasks. If that happens then two purposes get served. Humanities and Social Sciences get better integrated with the undergraduate education and assume a role which is much more than just providing a service. A certain number of trained students could become available to the faculty of Humanities and Social Sciences as project and research collaborators, thereby increasing their involvement, productivity, motivation, and commitment to the institutional objectives while also adding to the faculty's own program.

To implement streams effectively will require a reasonably large and well-planned basket of courses to be offered every semester in each stream area. The implication is that there will need to be a group of at least five to seven faculty members in each area. This is an additional attraction of the concept of streams. Each group will have enough critical mass for conducting viable quality post graduate programmes as well as provide a disciplinary community for faculty. This aspect combined with a shift from what is viewed as mainly undergraduate service teaching, would also help in attracting and retaining faculty. However, it will limit the number of areas that will be represented in the Humanities and Social Sciences group to about four/five. Such areas include economics, history, linguistics, literature, philosophy, political science, psychology and sociology.

Coming to an agreement on which disciplines to focus will not be easy since different people will have different preferences and it is impossible to come up with a solution set that will satisfy everyone. But a process of wide and open consultation (with students as well as faculty) should help facilitate this decision-making process.

The Committee recognizes that remedial English teaching should not be the role of faculty of Humanities and Social Sciences. This is an area which requires entirely different skill sets and mentalities. Specialists will need to be hired on the basis of requirements on short term contractual basis. The other model to explore could be to hire agencies that provide this expertise to improve the English skill set of manpower such as in IT industry. The Committee is also of the view that intensive remedial English course work should generate credits for students using the same formula as followed for other courses of the Institute. It should count towards satisfying degree requirements for those credits which are not prescribed (in effect open) in the undergraduate programme.

2.4 Project

At IIT Delhi and at other institutions the Programme Requirements, Major Project, and Industry Internship are normally clubbed under Programme Core, i.e. that part of the academic curriculum of an undergraduate degree programme that the academic planners consider as must for every student of that programme. It is our belief that this leads to unnecessary and undesirable compartmentalization. When the practice of engineering is increasingly interdisciplinary, restricting the project activity of a student to narrowly defined departmental boundaries is simply parochial. It is true that good projects would be closely linked to a faculty members interests. But there is no reason to believe that the interests of a faculty member, to take an extreme example, working in the Chemistry department cannot match with that of a student of Computer Science or Mechanical Engineering. Consider the possibility that the research requires development of a robotics control of a delicate chemical experiment. One would like to visualize that the Chemistry faculty would advertise the requirements and interested students could work under him/her, design and prototype the complete system and earn project credits. A student who has done a number of courses in the Economics stream may like to do the project under an Economics professor. A student should be encouraged to follow his/her passion rather than be forced to satisfy the requirements of doing a project in the department in an uninvolved detached manner. The negative vibrations generated do not just remain confined to the student, but permeate the environment.

The Committee feels that the Core Project that every student needs to do and experience working on should not have credits more than the equivalent of two courses. It should be recognized that students are busy with a number of activities at that stage of their career and that their attention and focus would naturally waver. Increasing credits for the project is a negative way of demanding attention. The idea is that the penalty for not performing is larger. The Committee recommends trying positive re-enforcement by removing boundaries and enabling students to work in teams where they want to and with whom they want to. It is for these reasons that Core Project should not have programme credits or for that matter programme based listing. Like General Engineering they should be in their own separate categories.

The Committee also recommends that beyond the Core Project it should be possible for a student to be a part of an ambitious project activity. Such a project would necessarily be done in a group of four to five (or more) students and would effectively be a full time activity for the entire duration of a semester akin to a full semester internship in industry. The Committee calls such a project a Capstone Project. It should be accepted that there may not be more than a few such projects on going at any time in the institute. But the impact of such projects on students as well as faculty members will be enormous. Students involved in such ambitious projects become role models for future students; they may even influence the students towards taking up a career around research and development. Moreover it would encourage faculty to take up challenging projects because quality manpower would be available for working on them. The Capstone Project should, therefore, be equivalent to a full semester load of four courses of the type that are part of the programme towards the end. A student's involvement in a Capstone Project is totally voluntary. To emphasize this aspect the Committee is of the view that its credits should not count towards the basic degree requirements. Also, a student's involvement needs to be focused in an ambitious activity like the Capstone Project without the distraction of coursework or other curricular activity. A student needs to plan his/her academic programme in such a way that he/she is fully free during the semester the Capstone Project activity is undertaken. This commitment is necessary if he/she doesn't want to stay in the Institute beyond the mandatory eight semesters. Capstone Projects, therefore, would need to be advertised sufficiently in advance to enable the team of students to be formed and enable each student to plan his/her involvement during the eighth semester. The Committee is of the view that a student should formally register for the Capstone Project after he/she has completed the Core Project and in effect all requirements for the B. Tech. degree. Also, sufficient amount of preparatory spade work has to be done by the team of faculty members and students prior to the full time involvement of the student team in its execution. It should be emphasised that the objective of a Capstone Project should be the development of a working product. It should involve use of professional project management processes and as such be viewed as training in many aspects of the culture of work practices that are the hall mark of current high technology start up initiatives.

2.5 Industry Internship

The Committee recommends that 50 working days internship in industry done during any summer after a student has completed six semesters of academic activity should be mandatory. For reasons which are essentially the same as for projects, this industry internship should not be limited to some specific places that find approval of the department. A chemical plant may feel that they can take a Computer Science student as an intern. If they need one and a Computer Science student is interested they should have the flexibility to indicate that as a possibility. If the Institute encourages industry to define their requirements, and to not feel confined to some slotting of their activities then there are good reasons to believe that many more openings will become available. Industry Internships should also not have programme credits or for that matter programme based listing. Like General Engineering and Projects they should be in their own separate categories.

The Committee also recommends that beyond the summer Industry Internship it should be possible for a student to spend more time in industry. The committee proposes that there should be a provision for a student to spend a full semester in industry as an intern if he/she wants to. This semester could be the one following the summer during which the student is undergoing summer internship. This would enable a student to spend as much as eight months at a stretch in industry. Its attractiveness lies in the possibility of a student doing a challenging activity at the place of internship and returning to the Institute with maturity and experience rare among undergraduate students. Such students can become role models, and influence prevailing student attitudes and thinking in very positive ways. There is no reason that a student should opt for this semester long internship in industry after three years of academic activity. Students should be permitted such long absences from the campus on account of industry internship as early as having completed two years of academic activity. Semester long industry internship should operate in the same way as a Capstone project. That is, it is voluntary, and its credits which should be the same as that for a Capstone Project, do not count towards degree requirements.

2.6 Programme Requirements

How should the programme requirements be structured and what percentage of the whole they should constitute is an issue of perennial debate among curriculum planners. The Committee has also debated this issue from all angles. The Committee, however, converged to a consensus quickly on the broad ills that many such exercises suffer from. These are rigidity, compartmentalization, and over specification.

It is the experience of the Committee members that many times the same course is taught in different departments with slightly different flavours. The underlying assumption for this phenomena is that the faculty members of a particular department know best as to what would suit the needs of their curriculum and would be suitable for the students of that specialization. Such compartmentalization goes against the interdisciplinary nature of a course. The curriculum planners should be encouraged to include courses of this type which have already been floated by a specialist of the field in some other department rather than replicating them. Learning happens best when a course is being taught by the specialist who is adding to the field rather than when the concepts are just being applied. If need be application aspects can be covered by introducing small modules of laboratory or tutorial cum laboratory where complementary focus and customization can be provided.

When the roots of rigidity and over specification in a programme are not attributable to strongly held views on what makes a complete engineer they often can often be traced to compartmentalization of the intra departmental nature. Programmes developed under such influences result in credit requirements that are high, increased coursework, and reduced opportunities for students to choose and explore, follow their excitement and to build collaborative relationships with faculty that depend upon possibilities of doing and sharing objectives outside the classroom.

Just as experiencing engineering design is an on going activity developing communication skills should be a part of the focus of all courses. Communication is so important an activity that there needs to be a culture of non classroom activities where students necessarily communicate their ideas in a structured formal way. This can be further complemented by courses where students not only have to make formal presentations but where their competency is tracked, deficiencies identified and a record kept of the progress made. Apart from the record of the standard grade in such courses competency level achieved in communication should also get recorded.

To encourage self learning it should be possible for students to register for a course which is conducted primarily as self study. This could be done in many ways. Students do the work, write exams, make presentations, and submit reports. It would be desirable that every student gets an opportunity to experience self study in this mode.

3. Curriculum Structure

3.1 Credit Definition and Structure

The credit definition at IITD and widely used at other institutions sets limits for one credit as follows: for 1 hour of in-class contact in lecture or tutorial along with one hour of self study, or 2 hours of laboratory work with two hours of self study for every one lecture credit and one hour of every tutorial and laboratory credit. Here, self study includes assignments, home work, reading the assigned material, revision, project work, etc. For the traditional load of 5 theory courses and 3 practical courses the weekly in-class contact is typically 15 (L) + 4 (T) + 10 (P) for 29 hours in-class contact and 24 credits, which requires 15+4+5 = 24 hours of self-study. The weekly time for academics works out to 53 which is on the higher side. With 4 theory courses and 3 practical courses, the load works out to: in class 12 (L) + 4 (T) + 10 (P) = 26 hours corresponding to 21 credits. The self study component becomes 12+4+5 = 21 hours; the time for academics now is 47 hours per week which is in line with load at similar institutions elsewhere. Total credit requirements for an eight semester undergraduate degree programme, therefore, should be around the ball park figure of 20-21 x 8 = 160-168. The Committee, keeping the academic requirements in mind, recommends that at IIT Punjab the credit requirements for the undergraduate engineering degree be 163 credits. This number is less than that prevailing at the present at most IITs but more in line with comparable institutions worldwide. This reduced load on the student means that he/she can devote more time for study of the courses registered. The faculty should enable this in-depth rigorous study by suitably designing the course and, especially, the self-study material.

The distribution of 163 credits among the categories discussed earlier is given below in Table 1. It is to be noted that the values given in Table 1 are for framing a viable curriculum for individual programmes. The students would then work out their individual limits based on these values.

The salient features of this distribution are as follows:

(a) The sum of minimum requirements of all categories is 141. The balance 22 credits can be opted for by the student giving him/her flexibility in selecting courses according to his/her interest.

(b) The average load per semester is about 20 credits.

(c) It is possible for a student to complete the course requirements in 7 semesters and utilize the 8^{th} semester for the Capstone Project or the Industry Internship over and above the credits requirements.

(d) Registration as full-time student for 8 semesters is mandatory for completing graduation requirements.

(e) NCC, NSS or NSO requirements would be over and above these requirements.

(f) Every student would have to take at least one course (in any appropriate category) related to Environment.

(g) Only some of the categories have the possibility of defining a minimum core that is programme specific. The Committee recognizes it is possible that all the knowledge (as defined by subjects) that is felt to be important to contemporary engineering and technology may not find a place in the core. Curriculum planners will have to prioritize and curriculum implementers would have to motivate students to go either beyond the degree requirements or choose wisely.

(h) One of the most important aspects of post-school education is that students should learn how to learn. Conventional teaching-learning processes do not adequately address this aspect. It is proposed that at each student should study one course from the regular listings as an *independent learning course*, one that is not being taught as a regular course that semester. The teacher will assign reading material and assignments, term papers, etc. and be available for and hour every week for discussions with the student. Tests will be held as usual.

Table 1. Credit structure of the B.Tech. programme.

Category	Symbol	Credits requirement	Remarks
Science Requirement	SR	28 (minimum)	At most 20 credits can be specified as core in a programme.
General Engineering Requirement	GR	16	16 credits as GE core for each programme
Programme core	PC	47 (maximum)	Compulsory part of the Programme credits can not exceed 47. This excludes credits for the Core Project and Summer Industry Internship.
Programme Elective	PE	19 (minimum)	PC+PE credit to be done by a student in a programme must be at least 66 credits.
Humanities and Social Sciences	HS	20 (minimum)	
Institute Core Project	CP	3 + 5 = 8	The Core Project, 3 + 5 credits over two semesters, is an Institutional requirement.
Core Industry Internship	CT	3 (Summer, followed by colloquium in one semester)	A Summer Industry Internship and a Colloquium for a total of 3 credits is an Institutional requirement. Internship will have only Satisfactory/Unsatisfactory/ Continuation grades.
Graduation requirements	**GR**	**163**	

Table 2. Options/Electives over and above the core requirement.

Category	Symbol	Credits requirement	Remarks
Capstone Projects	EP	12 (one semester)	A student may also do a 12 credit Capstone Project the credits for which will be beyond the minimum graduation requirement.
Industry Internship	ET	12 (one semester)	The Semester Industry Internship of 12 credits is optional and beyond the graduation requirement of 150 credits. Internship will be assessed with Satisfactory/Unsatisfactory/Continuation grades.

Table 3. Non-credit mandatory requirements.

Category	Symbol	Credits requirement	Remarks
NCC, NSS or NSO	NN	Nil	A student is required to complete the requirements for NCC, NSS or NSO for two semesters. Grading will be Satisfactory/Unsatisfactory.
Introduction to the Programme	NP	Nil	The student is required to complete the requirements for one semester. Grading will be Satisfactory/Unsatisfactory/ Continuation.
Introduction to Humanities and Social Sciences	NH	Nil	The student is required to complete the requirements for one semester. Grading will be Satisfactory/Unsatisfactory/ Continuation.

(i) It is strongly recommended that the 12-credit Capstone Project be conducted to replicate as closely as possible real-world industry projects whose hallmarks are teamwork (5-10 persons), well-defined deliverable product for the customer, cross-disciplinary nature of work and product, regular work, and project management amongst others.

(j) A simple mechanism for transferring credits from other institutions be evolved; this would encourage students to spend a semester at comparable institutions, such as, other IITs.

(k) The pre-requisite of a PC-category course should be a core course(s) of the programme. Electives as pre-requisite for core courses are not permitted. Also, pre-requisite of a PE-category course(s) should be a core course(s) or none.

(l) The General Engineering core shall consist of the following four courses for 16 credits. These courses are considered to be fundamental to being an "Engineer". It is not mandatory that these courses be done in the 1st year itself.

Principles of Electrical Engineering	3-0-2	4 credits
Introduction to Computing	3-0-2	4 credits
Materials Science and Engineering	3-0-2	4 credits
Product Design and Realization – I	1-0-6	4 credits

3.2 B.Tech. (Honours) Degree

The Committee recommends that students who complete the Capstone Project with a minimum grade of 'B' be eligible for the award of the B.Tech. (Honours) degree. A student must declare his/her intention to work for the honours degree by the end of third semester if he/she is interested in completing the requirements for the degree in eight semesters. If a student has maintained CGPA of at least 7.5 at the time of declaring the intention for the honours degree and has accumulated on the average 20 credits for each registered semester, permission could be granted for completing the 163 credits for the B.Tech. degree in seven semesters in the accelerated mode by registering for up to 25 credits every semester. Permission for continuation of registration in the accelerated mode is contingent upon the student maintaining a SGPA of at least 7.0 and getting a pass grade in all courses registered in the previous semester. A student who has completed the degree requirement with a CGPA of 7.5 will be given permission for working for the honours degree. Since a Capstone Project is team effort of an ambitious nature it would be necessary that at least two semesters prior to the one in which the Capstone Project work will formally be executed, that the work be identified, team formulated and preparatory work started.

3.3 Attendance Requirements

A student is expected to attend all classes, laboratory, and tutorial sessions that are formally scheduled and a formal attendance will be taken in each such session. It is recognised that due to illness and other emergent reasons there will instances when a student may be absent from scheduled academic activities; a leave application should normally be submitted in such cases at the earliest. Such absences can not be more than 25 % of the total sessions held in a course. Attendance less than 75 % in a course is considered unsatisfactory and an instructor may award a fail grade to a student in that course on account of unsatisfactory attendance. If a student has been ill and/or there are other emergent reasons for which he/she has continuously been absent from the Institute for four weeks he/she may apply for semester withdrawal citing reasons and providing documentary evidence thereof.

3.4 Semester Duration

The Committee recommends that there be 65 teaching days, i.e. thirteen 5-day weeks, in a semester. Teaching days exclude days on which examinations are scheduled, and scheduled or unscheduled holidays. The Committee also recommends that disruptions in teaching due to tests and extra-curricular activities be minimized.

3.5 Special Requirements

(a) English Language Proficiency

English language deficiency needs of new students should be addressed in a comprehensive manner. On reporting to the Institute, proficiency testing needs to be done, possibly on the days of registration or within the first week. Students who need remedial English language instruction will have to do so during the first semester. This should take the form of an intensive structured course in the first semester conducted by professionals specifically trained in English instruction as well as resources for online self learning. The mode of operation be such that the students would have to achieve a certain level of competency in their first semester. The time effort for learning English should be recognized and credits in the open category should be granted for the English deficiency course conducted during the first semester. For these students the first year programme would have to be restructured to ensure that the students do not enroll in courses in the first semester where English deficiency would severe handicap for understanding and performance in examinations.

It is hoped that from the second semester onwards, the language handicap will be considerably reduced. The shortfall in courses/credits, if any, can be made up in summer so that at the end of the 1st year there is none, or very little, back log. It should be emphasised that on-line learning resources and testing material for English language studies should be made available so that students can self pace their learning during their entire stay at the Institute. English language course(s) could be offered in either semester and they should address varying levels of deficiencies. This facility will enable a student to take a course of his/her standing if he/she so realizes at the end of the first semester.

(b) Communication Skills

In today’s world of engineering and technology, the ability to communicate is regarded as being as important as domain knowledge. Good communication skills are pivotal to one’s career growth. Developing communication skills is, therefore, very important and ought to be addressed proactively. The attempt here should be to create an environment so that through non-formal activities students are encouraged to develop their communication skill. Departments should identify the courses which require students to make presentation and keep a tracking system for those who need significant help in this area. In such cases, the student be asked to take a regular course on this aspect, for credit. For such an effort to be fruitful, the faculty at large needs to be Along with the course credits, instructors register on the academic site the level of competency of the student in communication.

4. Performance Requirements and Monitoring

The Committee considered various facets of the academic performance. The Committee dwelt at length upon three sets of issues:

(i) need for termination of registration,

(ii) causes of weak academic performance: English language proficiency, co-curricular and extra curricular activities, hostel environment, amongst others,

(iii) proactive measures to help weak students: mentorship, recognizing good teaching, and improving learning/study resources.

The Committee deliberated at length about the desirability of termination of registration because of poor academic performance. There are several reasons for termination of registration, which in the opinion of the Committee are important:

(a) To maintain excellence, it is imperative that students are aware of the minimum acceptable performance level. This awareness is likely to motivate students to perform to their potential.

(b) Students who are not able to cope up with the rigours of the curriculum, or are not suitably motivated, are better served if they are guided at an early stage to look for alternative education that is better suited to them.

(c) The continued presence of long-term low performing students can lead to deterioration of overall discipline in the campus, especially in the hostels. This has been the experience at IIT Delhi as well as other universities in the country. Thus, an upper limit on the duration of their stay in the institute is necessary.

The Committee is, therefore, in favour of providing for the provision of termination of registration. Termination of registration may take place at various stages. As stated above, very poor performance in the initial stages is indicative of the student's inability to cope with the academic programme of the Institute. In these situations it is desirable that the student starts afresh at a new place whose standards he/she can cope with. In some cases this fresh start could be at the Institution itself. Those students who show that they can cope with the IIT standards in the first year usually go on to finish the degree requirements sometimes taking more time than the norm. There still are situations that occur which result in sudden deterioration in a student's performance. In these cases it is desirable that the student is encouraged to solve the problems that are the cause of this drop in performance before continuing with full time academic activity. It is the Committee's view that these periods of absence should not count towards the total time available for a student to complete all requirements for the undergraduate degree. At present in the IIT system the total duration for degree completion for any programme is number of continuous academic years from the date of joining the programme. At some institutes this total period includes semesters withdrawn on medical or other grounds, such as, the semesters that the student is suspended on disciplinary grounds. The Committee recommends that these absences should not count towards time available for completing degree requirements. The Committee notes that many times there are instances when it is desirable for a student to lower the pace at which he/she accumulates credits in a structured and guided manner. In effect the student joins a slow paced programme. The total time available for completing degree requirements must be different for the slow paced students. This is necessary because it is our experience that students who are doing badly are extremely conscious of the over all limits and do not want to the slow paced programme to make those limits become more looming.

The Committee recommends that the maximum permitted duration of each programme be determined in terms of number of registered regular semesters, hereinafter called registered semesters. Any semester in which a student has registered for a course will be called a registered semester subject to the following:

(a) Only the first and second semesters of an academic year can be registered semesters. The summer semester will not be considered as a registered semester.

(b) A semester when a student has been granted semester withdrawal or granted leave will not be considered as a registered semester.

(c) The semester when a student is suspended from the Institute on disciplinary grounds will not be counted towards the number of registered semesters.

The summer semesters falling in between the permitted registered semesters shall be available for earning credits. After the student has registered for the maximum permissible number of registered semesters, the subsequent summer semesters will not be available for earning credits.

The Committee recommends that the maximum permissible number of registered semesters for completing all degree requirements for the B.Tech. degree should be 12. If a student opts for the slow-paced programme (as defined later), then the maximum permissible number of registered semesters shall be increased by two semesters.

4.1 Conditions for Termination of Registration, Probation and Warning

The Committee recommends that if the performance at the end of first two registered semesters is very poor, then registration be terminated. We believe that students performing at this level will be unable to cope with the rigorous IITR curriculum and therefore it is in the best interest of these students if they are guided to look for alternative educational institutions that better suit their academic skills and/or interests. If the performance is poor but not very poor, then the student should be given an option to start afresh. The criteria for “very poor” and “poor” performance are defined in Table 2.

Table 2. Rules for termination of registration at the end of the second registered semester.

Quality of performance	**Earned credits**		**Decision**
	GE/OBC	SC/ST/PD	
Very poor performance	Less than or equal to 13	Less than or equal to 09	Termination of registration
Poor performance	14 – 20 Both included	10 – 20 Both included	Re-start (once only) or Termination of registration

(a) If a student chooses to restart after the first two registered semesters, then his/her credits earned and semesters registered will not be carried over. The re-start will be indicated on the transcript. The re-start will be permitted only once. If at the end of two registered semesters after re-start, the earned credits are less than or equal to 20 then the registration will be terminated.

(b) Each student is expected to earn at least 10 credits in the first registered semester and 12 credits in each subsequent registered semester with a SGPA greater than or equal to 5.0. If the performance of a student at the end of any registered semester is below this minimum acceptable level, then he/she should be placed on probation and a warning should be given to him/her and intimation sent to the parents also.

(c) The student placed on probation shall be monitored, including mandatory attendance in classes, special tutorials and mentoring.

(d) If the performance of a student on probation does not meet the above criterion (b) in the following registered semester, then the student should be permitted to register only if the department makes a favourable recommendation. The Head of the Department’s recommendation shall be prepared after consultation with the student, and should include (i) feasibility of completing the degree requirements, and (ii) identification of remedial measures for the problems leading to poor performance.

(e) The registration of any student should be limited to 1.25 times the average earned credits of the previous two semesters, subject to a minimum of 9 credits and a maximum of 24 credits.

(f) The minimum CGPA for award of the B.Tech. degree should be 5.0.

The Committee deliberated at length on the possible causes of under-performance and ways to ameliorate the same. The issues are detailed below.

(a) It has been observed that many students consider success at JEE as an end in itself and they tend to ignore the academic demands and rigour of first year at IIT. The first one or two semesters are taken in “celebration” mode resulting in extensive time being spent on computer games, movies, etc.

(b) Prior preparation in foundation courses, viz., Physics, Mathematics and Chemistry, is weak because the current JEE format leaves scope for attaining relatively high scores without a strong understanding of the subject fundamentals. The wide-spread culture of intensive coaching makes students deficient in self-driven learning.

(c) Students lose motivation and interest in academics after coming to IIT because of burnout resulting from the years of intensive coaching for JEE.

(d) Poor proficiency in English results in inability to follow the teachers in classes.

(e) Students could be overwhelmed by IIT. Most of them are toppers from their schools and on finding themselves suddenly doing poorly relative to brighter students, they lose self-esteem and self confidence.

(f) Major disruptive events in their personal lives, e.g. serious illness, family member's/friend's death, financial difficulties, etc., lead to difficulties in coping with academics.

The Committee believes that these are some of the reasons for drop in performance among students at IITD. Administrators at IIT Ropar may like to keep this in mind and put in place a system to analyse these and other related causes of poor performance among students there. A proper understanding of these causes could lead to design of interventions that could eliminate them or at least minimize their adverse impact. Some suggestions for handling these issues are given in the following sections.

4.2 Slow-paced Programme

A student who has earned between 21 and 30 credits at the end of the first two registered semesters will be eligible to opt for the slow-paced programme. A student opting for such a programme shall be permitted two additional registered semesters for completing degree requirements.

In the slow paced programme, the upper limit for credits registered in a semester will be 14. A student in this programme is expected to earn at least 9 credits with minimum SGPA 5.0 in any semester, failing which he/she will be issued a warning and placed on probation.

(a) The student placed on probation shall be monitored, including mandatory attendance in classes, special tutorials and mentoring.

(b) If the performance of a student on probation does not meet the above criterion in the following registered semester, then the student should be permitted to register only if the department makes a favourable recommendation. The Head of the Department's recommendation shall be prepared after consultation with the student, and should include (i) feasibility of completing the programme, and (ii) identification of remedial measures for the problems leading to poor performance.

Such slow-paced programmes need to be defined by the respective department for each student.

4.3 Proactive Measures for Weak Students

There is a need to put in place a system for monitoring and advising for weak students. The Committee recommends the following strategies be considered.

(a) There should be a mentorship programme to help the first year students. The mentors should be mature senior students and research scholars who are willing to take the responsibility of interacting with first year students so that they can overcome the difficulties of settling down at IIT.

(b) There should be student counseling cell run by professionally trained student counselor. Selection, sensitization and training of student mentors along with a continual interaction with them would be a part of the student counselor's responsibility.

(iii) Poorly performing students need to be identified at the end of each academic semester and the following mechanism is suggested for operationalizing assistance to poorly performing students:

(a) Structured interactions of the poorly performing students with their mentors and others identified to offer individualized attention should be organised. For the first year students this could take place in the form of structured collective informal tutorials in the evenings.

(b) All course coordinators should monitor the performance of poorly performing students and bring to the notice of the concerned cell set up for assisting poorly performing students those who have performed poorly in various tests, quizzes, etc. to enable more focused attention to be given to those who are performing particularly poorly.

(c) Parents of such students should be informed about the poor performance of their ward. The active cooperation of the parents should be sought to ensure that their wards attend special classes arranged for them.

4.4 Conduct of a Course

How should a course be conducted to ensure that students' learning experience is not limited to preparing for the mid-term and end of term examinations? In the IIT system, solutions to this important pedagogical question has been found around mid term examinations, weekly tutorial sessions, home works of variety of forms ranging from problem sets to individual and/or group class projects. What should the quantum of this work be is left to the course instructor. Over the years it has been observed that instructors do not give regular home works which are evaluated and returned to the students. Regularity in work by students and keeping up with what is happening in class is attempted by instructors through tutorials where discussions and sometimes quizzes are held. Evaluation has tended to become examination centric. It, therefore, should not come as a surprise that students' preferred strategies are to prepare intensively before an announced test/quiz and slacken out during times when no examination oriented evaluation is scheduled. Student focus during these periods of lull shifts to other activities and over a period of time these activities become an end in themselves. Involvement in these activities provides students with a sense of direction and a feeling of positive accomplishment. The down side of this scenario is that academic activity starts to seem secondary to both teachers and students and educational environment tends to become more examination centric with consequent greater emphasis on hostel oriented extra curricular activities.

It is the Committee's belief that this state of affairs is not inevitable. It can be arrested by defining academic work that students have to do regularly. Weekly home works that are required to be submitted and evaluated, group projects which require students to research, plan, implement, submit reports and make presentations, student initiated projects which encourage and reward deeper investigation of a topic than is possible in the classroom are few of the strategies that are used in institutions that are known to be rigorous and demanding from their students the world over. In institutions which are primarily undergraduate, this work is done by the instructor. However, at research focused academic institutions where faculty members are involved in many other activities evaluation of student work arising out of home works, project submissions etc. is done by teaching assistants. T.A.s are normally Masters and Ph.D. students in the institute.

For effective performance by the teaching assistant it is desirable that all the work that he/she is supposed to evaluate is first done by him/her. This requires that instructor and teaching assistant for a course are identified four/five months in advance and the instructor uses this lead time to develop the home work material and getting it done by the designated teaching assistants. Such course planning is routinely done in research universities where use of teaching assistants in the conduct of courses is prevalent. It should be noted that this work done by teaching assistants also contributes to their academic training and, therefore, should be actively encouraged.

To ensure that these preparatory activities get institutionalised it would be desirable that they are integrated into the academic calendar and developed home works, course plan, preparatory work done by the teaching assistants are filed, monitored and evaluated. This process is necessary to ensure that effective teaching is not looked upon as just good class room delivery but a system of support to students that ensures that their learning experience is not just preparing for examinations.

4.5 Related Issues

During the Committee's deliberations, several issues related to the academic performance of the students were highlighted. While many of these may be seen as not directly related to academic performance, the Committee believes that true progress in achieving our goals of improving academic performance of weak students, and indeed students across the board, cannot be achieved unless such issues are addressed.

(i) Each student should have a faculty advisor. Faculty advisers should arrange regular meetings with the poorly performing students to obtain feedback on the mentorship programme.

(ii) Learning resource centres need to be established where students can get assistance related to their courses. Space and web resources should be made available for this purpose.

(iii). It should be ensured that the first year courses are taught by the best faculty available in the Institute so as to inspire and to retain students' interest and enthusiasm. Benefit of the Institute's best faculty should be available to all students. This requires that early classes should be in the large.

(iv) Lecture theaters that can hold 200 students should be planned with all the modern educational technology tools available.

(v) Instructors of courses with student registration of at least 30 must be supported by teaching assistants. T.A.s are masters and Ph.D. students of the Institute. Among the activities to be carried out by a T.A. include grading of weekly homework, assistance in the conduct of laboratory sessions, holding evening tutorials and providing assistance to poorly performing students, and providing general support needed by an instructor to conduct the course. T.A. assignment should get done at least three to four months prior to the start of the semester to enable enough time the instructor to train T.A.s by defining requirements and assessing

T.A.'s preparation for delivering satisfactorily. A T.A. should be asked to solve all the home work problems and do all the laboratory projects that the students will get assigned prior to the start of the course.

(vi) Good teaching should be rewarded. Teaching evaluations should be used for evaluating faculty performance. Teaching evaluations should be computerized and be publicly available.

(vii) Faculty should earmark and publicize an additional one hour per week for meeting students for course-related difficulties and this should be counted as teaching load.

(viii) Classroom environment and facilities should enhance learning ambience. Lecture theatres should be clustered and student discussion spaces around them should be planned. The over all ambience should be such that students are attracted to spend time there.

(ix) There should be study spaces, individual as well as group, planned both in the hostels and in the academic area.

(x) Extra-curricular competitive events should be organised only over the week ends and none should be planned in the first two and last two weeks of the semester.

(xi) Should the first year students be in a separate hostel needs to be discussed among the campus planners and resolved before the campus master plan is decided. Keeping the first year students separate would help in controlling and eliminating ragging. It should be kept in mind that ragging is not just physical and mental domination but a world view that there are things that first year students need to do to integrate into the existing student culture such as socially enforced participation in activities – cultural, sports, poster making etc. and generally act as gophers. These may not pass the legal definition of ragging, but are distracting enough to have a detrimental influence on both the world view as well as academic performance of impressionable first year students.

5. Course Descriptions

5.1 General Engineering

GEL101 Product Design and Realization – I, 4 (1-0-6)
Pre-requisites: Nil

Analysis and synthesis of engineered products; Representation of engineering designs – visualization, sketching, communicating engineering ides/designs role of s/w and h/w; engineering drawings involving mechanical, electrical, civil, etc. aspects, packages typically used in industry, component, sub-assembly, assembly and exploded assembly drawings; Product dissection – product analysis, disassembly process planning, tooling and sequence, preparing drawings, parts list, specifications, functional requirements, inspection including fits, tolerances and surface roughness, materials, assembly issues; Assembly – tooling, inspection, checking and inspection, operation. Manufacture of a product – planning and manufacturing as per detailed design given using some bought out items; assembly and operation. Activities will be done in teams of 4-6 students as per professional practices.

GEL102 Materials Science and Engineering, 4 (3-0-2)
Pre-requisites: Nil

Structure of materials, - crystal structure, substructure, microstructure, phase diagram and phase transformation; Material properties – mechanical, electrical, physical, corrosion, etc. properties; Material treatment – heat, surface, etc.; Alloys – metals, effects of different alloying elements, super alloys; Ceramics – classification, characterization, properties; Polymers – classification, properties, processing; Composite materials – structure, properties, classification, processing; Conductors, semi-conductors and magnetic materials – properties, production; Surface engineering and applications – techniques, coatings, processing and heat treatment; Materials classifications – engineering standards, material selection (CES type packages); Special materials; Environmental impact; Reprocessing; Applications.

GEL103 Introduction to Computing, 4 (3-0-2)
Prerequisites: Nil

Connection between mathematics and computation. The main abstractions in computation (processor, storage, communication) and their realization in architecture. Introduction to elementary software artifacts (IDEs, compilers, operating systems, etc.) for creating and executing programs.

Elementary and inductive data types and their representation in high-level languages: integers, strings, reals, sequences, etc. Rigorous specification of problems and solutions over these types. Concept of an algorithm; termination and correctness. From algorithms to programs: specification, top-down development and stepwise refinement. Use of a high level programming language for the systematic development of programs.

Introduction to the design and implementation of correct, efficient and maintainable programs. Stateful data structures such as arrays. Efficiency issues in programming; time and space measures. Elementary control structures in an imperative model. Assertions, representational invariants and loop invariants. Encapsulation of data. Objects and classes.

GEL104 Principles of Electrical Engineering, 4 (3-0-2)

DC circuits, KCL, KVL, Network Theorems, mesh and nodal analysis, step response and transients. RC, RL and RLC circuits, Phasor diagram solution of AC circuits, Power in 1- and 3-phase AC circuits, Diodes: rectifiers, clipping and clamping. Two port networks. Operational Amplifiers: model and applications. Magnetic circuits. Transformers: modeling and analysis. Energy in magnetic field, production of force and EMF. Principles of measurement.

5.2 Projects

CPP301 Core Project-1, 3 (0-0-6)
Prerequisite: Accumulated at least 90 credits

Could be done singly or in a group of two/three students; involves working under a faculty member and carrying out a detailed feasibility study and literature survey for solving the problem specified by the faculty member; preparing a work plan and making presentations to a committee appointed to evaluate the progress.

CPP302 Core Project-2, 5 (0-0-10)
Pre-requisite: Successful completion of Core Project-1

Continuation of Core Project-1; objective is to complete the work as per the prepared work plan; prepare a detailed project report and defend the work done by making presentations and demonstrations to the committee.

CPP303 Capstone Project, 12 (0-0-24)
Prerequisite: Completion of all requirements for the B.Tech. degree

Involves working in a large group of 6 to 8 students with the objective of building a sophisticated system requiring interdisciplinary inputs; getting permission to register for this project will be on the basis of a project report which will establish the feasibility of achieving the aims from all angles, i.e. time required, skill set of the team, availability of material and finances, and a clear plan of work and individual responsibilities.

5.3 Industry Internship

IIP201 Core Industry Internship and Colloquium, 3
Prerequisites: Accumulation of 75 credits

Involves working in industry, consultancy organisation, or a research centre for a period of at least ten weeks during a summer. On return from training, the work will be evaluated at the institute on the basis of a detailed written report of the work done and a presentation to a committee and to students. Daily diary of work done will need to be maintained and award of "satisfactory" grade will require concurrence from the supervisor of the internship. As part of Colloquium, every student would also have to make presentations on assigned topics.

IIP301 Semester Industry Internship, 12
Pre-requisites: Accumulation of at least 90 credits and completion of Core Industry Internship

Involves working in industry, consultancy organization or a research centre for a full summer and the following semester. Permission for semester internship will be given on the basis of a proposal wherein the work to be done during internship is detailed and recommended by the supervisor under whom the work will get done. The work will be evaluated at the institute on the basis of a detailed written report of the work done and a presentation to a committee. Daily diary of work done will need to be maintained and award of "satisfactory" grade will require concurrence from the supervisor of the internship. Credits for this internship will not count towards degree requirements.

5.4 Chemistry

CYL100 Structure, Reactivity and Dynamics, 4 (3-1-0)
Prerequisites: Nil

Quantum Mechanical principles of structure and bonding in molecules. Reaction rates. Free energy and entropy changes in chemical processes. Structure and stereoisomersism. Conformational analysis. Reactivity – Acids and bases, kinetic and thermodynamic criteria for reactions. Reactivity and potential energy surfaces, S vs E processes. Determination of mechanisms. Transition metal complexes – Crystal field theory, electronic spectra & magnetism. Organometallics – EAN rule, metal carbonyls, metallocenes. Inorganic solids – structure & applications.

CYP100 Chemistry Laboratory, 4 (0-0-4)
Prerequisites: Nil

Integrated course with an emphasis on experiment design. Focus on measurement techniques and the interpretation of results.

CYL200 Synthesis and Catalysis, 4 (3-1-0)
Prerequisites: CYL100

Structure – activity relationships in simple organic molecules. Strategies for C-C bond formation. Pericyclic reactions. Basic heterocyclic and organo-metallic chemistry. Catalysis – heterogeneous, homogeneous and phase transfer. Catalytic cycles.

CYL210 Materials Chemistry, 4 (3-1-0)
Prerequisites: CYL100

Synthesis of molecular, non molecular and composite materials. Characterisation techniques. Structure – property relationships. Applications – Clean energy, environmental remediation.

CYL220 Polymers and Soft Materials, 4 (3-1-0)
Prerequisites: CYL100

Polymer classification. Molecular weight, structure and morphology determination. Polymerisation techniques. Kinetics and mechanism of chain growth. Copolymers – engineering the properties of materials.

CYL230 Theoretical Chemistry, 4 (3-1-0)
Prerequisites: CYL100

Force fields and molecular mechanics. Quantum mechanics of atomic structure. Operator algebra. MO methods. Computational investigation of structure and properties. Evaluating potential energy surfaces for simple cases.

CYL240 Chemistry of Life – An Introduction, 4 (3-1-0)
Prerequisites: CYL100

Prokaryotic and eukaryotic cells structure, Major cell organelles and their function. The cell membrane and its function. Biomolecules - Structure and function of carbohydrates, lipids, proteins and nucleic acids and vitamins. Enzymes as biocatalysts, classification based on structure, major functions. Nucleic acids: Understanding DNA as a hereditary material. Structure of DNA and RNA, concept of gene and genome. Basic outline of the central dogma, concepts of replication, transcription and translation. Metabolism - ATP and energy generation Outline of Glycolysis, the TCA cycle, deamination and the urea cycle, b- oxidation. Biotechnology - Industrial applications of biochemical pathways.

CYL300 Measuring Molecules, 4 (3-1-0)
Prerequisites: CYL100

Spectroscopy - Radiation matter interactions : IR, UV, NMR etc. Theoretical basis and instrument design. Data analysis.

5.5 Computer Science and Engineering

CSL105 Discrete Mathematical Structures, 4 (3-1-0)
Prerequisites: Nil

Fundamental structures using sets. Functions (surjections, injections, inverses, composition); relations (reflexivity, symmetry, transitivity, equivalence relations); sets (union, intersection, complements, Cartesian products, power sets); pigeonhole principle; cardinality and countability.

Syntax and semantics of logic: Propositional logic: logical connectives; truth tables; normal forms (conjunctive and disjunctive); validity. First-order logic; limitations of predicate logic, universal and existential quantification; modus ponens and modus tollens. Elementary Proof techniques: Notions of implication, converse, inverse, contrapositive, negation, and contradiction; the structure of formal proofs; direct proofs; proof by counterexample; proof by contraposition; proof by contradiction; mathematical induction; strong induction; recursive mathematical definitions; well orderings.

Basics of counting: Counting arguments; pigeonhole principle; permutations and combinations; inclusion-exclusion, recurrence relations, generating functions. Elementary Graph Theory.

CSL201 Data Structures, 5 (3-0-4)
Prerequisites: Introduction to Computing.

Revision of notions of time and space complexity, and trade-offs in the design of data structures. Introduction to object-oriented programming through stacks, queues and linked lists. Dictionaries; skip-lists, hashing, analysis of collision resolution techniques. Trees, traversals, binary search trees. Balanced BSTs, tries, priority queues and binary heaps. Object oriented implementation and building libraries. Applications to discrete event simulation. Sorting: merge, quick, radix, selection and heap sort, Graphs: Breadth first search and connected components. Depth first search in directed and undirected graphs. Union-find data structure and applications. Directed acyclic graphs; topological sort.

CSL202 Programming Paradigms and Pragmatics, 5 (3-0-4)
Prerequisites: Data Structures

Notions of syntax and semantics of programming languages; introduction to operational and mathematical semantics of declarative (functional and logic) and imperative languages. Exposure to different programming language paradigms.

Data abstractions and control constructs; block-structure and scope, principles of abstraction, qualification and correspondence; parameter passing mechanisms; runtime structure and operating environment; practical and implementation issues in run-time systems and environment; abstract machines; features of functional and imperative languages.

The untyped and simply-typed Lambda calculus, type systems for programming languages including simple types and polymorphism; objects; classes and inheritance in object-oriented languages.

CSP203 Software Systems Laboratory, 2 (0-0-4)
Prerequisites: Data Structures.

Programming exercises and projects using software tools. IDEs, spreadsheets, configuration management, make, version control, documentation tools, literate programming (noweb); scientific document type-setting software (LaTeX), XML, scripting languages and tools (Perl, awk, etc). Booting systems, and installation and compression tools. Archiving and creation of libraries. Security and encryption software. Application software development tools. Simulation tools, Sockets and RPCs, pthreads. Numerical packages. Using query languages and data bases. Validation, testing and verification tools and techniques.

CSL211 Computer Architecture, 5 (3-1-2)
Prerequisites: Introduction to Computing; and Principles of Electrical Engineering
Suggested additional background: Digital Electronic Circuits.

Subsystems of a computer; Instructions and their formats; Assembly programming; Performance metrics; Performance comparison; Information representation; Integer and floating point arithmetic; Processor data-path design; Control unit design; Microprogramming; Performance improvement with pipelining; Memory organization - cache and virtual memory; input/output organization, interrupts and DMA.

CSL333 Operating Systems, 4 (3-0-4)
Prerequisites: Data Structures, and Computer Architecture

Overview: functions of Operating Systems, layered architecture basic concepts; interrupt architecture, system calls and notion of process and threads; synchronization and protection issues; scheduling; memory management including virtual memory and paging techniques; input-output architecture and device management; file systems; distributed file systems. Case studies of Unix, Windows NT. Design and implementation of small operating systems.

CSL343 Computer Networks, 4.5 (3-0-3)
Prerequisites: Data Structures
Suggested additional background: Signals and Systems, and Operating Systems

Fundamentals of Digital Communications, including channel capacity, error rates, multiplexing, framing and synchronization. Broadcast network and multi-access protocols, including CSMA/CD. Data link protocols, network protocols including routing and congestion control, IP protocol. Transport protocol including TCP. Network application services and protocols including email, www, DNS. Network security and management.

CSL355 Logic and Computability, 4 (3-1-0)
Prerequisites: Discrete Mathematical Structures
Suggested additional background: Logic for Computer Science

Myhill-Nerode Theorem, introduction to non-determinism, Context free grammars, Pushdown automata, equivalence and applications. Turing machines, Recursive and Recursively enumerable sets, non-determinism, RAMs and equivalence, Universal Turing Machines, undecidability, Rice's theorems for RE sets, Post machines, Basics of Recursive function theory. Equivalence, Church's thesis, computational complexity, space and time complexity of Turing Machines, Relationships, Savage's theorem, Complexity classes, Complete problems, NP-completeness, Cook-Levin theorem.

CSL356 Analysis and Design of Algorithms, 4 (3-1-0)
Prerequisites: Discrete Mathematical Structures, and Data Structures

RAM model and complexity; *O(log n)* bit model, integer sorting and string sorting. Review of fundamental data structures; Red-black trees, mergeable heaps, interval trees. Fundamental design methodologies and their implementations; Search Techniques, Dynamic Programming, Greedy algorithms, Divide-and-Conquer, Randomised techniques. Algorithms for set manipulations, their implementations and applications; Union-Find Randomized data structures; Skip lists, Universal Hash functions, Graph Algorithms with implementation issues; Depth-First Search and its applications, minimum Spanning Trees and Shortest Paths. Convex hulls, sorting, Selection Matrix multiplication, pattern matching, integer and polynomial arithmetic, FFT, introduction to the theory of lower bounds, NP-Completeness and Reductions. Approximation algorithms.

ELECTIVE COURSES

CSL311 Introduction to Database Systems, 4 (3-0-2)
Prerequisites: Data Structures.

The world of Database Systems. The E-R Model, The three database models, Representation and Evaluation of Relationship. The Relational Database Model, Functional Dependencies, Multi-valued and join dependency, Normalization theory, Concurrency Control in Relational Databases. Object-oriented Data Models.

CSL312 Artificial Intelligence, 4 (3-0-2)
Prerequisites: Data Structures.

Problem solving, search techniques, control strategies, game playing (mini-max), reasoning, knowledge representation through predicate logic, rule-based systems, semantic nets, frames, conceptual dependency formalism. Planning. Handling uncertainty: Bayesian Networks, Dempster-Shafer theory, certainty factors, Fuzzy logic, Learning through Neural nets -- Back propagation, radial basis functions, Neural computational models - Hopfield Nets, Bolzman machines. PROLOG programming.

CSL313 Logic for Computer Science, 4 (3-0-2)
Prerequisites: Discrete Mathematical Structures

Review of the principle of mathematical induction; the principle of structural induction; review of Boolean algebras; Syntax of propositional formulas; Truth and the semantics of propositional logic; Notions of satisfiability, validity, inconsistency; Deduction systems for propositional logic; Soundness and Completeness of deduction systems; First order logic (FOL): syntax and semantics; Proof theory for FOL; introduction to model theory; completeness and compactness theorems; First order theories. Introduction to modal logics.

Programming exercises will include representation and evaluation; conversion to normal-forms; tautology checking; proof normalization; resolution; unification; Skolemization, conversion to Horn-clauses; binary-decision diagrams.

CSL314 Numerical and Scientific Computing, 5 (3-1-2)
Prerequisites: Introduction to Computing, Linear Algebra

Introduction to Scientific Computing (floating point arithmetic). Review of matrices and linear systems, Linear Least Squares, Eigenvalue Problems. Review of Singular value decomposition. Direct methods: Gauss, Cholesky and Householder's methods, Matrix iterative methods: Jacobi, Gauss-Siedel and relaxation methods, conjugate gradient methods and its pre-conditioning, Computation of Eigenvalues and Eigenvectors: Jacobi, Givens, Householder, QR and inverse methods.

Nonlinear Equations. Optimization, interpolation, Numerical integration and Differentiation, Initial and Boundary Value Problems for Ordinary Differential Equations. Partial Differential Equations, Fast Fourier Transform.

Throughout the course implementation of the various methods and their comparisons with professionally written software such as LINPAC, ITPACK, EISPACK, LAPACK, SPARSE PACK will be emphasized with the understanding of various data structures, storage schemes etc. Existence and uniqueness, sensitivity and condition, convergence and error analysis will be part of every topic.

CSL315 Compiler Design, 4 (3-0-2)
Prerequisites: Programming Paradigms and Pragmatics
Suggested additional background: Logic and Computability.

Compilers and translators; lexical and syntactic analysis, top-down and bottom up parsing techniques; internal form of source programs; semantic analysis, symbol tables, error detection and recovery, code generation and optimization. Data flow and control flow analysis. Type checking and static analysis. Algorithms and implementation techniques for type-checking, code generation and optimization. Students will design and implement translators, static analysis, type-checking and optimization.

CSL316 Software Engineering, 4 (3-0-2)
Prerequisites: Data Structures, Programming Paradigms and Pragmatics.

Concepts and techniques relevant to production of large software systems: Structured programming, Requirements specification and analysis . Top-down design and development, Information hiding, abstraction, modularity, object-oriented techniques. Separate compilation, configuration management, program libraries Design patterns, UML Documentation, validation, Quality assurance, safety, Testing and test case generation, Software metrics, Cost analysis and estimation, manpower and time management. Organization and management of large software design projects.

Constraints and triggers, Disk Storage, Disk and Memory Organization for Relational Operators, Representing Data Elements, Index Structures, Query execution, Query Compilation, Query Optimization, Coping with System Failures, Concurrency Control, Transaction Management, Representation of Date.

CSL317 Computer Graphics, 4 (3-0-2)
Prerequisites: Data Structures

Graphics pipeline; Graphics hardware: Display devices, input devices; Raster Graphics; line and circle drawing algorithms; Windowing and 2D/3D clipping. Cohen and Sutherland line clipping, Cyrus Beck clipping method; 2D and 3D Geometrical Transformations: scaling, translation, rotation, reflection; Viewing Transformations: parallel and perspective projection; Curves and Surfaces: cubic splines, Bezier curves, B-splines, Parametric surfaces. Surface of revolution Sweep surfaces, Fractal curves and surfaces; Hidden line / surface removal methods; illuminations model; shading: Gouraud, Phong; Introduction to Ray-tracing; Animation; Programming practices with standard graphics libraries like openGL.

CSL319 Architecture of High Performance Computers, 4 (3-0-2)
Prerequisites: Computer Architecture; Operating Systems.

Classification of parallel computing structures, instruction level parallelism - static and dynamic pipelining, improving branch performance, superscalar and VLIW processors; High performance memory system; Shared memory multiprocessors and cache coherence; Multiprocessor interconnection networks; Performance modeling; issues in programming multiprocessors; Data parallel architectures.

CSL401 Advanced Algorithms, 4 (3-0-0)
Prerequisites: Analysis and Design of Algorithms.

Advanced data structures: self-adjustment, persistence and multi-dimensional trees. Randomized algorithms: Use of probabilistic inequalities in analysis, Geometric algorithms; Point location, Convex hulls and Voronoi diagrams. Arrangements applications using examples, Graph algorithms; Matching and Flows. Approximation algorithms; Use of Linear programming and primal dual, local search heuristics. Parallel algorithms; Basic techniques for sorting, searching merging, list ranking in PRAMs, and interconnection networks.

CSL402 Digital Image Analysis, 4 (3-0-2)
Prerequisites: Data Structures; Signals and Systems.

Digital Image Fundamentals; Image Enhancement in Spatial Domain; Gray Level Transformation, Histogram Processing, Spatial Filters; Image Transforms; Fourier Transform and their properties, Fast Fourier Transform, Other Transforms; Image Enhancement in Frequency Domain; Colour Image Processing; Image warping and restoration; Image Compression; Image Segmentation; edge detection, Hough transform, region based segmentation; Morphological operators; Representation and Description; Features based matching and Bayes classification; Introduction to some computer vision techniques; Imaging geometry, shape from shading, optical flow; Laboratory exercises will emphasize development and evaluation of image processing methods.

CSL404 Computer Vision, 4 (3-0-2)

Camera models, Calibration, multi-views projective geometry and invariants. Edge/feature extraction, correspondence and tracking, 3D structure/motion estimation. Object recognition, Scene and activity interpretation.

CSL405 Complexity Theory, 3 (3-0-0)
Prerequisites: Logic and Computability, Analysis and Design of Algorithms.

Turing machines and non-determinism, models of computation like RAM and pointer machines. Relations between complexity classes. Time-space tradeoffs for some fundamental problems. Reductions and completeness, Randomized complexity classes, Boolean circuit complexity. Cryptography and one-way functions. Polynomial hierarchy, P-space completeness, Interactive proofs and Hardness of approximation, Parallel complexity classes.

CSL406 Advanced Computer Networks, 4 (3-0-0)
Prerequisites: Computer Networks.

Flow and Congestion Control; Window and Rate Based Schemes, Decbit, TCP. ATM, ABR, hop-by-hop schemes, Quality of Service: in ATM, IETF integrated services model, Differentiated Services Model. Flow identification, Packet Classifiers and Filters. Scheduling. Network Management: ASN, SNMP, CMIP. Issues in the management of large networks. Multicast: IGMP, PIM, DVMRP, Mobility: Mobile IP.

5.6 Electrical Engineering

EEL201 Signals and Systems, 4 (3-1-0)

Classification of signals and systems, various system representation techniques, differential, difference and state-space representations, Fourier transforms and series, application to analysis of systems, Laplace transform, its properties, and its application to system analysis, Z-transforms, its properties and applications, Random variables and random process, characterization of random variables and random process, linear systems and random signals.

EEL202 Circuit Theory, 4 (3-1-0)

Overview of network analysis techniques, Network theorems, Transient and steady state sinusoidal response. Network graphs and their applications in network analysis.Tellengen's theorem, Two-port networks, z, y, h and transmission parameters, combination of two ports, Analysis of common two ports, Resonance, Coupled circuits, Scattering matrix and its application in network analysis. Network functions, parts of network functions, obtaining a network function from a given part. Network transmission criteria; delay and rise time, Elmore's and other definitions of cascading. Elements of network synthesis techniques. Butterworth and Chebyshev Approximation.

EEL203 Electromechanics, 4 (3-1-0)

Review of 1-phase, 3- phase circuits and magnetic circuits, transformers- 1-phase and 3-phase, special multiphase transformers and their applications, Electro mechanical Energy conversion principles and rotating machines, DC machines- construction, characteristics, commutation, armature reaction, speed control of DC motors and applications in drives; Synchronous machine-construction, characteristics, regulation, V-curves, parallel operation; Induction machines- 3-phase and 1- phase- construction, characteristics, starting, braking and speed control, Induction generators and applications- Fractional kW motors, special machines- PM machines, SRM, stepper motors and their applications.

EEL204 Analog Electronics, 4 (3-1-0)

Review of working of BJT, JFET and MOSFET and their small signal equivalent Circuit; Biasing of BJT, JFET and MOSFET circuits; Analysis and Design of various single stage amplifier configurations; Multi Stage Amplifiers; Differential Amplifier and Operational Amplifier; Feedback Amplifiers; Tuned Amplifiers; Oscillators.

EEL205 Control Engineering, 4 (3-1-0)

Introduction to the control problem, Industrial control examples, Transfer function models of suitable mechanical, electrical, thermal and pneumatic systems. Systems with dead time, Control hardware and their models: Potentiometers, synchros, LVDT, DC and AC servo motors, tachogenerators, electro-hydraulic valves, and pneumatic actuators. Closed loop control systems, Block diagram and signal flow analysis, Basic Characteristics of feedback control systems : stability, steady- state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness. Basic modes of feedback control :Proportional Integral, Derivative. Concept of stability and Routh stability criterion. Time response of 2nd order system, steady state error and error constants, Performance specifications in the time domain. Root locus method of design. Lead and lag compensation. Nyquist stability criterion. Frequency response analysis: Nyquist plots, constant M circles, constant N-circles, Bode plots, Nichols Charts Performance specifications in frequency domain, Frequency-domain methods of design. Lead and lag.

EEL206 Digital Electronic Circuits, 4 (3-1-0)

Review of Boolean Algebra, Karnaugh Map and Logic Gates; Designing combinational Circuits using gates and/or Multiplexers; Introduction to logic families: TTL, ECL, CMOS; PLAs and FPGAs; Sequential Circuits: Flip Flops, Counters and Registers; Design of Sequential Circuits: STD and applications; Pipelining and Timing issues; Memories.

EEL207 Engineering Electromagnetics, 4 (3-1-0)

Review of Maxwell’s equations, wave propagations in unbounded medium. Boundary conditions, reflection and refraction of plane waves. Transmission Lines: distributed parameter circuits, traveling and standing waves, impedance matching, Smith chart, analogy with plane waves. Waveguides: parallel-plane guide, TE, TM and TEM waves, rectangular and cylindrical waveguides, resonators. Planar transmission lines: stripline, microstripline, application of numerical techniques. Dielectric guides and optical fibres. Radiation: retarded potentials, Hertzian dipole, short loop, antenna parameters. Radio-wave propagation: ground-wave, sky-wave, space-wave.

EEL208 Communication Engineering, 4 (3-1-0)

Review of Fourier Series and Transforms. Hilbert Transforms, Bandpass Signal and System Representation. Random Processes, Stationarity, Power Spectral Density, Gaussian Process, Noise. Amplitude Modulation, DSBSC, SSB, VSB: Signal Representation, Generation and Demodulation. Frequency Modulation: Signal Representation, Generation and Demodulation. Mixing, Superheterodyne Receiver, Phase Recovery with PLLs. Noise: in AM Receivers using Coherent Detection, in AM Receivers using Envelope Detection, in FM Receivers. Sampling, Pulse-Amplitude Modulation. Quantization, Pulse-Code Modulation. Noise Considerations in PCM, Time Division Multiplexing, Delta Modulation.

EEL209 Power Systems, 4 (3-1-0)

Energy resources, power generation: Thermal, hydro and nuclear power plants. Transmission lines, line parameters, corona, interference of power lines with communication circuits, line insulators. Cables, per unit system, symmetrical components, fault analysis, switching surges. Integrated operation of power systems, basic concepts of load flow, economic operation, stability, protection, HVDC transmission. Load management and tariffs.

EEP204 Analog Electronics Laboratory, 1.5 (0-0-3)

Experiments based on design and testing of single stage and multistage amplifiers, power amplifiers, and oscillators on bread board.

EEP206 Digital Electronics Laboratory, 1.5 (0-0-3)

The experiments would be divided into two parts. The objective of the experiments for the first part would be to familiarize the students with basic digital electronic techniques. The second part would on designing and fabricating a digital module.

EEP303 Electromechanics Laboratory, 1.5 (0-0-3)

Experiments on transformers, DC and AC machines.

EEP305 Control Engineering Laboratory, 1.5 (0-0-3)
Prerequisites: Control Engineering

First and second order electrical systems, A.C. and D.C. servo motors and experiments related to the course Control Engineering.

EEP307 Engineering Electromagnetics Laboratory, 1.5 (0-0-3)
Prerequisites: Engineering Electromagnetics

Laboratory experiments on different transmission lines, antennas, microwave sources and devices.

EEP308 Communication Engineering Laboratory, 1.5 (0-0-3)
Prerequisites: Communication Engineering

Laboratory experiments on analog, pulse and basic digital modulation and demodulation techniques.

EEP309 Power Systems Laboratory, 1.5 (0-0-3)
Prerequisites: Power Systems

Experiments related to the course Power Systems.

- - - - - ELECTIVE COURSES - - - - -

CSL319	Parallel and Distributed Processing
CSL333	Operating Systems
CSL343	Computer Networks
CSL402	Digital Image Analysis
EEL311	Digital Signal Processing
EEL312	Digital Communication
EEL313	Information Theory and Coding
EEL314	Microwave Theory and Techniques

EEL315	Antennas and Propagation
EEL316	Embedded Systems
EEL321	Control Engineering – II
EEL322	Mechatronics
EEL323	Measurements and Instrumentations
EEL324	Physical Electronics
EEL325	VLSI Technology and Design
EEL326	Fault Diagnosis of Digital Circuits
EEL327	Soft Computing
EEL328	Digital Signal Processing Laboratory
EEL331	Power Electronics
EEL332	DSP Based Control of Electric Drives
EEL333	Flexible A.C. Transmission Systems
EEL334	Power System Protection
EEL335	Power System Planning
EEL336	Switched-Mode Power Conversion
EEL337	HVDC Transmission
EEL338	Advanced Electromechanics
EEL339	Power Quality
EEL341	Power System Optimization
EEL342	Distribution Automation
EEL343	Modeling and Simulation of Electrical Machines
EEL344	Special Electromechanical Systems
EEL411	Selected Topics in Control Engineering
EEL412	Selected Topics in Communication Engineering
EEL413	Selected Topics in Computers
EEL414	Selected Topics in Electrical Machines
EEL415	Selected Topics in Electronics
EEL416	Selected Topics in Power and Machines
EEL417	Selected Topics in Power Electronics
EEL418	Selected Topics in Power Systems

P.S. : All computer science related courses, including computer architecture, to be taught by Computer Science Department

EEL311 Digital Signal Processing, 4 (3-0-2)

Pre-requisites: EEL201

Review of Signals and Systems, Sampling and data reconstruction processes. Z transforms. Discrete linear systems. Frequency domain design of digital filters. Quantization effects in digital filters. Discrete Fourier transform and FFT algorithms. High speed convolution and its application to digital filtering.

EEL312 Digital Communication, 4 (3-0-2)

Pre-requisites: EEL208

Matched Filter, Error Rate due to Noise. Intersymbol Interference, Nyquist's Criterion, Duobinary Signaling. Optimum Linear Receiver. Geometric Representation of Signals. Coherent Detection of Signals in Noise, Probability of Error. Coherent Digital Modulation Schemes: MPSK, MFSK, MQAM; Error Analysis. Noncoherent FSK, Differential PSK. Comparison of Digital Modulation Schemes, Bandwidth Efficiency. Pseudo-Noise Sequences and Spread Spectrum. Information Theory, Entropy, and Source-Coding.

EEL412 Selected Topics in Communication Engineering-I, 3 (3-0-0)

Pre-requisites: EEL208 and EC 120

Topics of current interest in communication engineering; details will be provided by the instructor.

EEL313 Information Theory and Coding, 3 (3-0-0)

Pre-requisites: EEL205

Entropy, relative entropy, and mutual information. Asymptotic equipartition property. Entropy rates of a stochastic process, Markov chains. Data compression: Kraft inequality, Huffman codes. Channel capacity: symmetric channels, channel coding theorem, Fano's inequality, feedback capacity. Differential entropy. The Gaussian channel: bandlimited channels, channels with coloured Gaussian noise, Gaussian channels with feedback. Rate distortion theory: rate distortion function, strongly typical sequences, computation of channel capacity. Network information theory: Gaussian multiple user channels, the multiple access channel, encoding of correlated sources, the braodcast channel, the relay channel, source coding and rate distortion with side information, multiterminal networks.

EEL314 Microwave Theory and Techniques. 3 (3-0-0)

Pre-requisites: EEL207

Review of EM theory: Maxwell's equations, plane waves in dielectric and conducting media, energy and power.Transmission lines and waveguides: closed and dielectric guides, planar transmission lines and optical fibre.Network analysis: scattering matrix other parameters, signal flow graphs and network representation.Impedance matching and tuning.Analysis of planar transmission lines. Analysis of design of passive components.

EEL315 Antennas and Propagation, 3 (3-0-0)

Pre-requisites: EEL207

Antennas: Introduction to various types of antennas. Fundamentals of electromagnetic radiation, radiation from thin wires and small loops. Different types of linear arrays. Pattern multiplication, long wire antennas, aperture antennas. Waveguides.

EEL316 Embedded Systems and Applications, 3 (3-0-0)

Pre-requisites: CSL211

Introduction to embedded system : Single purpose hardware and software. Architectural Issues : CISC, RISC, DSP Architectures. Component Interfacing : Interrupt, DMA, I/O Bus Structure, I/O devices. Software for Embedded Systems : Program Design and Optimisation techniques, O.S for Embedded Systems, Real-time Issues. Designing Embedded Systems : Design Issues, Hardware-Software Co-design, Use of UML. Embedded Control Applications : Open Loop and Closed Loop Control, Software Coding of PID Controller, applications – washing machine, automobiles. Networked Embedded Systems : Distributed Embedded Architectures, Protocol Design issues,wireless network. Embedded Multimedia and Telecommunication Applications: Digital Camera, Digital TV, Set-top Box, Voice and Video telephony.

EEL413 Selected Topics in Computers, 3 (3-0-0)
Pre-requisites: CSL201 and EC 120

Topics of current interest related to computers; details will be provided by the instructor.

EEL321 Control Engineering – II, 3 (3-0-0)
Pre-requisites: EEL205

Introduction to digital control systems,Principles of signal conversion,sampling and reconstruction. Principle of discretization. Impulse and step invariance. Finite difference approximation. Bilinear transformation, Mathematical models discrete time signals and systems. Transfer function and system response. Stability on the z- domain. Closed loop digital control systems. System with dead time. Commonly used digital devices. Examples of industrial control systems. Transform design of digital controllers. Root locus methods and frequency domain method.State variable representation of continious and discrete time systems. Conversions state variable models to transfer function models. Conversion of transfer function to canonical models. Eigen values and eigen vectors. Solution of state equations. Controllability and observability properties. Pole placement design using state feedback. Dead beat control.

EEL322 Mechatronics, 3 (3-0-0)
Pre-requisites: EEL205 & EEL206

Mechatronics:definitions and terminology,its elements such as mechanics,electronics, microelectronics, power electronics and information technology. Mechanical elements with integrated electronics suspension systems, vibration dampers, clutches, bearing mechanical or magnetic, gears etc. Machines with integrated electronics, electric drives, pneumatic and hydraulic drives, water steam or gas turbines, combustion engines, etc. Generators, pumps, compressors, machines tools, robots, printing machines, vehicles: automobiles, ships and aircraft. Precision machines with integrated electronics devices for telecommunication, consumer electronics, data processing devices, sensors, actuators, optical devices and medical devices, Power electronics converters.

EEL411 Selected Topics in Control Engineering, 3 (3-0-0)
Pre-requisites: EEL321

Select topics in control engineering; details will be decided by the instructor.

EEL323 Measurements and Instrumentation, 3 (3-0-0)
Pre-requisites: GEL104

Principles of Measurement, bridge measurements, oscilloscope, measurements of analog waveforms, Q-meter, Spectrum Analysis, Special transducers, A/D and D/A, Telemetering, Data recording and display, Computer-aided Measurement systems.

EEL324 Physical Electronics, 3 (3-0-0)

Pre-requisites: GEL104

Band model of solids, electrons and holes in semiconductors, carrier statistics, current flow in semiconductors, Junction devices, Metal-oxide-semiconductor devices, Schottky and optoelectronic devices.

EEL325 VLSI Technology and Design, 4 (3-0-2)
Pre-requisites: EEL206

MOS transistors. CMOS and Pseudo NMOS inverters. Pass transistors. Designing Logic gates in CMOS. CMOS sequential circuits. Timing issues, Basic CMOS technology, Layout design rules and CMOS gate layout, Circuit and Logic simulation. Layout generations- partitioning, placements and routing.

EEL415 Selected Topics in Electronics, 3 (3-0-0)
Pre-requisites: EEL204 and EC 120

Topics of interest in areas of electronics; details will be provided by the instructor.

EEL326 Fault Diagnosis of Digital Circuits, 3 (3-0-0)
Pre-requisites: EEL206

Concepts of faults and fault models; test generation, test selection, and fault dictionaries. Test generation for fault detection, fault location and fault correction. Some basic reliability-enhancing design techniques for digital circuits and systems.

EEL327 Soft Computing, 3 (3-0-0)
Pre-requisites: MAL213

Introduction to Soft Computing: Rationale and Basics of Learning: Neural Networks: Multi-layer Feed-forward Networks, Recurrent Networks, Self-organising Networks; Fuzzy Logic: Basics, inferencing scheme, Neuro-Fuzzy systems; Evolutionary Algorithms: GA and Optimisation, Evolutionary Systems, Genetic Programming; Introduction to Rough Sets, Rough-Fuzzy representations, Belief Networks; Principles of SVM; Applications.

EEL331 Power Electronics Devices and Circuits, 4 (3-1-0)
Pre-requisites: GEL104

Basic features of semiconductor junctions, the BJT operations at high currents, switching features of the BJT and MOS transistors. The thyristor operation, distributed gates. IGBT operation, principles and ratings. Boost and buck converters using BJT and IGBT circuits- problems, design and operation. Snubber designs and protection. Firing circuits. Thyristor and BJT based converters-design, phase control, effects on power factor and harmonics, firing circuits and their designs. Inverter circuits operation. Designs using BJT’s and MOS devices. Base and gate drive circuits, snubbers, operational problems. The basic concept of PWM control and advantages against phase control. AC voltage controllers, choppers and cycloconverters.

EEL332 DSP based Control of Electric Drive, 3 (3-0-0)

Pre-requisites: EEL203

Features of a DSP in comparison to those of ordinary processors, computational advantage handicaps regarding analog and digital interface.Communication advantages. Harmonic analysis in real time using DSP specific assembly language features for a DSP.On chip RAM and external RAM interface. PWD and firing pulse generation through typical DSP, look up tables and real time computation. Inetrfacing and actuation circuits for DSP based controllers. Realization of computationally intensive algorithms like variable structure adaptive and neural network scheme for drive systems.

EEL333 Flexible a.c transmission systems, 3 (3-0-0)

Pre-requisites: EEL203

The phenomenon of voltage collapse; the basic theory of line compensation. Static excitation systems; static VAR compensators; static phase shifters; thyristor controlled series capacitors. Co-ordination of FACTS devices with HVDC links. The FACTS optimization problem Transient and dynamic stability enhancement using FACTS components.Advanced FACTS devices-the STATCON and the unified power flow controller.

EEL334 Power System Protection, 3 (3-0-0)

Pre-requisites: EEL203

Basic Principles – CTs, PTs. Static relays. Modern circuit breakers, Protection of power transformers, alternators, transmission lines, cables, reactors and capacitors. Protection of motors, rectifiers and thyristors. HVDC protection. Relay Coordination, Numerical relaying algorithms, Traveling wave relays, adaptive relaying.

EEL335 Power System Plannig, 3 (3-0-0)

Pre-requisites: EEL303

Load forecasting, generation system reliability, transmission system reliability and distribution system reliability. Generation system expansion planning, Transmission system expansion planning and distribution system expansion planning, Reactive power planning, Integrated power system planning.

EEL336 Switched-Mode Power Conversion, 3 (3-0-0)

Pre-requisites: EEL203

The course coordinator will decide details.

EEL337 HVDC Transmission, 3 (3-0-0)

Pre-requisites: EEL209

Comparison of HVAC and HVDC transmission, HVDC transmission schemes, Component description, converter: principles, characteristics, control circuits, HVDC system control, Protection, Harmonics and filters, AC-DC system interaction, AC-DC load flow.

EEL338 Advanced Electromechanics, 3 (3-0-0)

Pre-requisites: EEL203

Review of electromagnetic field concepts, Maxwell’s equations for quasi-stationary fields. Boundary values problems in electrostatics: Laplace and Poisson’s equations. Solutions in rectangular, spherical and cylindrical coordinates: method of Images: field plotting. Conformal transformation techniques, numerical methods: finite difference methods, finite element based software. Magnetostatic fields – vector potential: Boundary value problems. Current sheet and flux sheets.Relation between field theory and circuit theory for electric machines. Advanced topics in electromechanics, dynamic modelling of D.C., synchronous and induction machines, d-q transformaions. Transient/dynamic analysis of machines using classical and numerical methods. Short circuit studies in synchronous machines. Effects of saliency, automatic voltage regulators. Unbalanced operation of Induction motors. Speed control of induction motors. Variable reluctance, permanent magnet and stepper motors.

EEL416 Selected Topics in Power and Machines, 3 (3-0-0)

Pre-requisites: EEL203 & EC 120

Topics of interest in the relevant areas.

EEL339 Power Quality, 3 (3-0-0)

Pre-requisites: EEL209

Overview and definition of power quality (PQ) Sources of pollution, international power quality standards, and regulations, Power quality problems: rapid voltage fluctuations voltage unbalance,voltage dips and voltage swells, short duration outages, Power system harmonics: harmonic analysis, harmonic sources- the static converters, transformer magnetization and non-linearities, rotating within the power system, interference with communication Hormonic measurements . Harmonic elimination-harmonic filters.

EEL344 Special Electromechanical Systems, 3 (3-0-0)

Pre-requisites: EEL203

Introduction to Special Electrical Machines and Magnetic Devices, Permanent Magnet Machines, Permanent Magnet Brushless DC Machines, Stepper Motors, Hysteresis Motors, Switched Reluctance Motors, Hybrid Motors, Linear Machines, Magnetic Devices, Applications in Robotics, Industry Automation, Electric Vehicles, Aerospace and Review of flip flops, shift registers, counters, introduction to digital filters - IIR and FIR. Review of optical components - LED, LD, PIN and APD. Design of LED and LD transmitters and receivers; optical isolator, OTDR measurements. Transducers and recorders in instrumentation.

EEL341 Power System Optimization, 3 (3-0-0)

Pre-requisites: EEL209

Economic load dispatch in thermal and hydro-thermal system; reactive power optimization; optimal power flow. Linear programming and non-linear programming techniques to optimal power flow problems. Security constrained optimization. Unit commitment and maintenance scheduling, Interchange evaluation, Minimum emission dispatch.

EEL342 Distribution Automation, 3 (3-0-0)
Pre-requisites: EEL209
Introduction to distribution automation, configuration of distribution system. Nature of loads and load forecasting. Layout of substations and feeders. Design considerations. Distribution system load flow. Optimum siting and sizing of substations, optimum capacitor placement. Distribution system monitoring and control : SCADA, Remote metering and load control strategies, Optimum feeder switching for loss minimization and load control. Distribution system restoration. Distribution system protection and switchgear. Power quality issues.

EEL343 Modeling and Simulation of Electrical Machines, 3 (3-0-0)
Pre-requisites: EEL203
Energy state functions, Modelling of electromechanical systems Matrix method and use of generalised circuit theory of machines. Different methods of transformation, phase variable instantaneous symmetrical component techniques, Development of basic performance equation and analysis of different rotating machines such as D. C., synchronous and induction machines, Dynamics and transients in electric machines. Switching transients and surges, Transient and short circuit studies on alternators Run-up reswitching and other transients in induction machines relevant computer techniques for machine analysis. Modelling of special electrical machines.

EEL414 Selected Topics in Electrical Machines, 3 (3-0-0)
Pre-requisites: EEL203 and EC 120
Topics of current interest related to electrical machines; details will be provided by the instructor.

EEL418 Selected Topics in Power Systems, 3 (3-0-0)
Pre-requisites: EEL209 & EC 120
Topics of interest in power systems; will be decided by the instructor.

EEL417 Selected Topics in Power Electronics, 3 (3-0-0)
Pre-requisites: EEL209 and EC 120
The instructor from among current areas of power systems will decide topics.

5.7 Mathematics

MAL111 Mathematics Laboratory, 2 (1-0-2)

Rank of a matrix, consistent linear system of equations, row reduced echelon matrices, inverse of a matrix, Gauss-Jordan method of finding an inverse of a matrix.
Mathsoftware Tools Practice Sheet No. 1

Eigenvalues and eigenvectors, diagonalisation of matrices, Caley-Hamilton theorem.
Mathsoftware Tools Practice Sheet No. 2

Hermitian, Unitary and Normal Matrices, bilinear and quadratic forms.
Mathsoftware Tools Practice Sheet No. 3

Roots of a polynomial; numerical solution of a system of algebraic equations: Newton-Raphson and iterative methods; interpolation: Lagrange interpolation formula, interpolation formula by use of differences.
Mathsoftware Tools Practice Sheet No. 4

Numerical differentiation; numerical integration: trapezoidal rule and Simson's formula; error estimates in numerical differentiation and integration.
Mathsoftware Tools Practice Sheet No. 5

Computer graphics: plotting of line, triangle and circle; plotting of cylinder, cube and sphere; projections; rotations.
Mathsoftware Tools Practice Sheet No. 6

MAL112 Advanced Calculus, 3 (2-1-0)

Calculus of functions of several variables, implicit functions, partial derivatives and total differentials, equality of mixed derivatives of composite functions, Taylor's Theorem, maxima and minima, constrained extrema, Lagrange multipliers
Self-study Problem Sheet No. 1

Definite integrals, differentiation under integral sign, differentiation of integrals with variable limits, improper integrals, Beta and Gamma functions.
Self-study Problem Sheet No. 2

Multiple integrals: definitions, properties and evaluation of multiple integrals, application of double integrals (in Cartesian and polar coordinates), change of coordinates, Jacobian, line integrals, Green's theorem, proof, first and second forms.
Self-study Problem Sheet No. 3

Solution of first order differential equations. Existence and uniqueness of solution, Picard's method of successive approximations.
Self-study Problem Sheet No. 4

MAL113 Vector Field Theory, 2 (2-0-0)

Vector calculus, arc length, directional derivative, differentiation and integration of vector valued functions, derivative of composite functions, vector equations: straight line, plane, space curves.
Self-study Problem Sheet No. 1

Gradient, curl and divergence.
Self-study Problem Sheet No. 2

Orthogonal curvilinear coordinates, line, area and volume elements, expressions for gradient, curl and divergence.
Self-study Problem Sheet No. 3

Line and double integrals, Green's theorem, surface integrals, triple integrals, Stokes and divergence theorems with applications. Conservative vector fields and path independence.
Self-study Problem Sheet No. 4

MAL114 Linear Algebra, 3 (2-0-2)

Vector spaces, bases and dimensions, linear transformations, matrix of linear transformations, change of bases, inner product spaces, Graham-Schmidt orthogonalization.
Mathsoftware/Tools Practice Sheet No. 1

Triangular form, matrix norms, conditioning of linear systems, Singular value decomposition.
Mathsoftware/Tools Practice Sheet No. 2

Direct methods: Gauss, Cholesky and Housholder's methods.
Mathsoftware/Tools Practice Sheet No. 3

Matrix iterative methods: Jacobi, Gauss-Siedel and relaxation methods, conjugate gradient methods and its pre-conditioning.
Mathsoftware/Tools Practice Sheet No. 4

Computation of eigenvalues and eigenvectors: Jacobi, Givens, Householder, QR and inverse methods.
Mathsoftware/Tools Practice Sheet No. 5

MAL115 Real Analysis, 2 (2-0-0)

Product of sets, mappings and their compositions, denumerable sets, upper and lower bounds, supremum and infimum.
Self-study Problem Sheet No. 1

Metric spaces: Definition and examples, open, closed and bounded sets; interior boundary, convergence and limit of a sequence.
Self-study Problem Sheet No. 2

Cauchy sequence, completeness, Bolzano-Weierstrass theorem, continuity, intermediate value theorem, and uniform continuity, connectedness, compactness and separability.
Self-study Problem Sheet No. 3

Integration: Riemann sums, Riemann integral of a function, integrability of a function on a closed interval, mean value theorem, improper integrals.
Self-study Problem Sheet No. 4

Fourier Series, Fourier Integrals and Fourier Transforms.
Self-study Problem Sheet No. 5

MAL116 Introduction to Ordinary Differential Equations, 3 (3-0-0)

Second order differential equations with constant coefficients: homogeneous and non-homogeneous differential equations, method of undermined coefficients, annihilation method, method of variation of parameters. Wronskian and linear independence of solutions, solution of ODE by Laplace transform.
Self-study Problem Sheet No. 1

Second order equations with variable coefficients: Euler equation, linearly independent solutions, solution of second order equation with one known solution, application of variation of parameters method to second order equations with variable coefficients,
Self-study Problem Sheet No. 2

Series solutions, Frobenius method, Legendre and Bessel equations, orthogonal properties of Legendre polynomials.
Self-study Problem Sheet No. 3

Higher order differential equations.
Self-study Problem Sheet No. 4

Boundary Value Problems and Sturm-Liouville Theory: Two point boundary value problems, Sturm-Liouville boundary value problems, non-homogeneous boundary value problems; series of orthogonal functions, mean convergence.
Self-study Problem Sheet No. 5

MAL211 Complex Analysis, 2 (2-0-0)

Limit, continuity and differentiability of functions of a complex variable, analytic functions, Cauchy-Riemann equations.
Self-study Problem Sheet No. 1

Definition of integral, Cauchy integral theorem, integral formula, derivatives of analytic functions, Morera's and Liouville's theorems, maximum modulus principle.
Self-study Problem Sheet No. 2

Poles and singularities, Taylor's and Laurent series, isolated singular points, Cauchy residue theorem, evaluation of real integrals.

Self-study Problem Sheet No. 3

Conformal and bilinear mappings.
Self-study Problem Sheet No. 4

MAL212 Modern Algebra, 3 (2-1-0)

Definition and examples of groups, Lagrange theorem, cyclic groups, linear groups, permutation groups.
Self-study Practice Sheet No. 1

Subgroups, normal subgroups, and factor groups, isomorphism theorems, Sylow theorems, and their applications
Self-study Practice Sheet No. 2

Rings and fields.
Self-study Practice Sheet No. 3

MAL213 Introduction to Probability Theory and Stochastic Processes, 3 (3-0-0)

Axioms of probability, conditional probability, probability space, random variable, distribution functions, standard probability distribution functions.
Self-study Practice Sheet No. 1

Multidimensional random variables, marginal and conditional probability distribution, independence of random variables, bivariate, normal and multinomial distributions.
Self-study Practice Sheet No. 2

Functions of several random variables, expectation, moments and moment generating functions, correlation, moment inequalities.
Self-study Practice Sheet No. 3.

Conditional expectation and regression, random sums, convergence in probability, weak law of large numbers and central limit theorem.
Self-study Practice Sheet No. 4.

Markov chains and random processes: Markov and other stochastic processes, stationary distributions and limit theorem, reversibility, branching processes and birth-death processes, Markov chains Monte Carlo.
Self-study Practice Sheet No. 5.

Queues: Single-server queues, M/M/1, M/G/1, G/M/1, and G/G/1 queues.
Self-study Practice Sheet No. 6.

MAL214 Introduction to Functional Analysis, 3 (2-1-0)

Calculus of variations and applications.

Self-study Practice Sheet No. 1

Normed linear spaces, Banach spaces, Hahn-Banach Theorem
Self-study Practice Sheet No. 2

Open mapping theorem, principle of uniform bounded, Hilbert Spaces
Self-study Practice Sheet No. 3

Orthogonal projections, self-adjoint, unitary and normal linear operators.
Self-study Practice Sheet No. 4

Orthogonal bases, Parseval's relation and Bessel's inequality, Riesz representation theorem and Lax-Milgram Theorem.
Self-study Practice Sheet No. 5

5.8 Mechanical Engineering

MEL101 Continuum Mechanics, 4 (3-1-0)
Prerequisites: None

Continuum Theory, Stress Principles, Kinematics of Deformation and Motion, Fundamental Laws and Equations, Linear Elasticity, Classical Fluids, Nar Elasticity, Linear Viscoelasticity.

MEL102 Energy Science and Technology, 4 (3-1-0)
Prerequisites: None

Energy resources – salient features and utilization. Renewable and non-renewable sources. Environmental and sustainability issues. Basic concepts and definitions – system, boundary, equilibrium, steady state, etc. Work and heat – definition and applications. 1st Law – internal energy and enthalpy, applications to non flow/closed and flow/open systems. 2nd Law – corollaries, Clausius inequality, entropy. Introduction to availability, irreversibility and exergy. Carnot cycle. Thermodynamic properties of a pure substance – saturated and other states. Basics of gas-vapor mixtures and reacting systems. Vapor power cycles – Rankine cycle and its modifications. Air standard cycles – Otto, Diesel, Brayton cycles. Vapor compression and absorption refrigeration cycles. Introduction to real cycles.

MEP103 Engineering Communication, 2 (0-0-4)
Prerequisites: None

Introduction to design process and drawings. Drawing standards and their use in industry. Review of sectioning, drawing standards, dimensioning and notes. Standard representations of fastening and joining. Machine assembly drawings with sectioning, exploded views and bill of materials, parts detailing and assembly. Relationship between form and function – limits, fits and tolerances, dimensional and geometric tolerances, surface finish. Process engineering diagrams for manufacturing and assembly. Schematic and process flow diagrams – standard equipment and symbols. Instrumentation and control diagrams. Architectural layout drawings, Sequence control diagrams, Project management charts. A combination of free hand drawing and use of industry standard software packages will be employed.

MEL201 Fluid Mechanics, 4 (3-1-0)
Prerequisites: Continuum Mechanics

Fluid kinematics: Lagrangian and Eulerian descriptions, pathlines, streaklines and streamlines, acceleration. Integral flow analysis: Reynolds transport theorem, conservation of mass/continuity equation and conservation of linear and angular momentum for a control volume in inertial and accelerating reference frames, energy equation, Bernoulli’s equation, engineering applications. Differential analysis of flow: Continuity and Navier-Stokes equations. Dimensional analysis and Similitude theory. Inviscid flows: Irrotational flow, circulation, velocity potential and applications. Viscous flows in pipes and ducts. External viscous flows: concept of boundary layer, momentum integral equation, drag and lift, separation. NPSH concept, similarity rules, applications.

MEL202 Manufacturing with Metallic Materials, 3 (3-0-0)
Prerequisites: Materials Science and Engineering

Product realization with metals, Material properties, Microstructure, Correlation between microstructure and properties, interfaces and intermetallics, Property modifications-heat treatment and allied process, Casting techniques and analysis, Forming techniques and analysis, Forging technique and analysis, Machining methods, Conventional and Non-conventional and their analysis, Assembly and fabrication techniques, Welding and allied processes, Product testing and quality control, Advanced applications in general engineering, aerospace, automobile and biomedical industries.

MEL203 Manufacturing with Non-metallic Materials, 3 (3-0-0)
Prerequisites: Materials Science and Engineering

Product realization with polymers and composites; Type of polymers - Thermoplastics, Thermosets and Elastomers; Correlation between microstructure and property; Property enhancement by blending, alloying, reinforcing; Manufacturing techniques for general polymer based products and its mold /die design fundamentals; extrusion, injection molding, blow molding, rota molding, etc.; FRP composites.

Lamina, laminate and lamination theory; Manufacturing of composites; Autoclave molding, Pultrusion, Filament winding, Compression molding; Carbon – Carbon Composites; Applications in automobile, aerospace and general engineering.

MEL204 Machine Element Design, 3 (3-0-0)
Prerequisites: Continuum Mechanics

Engineering design vis-à-vis Solid mechanics, factor of safety, standards and design equations. Application of theories of failure to design. Design procedure and its application to static strength. Design based on static loads: screws including power screws, bolted joints including eccentrically loaded joints, axles, and coupling, clutches and brakes. Introduction to design for fatigue strength. Endurance and modifying factors. Surface strength. Review of design procedure of fatigue failure with application to the design of bolts and springs subjected to fatigue loading. Design of shafts, spur, helical, bevel and worm gears, journal and rolling contact bearings, belts and chains.

MEP205 Product Design and Realization – Intermediate, 2 (0-0-4)
Prerequisites: Product Design and Realization – I, and Engineering Communication

Fabrication of a finished product through: (a) Identification of engineering solution parameters like materials, manufacturing and configuration variables, (b) Study and improvement of existing designs, (c) Open ended design problems for generating innovative designs/solutions and engineering problem solving, and (d) Product design with other life-cycle considerations in mind such as manufacturing, maintenance and environmental considerations (e) application of core mechanical engineering principles and practices.

MEL301 Heat and Mass Transfer, 4 (3-1-0)
Prerequisites: Fluid Mechanics

Modes of heat transfer in various applications. Conduction: Heat diffusion equation, 1-D steady state conduction in extended surfaces, infinite and semi-infinite walls, heat generation, lumped capacitance and simple transient models. Convection: Forced and free convection - mass, momentum and energy conservation equations, non-dimensional numbers, hydrodynamic and thermal boundary layers, basics of heat transfer in external and internal laminar and turbulent flows, and use of co-relations. Boiling and condensation: physical phenomena and co-relations. Mass transfer – Fick’s law, similarity with convection and correlations. Radiation: properties, Laws, 3-

surface network for diffuse-gray surfaces. Heat exchanger fundamentals and design.

MEP302 Manufacturing Laboratory, 3 (0-0-6)
Prerequisites: Manufacturing with Metallic Materials, Manufacturing with Non-metallic Materials

Practice on the use of processes to produce high precision and multifunction components with metals and non-metals.

MEL303 Theory of Machines, 3 (3-0-0)
Prerequisites: Machine Element Design, and Classical Mechanics

Kinematic pairs, diagram and inversion. Mobility and range of movements. Displacement, velocity and acceleration analysis of planar linkages. Dimensional synthesis for motion, function and path generation. profile synthesis. Gears. Dynamic force analysis, flywheel, inertia forces and their balancing for rotating and reciprocating machines.

MEP304 Design Laboratory, 2 (0-0-4)
Prerequisites: Theory of Machines

Laboratory experiments on motion, forces, stresses and durability of mechanical components.

MEP305 Control Engineering Laboratory, 1.5 (0-0-3)
Prerequisites: Control Engineering

Laboratory experiments on the design and use of pneumatic, hydraulic, and electronic controllers for control of parameters like displacement/position, pressure, flow rate, temperature, level, speed, etc.

MEP401 Thermo-fluids Laboratory, 1.5 (0-0-3)
Prerequisites: Fluid Mechanics, Heat and Mass Transfer, Energy Science and Technology

Experiments in fluid mechanics and heat transfer.

MEL402 Manufacturing Systems, 3 (3-0-0)
Prerequisites: Core Industry Internship

Generalized model of a production system. Financial evaluation of new product polices. Profit Volume Charts, Risk analysis, Product mix decisions, Location and layout analysis, Product, process and cellular layouts, Demand forecasting, Aggregate production planning, Materials planning, MRP and inventory management, scheduling in job and flow shops.

LIST OF PROGRAMME ELECIVES

MEL411	Transportation Mechanics
MEL412	Propulsion Technologies
MEL413	Indoor Environment Control
MEL414	Electric Power Generation
MEL415	Biomechanics
MEL416	Tribology
MEL417	Noise and Vibration
MEL418	Robotics

MEL419 Mechatronics
MEL421 Medical Devices and Equipment
MEL422 Composite Materials
MEL423 Micro-manufacturing

MEL411 Transportation Mechanics, 4 (3-0-2)
Prerequisites: Classical mechanics & 120 credits

Basic features of surface transport on land and water. Mechanics of passenger transport equipment - hand carts, bicycle, tri-cycle, cycle rickshaw, motorized 2-wheelers, automobile, bus, train, trams, cable cars, etc. Freight transport – trucks, tractor trailers, trains, etc. Water transport – manual and motor powered boats, ships, and hovercraft. Earth moving equipment – bulldozers, backhoe, dumper, etc. Topics will include powering device, transmission, drive train aspects, ride comfort and stability, and safety features, amongst others.

MEL412 Propulsion Technologies, 4 (3-0-2)
Prerequisites: MEL102

Prime movers – I.C. engine, gas turbine, steam turbine, electric motor. I.C. engine fundamentals covering mechanisms, thermodynamics, controls and operation, and components, their materials and manufacture; applications in land and water propulsion; Jet propulsion – fundamentals, types of engines, their characteristics and applications; construction features and materials; applications in surface (land and water) transport and aircraft propulsion. Rocket propulsion – basics, solid and liquid propelled engines, construction features, multi-stage rockets. Energy and environmental impacts.

MEL413 Indoor Environment Control, 4 (3-0-2)
Prerequisites: MEL102

Air quality and comfort – temperature and humidity, dust and contaminants; standards, ambient air quality, measurement techniques; Space cooling techniques – ceiling fans, evaporative cooling and air-conditioning, fundamentals, systems and components, construction features; vapour compression and vapour absorption systems; cooling load estimations. Space heating techniques – fire place, electric and gas heating, solar heating; load estimations. Clean room – classification and systems. Applications for domestic, office, transport, and specialized uses, such as, hospitals, factories, assembly areas, etc. Energy and environmental impact.

MEL414 Electric Power Generation, 4 (3-0-2)
Prerequisites: MEL102

Centralized and de-centralized electric systems, grid and its management, demand variation and forecasting; Thermodynamics, systems, components and construction features of diesel generating sets, coal/oil/gas burning, combined cycle, solar thermal, geothermal, ocean thermal power plants. Nuclear power plants – types, basic nuclear physics and construction features, fuel, moderator and coolant, steam cycle; Hydroelectric plants – fundamentals, construction features; Fuel cells; Solar photovoltaic systems; Carbon footprint and future trends.

MEL415 Biomechanics, 4 (3-0-2)
Prerequisites: Classical mechanics

Basics of kinematics and dynamics; Physiology of various life forms, structural aspects.

Locomotion principles. Properties of tissue, analysis of motion and forces. Mechanics of injuries and ageing effects; Design and use of implants their materials of construction features and manufacture.

MEL416 Tribology, 4 (3-0-2)
Prerequisites: MEL204

Tribology basics, surfaces and their characterization and measurement; Apparent and real area of contact; Contact pressure and deformation. Genesis of friction, friction in contacting surfaces, sliding and rolling friction, laws and theory of friction. Stick-slip friction behaviour, frictional heating and temperature rise. Wear: types, mechanisms - adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc. Wear models, rates their control and damage. Lubrication – types, hydrodynamics lubrication regimes, lubricating oils, their specification, contamination in use; lube oil systems for engineering equipment, such as, hydraulic and steam turbines, IC engines, industrial machinery, brakes and clutches, etc. Micro- and nano-tribology.

MEL417 Noise and Vibration, 4 (3-0-2)
Prerequisites: MEL204

Introduction to engineering acoustics. Noise – properties, loudness and weighing networks, octave and FFT analysis, Sound power, intensity; Measurements and diagnostics. Noise control techniques; Noise from machines, such as, fans, engines, bearings, turbines, motors, jets, etc. Noise standards. Introduction to vibration engineering, Spatial, modal and response models; Lumped parameter and distributed parameter modeling; free- and forced-vibrations and single- and multi-degree of freedom systems. Balancing of rotating and reciprocating machines; vibration isolators and shock absorber design, construction and properties. Flow-induced vibrations. Measurement and instrumentation.

MEL418 Robotics, 4 (3-0-2)
Prerequisites: MEL303

Evolution of automatons, manipulators and autonomous systems, Forward and inverse kinematics, velocity control; Jacobian control of systems; singular value decompositions and null spaces; Interpolation in 3-D spaces, dual numbers, quaternions and screws, dynamics of manipulators, EL and NE formulations, Parallel manipulators, basics of vision systems, Robotic AI paradigms and navigation.

MEL419 Mechatronics, 4 (3-0-2)
Prerequisites: EEL205

Introduction to mechatronics systems and components; Basics, interfacing and integration of microprocessors, sensors, actuators, and other hardware; Interfacing, AD and DA converters, software and hardware tools; component selection including: sensors – encoders and resolvers, actuators – stepper and servo motors, solenoids; transmission elements – ball screws; controllers. Analysis and synthesis of systems for robotics, CNC and industrial applications.

MEL421 Medical Devices and Equipment, 4 (3-0-2)
Prerequisites: 90 credits

Basic anatomy and physiology of human systems, such as, circulation, respiration, etc. and organs and associated tissues; Requirement of devices and equipment for various procedures, e.g. surgery, dental procedures, dialysis, etc.; inserts, implants, artificial limbs; etc. – design, manufacturing, installation and use.

MEL422 Composite Materials, 4 (3-0-2)
Prerequisites: MEL203

Types of composites, natural composites; fiber types, forms and properties; lamina and laminate; micro- and macro-mechanical analysis and properties, failure theories; primary and secondary manufacturing – lay-up, filament winding, pultrusion, compression moulding, RTM, RIM, SRIM; Machining, drilling, joining, routing, etc.; Applications – metal matrix composites, ceramic matrix composites, etc. – components and processing techniques.

MEL423 Micro-manufacturing, 4 (3-0-2)
Prerequisites: GEL101 & 90 credits

Overview of micro- and nano-maechanical systems and their applications; MEMS microfabrication methods, silicon micromachining, laser micromachining, mechanical micromachining; nanomanufacturing methods, CAD and CAM tools for micro- and nano-manufacturing techniques.

5.9 Physics

PHL101 Electromagnetics, 4 (3-1-0)

Gauss' law in vector form and application to electrostatics, Electric polarization, electric permittivity, Displacement vector; Laplace's equation and Poisson's equation and solutions in simple situations; Amperes law, Magnetization, Faraday's law of induction, Equation of continuity; Displacement current, Maxwell's equations; electromagnetic waves in dielectrics; reflection and refraction of electromagnetic waves, polarization, transmission lines and metal waveguides; Special theory of relativity, Michelson Morley experiment, Lorentz transformations, time dilation, length contraction and velocity addition.

PHL102 Quantum Physics, 4 (3-1-0)

Particles and Waves in classical Physics:- Need for quantum mechanics (Planck's law of radiation, Photoelectric effect, Compton scattering, Raman effect and Stern Gerlach experiment); Double Slit experiment with light; Matter waves; Postulates of Quantum Mechanics:- States and operators; Hilbert space; Dirac's bra and ket notations: Schroedinger equation (time dependent and time independent); Uncertainty principle; Applications of Schoredinger equation in one spatial dimension:- Potential well and barrier: scattering and bound states: Tunneling. Harmonic oscillator; Symmetries in Quantum mechanics:- Translational invariance; Rotational invariance and Angular momentum operators: Discrete symmetry: Parity, lattice translational symmetry - Bloch equation; Time reversal symmetry; Schoredinger equation in higher dimension:- Motion of a charged particle in a uniform magnetic field: Hydrogen atom: concept of degeneracy; Spin and dynamics of spin:- Zeeman Effect; Entanglement in quantum system:- EPR paradox, Philosophical issues.

PHL103 Classical Mechanics, 4 (3-1-0)

Constraints, virtual work and D'Alemberts principle. Generalized coordinates and Lagrange's equation, Basics of the calculus of variations. Hamilton's principle and Lagrange equations. Cyclic coordinates, conservation laws. Central force and analysis using effective potentials, Kepler's problem. Scattering of particles by a central force. Rutherford's law. Rigid body motion, body and space coordinates, Euler angles, non inertial frames. Eulers theorem, moment of inertia tensor, principal axis transformation and Euler'equations of motion. Centrifugal and Coriolis force. Precession and nutation of rigid bodies. Small oscillation theory, nature of equilibrium and normal modes. Hamilton equations of motion, principle of least action. Canonical transformations, Poisson brackets. Jacobi's action angle variables, Liouville's theorem. Phase space plots, stability of fixed points, period doubling bifurcations and chaos. classical theory of fields, Lagrangian and Hamiltonian formulation. Noether's theorem.

PHL104 Optics and Lasers, 4 (3-1-0)

Plane waves and spherical waves; Interference: two beam and multiple beam interference; Michelson, Sagnac, Fabry Perot interferometers; Diffraction: Fraunhofer and Fresnel diffraction, Fraunhofer diffraction by rectangular and circular apertures; Resolution of optical instruments;

Fourier optics and spatial frequency filtering; Fresnel diffraction: Diffraction of a Gaussian beam; Polarization and polarization components; Basics of lasers, Einstein coefficients, population inversion and optical amplification; Threshold for laser oscillation; Optical resonators, stability condition, transverse and longitudinal modes; Mode selection; Q-switching and mode locking; Properties of laser beams; Types of lasers; Some laser applications.

PHP100 Physics Laboratory, 2 (0-0-4)

List of Experiments: 1 Coupled pendulum, 2 Torsional harmonic oscillator, 3 Study of DC power supply, 4 Experiments on electromagnetic induction, 5 Measurements of magnetic field using Helmholtz coil, 6 Measurement of wavelength of light using Newton's rings, 7 Diffraction of light from single slit and multiple slits and Heisenberg uncertainty principle, 8 Measurement of Planck's constant using photoelectric effect, 9 Hall effect measurements in semiconductors and metals, 10 Quantum analog. Experiments 1 and 2 belong to mechanics, experiments 3 to 5 belong to electricity and magnetism, experiments 6 and 7 belong to optics and experiments 8 to 10 belong to the area of modern physics.

PHL201 Thermal and Statistical Physics, 4 (3-1-0)
Prerequisite : Course on Quantum Physics, Suitability : Third semester and above.

Elements of Thermodynamics:- Laws of thermodynamics, entropy, thermodynamic potentials and Maxwell relations; Elementary probability theory:- Binomial, Poisson and Gaussian distributions, introduced via the random walk problem, central limit theorem and its significance; Kinetic theory of gases:- Averages and distributions of molecules in a gas, random walk and Brownian motion, random walk and diffusion; Statistical basis for thermodynamics:- Macrostates and microstates, postulates of statistical mechanics; Gibb's paradox; Elements of ensemble theory:- Partition function, rules of calculation through microcanonical, canonical and grandcanonical ensemble, applications to systems of ideal gas molecules, paramagnetic spins, harmonic oscillators, etc.; Quantum statistical mechanics:- Bose-Einstein, Fermi-Dirac and Maxwell-Boltzmann statistics; their utility in Bose-Einstein condensation, black body radiation, etc.

PHL202 Physics of Materials, 4 (3-1-0)
Prerequisite : Course on Quantum mechanics

Brief review of essential concepts of quantum mechanics, Classical and Quantum distribution functions and their comparison, Free electron theory, Origin of energy bands in solids, Density of states, E-k diagrams, Brillouin zones, Effective mass, Metals, semimetals, semiconductors and insulator and resistivity of metals, Semiconductors: Intrinsic and Extrinsic semiconductors, Fermi level, Temperature and carrier concentration variation of Fermi level, Metal-semiconductor junction, p-n junction, tunnel diode, solar cell and LED, Superconductivity: Zero resistance, critical temperature, current and field, Isotope Effect, Type-I and II Superconductors, London penetration depth and coherence length, BCS Theory (qualitative), Josephson Junctions.

6. B. Tech. in Computer Science and Engineering

Core Curricular Structure

SCIENCE CORE

1.	MAL115	Real Analysis	2	(2-0-0)
2.	MAL111	Mathematics Laboratory	2	(1-0-2)
3.	MAL213	Introduction to Probability Theory and Stochastic Processes	3	(3-0-0)
4.	CYL101	Structure, Reactivity, and Dynamics	4	(3-1-0)
5.	One of PHL101/PHL102/PHL103		4	(3-1-0)
6.	PHP100	Physics Laboratory	2	(0-0-4)
7.	CYP100	Chemistry Laboratory	2	(0-0-4)
	Science core credits		**19**	**(12-2-10)**

PROGRAMME CORE

1.	CSL105	Discrete Mathematical Structures	4	(3-1-0)
2.	CSL201	Data Structures	5	(3-0-4)
3.	CSL202	Programming Paradigms and Pragmatics	5	(3-0-4)
4.	CSP203	Software Systems Laboratory	2	(0-0-4)
5.	CSL211	Computer Architecture	5	(3-1-2)
6.	CSL333	Operating Systems	5	(3-0-4)
7.	CSL343	Computer Networks	4.5	(3-0-3)
8.	CSL355	Logic and Computability	4	(3-1-0)
9.	CSL356	Analysis and Design of Algorithms	4	(3-1-0)
10.	EEL206	Digital Electronics Circuits	4	(3-1-0)
11.	EEP206	Digital Electronics Laboratory	1.5	(0-0-3)
	Programme core credits		**44**	**(27-5-26)**

Scheduling of Core Courses (typical)

B.Tech. in Computer Science and Engineering

First semester

MAL111	Mathematics Laboratory
MAL115	Real Analysis
CYL101	Structure, Reactivity and Dynamics
CYP100	Chemistry Laboratory

Second semester

CSL105	Discrete Mathematical Structures
PHL10x	
PHP100	Physics Laboratory

Students are advised to do one of PHL101/PHL102/PHL103 during the first year.

Core credits: 10

Core credits: 10

Third semester

EEL206	Digital Electronic Circuits
EEP206	Digital Electronics Laboratory
CSL201	Data Structures
CSL211	Computer Architecture

Core credits: 15.5

Fourth semester

CSL202	Programming Paradigms and Pragmatics
MAL213	Introduction to Probability Theory and Stochastic Processes
CSP203	Software Systems Laboratory

Core credits: 10

Fifth semester

CSL333	Operating Systems
CSL356	Analysis and Design of Algorithms

Core credits: 8

Sixth semester

CSL343	Computer Networks
CSL355	Logic and Computability

Core credits: 8.5

Summer

IIP201	Summer Industry Internship and Colloquium

Seventh semester

CPP301	Core Project I
IIP201	Summer Industry Internship and Colloquium

Core credits: 6

Eight semester

CPP302	Core Project II

Core credits: 5

7. B.Tech. in Electrical Engineering

Core Curricular Structure

SCIENCE CORE

1.	PHL101	Electromagnetics	4	(3-1-0)
2.	MAL111	Mathematics Laboratory	2	(1-0-2)
3.	MAL114	Linear Algebra	3	(2-0-2)
4.	MAL213	Introduction to Probability Theory and Stochastic Processes	3	(3-0-0)
5.	CYL101	Structure, Reactivity and Dynamics	4	(3-1-0)
6.	PHP100	Physics Laboratory	2	(0-0-4)
7.	CYP100	Chemistry Laboratory	2	(0-0-4)
		Science core credits	**20**	**(12-2-12)**

PROGRAMME CORE

1.	EEL201	Signals and Systems	4	(3-1-0)
2.	EEL202	Circuit Theory	4	(3-1-0)
3.	EEL203	Electromechanics	4	(3-1-0)
4.	EEL204	Analog Electronics	4	(3-1-0)
5.	EEL205	Control Engineering	4	(3-1-0)
6.	EEL206	Digital Electronic Circuits	4	(3-1-0)
7.	EEL207	Engineering Electromagnetics	4	(3-1-0)
8.	EEL208	Communication Engineering	4	(3-1-0)
9.	EEL209	Power Systems	4	(3-1-0)
10.	EEP204	Analog Electronics Laboratory	1.5	(0-0-3)
11.	EEP206	Digital Electronics Laboratory	1.5	(0-0-3)
12.	EEP303	Electromechanics Laboratory	1.5	(0-0-3)
13.	EEP305	Control Engineering Laboratory	1.5	(0-0-3)
14.	EEP307	Engineering Electromagnetics Laboratory	1.5	(0-0-3)
15.	EEP308	Communication Engineering Laboratory	1.5	(0-0-3)
16.	EEP309	Power Systems Laboratory	1.5	(0-0-3)
	Programme core credits		**46.5**	**(27-9-20)**

Scheduling of core courses (typical)

B.Tech. in Electrical Engineering

First semester

MAL111 Mathematics Laboratory
PHL101 Electromagnetics
CYL101 Structure, Reactivity and Dynamics
CYP100 Chemistry Laboratory

Core credits: 12

Second semester

EEL201 Signals and Systems
MAL114 Linear Algebra
PHL103 Classical Mechanics
PHP100 Physics Laboratory

Core credits: 13

Third semester

EEL202 Circuit Theory
EEL203 Electromechanics
EEL206 Digital Electronics Circuits
EEP206 Digital Electronics Laboratory

Core credits: 13.5

Fourth semester

EEL204 Analog Electronics
EEL205 Control Engineering
EEL208 Communication Engineering
EEP204 Analog Electronics Laboratory
EEP303 Electromechanics Laboratory
MAL213 Introduction to Probability Theory and Stochastic Processes

Core credits: 18

Fifth semester

EEL207 Engineering Electromagnetics
EEL209 Power Systems
EEP305 Control Engineering Laboratory
EEP308 Communication Engineering Laboratory

Core credits: 11

Sixth semester

EEP309 Power Systems Laboratory
EEP307 Engineering Electromagnetics Laboratory

Core credits: 3

Summer

IIP201 Summer Industry Internship and Colloquium

Seventh semester

CPP301 Core Project I
IIP201 Summer Industry Internship and Colloquium

Core credits: 6

Eight semester

CPP302 Core Project II

Core credits: 5

8. B.Tech. in Mechanical Engineering

Core Curricular Structure

SCIENCE CORE

1.	PHL103	Classical Mechanics	4	(3-1-0)
2.	MAL111	Mathematics Laboratory	2	(1-0-2)
3.	MAL116	Introduction to Ordinary Differential Equations	3	(3-0-0)
4.	MAL213	Introduction to Probability Theory and Stochastic Processes	3	(3-0-0)
5.	CYL101	Structure, Reactivity and Dynamics	4	(3-1-0)
6.	PHP100	Physics Laboratory	2	(0-0-4)
7.	CYP100	Chemistry Laboratory	2	(0-0-4)
		Science core credits	**20**	**(13-2-10)**

PROGRAMME CORE

1.	MEL101	Continuum Mechanics	4	(3-1-0)
2.	MEL102	Energy Science and Technology	4	(3-1-0)
3.	MEP103	Engineering Communication	2	(0-0-4)
4.	MEL201	Fluid Mechanics	4	(3-1-0)
5.	MEL202	Manufacturing with Metallic Materials	3	(3-0-0)
6.	MEL203	Manufacturing with Non-metallic Materials	3	(3-0-0)
7.	MEL204	Machine Element Design	3	(3-0-0)
8.	MEP205	Product Design and Realization – Intermediate	2	(0-0-4)
9.	MEL301	Heat and Mass Transfer	4	(3-1-0)
10.	MEP302	Manufacturing Laboratory	3	(0-0-6)
11.	MEL303	Theory of Machines	3	(3-0-0)
12.	MEP304	Design Laboratory	2	(0-0-4)
13.	MEP305	Control Engineering Laboratory	1.5	(0-0-3)
14.	MEP401	Thermo-fluids Laboratory	1.5	(0-0-3)
15.	MEL402	Manufacturing Systems	3	(3-0-0)
16.	EEL205	Control Engineering	4	(3-1-0)
	Programme core credits		**47**	**(30-5-24)**

Scheduling of Core Courses (typical)

B.Tech in Mechanical Engineering

First semester

MAL111 Mathematics Laboratory
CYL101 Structure, Reactivity and Dynamics
CYP100 Chemistry Laboratory

Core credits: 8

Second semester

MEL101 Continuum Mechanics
PHL103 Classical Mechanics
MAL116 Introduction to Ordinary Differential Equations
PHP100 Physics Laboratory

Core credits: 13

Third semester

MEL102 Energy Science and Technology
MEL204 Machine Element Design
MEP103 Engineering Communication

Core credits: 10

Fourth semester

MEL201 Fluid Mechanics
EEL205 Control Engineering
MEP205 Product Design and Realization – Intermediate

Core credits: 10

Fifth semester

MEL301 Heat and Mass Transfer
MEL202 Manufacturing with Metallic Materials
MEL303 Theory of Machines
MEP305 Control Engineering Laboratory

Core credits: 10

Sixth semester

MEP401 Thermo-fluids Laboratory
MEP304 Design Laboratory
MEL203 Manufacturing with Non-metallic Materials

Core credits: 6.5

Summer

IIP201 Summer Industry Internship and Colloquium

Seventh semester

MEP302 Manufacturing Laboratory
MEL402 Manufacturing Systems
CPP301 Core Project I
IIP201 Summer Industry Internship and Colloquium

Core credits: 12

Eighth semester

CPP302 Core Project II

Core credits: 5

9. Scheduling of Sciences and General Engineering Courses

Monsoon semester

CYP100	Chemistry Laboratory
GEL101	Product Design and Realization – I
GEL102	Materials Science and Engineering
GEL104	Principles of Electrical Engineering
MAL111	Mathematics Laboratory
MAL112	Advanced Calculus
MAL115	Real Analysis
PHP100	Physics Laboratory
PHL101	Electromagnetics
PHL103	Classical Mechanics

Winter semester

CYP100	Chemistry Laboratory
GEL101	Product Design and Realization – I
GEL102	Materials Science and Engineering
GEL103	Introduction to Computing
GEL104	Principles of Electrical Engineering
MAL114	Linear Algebra
MAL213	Introduction to Probability Theory and Stochastic Processes
PHP100	Physics Laboratory
PHL102	Quantum Physics
PHL104	Optics and Lasers

10. ANNEXURE

Comparison with IIT Delhi Curriculum

		Credits with no. of courses in brackets	
		IIT Ropar	**IIT Delhi**
Sciences		28	20 – 24 (BS)
General Engineering		16	20 – 24 (EAS)
Programme core (Excl. BTP, Colloq, Intro to Prog)	CS	45 (9)	49 (10)
	EE	46.5 (9)	54 (10)
	ME	47 (10)	51 (10)
Programme elective	CS	21	24
	EE	19.5	21
	ME	19	24
Humanities and Social Sciences		20	15
Core Project		8	10-12
Core Industry Internship and Colloquium		3	3