COURSES OF STUDY

June 2025

(Applicable for 2023 Batch onwards)

Indian Institute of Technology Bhilai

Contents

Terms Used

Undergraduate	A first-level degree program offered by the Institute.
Postgraduate	Degree programs offered by the Institute beyond the first-level.
Academic Program *aka* Program	The degree programs offered by the Institute, including undergraduate, postgraduate and research programs.
Academic Senate *aka* Senate	The Institute authority responsible for the promotion and maintenance of standards of research, instruction, education and examination. The senate carries out all decision making towards the academic and related activities.
Academic Year	An academic year starts in the month of July each calendar year and ends in the month of June of the next calendar year.
Semester	Each academic year (July-June) comprises of three semesters – 2 regular semesters (Monsoon and Winter) and a Summer semester.
Monsoon Semester	A semester normally starting in the fourth week of July and continuing until the first week of December.
Winter Semester	A semester normally starting in the fourth week of December and continuing until the first week of May of the next calendar year.
Summer Semester	A semester normally starting in the second week of May and continuing until the second week of July.
DUGC	Discipline Undergraduate Committee.
DPGC	Discipline Postgraduate Committee.
Department	Department is an administrative unit having one or more disciplines
Discipline	Discipline is an academic unit offering two or more programs (undergraduate &/or postgraduate programs)
Grade	A letter e.g. ‘A’, ‘B’, etc. to indicate the performance of the students. Grades are awarded by the instructor in-charge of the course/thesis for the student. Each grade carries associated numeric points.

CGPA	Cumulative Grade Point Average. A weighted average of numeric points obtained in the courses cleared by a student.
SGPA	Semester Grade Point Average. A weighted average of numeric points obtained in the courses within a semester cleared by a student.
Credit	The numeric value associated with courses to indicate the load for a course.
Institute Core (IC) courses	Institute shall specify a mandatory set of courses that every student must register for and pass.
Program Linked (PL) courses	PL courses are those courses which link basic (IC) courses and program core courses. A discipline may specify a set of courses for each program that every student of specific discipline in the program must register for and pass.
Program core (PC) courses	A discipline shall specify a set of courses for each program that every student of the discipline in the program must register for and must pass.
Program elective (PE) courses	A bouquet of courses offered by the discipline out of which the students must choose to register in order to fulfil the requirements of the program and must pass. Discipline may also declare some specific courses offered by other discipline a-priori as program elective courses. Discipline shall specify the total number of credits that should be cleared with program elective courses.
Open elective (OE) courses	A bouquet of courses offered by various disciplines of the institute which the students must choose to register from his/her own discipline or from any other discipline and clear. Open electives are meant to widen the knowledge beyond the parent discipline and broaden the horizon by exposing the problems/areas in other disciplines. Disciplines shall specify the credits that should be earned with open elective courses.
Liberal Arts (LA) courses	The Institute believes in a well-rounded development of its students. To that extent, Institute specifies program-wise credits to be earned by students amongst a bouquet of courses in Liberal Arts.

Scope

The provisions of this *course of study* are applicable to all programs and disciplines. The academic Senate may change any or all parts of this *course of study* at any time. The academic Senate may also authorize Dean of Academic Affairs to change any or all parts of this course of study.

1. INTRODUCTION

1.1 Background

IIT Bhilai offers a semester-oriented undergraduate, postgraduate and research programs with an objective of imparting best quality science and engineering education. Admissions to the academic programs are synchronized with an academic year, though in some cases, it may be synchronized to the start of a semester. An academic year starts in the month of July each calendar year and ends in the month of June of the next calendar year. Each academic year is divided into three semesters – Monsoon, Winter and Summer semesters. The Monsoon and Winter semesters are two regular semesters. The Summer semester is a shorter semester and only applicable for BTech and MSc programs. IIT Bhilai is currently offering Bachelor of Technology (BTech), Master of Science (MSc), Master of Technology (MTech) and Doctor of Philosophy (PhD) programs in various disciplines. *The medium of instruction in both theory and practical classes of the BTech, MSc, MTech and PhD programs is English.* This document provides the curricula of all programs at IIT Bhilai along with the list of courses as on date.

1.2 Disciplines

Any program and course are offered by an Academic Unit or discipline. The names of disciplines, associated department(s) and their discipline codes are given in Table 1.

Table 1: Academic Disciplines

S. No.	Discipline	Associated with department(s) of	Discipline code
1.	Bioscience and Biomedical Engineering	Bioscience and Biomedical Engineering	BM
2.	Chemistry	Chemistry	CY
3.	Computer Science and Engineering	Computer Science and Engineering	CS
4.	Data Science and Artificial Intelligence	Computer Science and Engineering	DS
5.	Electric Vehicle Technology	Electrical Engineering	EV
6.	Electrical Engineering	Electrical Engineering	EE
7.	Electronics and Communication Engineering	Electronics and Communication Engineering	EC
8.	Liberal Arts	Liberal Arts	LA

9.	Materials Science and Metallurgical Engineering	Materials Science and Metallurgical Engineering	MM
10.	Mathematics	Mathematics	MA
11.	Mechanical Engineering	Mechanical Engineering	ME
12.	Mechatronics Engineering	Mechatronics Engineering	MT
13.	Physics	Physics	PH

1.3 Programs Offered

IIT Bhilai offers various academic programs for students with different backgrounds. Admission to many of these programs are based on performance in national level tests/entrance examinations. The programs offered by IIT Bhilai are currently classified as Undergraduate (UG) and Postgraduate (PG) programs. Various degree programs offered by the Institute are listed below.

Table 2: Programs offered

Program	**Offered in**	**Offered by department(s)**
Bachelor of Technology (BTech)	Computer Science and Engineering	Computer Science and Engineering
	Data Science and Artificial Intelligence	
	Electrical Engineering	Electrical Engineering
	Electronics & Communication Engineering	Electronics & Communication Engineering
	Materials Science and Metallurgical Engineering	Materials Science and Metallurgical Engineering
	Mechanical Engineering	Mechanical Engineering
	Mechatronics Engineering	Mechatronics Engineering
Master of Science (MSc)	Chemistry	Chemistry
	Mathematics and computing	Mathematics
	Physics	Physics
Master of Technology (MTech)	Bioengineering	Bioscience and Biomedical Engineering
	Biomedical Devices	
	Computer Science and Engineering	Computer Science and Engineering
	Data Science and Artificial Intelligence	
	Electronics & Communication Engineering	Electronics & Communication Engineering
	Microelectronics and VLSI	
	Control and Instrumentation	Electrical Engineering
	Power Systems and Power Electronics	

	Electric Vehicle Technology	
	Materials Science and Metallurgical Engineering	Materials Science and Metallurgical Engineering
	Design and Manufacturing	Mechanical Engineering
	Thermal and Fluids Engineering	
	Mechatronics Engineering	Mechatronics Engineering
Doctor of Philosophy (PhD)	Bioscience and Biomedical Engineering	Bioscience and Biomedical Engineering
	Chemistry	Chemistry
	Computer Science and Engineering	Computer Science and Engineering
	Data Science and Artificial Intelligence	
	Electrical Engineering	Electrical Engineering
	Electric Vehicle Technology	
	Electronics & Communication Engineering	Electronics & Communication Engineering
	Liberal Arts	Liberal Arts
	Materials Science and Metallurgical Engineering	Materials Science and Metallurgical Engineering
	Mathematics	Mathematics
	Mechanical Engineering	Mechanical Engineering
	Mechatronics Engineering	Mechatronics Engineering
	Physics	Physics

The admissions are carried out in Bachelor of Technology (BTech) program, Master of Science (MSc) program, Master of Technology (MTech) program and Doctor of Philosophy (PhD) program. A BTech student may also opt to convert his program to BTech-MTech dual degree program. If the conversion is permitted by the Institute, the student shall get two degrees after successful completion of MTech program requirements. A student of an MSc or MTech program shall also be eligible for conversion to the MSc/MTech-PhD dual degree program. If the conversion is permitted by the Institute, the student shall get PhD degree as well as MTech or MSc degree after successful completion of program requirements. A student of BTech program whose program is converted to MTech program will also be eligible for conversion to PhD program.

2. COURSE STRUCTURE AND CREDIT SYSTEM

2.1 Description of Course Content

Course content description consists of following components: (i) Course code, (ii) Title of the course, (iii) L-T-P-C (Lecture, tutorial, practical and credits), (iv) Pre-requisite(s) and (v) overlapping courses, if any, and (v) List of broad topics covered in the course. Course content of all Institute courses are given towards the end of this document.

2.1.1 Category of courses

The course classification at IIT Bhilai is specific to the program and is categorized under the following broad categories.

1. **Institute core (IC) courses:** A set of courses that every student of an undergraduate program at IIT Bhilai must register for and pass.
2. **Program linked (PL) courses:** A set of courses which link basic (IC) courses and program core courses. A discipline may specify a set of courses for each program that every student of specific discipline in the program must register for and pass.
3. **Program core (PC) courses**: For a program, the discipline may specify a set of courses that every student of the specific discipline must register for and pass.
4. **Program elective (PE) courses:** A bouquet of courses declared by the discipline out of which students must register for and pass specified minimum number of credits to fulfil the program requirements.
5. **Open elective (OE) courses:** A bouquet of courses offered by various disciplines of the institute, out of which the students must choose to register for and pass a number of courses to meet the minimum specified OE credit requirements for a program. Open electives courses are meant to widen the knowledge beyond the parent discipline and broaden the horizon by exposing the problems/areas in other disciplines. MSc, MTech and PhD students cannot take LA courses as open elective.
6. **Liberal Art (LA) courses:** The Institute believes in a well-rounded development of its students. To that extent, the Institute specifies a minimum number of credits to be earned by students amongst a bouquet of courses in Liberal Arts.
7. **Non-graded core (NC) courses:** These are mandatory requirements and can be earned through formal academic activity and informal co-curricular or extra-curricular activities.

2.1.2 Course numbering scheme

Each course is denoted by a unique code consisting of three alphabets followed

by three numerals:

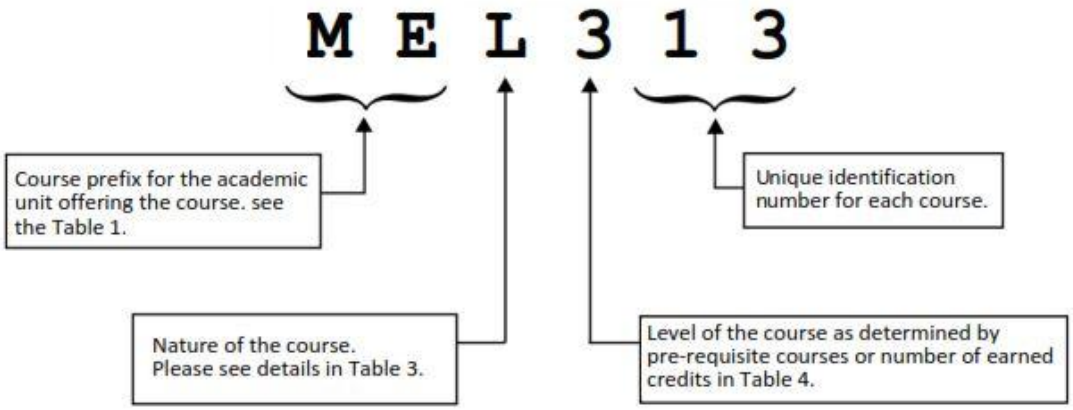

Table 3: Codes defining nature of the course

D	Courses involving demonstration and/or discussion during lectures and involves presentation/project-based evaluation
L	Lecture based courses (L-T-P structures of lecture-based courses are primarily dominated by Lecture and Tutorial components) and primarily evaluation is based on written exams
P	Practical/practice-based courses (all the lab courses, courses which contains major components of hands-on etc.; L-T-P structure is dominated by practical sessions)
Q	Project based courses (minor/major project, BTech/MSc project or independent project)
T	Thesis based courses
N	Non-graded courses
V[#]	Lectures courses on special topics by external experts or NPTEL courses (at most 1-2 credits)

[#] *These courses shall run for duration not less than 1 month. BTech students can take such courses maximum of 6 credits during the entire program.*

Table 4: Level of course

Level	**Description**
100-400	Core and elective courses for UG programs
400-600	Core courses for MSc Programs (500 and 600 level courses may be opened for 3rd and final year BTech students as elective courses only)
500-700	Courses for MTech program (700 may be opened for final year BTech students and MSc as elective courses only)
500-800	Courses for PhD programs

2.1.3 Assignment of Credits to Courses

Every course at IIT Bhilai conventionally runs for the entire semester (~ 14 weeks in case of a regular semester). Only exception is for V-type courses which may run for part of the semester. A student registers for the courses that he/she wants to study and at the end of the semester a grade is awarded. On obtaining a pass grade, the student earns all the credits associated with the course while a fail grade does not get any credit. Partial credits are not awarded.

Each course has a certain number of credit(s) or non-graded unit(s) assigned to it depending upon the L-T-P structure of the course. Accordingly, L-T-P-C structure of each course (except thesis-based courses) is defined where L denotes lectures per week (in hours), T denotes tutorials per week (in hours), P denotes practical/lab/practice sessions per week (in hours) and C denotes total credits associated with the course. Credits are assigned to a course with specified L-T-P as follows:

L :	If a course involves 1 lecture hour (50-55 mins) per week and runs for 14 weeks, 1 credit will be assigned to the course
T :	If a course involves 1 tutorial hour (50-55 mins) per week and runs for 14 weeks, 1 credit will be assigned to the course
P :	If a course involves 2 practical/practice/lab hour (2 hours) per week and runs for 14 weeks, 1 credit will be assigned to the course

Credit assignment explained above can be understood well from following examples showing courses and associated L-T-P-C structure:

MEyxxx (L-T-P-C: 3-0-0-3) or CSyxxx (L-T-P-C: 3-1-0-4) or

PHyxxx (L-T-P-C: 0-0-2-1) or EEyxxx (L-T-P-C: 0-1-4-3)

2.1.4 Pre-requisite(s)

Each course, other than 100 level courses, may have specified pre-requisite(s) in terms of other course(s). A student who has obtained F grade in the pre-requisite(s) specified will not be eligible to register for the course. For example:

MEL612 Conduction and Radiation Heat Transfer

3 Credits (3-0-0)

Pre-requisite(s): MEL313 or equivalent

A student who has obtained a grade other than F grade in MEL313 will be eligible to register for this course.

2.1.5 Overlapping/Equivalent Courses

Wherever applicable, overlapping, and equivalent courses have been identified for each course. A student is not permitted to earn credits by registering for a course having more than 25% overlap with other approved courses which is already

credited by the student. For example:

MEL304 Applied Numerical Methods
3.0 Credits (3-0-0)
Pre-requisite(s): Nil
Overlap with: MAL101 (10%)

If a course (course *X*) has more than 25% overlapping content with another course (course *Y*) which is already credited by the student, then a student is not eligible to register for the course (course *X*).

2.2 Credit System

Semester-based credit system of study is followed at IIT Bhilai. A registered student is allowed to attend classes of the registered courses and earn credit for the registered courses.

2.2.1 Earning Credit

At the end of every semester, a grade is awarded by the course instructor of each course in which a student has registered. On obtaining a pass grade (other than F grade), the student accumulates the course credits as earned credits. The credits earned for the course or thesis are valid for up to seven years only (irrespective of whether the student was on leave or not) and shall not be counted towards the requirements of the degree if they are acquired earlier than seven years or more. The credits earned more than seven years back are deemed expired and must be earned again. A student has the option of auditing some courses. Grades obtained in audit courses are not counted for computing SGPA/CGPA although the grade earned by the student is reflected in the grade card or transcript. However, a pass grade (other than F grade) is essential for completing an audit course.

2.2.2 Grading System

Depending upon the performance of the students, the course instructor, shall award a grade to the student. Each grade carries associated numeric points as given below.

Grades for Regular Courses

A+	A	A–	B	B–	C	C–	D	F	FS	I
10	10	9	8	7	6	5	4	0	0	0

Grades for Non-graded courses

S	X

Grades for Thesis (PhD Thesis) and Candidacy

S	X

Grades for Thesis (other than PhD Thesis)

A	A–	B	B–	C	F
10	9	8	7	6	0

The course is said to be passed if the student receives a grade other than F, FS, I or X.

All students shall appear in all examinations (including the mid-semester and end-semester examinations). Failure to appear in any examination will cause 0 (zero) marks to be awarded in that examination and the grading to be carried out accordingly. A student who fails to appear in any written examination (mid-semester or end-semester examination) due to genuine medical or unavoidable reasons may be permitted by the course instructor to take make-up examination subject to certification by the Institute doctor on the severity of the medical condition. The student should make a request for this purpose supported by all documents. Such a request shall reach the course instructor within two days of last date of mid-semester examination or end-semester examination (whichever exam is missed by the student). In exceptional circumstances, course instructors may also allow students to appear in the make-up examination to provide them with an additional chance to improve their performance. Students who are permitted to appear in the make-up examination shall be awarded FS grade. If the student fails to appear in the make-up examination as per the academic calendar, the FS grade is converted to regular grade. The make-up examination shall be used to substitute the marks of the examination missed by the student and the grading shall be carried out by the instructor as per the regular class grading.

F or X grade is given by the course instructor when he/she is convinced that the student must repeat the course, including all lectures, labs, examinations etc. The student must repeat the course if it is not a PE or OE course. For PE or OE courses, the student can replace the course with another course of the same category.

I grade is given by the course instructor when the student fails to complete the course and will require some extra time to finish the project work or assignment. I grade must be converted to a regular grade within one week of the end of the semester (last day of the end-semester examination). An unconverted I grade is automatically converted to F grade.

S grade is given by the course instructor when he/she is convinced that the performance of the student is satisfactory in the thesis or non-graded core courses.

Students shall be awarded regular grades (A+, A, A-, B, B-, C, C-, D, F) in the audited courses and the same shall be reflected in the grade card or transcript of the student. However, grades of the audited courses shall not be considered in the SGPA/CGPA calculation.

2.2.3 Evaluation System

IIT Bhilai supports continuous evaluation of performance of students in various courses. Course instructor of a course is responsible for conducting written examinations, surprised/announced quizzes, home assignments, project works, lab assignments, presentations, interviews, oral examinations or any other method of evaluation. The weightage for each of these components shall be announced by the course instructor a-priori. Among such examination methods, the formal written examinations (mid-semester and end-semester examinations) shall be carried out as per the academic calendar of the Institute. The course instructor may choose the method of evaluation depending upon the nature of the course and shall make it known to the class in the beginning.

The academic calendar of the Institute shall reserve slots for mid-semester and end-semester examinations. The examinations shall be carried out only during this schedule.

2.2.4 Evaluation of Performance

The performance of a student will be evaluated in terms of two indices, viz., the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. The SGPA is a weighted sum of the associated numeric points earned by the student for each course registered in a particular semester with weights being the credit of the course. CGPA is the weighted sum of all courses in the program. The academic performance of a student is typically indicated by SGPA and CGPA.
For example, if the courses and corresponding credits registered for by a student in a semester and the numeric points obtained (corresponding to the grades) are as per the given table, the SGPA shall be computed as per the given formula.

Sl No.	Course	Credits registered	Numeric Points obtained for the corresponding grade.
1	Course Title 1	C_1	N_1
2	Course Title 2	C_2	N_2
3	Course Title 3	C_3	N_3
4	Course Title 4	C_4	N_4
5	Course Title 5	C_5	N_5

$$\text{SGPA} = \frac{C_1N_1 + C_2N_2 + C_3N_3 + C_4N_4 + C_5N_5}{C_1 + C_2 + C_3 + C_4 + C_5}$$

CGPA is computed in a similar way except that the courses are taken across all semesters. While computing SGPA and CGPA, the rules of repetition of courses are followed.
The institute award CGPA on a scale of 10 (Ten) after the assessment of the

students. The institute does not offer any formula for the conversion of CGPA to percentage or any other scale. However, wherever percentage is the norm, the CGPA of all IIT Bhilai graduates be notionally converted into percentage by multiplying the CGPA by a factor of 10 (Ten). For the purpose of employment or requirement of any external body, IIT Bhilai graduate having 6 (Six) CGPA and above be taken as First Class.

2.2.5 Course Instructor and Course Coordinator

Every course is taught by one faculty member (sometime more than one faculty member) of a discipline. This faculty member is designated as the Course instructor. Course instructor has the full responsibility for conducting the course, coordinating the work of teaching assistants involved in that course, administering assignments, conducting and evaluating the quizzes/examinations as well as moderating and awarding the grades. If there are more than one faculty member teaching a course in a semester, one of the course instructors is designated as Course coordinator. Course coordinator has the full responsibility for coordinating the work of other members of the faculty and teaching assistants involved in that course, administering assignments, conducting and evaluating the quizzes/examinations as well as moderating and awarding the grades. For any difficulty related to a course, students are expected to approach the respective course instructor for advice and clarification. The distribution of the weightage for written examinations, quizzes, assignments, laboratory work, workshop and drawing assignment, term paper, etc. that will be the basis for award of grade in a course will be decided by the course coordinator of that course, in consultation with all the course instructors involved, and announced at the beginning of the semester.

3. PROGRAM REQUIREMENTS AND GENERAL STRUCTURE

3.1 BTech Program

BTech program at IIT Bhilai is a fully residential program with a nominal duration of 4 years (i.e., 8 semesters). Accordingly, the minimum credit requirements for students in various categories of courses to become eligible for the award of BTech Degree from IIT Bhilai is as follows.

S. No	Category	Credits
1	Institute core (IC) courses	40.5
2	Program linked (PL) courses	3 to 7
3	Program core (PC) courses	46.5 to 57.5
4	Program elective (PE) courses	21 to 25
5	Open elective (OE) Courses	15

6	Liberal art (LA) courses	10
7	Non-graded core (NC) courses	12 units
Total Credits (Minimum requirement)		**144 + 12 non-graded core units**

Credit requirements for various categories of courses (PC, PL, and PE courses) can be different for different BTech programs. Program specific requirements can be seen in later sections.

Non-graded core (NC) courses: Non-graded core (NC) courses have been prescribed as core requirements for the BTech degree program. These units can be earned through a combination of formal academic activity and informal co-curricular or extra-curricular activities. 1 unit implies total involvement of about 14 hours. Following non-graded core courses are mandatory to become eligible for the award of BTech Degree from IIT Bhilai:

S. No.	Course code	Course Title	Units
1.	LAN102	Speaking and Writing Skills	2 units
2.	LAN103	Professional ethics	1 unit
3.	NCN100	Practices for Comprehensive wellbeing	1 unit
4	NCN101/ NCN102	National Service Scheme/National Sports Organization	8 units
Total			**12 units**

A student must get S grades to earn these units. Incomplete performance in these components will be indicated by a X grade. A brief description of the four non-graded core courses is given below.

(a) Speaking and Writing Skills (LAN102) (2 units)

This learner-centric course is specially designed for students who need additional attention to improve their speaking and writing skills. The course will run primarily in workshop mode, with intensive teacher-student interaction and recurring classroom activities. It will aim to instil confidence in students about their latent English language competencies with specific reference to speaking and writing, and to acquaint them with workable ways of transitioning towards gaining proficiency in the same. Instructor can conduct an English communication exam at the beginning of the first semester to judge skills of the students. Attending the entire course (LAN102) can be waived off for students passing an English communication exam conducted at the beginning of the first semester.

(b) Professional ethics (LAN103) (1 unit)

This course offers an understanding of the basic theories of ethics as well as the relevance of their application in professional environments. The course will engage with notions such as code of conduct, work ethics, research ethics, ethical

decision making, and social responsibility as professionals. Its aim is to equip students to critically reflect on and apply ethical reasoning to decision-making in the workplace.

(c) Practices for Comprehensive Wellbeing (NCN100) (1 unit)
The course aims at the development of a healthy and balanced lifestyle in students through regular practice of sports, yoga and meditation.
(d) NSS/NSO (NCN101/NCN102) (8 unit)
Students have to spend a minimum of 120 hours in the National Service Scheme (NSS) or National Sports Organization (NSO) activities and earn 8 units. Students are encouraged to complete NSS/NSO units within the first four semesters.

National Service Scheme (NCN101) (8 unit)
The NSS course proposal at IIT Bhilai aims to cultivate responsible citizens through community service. The course objectives include creating awareness, fostering responsibility and empathy, developing essential skills for community engagement, promoting active participation, and fostering collaborations with NGOs. By the end of the course, students will understand the principles of community service, identify community needs, plan and organize events effectively, demonstrate communication and leadership skills, collaborate in teams, evaluate impact, and develop a lifelong commitment to social responsibility. They will gain practical experience in healthcare, teaching, social awareness, and environmental initiatives. By engaging with local NGOs, students will contribute to society while enhancing personal and professional growth. Ultimately, this course aims to inspire students to become agents of positive change and make a meaningful difference in their communities.

National Sports Organization (NCN102) (8 unit)
The course aims for regular involvement of the students in sports and physical activity leading to a healthy and balanced lifestyle. This also nurtures the sports talents in the institute.

3.2 MSc program

The MSc program offered at IIT Bhilai is a fully residential program with a nominal duration of 2 years (i.e., 4 semesters). Accordingly, the minimum credit requirements for students in various categories of courses to become eligible for the award of MSc Degree from IIT Bhilai is as follows.

Course Category	Credits
Program core (PC) courses	33 to 48
Program elective (PE) courses	3 to 15

Project/Program elective (PE)/Open elective (OE) courses	0 to 18
Thesis	0 to 24
Minimum Credit Requirement	**72**

Credit requirements for various categories of courses can be different for different MSc programs. Program specific requirements can be seen in later sections.

3.3 MTech Program

MTech program in IIT Bhilai had a nominal duration of two years (i.e., 4 regular semesters) with a minimum residential requirement of two regular semesters. The minimum credit requirements for students in various categories of courses for the award of MTech Degree from IIT Bhilai is provided in the following table.

Course Category	Credits
Program core (PC) courses	12 to 15
Program elective (PE) courses	9 to 12
Program elective (PE)/Open elective (OE) courses	0 to 3
Thesis/ Program elective (PE)/Open elective (OE) courses	3 to 9
Thesis	24
Minimum Credit Requirement	**54**

Credit requirements for various categories of courses can be different for different MTech programs. Program specific requirements can be seen in later sections.

3.4 PhD Program

Candidates are admitted to PhD program in IIT Bhilai either after completion of Undergraduate (UG) or Postgraduate (PG) program subject to fulfilling the other eligibility criteria defined by the Institute. The minimum credit requirements for students in various categories of courses for the award of PhD Degree from IIT Bhilai is provided in the following tables:

3.4.1 PhD (Engineering discipline)

Course Category	Minimum Credits (Students with	Minimum Credits (Students with UG degree in

	PG degree in Engineering)	Engineering or PG in Science)
Program elective (PE) courses	-	12
Program elective (PE)/Open elective (OE) courses	12	12
Thesis/Program elective (PE)/Open elective (OE) courses	06	06
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

3.4.2 PhD (Science or Liberal Arts discipline)

Course Category	Minimum Credits (Students with PG degree in Science/LA or UG/PG in Engineering)
Program elective (PE)/Open elective (OE) courses	12
Thesis	60
Minimum Credit Requirement	**72**

Credit requirements for various categories of courses can be different for different PhD programs. However, nominal load for the full-time and part-time PhD students shall be 12 and 9 credits respectively. Also, PhD students can be permitted to register for thesis from second semester onwards. Program specific requirements can be seen in later sections.

Course Curriculum
(BTech Programs)

BTech in Computer Science and Engineering

Course category	Minimum credits
Institute core (IC) courses	40.5
Program linked (PL) courses	4
Program core (PC) courses	52
Program elective (PE) courses	22.5
Open elective (OE) Courses	15
Liberal art (LA) courses	10
Non-graded core (NC) courses	**12 units**
Minimum credit requirement	**144 + 12 non-graded core units**

Institute core (IC) courses

Course code	Course Name	L-T-P-C
BML101	Biology for Engineers	3-0-0-3
CYL100	Applied Chemistry	3-0-0-3
CYP102	Chemistry lab	0-0-3-1.5
PHP102	Physics lab	0-0-3-1.5
PHL101	Physics for Engineers	3-1-0-4
MAL100	Mathematics-I	3-1-0-4
MAL101	Mathematics-II	3-1-0-4
CSL100	Introduction to programming	2-1-3-4.5
MEP102	Digital fabrication	1-0.5-3-3
CYL101	Environmental Science	1-0-0-1
EEL101	Basic Electrical Engineering	3-0-2-4
ECL101	Basic Electronics Engineering	3-0-2-4
LAL100	Introduction to Communication Skills	1-1-0-2
LAL101	Introduction to Finance	1-0-0-1

Program linked (PL) Courses

MAL403	Probability & Statistics	3-1-0-4

Program core (PC) courses

CSP203	Software Tools & Technologies Lab	1-0-4-3
CSL201	Discrete Mathematics	3-1-0-4
CSL202	Data Structures	2-1-2-4
CSL252	Design and Analysis of Algorithms	3-1-0-4
CSL253	Theory of Computation	3-1-0-4
CSL301	Operating Systems	3-0-2-4
	Compiler Design	3-0-2-4
CSL303	Database Management Systems	3-0-2-4
CSL251	Computer Organization and Architecture	3-0-2-4
CSL351	Computer Networks	3-0-2-4
CSL304	Artificial Intelligence	3-0-2-4
CSQ401	BTech Project-I	0-0-6-3
CSQ402	BTech Project-II	0-0-6-3
UGQ301	Interdisciplinary Undergraduate Project	0-0-6-3

BTech in Computer Science and Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Course-7	Credits
I	**CSL100**	**CYP102 / PHP102**	**MAL100**	**CYL100**	**PHL101**	**CYL101**	**NCN100**	18
	Introduction to programming	Chemistry lab/ Physics lab	Mathematics-I	Applied Chemistry	Physics for Engineers	Environmental Science	Practices for Comprehensive wellbeing	
	2-1-3-4.5	**0-0-3-1.5**	**3-1-0-4**	**3-0-0-3**	**3-1-0-4**	**1-0-0-1**	**-**	
II	**MEP102**	**EEL101**	**PHP102 / CYP102**	**MAL101**	**ECL101**	**BML101**	**LAN103**	19.5
	Digital fabrication	Basic Electrical Engineering	Physics lab/ Chemistry lab	Mathematics-II	Basic Electronics Engineering	Biology for Engineers	Professional Ethics	
	1-0.5-3-3	**3-0-2-4**	**0-0-3-1.5**	**3-1-0-4**	**3-0-2-4**	**3-0-0-3**	**-**	
III	**MAL403**	**CSL201**	**CSL202**	**CSP203**	**LAL100**			19
	Probability and Statistics	Discrete Mathematics	Data Structures	Software Tool & Technologies Lab	Introduction to Communication Skills	LA Courses		
	3-1-0-4	**3-1-0-4**	**2-1-2-4**	**1-0-4-3**	**1-1-0-2**	**X-X-X-2**		
IV	**CSL251**	**CSL252**	**CSL253**	**LAL101**				17
	Computer Organization and Architecture	Design and Analysis of Algorithms	Theory of Computation	Introduction to Finance	LA Courses			
	3-0-2-4	**3-1-0-4**	**3-1-0-4**	**1-0-0-1**	**X-X-X-4**			
V	**CSL301**	**CSL302**	**CSL303**	**CSL304**				18
	Operating Systems	Compiler Design	Database Management Systems	Artificial Intelligence	LA Courses			
	3-0-2-4	**3-0-2-4**	**3-0-2-4**	**3-0-2-4**	**X-X-X-2**			
VI	**CSL351**	**CSLXXX**		**UGQ301**				18
	Computer Networks	PE	OE	Interdisciplinary Undergraduate Project	LA Courses			
	3-0-2-4	**X-X-X-6**	**X-X-X-3**	**0-0-6-3**	**X-X-X-2**			
VII	**CSQ401**	**CSLXXX**						17.5
	BTech Project-I	PE	OE					
	0-0-6-3	**X-X-X-8.5**	**X-X-X-6**					
VIII	**CSQ402**	**CSLXXX**						17
	BTech Project-II	PE	OE					
	0-0-6-3	**X-X-X-8**	**X-X-X-6**					

BTech in Data Science and Artificial Intelligence

Course category	Minimum credits
Institute core (IC) courses	40.5
Program linked (PL) courses	4
Program core (PC) courses	51.5
Program elective (PE) courses	23
Open elective (OE) Courses	15
Liberal art (LA) courses	10
Non-graded core (NC) courses	**12 units**
Minimum credit requirement	**144 + 12 non-graded core units**

Institute core (IC) courses

Course code	Course Name	L-T-P-C
BML101	Biology for Engineers	3-0-0-3
CYL100	Applied Chemistry	3-0-0-3
CYP102	Chemistry lab	0-0-3-1.5
PHP102	Physics lab	0-0-3-1.5
PHL101	Physics for Engineers	3-1-0-4
MAL100	Mathematics-I	3-1-0-4
MAL101	Mathematics-II	3-1-0-4
CSL100	Introduction to programming	2-1-3-4.5
MEP102	Digital fabrication	1-0.5-3-3
CYL101	Environmental Science	1-0-0-1
EEL101	Basic Electrical Engineering	3-0-2-4
ECL101	Basic Electronics Engineering	3-0-2-4
LAL100	Introduction to Communication Skills	1-1-0-2
LAL101	Introduction to Finance	1-0-0-1

Program linked (PL) Courses

MAL403	Probability & Statistics	3-1-0-4

Program core (PC) courses

CSL201	Discrete Mathematics	3-1-0-4
CSL202	Data Structures	2-1-2-4
CSL252	Design and Analysis of Algorithms	3-1-0-4
CSL303	Database Management Systems	3-0-2-4
DSL201	Mathematical Foundations for Data Science	3-1-0-4
DSL251	Data Analytics and Visualization	3-0-0-3
DSP252	Data Analytics and Visualization Lab	0-0-2-1
DSL351	Bigdata Analytics	3-0-0-3
DSP352	Bigdata Analytics Lab	0-0-2-1
DSL253	Statistical Programming	1-0-2-2
CSL304	Artificial Intelligence	3-0-2-4
CSL251	Computer Organization and Architecture	3-0-2-4
DSP301	AI and ML Lab	0-0-3-1.5
DSL353	Information Security	2-0-2-3
DSQ401	BTech Project-I	0-0-6-3
DSQ402	BTech Project-II	0-0-6-3
UGQ301	Interdisciplinary Undergraduate Project	0-0-6-3

BTech in Data Science and Artificial Intelligence

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Course-7	Credits
I	**CSL100**	**CYP102 / PHP102**	**MAL100**	**CYL100**	**PHL101**	**CYL101**	**NCN100**	18
	Introduction to programming	Chemistry lab/ Physics lab	Mathematics-I	Applied Chemistry	Physics for Engineers	Environmental Science	Practices for Comprehensive wellbeing	
	2-1-3-4.5	**0-0-3-1.5**	**3-1-0-4**	**3-0-0-3**	**3-1-0-4**	**1-0-0-1**	**-**	
II	**MEP102**	**EEL101**	**PHP102 / CYP102**	**MAL101**	**ECL101**	**BML101**	**LAN103**	19.5
	Digital fabrication	Basic Electrical Engineering	Physics lab/ Chemistry lab	Mathematics-II	Basic Electronics Engineering	Biology for Engineers	Professional Ethics	
	1-0.5-3-3	**3-0-2-4**	**0-0-3-1.5**	**3-1-0-4**	**3-0-2-4**	**3-0-0-3**	**-**	
III	**MAL403**	**CSL201**	**CSL202**	**DSL201**	**LAL100**			19
	Probability and Statistics	Discrete Mathematics	Data Structures	Mathematical Foundations for Data Science	Introduction to Communication Skills	LA Courses		
	3-1-0-4	**3-1-0-4**	**2-1-2-4**	**3-1-0-4**	**1-1-0-2**	**X-X-X-1**		
IV	**CSL251**	**CSL252**	**DSL251**	**DSP252**	**DSL253**	**LAL101**		18
	Computer Organization and Architecture	Design and Analysis of Algorithms	Data Analytics and Visualization	Data Analytics and Visualization Lab	Statistical Programming	Introduction to Finance	LA Courses	
	3-0-2-4	**3-1-0-4**	**3-0-0-3**	**0-0-2-1**	**1-0-2-2**	**1-0-0-1**	**X-X-X-3**	
V	**DSP301**	**CSL303**	**CSL304**					18.5
	AI and ML Lab	Database Management Systems	Artificial Intelligence	PE	LA Courses			
	0-0-3-1.5	**3-0-2-4**	**3-0-2-4**	**X-X-X-7**	**X-X-X-2**			
VI	**DSL351**	**DSP352**	**DSP353**	**DSQ401**	**UGQ301**			18
	Bigdata Analytics	Big Data Analytics Lab	Information Security	BTech Project-I	Interdisciplinary Undergraduate Project	PE	LA Courses	
	3-0-0-3	**0-0-2-1**	**3-0-0-3**	**0-0-6-3**	**0-0-6-3**	**X-X-X-3**	**X-X-X-2**	
VII	**DSQ402**							17
	BTech Project-II	PE	OE					
	0-0-6-3	**X-X-X-8**	**X-X-X-6**					
VIII								17
	PE	OE	LA Courses					
	X-X-X-5	**X-X-X-9**	**X-X-X-3**					

BTech in Electrical Engineering

Course category	Minimum credits
Institute core (IC) courses	40.5
Program linked (PL) courses	3
Program core (PC) courses	51.5
Program elective (PE) courses	24
Open elective (OE) Courses	15
Liberal art (LA) courses	10
Non-graded core (NC) courses	**12 units**
Minimum credit requirement	**144 + 12 non-graded core units**

Institute core (IC) courses

Course code	Course Name	L-T-P-C
BML101	Biology for Engineers	3-0-0-3
CYL100	Applied Chemistry	3-0-0-3
CYP102	Chemistry lab	0-0-3-1.5
PHP102	Physics lab	0-0-3-1.5
PHL101	Physics for Engineers	3-1-0-4
MAL100	Mathematics-I	3-1-0-4
MAL101	Mathematics-II	3-1-0-4
CSL100	Introduction to programming	2-1-3-4.5
MEP102	Digital fabrication	1-0.5-3-3
CYL101	Environmental Science	1-0-0-1
EEL101	Basic Electrical Engineering	3-0-2-4
ECL101	Basic Electronics Engineering	3-0-2-4
LAL100	Introduction to Communication Skills	1-1-0-2
LAL101	Introduction to Finance	1-0-0-1

Program linked (PL) Courses

MAL403	Probability & Statistics	3-1-0-4

Program core (PC) courses

EEL201	Circuit and System	3-1-0-4
EEL202	Analog Circuits	3-1-0-4
EEL203	Digital Circuits	2-0-0-2
EEP209	Device and Circuit Lab	0-0-3-1.5
EEL205	Control Systems	3-1-0-4
EEL204	Engineering Electromagnetics	3-0-0-3
EEP210	Digital Electronics Lab	0-0-3-1.5
EEP308	Control Lab	0-0-3-1.5
EEL208	Sensors and Instrumentation	3-0-0-3
EEL206	Electrical Machines-I	3-0-0-3
EEP304	Sensor Lab	0-0-3-1.5
EEL302	Digital Control	3-1-0-4
EEP306	Machines Lab	0-0-3-1.5
EEL207	Power system Analysis	3-0-0-3
EEP307	Instrumentation Lab	0-0-3-1.5
EEL301	Electrical Machines-II	2-0-0-2
EEL303	Power Electronics	3-0-0-3
EEP305	Power System Lab	0-0-3-1.5
EEP309	Power Electronics Lab	0-0-3-1.5
EEQ401	Minor Project	0-0-3-1.5
UGQ301	Interdisciplinary Undergraduate Project	0-0-6-3

BTech in Electrical Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Course-7	Course-8	Credits
I	**CSL100**	**CYP102/ PHP102**	**MAL100**	**CYL100**	**PHL101**	**CYL101**	**NCN100**		18
	Introduction to programming	Chemistry lab/ Physics lab	Mathematics-I	Applied Chemistry	Physics for Engineers	Environmental Science	Practices for Comprehensive wellbeing		
	2-1-3-4.5	**0-0-3-1.5**	**3-1-0-4**	**3-0-0-3**	**3-1-0-4**	**1-0-0-1**	**-**		
II	**MEP102**	**EEL101**	**PHP102 / CYP102**	**MAL101**	**ECL101**	**BML101**	**LAN103**		19.5
	Digital fabrication	Basic Electrical Engineering	Physics lab/ Chemistry lab	Mathematics-II	Basic Electronics Engineering	Biology for Engineers	Professional Ethics		
	1-0.5-3-3	**3-0-2-4**	**0-0-3-1.5**	**3-1-0-4**	**3-0-2-4**	**2-0-0-2**	**-**		
III	**EEL201**	**EEL202**	**EEL203**	**EEL204**	**MAL403**	**LAL100**			18
	Circuit and System	Analog Circuits	Digital Circuits	Engineering Electromagnetics	Probability and Statistics	Introduction to Communication Skills			
	3-1-0-4	**3-1-0-4**	**2-0-0-2**	**3-0-0-3**	**2-1-0-3**	**1-1-0-2**			
IV	**EEL205**	**EEL206**	**EEL207**	**EEL208**	**EEP209**	**EEP210**	**LAL101**		18
	Control Systems	Electrical Machines-I	Power System Analysis	Sensors and Instrumentation	Device and Circuit Lab	Digital Electronics Lab	Introduction to Finance	LA Courses	
	3-1-0-4	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**0-0-3-1.5**	**0-0-3-1.5**	**1-0-0-1**	**X-X-X-1**	
V	**EEL301**	**EEL302**	**EEL303**	**EEP304**	**EEP305**				18
	Electrical Machines-II	Digital Control	Power Electronics	Sensor Lab	Power System Lab	OE	LA Courses		
	2-0-0-2	**3-1-0-4**	**3-0-0-3**	**0-0-3-1.5**	**0-0-3-1.5**	**x-x-x-3**	**X-X-X-3**		
VI	**EEP306**	**EEP307**	**EEP308**	**EEP309**		**UGQ301**			18
	Machines Lab	Instrumentation Lab	Control Lab	Power electronics Lab	PE	Interdisciplinary Undergraduate Project	OE		
	0-0-3-1.5	**0-0-3-1.5**	**0-0-3-1.5**	**0-0-3-1.5**	**X-X-X-6**	**0-0-6-3**	**X-X-X-3**		
VII	**EEQ401**	**EELXXX**							17.5
	Minor Project	PE	OE	LA Courses					
	0-0-3-1.5	**X-X-X-9**	**X-X-X-3**	**X-X-X-4**					
VIII	**EELXXX**								17
	PE	OE	LA Courses						
	X-X-X-9	**X-X-X-6**	**X-X-X-2**						

BTech in Electronics & Communication Engineering

Course category	Minimum credits
Institute core (IC) courses	40.5
Program linked (PL) courses	4
Program core (PC) courses	53.5
Program elective (PE) courses	21
Open elective (OE) Courses	15
Liberal art (LA) courses	10
Non-graded core (NC) courses	**12 units**
Minimum credit requirement	**144 + 12 non-graded core units**

Institute core (IC) courses

Course code	Course Name	L-T-P-C
BML101	Biology for Engineers	3-0-0-3
CYL100	Applied Chemistry	3-0-0-3
CYP102	Chemistry lab	0-0-3-1.5
PHP102	Physics lab	0-0-3-1.5
PHL101	Physics for Engineers	3-1-0-4
MAL100	Mathematics-I	3-1-0-4
MAL101	Mathematics-II	3-1-0-4
CSL100	Introduction to programming	2-1-3-4.5
MEP102	Digital fabrication	1-0.5-3-3
CYL101	Environmental Science	1-0-0-1
EEL101	Basic Electrical Engineering	3-0-2-4
ECL101	Basic Electronics Engineering	3-0-2-4
LAL100	Introduction to Communication Skills	1-1-0-2
LAL101	Introduction to Finance	1-0-0-1

Program linked (PL) Courses

MAL403	Probability & Statistics	3-1-0-4

Program core (PC) courses

ECL201	Digital Design	3-0-0-3
ECL202	Signals and Systems	3-0-0-3
ECL203	Introduction to Electronics	3-0-0-3
ECL204	Network Theory	3-0-0-3
ECL211	Microcontroller and Embedded Systems	3-0-0-3
ECL212	Digital Signal Processing	3-0-0-3
ECL213	Communication Systems	3-0-0-3
ECL214	Solid State Devices	3-0-0-3
ECL301	Digital Communication	3-0-0-3
ECL302	Electromagnetic Theory	3-0-0-3
ECL303	Control System Engineering	3-0-0-3
ECL304	Analog Electronic Circuits	3-0-0-3
ECL311	VLSI Technology	3-0-0-3
ECL312	FPGA for Digital Design	2-0-2-3
ECP211	Microcontroller and Embedded Systems Lab	0-0-3-1.5
ECP212	Digital Signal Processing lab	0-0-3-1.5
ECP301	Communication Lab	0-0-3-1.5
ECP304	Analog Electronics Lab	0-0-3-1.5
ECP305	Digital Electronics Lab	0-0-2-1
ECP411	Device Fabrication and VLSI Lab	0-0-3-1.5
UGQ301	Interdisciplinary Undergraduate Project	0-0-6-3

BTech in Electronics & Communication Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Course-7	Course-8	Credits
I	**CSL100**	**CYP102/ PHP102**	**MAL100**	**CYL100**	**PHL101**	**CYL101**	**NCN100**		18
	Introduction to programming	Chemistry lab/ Physics lab	Mathematics-I	Applied Chemistry	Physics for Engineers	Environmental Science	Practices for Comprehensive wellbeing		
	2-1-3-4.5	**0-0-3-1.5**	**3-1-0-4**	**3-0-0-3**	**3-1-0-4**	**1-0-0-1**	**-**		
II	**MEP102**	**EEL101**	**PHP102 / CYP102**	**MAL101**	**ECL101**	**BML101**	**LAN103**		19.5
	Digital fabrication	Basic Electrical Engineering	Physics lab/ Chemistry lab	Mathematics-II	Basic Electronics Engineering	Biology for Engineers	Professional Ethics		
	1-0.5-3-3	**3-0-2-4**	**0-0-3-1.5**	**3-1-0-4**	**3-0-2-4**	**2-0-0-2**	**-**		
III	**ECL201**	**ECL202**	**ECL203**	**ECL204**		**MAL 403**	**LAL100**		19
	Digital Design	Signals and Systems	Introduction to Electronics	Network Theory	LA Courses	Probability and Statistics	Introduction to Communication Skills		
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**x-x-x-1**	**3-1-0-4**	**1-1-0-2**		
IV	**ECL211**	**ECL212**	**ECL213**	**ECL214**		**ECP211**	**LAL101**	**ECP212**	17
	Microcontroller and Embedded Systems	Digital Signal Processing	Communication Systems	Solid State Devices	LA Courses	Microcontroller and Embedded Systems Lab	Introduction to Finance	Digital Signal Processing lab	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**x-x-x-1**	**0-0-3-1.5**	**1-0-0-1**	**0-0-3-1.5**	
V	**ECL301**	**ECL302**	**ECL303**	**ECL304**		**ECP304**	**ECP301**	**ECP305**	18
	Digital Communication	Electromagnetic Theory	Control System Engineering	Analog Electronic Circuits	LA Courses	Analog Electronics Lab	Communication Lab	Digital Electronics Lab	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**x-x-x-2**	**0-0-3-1.5**	**0-0-3-1.5**	**0-0-2-1**	
VI	**ECL311**	**ECL312**	**ECLXXX**	**UGQ301**					18
	VLSI Technology	FPGA for Digital Design	PE	Interdisciplinary Undergraduate Project	LA Courses		OE		
	3-0-0-3	**2-0-2-3**	**x-x-x-3**	**0-0-6-3**	**x-x-x-3**		**x-x-x-3**		
VII	**ECP411**		**ECLXXX**						17.5
	Device Fabrication and VLSI Lab		PE		LA Courses		OE		
	0-0-3-1.5		**x-x-x-9**		**x-x-x-1**		**x-x-x-6**		
VIII			**ECLXXX**						17
			PE		LA Courses		OE		
			x-x-x-9		**x-x-x-2**		**x-x-x-6**		

BTech in Materials Science and Metallurgical Engineering

Course category	Minimum credits
Institute core (IC) courses	40.5
Program linked (PL) courses	3
Program core (PC) courses	51.5
Program elective (PE) courses	24
Open elective (OE) Courses	15
Liberal art (LA) courses	10
Non-graded core (NC) courses	**12 units**
Minimum credit requirement	**144 + 12 non-graded core units**

Institute core (IC) courses

Course code	Course Name	L-T-P-C
BML101	Biology for Engineers	3-0-0-3
CYL100	Applied Chemistry	3-0-0-3
CYP102	Chemistry lab	0-0-3-1.5
PHP102	Physics lab	0-0-3-1.5
PHL101	Physics for Engineers	3-1-0-4
MAL100	Mathematics-I	3-1-0-4
MAL101	Mathematics-II	3-1-0-4
CSL100	Introduction to programming	2-1-3-4.5
MEP102	Digital fabrication	1-0.5-3-3
CYL101	Environmental Science	1-0-0-1
EEL101	Basic Electrical Engineering	3-0-2-4
ECL101	Basic Electronics Engineering	3-0-2-4
LAL100	Introduction to Communication Skills	1-1-0-2
LAL101	Introduction to Finance	1-0-0-1

Program linked (PL) Courses

MML204	Properties and phase transformation of Materials	3-0-0-3

Program core (PC) courses

MML201	Thermodynamics of Materials	3-0-0-3
MML202	Structure of Materials	3-0-0-3
MML203	Chemical Synthesis of Materials	3-0-0-3
MML205	Principles of Extractive metallurgy	3-0-0-3
MML251	Physical Properties of Materials	3-0-0-3
MML252	Materials Characterization-Scattering and Imaging	3-0-0-3
MML253	Computational Materials Science and Engineering	3-0-0-3
MML254	Mechanical behavior of Materials	3-0-0-3
MMP251	Chemical Synthesis and characterization lab	0-0-3-1.5
MML301	Materials Characterization – spectroscopy and other analytical tools	3-0-0-3
MML302	Iron making And Steelmaking	3-0-0-3
MML303	Polymeric Materials and Engineering	3-0-0-3
MMP301	Computational Materials Science and Engineering lab	0-0-2-1
MMP302	Industrial exposure to metals processing	0-0-2-1
MMP303	Metallurgical/Metallography Lab	0-0-3-1.5
MML351	Technologies of Thin-film Fabrication	3-0-0-3
MEL251	Casting, Forming and Welding	3-0-0-3
MML401	Environmental Degradation of Materials	3-0-0-3
MMP401	Thin film fabrication and Characterization Lab	0-0-3-1.5
UGQ301	Interdisciplinary Undergraduate Project	0-0-6-3

BTech in Materials Science and Metallurgical Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Course-7	Course-8	Credits
I	**CSL100**	**CYP102/PHP102**	**MAL100**	**CYL100**	**PHL101**	**CYL101**	**NCN100**		18
	Introduction to programming	Chemistry lab/ Physics lab	Mathematics-I	Applied Chemistry	Physics for Engineers	Environmental Science	Practices for Comprehensive wellbeing		
	2-1-3-4.5	**0-0-3-1.5**	**3-1-0-4**	**3-0-0-3**	**3-1-0-4**	**1-0-0-1**	**-**		
II	**MEP102**	**EEL101**	**PHP102 / CYP102**	**MAL101**	**ECL101**	**BML101**	**LAN103**		19.5
	Digital fabrication	Basic Electrical Engineering	Physics lab/ Chemistry lab	Mathematics-II	Basic Electronics Engineering	Biology for Engineers	Professional Ethics		
	1-0.5-3-3	**3-0-2-4**	**0-0-3-1.5**	**3-1-0-4**	**3-0-2-4**	**2-0-0-2**	**-**		
III	**MML201**	**MML202**	**MML203**	**MML204**	**MML205**	**LAL100**	**LALXXX**		18
	Thermodynamics of Materials	Structure of Materials	Chemical Synthesis of Materials	Properties and phase transformation of Materials	Principles of Extractive metallurgy	Introduction to Communication Skills	LA Courses		
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**1-1-0-2**	**X-X-X-1**		
IV	**MML251**	**MML252**	**MML253**	**MML254**	**MMP251**		**LAL101**	**LALXXX**	18.5
	Physical Properties of Materials	Materials Characterization-Scattering and Imaging	Computational Materials Science and Engineering	Mechanical behavior of Materials	Chemical synthesis and characterization lab	PE	Introduction to Finance	LA Courses	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**0-0-3-1.5**	**X-X-X-3**	**1-0-0-1**	**X-X-X-1**	
V	**MML301**	**MML302**	**MML303**	**MMP301**	**MMP302**	**MMP303**			17.5
	Materials Characterization – spectroscopy and other analytical tools	Iron making And Steelmaking	Polymeric Materials and Engineering	Computational Materials Science and Engineering lab	Industrial exposure to metals processing	Metallurgical/Metallography Lab	PE	LA Courses	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**0-0-2-1**	**0-0-2-1**	**0-0-3-1.5**	**X-X-X-3**	**X-X-X-2**	
VI	**MML351**	**MEL251**			**UGP301**				17
	Technologies of Thin-film Fabrication	Casting, Forming and Welding	PE	OE	Interdisciplinary Undergraduate Project	LA Courses			
	3-0-0-3	**3-0-0-3**	**X-X-X-3**	**X-X-X-3**	**0-0-6-3**	**X-X-X-2**			
VII	**MML401**	**MMP401**			**LALXXX**				18.5
	Environmental Degradation of Materials	Thin film fabrication and characterization Lab	PE	OE	LA Courses				
	3-0-0-3	**0-0-3-1.5**	**X-X-X-6**	**X-X-X-6**	**X-X-X-2**				
VIII									17
	PE	OE	**LA Courses**						
	X-X-X-9	**X-X-X-6**	**X-X-X-2**						

BTech in Mechanical Engineering

Course category	Minimum credits
Institute core (IC) courses	40.5
Program linked (PL) courses	6
Program core (PC) courses	47.5
Program elective (PE) courses	25
Open elective (OE) Courses	15
Liberal art (LA) courses	10
Non-graded core (NC) courses	**12 units**
Minimum credit requirement	**144 + 12 non-graded core units**

Institute core (IC) courses

Course code	Course Name	L-T-P-C
BML101	Biology for Engineers	3-0-0-3
CYL100	Applied Chemistry	3-0-0-3
CYP102	Chemistry lab	0-0-3-1.5
PHP102	Physics lab	0-0-3-1.5
PHL101	Physics for Engineers	3-1-0-4
MAL100	Mathematics-I	3-1-0-4
MAL101	Mathematics-II	3-1-0-4
CSL100	Introduction to programming	2-1-3-4.5
MEP102	Digital fabrication	1-0.5-3-3
CYL101	Environmental Science	1-0-0-1
EEL101	Basic Electrical Engineering	3-0-2-4
ECL101	Basic Electronics Engineering	3-0-2-4
LAL100	Introduction to Communication Skills	1-1-0-2
LAL101	Introduction to Finance	1-0-0-1

Program linked (PL) Courses

MML204	Properties and phase transformation of Materials	3-0-0-3
EEL208	Sensors & Instrumentation	3-0-0-3

Program core (PC) courses

MEL231	Engineering Mechanics	2-1-0-3
MEL211	Thermodynamics	2-1-0-3
MEL232	Mechanics of Solids	2-1-0-3
MEL212	Fluid Mechanics	3-1-0-4
MEL251	Casting, Forming & Welding	3-0-0-3
MEL304	Applied Numerical Methods	3-0-0-3
MEL313	Heat and Mass Transfer	3-0.5-0-3.5
MEP302	Engineering and Machine Drawing	0-0-4-2
MEL333	Design of Machine Elements	3-0.5-0-3.5
MEL351	Machining and Machine Tools	3-0-0-3
MEL334	Theory of Mechanisms and Machines	3-0.5-0-3.5
MEL214	Applied Thermal Engineering	2-1-0-3
MEP381	Manufacturing and Metrology Lab	0-0-3-1.5
MEP371	Thermal and Fluid Engineering Lab	0-0-3-1.5
MEL252	Fundamentals of Industrial Engineering	3-0-0-3
MEP376	Solid Mechanics and Dynamics Lab	0-0-2-1
UGQ301	Interdisciplinary undergraduate project	0-0-6-3

BTech in Mechanical Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Course-7	Credits
I	**CSL100**	**CYP102/ PHP102**	**MAL100**	**CYL100**	**PHL101**	**CYL101**	**NCN100**	18
	Introduction to programming	Chemistry lab/ Physics lab	Mathematics-I	Applied Chemistry	Physics for Engineers	Environmental Science	Practices for Comprehensive wellbeing	
	2-1-3-4.5	**0-0-3-1.5**	**3-1-0-4**	**3-0-0-3**	**3-1-0-4**	**1-0-0-1**	**-**	
II	**MEP102**	**EEL101**	**PHP102/ CYP102**	**MAL101**	**ECL101**	**BML101**	**LAN103**	19.5
	Digital fabrication	Basic Electrical Engineering	Physics lab/ Chemistry lab	Mathematics-II	Basic Electronics Engineering	Biology for Engineers	Professional Ethics	
	1-0.5-3-3	**3-0-2-4**	**0-0-3-1.5**	**3-1-0-4**	**3-0-2-4**	**3-0-0-3**	**-**	
III	**MEL231**	**MEL211**	**MML204**	**MEL251**	**LAL100**			18
	Engineering Mechanics	Thermodynamics	Properties and phase transformation of Materials	Casting, forming & Welding	Introduction to Communication Skills	LA Courses		
	2-1-0-3	**2-1-0-3**	**3-0-0-3**	3-0-0-3	**1-1-0-2**	**X-X-X-4**		
IV	**MEL232**	**MEL214**	**MEL212**	**MEL252**	**LAL101**			18
	Mechanics of Solids	Applied Thermal Engineering	Fluid Mechanics	Fundamentals of Industrial Engineering	Introduction to Finance	LA Courses	OE	
	2-1-0-3	2-1-0-3	3-1-0-4	3-0-0-3	**1-0-0-1**	X-X-X-1	X-X-X-3	
V	**MEL333**	**MEL313**	**MEL351**	**MEP381**	**MEP371**			17
	Design of Machine Elements	Heat and Mass Transfer	Machining and Machine Tools	Manufacturing and Metrology Lab	Thermal and Fluid Engineering Lab	PE/OE	LA Courses	
	3-0.5-0-3.5	3-0.5-0-3.5	3-0-0-3	0-0-3-1.5	0-0-3-1.5	X-X-X-3	X-X-X-1	
VI	**MEL334**	**EEL208**	**MEL304**	**MEP302**	**MEP376**	**UGQ301**		18.5
	Theory of Mechanisms and Machines	Sensors and Instrumentation	Applied Numerical Methods	Engineering and Machine Drawing	Solid Mechanics and Dynamics Lab	Interdisciplinary Undergraduate Project	PE/OE	
	3-0.5-0-3.5	3-0-0-3	3-0-0-3	0-0-4-2	0-0-2-1	0-0-6-3	X-X-X-3	
VII								18
	PE	PE/OE						
	X-X-X-6	X-X-X-12						
VIII								17
	PE	PE/OE	LA Courses					
	X-X-X-1	X-X-X-12	X-X-X-4					

BTech in Mechatronics Engineering

Course category	Minimum credits
Institute core (IC) courses	40.5
Program linked (PL) courses	7
Program core (PC) courses	46.5
Program elective (PE) courses	25
Open elective (OE) Courses	15
Liberal art (LA) courses	10
Non-graded core (NC) courses	**12 units**
Minimum credit requirement	**144 + 12 non-graded core units**

Institute core (IC) courses

Course code	Course Name	L-T-P-C
BML101	Biology for Engineers	3-0-0-3
CYL100	Applied Chemistry	3-0-0-3
CYP102	Chemistry lab	0-0-3-1.5
PHP102	Physics lab	0-0-3-1.5
PHL101	Physics for Engineers	3-1-0-4
MAL100	Mathematics-I	3-1-0-4
MAL101	Mathematics-II	3-1-0-4
CSL100	Introduction to programming	2-1-3-4.5
MEP102	Digital fabrication	1-0.5-3-3
CYL101	Environmental	1-0-0-1
EEL101	Basic Electrical Engineering	3-0-2-4
ECL101	Basic Electronics Engineering	3-0-2-4
LAL100	Introduction to Communication Skills	1-1-0-2
LAL101	Introduction to Finance	1-0-0-1

Program linked (PL) Courses

MAL403	Probability & Statistics	3-1-0-4
EEL208	Sensors & Instrumentation	3-0-0-3

Program core (PC) courses

EEL201	Circuit and Systems	3-1-0-4
EEL205	Control Systems	3-1-0-4
EEL302	Digital Control	3-1-0-4
MEL231	Engineering Mechanics	2-1-0-3
MEL232	Mechanics of Solids	2-1-0-3
MEL333	Design of Machine Elements	3-0.5-0-3.5
MEL334	Theory of Mechanisms and Machine	3-0.5-0-3.5
CSL304	Artificial Intelligence	3-0-2-4
MTL201	Fluid Power System	3-0-2-4
MTL202	Industry 4.0	3-0-0-3
MTL301	Fundamental of Robotics	3-0-0-3
MTP301	Mechanism Lab	0-0-3-1.5
MTP302	Mechatronics Lab	0-0-3-1.5
MTQ401	Minor Project	0-0-3-1.5
UGQ301	Interdisciplinary undergraduate project	0-0-6-3

BTech in Mechatronics Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Course-7	Credits
I	**CSL100**	**CYP102/ PHP102**	**MAL100**	**CYL100**	**PHL101**	**CYL101**	**NCN100**	18
	Introduction to programming	Chemistry lab/ Physics lab	Mathematics-I	Applied Chemistry	Physics for Engineers	Environmental Science	Practices for Comprehensive wellbeing	
	2-1-3-4.5	**0-0-3-1.5**	**3-1-0-4**	**3-0-0-3**	**3-1-0-4**	**1-0-0-1**	**-**	
II	**MEP102**	**EEL101**	**PHP102/ CYP102**	**MAL101**	**ECL101**	**BML101**	**LAN103**	19.5
	Digital fabrication	Basic Electrical Engineering	Physics lab/ Chemistry lab	Mathematics-II	Basic Electronics Engineering	Biology for Engineers	Professional Ethics	
	1-0.5-3-3	**3-0-2-4**	**0-0-3-1.5**	**3-1-0-4**	**3-0-2-4**	**3-0-0-3**	**-**	
III	**EEL201**	**MEL231**	**MTL201**	**MAL403**	**LAL100**			18
	Circuit and System	Engineering Mechanics	Fluid Power System	Probability and statistics	Introduction to Communication Skills	LA Courses		
	3-1-0-4	**2-1-0-3**	**3-0-2-4**	**3-1-0-4**	**1-1-0-2**	**X-X-X-1**		
IV	**EEL205**	**MEL232**	**MEL334**	**MTL202**	**EEL208**	**LAL101**		17.5
	Control Systems	Mechanics of Solids	Theory of Mechanisms and Machine	Industry 4.0	Sensors and Instrumentation	Introduction to Finance		
	3-1-0-4	**2-1-0-3**	**3-0.5-0-3.5**	**3-0-0-3**	**3-0-0-3**	**1-0-0-1**		
V	**MEL333**	**EEL302**	**MTL301**	**CSL304**				18.5
	Design of Machine Elements	Digital Control	Fundamental of Robotics	Artificial Intelligence	OE	LA Courses		
	3-0.5-0-3.5	**3-1-0-4**	**3-0-0-3**	**3-0-2-4**	**X-X-X-3**	**X-X-X-1**		
VI	**MTP302**	**MTP301**		**UGQ301**				18
	Mechatronics Lab	Mechanism Lab	PE	Interdisciplinary Undergraduate Project	LA Courses			
	0-0-3-1.5	0-0-3-1.5	X-X-X-9	0-0-6-3	**X-X-X-3**			
VII	**MTQ401**							17.5
	Minor Project	PE	LA Courses					
	0-0-3-1.5	X-X-X-12	X-X-X-4					
VIII								17
	PE	OE	LA Courses					
	X-X-X-4	X-X-X-12	X-X-X-1					

Course Curriculum
(MSc Programs)

MSc in Chemistry

Course category	Minimum credits
Program core (PC) courses	33
Program elective (PE) courses	15
Thesis	24
Minimum credit requirement	**72**

Program core (PC) courses

Course code	Course Name	L-T-P-C
CYL500	Quantum Chemistry	3-0-0-3
CYL400	Chemical Kinetics and Surface Science	3-0-0-3
CYL401	Coordination Chemistry	3-0-0-3
CYL501	Stereochemistry and Reaction Mechanism	3-0-0-3
CYP502	Organic and Inorganic Laboratory	0-0-6-3
CYP503	Physical and Computational Laboratory	0-0-6-3
CYL504	Thermodynamics and Statistical Mechanics	3-0-0-3
CYL505	Organic Reactions and Reagents	3-0-0-3
CYL506	Bioinorganic Chemistry	3-0-0-3
CYL600	Advanced Organic Chemistry	3-0-0-3
CYL601	Organometallic Chemistry	3-0-0-3
CYT699	Thesis	X-X-X-X

MSc in Chemistry

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Credits
I	**CYL500**	**CYL400**	**CYL401**	**CYL501**	**CYP502**	**CYP503**	**18**
	Quantum Chemistry	Chemical Kinetics and Surface Science	Coordination Chemistry	Stereochemistry and Reaction Mechanism	Organic and Inorganic Laboratory	Physical and Computational Laboratory	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**0-0-6-3**	**0-0-6-3**	
II	**CYL504**	**CYL505**	**CYL506**				**18**
	Thermodynamics and Statistical Mechanics	Organic Reactions and Reagents	Bioinorganic Chemistry	PE			
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**X-X-X-9**			
III	**CYL600**	**CYL601**	**CYT699**				**18**
	Advanced Organic Chemistry	Organometallic Chemistry	Thesis	PE			
	3-0-0-3	**3-0-0-3**	**X-X-X-6**	**X-X-X-6**			
IV	**CYT699**						**18**
	Thesis						
	X-X-X-18						

MSc in Mathematics and Computing

Course category	Minimum credits
Program core (PC) courses	48
Program elective (PE) courses	3
Program elective (PE) courses/ Open elective (OE) courses	3
Project/ Program elective (PE) courses/ Open elective (OE) courses	18
Minimum credit requirement	**72**

Program core (PC) courses

Course code	Course Name	L-T-P-C
MAL400	Introduction to Programming	2-1-3-4.5
MAL401	Linear Algebra	3-0-0-3
MAL402	Real Analysis	3-0.5-0-3.5
MAL403	Probability and Statistics	3-1-0-4
MAL404	Modern Algebra	3-0-0-3
MAL405	Differential Equations	3-1-0-4
MAL406	Numerical Analysis	3-1-0-4
MAL500	Topology	3-0-0-3
MAL501	Complex Analysis	3-0-0-3
MAL502	Functional Analysis	3-1-0-4
MAL503	Discrete Mathematics	3-1-0-4
MAL504	Data Structure	2-1-2-4
MAL505	Database Management Systems	3-0-2-4
MAQ699	Project	x-x-x-x

MSc in Mathematics and Computing

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Credits
I	**MAL400**	**MAL401**	**MAL402**	**MAL403**	**MAL404**	**18**
	Introduction to Programming	Linear Algebra	Real Analysis	Probability and Statistics	Modern Algebra	
	2-1-3-4.5	**3-0-0-3**	**3-0.5-0-3.5**	**3-1-0-4**	**3-0-0-3**	
II	**MAL405**	**MAL406**	**MAL500**	**MAL501**	**MAL502**	**18**
	Differential Equations	Numerical Analysis	Topology	Complex Analysis	Functional Analysis	
	3-1-0-4	**3-1-0-4**	**3-0-0-3**	**3-0-0-3**	**3-1-0-4**	
III	**MAL503**	**MAL504**	**MAL505**			**18**
	Discrete Mathematics	Data Structure	Database Management Systems	PE	PE/OE	
	3-1-0-4	**2-1-2-4**	**3-0-2-4**	**X-X-X-3**	**X-X-X-3**	
IV						**18**
	Project/PE/OE					
	X-X-X-18					

MSc in Physics

Course category	Minimum credits
Program core (PC) courses	33
Program elective (PE) courses	15
Thesis	24
Minimum credit requirement	**72**

Program core (PC) courses

Course code	Course Name	L-T-P-C
PHL501	Classical Mechanics	3-0-0-3
PHL502	Quantum Mechanics	3-0-0-3
PHL403	Mathematical Physics	3-0-0-3
PHL404	Electronics	3-0-0-3
PHL505	Electrodynamics	3-0-0-3
PHP506	Electronics Laboratory	0-0-6-3
PHL507	Statistical Mechanics	3-0-0-3
PHL508	Solid State Physics	3-0-0-3
PHL509	Nuclear and Particle Physics	3-0-0-3
PHL510	Atomic and Molecular Physics	3-0-0-3
PHP511	General Physics Laboratory	0-0-6-3
PHT699	Thesis	X-X-X-X

MSc in Physics

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Credits
I	**PHL501**	**PHL502**	**PHL403**	**PHL404**	**PHL505**	**PHP506**	**18**
	Classical Mechanics	Quantum Mechanics	Mathematical Physics	Electronics	Electrodynamics	Electronics Laboratory	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**0-0-6-3**	
II	**PHL507**	**PHL508**	**PHL509**	**PHL510**	**PHP511**		**18**
	Statistical Mechanics	Solid State Physics	Nuclear and Particle Physics	Atomic and Molecular Physics	General Physics Laboratory	PE	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	**0-0-6-3**	**3-0-0-3**	
III		**PHT699**					**18**
	PE	Thesis					
	X-X-X-12	**X-X-X-6**					
IV	**PHT699**						**18**
	Thesis						
	X-X-X-18						

Course Curriculum
(MTech Programs)

MTech in Bioengineering

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Program elective (PE)/Open elective (OE) Courses	3
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	6
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
BML511	Physiology	2-0-0-2
BML512	Molecular Biology	3-0-0-3
BML513	Biochemistry	2-0-0-2
BML551	Instrumentation in Biomedical Engineering	3-0-0-3
BMP581	Bioengineering Lab 1	0-0-2-1
BMP582	Bioengineering Lab 2	0-0-2-1
BMT799	Thesis	X-X-X-X

MTech in Bioengineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Credits
I	**BML511**	**BML512**	**BML513**	**BMP581**		**11**
	Physiology	Molecular Biology	Biochemistry	Bioengineering Lab 1	PE	
	2-0-0-2	**3-0-0-3**	**2-0-0-2**	**0-0-2-1**	**X-X-X-3**	
II	**BML551**	**BMP582**				**13**
	Instrumentation in Biomedical Engineering	Bioengineering Lab 2	PE	PE/OE		
	3-0-0-3	**0-0-2-1**	**X-X-X-6**	**X-X-X-3**		
III		**BMT799**				**15**
	PE/OE/Thesis	Thesis				
	X-X-X-6	**X-X-X-9**				
IV	**BMT799**					**15**
	Thesis					
	X-X-X-15					

MTech in Biomedical Devices

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Program elective (PE)/Open elective (OE) Courses	3
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	6
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
BMP501	Biomedical Engineering Lab	0-0-2-1
BML511	Physiology	2-0-0-2
BML551	Instrumentation in Biomedical Engineering	3-0-0-3
BMP601	Biomedical Devices Lab	0-0-2-1
BML617	Biomedical imaging and signal analysis	3-0-0-3
BML651	Magnetic Resonance Imaging (MRI) and Contrast Agents	3-0-0-3
BMT799	Thesis	X-X-X-X

MTech in Biomedical Devices

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Credits
I	**BML511**	**BML617**	**BMP501**			**12**
	Physiology	Biomedical imaging and signal analysis	Biomedical Engineering Lab	PE	PE	
	2-0-0-2	**3-0-0-3**	**0-0-2-1**	**X-X-X-3**	**X-X-X-3**	
II	**BML551**	**BML651**	**BMP601**			**12**
	Instrumentation in Biomedical Engineering	Magnetic Resonance Imaging (MRI) and Contrast Agents	Biomedical Devices Lab	PE	OE	
	3-0-0-3	**2-0-0-2**	**0-0-2-1**	**X-X-X-3**	**X-X-X-3**	
III		**BMT799**				**15**
	PE/OE/Thesis	Thesis				
	X-X-X-3	**X-X-X-12**				
IV		**BMT799**				**15**
	PE/OE/Thesis	Thesis				
	X-X-X-3	**X-X-X-12**				

MTech in Computer Science and Engineering

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Program elective (PE)/Open elective (OE) Courses	3
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	6
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
CSL502	Foundation of Computer Science	3-0-0-3
CSL503	Computer Systems Engineering	2-0-2-3
CSL606	Advance Data Structures and Algorithms	3-0-0-3
CSL605	Computer Networks and Cyber Security	2-0-2-3
CST799	Thesis	X-X-X-X

MTech in Computer Science and Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Credits
I	**CSL502**	**CSL503**	**CSL606**	**CSL605**		**12**
	Foundation of Computer Science	Computer Systems Engineering	Advance Data Structure and Algorithms	Computer Networks and Cyber Security		
	3-0-0-3	**2-0-2-3**	**3-0-0-3**	**2-0-2-3**		
II	**CSLXXX**	**CSXXXX**				**12**
	PE	PE/OE				
	X-X-X-9	**X-X-X-3**				
III		**CST799**				**15**
	PE/OE/Thesis	Thesis				
	X-X-X-6	**X-X-X-9**				
IV	**CST799**					**15**
	Thesis					
	X-X-X-15					

MTech in Control and Instrumentation

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Thesis/Program elective (PE) courses	9
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
EEP501	Control Systems Lab	0-0-3-1.5
EEP502	Sensors and Instrumentation Lab	0-0-3-1.5
EEL601	Advanced Control Theory	3-0-0-3
EEL602	Advanced Sensing Techniques	3-0-0-3
EEL603	Optimal Control	3-0-0-3
EET799	Thesis	X-X-X-X

MTech in Control and Instrumentation

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Credits
I	**EEL601**	**EEP501**	**EEP502**			**12**
	Advanced Control Theory	Control Systems Lab	Sensors and Instrumentation Lab	PE		
	3-0-0-3	**0-0-3-1.5**	**0-0-3-1.5**	**X-X-X-6**		
II	**EEL602**	**EEL603**				**12**
	Advanced Sensing Techniques	Optimal Control	PE/Thesis			
	3-0-0-3	**3-0-0-3**	**X-X-X-6**			
III	**EET799**					**15**
	Thesis	PE/Thesis				
	X-X-X-9	**X-X-X-6**				
IV	**EET799**					**15**
	Thesis					
	X-X-X-15					

MTech in Data Science and Artificial Intelligence

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Program elective (PE)/Open elective (OE) Courses	3
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	6
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
DSL502	Basic Mathematics for Data Science and Artificial Intelligence	2-1-0-3
DSP505	Programming Lab for Data Science and Artificial Intelligence	1-0-2-2
DSL501	Machine Learning	3-0-2-4
CSL606	Advance Data structures and Algorithm	3-0-0-3
DST799	Thesis	X-X-X-X

MTech in Data Science and Artificial Intelligence

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Credits
I	**DSL502**	**DSP505**	**DSL501**	**CSL606**		**12**
	Basic Mathematics for Data Science and Artificial Intelligence	Programming Lab for Data Science and Artificial Intelligence	Machine Learning	Advanced Algorithms and Data Structure		
	2-1-0-3	**1-0-2-2**	**3-0-2-4**	**3-0-0-3**		
II						**12**
	PE	PE/OE				
	X-X-X-9	**X-X-X-3**				
III		**DST799**				**15**
	PE/OE/Thesis	Thesis				
	X-X-X-3	**X-X-X-12**				
IV	**DST799**					**15**
	Thesis	PE/OE/Thesis				
	X-X-X-12	**X-X-X-3**				

MTech in Design and Manufacturing

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Program elective (PE)/Open elective (OE) Courses	3
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	6
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
MEL501	Advanced Engineering Mathematics	3-0-0-3
MEL631	Continuum Mechanics	3-0-0-3
MEL651	Additive Manufacturing	3-0-0-3
MEL633	Finite Element Method	2-1-0-3
MET799	Thesis	X-X-X-X

MTech in Design and Manufacturing

Semester	Course-1	Course-2	Course-3	Course-4	Credits
I	**MEL501**	**MEL631**			**12**
	Advanced Engineering Mathematics	Continuum Mechanics	PE		
	3-0-0-3	**3-0-0-3**	**X-X-X-6**		
II	**MEL651**	**MEL633**			**12**
	Additive Manufacturing	Finite Element Method	PE	PE/OE	
	3-0-0-3	**2-1-0-3**	**X-X-X-3**	**X-X-X-3**	
III	**MET799**				**15**
	Thesis	PE/OE/Thesis			
	X-X-X-9	**X-X-X-6**			
IV	**MET799**				**15**
	Thesis				
	X-X-X-15				

MTech in Electric Vehicle Technology

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Program elective (PE)/Open elective (OE) Courses	3
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	6
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
EVL500	Electrochemical Energy Conversion and Storage Technologies	3-0-0-3
EVL501	Introduction of EV and HEV	2-0-0-2
EVL502	EV Policies and Regulations	1-0-0-1
EVL503	Motor Drives for EV	3-0-0-3
EVL600	Battery Chemistry-Components and Manufacturing	3-0-0-3
EVT799	Thesis	X-X-X-X

MTech in Electric Vehicle Technology

Semester	Course-1	Course-2	Course-3	Course-4	Credits
I	**EVL500**	**EVL501**	**EVL502**		**12**
	Electrochemical Energy Conversion and Storage Technologies	Introduction of EV and HEV	EV Policies and Regulations	PE	
	3-0-0-3	**2-0-0-2**	**1-0-0-1**	**X-X-X-6**	
II	**EVL503**	**EVL600**			**12**
	Motor Drives for EV	Battery Chemistry-Components and Manufacturing	PE	PE/OE	
	3-0-0-3	**3-0-0-3**	**X-X-X-3**	**X-X-X-3**	
III		**EVT799**			**15**
	Thesis/OE/PE	Thesis			
	X-X-X-3	**X-X-X-12**			
IV		**EVT799**			**15**
	Thesis/OE/PE	Thesis			
	X-X-X-3	**X-X-X-12**			

MTech in Electronics & Communication Engineering

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Program elective (PE)/Open elective (OE) Courses	3
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	6
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
ECL501	Computer Communications	2-0-2-3
ECL502	Advanced Digital Communication	3-0-0-3
ECL503	Digital IC Design	3-0-0-3
ECL504	Semiconductor Devices	3-0-0-3
ECT799	Thesis	X-X-X-X

MTech in Electronics & Communication Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Credits
I	**ECL502**	**ECL503**	**ECL504**		**12**
	Advanced Digital Communication	Digital IC Design	Semiconductor Devices	PE	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**X-X-X-3**	
II	**ECL501**				**12**
	Computer Communications	PE	PE/OE	PE/OE/Thesis	
	2-0-2-3	**X-X-X-3**	**X-X-X-3**	**X-X-X-3**	
III					**15**
	Thesis	PE/OE/Thesis			
	X-X-X-12	**X-X-X-3**			
IV					**15**
	Thesis	PE/OE/Thesis			
	X-X-X-12	**X-X-X-3**			

MTech in Materials Science and Metallurgical Engineering

Course category	Minimum credits
Program core (PC) courses	15
Program elective (PE) courses	12
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	3
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
MML501	Characterization and Testing of Materials	3-0-0-3
MMP501	Material Characterization Laboratory	0-0-4-2
MML551	Thermodynamics and Phase Diagram	2-0-0-2
MML552	Fundamentals of Crystallography	1-0-0-1
MML553	Material Synthesis and Processing	2-0-0-2
MMP553	Material Fabrication Laboratory	0-0-4-2
MML554	Computational Methods in Materials Science	3-0-0-3
MMT799	Thesis	X-X-X-X

MTech in Materials Science and Metallurgical Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Credits
I	**MML501**	**MML551**	**MML552**	**MML553**	**MMP553**		**15**
	Characterization and Testing of Materials	Thermodynamics and Phase Diagram	Fundamentals of crystallography	Material synthesis and processing	Material fabrication Laboratory	PE	
	3-0-0-3	**2-0-0-2**	**1-0-0-1**	**2-0-0-2**	**0-0-4-2**	**X-X-X-5**	
II	**MMP501**	**MML554**					**15**
	Material characterization laboratory	Computational methods in Materials science	PE	PE/OE/ Thesis			
	0-0-4-2	**3-0-0-3**	**X-X-X-7**	**X-X-X-3**			
III	**MMT799**						**12**
	Thesis						
	X-X-X-12						
IV	**MMT799**						**12**
	Thesis						
	X-X-X-12						

MTech in Mechatronics Engineering

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Thesis/Program elective (PE) courses	9
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
MTL501	Fundamental of Mechatronics	2-0-2-3
EEL601	Advance Control Theory	3-0-0-3
MTL602	Design and Analysis of Robotic System	3-0-0-3
MTL655	Automation in Production Systems	3-0-0-3
MTT799	Thesis	X-X-X-X

MTech in Mechatronics Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Credits
I	**MTL501**	**EEL601**			**12**
	Fundamental of Mechatronics	Advance Control Theory	PE		
	2-0-2-3	**3-0-0-3**	**X-X-X-6**		
II	**MTL602**	**MTL655**			**12**
	Design and Analysis of Robotic System	Automation in Production Systems	PE	PE/Thesis	
	3-0-0-3	**3-0-0-3**	**X-X-X-3**	**X-X-X-3**	
III	**MTT799**				**15**
	Thesis	PE/Thesis			
	X-X-X-12	**X-X-X-3**			
IV	**MTT799**				**15**
	Thesis	PE/Thesis			
	X-X-X-12	**X-X-X-3**			

MTech in Microelectronics and VLSI

Course category	Minimum credits
Program core (PC) courses	15
Program elective (PE) courses	9
Program Elective/Open Elective Courses	3
Thesis/Program elective (PE) courses	3
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
ECP540	Microfabrication Lab	0-0-3-1.5
ECP541	VLSI Design Lab	0-0-3-1.5
ECL530	Semiconductor Device Modeling	3-0-0-3
ECL551	CMOS Analog IC Design	3-0-0-3
ECL503	Digital Integrated Circuit Design	3-0-0-3
ECL531	Integrated Circuit Technology	3-0-0-3
ECT799	Thesis	X-X-X-X

MTech in Microelectronics and VLSI

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Credits
I	**ECP540**	**ECP541**	**ECL530**	**ECL551**	**ECL503**	**12**
	Microfabrication Lab	VLSI Design Lab	Semiconductor Device Modeling	CMOS Analog IC Design	Digital Integrated Circuit Design	
	0-0-3-1.5	**0-0-3-1.5**	**3-0-0-3**	**3-0-0-3**	**3-0-0-3**	
II	**ECL531**					**15**
	Integrated Circuit Technology	PE	PE/OE/Thesis			
	3-0-0-3	**X-X-X-9**	**X-X-X-3**			
III						**15**
	PE/OE/Thesis	Thesis				
	X-X-X-3	**X-X-X-12**				
IV	**DST799**					**12**
	Thesis					
	X-X-X-12					

MTech in Power Systems and Power Electronics

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Thesis/Program elective (PE) courses	9
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
EEP522	Power Electronics Lab	0-0-3-1.5
EEL521	Renewable and Distributed Energy Systems	3-0-0-3
EEP523	Power Systems Lab	0-0-3-1.5
EEL621	Advanced Power Electronics	3-0-0-3
EEL622	Power Quality	3-0-0-3
EET799	Thesis	X-X-X-X

MTech in Power Systems and Power Electronics

Semester	Course-1	Course-2	Course-3	Course-4	Credits
I	**EEL521**	**EEL621**			**12**
	Renewable and Distributed Energy Systems	Advanced Power Electronics	PE		
	3-0-0-3	**3-0-0-3**	**X-X-X-6**		
II	**EEP522**	**EEP523**	**EEL622**		**12**
	Power Electronics Lab	Power Systems Lab	Power Quality	PE/Thesis	
	0-0-3-1.5	**0-0-3-1.5**	**3-0-0-3**	**X-X-X-6**	
III	**EET799**				**15**
	Thesis	PE/Thesis			
	X-X-X-9	**X-X-X-6**			
IV	**EET799**				**15**
	Thesis				
	X-X-X-15				

MTech in Thermal and Fluids Engineering

Course category	Minimum credits
Program core (PC) courses	12
Program elective (PE) courses	9
Program elective (PE)/Open elective (OE) Courses	3
Thesis/Open elective (OE) Courses/ Program elective (PE) courses	6
Thesis	24
Minimum credit requirement	**54**

Program core (PC) courses

Course code	Course Name	L-T-P-C
MEL501	Advanced Engineering Mathematics	3-0-0-3
MEL611	Advanced Fluid Mechanics	3-0-0-3
MEL612	Conduction and Radiation Heat Transfer	3-0-0-3
MEL613	Convective Heat Transfer	3-0-0-3
MET799	Thesis	X-X-X-X

MTech in Thermal and Fluids Engineering

Semester	Course-1	Course-2	Course-3	Course-4	Credits
I	**MEL501**	**MEL611**	**MEL612**	**MELXXX**	**12**
	Advanced Engineering Mathematics	Advanced Fluid Mechanics	Conduction and Radiation Heat Transfer	PE	
	3-0-0-3	**3-0-0-3**	**3-0-0-3**	**X-X-X-3**	
II	**MEL613**				**12**
	Convective Heat Transfer	PE	PE/OE		
	3-0-0-3	**X-X-X-6**	**X-X-X-3**		
III	**MET799**				**15**
	Thesis	PE/OE/Thesis			
	X-X-X-9	**X-X-X-6**			
IV	**MET799**				**15**
	Thesis				
	X-X-X-15				

Course Curriculum
(PhD Programs)

Doctor of Philosophy (PhD) in Bioscience and Biomedical Engineering

Minimum course credit requirement for PhD program in Bioscience and Biomedical Engineering is as follows:

Course Category	**Minimum Credits (Students with PG degree in Engineering)**	**Minimum Credits (Students with UG degree in Engineering or PG in Science)**
Program elective (PE) courses	-	12
Program elective (PE)/Open elective (OE) courses	12	12
Thesis/Program elective (PE)/Open elective (OE) courses	06	06
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

Department shall evaluate student's qualification and his/her specialization in previous degree. They shall map the courses completed by the student in the previous degree against the program core course of the MTech program offered the department. Accordingly, the department shall decide the minimum course work requirement for the student and the same shall be informed to the student and academic section at the time of joining the program. In any case, the course work requirement cannot be lower than 12 credits.

Doctor of Philosophy (PhD) in Chemistry

Minimum course credit requirement for PhD program in Chemistry is as follows:

Course Category	**Minimum Credits (Students with PG degree in Science/LA or UG/PG in Engineering)**
Program elective (PE)/Open elective (OE)	12
Thesis	60
Minimum Credit Requirement	**72**

Doctor of Philosophy (PhD) in Computer Science and Engineering

Minimum course credit requirement for PhD program in Computer Science and Engineering is as follows:

Course Category	Minimum Credits (Students with PG degree in Engineering)	Minimum Credits (Students with UG degree in Engineering or PG in Science)
Program elective (PE) courses	-	12
Program elective (PE)/Open elective (OE) courses	12	12
Thesis/Program elective (PE)/Open elective (OE) courses	06	06
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

Doctor of Philosophy (PhD) in Data Science and Artificial Intelligence

Minimum course credit requirement for PhD program in Data Science and Artificial Intelligence is as follows:

Course Category	Minimum Credits (Students with PG degree in Engineering)	Minimum Credits (Students with UG degree in Engineering or PG in Science)
Program elective (PE) courses	-	12
Program elective (PE)/Open elective (OE) courses	12	12
Thesis/Program elective (PE)/Open elective (OE) courses	06	06
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

Doctor of Philosophy (PhD) in Electric Vehicle Technology

Minimum course credit requirement for PhD program in Electric Vehicle Technology is as follows:

Course Category	**Minimum Credits (Students with PG degree in Engineering)**	**Minimum Credits (Students with UG degree in Engineering or PG in Science)**
Program elective (PE) courses	-	12
Program elective (PE)/Open elective (OE) courses	12	12
Thesis/Program elective (PE)/Open elective (OE) courses	06	06
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

Doctor of Philosophy (PhD) in Electrical Engineering

Minimum course credit requirement for PhD program in Electrical Engineering is as follows:

Course Category	**Minimum Credits (Students with PG degree in Engineering)**	**Minimum Credits (Students with UG degree in Engineering or PG in Science)**
Program elective (PE) courses	12	24
Thesis/Program elective (PE) courses	06	06
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

Doctor of Philosophy (PhD) in Liberal Arts

Minimum course credit requirement for PhD program in Liberal Arts is as follows:

Course Category	**Minimum Credits (Students with PG degree in Science/LA or UG/PG in Engineering)**
Program elective (PE)/Open elective (OE) courses	12
Thesis	60
Minimum Credit Requirement	**72**

Doctor of Philosophy (PhD) in Materials Science and Metallurgical Engineering

Minimum course credit requirement for PhD program in Materials Science and Metallurgical Engineering is as follows:

Course Category	**Minimum Credits (Students with PG degree in Engineering)**	**Minimum Credits (Students with UG degree in Engineering or PG in Science)**
Program elective (PE) courses	-	12
Program elective (PE)/Open elective (OE) courses	12	12
Thesis/Program elective (PE)/Open elective (OE) courses	06	06
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

Department shall evaluate student's qualification and his/her specialization in previous degree. They shall map the courses completed by the student in the previous degree against the program core course of the MTech program offered the department. Accordingly, the department shall decide the minimum course work requirement for the student and the same shall be informed to the student and academic section at the time of joining the program. In any case, the course work requirement shall not be lower than 12 credits.

Doctor of Philosophy (PhD) in Mathematics

Minimum course credit requirement for PhD program in Mathematics is as follows:

Course Category	Minimum Credits (Students with PG degree in Science/LA or UG/PG in Engineering)
Program elective (PE)	12
Thesis	60
Minimum Credit Requirement	**72**

Doctor of Philosophy (PhD) in Mechanical Engineering

Minimum course credit requirement for PhD program in Mechanical Engineering is as follows:

Course Category	Minimum Credits (Students with PG degree in Engineering)	Minimum Credits (Students with UG degree in Engineering or PG in Science)
Program elective (PE) courses	9	18
Program elective (PE)/Open elective (OE) courses	3	6
Thesis/Program elective (PE)/Open elective (OE) courses	6	6
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

Doctor of Philosophy (PhD) in Mechatronics Engineering

Minimum course credit requirement for PhD program in Mechatronics Engineering is as follows:

Course Category	**Minimum Credits (Students with PG degree in Engineering)**	**Minimum Credits (Students with UG degree in Engineering or PG in Science)**
Program elective (PE) courses	-	12
Program elective (PE)/Open elective (OE) courses	12	12
Thesis/Program elective (PE)/Open elective (OE) courses	06	06
Thesis	54	54
Minimum Credit Requirement	**72**	**84**

Doctor of Philosophy (PhD) in Physics

Minimum course credit requirement for PhD program in Physics is as follows:

Course Category	**Minimum Credits (Students with PG degree in Science/LA or UG/PG in Engineering)**
Program elective (PE)/Open elective (OE)	12
Thesis	60
Minimum Credit Requirement	**72**

Course Contents

Courses offered in the Discipline of Bioscience and Biomedical Engineering

BML101 Biology for Engineers

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Origin of life and Evolution; Water; Biological molecules: Proteins, DNA, RNA, Genes, Carbohydrates; Lipids; Enzymes and Introduction to metabolism, Nutrients; Introduction to Cells in Biology, Cellular processes, cell organelles and cell structure, Cell cycle, Culture growth; The Central Dogma, Chromatin, DNA structure, replication, transcription and translation; Respiration and photosynthesis; Homeostasis; Basics of human physiology.

BML511 Physiology

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: NA

General and Nerve-muscle Physiology, Cardio-vascular Physiology, Respiratory Physiology, Renal Physiology and Acid-Base Balance, Endocrine & Reproductive Physiology, Gastro-Intestinal Physiology, Nervous System, Special Senses: Vision and Auditory Sense, Principles of Optics, signal transduction & visual pathway, functional anatomy of ear and mechanism of hearing.

BML512 Molecular Biology

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: BML101 (10%)

Cell – Cell as a basic unit of life, structure and function. Types of cells, prokaryotic versus eukaryotic cell, their organization. Cell cycle, regulation of mitotic and meiosis cell division. Cell signaling, surface receptors, intracellular signaling and G-protein coupled receptors; Cell Organelles – different types, their organization and function; Chromosomes – Structure, nucleosome, chromatin, concept of genes and their organization and regulation. non-coding DNA, mobile DNA, organelle DNAs. (6 lectures)
Cytoskeleton – Microtubules, actin filaments. Molecular motors, exocytosis and endocytosis; Replication – Replication in prokaryotes and eukaryotes, mechanism, regulation, double and single stranded DNA, telomerase. DNA repair mechanism; Transcription – Mechanism in eukaryotes and prokaryotes. RNA processing: poly-A capping and splicing. Heterogeneous nuclear RNA. Lac operon and concept of promoters, activators and repressors of transcription; Translation – Concept of genetic code, degeneracy and mechanism of protein synthesis: initiation, elongation and termination. Role of three types of RNAs in translation; Variants – Concept of reading frames, nonsense, missense, frameshift and point mutations. Genetic analyses of mutations; Molecular techniques – Recombinant DNA technology, model organisms, DNA cloning and characterization, genome wide analyses, gene structure, regulation and expression. Gene therapy. Inactivation of genes.

BML513 Biochemistry

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: BML101 (10%)

Properties of water – Water as biological solvents, role of water for life on earth, physiological buffers, fitness of aqueous environment for living organisms, Henderson Hasselbach equations; Biomolecules – Nucleic acids, proteins, carbohydrates, lipids and vitamins – their structure, function and metabolism. Central dogma. Helical structure of DNA and RNA; Protein – Different level of structure and folding, Ramachandran plot and its significant, intermolecular interactions. Glycoproteins and glycolipids. Structure determination – Experimental methods to identify biomolecular structures: NMR, Xray crystallography, cryo-electron microscopy; Enzymes kinetics – Michaelis-Menten kinetics, lock and key hypothesis, enzyme inhibitors. RNA enzymes (ribozymes). Enzyme engineering and its applications; Membrane proteins – Lipid bilayer structure and their assembly. Membrane proteins, transporters, channels, receptors and GPCRs; Respiration – Glycolysis, TCA cycle and oxidative phosphorylation. Role of mitochondria; Photosynthesis – Light and dark reactions, photophosphorylation, pentose phosphate pathway.

BML551 Instrumentation in Biomedical Engineering

3 Credits (3-0-0)
Prerequisite(s): BML511
Overlap with: NA

Introduction to Biomedical Engineering and Instrumentation, Biomedical Sensors and Transducers, Bioelectric Signals and Electrodes, Biomedical Imaging Techniques, Biomedical Optics and Photonics, Biomechanics, Biomedical Signal Processing, Biofeedback and Neurofeedback, Bioinstrumentation for Therapeutics, Wearable Biomedical Sensors, Instrumentation for Gait Analysis and Motion Capture, Biomedical Instrumentation in Cardiology, Neurology, Respiratory Care, Anesthesia, Intensive Care, Radiology, Radiation Therapy, Surgical Applications, Rehabilitation, Medical robotics, Lasers in Medicine, Mechanical ventilators, Point-of-Care Devices, Nanotechnology, Regulations, Biocompatibility and Safety.

BMP581 Bioengineering Lab 1

1 Credits (0-0-2)
Prerequisite(s): None
Overlap with: NA

General physiology, RT PCR amplification of DNA, ELISA of blood insulin, microfluidics, Bacterial growth kinetics, Macromolecular simulations, SEM of biological samples, Cytotoxicity, MRI probe relaxivity studies, Confocal Microscope.

BMP582 Bioengineering Lab 2

1 Credits (0-0-2)
Prerequisite(s): None
Overlap with: NA

Study of biomedical equipment and devices, Nanotechnology in Biomedical Instrumentation, Lab-on-a-Chip and Point-of-Care Devices, wearable sensor fabrication, Biomedical data analysis using computations, Signal processing, AI tools for biology.

BML611 Biomicrofluidics and Lab-on-Chip

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction to Biomicrofluidics, Engineers' guide to the cell, Fluidics in living systems and mechanobiology, Pressure driven flows, Surface tension driven flows, Modulating surface tension, Lab on a CD, Introduction to Electro-kinetics. Fabrication of microfluidic devices; Flow control using pumps and valves; Droplet generation and manipulation; Microfluidic cell culture, On-chip cellular assay techniques, Microfluidics for understanding biology, Organ-on-a-chip, Lab-on-a-chip for genetic analysis, Microfluidic technology for monoclonal antibody production, Microelectronic-fabrication processes, paper-based microfluidics and its applications in diagnostics. Microfluidics for health care.

BML612 Bioinformatics

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction – History, types of Biological data. Biological databases – Nucleic acid and Protein, Sequence and structure databases. Working on databases: NCBI, PDB, NDB, UniProt, Swiss-Prot GenBank, EMBL, DDBJ. Searching databases: BLAST, PDB, Uniprot. Literature databases: PubMed, PubMed Central. Sequence alignment – Local and global, pairwise and multiple, scoring alignment, working on EMBOSS and Clustal omega tools. Matrices and dynamic programming: Dot matrix, Smith Waterman and Needleman Wunsch algorithms. Phylogenetics – Concept of similarity, identity, homolog, ortholog, paralog and related terms, tree building. Protein Structures – Conserved elements: Concept of motif, domain and protein folds. Prediction methods.

BML613 Bionanotechnology

1 Credits (1-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction to nanomaterials and bionanomaterials, nucleic acid nanotechnology and applications; synthesis and biofunctionalization of nanoparticles; RNA interference for gene-knockdown; CRISPR-Cas9 for genomic engineering; protein nanotechnology and design methods; amyloids, antibodies and their applications ; nanopore technology, artificial organelles, and cells.

BML614 BioMEMS and Biosensors

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: BML611 (10%)

MEMS Technology and BioMEMS Introduction

BioMEMS: Device structures, analysis of structures to design and test of these devices and systems. Semiconductor sensors for physical measurements and Physico-chemical sensors integrable on silicon.
Microfabrication processes: Fabrication and process integration of silicon based devices for biosensing applications. Cantilever Biosensors, their functioning and fabrication. Scaling laws. Piezoresistive cantilever fabrication.
Introduction to Sensor, their classification and sensing principles, Introduction to biosensors, optical biosensors, electrochemical biosensors, semiconductor biosensors, examples of sensing of DNA, proteins and single-cell organisms, Surface Plasmon biosensors, etc.
Microfluidic control with electrostatic and electromagnetic techniques, Micro-fluidics involving statics and dynamics of fluids in tubes and channels of micrometer size dimensions, Micro total analysis systems, Micromixing, etc.
Lab-on-a-chip devices, Glucose sensors, Biosensor arrays and implantable devices, Electronic interface for biosensors, Rare cell detection, Microsurgical tools, microneedles and drug delivery Product development challenges/opportunities prevalent in the current Bio-sensors area.

BML615 Biomaterials Science and Engineering

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: BML512 (5%)

Introduction to Biomaterials, Background history. Properties (Mechanical and Physicochemical), Resorb ability, biodegradation. Biofilm, Material characterization — Analytical instruments. Biological responses, compatibility, cytotoxicity, Proteins, Tissue and blood. Response Cell-biomaterial interaction. Animal trials (in vivo models). Metals types, classifications, applications. Polymers-types, classifications, applications. Biopolymers, Hydrogels. Drug delivery systems/encapsulation. Biomaterials for cardiovascular/ pulmonary/ ophthalmological applications. Biomaterials for cancer.

BML616 Bioanalytical Methods

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction: Modern approaches in Bioanalysis and Bioassays. Spectroscopic techniques: UV-Visible spectroscopy, Fluorescence spectroscopy, IR spectroscopy, CD spectroscopy, and NMR and Mass spectroscopy/spectrometry. Microscopic Techniques: Light Microscopy; Fluorescence microscopy, atomic force microscope, Electron microscope, Scanning electron microscopy, Transmission Electron microscope. Application of microscope in analyzing biological samples. Electrophoretic Techniques: Electrophoresis; Principle, Design of horizontal and vertical gel electrophoresis apparatus, performing electrophoresis techniques, application of electrophoresis in analyzing macromolecules. Chromatographic Techniques Chromatographic techniques; Principles, Column chromatography, HPLC, TLC, Paper chromatography. Imaging Techniques: X-ray, MRI, PET, fluorescence, and ultrasound imaging techniques.

Courses offered in the Discipline of Chemistry

CYL100 Applied Chemistry

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Electrochemical Systems: Electrochemical cells and EMF, Applications of EMF measurements, Nernst Equation, Batteries, Fuel cell, corrosion and its control; Kinetics of Chemical Reactions and catalysis: Reversible, consecutive and parallel reactions, Steady state approximation, and Chain reactions. Physical adsorption, chemisorption, Freundlich's expression, Langmuir adsorption isotherm, and heterogeneous catalysis; Bonding Models in inorganic Chemistry: Molecular orbital theory, Valence-bond theory, LCAO, and Crystal field theory; Coordination Chemistry: Coordination numbers, Chelate effect, Coordination complexes and application, Bio-inorganic chemistry: Metal ions in Biological systems, environmental aspects of Metals, Organometallic chemistry, 18 electron rules, Industrially relevant chemical reactions and mechanism, Meallic-lithium, sodium and its compounds and their energy storage applications; Engineering materials and Polymer Chemistry: Glass, ceramics, refractory, composites, magnetic materials, Polymer, Properties, Polymer processing, Industrial polymers, conducting polymers; Natural Products and Biomolecules: Amino acids/nucleic acids/proteins/lipids, Enzymes, Vitamins, Biomacromolecules, and Solid phase synthesis; Fuels and Combustion: Properties of fuels, Calorific value, Petroleum and petrochemicals, biofuels.

CYL101 Environmental Studies

1 Credits (1-0-0)
Prerequisite(s): None
Overlap with: NA

Understanding our environment: atmosphere composition and behaviour, temperature and pressure profile of atmosphere, Atmospheric Photochemistry: Electromagnetic radiations, kinetics of thermal and photochemical processes, Reactions in the upper atmosphere, photo processes in the troposphere, photochemical smog, photosynthesis, Ozone chemistry, brief overviews of ozone depletion and atmospheric pollutants. Air pollution: Standards, effect of air pollutants, origin and fate of air pollutants, atmospheric dispersion. Global warming: greenhouse gases, results of global warming, Principle and applications, green chemical industrial process, sustainable fuel for automobiles and power generation. Water pollution: Chemistry in aqueous media; Chemical and physical reactions in the water environment; Major contaminant groups and their natural pathways for removal from lakes, rivers and oceans. Soil pollution: Groundwater and subsurface contamination, Soil profiles, Acid-base and ion exchange reactions in soils, Fertilizers, wastes and pollutants in soil. Organic and Inorganic chemicals in environment: Ecosystem, flow of energy and nutrient cycles, sustainability, toxicity, polychlorinated hydrocarbons like DDT, polymers, detergents. impact on environment.

CYP102 Chemistry Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: NA

Indicative Experiments; Synthesis of drugs (Paracetamol and Aspirin); Analysis of Organic Compound; Estimation of Phenol; Estimation of Copper in Brassy Determination of Hardness of Water by EDTA titration; Synthesis of potash alum from scrap aluminium (recycling of aluminium waste); Reaction Kinetics (Ester hydrolysis); Red-ox titration; Acid Strength in Citrus Fruit juice by using pH meter and conductivity meter; Estimation of Cu in brass by colourimetric method.

CYL400 Chemical Kinetics and Surface Science

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CYL100 - 10%

Introduction to chemical Kinetics, Chain reactions (free radical reaction, polymerization), Enzyme reaction, Inhibition kinetics; Temperature dependence of reaction rate: Linear and non-linear Arrhenius equation, Interpretation of Arrhenius parameters Various theories of unimolecular reactions, Potential energy surfaces for bimolecular reactions; Collision theory. Transition state theory, Activation/thermodynamic parameters, Erying equation; Kinetics in the excited state: Jablonski diagram, Kinetics of Unimolecular and bimolecular photophysical and photochemical processes, Quantum yield calculation, Excited state lifetime-quenching constant, Resonance energy transfer rates (RET), Rate and efficiency of RET; Dynamics of electron transfer, Solvent reorganization energy, Marcus theory of electron transfer; Importance of interfaces (solid-solid, solid-gas), adsorption isotherms, surface charge and zeta potentials, surface tension; Surface of nanostructured materials, Organic solid state materials, fullerenes, carbon nanotubes and graphene, Surface reactions, Introduction to surface characterization techniques (SEM, XPS, UPS, LEED).

CYL401 Coordination Chemistry

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction to coordination chemistry: The central atom and the ligand, bonding, coordinate (dative) bond, historical background, coordination compounds in chemistry and beyond, basic nomenclature. Ligand types: Classification of ligands, denticity and hapticity, representative ligand families; Transition Metal Chemistry: Properties of transition metal ligand complexes - geometry, coordination number, isomerism, thermodynamic stability, chelate and macrocyclic effect, metal-metal bonds, clusters; Bonding in coordination compounds: Lewis acidity and basicity (donors and acceptors), Crystal Field Theory, Ligand Field Theory, Sigma and Pi Orbitals, limitations of bonding theories, d-orbital splitting, low spin and high spin complexes,Term Symbols, microstates, R-S coupling, Orgel and Tanabe Sugano Diagrams, CFSE for d0 to d10 systems, pairing energy, Applications of CFT and Spinels, Magnetic properties of complexes, J-T distortion, Spin Crossover; Selection rules of electronic transition: Laporte Forbidden Rule, Spin Selection Rule Charge Transfer Spectra (CT), different CT transitions, molecular orbital (MO) theory of small molecules; Reactivity of complexes: Substitution in Oh and Square Planner complexes, Thermodynamics and kinetics, stability and lability of complexes, trans-effect and trans-influence, conjugate base mechanism, racemization, oxidative addition and reductive elimination, steric and electronic factors, redox reactions; Electron transfer reaction: inner sphere and outer sphere mechanism, mechanism of redox reactions, Marcus theory; Photosubstitution and photo redox reactions of Cr, Co, and Ru compounds.

CYL500 Quantum Chemistry

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Why and how quantum mechanics came into existence; Difficulties with classical theory; Black-body radiation, photoelectric effect, Bohr's theory of hydrogen atom, wave-particle duality, de Broglie's idea, double-slit experiment, concept of matter-wave, group and phase velocity, Heisenberg Uncertainty principle; Postulates of quantum mechanics – meaning of wavefunction, operators, eigenvalue problems, Time- dependent and time-independent Schrödinger equation; Model problems – the particle-in-a-box, the harmonic oscillator, and molecular vibration and normal modes, Angular momentum; Hydrogen atom, concept of atomic orbitals, probabilities and electron- density distribution, Born-Oppenheimer approximation – limitations and applications; Molecular orbitals from valence bond and molecular orbital theory; Concept of LCAO and introduction to basis- set; Concepts in computational chemistry; Hartree-Fock Self-Consistent Field (SCF) theory and concept of electron correlation and variational principle; Electron spin and the Pauli principle; Relativity in chemistry – Brief introduction to relativistic quantum mechanics.

CYL501 Stereochemistry and Reaction Mechanism

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Stereochemistry: Introduction to molecular symmetry and point groups. Topicity and prostereoisomerism, nomenclature of stereotopic ligands and faces, stereoheterotopic ligands. Basic terminology: threo and erythro isomers, endo- and exo- compounds, atropisomerism. Centre of chirality, assignment of absolute stereochemistry, CIP rules. Axial chirality (biaryls, spiro compounds, adamentoids, allenes, hemispiranes/alkylidene cycloalkanes and catenanes), planar chirality (cyclophanes, metallocenes and transcycloalkene) and helicity, descriptors for absolute stereochemistry
Conformational analysis: acyclic systems, cyclic systems, cyclohexane and decalins, conformation and reactivity with examples from molecular rearrangements, neighbouring group participation, elimination reactions, formation and cleavage of epoxides, quantitative correlation between conformation and reactivity.
Stereoselectivity: Classification, terminology such as stereomutation, stereoablation, and stereodiscordance, principle of stereoselectivity, examples of diastereoselectivity and enantioselectivity. Stereoselectivity using chiral reagent, chiral catalysts, chiral auxiliary and chiral substrates. Kinetic resolution, parallel kinetic resolution, dynamic kinetic resolution. Circular dichroism, ORD, cotton effect, application of ORD and CD in steriods, examples illustrating the usefulness of Cotton effect.
Reaction mechanisms: Nucleophilic substitution, various types, stability and reactivity of carbocations, nucleophilicity and basicity, neighbouring group participation and rearrangements, steric effects in substitution reactions, classical and non-classical carbocations. Umpolung chemistry with emphasis on thiamine, triazolium, cyanohydrins, metallophosphites and dithianes. Cyclization in organic chemistry, anionic and cationic cascades cyclization, radical induced cyclization, ring-closing metathesis, organocatalysts in cyclization.
Rearrangements: neighboring group participation, ring expansion, carbocation, pinacol, dienone-phenol, benzilic, Favorskii, Baeyer-Villiger and Beckmann rearrangements.

CYP502 Organic and Inorganic Laboratory

3 Credits (0-0-6)
Prerequisite(s): None
Overlap with: NA

Inorganic Lab: Synthesis and characterization of coordination compounds (2 experiments); Study their magnetic moment. Synthesis and characterization of oraganometallic compounds (2 experiments). Catalytic reaction and techniques; Purification and separation techniques (1 experiment), Characterization through analytical techniques, Qualitative determination of compounds, molecules and elements, Quantitative estimation of compounds, molecules and elements.
Organic Lab: Separation of an Unknown Mixture: Acid-Base Solvent Extraction. Nitration Reaction: Thin layer chromatography and column chromatography. Grignard Reaction: Preparation of a grignard reagent, synthesis of triphenylmethanol. Wittig Reaction: Synthesis of alkene from aldehyde. Synthesis of organic (bio)molecules via acid/amine coupling and other coupling strategies and their molecular characterization using different analytical tools, target oriented synthesis of (bio)macromolecules and their molecular characterization, investigation of the physicochemical properties of the synthesized (bio)(macro)molecules.

CYP503 Physical and Computational Chemistry Lab

3 Credits (0-0-6)
Prerequisite(s): None
Overlap with: NA

Study of charge transfer complexes using colorimetric method; Study of fluorescence quenching; Phase behaviour studies; Reaction kinetics study (spectroscopic and polarometric); Study of intermolecular hydrogen bonding; Nanomaterial synthesis and characterizations; Denaturation Studies of biomolecules; Programming, computing platforms, computer simulations; electronic and molecular structure calculations.

CYL504 Thermodynamics and Statistical Mechanics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MEL211 (15-20%); MML201 (15-20%)

Why study statistical mechanics? Introduction to Thermodynamics; Equilibrium Thermodynamics: Thermodynamic Equilibrium state, properties of ideal gases and how they differ from real gases, laws of thermodynamics, thermodynamic potentials, concepts of state and path functions; work and heat as path functions and internal energy as state function, phase diagram, thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; Temperature and pressure dependence of thermodynamic quantities; Le Chatelier's principle; Basic concepts and postulates of statistical mechanics; Ensembles: microcanonical, canonical and grand canonical ensembles, applications of ensembles, thermostat, Barostat, calculation of different thermodynamic quantities such as average pressure, average energy. Partition functions and distributions, canonical and grand canonical partition functions, phase space, fluctuations; Boltzmann, Fermi-Dirac and Bose-Einstein distributions. Canonical partition function in terms of molecular partition function of non-interacting particles, Translational, rotational and vibrational partition functions; Temperature dependence of the second virial coefficient. Thermodynamics of solids - Einstein and Debye models. T3 dependence of

heat capacity of solids at low temperatures Fermi function, Fermi energy, free electron model and density of states, chemical potential of conduction electrons; Introduction to computer simulation methods in statistical mechanics. ergodicity, random numbers, Monte Carlo methods, Molecular Dynamics, constant temperature MD.

CYL505 Organic Reactions and Reagents

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

A brief introduction to substitution, elimination, addition, oxidation, reduction, rearrangement and pericyclic reactions. Functional group transformations: alcohols to alkylating agents, Mitsunobu and related reactions, introduction of functional groups by nucleophilic substitution at saturated carbon, nucleophilic cleavage of C-O bonds in ethers and esters and interconversion of carboxylic acid derivatives.
Oxidation: Metal based oxidizing reagents: A review and detailed discussion of chromium, manganese, ruthenium, silver and other metal based reagents. Non-metal based oxidizing reagents: DMSO, peroxide, peracid and oxygen based oxidation. Miscellaneous oxidizing reagents like IBX, DMP, CAN, DDQ, periodate etc.
Reduction: Homogeneous and heterogeneous; Discussion on borane based racemic and chiral reagents, hydrogenations aluminium, tin, silicon based reducing agents. Dissolving metal reductions.
Selectivity and protecting groups: Illustration of chemoselectivity, regioselectivity and stereoselectivity with examples; protecting groups for alcohols, amines, acids, ketones and aldehydes.

CYL506 Bioinorganic Chemistry

3 Credits (3-0-0)
Prerequisite(s): CYL503
Overlap with: CYL100 (5%)

Metal ions in biology: occurrence and function, active-site structure and function of metalloproteins and metalloenzymes with various transition metal ions and ligand systems; oxygen binding properties of heme and non-heme proteins, their coordination geometry and electronic structure.
Electron Transfer Proteins: Types of copper proteins and enzymes, mechanism of electron transport, structure and bonding of plastocyanin, azurin. - Fe-S proteins and Rieske iron-sulfur proteins [2Fe-2S], cytochromes and their comparisons.
Electron transport and energy metabolism: Photosynthesis (Photosystem I and II), Mn-cluster for electron release.
Mobilization of iron: Siderophores; transport of iron: transferrin, storage of iron: Ferritin – hemosiderine.
Oxygen transport and storage: Hemoglobin - myoglobin - co-operativity effect, Hill coefficient and Bohr Effect; hemerythrine - hemocyanine. characterization of O bound species by Raman and infrared spectroscopic methods.
Small molecule activation: Nitrogen fixation and mechanism, hydrogenases. Oxygen activation: Cu and Fe containing enzymes - representative synthetic models of heme and non-heme systems and cytochrome P450, Cu-Zn-superoxide dismutase - Zn-containing enzymes - types of Mo-enzymes.
Metals in medicine: Vitamin B12 and its mechanisms of action, MRI contrast agents, radio-isotopes (e.g., Tc & I) and therapeutic applications of cis-platin and Au complex. Toxicity of metals: Cd, Hg and Cr toxic effects with specific examples.

CYL507 Chemistry of Main Group Elements

3 Credits (3-0-0)
Prerequisite(s): CYL401
Overlap with: NA

Basic introduction, physical properties of the main group elements, shapes and sizes of the main group elements, structure and bonding in main group compounds including hypervalency and multiple bond. Hydrogen and classical hydrogen bond, water, hydrates, hydrogen ions, metal hydrides, activation of hydrogen complexes; alkali metals in liquid ammonia; boron, boranes, carboranes, borazines and borates; allotropy of carbon; silane and polysilanes, silicones.
Polymers, silicates; compounds of nitrogen, activation of nitrogen, nitrogen fixation, hydrogen, halogen, oxygen and nitrogen compounds of phosphorous; oxygen and singlet oxygen, ozone, complexes of molecular oxygen; N-S compounds; sulphides, oxides and oxoacids of sulphur, chalcogenides and polychalcogenides; halogens, polyhalides, interhalogen compounds, charge-transfer complexes of Halogens; compounds of Xenon and other noble gases; Zintl compounds and homometallic clusters.
Recent advances and their properties of various main group compounds, such as Group 1, Group 2, and Group 13-18.

CYL508 Organic Photochemistry and Pericyclic reactions

3 Credits (3-0-0)
Prerequisite(s): CYL505
Overlap with: NA

Photochemistry: Basics principles of organic photochemistry - Reactivity of simple chromophores – photochemistry of carbon centered radicals.
Photochemistry of Alkenes: Excited States of alkenes - photochemistry of alkene - geometrical isomerisation - photosensitised geometrical isomerisation – photocycloaddition reactions of alkene-di-pi-methane rearrangement - electron transfer mediated reactions of alkene.
Photochemistry of carbonyl compounds: Norrish type I and type II reactions – photochemical cycloadditions- photochemistry of aromatic systems- electron transfer and nucleophile.
Introduction to Pericyclic Reaction. Cycloaddition reactions: Diels-Alder reaction; general features, dienes, dienophiles, selectivity, intramolecular and intermolecular reactions, hetero-Diels Alder reaction. 1,3-dipolar Gycloaddition reactions; general features, dipoles, dipolarophiles. Cycloaddition reactions; general features, selected examples.
Molecular rearrangements: Illustration of electron deficient and electron rich skeletal rearrangements with examples; Sigmatropic rearrangements-Claisen and related rearrangements, Copeandoxy-Coperearrangements;2,3-sigmatropicrearrangements and ene reaction.

CYL509 Molecular Spectroscopy and Computational Chemistry

3 Credits (3-0-0)
Prerequisite(s): CYL500
Overlap with: PHL509 (10%)

Rotational Spectroscopy: Rigid roto model for diatomic molecules, selection rules, intensity of rotational transitions, role of nuclear spin, Isotopic substitution.

Vibrational spectroscopy: Harmonic and anharmonic oscillators, Morse potential, mechanical and electrical anharmonicity, selection rules. The determination of anharmonicity constant and equilibrium vibrational frequency from fundamental and overtones.
Electronic transitions: Franck-Condon principle. Vertical transitions. Selection rules, parity, symmetry and spin selection rules. Polarization of transitions. Fluorescence and phosphorescence.
Raman spectroscopy: Polarizability and selection rules for rotation and vibrational Raman spectra.
Perturbation theory: Time-dependent and time-independent perturbation theory with simple application Atomic term symbols for atoms.
Conjugated pi-systems and Hückel theory.
Group Theory: Concept of groups, symmetry operations, and symmetry elements in different molecules, matrix representations of symmetry operations, point groups, Great orthogonality theorem and Character table.
Application of group theory to molecular orbital theory, molecular vibrations and vibrational spectroscopy.

CYL510 Physical Organic Chemistry

3 Credits (3-0-0)
Prerequisite(s): CYL501
Overlap with: NA

Symmetry-adapted orbitals. Mixing rules and buildup approach to molecules and molecular complexes. Energy surface for bond breaking and making, pre-reacting complex, transition state, activation-strain analysis, Gibbs free energy profile for C-H activation using Pd-catalyst and also using Iodine(III).
Kinetic vs thermodynamic control of products, Curtin-Hammett principle, Hammond Postulate, isotope effects. Examples of Curtin—Hammett paradigm for stereo control in organocatalysis, and intramolecular cyclization.
Reactive intermediates: Carbocations, carbanions, carbenes, benzyne. Empirical scales for electronic, steric, and solvent effects (dielectric constant), salt effects, ion pairs in solvolysis reaction, stereoelectronic effects such as effect of anchimeric assistance on rate of the reaction.
Mechanism according to free-energy correlation and correspondence with theory of orbital interaction. Linear free energy relationship, Yukawa-tsuno equation, Hammett and Taft equations with Illustrative examples: hydrolysis of aryl ester, acetolysis substituted aryl brosylate.

CYL511 An Introduction to Catalyst Design: Function and Application

2 Credits (2-0-0)
Prerequisite(s): CYL401
Overlap with: NA

Basic introduction, green catalysis and various parameters to determine the green catalysis, catalysts poisoning, transition state model, homogeneous catalysis and heterogeneous catalysis.
Engineering a catalyst: preparative protocol and characterization techniques.
Concepts in catalysts: rationale behind designing a catalyst, functional groups associated with various catalytic reactions, main-group catalysis, transition metal-based catalysis, tandem catalysis; frustrated Lewis pair (FLP) systems and molecular activation leading to catalytic reactions.
Catalyst Function: selected examples of industrially important catalytic processes and their mechanistic understanding, various important oxidation and reduction reactions, hydrocarbon activation.

CYL600 Advanced Organic Chemistry

3 Credits (3-0-0)
Prerequisite(s): CY504 and CY508
Overlap with: NA

Retrosynthesis: Basic principles and terminology of retrosynthesis, concepts of latent polarity, umpolung, and synthetic equivalents, important functional group transposition and functional group interconversions, important strategies of retrosysnthesis, synthesis of monofunctional, difunctional and multifunctional group target molecules, synthesis of aromatic target molecules, concept of enzymatic retrosynthsis.
Protecting groups: Protection and deprotection of hydroxy, carboxyl, carbonyl, carboxy amino groups and carbon-carbon multiple bonds; chemo- and regioselective protection and deprotection, illustration of protection and deprotection in organic synthesis.
Construction of ring systems: Baldwin's rules, methodolgies for the construction of three, four, five, six and seven membered rings, medium and large rings, methods for ring contration, application in total synthesis.
Target oriented synthesis: Scope and brief history of total synthesis, tactics, strategy and control in organic synthesis, concept of semi-synthesis, linear, convergent, cascasde and diversity-oriented synthesis, total synthesis of biologically active representative molecules.

CYL601 Organometallic Chemistry: Principles and Applications

3 Credits (3-0-0)
Prerequisite(s): CYL503
Overlap with: CYL100 (5%)

Definition, the first few organometallic complexes, thermodynamics and kinetics of organometallic compounds, the 18-electron rule; Different types organometallic bonding: Metal- alkyls, aryls, hydrides, organometallic bonding with multiple bonds, complexes of pi-bound ligands such as carbonyls, phosphine complexes, carbenes, MO theory of organometallic complexes, isolobal analogy; Fundamental reaction process: oxidative addition and reductive elimination; insertion and elimination; ligand substitution processes, transmetallation, nucleophilic and electrophilic addition and abstraction; Preparative and characterization methods: general methods for the preparation of organometallic compounds and spectroscopic and analytical techniques for the elucidation of structure, properties and reactivates; Synthetic Applications: Coupling reactions, cyclization reactions, addition reactions, carbonylation, olefin oxidation, carbenes and activation reactions, hydrogenation, hydroformylation, isomerization, metathesis and polymerization reactions. CO2 activation, C-H activation, C-C activation, click catalysis, oxidation reaction.

CYL602 Interpretative Molecular Spectroscopy

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Mass spectrometry: the production and analysis of positive ions, molecular ions, application of isotopic abundance measurements, fragmentation modes and rearrangement of ions. Mass spectra of certain chemical classes.
Electronic spectroscopy (UV-visible, fluorescence and phosphorescence): Simple chromophoric groups, conjugated and aromatic systems. Characteristic absorption of organic and inorganic compounds.

Infrared spectroscopy: Characteristic group frequencies of organic and inorganic molecules.
Nuclear magnetic resonance spectroscopy of compounds containing 1H,13C,19F and 31P nuclei. Identification of organic and inorganic compounds using combination of spectral data.

CYL603 Chemistry of Heterocyclic Compounds and Natural Products

3 Credits (3-0-0)
Prerequisite(s): CYL501

Overlap with: NA

Heterocyclic Compounds: Introduction to heterocyclic compounds, importance of heterocycles in medicine and materials, systematic nomenclature of heterocyclic compounds. Preparation, reactions and chemical properties of three membered heterocyclic compounds with one and two hetero atom, four membered heterocyclic compounds with one hetero atom. Structure, synthesis and reactivity of five and six membered heterocyclic compounds.
Aromatic heterocyclic compounds: Pyrrole, furan, thiophene, pyridine, quinoline, isoquinoline, indole, etc. Named reactions of heterocyclic compound synthesis such as Fiest Benary furan synthesis, Knorr and Paal-Knorr pyrrole synthesis, Barton-Zard reaction, Robinson-Gabriel synthesis, Hofmann-Loffler-Freytag reaction, Hantzsch pyridine synthesis, Biginelli and Chichibabin reations.
Natural Products: Role of natural products in drug discovery, structure and chemical properties of alkaloids, terpinoids, and steroids. Physio-chemical properties of amino acids, chemical synthesis of peptides, properties of mono-and di-saccharides.

CYL605 Electron Paramagnetic Resonance (EPR) Spectroscopy and its Applications

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: CYL508 (5%); CYL602 (5%)

Principles of EPR - Presentation of the spectrum-EPR spectrum of hydrogen atom (first-order treatment), g factors, Hyperfine splitting: nuclear spin (I = 1/2, 1, 3/2, 5/2) interaction with electron spin, hyperfine coupling constants, EPR spectra of organic radicals (AA and AB type), EPR spectra of heteronuclear compounds, McConnell's relation, Introduction to multi-electron systems: zero-field splitting, multi-electron systems, Kramer’s degeneracy.
Applications of EPR spectra for inorganic compounds (Cu^{2+}, Ni^{2+}, Fe^{3+}, V^{4+}, Mn^{2+} and $Cr^{3+}$and etc), structure and geometry predictions, anisotropy in the hyperfine coupling constant. Characterization of Metalloproteins. EPR Imaging.

CYL610 Solar Energy Harvesting Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Light harvesting materials, Light mater interaction, the concept of diffusion length, exciton binding energy, transport gap, mobility, lifetime and metal-semiconductor junction. Excited state electron transfer kinetics.
Conjugated polymer-based systems and their synthesis and properties, donor-acceptor systems, electron transfer mechanism, in organic systems, doping and band-gap engineering inorganic semiconductors.

Dye, Quantum dot, and perovskite-based systems. Solar to value-added product generation using such systems. Artificial photosynthesis, Hybrid semiconductors and composite semiconductors, introduction to light to energy storage using hybrid and composite semiconductors. A comparison of various classes of semiconductors-based solar cells with their working principle.

Courses offered in the Discipline of Computer Science and Engineering

CSL100 Introduction to Programming

4.5 Credits (2-1-3)
Prerequisite(s): None
Overlap with: NA

Basics of programming using C; Basic UNIX commands, Primitives and Datatypes, Arithmetic operations, Input and output functions; Conditional statement; Loops, Introduction to Functions, Macros, Recursion, Arrays, Strings, Dynamic Memory Allocation, Pointers, Complex Data Types, File Handling, Introduction to Linked List, sorting, Searching, Bitwise Operator.

CSL201 Discrete Mathematics

4 Credits (3-1-0)
Prerequisite(s): None
Overlap with: NA

Sets, relations, functions, Equivalence and Partial order relations; Formal logic: Propositional logic and truth tables, normal forms, Predicates and Quantification; Notion of proof: proof techniques, Mathematical Induction; Combinatorics: Basic counting techniques, The pigeonhole principle, countable and uncountable sets, recurrence relations The principle of Inclusion-exclusion; Graph theory: Graph terminology, representation of graphs, Isomorphism, trees, Eulerian and Hamiltonian graphs, Graph coloring and Planar graphs; Number theory: Divisibility, GCD, The Euclidean algorithm, The fundamental theorem of arithmetic, Modular arithmetic; Group theory: Groups, subgroups, finite groups, cyclic groups, permutation groups.

CSL202 Data Structures

4 Credits (2-1-2)
Prerequisite(s): CSL100
Overlap with: NA

Stacks, Queues, Lists; Sorting and Searching; Trees, Tree Traversals; Heaps, Binary Search; Binary Search Trees, Balanced BSTs; Graphs: Representations, Depth First Search, Breadth First Search.

CSP203 Software Tools & Technologies Lab

3 Credits (1-0-4)
Prerequisite(s): CSL100
Overlap with: NA

Basics of Linux: Linux commands – text editors; Scripting languages; Web programming; Plotting tools; Document processing tools; Version control systems; Debuggers, such as gdb; Containerization with Docker.

CSL251 Computer Organization & Architecture

4 Credits (3-0-2)
Prerequisite(s): CSL100 and ECL101.
Overlap with: NA

Introduction: Overview of basic digital building blocks – truth tables – basic structure of a digital computer – number representation; achine Instructions and Program: Assembly language programming for some processors; Arithmetic Unit: Basic building blocks for the ALU – adder – subtractor – Shifter – Multiplication and division circuits – Control path microprogramming (only the idea), hardwired; Memory organization; Technology-ROM, RAM, EPROM, Flash etc. – cache memories – cache coherence protocol for uniprocessor (simple) – virtual Memory – secondary storage. Input/Output Organization: I/O Subblock – I/O techniques – interrupts – polling – DMA; Pipelining: Instructions pipeline, hazards.

CSL252 Design and Analysis of Algorithms

4 Credits (3-1-0)
Prerequisite(s): CSL100, CSL201, CSL202
Overlap with: NA

Algorithm analysis; worst and average case; Recurrences and asymptotes; Algorithms for sorting and selection; Randomized techniques, Divide and Conquer; Dynamic programming and greedy algorithms; Graph algorithms: breadth-first search, depth-first search and applications, MSTs, shortest paths; NP-Complete problems and Approximation Algorithms.

CSL253 Theory of Computation

4 Credits (3-1-0)
Prerequisite(s): CSL201 and CSL202
Overlap with: NA

Alphabets, languages finite state machines; Context Free Grammars and Context-Free Languages, Parse trees, PushDown Automata, CYK algorithm; Turing machines, Variants;
Undecidability theory, Space and Time complexity, NP-Completeness.

CSL301 Operating Systems

4 Credits (3-0-2)
Prerequisite(s): CSL202 and CSL251
Overlap with: NA

Introduction: Introduction to OS, Virtualization, Concurrency, Persistence; CPU Virtualization: Process, Process API, PCB, Mechanism, CPU Scheduling, Multilevel feedback queue; Memory Virtualization: Address space, Memory API, Mechanism, address translation, segmentation, paging, TLBs, policies, swapping; Concurrency: concurrency and threads, Thread API, locks, condition variables, semaphore, concurrency bugs; Persistence: I/O devices, Hard disk drives, Redundant Arrays of Independent Disks (RAID), file and directories, file system implementation; Security: Introduction to Operating System Security, Authentication, Access Control, Protecting Information With Cryptography, Distributed System Security; Tools: xv6.

CSL302 Compiler Design

4 Credits (3-0-2)
Prerequisite(s): CSL251 and CSL253
Overlap with: NA

Compiler structure: analysis-synthesis model of compilation – various phases of a compiler – tool based approach to compiler construction; Phases of compiler design: Lexical analysis; syntax analysis; syntax-directed translation; type checking; run time system; intermediate code generation; machine-independent optimizations; code generation.

CSL303 Database Management Systems

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: NA

Database System Concepts: Data models, schemas and instances, database languages, classification; Relational Algebra: SELECT and PROJECT, set operations, JOIN and DIVISION; Entity-relationship (EE) and Enhanced Entity-relationship (EER) models: Entity types, entity sets, attributes and keys; relationship types, relationship sets, roles; subclasses, superclasses and inheritance; DBMS design using relational mapping from EE and EER models; Normalization: Functional dependencies, normal forms based on primary keys, second and third normal forms, Boyce-Codd normal form; Database programming techniques: SQL programming techniques, PHP.

CSL304 Artificial Intelligence

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: NA

Introduction - Course Introduction, Motivation; Problem solving by search - State Space, Problem Reduction, Graph Search, Game Playing, Constraint Satisfaction; Automated Reasoning - Proposition and first order logic, inference and deduction, resolution refutation, answer extraction, knowledge based systems, logic programming and constrained logic programming, non-monotonic reasoning; Planning - State-space, plan space and partial order planning, planning algorithms; Reasoning under uncertainty - Probabilistic reasoning, belief networks, Fuzzy logic; Reinforcement Learning - MDP, Policy Search, Q-Learning, Applications.

CSL351 Computer Networks

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: NA

Introduction: Layer approach, Packet switching techniques, Performance metrics; Applications: Application layer services, HTTP & Web, DNS, SMTP, CDNs, P2P; Transport Layer: Transport layer services, Connection oriented-TCP, flow control, error control, congestion control, TCP variants, UDP, QUIC; Socket Programming: TCP and UDP Socket programming; Network Layer: Network layer services, IP header, Fragmentation, IP addressing, NAT, Routing and the related protocols, ICMP, ARP, RARP, DHCP, IPv6, RIP, OSPF; Data link layer: Data link layer services, framing, medium

access mechanism, CSMA/CD, CSMA/CA, Ethernet, Wi-Fi; Network security: Public key and private key cryptography, digital signature, firewalls; Advanced topics: SDN and Open flow Architectures; The tool-set: NS-3, Wireshark, Mininet, RYU/ONOS Controller.

CSQ401 BTech Project-I

3 Credits (0-0-6)
Prerequisite(s): None
Overlap with: NA

Research and development-oriented projects based on problems of practical and theoretical interest. Students are generally expected to work towards the goals set by the project supervisor. Evaluation is done based on regular presentations, written reports.

CSP402 Nand to Tetris

2 Credits (0-0-4)
Prerequisite(s): IC100, IC150, CS204, CS250, CS251
Overlap with: IC150 (10%), CS204 (10%), CS250 (10%), CS251 (10%)

Introduction: Scope of the course and overview, The roles of abstraction and implementation in systems design, the road ahead.
Boolean function and gate logic: Boolean Logic, Boolean Functions Synthesis, Logic Gates, Hardware Description Language, Hardware Simulation, Multi-Bit Buses, Project 1.
Boolean Arithmetic and the ALU: Binary Numbers, Binary Addition, Negative Numbers, Arithmetic Logic Unit, Project 2.
Memory: Sequential Logic, Flip Flops, Memory Units, Counters, Project 3.
Machine Language: Machine Languages: Overview and Elements, The Hack Computer and Machine Language, Hack Language Specification, Input / Output, Hack Programming, Project 4.
Computer Architecture: Von Neumann Architecture, The Fetch-Execute Cycle, Central Processing Unit, The Hack Computer, Project 5.
Assembler: Assembly Languages and Assemblers, The Hack Assembly Language, The Assembly Process - Handling Instructions, The Assembly Process - Handling Symbols, Developing a Hack Assembler, Project 6.
Virtual Machine: Program Compilation Preview, VM Abstraction: the Stack & Memory Segments, VM Implementation: the Stack & Memory Segments, The VM Emulator, VM Implementation on the Hack Platform, VM Translator: Proposed Implementation, Project 7. Program Control, Branching, Functions: Abstraction, Function Call and Return: Implementation Preview & Run-time Simulation & Implementation, VM Implementation on the Hack Platform, VM Translator, Project 8.
High Level Language: The Jack Language in a nutshell, Object-Based Programming, List Processing, Jack Language. Specification: Syntax, Data Types, Classes, Methods, Developing Apps using the Jack language and OS, A Sample Jack App: Square Dance, Graphics Optimization, Project 9.
Compiler: Syntax Analysis, Lexical Analysis, Grammars, ParseTrees, Parser Logic, The Jack Grammar, The Jack Analyzer, Project 10. Code Generation, Handling Variables, Handling Expressions, Handling Flow of Control, Handling Objects: Low-Level Aspects, Construction, Manipulation, Handling Arrays, Standard Mapping Over the Virtual Machine, Completing the Compiler, Project 11.
Operating System: Operating System, Mathematical Operations, Memory Access, Heap Management, Graphics, Line Drawing, Handling Textual Output, Input, String Processing, Array Processing, The Sys Class, Project 12.

CSQ402 BTech Project-II

3 Credits (0-0-6)
Prerequisite(s): None
Overlap with: NA

The students are expected to work towards the goals set in CSQ401. At the end of the project students are expected to demonstrate a solution and possible future work on the same problem. Students need to submit a report outlining the details of the problem, including a literature survey and various results obtained along with their solutions.

CSL502 Foundation of Computer Science

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CSL253 (10%) and CSL201 (10%)

Basic proof techniques, Set, relation and Function; Advanced Counting and combinatorics; Advance topics in Graph theory and Number theory; Review of Regular languages, Context free languages and grammars, Turing machines; Undecidability theory, Time and Space bounded computation; Advanced topics and computability theory; Intractability; Advanced topics of complexity theory.

CSL503 Computer Systems Engineering

3 Credits (2-0-2)
Prerequisite(s): None
Overlap with: CSL250 (30%) and CSL204 (15%)

Processor architecture: Instruction Set Architecture (ISA) – instruction pipelining and hazards – out-of-order execution – speculative execution – superscalar execution – introduction to multi-core processors; Memory hierarchy: Caches – SRAM – DRAM organization; Operating systems: Basics of Linux and shell – kernel mode execution – processes and threads – shell design – kernel programming – CPU Scheduling – memory management; Concurrency - Multi-threaded programming, OS security; System programming: Linkers – loaders – tools for developing large scale applications.

CSL504 Graph Theory and Applications

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CSL201 (10%) and CS502-old (90%)

Fundamental concepts and definitions of graph theory: Graphs, digraphs, representation of graphs, isomorphism, graphic sequences, bipartite graphs.
Trees and distance in graphs.
Matchings and covers, Independent sets, Hall's theorem, Tutte's theorem, Stable Matchings.
Cuts and Connectivity: Cut vertices, Cut edges, Vertex connectivity, Edge connectivity, blocks, Menger's theorem.

Graph Coloring: Vertex coloring, Brooks theorem, Turan's theorem, color critical graphs, line graphs, edge coloring, Vizing's theorem.
Eulerian Graphs, Hamiltonian Graph sand Applications.
Planar Graphs: Euler's formula, coloring of planar graphs, Kuratowski's theorem, outer planar graphs.
Graph classes: Interval graphs, Chordal graphs, Split graphs, Comparable and Co-comparable graphs, Perfect graphs.

CSL505 Cryptography

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CS553 (100%)

Introduction, Formal Notions, Maths Recap, Historical Ciphers; More Historical Ciphers, Attack Models, Informational and Computational Security, Perfect Secrecy; Block Ciphers and Block Cipher Cryptanalysis; More on Differential Cryptanalysis and Automated Cryptanalysis; Linear Cryptanalysis; AES; Analysing AES; Mode of Operation and Stream Ciphers; LFSR and Hash Functions; Hash Collisions and Birthday Paradox, Concrete Hash Constructions; Keyed Hashing- MAC, Authenticated Encryption, Computational Hardness; Public Key Cryptography, RSA, ECC; Quantum Cryptography, Case-Studies: PKI, VPN, Secure Messaging.

CSL510 Approximation Algorithms

3 Credits (3-0-0)
Prerequisite(s): CSL252
Overlap with: CS510 (100%)

Brief Introduction to NP-completeness and approximation algorithms; Greedy algorithms; Local search; Rounding data and dynamic programming; Linear programming and relaxations; Randomized approximation algorithms; Primal dual method; Metric Rounding of LP Relaxations; Hardness of approximations; Semidefinite programing.

CSL511 Introduction to Formal Verification and its Applications

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CS511 (100%)

Introduction to formal methods and hardware verification. Review of logics: Propositional Calculus and Predicate Calculus. Axioms and rules of Floyd-Hoare Logic. Application of Floyd-Hoare logic to verify hardware circuits.
Introduction to Binary Decision Diagram (BDD) and modelling hardware with BDDs. Algorithms for BDD operation. Concept of BDDs and ROBDDs and operation in ROBDDs.
Introduction to Temporal Logic. Linear and Branching time temporal logic. Expressing properties in CTL and CTL*. CTL model checking algorithm.
State space explosion problem: Symbolic data structure and symbolic model checking algorithms. Study of verification tools: SPIN and NuSMV.

CSL512 Parallel Algorithms

3 Credits (3-0-0)

Prerequisite(s): CSL252
Overlap with: CS512 (100%)

Introduction: Different models of parallel computation, PRAM model and variations, interconnection networks, synchronous and asynchronous models, Performance Analysis.
Basic techniques: Matrix multiplications, Sorting, Searching and Selection, Balanced Trees, divide and conquer, Partitioning, Pipelining, Tree contraction, Euler tour technique.
Graph Algorithms: Connected Components, Graph colouring, MST and shortest path algorithms.
Algorithms on Asynchronous model, Limit of Parallelizability, NC-reductions, P-completeness.
Implementation: Introduction to Parallel Programming. Basic introduction to MPI and OpenCL.

CSL515 Randomized Algorithms

3 Credits (3-0-0)
Prerequisite(s): CSL252
Overlap with: CS512 (10%) and CS515 (90%)

Introduction and basic tools: random sequence. Generating uniform random numbers: the linear congruential method and others.
Statistical tests for random numbers: Chi-square test, Kolmogorov-Smirnov test, empirical I theoretical I spectral tests. Non-uniform random sequences.
Tools and techniques of randomized algorithms: game theoretic techniques, moments and deviations, tail inequalities.
The probabilistic method: Lovasz Local Lemma, Markov chains and random walks, algebraic techniques.

CSL516 Parallelization of Programs

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CS516 (90%)

Introduction to parallel processing; Overview of parallel architectures; Performance of parallel programs; Parallel Programming on GPUs using CUDA: Introduction to GPUs and CUDA—CUDA Thread Organization -- GPU Memories -- Synchronization -- Optimizing Data Transfers – Case Studies. Extracting Parallelism from Sequential Programs: Dependency analysis and testing -- Compile-time parallelization techniques -- Run-time parallelization techniques.

CSL517 Software Defined Networking

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CS517 (90%)

Introduction: Overview of traditional networks, Introduction to SDN, SDN origin and evolution, Network Architecture.
Control and Data Plane: Programmable control and data planes, network abstraction, northbound/southbound interfaces, centralized and distributed SDN, Open vSwitch, Routing.
Openflow protocol: Introduction to Openflow protocol, different Openflow protocol versions.
Network Function Virtualization: Introduction to network function virtualization, NFV Architecture, service function chaining and network slicing.

SDN and NFV in Wireless Networks: Introduction to Wireless SDN, 5G with SDN and NFV.
Hands-on using Mininet and RYU/ONOS controller: Introduction to network emulator tools like Mininet and OpenFlow protocol-supported controllers like RYU and ONOS.

CSL519 High Performance Computer Architecture

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CS519 (100%)

Introduction and overview of processor architectures.
Single core processor architectures: Pipelining and memory hierarchy.
Shared memory processor architectures: Organization – programming – Cache coherence protocols – Memory consistency models.
Data parallel architectures: GPUs – architectural optimizations.
Distributed memory architectures: Organization – programming paradigms – MPI – interconnect.

CSL559 Computer Systems Design

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: CSL301 (10%), CS559 (90%)

Introduction to systems: Example Systems- Operating Systems-Distributed File Systems-Databases-Web Frameworks-Networks.
Systems design intro: Setting goals for your system-Principles of good design.
Modeling Fundamental: Quantitative Systems Design-Queuing Systems-Fundamental Laws and Applications-Asymptotic Bounds.
Naming Schemes: Unix File System-Git-Network Naming.
Caching: CPU Caching-CDN Caching.
Resource Management: Scheduling-Load Balancing-TCP throughput Model.
Other Topics: Virtualization-Security and Access Control-Reliability Models.

CSL601 Network Science

3 Credits (2-1-0)
Prerequisite(s): None
Overlap with: CS552 (100%)

Background, Graph theory related concepts.
Network analysis metrics, Properties of many real network.
Network models and characteristics: Random Networks, Scale-free Networks, Small-world Networks.
Degree Correlations.
Community detection.
Speeding Phenomena.

CSL602 Lightweight Cryptography

3 Credits (2-1-0)
Prerequisite(s): None
Overlap with: CS503 (100%)

Track-1 – Lightweight Ciphers – PRESENT, PRINCE, GIFT, Standardisation efforts in Lightweight Cryptography.
Track-2 – Advanced Symmetric-Key Cryptanalysis – Impossible Differential Cryptanalysis, Impossible Differential Attack on AES, Truncated Differential Cryptanalysis, Boomerang Attack, Sandwich Attack, Ladder, Switch, Sbox Switch, Murphys Incompatible Trail.
Track-3 – Automated Cryptanalysis – Mixed Integer Linear Programming (MILP), Satisfiability (SAT), Satisfiability modulo theories (SMT) Solvers, Familiarization with tools: Sage, Gurobi, Z3.
Track-4 – Design strategies for (lightweight) cryptographic hardware: ASIC/FPGA design flows, Familiarization with tools: Cadence Genus, NCsim, Xilinx Vivado, Hardware Performance Metrics

CSL603 Blockchain Technologies

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CS554 (100%)

Evolution of money: Barter system, gold/silver coins, paper notes, money vs credit, banking system, inflation, GDP, recession, digital money.
Introduction to cryptography: hash function, cryptographic signature schemes, zero-knowledge proof, multiparty protocol.
Bitcoin: transaction, block, blockchain, proof of work, double spending, public vs. private networks.
Ethereum: Transaction, block, blockchain, proof of work, proof of stake, NFT, DeFl, sharding.
Current research: Token economy, Web3. Regulation.

CSL604 Mobile and Wireless Networks

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: EE529 (15%), EE577 (20%)

Introduction: Overview of the electromagnetic spectrum, Standardization bodies (3GPP and non-3GPP like IEEE), and their technologies.
Wireless LANs: Brief overview on Evolution of IEEE 802.11 a/b/g/n/ac/ad/ax, MAC protocol (CSMA/CA), QoS enhancements: 802.11e (EDCA), Wi-Fi security, Rate adaption algorithms, Power saving, Dynamic Frequency selection, Hidden/expose terminal problem (use of RTS/CTS), Frame aggregation, Transmission Opportunity (TXOP), Wi-Hi Security (WPA, WPA2, WPA3).
Cellular Networks: Brief overview on the evolution of cellular networks, 3GPP Standardization process, 4G/5G protocol stack, Frame structure, Scheduling, handover management, Heterogenous Networks, Cloud-Radio Access Networks (C-RAN), Integrated Access and Backhaul (IAB), 4G/5GSecurity.
Coexistence of cellular and Wi-Fi networks: 4G/5Gin Unlicensed Spectrum (LTE-U/NR-U), 3GPP standardization activities in unlicensed spectrum, Licensed Assisted Access (LAA), LTE-Wi-Fi Interworking (LWA), and Coexistence, Multi-Numerology in NR-U and its effect on fairness.
Advanced Topics: Non-terrestrial Networks, Satellite Communication Architecture, Integrated Terrestrial and Non-terrestrial Networks, and beyond 5G networks and systems.
Tool-set: NS-3, NR-U Simulator, Wireshark, Open Wi-Fi, and Open Air Interface (OAI)

CSL605 Computer Networks and Cyber Security

3 Credits (2-0-2)
Prerequisite(s): None

Overlap with: CSL351 (15%)

Introduction to Computer Networks: Overview of computer networks, TCP/IP suite of Protocols; Application Layer: HTTP, DNS; Transport Layer: TCP, UDP, Congestion and flow control, QUIC, client-server; communication using socket programming; Network Layer: IP addressing, ICMP, ARP, DHCP, Routing, BGP, OSPF; Data Link Layer: Ethernet, Wi-Fi, MAC protocols for high-speed LANs and wireless LANs; IPv6: basic protocol, extensions, and options; Advanced Topics: SDN and OpenFlow protocol; The tool-set: NS-3, Wireshark, Socket Programming, Mininet, RYU/ONOS Controller; Understanding Cyber Security: Attacks vectors, Attack surface; The underlying framework; Cryptography— privacy, integrity, authenticity, symmetric/asymmetric cryptosystems, modern ciphers, hash functions, MACs, digital signature schemes; Data at Rest Security: System Security: OS Security, Trojan, Rootkit, Backdoors; Data in Motion Security: Network security: firewall, access control, VPN, VLAN, DNS, DHCP; Web security— database vulnerability, XSS, XXE, CSRF, penetration testing, clickjacking, API vulnerabilities; Botnets, Malware and ransomware; The IAM Paradigm - Identity Access Management; The tool-set: WireShark, Cain and Abel, Kali, Metasploit.

CSL606 Advance Data Structure and Algorithms

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CSL202 (10%), and CSL252 (10%)

Review of basic Data structure: stack Queue linked list, balanced binary search trees, graph data structure; Review of basic algorithms: sorting and searching, greedy algorithms and dynamic programming, graph algorithms; Advanced topics: Amortised analysis; Disjoint sets / union-find; Mergeable heaps; Linear programming; Max flow in networks; String matching; NP completeness, Approximation algorithms; Randomized Algorithm, Stable matching.

CSL607 Adversarial Machine Learning: Security and Privacy of ML

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CS607 (100%)

Introduction to Adversarial Machine Learning (AML): Basic vulnerabilities associated with Machine Learning. Implementation of attacks on object detection model.
Adversarial Training: The formal approach to secure machine learning models.
Adversarial Attack and Defense: Decision Time Attack and Defense, Data Poisoning Attack and Defense, Black box and white box attack and defenses.
Generative Models in defense against adversarial attacks.
Backdoors, Trojans and Honeypots in Machine learning models.
Model Inversion and Membership inference attacks.
Differential Privacy in adversarial defense.

CSL608 Advanced Graph Algorithms

3 Credits (3-0-0)
Prerequisite(s): CSL252
Overlap with: CSL252 (15%), CS608 (100%)

Review of polynomial time reductions, NP-completeness

Exact exponential algorithms
Efficient algorithms on special graph classes: perfect graphs, cographs, interval graphs, permutation graphs
Parameterized Algorithms: fixed-parameter algorithms, kernelization, bounded search trees, iterative compression, parameterized reductions and intractability, tree-decompositions and tree-width.

CSL610 Lower Bounds and Impossibilities

3 Credits (3-0-0)
Prerequisite(s): CSL252
Overlap with: CS610 (100%)

Introduction to lower bounds; Different techniques: counting, reduction, decision tree, indistinguishability, adversaries, valency, covering, graph theory and linear algebra.
Lower bounds results in data structures, Computational complexity theory, Communication complexity theory, distributed computing, and parallel computing.

CSL612 Introduction to Computational Complexity

3 Credits (3-0-0)
Prerequisite(s): CSL253
Overlap with: CS612 (100%) and CSL253 (15%)

The Computational Model, Truing Machines, Decidability, Reducibility, Time Complexity, Space Complexity, Hierarchy Theorems, Boolean Circuits, Circuit Complexity, Limits of the diagonalization method, Randomized Computation, Probabilistic Turing machine, Interactive Proofs, Introduction to Quantum Computation and Algorithms.

CSL613 Social Network Analysis

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CS601 (15%) and CS613 (100%)

Introduction, Handling Real-world Network Datasets, Strength of Weak Ties, Strong and Weak Relationships and Homophily, positive and negative relationships.
Link Analysis, Community Detection, Cascade Behavior and Network Effect, Contagion and Complex Contagion, Power Laws and Rich-Get-Richer Phenomena, Small World Phenomenon, Pseudocore, Anomaly Detection.

CSL614 Quantum Symmetric-Key Cryptanalysis

3 Credits (3-0-0)
Prerequisite(s): CSL503
Overlap with: CS614 (100%)

Overview of quantum information and quantum computing: Qubits, quantum states, quantum gates, Superdense coding, Quantum circuits and reversible computation, (Partial) measurements, Quantum Entanglement, Quantum Teleportation, Deutsch's Algorithm.
Quantum search: A simple searching algorithm: the Deutsch-Jozsa algorithm, Simon's algorithm, Amplitude amplification and Grover's Algorithm, Brassard Hoyer Tapp (BHT) Algorithm.

Shor's factoring algorithm and its impact on cryptography, Quantum cryptanalysis: Quantum Adversarial/Attack Models, Application of Simon's and Grover's search algorithm in symmetric key cryptanalysis (Grover-meets-Simon, Offline Simon's Algorithm), Quantum security analysis of AES, Quantum collision finding on hash functions.
Quantum resource estimation: Synthesis and optimization of quantum circuits
Quantum Programming with Qiskit and Project Q.

CSL622 Quantum Computing for Computer Scientists

3 Credits (2-0-2)
Prerequisite(s): None
Overlap with: CS614 (20%)

The Leap from Classical to Quantum: Classical Deterministic Systems, Probabilistic Systems, Quantum Systems, Dynamic of a Composite System.
Basic Quantum Theory- Quantum Information-Qubits, Classical Gates from Quantum Perspective.
Reversible gates and reversible computation, Quantum gates, Quantum circuits, Circuit Slicing, (Partial) measurements, Quantum RAM.
Protocols: Superdense coding, Quantum Entanglement, Quantum Teleportation.
Algorithms: Deutsch's Algorithm, Quantum search: A simple algorithm, Simon's algorithm, Amplitude amplification and Grover's Algorithm, Shor's algorithm and its impact on Cryptography.
Quantum Cryptography, Quantum Key Distribution.
Lab Component: Introduction to Qiskit and basic set-up for lab, Functions and Permutations, Superdense coding, Quantum Teleportation, Bernstein-Vazirani algorithm, Deutsch-Josza algorithm, Grover's algorithm, Simon's algorithm, Shor's algorithm.

Courses offered in the Discipline of Data Science and Artificial Intelligence

DSL201 Mathematical Foundations of Data Science

4 Credits (3-1-0)
Prerequisite(s): None
Overlap with: MAL100 (10%), and MAL201 (10%)

Probability review: Bayes Rule and its connection to inference, various sampling methods, Modern PAC analysis; Linear Algebra Review and Distance metrics: Geometry of high-dimensional space, distance metrics used for numerical and text data. Locality sensitive hashing (LSH). Matrix approximation techniques: Eigenvalues and Eigenvectors, Eigen decomposition and Diagonalization, Principal Component Analysis, SVD and dimensionality reduction, Multidimensional Scaling. Unitary transform: Fourier transform and its application. Regression and Continuous Optimization: Linear regression gradient descent, Fitting a Model to Data. Density Estimation: Parametric, parameter learning using maximum likelihood, Nonparametric approach, Parzen window.

DSL251 Data Analytics and Visualization

3 Credits (3-0-0)
Prerequisite(s): DSL201
Overlap with: NA

Introduction to Data science workflow; Data Collection and Exploratory Analysis: Automated methods for data collection, Data and Visualization Models, Data wrangling and cleaning, and Exploratory data analysis; Building Models for: Classification, Clustering, Regression; Model evaluation: statistical tests for significance of predictors; Time-series Analysis: Characteristics, Regression, Exploratory data analysis, ARIMA Models; Visualization Design: Introduction, Abstractions, Validation, Marks and Channels; Visualization of Different Data Types: Tabular Data, Multidimensional Data, Spatial Data, Graphs, Text Data; Assorted Topics: Graphical Perception, Interaction dynamics for Visual Analysis, Using Space Effectively, Stacked Graphs, Geometry & Aesthetics.

DSP252 Data Analytics and Visualization Lab

1 Credits (0-0-2)
Prerequisite(s): DSL201
Overlap with: NA

Data handling - Numpy, Pandas; Data Scraping & Preprocessing – Crawling using API, Scraping Html/CSS, BeautifulSoup, Legality; Visualization and Dimensionality - Histograms, Plots (matplotlib, seaborn, and plotly), Dimensionality Reduction and T-SNE; Time Series - Time series Modelling (ARMA, ARIMA) & Visualization; Basic ML - SKLearn - Training, Testing, Validation, SVM, DT, RF, LR; Basic NLP - Spelling Correction, POS Tagging, Sentiment Analysis, Word Vectors, Application; Basic Image Processing - Image loading, Transformations, Denoising, Edge Detection, Application; Graph Analysis - NetworkX, Gephi and Neo4J; Data Storage and Search: SQL, MongoDB, Elastic Search.

DSL253 Statistical Programming

2 Credits (1-0-2)
Prerequisite(s): MAL403
Overlap with: NA

Probability and statistics review: distributions; Sampling and Descriptive Statistics, Statistical measures; Estimation and Hypothesis Testing; Resampling Techniques, and Bootstrapping.

DSP301 AI and Machine Learning Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: NA

Design and implementation of AI and machine learning models for image processing; Design and implementation of AI and machine learning models for speech processing; Design and implementation of AI and machine learning models for NLP; Design and implementation of AI and machine learning models for Game playing; Deploy machine learning models on mobile; Developing applications with AI/ML development board/kits.

DSL351 Big Data Analytics

3 Credits (3-0-0)
Prerequisite(s): CSL303
Overlap with: NA

Introduction - Course Introduction, Motivation; NOSQL Databases - Different kinds of NOSQL databases and their use cases; Design of distributed program models and abstractions,- MapReduce, Dataflow and Vertex-centric models, for processing volume, velocity, and linked datasets, and for storing and querying over NoSQL datasets Translation of existing architectures to big data- Approaches and design patterns to translate existing data-intensive algorithms and analytics into these distributed programming abstractions. Distributed software architectures- Distributed software architectures, runtime and storage strategies used by Big Data platforms, such as Apache Hadoop, Spark, Storm, Giraph, and Hive to execute applications developed; using these models on commodity clusters and Clouds in a scalable manner; Performance Tuning for Big Data - Optimization and performance tradeoff of Big Data systems.

DSP352 Big Data Analytics Lab

1 Credits (0-0-2)
Prerequisite(s): CSL303
Overlap with: NA

Map Reduce Basic Design patterns: Word Count, Summarization, Indexing, Filtering, Top-K, Partitioning, Binning; Map Reduce Advanced Design patterns: Joins, Job Chaining, I/O Patterns; Map Reduce Scheduling with YARN; Hadoop Ecosystem: Pig, Hive, Hbase; Apache Spark; Apache Cassandra; MongoDB; Complete end-to-end pipeline in project mode.

DSL353 Information Security

3 Credits (2-0-2)
Prerequisite(s): None
Overlap with: NA

Cryptography: Cipher, hash function, signature schemes; Computer Security: Buffer/Heap overflow, malware, DDoS, social engineering, access control; Network/Database Security: Firewall, spoofing, VPN, IPSec, TOR, SQL injection, cross-site scripting, network traffic analysis, intrusion detection; Policy: Data protection regulation, sensitive personal identity, digital rights.

DSQ401 BTech Project-I

3 Credits (0-0-6)
Prerequisite(s): None
Overlap with: NA

Research and development oriented projects based on problems of practical and theoretical interest. Students are generally expected to work towards the goals set by the project supervisor. Evaluation is done based on regular presentations, written reports.

DSQ402 BTech Project-II

3 Credits (0-0-6)
Prerequisite(s): None
Overlap with: NA

The student are expected to work towards the goals set in DSQ401. At the end of the project students are expected to demonstrate a solution and possible future work on the same problem. Students need to submit a report outlining the details of the problem, including a literature survey and various results obtained along with their solutions.

DSL501 Machine Learning

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: DSL250 (10%)

Introduction: Types of machine learning- Unsupervised, Supervised Learning- Regression, Classification, Reinforcement Learning; Linear models: Linear Regression- Logistic Regression- Generalized Linear Models- Sparse Modeling and Estimation-Regularization-Evaluating Machine Learning algorithms and Model Selection; Support Vector Machines: Optimization Formulation, Nonlinearity and Kernel Methods- Multi-class/Structured Outputs; Decision Trees: Training and Testing, Entropy Minimization, Regularization; Ensemble Methods: Boosting, Bagging, Random Forests; Deep Learning: MultiLayer Perceptrons, Optimizers, Regularization, Feature. Representation Learning; Deep Computer Vision: CNN architectures, Segmentation; Recurrent Neural Networks; Generative Models: Autoencoders, Generative Models, Diffusion Models; Reinforcement learning: Policy Search, Markov Decision process, Q-Learning.

DSL502 Basic Mathematics for Data science and Artificial Intelligence

3 Credits (2.5-0.5-0)
Prerequisite(s): None
Overlap with: MAL403 (35%), DSL201 (60%), MAL401 (30%)

Brief overview of Linear algebra: Vector Spaces and Subspaces, Orthogonality, Systems of Linear Equations Eigen decomposition and Diagonalization, Low rank Matrix Approximation, Principal component analysis, Matrix factorisation; Optimization: Optimization of Univariate and multivariate function, Fitting model to Data, Linear programming, Gradient Descent, Stochastic Gradient Descent; Probability and Statistic: Probability and Random Variables, Discrete and Continuous Probabilities, Density function and estimation, Expected Value, Variance, Joint, Marginal, and Conditional Distributions, Bayes' Rule, Statistical Independence, Model Given Data. Transformation of random variables. Geometry of high-dimensional space.

DSL503 Advanced Data Analytics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: Network Science (15%) and DS503 (100%)

Near Neighbor Search in High Dimensional Data, Locality Sensitive Hashing (LSH), Dimensionality reduction, Clustering of High Dimensional Data, Cluster Visualization.
Network Analysis, influence maximization; disease outbreak detection, social network analysis.
Representation learning and Graph Neural Networks; Label Propagation, Heteroenous Graphs, Scaling up GNNs on large graphs; Reasoning over Knowledge Graphs.
Advanced techniques for Time Series analysis: Motifs, Anomaly detection, Matrix Profile Technique, Visualization of Large Time Series Data.
Streaming Algorithms: Stream Data Model, Stream Queries, Sampling, Bloom Filters, Moment Estimation, CountDistinct, Counting Ones in a Window, Decaying Windows.

DSL504 Natural Language Processing

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: DS504 (100%)

Basic Text Processing: Tokenization, Stemming, Spelling Correction;
Language Modelling: N-grams, smoothing; Morphology, Parts of Speech Tagging;
Syntax: PCFGs, Dependency Parsing;
Semantics: Topic Models; Distributional Semantics; Lexical Semantics, Word Sense Disambiguation, Word Vectors;
Deep Learning for NLP: Basic and Advanced Models (Seq-to-Seq, CBN, BERT)
Information Extraction and NLP tasks: Relation extraction; named entity recognition, coreference resolution, sentiment analysis, document summarization.

DSP505 Programming Lab for Data Science and Artificial Intelligence

2 Credits (1-0-2)
Prerequisite(s): None
Overlap with: DSP252 (40%)

Basic Python Coding and Data handling - Lists, Dictionary, Tuples, Sets, Functions/Recursion, File Handling, Numpy, Pandas; Visualization and Dimensionality - Histograms, Plots (matplotlib, seaborn, and plotly), Dimensionality Reduction and T-SNE; Basic ML - SKLearn - SVM, DT, RF, LR; Deep Learning - Running LSTM, CNN, Transformer using Pytorch/Tensorflow; Low Code Data Analysis and Visualization Tools: Tableau/Alteryx; Graph Analysis - NetworkX, Gephi and Neo4J; Data Storage and Search: SQL, MongoDB, ElasticSearch; Data Scraping – Crawling using API, Scraping Html/CSS, Legality; Big Data handling - Map-Reduce, Hadoop.

DSL506 Deep Learning for Computer Vision

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: NA

Introduction and Overview: Course Overview and Motivation; Introduction to Image Formation, Capture and Representation; Linear Filtering, Correlation, Convolution.
Visual Features and Representations: Edge, Blobs, Corner Detection; Scale Space and Scale Selection; SIFT, SURF; HoG, LBP, etc.
Visual Matching: Bag-of-words, VLAD; RANSAC, Hough transform; Pyramid Matching; Optical Flow.
Convolutional Neural Networks (CNNs): Introduction to CNNs; Evolution of CNN Architectures: AlexNet, ZFNet, VGG, InceptionNets, ResNets, DenseNets.
CNNs for Recognition, Verification, Detection, Segmentation: CNNs for Recognition and Verification (Siamese Networks, Triplet Loss, Ranking Loss); CNNs for Detection: R-CNN, Fast R-CNN, YOLO; CNNs for Segmentation: FCN, SegNet, U-Net, Mask-RCNN.
Recurrent Neural Networks (RNNs): Review of RNNs; CNN+ RNN Models for Video Understanding: Spatio-temporal Models, Action/Activity Recognition.
Attention Models: Introduction to Attention Models in Vision; Vision and Language: Image Captioning, Visual QA, Visual Dialog; Spatial Transformers; Transformer Networks
Deep Generative Models: Review of (Popular) Deep Generative Models: GANs, VAEs; Other Generative Models: PixelRNNs, NADE, Normalizing Flows, etc.
Variants and Applications of Generative Models in Vision: Applications: Image Editing, lnpainting, Superresolution, Variants: CycleGANs, Progressive GANs, StackGANs, Pix2Pix, etc.
Recent Trends: Zero-shot, One-shot, Few-shot Learning; Self-supervised Learning; Reinforcement Learning in Vision.

DSL601 Information Retrieval

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: DS501 (100%)

Document Indexing: Indexing schemes, Storage and Index Compression.
Retrieval Models: Boolean Retrieval, Tolerant Retrieval, Vector Space Retrieval.
Performance Evaluation: MAP, F1score, AUC-ROC, NDCG.

Probabilistic IR and Language Modelling: Probabilistic Ranking Principle, Binary Independence Model, BM25, Language Model based IR.
Relevance Feedback & Query Expansion: Rocchio relevance feedback, Pseudo Relevance Feedback, Wordnet based Query Expansion, Co-occurrence based query expansion.
Text Classification & Clustering: Naive Bayes, Rocchio Classification, KNN, K means clustering, Agglomerative Clustering.
Web Information Retrieval: PageRank, HITS, Web crawling.
Neural IR: Neural Retrieval Models, Learning to rank.
Advanced Topics: Question answering, Recommender Systems, Explainability in IR, Bias in IR, Multilingual IR.

DSL602 Digital Speech Processing

4 Credits (3-2-0)
Prerequisite(s): NA
Overlap with: DS602 (100%)

Review of digital signal processing: Discrete-time signals and systems, transform representation of signals and systems, fundamentals of digital filters, sampling.
Fundamentals of human hearing and speech perception, Speech production, short-time Fourier transform, acoustic phonetics, Anatomy and functions of the ear, the perception of sound, auditory models, lossless tube models.
Time-domain and Frequency-domain methods for speech processing Short-time analysis (energy, magnitude, zero-crossing rate, autocorrelation), Discrete-time Fourier analysis, short-time Fourier analysis, spectrograms, Overlap-add method of synthesis, filter-bank summation method of synthesis.
Cepstrum and homomorphic speech processing Homomorphic analysis, computing the short-time cepstrum and the complex cepstrum, cepstrum analysis of all-pole models, cepstrum distance measures.
Linear predictive analysis of speech Basic ideas, gain computation, frequency-domain interpretation, solving LPC equations, the prediction error signal, representations of LP parameters.
Algorithms for estimating speech parameters Median smoothing, speech-background discrimination, pitch period estimation, formant estimation
Applications: speech recognition, speech enhancement, speaker recognition, Hidden Markov models for speech recognition, statistical methods for speech enhancement, factor analysis for speaker recognition
* Programming assignment will be given based on the theory taught in the class.

DSL603 Advanced Machine Learning

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: DS602 (100%)

Privacy of data-differential privacy-Differentially Private ML.
Federated learning Convergence Analysis of Federated Learning Algorithms.
Biases and Fairness: Fair representation learning- fairness through input manipulation- Fair NLP-Fairness in vision representations- Fair causal reasoning.
Interpretability and transparency: feature interaction for interpretability- Example and visualization-based methods- interpreting deep neural networks.

DSL604 Machine Learning for Edge Applications

3 Credits (2-0-2)
Prerequisite(s): None
Overlap with: CSL501 (20%), DSL503 (10%)

Introductory Topics: Introduction to Internet of things (IoT) - Edge computing paradigms- Introduction to Machine Learning- Introduction to Neural Networks
Data management: Data Privacy, Scalability
Predictive analysis to support edge application deployment
Image Classification: Applications - Convolutional Neural Networks
Time Series Analysis: Applications – Model Training
Audio Classification: Applications - MFCC – Model Training.
Optimization: Energy Optimization – Latency Optimization – Memory Optimization Debugging
Privacy, Security and Deployment
Integrating cloud, IoT, edge infrastructures: System Modeling and Research Challenges in Federating Edge resources.

DSL605 Deep Learning for Low Resource NLP

3 Credits (3-0-0)
Prerequisite(s): DSL504
Overlap with: DS504 (10%)

Introduction to Natural Language Processing: Language and Types of Language, Phonetics, Phonology, Morphology, Syntax, Semantics, Pragmatics, Discourse Analysis, WordNet, Tokens, Types, BPE, tf-idf, CBOW, Gram-based model, Similarities, Conditional Generation, Document Level Analysis.
Introduction to Deep Learning: Discriminative and Generative models, Models with Latent Random Variables, Teacher forcing, Encoder-decoder models, Attention Mechanisms-Local, Global, Soft, Chunk, Self and Multi-head, ELMo, BERT, BART, GPT, Advanced Search, Adversarial Methods.
Handling Low Resource: Data Augmentations, Fine-tuning, Transfer Learning, Meta Learning, Zero-Shot Learning, Multi-task, Multi-domain and Multi-lingual Learning, Prompting, Bias and Fairness.
Applications of NLP: Opinion Mining, Sequence Labelling, Machine Translation- Inter-lingua, Statistical and Neural, Speech Recognition and Synthesis, Knowledge Base and Reasoning.

Courses offered in the Discipline of Electric Vehicle Technology

EVL500 Electrochemical Energy Conversion and Storage Technologies

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction - origin of energy conversion and storage systems and devices, fossil fuels, the carbon cycle, classification and key parameters of energy conversion and storage technologies; Electrochemical cell, Fuel Cell, PEM Fuel Cells, Solid oxide fuel cells, Electrochemical hydrogen production and storage; Rechargeable batteries and their Fundamental electrochemistry: Lithium batteries, Nickel metal hydride battery, Lead-acid battery, Li-ion batteries, Na-ion batteries, Solid state batteries and Redox flow batteries; Electrochemical double-layer capacitors and supercapacitors, Hybrid capacitors, Super Batteries, their characteristics, efficiency, ageing and application; Electrochemical Energy Storage - key parameters of battery cells, losses and an in-depth look into the processes happening in Lead-acid batteries, Li-ion batteries and Supercapacitors; Chemical Energy Storage - various aspects of (green) hydrogen and (green) methane production; Battery terminologies, Battery design parameters for several Electric Vehicles, Battery Architecture and Engineering; Manufacturing technologies of batteries, Sustainable design of batteries, Hybridization of battery, Battery applications for stationary and secondary use.

EVL501 Introduction of EV and HEV

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: EEL303 - 20%, EVL500 - 10%, EE503 - 15%

Introduction: Need for electrification and challenges, Past present and future of EV, Dynamics of automobile, EV sizing and placement; Architecture of Hybrid and Electric Vehicles: Types of xEV (BEV, PHEV, FCEV, strong and mild hybrid), IC engine for HEV, Series, parallel and series parallel hybrid, transmission in HEV, Design considerations: aerodynamics, rolling resistance, vehicle mass, transmission efficiency; Power electronics for Evs: DC/DC converters (Buck, boost, full bridge, flyback, DAB), Voltage source inverters - topology and PWM techniques, Multi level inverters; Energy storage systems: Li Ion batteries (characteristics, model, degradation), Fuel cell, Battery management systems, Supercapacitors; Electrical Machines and drives for Hybrid and Electric Vehicles: Induction machines, Permanent Magnet synchronous motor, Switched reluctance moto.

EVL502 EV Policies and Regulations

1 Credits (1-0-0)
Prerequisite(s): None
Overlap with: NA

Guidelines and Standards; Battery Electric Vehicles; Charging Infrastructure; Battery Charging/Swapping Stations; Demand-side Incentives for EV, Supply-side Incentives for EV, Development of Manufacturing EV Manufacturing Ecosystem, Recycling ecosystem - Battery and EVs.

EVL503 Motor Drives For EV

3 Credits (3-0-0)
Prerequisite(s): EEL101
Overlap with: NA

Motors Drives- An Introduction; Introduction of motor Drives, Choice of machine Drives for EV, Dynamics of Electrical Drives, Concept of Multi-quadrant and multi-Motor operation, Selection of motor power rating. DC Motor Drives for EV; DC motors and their performance, starting, braking, Transient analysis of various DC motor drives and speed control; Induction Motor Drives- for EV; Scalar control schemes for IM, Analysis, design and simulation of scalar control with slip compensation scheme, Principle of vector control of IM, Direct and Indirect vector control schemes, Principle of direct torque control, its analysis and simulation. BLDC and PMSM Drives for EV; Principle of operation of BLDC and PMSM, Flux weakening operation Torque-speed characteristics, Open loop control and close loop control for BLDC and PMSM motor drives.

EVL504 Energy Storage Technologies

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: EVL501 (10%)

Introduction: Overview of electric vehicle market, Energy storage in power and transportation sectors for sustainable energy systems, scope, importance and opportunities in energy storage for EV. Mechanical energy storage technologies: Mechanical – Pumped hydro, compressed air, flywheel. Chemical energy storage technologies: Chemical – Hydrogen, methane, liquid hydrocarbons, concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects. Thermal energy storage technologies: Thermal – heat pumps, hot water storage tank, solar thermal collector, application of phase change materials for heat storage. Batteries: Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages, Lithium based batteries, Lead-acid battery, Nickel-cadmium battery, Sodium-sulfur battery, Nickel metal hydride battery, Manufacturing technologies, Ragone plots. Fuel Cells: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems. Battery storage systems for EVs: Sizing of EV batteries, Energy density, Amp hour density, energy efficiency, Cost, Operating temperature, number of life cycles, recharge and self-discharge rates and commercial availability.
Battery management system: Objectives of the BMS, Discharging/Charging control, State-of-Charge determination, State-of-Health determination, Cell balancing; BMS topologies, battery design for transportation, mechanical design and packaging of battery packs for electric vehicles, overview of chargers for electric vehicles, charging optimization methods, recycling of batteries from electric vehicles. Other electrical storage systems: Supercapacitors: Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics. Superconducting magnetic energy storage. Special topics: Latest research papers on batteries for EVs, BMS, innovative storage technologies, energy storage systems for renewable-powered EV charging.

EVL600 Battery Chemistry- Components and Manufacturing

3 Credits (3-0-0)
Prerequisite(s): EVL500
Overlap with: NA

Introduction to Battery materials, Battery chemistries and Battery components; Comparison between different battery chemistry w.r.t. specific power, specific energy, safety, lifespan, performance, cost etc ; Mechanism of metal-ion transport, change in oxidation-reduction state and structural features, Charge balancing during charging and discharging of the metal-ion battery; Different electrode materials for Li-ion, Li-S, Na-ion and K-ion batteries ; State of the art cathode and anode electrode materials ; Limits and demerits of the Cathode and Anode materials in different battery chemistries ; Synthetic methodologies of cathode and anode materials; Selection criteria for electrolytes, separator, conductive additives, binder, current collector and other components of the battery ; State of the art for the electrode manufacturing technologies including wet and advanced dry electrode technologies; In depth understanding of key electrode processing steps and key battery assembly stages; Manufacturing or processing constraints ; Manufacturing of batteries of different formats including Coin cell, Pouch cell, Prismatic cell, cylindrical battery, Hexagonal prism battery, Tab-less battery etc.; Different testing protocols and battery terminologies such as Capacity, Cycle life, SOH, SOC, SOD, DOD, DOC, BMS, C-rate, Ragone plots, Energy density, Power density, Volumetric capacity etc., Factors influencing the performance of batteries like temperature, cycling speed, voltage etc.

Courses offered in the Discipline of Electrical Engineering

EEL101 Basic Electrical Engineering

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: NA

DC and AC Circuits: Voltage and current sources, Dependent Sources, Kirchoff current and voltage laws, Star-Delta, Superposition, Thevenin and Norton Theorems. Telegen, Millman, Compensation, MPT Theorems. Phasor, Complex Impedance and Complex Power. Analysis of single-phase ac circuits in complex domain, Resonance. LTI System. Balanced Three-phase circuits in star and delta connections. 3 phase wattmeter, Energy meter.

Transformers: Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

Electrical Machines: Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single Phase Induction Motor. Construction, working, torque-speed characteristic and speed control of separately excited and self-excited dc motor. Stepper motors and encoders.

Electrical Installations: Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.

List of Experiments: Basic safety precautions. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Characteristics of practical resistors, capacitors and inductors; Impedance calculation in RL, RC and RLC Circuit. Voltage and Current Phasor, Signal parameters, Resonance in RLC. Non sinusoidal Signals; Transformers: Observation of the no-load current waveform on an oscilloscope (non-sinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary voltages and currents, and power; Three-phase transformers: Star and Delta connections. Voltage and Current relationships (line-line voltage, phase-to-neutral voltage, line and phase currents). Phase-shifts between the primary and secondary side. Cumulative three-phase power in balanced three-phase circuits; Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), and single-phase induction machine.

EEL201 Circuits and Systems

4 Credits (3-1-0)
Prerequisite(s): EEL101
Overlap with: EEL205 (5%)

Analog Signals: Introduction to Signals – Fourier Series (Trigonometric and Exponential) – Fourier Transform – Reconstruction of Signals – Symmetry; Laplace Transform: Origin of LT – Fundamental

Formula – Laplace Transform of Signals – Application on Circuit Analysis – Inverse LT – Initial Condition; Time Response: LTI System – Transfer Function – Pole and Zeroes – First and Second Order System – Time Response Parameters – Steady State – Final Value Theorem; Two Port Network: Definitions – Types (Z, Y, ABCD, Inv. ABCD, g, h) and Parameters – Interconnection – Inter-conversion; Circuit Synthesis : Nullator and Norator – Foster I and II – Coyer I and II; Filters: Introduction – Types (LP, HP, BP, BR and AP) – Transfer Functions (First and Second Order) – Butterworth Filter – Chebyshev and Inverse Chebyshev Filter – Elliptical Filter (Brief idea) – Passive Realization – Active Realization – Twin T Notch – PSpice Simulations.

EEL202 Analog Circuits

4 Credits (3-1-0)
Prerequisite(s): EEL101 and ECL101
Overlap with: ECL101 (10%)

Introduction to Analog Electronics, MOS and BJT transistors, Diode circuits; MOSFET amplifiers – amplifier design, small signal analysis, current sources/mirrors; BJT circuits, Differential amplifiers, Multi-stage amplifiers, OP-AMPs, OP-AMP circuits; Frequency response of amplifiers, Power amplifiers, Oscillators, Voltage regulators.

EEL203 Digital Circuits

2 Credits (2-0-0)
Prerequisite(s): ECL101
Overlap with: NA

Introduction to digital systems – logic families, Combinational Circuits – Logic gates, Boolean Algebra, gate-level minimization, Circuit design and implementation, Adders, Comparators, Multiplexers, Decoders/encoders, Applications; Data storage elements – Latches, Flip-Flops, Registers, Memory; Sequential Circuits – State tables and diagrams, State representation in HDLs, Timing in sequential circuits, Shift register, Counters.

EEL204 Engineering Electromagnetics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: PHL101 (10%) and EEL101 (10%)

General field properties; Review of vector calculus and coordinate systems; static electric fields, static magnetic fields; Biot-Savart and Ampere's laws; Boundary value problems and method of images; Magnetic vector potential; Materials: dielectric and magnetic materials, their properties, capacitance and inductance, applications, Transformers and electrical machines; Time-varying fields and Maxwell's equations in differential, integral and phasor forms. Wave equation, Transmission lines, Smith Charts, Impedance matching; Waveguides and Antennas (12 lectures).

EEL205 Control Systems

4 Credits (3-1-0)
Prerequisite(s): EEL201
Overlap with: EEL201 (2%)

Introduction: Open loop and Closed loop – Feedback and Feed forward – Block Diagram – Noise and Disturbance – Transfer Function – Order, Type, Pole and Zero; Modelling: Physical System Dynamics– Block Diagram Reduction – Mason's Gain Formula – Analogous System; Time Response: First and Second Order Transient – Steady States – Impulse, Step and Ramp Response – Performance Indices – Effect of Zero – MATLAB simulation; Stability: BIBO stability – Asymptotic Stability – RH Criteria – Root Locus – Root Contour; Frequency Response: Frequency Response – Resonant Peak of Second Order System – Polar Plots – Bode Plots – Nyquist Plots – Principle of Augmentation – Relative Stability – GM, PM, GCF, PCF – Non-minimal Phase System – Transportation Lag; Compensators : Lead – Lag – Lead Lag – Design using Time Response Analysis – Simulation – PID Controller; State Space Control – State Variables – Uniqueness – Transfer Function – Transformation Matrix – Eigen Values – Minimal Representations – Generalized Eigen Vector – State Transition Matrix – Controllability – Observability – State Feedback Control - State Observer – MATLAB Simulation.

EEL206 Electrical Machines-I

3 Credits (3-0-0)
Prerequisite(s): EEL101
Overlap with: NA

Introduction: principle of Electromechanical Energy Conversion, DC circuits, and single phase and three phase AC circuits, magnetic circuits; Transformers: Introduction, Amp-Turn balance, Ideal and Practical Transformers, Equivalent circuit and reduction of leakage, Open circuit and short circuit tests, Determination of equivalent parameters, voltage regulation and efficiency, per unit notation of transformer, Introduction to Three phase and Auto transformers; DC Machines: Principle of operation and construction features of DC machines, EMF and torque equations, generator operation, type of DC machines, characteristics for DC motor and DC generators, Armature reactions, starting and braking operations, commutations, speed control of DC machines. Single phase Induction Machines: Introduction, principle of operation, Double revolving theory, equivalent circuit, method of starting, split phase induction motor (IM), shaded pole IM, repulsion motor, universal motor and series motor.

EEL207 Power System Analysis

3 Credits (3-0-0)
Prerequisite(s): EEL101, EEL201
Overlap with: NA

Power Systems Evolution of Power Systems, Energy Sources Structure of Bulk Power Systems Basic three phase system concepts Power System Components: Generators, Loads, Transformers, Transmission Lines etc.; Modeling of Short, Medium, and Long Transmission Lines; Solution of steady state equations for interconnected systems: Balanced and Unbalanced systems. Positive Sequence Network, Per Unit System, Y-bus formation Simple example of a load flow solution; Introduction to generator swing equations and stability issues, Simple Example of Loss of synchronism Interconnected System Operation and Control: Operational Objectives, Frequency Control, Voltage

Control and Power Flow Control: Analysis of Faulted Power Systems and Protection: Unbalanced System Analysis using Sequence Components.

EEL208 Sensor and Instrumentation

3 Credits (3-0-0)
Prerequisite(s): EEL101
Overlap with: EEL603 (25%)

Introduction: Sensors and Transducers – Basic Block Diagrams – Sensor Parameters (Range, Accuracy, Precision, Nonlinearity, Sensitivity) – Statistical Components – Errors – Noise and Signals; Thermal Sensors: RTD – Thermistor – Thermocouple – PTC Semiconductor sensors – Resistance Bridges – Linearizing Circuit – Amplifiers – Cold Junction Compensation – Numericals; Motion Sensors: LVDT – Induction Bridges – Level Sensors – Capacitance Bridges – Push-Pull Arrangements – Diaphram – Tachogen – Wein Bridge – Accelerometer – Hall Effect Sensors; Force Sensors: Strain Gauge – Bridge Circuits and Gauge Position – Cantilever and Load Cell – Piezoelectric – Charge Amplifier – Bourdon Gauge; Flow Sensors: Flow Types – Reynold's Number – Bernoulli Theorem and Continuity Theorem – Pitot Tube – Orifice Plate– Permanent Pressure loss – Venturimeter – Ultrasonic Flowmeter – Optical Flowmeter – Vortex Flowmeter – Turbine Flowmeter; Chemical Sensors: Moisture Sensors – Gas Chromatography – Voltametry (CV and DPV) – Dopanin Sensor – pH Sensor; Signal Conditioning Circuit : Filters and Instrumentation Amplifiers – CMRR – GBP – ADC– Resolution of a meter – LoD; Data Analysis – Regression Model – Calibration and Standards – Inverse Function – Python Programming – LCD Display – Online Data Transmission.

EEP209 Devices and Circuits Lab

1.5 Credits (0-0-3)
Prerequisite(s): ECL101, EEL101, and EEL202
Overlap with: NA

MOSFET - Determination of equivalent Model by AC small signal analysis; Op Amp - Open and closed loop characterization, Bode plots, Realization of Inverting and non-inverting amplifiers; Mathematical operation with Op amps - summing, differentiating, log and antilog amplifiers, integrator and differentiator; RC and RLC circuits - C-V characterization, time and frequency response, resonance; Twin-T network - Determine of two port parameters (Z, Y, ABCD and hybrid parameters) study on filtering action of Twin T; Signal generators and Multivibrators-Sine, Square and Triangular wave generator; Design of Active filters: Sallen-key and State variable filters; Gyrator circuits: Op amp-based inductor realization and negative resistors; Evaluation.

EEP210 Digital Electronics Lab

1.5 Credits (0-0-3)
Prerequisite(s): ECL101, EEL203
Overlap with: NA

To make hands-free with FPGA Board (Spartan 6) using Xilinx 14.7. When the push button is pressed, led turns ON and otherwise, it remains OFF; Write a Verilog code (Behavioural) to implement A + B. Assume that A and B are 4 Bit Binary numbers. Simulate and implement in hardware. And Write a Verilog code (Behavioural) to implement A - B. Assume that A and B are 4 Bit Binary numbers and A >= B. Simulate and implement in hardware; Verilog code to implement sector blocks and control line

simulation and hardware design over the FPGA board; Verilog code to implement BCD to 7 seven-segment display interface circuit; Implement up counter (0-9) display the result in 7 segment display. Use a slow clock so that manually the output can be visualized; Verilog code to implement Johnson Counter on the FPGA board; Verilog code to Switch de-bouncing and state machines.

EEL301 Electrical Machines-II

2 Credits (2-0-0)
Prerequisite(s): EEL206
Overlap with: EEL101 (5%)

Three Phase Induction Machines: Introduction, construction, principle of operation, types of three-phase induction motors, rotating magnetic field, emf equation of an AC Machine, effect of slip, torque developed in an induction motor, equivalent circuit model, torque-speed characteristics, cogging and crawling starting & its speed control. Synchronous Machines: Construction, principle of operation of synchronous machine, A.C armature windings, equivalent circuit, phasor diagrams, voltage regulation, parallel operation, synchronization, Power Angle characteristics, effect of field excitation change, Synchronous Motor, principle, starting, hunting, damper windings.

EEL302 Digital Control

4 Credits (3-1-0)
Prerequisite(s): EEL205
Overlap with: EEL601 (30%)

Discrete System: Discrete Time System and Signal – Difference Equation – Z-Transform – Inverse Z Transfor – Discrete Transfer Function – FIR and IIR Filters (Butterworth, Chebyshev); Discretization: Sampling – Reconstruction – Nyquist Frequency – Aliasing – Frequency Response (DFT) – Sample and Hold Operation – Ideal Sampler – Step and Impulse Invariance – Rectilinear Method – Bilinear Method – Warping; Discrete System Stability: System Modelling – Solution of Difference Equation – Convolution Sum – Stability – Location of Poles – Jury's Criteria – Stability Analysis through bilinear transform – MATLAB Simulation ; State Model: Minimal Realization – State Transition Matrix – Controllability and Observability – State Feed Back Controller – State Observer – MIMO system; Digital Controller: Dead time modelling – Tuneable PID Control – Digital temperature Control – Stepper Motor Control – PLC – Dead beat control by SFC and deadbeat observers; Fuzzy Control – Fuzzy quantification of knowledge – fuzzy inference – fuzzy controller – GA.

EEL303 Power Electronics

3 Credits (3-0-0)
Prerequisite(s): EEL201 and EEL202
Overlap with: NA

Introduction and motivation: History of power electronics: applications in Renewable energy- Electric vehicles- industrial drives- SMPS; Power semiconductor devices: Diode- Thyristor- Triac- GTO- MOSFET- IGBT-Materials (Silicon, Silicon Carbide, Gallium Nitride); Controlled and Uncontrolled Rectifiers; 3 phase rectifiers; DC to DC conversion: Buck- Boost- Buck-Boost converters; Single phase and three phase inverters; pulse width modulation techniques.

EEP304 Sensor Lab

1.5 Credits (0-0-3)
Prerequisite(s): EEL208
Overlap with: EEP502 (40%)

Physical Sensor I: Temperature Sensors – Cold junction compensation for thermocouple – linearization of thermistor using bridge circuits; Physical Sensor II: Capacitive and Inductive Sensors– LVDT, Level sensor – Sensor Parameters; Physical Sensor III: Motion sensors– Velocity and Acceleration sensors – flow sensors; Physical Sensor IV: Load cell – 1, 2, 4 bridge strain gauges, Piezoelectric– charge amplifiers; Biomedical Instrumentation: ECG signal processing– Notch Filters– FFT and Digital Filters; Chemical Sensors: Water Quality Monitor – pH – TDS – Conductivity – Urea sensors; Image Processing: Image smoothing – Edge Detection – region-based segmentation – Object Identification; Evaluation.

EEP305 Power System Lab

1.5 Credits (0-0-3)
Prerequisite(s): EEL207
Overlap with: NA

Familiarization with PSCAD/EMTDC and Understanding of Reactive Power and Power Factor Correction in AC Circuits; Obtaining Parameters of a 345 kV Transmission Line and Modeling it in PSCAD/EMTDC; Bus Admittance Matrix Formulation in PowerWorld; Power Flow of IEEE 9 Bus System using MATLAB and PowerWorld; Including Transformers in Power Flow using PowerWorld and Confirmation by MATLAB; Synchronous Generators: To obtain the effect of sudden short-circuit on a synchronous generator; Transmission Line Short Circuit Faults using MATLAB and PowerWorld, and Overloading of Transmission Lines using PowerWorld.

EEP306 Machines Lab

1.5 Credits (0-0-3)
Prerequisite(s): EEL206, EEL301
Overlap with: NA

To Study open circuit and short circuit tests of single-phase transformer; To Study Polarity and Sumpner's test of a transformer; To Study Speed control of a DC shunt motor; To Study V, and inverted V curves of synchronous motor; To Study No load test and blocked rotor tests of a 3-phase induction motor; Determination of the open circuit characteristics of a 3-phase Synchronous generator; Determination of the open circuit characteristics of a DC shunt generator.

EEP307 Instrumentation Lab

1.5 Credits (0-0-3)
Prerequisite(s): EEL208
Overlap with: EEP502 (20%)

Design of Autocar: Line following – Obstacle Avoidance – Motion Change; Point of Care Health Monitor: Artificial Body Fluids – Disposable Sensor Fabrication – Experimentation – Data Analysis – App Development; Environment Monitoring: Soil Moisture Sensor – NKT Sensors – Parameter

Adjustment – Remote Sensing; Computer vision: Face, Facial Expression Recognition – Image Fusion – Gesture Recognition.

EEP308 Control Lab

1.5 Credits (0-0-3)
Prerequisite(s): EEL205
Overlap with: EEP501 (35%)

Time response and Frequency Response: Transients – Parameters – Stability Margins; Control of DC motor: Motor Model – Control Algorithm – Speed Control – Position Control; Electronic Compensator: Analogous System – Transient Study – Compensator Design; PLC: Basic Instruction – Sequencing – Case Studies; Dynamic stability control of cart pendulum system and Maglev; Digital Control: State Feedback – State Observer; Evaluation.

EEP309 Power Electronics Lab

1.5 Credits (0-0-3)
Prerequisite(s): EEL201, EEL207, and EEL303
Overlap with: EEP521 (35%)

Study the device characteristics; Gate or Base drive triggering circuit; Study various SCR commutation circuits; Single phase controlled and uncontrolled rectifier; Three phase controlled and uncontrolled rectifier; Study of DC-DC convertors; Study of Flyback convertors; Speed Control of DC Motor; Study of 3 phase inverter.

EEP501 Control System Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: EEP308 (28%)

Modelling of PMDC motor: Modelling – identification – Disturbance observer; Speed and Position control of PMDC motor: Ziegler-Nichols tuning; Close loop control of power converter: PID tuning using GA, PSO and MA based optimization; Emulation flight dynamics of aerial vehicles: Course and Elevation; Loop closure control of aerial vehicles: Design and MATLAB simulation; Non-linear Control of Two tank system; Dynamic stability control of cart pendulum system; Study on Maglev; Digital state feedback control for PMDC motor; Evaluation.

EEP502 Instrumentation Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: EEP304 (40%), EEP307 (14%)

Physical Sensor I: Temperature Sensors – Cold junction compensation for thermocouple – linearization of thermistor using bridge circuits; Physical Sensor II: Capacitive and Inductive Sensors– LVDT, Level sensor– Study on linearity, gain error and offset error, hysteresis, calibration and sensitivity; Physical Sensor III: Motion sensors– Velocity and Acceleration sensors; Physical Sensor IV: Load cell – 1, 2, 4 bridge strain gauges, Piezoelectric– charge amplifiers; Signal conditioning circuits: Oscillators– IA– Filters; Biomedical Instrumentation: ECG signal processing– Notch Filters– FFT and Digital Filters;

Chemical Sensors: Glucose sensors– Selectivity, Data analysis and Machine Learning; Robot Car movement: Proximity sensors – Track identification; Image Processing: Image smoothing – Edge Detection – region-based segmentation – Object Identification; Computer vision: Face, Facial Expression Recognition – Image Fusion – Gesture Recognition.

EEL509 Power Electronics

3 Credits (3-0-0)
Prerequisite(s): EEL20X, EEL15X
Overlap with: EE509

Power semiconductor devices: Diode- Thyristor- Triac- GTO- MOSFET- IGBT- Materials (Silicon, Silicon Carbide, Gallium Nitride), Controlled and Uncontrolled Rectifiers, 3 phase rectifiers, DC to DC conversion: Buck- Boost converters. Single phase and three phase inverters. Pulse width modulation techniques. Group Project Presentations.

EEL521 Renewable and Distributed Energy Systems

3 Credits (3-0-0)
Prerequisite(s): EEL303
Overlap with: NA

Introduction to Energy Resources: Introduction to Energy sector and Energy economics, Energy for sustainable development, Review of Renewable and Non-renewable Energy sources. Wind Energy Conversion System: Modeling of wind resource, aerodynamic characteristics, wind energy generators steady-state and dynamic modeling, electrical and pitch controller design, effect of induction generators on grid operation. Solar Energy Conversion System: Solar Photovoltaic systems steady state and dynamic modeling, MPPT operation, power electronic systems for solar PV Distributed Generation, power converter topologies for grid interconnection, inverter modelling, control of grid interactive power converters, synchronization and phase locking techniques, current control, and recent trends in DG interconnection. Microgrid – Introduction. Introduction to Fuel Cell and Hydro energy Systems: electric equivalent circuits of fuel cells, mini and micro hydro, small hydro systems, Different types of hydro turbines, generators & their controls.

EEP522 Power Electronics Lab

1.5 Credits (0-0-3)
Prerequisite(s): EEL621
Overlap with: NA

Simulate the power electronic circuits in Matlab/pscad/ltspice; Generate gate pulses using TL494/SG3525; Selection and identification of HW components; Design magnetics; Open loop hardware; Closed loop control; Realization in PCB (Eagle/Kicad/Diptrace).

EEP523 Power System Lab

1.5 Credits (0-0-3)
Prerequisite(s): EEL622
Overlap with: NA

Including an HVDC Transmission Line for Power Flow Calculations in PowerWorld and Modeling of Thyristor Converters in PSCAD/EMTDC; Power Quality: To obtain the current harmonics drawn by power electronics interface; Voltage Regulation; To study the effect of real and reactive powers on bus voltages; Modeling of Thyristor Controlled Reactors (TCR); Modeling of Thyristor Controlled Series Capacitors (TCSC); To calculate transient stability in a 3-bus example power system; AGC using Simulink and Economic Dispatch using PowerWorld; Switching Over-Voltages and Modelling of Surge Arresters using PSCAD/EMTDC; Lightening and TOV Studies

EEL601 Advanced Control Theory

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: EEL302 (30%)

State Variable Modelling: linear vector space and State model – Invariance – Generalized Eigen Values and Eigen Vectors – Minimal realization of SISO, SIMO, MISO transfer function – State Transition Matrix – Controllability and Observability; Modern Control Design: State Feedback Controller – State Observer – Control Observer based controller design– Reduced order observer design– Internal stability of a system– Singular Value Decomposition (SVD) – Model decomposition and Decoupling by state feedback– Disturbance rejection, sensitivity, and complementary sensitivity functions; Digital Controller: Discretization (Impulse Invariance, Bilinear etc) – FIR and IIR Realization – DFT – Aliasing and Frequency Warping – Solution to Difference Equation – Z domain Transfer Function – State Transition Matrix – State Feedback Controller and State Observer in Discrete Domain – MATLAB Simulation; Nonlinear System: Fundamental Nonlinearity – Describing functions – Examples: Cart Pendulum etc. – Linearization, input-state linearization, input-output linearization – Jacobian – Phase plane analysis – Singular points characterization– Limit Cycles– Lyapunov Stability Criteria– Aizermans and Kalmans conjecture; Nonlinear Control: Lure Problem– Popov's hyperstability theorem– Disturbance issues in nonlinear control– Concept of variable-structure controller and sliding mode control– Application: flight control, magnetic levitation and robotic manipulator.

EEL602 Advanced Sensing Techniques

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: EEL208 (25%)

Physical Sensors: Thermal Sensors – Motion Sensors – Force Sensors – Flow sensors – MEMS Sensors; Signal Conditioning Circuits: Bridges – Op amps – IA – Filters – FIR and IIR Filters; Chemical Sensors: Optical chemical sensor – biochemical sensor – enzyme sensor – Sensor array – Lab on chip/senor platform technology; Data Analysis: Statistical Parameters – Principal Component Analysis – Machine Learning Classifiers – Neural Network in designing Sensor Array; Sensors for Control Application: Robot Sensors Introduction – Vision sensors – Robotic Perception – Exteroceptive Sensors – Tactile Sensors – Interoceptive Sensors; Reconstruction: Feature extraction – State estimation – Kalman Filter – Multi Sensor Fusion – Environmental modelling.

EEL603 Optimal Control

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Static Optimization: Introduction – Constraints and Classifications – Sylvester's Criteria – Hessian Matrix – Unconstraint Optimizations – Steepest Descent Method – Conjugate Gradient Method – Constraint Optimizations – Lagrange Multipliers, KKT Conditions – Convex Optimizations – Linear Programming; Dynamic Optimization: Calculus of Variation – EL Equation – Two points / single point boundary value NL problem – Transversality Condition – Hamiltonian – MATLAB Simulation – Bolza Problem; Optimal Control: Finite time and Infinite time Linear Quadratic Regulator (LQR) – Hamiltonian System – Matrix Differential Riccati Equation (MDRE) – Algebraic Riccati Equation (ARE) – Gain scheduling, Model reference and Self-tuning control problem – Evolutionary methods – Genetic algorithms – MATLAB Toolbox; Robust Controller Design: Concept of close loop robustness and sensitivity analysis – Kharitonov theorem – uncertainty models and Quantitative Feedback Theory (QFT) for robust design – State estimation in noisy environment – Recursive least-squares filters – Optimal & Robust State Feedback Control – the separation principle – Linear Quadratic Gaussian – H-alpha framework.

EEL605 Digital Image Processing

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Fundamentals – Visual perception, image representation, image sampling and quantization, image interpolation; Intensity transformation – point operations and transformations for enhancement, histogram equalization; Spatial filtering – convolution, linear and order statistic filters, unsharp masking, image smoothing, specialized filters (Gaussian, Laplacian, etc.). Image Transforms and Transform domain processing – discrete Fourier transform, discrete cosine transform; Image restoration – using spatial filters, Weiner filter. Image Segmentation – edge detection, thresholding, binarization, region-based segmentation. Morphological image processing – erosion and dilation, opening and closing, hit-or-miss transform, thinning and shape decomposition. Image compression – fundamentals, lossless coding, predictive coding, transform coding.

EEL621 Advanced Power Electronics

3 Credits (3-0-0)
Prerequisite(s): EEL303
Overlap with: NA

DC-DC converters: Analysis and detailed design of buck, boost, buck-boost, Continuous and discontinuous current modes of operation; Introduction to higher order converters: SEPIC, Cuk, Zeta converters; Isolated DC/DC converters: flyback, forward, Push-pull, full bridge.; Soft switching converters: resonant and Dual Active Bridge converter. Analysis and control of DC/DC converters: State space averaging, Linearization, small-signal modeling of dc-dc converters; Review of linear control theory; Voltage mode and current mode control design methods; AC-DC PWM rectifiers; Power quality issues; Boost and flyback converter-based power factor correction circuits; (PFC) Models, design, and control of PFC; Full bridge bi-directional PWM rectifiers, applications in front end of motor

drives. DC-AC PWM inverters: Voltage source inverters - topology and PWM techniques; Models of single phase and three phase inverters and control methods; Applications in low frequency AC synthesis; Three-phase PWM techniques; High voltage converters and application; Multi level converters: Neutral point clamp, flying capacitor, Cascade H bridge; Modular MultiLevel converter: structure, control, issues; Miscellaneous topics in power electronics: Gate driver; Sensing and protection circuits; EMI issues and filter structure; Magnetics in power electronics.

EEL622 Power Quality

3 Credits (3-0-0)
Prerequisite(s): EEL303
Overlap with: NA

Introduction to Power Quality: Review of Power quality, terms and definitions, Types of Power Quality Problems, International Standards of Power Quality, Root Causes of Power Quality Problems, power quality monitoring. Load Causes the Power Quality: Various types of nonlinear loads such as converter based nonlinear loads, Current fed type of nonlinear loads, and Voltage fed type of nonlinear loads, Effect of Power Quality Problems. Passive Filters for Mitigation of Power Quality Issue: Power quality mitigation techniques, Passive filters, shunt, series and hybrid configurations, Principal and operation of passive filters, Design and analysis of Passive filters, Resonance of passive filters with supply system and its mitigation. Shunt Active Filters for Mitigation of Power Quality Issue: Principle of operation and control of single-phase Shunt active power filters and single-phase DSTATCOM using DQ Theory, Principal of operation and control of three phase shunt active filters and DSTATCOM, SRF theory-based control, IRPT based control, and Unit Template based control and some adaptive control schemes. Series Active Filters for Mitigation of Power Quality Issue: Principle of operation and control of series active power filters, Control algorithm for Elimination of voltage harmonics, Control algorithm for Elimination of current harmonics, working principle and control of Unified Power Quality Compensator, Specific Power quality control schemes: for Induction motor drives, PMBLDC drives, PMSM drives and SyRM drives.

Courses offered in the Discipline of Electronics and Communication Engineering

ECL101 Basic Electronics Engineering

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: NA

Semiconductor Diode, V-I characteristics of Diode, Half-Wave and Full-Wave Rectifier Circuits. Transistors: Bipolar Junction Transistor, MOSFET: Biasing, Small Signal model, Amplifiers Operational Amplifiers: Ideal Op-Amp, Application of Op-Amp; Diode Characteristics and applications (rectifiers/clipping). Transistors with at least one application (amplification/switching). Op-Amp: Analog to digital converter implementation; Logic Gates and Combinational Circuits: Number Systems and Binary Codes, Boolean Algebra and Logic Gates, DeMorgan's Theorems, Sum-of Product and Product-of-Sum Forms, Algebraic Simplification, Karnaugh-Map Method, Combinational Logic Circuits, Binary Half and Full adder-subtractor, Adders, Comparators, Multiplexers, Decoders/encoders, Parity Generator-Checker; Basic Combinational Circuits. Synchronous and Ripple Counters. (Done using discrete components); Communications: Analog and Digital communication introduction and implementation. Frequency modulation and its circuit using discrete electrical/electronic components, Digital communication using Visible Light Communication (concept of digital communications, using parity bits); FM Demodulator hardware, FM Demodulator in USRP using gnuradio, Visible light communication using Arduino.

ECL501 Computer Communications

3 Credits (2-0-2)
Prerequisite(s): None
Overlap with: CSL351 (25%)

Communication Networks basics. Circuit Switched Networks. Switching Concepts. Layered Architecture, Introduction to DLL Layer. MAC Protocols – Ethernet, Wireless LAN, PON. Network Layer – IP; Routing Algorithms and Associated Protocols; Transport Layer and its performance modelling; Introduction to Queuing. Application of Queuing theory for Design of Circuit Networks. Performance analysis of CSMA CD, CSMA CA; Hands-on with Python network programming.

ECL502 Advanced Digital Communication

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Digital modulation, Baseband signaling and pulse shaping, Passband Pulse- and Quadrature-Amplitude Modulation, Multi-carrier modulation, Maximum-likelihood detection, Whitened matched filter, Viterbi algorithm, Probability of error, Linear equalization, Decision-feedback equalization, Informations theory- source coding, channel coding, channel capacity; Introduction to Digital Communication, Sampling, Quantization, PCM, and Delta Modulation; Probability and Random Process; Channels and Their Models; Information Theory; Bandpass Signal Representation; Digital Modulation Techniques: Pulse Amplitude Modulation, Demodulation Techniques for PAM Signals; PSK (Phase Shift Keying), PSK and QAM (Quadrature Amplitude Modulation); Some Basic Linear Algebra

for Digital Modulation; Frequency Shift Keying (FSK), Pulse Position Modulation (PPM); Biorthogonal Signals, Demodulation; Demodulation: PAM, PSK, QAM, FSK, PPM, etc.; Digital Modulation Techniques: Eye Diagram, Mapper; Calculation of Probability of Error for PAM and Binary PAM; Calculation of Probability of Error for QAM, FSK, and PPM; Calculation of Probability of Error for Biorthogonal Signal Sets, Upper Bound on Probability of Error; Equalizers; Source Coding: Introduction, Huffman Code; Source Coding: Kraft Inequality, Optimal Codes; Source Coding: Block-wise Source Coding, Shannon-Fano-Elias Code; Source Coding: Arithmetic Coding, Lempel-Ziv Code; Channel Coding; Fundamentals of OFDM; Conclusion.

ECL503 Digital IC Design

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction, MOS Transistor Basics and Theory; Threshold voltage, MOSFET I-V and C-V characteristics, characterization of resistive, capacitive elements of MOS devices; Logic implementation by CMOS; Static CMOS inverter and its Transfer characteristics. Transistor sizing, Technology scaling, Gate delay and power models; Static and Dynamic characteristics, Noise margins, Interconnect basics and crosstalk; Logical effort, Electrical effort, intrinsic/extrinsic delay; Circuit topologies and transistor sizing for optimal delay and power; Circuit Styles: Static CMOS circuits, Pass transistor logic, Transmission gate, Dynamic CMOS, Dual-rail-domino logic, Pseudo MOS logic and other families; Combination circuit design with various architectures; Sequential circuit design, Basic understanding, design and timing analysis of sequential circuits like Flip- Flops and Latches; Time borrowing and pipelining; Circuit pitfalls, Clocking techniques, and Layout design basics; Memory design, EEPROM, DRAM, SRAM and sense amplifiers; IOs,Low Power Techniques, Design methods and tools, CMOS testing, System Design Examples; Conclusion.

ECL504 Semiconductor Devices

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Physics of Semiconductor Devices: Introduction of fundamentals, evolution and uniqueness of Semiconductor Technology; Column IV, III-V and II-VI, semiconductor materials and compounds. Basic fabrication steps; Device at thermal and electrical equilibrium, concept of electrons and holes, intrinsic/ extrinsic Semiconductors, carrier concentration, effective mass Fermi level, energy band models and direct/indirect semiconductors; Concept of the Excess carriers, generation and recombination, Injection level, doping, lifetime, scattering, mobility, conductivity, scattering and temperature dependency. Analysis of Semiconductor Devices: Analysis of the semiconductor devices; Drift/diffusion and thermal current; Device modeling using basic transport/ continuity equations and various approximations. PN Junction Diodes and Hetero junction devices: Device at equilibrium, Diode I-V characteristics, forward and reverse bias of the device and mathematical modelling of full operation of the PN junction; Avalanche/ zener breakdown, capacitance modeling, Small-signal equivalent circuit and switching characteristics; Schottky/ ohmic contacts and other type of the diodes like varactor, LED, zener, and Schottky diode. Bipolar Junction Transistor (BJT): History, Device structures and fabrication, Transistor action and amplification, Common base and common emitter DC characteristics; breakdown operation, base width modulation, Small-signal Equivalent circuit vs Ebers Moll model, SPICE model and circuit level applications of the transistors; MOSFET: Metal Oxide Field Effect Transistor History, Device

structures and fabrication, MOS Junction, Mos capacitance, equivalent resistance, C-V characteristics, threshold voltage calculation; I-V characteristics of the MOSFET and second order effects like body effect, channel length modulation, velocity saturation. IDBL, GIDL, and mobility degradation; Common source DC characteristics Small-signal equivalent circuit SPICE level-1 model Differences between a MOSFET and a BJT, Junction FET and MESFET 2. State-of-the-Art Technology and summary of the course: Introduction of FINFETs, LDMOS, Polysilicon emitter transistors, Heterojunctions, 2D electron gas, band alignment, SiGe HBTs, SOI MOSFETs, Floating body effect, Source/drain engineering, Brief introduction to HEMTs, MESFETs and MODFETs; Nanowire Electronics, challenges and future trends and Conclusion.

ECL511 Machine Learning Applications for Wireless Communications

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: Old EE522 (100%)

Introduction to Machine Learning: Overview of supervised, un-supervised, reinforcement learning. Introduction to Communication Systems: Application of ML in various OSI layers of a communication system. Use of ML in Real time schedulers. Connections between signal processing, adaptive filtering and machine learning connections between Weiner filtering and regression techniques in ML, filtering techniques such as FIR, IIR and the deep neural Network architectures such as CNN, RNN. Supervised Learning and its applications in wireless systems. Applications in modulation classification, adaptive modulation and coding mechanisms for wireless systems, etc. Un-supervised Learning and its applications in wireless systems. Use of principal component in massive MIMO system design, auto encoders in wireless communications transceiver design, etc. Connections between wireless communications and machine learning. Hidden Markov model and Viterbi algorithm in convolutional decoders.

ECL527 Machine Learning for Signal Processing

3 Credits (2-0-2)
Prerequisite(s): No
Overlap with: DSL501 (25%)
Introduction to real-world signals: Audio, speech, image, and video. Programming Basics. Review of Digital Signal Processing, Signal Representation and Feature Extraction, Optimization-based feature extraction. Machine Learning (ML) basics: Supervised and Unsupervised Learning for Signal Processing, Classification and Regression. Neural Networks and Deep Learning. Real-world applications of ML in Signal Processing: Audio Signal Classification-Time Series Analysis, Long Short-Term Memory, Convolutional Neural Networks, Speech Recognition-Hidden Markov Models, Gaussian Mixture Models, Image and Video Processing-Generative Adversarial Networks, Transfer Learning, Attention models, Biomedical Signal Analysis-Graph Neural Networks.
Lab Activities: Basic Python programming, Signal Representation and Feature Extraction, Convolutional Neural Networks, Audio Signal Classification, Speech Recognition, Image and Video Processing, Biomedical Signal Analysis.

ECL529 Introduction to Wireless and Cellular Communications

3 Credits (3-0-0)
Prerequisite(s): EE301 or equivalent
Overlap with: EE529 (100%)

Overview of Cellular Systems and evaluation 2G/3G/4G/5G,
Cellular Concepts – Frequency reuse, Co-channel and Adjacent channel Interference, Handoff, Blocking, Erlang Capacity,
Wireless propagation – Link budget, Free-space path loss, Noise figure of receiver,
Wireless propagation – Multipath fading, Shadowing, Fading margin, Shadowing margin, Large Scale Propagation effects and Channel Models.
Wide Sense Stationary Uncorrelated Scattering Channel Model
Antenna Diversity, Wireless Channel Capacity
Introduction to MIMO, CDMA, OFDM.

ECL599 Wireless Communication Security with SDRs

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: EE515 (50%)

Introduction to Wireless Communications using SDRS: Physical layer security schemes, Spreading techniques and their application in jamming-resilient communication. Security analysis of simple systems: Key-Fobs. Bluetooth Security analysis: Protocol Description followed by sniffer analysis. WiFi Security analysis: Protocol Description followed by sniffer analysis. LTE Security analysis: Protocol Description followed by sniffer analysis. Study of attack models for selective protocols.

ECL603 Error Control Coding

3 Credits (3-0-0)
Prerequisite(s): EE301 or equivalent
Overlap with: Nil

Mathematical Preliminaries Groups, rings, fields, vector spaces, linear algebra review. Finite fields: construction, structure of fields, polynomials over finite fields, minimal polynomials, factorization of polynomials.
Linear block codes Generator and parity check matrices, dual code, distance of a code. Decoding linear codes: MAP decoder, ML decoder, standard array and syndrome decoding, bounded distance decoder. Bounds on codes: Singleton, Hamming, Plotkin, Gilbert-Varshamov bounds and asymptotic bounds Weight enumerators, MacWilliams relation for binary block codes. Code constructions: puncturing, extending, shortening, direct sum, product construction, interleaving, concatenation Performance of block codes.
Important algebraic block codes, Cyclic codes, BCH codes, Reed-Solomon codes, Reed-Muller codes and Hamming codes. Berlekamp-Massey algorithm for decoding BCH and Reed-Solomon codes.
Convolutional codes Various formulations of convolutional codes using shift registers, generator sequences, polynomials and matrices, recursive and non recursive encoders Code parameters: constraint length, memory, free distance Structural properties of convolutional codes: state diagram, trellis diagram, non-catastrophic encoders, weight enumerators Decoding convolutional codes: Viterbi and BCJR algorithms, hard decision and soft decision decoding Performance of convolutional codes.
Capacity achieving codes LDPC codes: Tanner graphs, Low density parity check (LDPC) codes, iterative decoding, bit flipping and sum product algorithms, introduction to turbo codes.
Applications in wireless and cellular standards.

ECL604 Signal Processing Algorithms to DSP Architectures

3 Credits (3-0-0)
Prerequisite(s): EE101 or equivalent
Overlap with: EE604 (100%)

Review: Digital systems, DSP, computer architecture. DSP system models; quality metrics and bounds; number representations.
Implementation: dedicated hardware; transforms; resource shoring; Scheduling: time and resource bounds; allocation, binding, scheduling, techniques.

Architectures: Programmable systems: FSMs and microprograms; instruction extensions; peripheral accelerators.
Memory and communication systems: bus structures; DMA; networks-on-chip. Specialized architectures: CORDIC; GPU. Applications in Physical layer of cellular systems Introduction

Courses offered in the Discipline of Liberal Arts

LAL100 Introduction to Communication Skills

2 Credits (1-1-0)
Prerequisite(s): None
Overlap with: NA

Barriers to communication: Basic concepts – Communication Models; Components of communication: Rhetoric and Argumentation Models and Strategies; Strategies for reading: Reading Methods, Skimming, Scanning, Intensive, and Extensive; Towards careful enunciation: Basics of phonetics; Techniques, common pitfalls; Making presentations: Public Speaking vs Presentations – Presentation styles; Structure and content, Persuasive Speech – Non- verbal communication; Handling group discussions: Types of group discussions, Basic structure; Time Management – Strategies; Writing for technical purposes: Fundamentals of Technical Writing – Types of Documents; Structure and Format – Common Pitfalls; Communication for workplaces: Etiquettes of Professional Communication – Situations at Workplace; Communication Ethics.

LAL101 Introduction to Finance

1 Credits (1-0-0)
Prerequisite(s): None
Overlap with: NA

Risk and Return; Time Value of Money and Net Present Value; Asset Pricing Models: CAPM and APT; Modern Portfolio Theory and Diversification; Bonds and Interest Rates; Derivatives: Futures and Options.

LAN102 Speaking & Writing Skills

0 Credits (0-0-2)
Prerequisite(s): None
Overlap with: NA

Recognising competencies: language phobia – everyday language – dismantling preconceptions; Learning words: commonly used words – word associations – idioms; Developing speaking skills: conversing – extempore; Language through literature: reading short stories – reading essays – reading op-eds; Writing skills: sentence formation – paragraphing – composition; Learning through performance: group discussion – skits.

LAN103 Professional Ethics

0 Credits (1-0-0)
Prerequisite(s): None
Overlap with: NA

Understanding Ethics: definitions and theories; Code of Conduct: honesty – integrity – rights and duties; Work ethics: teamwork –ethical decision-making – conflicts of interest; Research ethics:

accountability – confidentiality – consent; Social responsibility: civic responsibilities – environmental accountability – technology and its impact.

LAL200 Macroeconomics

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: LA321 (80%)

Introduction: Circular flow of income; National Income Accounts and Distribution of Income/GDP: concept, methods of measurement, composition; GNP, NNP; Real GDP=nominal GDP-GDP deflator; inflation-Consumer price index; unemployment- natural rate of unemployment- Okun's Law- The Philips curve.
Classical Theory: Economy in long run-factors of production- production function-supply of goods and services; Factor prices-firms demand for factors-division of national income; Demand for goods & services-consumption and investment-goods market equilibrium-financial market equilibrium.
Money and Inflation: Functions, types- role of banks in the monetary system-money supply-instruments of monetary policy-role of central bank- money demand function-Quantity Theory of Money-inflation and interest rates-real and nominal interest rate-Demand for money -hyperinflation-classical dichotomy.
Business cycle theory: Economy in short run- aggregate demand and supply-stabilization policy-IS-LM framework-fluctuations and shocks in IS-LM model-policy analysis- Great depression spending and money hypothesis.
Open economy: International flow of capital and goods-exports-trade balance – trade openness-capital mobility and small open economy-exchange rates-Mundell-Fleming Model-Asian financial crisis 1997 and Financial crisis 2008.
Indian Economy: Fiscal Policy analysis, Functions of Reserve Bank, Monetary Policy Committee, Inflation targeting and Monetary policy analysis.

LAL201 Microeconomics

1 Credits (1-0-0)
Prerequisite(s): None
Overlap with: LA322 (60%), LA346 (10%)

Introduction to microeconomics-scarcity, choice and opportunity cost. Demand and supply analysis-basic concepts, utility, indifference curves, consumer surplus, price elasticity of demand. Production analysis-factors of production, Law of variable proportions, returns to scale. Cost analysis-types of cost, short run and long run cost, revenue function, marginal revenue. Market structure- perfect competition, monopoly, imperfect competition and oligopoly.

LAL202 International Trade

2 Credits (2-0-0)
Prerequisite(s): Nil
Overlap with: Nil

Introduction: International economics-Gains from trade-pattern of trade -International capital market-Trade protectionism – reasons and strategies; India's international trade-World trade overview.
Theory of trade: Classical theories-Mercantilism, comparative advantage theory; offer curves and Terms of Trade; New theories of trade- Factor Endowments, Heckscher-Ohlin Theory, Empirical

evidence on H-O model- Stolper-Samuelson Theorem, Gravity model; Economies of scale, Economic growth and international trade.
International trade policy: Trade restrictions-tariffs, non-tariff barriers, new protectionism policies; Economic integration-Customs Unions, inter-regional trade, trade blocks and free trade Areas; International resource movement; World Trade Organisation (WTO).
Balance of Payments and Foreign exchange market: Capital and current accounts-BoP-Foreign exchange rates-exchange rate determination.
International Monetary System: Price adjustment mechanism with flexible and fixed exchange rates; Income adjustment mechanism-automatic adjustments; Open economy adjustment policies; IMF; International monetary system and policy coordination.

LAL221 Indian Writing in English

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: LA302 (100%)

Introduction to IWE: 'Indianness' in IWE and its interpretations, tracing the beginnings, literary Phases.
Nation and Literary history: Pre-independent literature, Nationalism, Gandhi, nationalist ideals, partition
Society and Caste: Literature of 1950s, Representation of social issues, Problematising caste in literature
Gender and Sexuality: Women in fiction, the gender question, identity.
The resurgence: IWE in the 1980s, Indian fiction as postcolonial literature, regionalism, diaspora.
The contemporary: Postmillennial literature, Commercial fiction, Metro reads, Urbanisation, emerging trends.

LAL222 City in Literature

2 Credits (2-0-0)
Prerequisite(s): Nil
Overlap with: LA305 (100%)
Planning: informality – risk
Home: design – family
Small Towns: community – aspiration
Love: desire – agency.

LAL223 Introduction to Partition Literature

2 Credits (2-0-0)
Prerequisite(s): Nil
Overlap with: LA327 (50%)
Historical background
Testimonies and accounts: Urvashi Butalia's *The Other Side of Silence*
Trauma and memory: Manto's "Toba Tek Singh" and "Khol Do" – Excerpts from Khuswant Singh's *Train to Pakistan* - Excerpts from Bhisham Sahni's *Tamas*
Women's experience – Chughtai's "Roots" – Uttamchandani's "Bhoori" – Manik Bandhopadhyay's "The Final Solution" – Amirta Pritam's "Ode to Waris Shah"
Partition Literature and film – *Garam Hava* – *Meghe Dhaka Tara*.

LAL224 Introduction to Postcolonial Literature

2 Credits (2-0-0)
Prerequisite(s): Nil
Overlap with: LA354 (50%)
Background: the history of colonialism
Defining the key terms: colonialism, imperialism, and postcolonialism
Commonwealth Literature: national vs. postcolonial literature [Rushdie's "Commonwealth Literature does not Exist"]
Eurocentrism: The Orient and the Occident – otherisation [Edward Said's Orientalism – Eduardo Galeano's *Mirrors* – Atwood's "Post-colonial"]
Politics of language: English vs. regional languages – language as cultural capital – class and aspiration [Macaulay's Minute on Indian Education – Ezekiel's "Goodbyr Party for Ms. Pushpa TS" – Fanon on language in *Black Skins, White Masks* – Aime Cesaire's *A Tempest*]
Diaspora: identity and belonging [Vikram Seth's "Diwali" – Mira Nair's *The Namesake* – excerpts from Lahiri's *The Namesake*].

LAL225 Self and Society in Modern India

2 Credits (2-0-0)
Prerequisite(s): Nil
Overlap with: LA360 (50%)
Life writing: autobiography – memoir – biography
Selfhood: self-fashioning – aspiration – privilege
Nation: modernity – decolonisation – globalisation
Gender: womanhood – transgendering - sexuality

LAL226 Experiencing the Indian University

1 Credits (1-0-0)
Prerequisite(s): None
Overlap with: LA353 (100%)
Campus cultures: Universities – institutions
Competition: Anxiety – Friendship
Caste: Meritocracy – reservations.

LAL227 Women's Literature

1 Credits (1-0-0)
Prerequisite(s): Nil
Overlap with: Nil
Introduction to women's writings: Early women's writings – idea of gender.
Women as writer: Stereotypes of women's representation – identity and subjectivity
Sexuality and desire: Problematizing patriarchy – writing the body – performativity of gender
Gender and ethnicity: Feminism of colour – postcolonial feminism
Gendering of space: Space and gender – imagining the nation – feminist writings from India
Post-feminism: Cyborg feminism – contemporary discourses.

LAL228 Travel in the pre-modern world

1 Credits (1-0-0)
Prerequisite(s): Nil
Overlap with: Nil
Introduction: Modes and means of travel – pre-modern cartographies – cultural ethnographies – narrative and archontic power
Trade and Travel: mobility and pluralistic selfhoods – Baghdad, Bulgars and the Khazars – Company pioneers and charlatans – Rus customs and the Seventh Clime
Diplomacy and Travel: Accidental Occidentalism – nascent Orientalism – Statecraft at Samarkand – Agra in European eyes.

LAL242 Basics of Organizational Behaviour

1 Credits (1-0-0)
Prerequisite(s): Nil
Overlap with: LA347 (100%)
The basic nature of Organizational Behaviour
Fundamental Assumptions- levels of organizational behviour
Brief History- Scientific management, Hawthrone studies, classical organizational theory, findings from social science, changes in the infotech age
Disciplines that contribute to OB
Challenges and opportunities due to globalization, workforce diversity and economic pressures, networked organizations, social media
New tides: Responding to the virtual office and work from home.

LAL243 Psychology of Memory

1 Credits (1-0-0)
Prerequisite(s): Nil
Overlap with: LA317 (100%)
Cognition – Understanding memory
Theories of memory – Atkinson and Shiffrin model, the neural networks model
Types of memory – Sensory memory, the working memory and long term memory-semantic, episodic and autobiographical memory.
Forgetting – as a result of interference – as a result of retrieval inhibition – distortion and influence of schemas, repression.
Mnemonic techniques – for improving memory and remembering better
Applications of memory- in Law, clinical psychology, education.

LAL244 Leadership: An Organizational Behaviour Perspective

1 Credits (1-0-0)
Prerequisite(s): Nil
Overlap with: LA324 (100%)
Introduction to organizational behviour.
Understanding the nature of leadership- defining leadership- characteristics of leadership- difference between leaders and managers.

Approaches to leadership- trait and behavioural - great person theory, the big five and meyer briggs characteristics, Blake and Mouton, Ohio and Michigan classifications.
Contingency approach- Fiedler model, Situation leadership theory, Path-goal theory, Leader-participation model.
Contemporary approach- Leaders and followers- leader-member exchange model, dynamics of in-group versus outgroup, charismatic, transactional and transformational leadership, Decision Theory: Vroom and Yettan's Leader Participation Model.
Leadership development- online leadership, selecting leaders, training leaders- 360 degree feedback, networking, executive coaching, mentoring, job assignments, action learning.
Global implications.

LAL245 Concepts of Personality Psychology

1 Credits (1-0-0)
Prerequisite(s): Nil
Overlap with: LA325 (100%)
Introduction to Personality Psychology – what is personality?
Introduction to Schools of Personality Psychology
Selected Trait and type approaches- search for basis traits- Allport and Cattle, the big five personality traits, body type theory, rajas, tamas and sattva theory, Friedman and Rosenman's theory
Psychoanalysis and Psychodynamic approaches- structure of the mind, psychosexual stages of development, neo-Freudians.
Behaviouristic Approach- Skinners, Watson and Pavlov's experiments and theories
Humanistic Approach- Maslow's hierarchy of needs, the study of self-actualizing persons, Roger's theory of the self.
Assessment of Personality- self report tests of personality, projective techniques, behavioural observations, interviews and biological methods.

LAL246 Positive Psychology

1 Credits (1-0-0)
Prerequisite(s): Nil
Overlap with: LA308 (100%)
Introduction brief overview: Shift from the traditional deficit approach to the strengths approach, History of well-being research; Overlaps among well-being concepts
Theories – hedonism – eudaimonism, authentic happiness – pleasant, engaged and meaningful life, PERMA, broaden-and-build, structure of psychological well-being
Contributors to well-being – Genetics, circumstances, actions
VIA Classification: Character strengths and virtues (any one strength in detail)
Assessment of well-being: Tools, methodological constraints, accepted indicators
Applications of positive psychology techniques- positive psychology interventions exercises, and practice.
Criticism and future of positive psychology and The positive side of negative emotions and defensive pessimism.

LAL247 Applied Positive Psychology

1 Credits (1-0-0)
Prerequisite(s): LAL246

Overlap with: LA365 (100%)

Meaning and purpose of applied positive psychology, Theories in applied positive psychology and character strengths- Learned optimism -PERMAH theory- LIFE Model- versions of character strengths, Characteristics of the mind that lead us to move in negative spirals- counteracting these cognitive biases, Internet based interventions and their effects - Techniques and problems related to online interventions - how to make them feasible and effective, Gratitude and closure- introduction to open memories— reframing process— grateful reappraisal, Culture and subjective well-being- interdependent self-construal and independent self-construal— identifying the self in the culture- strategies to use these to improve subjective well-being, Buffering and building mental health— integrated findings on physical health, organizational health, and inter-personal processes- critique and future directions.

LAL248 Understanding Health Behaviour Change

1 Credits (1-0-0)
Prerequisite(s): LAL246
Overlap with: LA365 (100%)

Introduction to theory and behaviour change:
Theory – Concept of theory, The role of theory in Health promotion and disease prevention

Behaviour Change – What is behaviour change? Why Health Behaviour Change (HBC), Disease Prevention and Health Promotion

Theories, models and techniques of health behaviour change:
Behaviour Theories and models: Health belief model, Theory of reasoned action, Theory of planned behaviour, Social cognitive theory, Cognitive stages of change theory, Social ecological model, self-determination theory, Value-Belief-Norm theory, dissonance theory, An integrative model of behaviour, self-regulation model.

Behaviour change Techniques:
Self-monitoring, Motivational interviewing, Goal setting and Action plan, Behaviour substitution, Associative learning, Self-control.

LAL249 Introduction to Understanding Psychological Disorders

2 Credits (2-0-0)
Prerequisite(s): Nil
Overlap with: Nil

Introduction:

Concepts of Abnormality and Psychological Disorders, Classification of Psychological Disorders, Causal factors in Abnormal Behviour, Neurosis and Psychosis: Concept and Difference, Personnel in mental health, Risk of self-diagnosis, Importance of approaching mental health professional and Seeking Help for Mental Health

Anxiety Disorder: (Symptoms and Etiology)
Generalised Anxiety Disorder, Phobia, Obsessive Compulsive Disorders, Panic Disorder Post Traumatic Stress Disorder.

Module 3: Mood Disorder: (Symptoms and Etiology)
Depression and Bipolar Disorder, Suicide

Module 4: Other Psychological Disorders: (Symptoms and Etiology)

Substance Use Disorder, Sleep Disorder, Eating Disorder.

LAL252 Introduction to Stress and Coping

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: NA

Stress: Meaning and nature of stress, types of stress: Stress, Distress, eustress. Physiological response to stress, Hans Seyle's General Adaptation Syndrome, Transactional theory of stress. Source of Stress: Internal factors, External factors, Systemic factors. Impact of Stress: Physical, Emotional and Behavioural level.
Coping: Meaning and definition. Types of coping: A) Adaptive coping styles- Confrontive coping, Planful problem solving, seeking social support, accepting responsibility, positive reappraisal; B) Maladaptive coping styles: Distancing, Escape-Avoidance, Denial, Mental Disengagement.
Stress Management techniques:
Managing stress through physical skills: Simple Breathing Exercise: Deep Breathing, Exhalation Breathing, Restful Sleep, Pranayama and Yoga, Meditation, Progressive Relaxation.
Managing stress through mental skills: Guided Imagery, Ventilate your Feelings, Irrational Thought Control, Reaching the Point of Satiation, The Method of Thought Substitution.
Stress Management at the Behavioural Level: SMART Goals, Develop Positive Disposition, Re-orientation to Work, Countering the Stress of Indecisiveness, Identification and Monitoring of Stress.

LAN710 Research Methodology

0 Credits (0-0-0)
Prerequisite(s): Nil
Overlap with: Nil
Introduction to Research:
Research and Research methodology
Philosophy of research: Research paradigms – Characteristics
Types of research
Identifying research topic: Research objective – Framing research questions – hypotheses
Literature review: why and how
Designing Research Plan
Ethics in Research: Research using human subjects – Significance of informed consent – Preparing an informed consent form – Issues related to authorship – Intellectual Property Rights – Plagiarism
Qualitative Research:
Approaches of Qualitative Research Design: Case Study Research – Grounded Theory Research – Narrative Research – Phenomenological Research – Ethnographic Research – Action Research.
Methods of Qualitative Data Collection and Analysis: Interview – Focus Group Discussion – Content Analysis – Thematic Analysis – Grounded Theory Coding – Interpretative Phenomenological Analysis – Discourse Analysis – Cultural materialism – Feminism – Narratology – Postcolonialism.
Quantitative Research:
Sampling: Concept – Techniques – Determining sample size
Methods of Quantitative Data Collection: Observation – Experiment – Survey
Research in digital age
Data Collection: Tools and methods – Managing data using digital tools – Using online resources for literature review – software and digital applications for data management
Data Management software: Reference Management tools.

LAL711 Modern Indian Literature: Currents and Countercurrents

3 Credits (3-0-0)

Prerequisite(s): Nil

Overlap with: LA710 (100%)

Modernity: *bhashas* – indigeneity – froms
Nation: decolonisation – Partition
Caste: ritualism – Dalits – aesthetics
Cities: everyday – risk – empowerment

LAL712 Cultural Studies: Theory and Practice

3 Credits (3-0-0)

Prerequisite(s): Nil

Overlap with: LA705 (100%)

Key concepts and debates
Debates on culture: Arnold – Leavis – Thompson – Williams
Popular culture and/or mass culture: Adorno – Hall – Fiske
Ideology – hegemony – power: Williams – Althusser – Gramsci – Foucault
Representation – Hall
Modern contexts: Globalisation – Neoliberalism – Social movements shaping questions of identity: gender, class, caste, race and sexuality
Texts and practices: Media – spaces – subcultures – everyday practices.

LAL713 Urban Writing in South Asia

3 Credits (3-0-0)

Prerequisite(s): Nil

Overlap with: Nil

Introduction: Literary canonisation – urban in literature – textuality and form – literary and linguistic registers
Affect and the city: nostalgia and belonging – love and /in the city – uncanny architectures – risk and violence.
South Asian urbanisms: urban histories of South Asia – urbanity in pre-modern literary traditions – modernity, imperialism, and institutionalisation – nationalism, planning, and globalisation
Planning and its imprints: colonialism and planning – parastatals and urban land development – aspirational planning and spectacular accumulation – formal and informal.
Experience home: public and private in South Asia – domestic typologies – livelihood and habitation – homelessness and alienation.

LAL714 Feminist Theory in Literature

3 Credits (3-0-0)

Prerequisite(s): Nil

Overlap with: Nil

Contextualizing Feminist Theory: Introduction of the feminist theory – Feminism-feminine and female – Feminist standpoint theory.
Women in Literary history: Revisiting Literary canon – Women's literary history – Subverting Canonical works – Classical women's literature – Ecriture feminine.
Women's literature in the postcolonial contexts: Feminist theory of colour – Womanism – Writing back from the postcolonial – Feminism in South Asian contexts – Feminist writing in India.
Feminist historiographies: History through feminist perspective – Deconstructing patriarchy in histography – Feminist methodology in Archival work – History of herstory – mnemonic fictions.

Feminist fictions and Intersectionality: Identity formation and woman's question in literary works – Nationalist movement and women's writings – Gender and caste – Subalternity – Women's writings from the margins.

LAL731 Advanced Positive Psychology

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: LA702 (100%), LAL247 (5%)

Introduction: Medical model and its differences with the strengths model. Shift from the traditional deficit approach to the strengths approach.
Historical and philosophical foundations both Western and Eastern.
Determinants of well-being- research, implications and areas to explore the study of Strengths: different strength classifications with focus on VIA (three/four strengths in detail).
The role of negative in positive psychology: charting the domain of uneasy but necessary emotions and experiences- resilience – post traumatic growth.
Positive Health- research and practice, effect of interventions.
Issues in Assessment of well-being: Tools and their standardization, methodological constraints, accepted physiological and psychological indicators.
Prospects, practices and prescriptions for attainment of well-being- Criticism and prospects of positive psychology - practice in clinical, organizational, health, and teaching.

LAL732 Positive Organizational Behaviour

3 Credits (3-0-0)
Prerequisite(s): Nil
Overlap with: LA703 (100%)

Introduction and brief overview- need and call for Positive Organizational Behaviour Understanding what is positive- traits, states and processes.
Understanding POB and Positive Organizational Scholarship (POS) and their differences.
Framework: Psychological Capital and its effects on the workplace
Framework: Work engagement and its effects on the workplace
Understanding the two major methodological challenges in POB
Positive Organizational Psychology in India: Current position of positive organizational psychology in India and identifying the areas which still need to be explored
Interventions in the workplace: effects on well-being and performance, current state of positive psychology interventions at the workplace in India, scope of cross-cultural interventions for influencing workplace well-being and performance, designing a workplace intervention.

LAL733 Statistical Analysis

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MA509 (15%), MA513 (30%)

Unit1: Descriptive statistics
Concept of Statistics, Types: Descriptive and Inferential Statistics, Parametric and nonparametric Statistics, Level of measurement: nominal, ordinal, interval and ratio, Frequency distribution, Measures of Central tendency, Measures of Variability, Normal Distribution.

Unit 2: Inferential statistics
Correlation and Regression: basic aS5umptions; Correlation methods: Karl Pearson's product moment correlation, bi-serial, point-bi-serial, partial, canonical, and multiple correlation Spearman‘s rank correlation; Regression tests: simple linear regression, multiple line regression, non-linear regression, and logistic regression, mediation and moderation analysis; t-test: Independent, paired & one sample test; Analysis of Variance: one-way, two-way, and repeated measures ANOVA, ANCOVA, MANOVA MANCOVA; simple effects, main effect, and interaction effect; Post-hoc testing: LSD, Tuke HSD, Scheffe, Neuman—Keuls test, Protected ‘t-test: Some non-parametric tests: chi-square test, Mann-Whitney U test, Kruskal Wallis H and median test, Wilcoxon sign test, Friedman.
Other: Cluster analysis, principal components analysis, path analysis; structural equation modelling; Meta-analysis; Statistical power of a test; Estimation of effect size; Analysis skills of SPSS, AMOS & jamovi (open source software).
Unit-3: Test construction
Scaling methods: Theories- Classical test theory, item response theory; Steps in test construction, Standard error of measurement
Reliability& Validity: Test-retest-alternate forms-split half, Cronbach's alpha-KR 20-inter scorer reliabilities, content-criterion (predictive and concurrent)-construct (convergent and discriminant) validities, factors affecting reliability and validity.
Item writing: General guidelines, types of items; Item analysis: Item difficulty (method of judgment, empirical method), Item discrimination (test of significance, correlational technique), Item characteristic curve, Item validity (factor analysis- exploratory, confirmatory, discriminant analysis); Norms development.

LAL734 Allied Health Studies

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA
Health: Knowledge and understandings
Meaning and definition of Health, determinants of health, strategies that influence health, frameworks, health measurements, health equity, Global burden of disease and risk factors, Maternal and child health issues, biomedical vs biopsychosocial model, programs — solutions to global health problems, Sustainable Development Goal.
Social, Behavioral factors and Health:
What is Belief, attitude and value, the relationship between beliefs, attitudes and values, Influence of beliefs, attitudes, values and norms on decision making of the health behaviour, theories and models of beliefs, attitudes, values and behaviour change.
Diseases: Prevention, control and management of diseases
Prevention, control and management of Non-communicable Diseases, Communicable Diseases, Neglected tropical diseases, waterborne diseases, vaccine preventable diseases.
Health Programme, Policy and Planning:
Health policy, process and planning, Programme planning and evaluation of public health programmes, Translating research into policy and health advocacy, Current issues in Health Policy: National and global perspective, Role of non-governmental organizations in health care.

LAL735 Culture and the study of human strengths

3 Credits (3-0-0)
Prerequisite(s): None

Overlap with: NA

Introduction to human strengths and different strength classifications- Gallup, Clifton and Seligman and Peterson classifications. Eastern and Western perspectives on strengths- value systems, orientation to time and thought processes. Identification of strengths — methods and tools. Understanding the debate on culture free and culturally embedded research and practice of strengths — individual case studies.

Courses offered in the Discipline of Materials Science and Metallurgical Engineering

MML201 Thermodynamics of Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MEL211 (15-20%); CYL504 (15-20%)

Importance of thermodynamics, definition of thermodynamic terms, concept of states, simple equilibrium; Equation of states, extensive and intensive properties, homogeneous and heterogeneous systems. Phase diagram of a single component system; Internal energy, First law of thermodynamics, heat capacity, enthalpy, isothermal, and adiabatic processes; Second law of thermodynamics, entropy, degree of reversibility and irreversibility, criteria of equilibrium, auxiliary functions, combined statements, Maxwells relations, transformation formula, Gibbs-Helmoltz equation; Concept of Third law, temperature dependence of entropy, statistical interpretation of entropy; Debye and Einstein concept of heat capacity, relation between Cp and Cv, consequences of third law, Fugacity, activity, equilibrium constant, use of S - functions, controlled atmospheres, homogeneous and heterogeneous equilibria. Ellingham Richardson diagrams; Solutions, partial molal quantities, ideal and non-ideal solutions, Raoults law, Henrys law, Gibbs - Duhem equation, regular solution, quasi-chemical approach to solution, statistical treatment. Alternative standard states, interaction coefficients, chemical potential; Phase relations and phase rule-its applications. Free energy-composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines. Effect of pressure on phase transformation and phase equilibria. Phase stability diagrams. Thermodynamics of electrochemical cells, solid electrolytes. Thermodynamics of point defects in solids; Introduction to metallurgical kinetics, Effect of concentration and temperature on the reaction rate, heterogeneous reaction kinetics-gas-solid, solid-liquid, liquid-liquid and solid-solid systems. Empirical and semi-empirical kinetics, concept of Johnson Mehl equation, thermal analysis.

MML202 Structure of Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MML552 (15%), MML254 (20%)

Introduction: Structure of non-crystalline, crystalline, and liquid-crystalline states across length scales, including short- and long-range ordering; Bonding: van der Waal's, ionic, covalent, and metallic bonding; classical versus a quantum mechanical picture of bonding; particle-wave duality, Schrodinger's equation; particle-in-a-box, metallic solid; hydrogen atom, covalent solid; band theory of solids; Defects: point, line and surface defects/imperfections. importance of defects on properties; dislocations and stacking faults; Structures: Crystal structure of the elements. Closed-packed metals-cubic and hexagonal packed structure. Crystal structure of some simple inorganic compounds. Crystals with general formula AXm, ABxCy; Crystal structures; points, directions and planes; unit cell; Bravais lattice; basis; symmetry- translation, rotation, inversion; 32 Crystallographic Point Groups; 230 Space Groups; real and reciprocal Lattices; Brillouin zones; application of reciprocal lattices to diffraction-scattering from electrons, atoms, crystals; structure factor; Diffraction and structure determination.

MML203 Chemical Synthesis of Materials

3 Credits (3-0-0)

Prerequisite(s): CYL100
Overlap with: NA

Introduction: Definition of synthesis; historical examples of key synthetic discoveries; prospects; Review of thermodynamics and kinetics in synthesis; Basics of nucleation and growth processes, ceramic synthesis, Scale-up of synthetic processes; Self-Assembly: Supramolecular self-assembly; Gels; 3D self-assembly; Self-assembling monolayers; Sol-Gel Reactions for Ceramic Synthesis: Synthesis of metal alkoxides; Gelation and calcination; Polymerization: Polycondensations, Addition chain growth, Copolymerization, Living polymerizations, Hyperbranching; Synthesis of Nanomaterials: Solid-liquid interface interactions Influence of reaction conditions on morphological properties of materials; Quantum dots; Nanowires; Carbon nanotubes; combustion methods, Supramolecular Nanostructures; intercalation, and mild methods; Dendrimers; Colloids; Vapor Phase Synthesis: Gas phase reactions; solid substrate-vapor interactions in CVD, PVD. Effect of vapor deposition conditions on growth and morphology thin films; molecular beam epitaxy; Composite Synthesis: Classification of composite materials; Metal matrix systems; Ceramic matrix systems; Polymer matrix systems.

MML204 Phases, Phase Transformations and Properties of Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction to crystal structures, planes and lattice, Defects and dislocations in materials; Principles of solidifications, evolution of microstructures in pure metals and alloys, concepts of grain and grain boundary; Introduction and classification of phase transformations. Diffusion in solids: laws and mechanism of diffusion, phenomenological approach and atomistic approach towards understanding diffusion; Nucleation and growth theories of vapour to liquid, liquid to solid, and solid to solid transformations; homogeneous and heterogeneous nucleation; interface-controlled growth and diffusion controlled growth; transformation kinetics; Iron-carbon alloy system: iron-carbon phase diagram, nucleation and growth of pearlite, cooling of hypo-eutectoid, eutectoid, and hyper-eutectoid steels, development of microstructures in cast irons; Introduction to physical and mechanical properties of materials, Heat treatment of steels: TTT and CCT diagrams, bainitic transformation, martensitic transformation, hardenability, role of alloying elements in steels, conventional heat treatment of steels; Massive transformation. Order-disorder transformation. Phase transformations and heat treatment of some common non-ferrous metals and alloys; Precipitation from solid solution: types of precipitation reactions, crystallographic description of precipitates, precipitation sequence and age hardening, spinoidal decomposition.

MML205 Principles of Extractive Metallurgy

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Mineral dressing, size reduction of solids, selection, breakage and classification function, particle size distributions, minimum sample size for ground material, slurry characterization, Metallurgical accounting and control, principles of flotation, design of mineral flotation circuits,floation columns; General equations of heat, mass and momentum balance, laminar, turbulent flow, concept of boundary layer, friction factor, heat and mass transfer coefficients and dimensionless correlations; Fluid flow and heat transfer in packed and fluidized bed, momentum transfer associated with high velocity gas jet and gas bubbles in liquid. Heat and mass transfer of moving boundary problems involving melting,

solidification and reactions; Radiative heat exchange in transparent and absorbing medium. Refractories and uses; Unit Processes in pyrometallurgy: Fuels for metallurgical processes; Drying, calcination, roasting, pelletising and sintering; Thermodynamics of metal extraction, Slags, classification and properties. Reduction smelting in shaft furnace, alternative reductants, hydrogen as reductant, metallothermic reduction; Reactor design considerations, sizing of fluidized and fixed bed metallurgical reactors; Thermodynamic principles and applications of matte smelting and converting. Flash smelting and submerged bath smelting; Principles of metal refining with examples for metals like copper, nickel, lead, and zinc; design of metal separation using high temperature distillation; Unit processes in hydrometallurgy: leaching, purification of leach liquor, solvent extraction and ion exchange systems and flow sheet design; Unit processes in electrometallurgy: Faradays laws of electrolysis, concept of overvoltage, limiting current density, overall cell voltage, series and parallel electrical circuits in refining. Electrowinning and electrorefining with reference to metals like Cu, Zu, Al and Mg.

MML251 Physical Properties of Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: PH513 (60%), MML202 (10%)

Electron transport in metals, semiconductors, organic semiconductors, transport mechanisms including hopping, hole transport, ionic conductors etc. Dielectric and optical properties of semiconductors and metals, excitons, dielectric constant, polarizability, sources of polarizaility- dipolar, ionic, electronic, complex dielectric constant, dielectric losses, optical transitions, selection rules, absorption, transmission, emission, direct and indirect transitions in inorganic and organic semiconductors. Magnetic Properties, microscopic origin of magnetism, dia-, para-, ferro-, ferri-, and antiferro-magnetism, anisotropic effects, magnetic domains, magnetostriction, soft and hard magnetic materials; Bonding of atoms, Crystal Structure and reciprocal lattice, Wigner seitz cells; Free-electron theory: electron gas, Fermi-Dirac distribution, density of states for electrons, Fermi Energy, Fermi surface, Fermi temperature; Band theory of solids, Bloch Theorem, Brillouin zone, Kronig Penney model, band gap and structure, effective mass, holes, conductivity of metals, semiconductors, impurity contributions, intrinsic and extrinsic semiconductors, carrier concentration, electrical conductivity and mobility of semiconductors, Hall effect, direct and indirect band gap; Lattice dynamics: phonons, Thermal properties, Drude model for electronic conductivity and thermal conductivity; Wiedemann Franz Law.

MMP251 Chemical Synthesis and Characterization Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: NA

Metal/Metal oxide Nanomaterials: Synthesis of Metal/Metal oxide Nanomaterials; Physicochemical characterizatio of Metal/Metal oxide Nanomaterials; Ceramic: Synthesis of ceramic materials; Physicochemical characterizatio of ceramic materials; Polymeric materials: Synthesis of polymeric materials; Physicochemical characterizatio of polymeric materials; Nanocompositie materials: Synthesis of nanocompositie materials; Physicochemical characterizatio of nanocompositie materials .

MML252 Materials Characterization-Scattering and Imaging

3 Credits (3-0-0)

Prerequisite(s): None
Overlap with: MML501 (50%)

Scattering: optical scattering, absorption, transmission, reflection, polarization, excitation and de-excitation; types of radiations; common bases of the spectroscopic/measurement techniques like signal-to-noise ratio, resolution, etc; Diffraction: optical, elastic interaction of X-ray with matter; X-ray scattering techniques, Laue method; crystal structure determination, powder XRD, GI-XRD, X-ray stress measurements; X-ray spectroscopy, Phase diagram determination, residual stress measurement, crystallite size, neutron diffraction, electron diffraction (RHEED etc); Imaging: optical imaging, light optics, microscope components, possibilities and limitations, different modes of microscopy, scanning electron microscopy, secondary electron and backscattered electron imaging, atomic force microscopy, magnetic force microscopy, electric force microscopy etc scanning tunneling microscopy, transmission electron microscopy, STEM; Types of electron-matter interactions and electronic emission; scanning (SEM+EDX) and transmission microscopy (TEM), electronic diffraction (SAED etc), scanning transmission electron microscopy, etc.

MML253 Computational Materials Science and Engineering

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MML554 (20%)

Introduction to computational material science and engineering – Goal and various approaches; Multiscale Simulation Methods – Finite element analysis, Monte Carlo Method, Molecular Dynamics, ab initio methods; Specific computer literacy required for computational material science: Linux, bash scripting, MATLAB; Atomistic theory of matter: Basics of quantum mechanics, Hartree-Fock theory, basis sets; Statistical mechanics of materials: equilibrium and non-equilibrium systems and ensembles, microcanonical, canonical, grand canonical ensembles; Stochastic processes and stochastic modelling: Genetic algorithm for atomic clusters; Introduction to basics of coarse graining in materials simulation: energy-, force-matching, and structure-based coarse graining.

MML254 Mechanical Behavior of Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MML202 (10%)

Force distributions in structures (review); failure in context, Displacement → strain; Internal forces: stress, Tensorial stress and strain; transformations; Introduction to elasticity, plasticity and theory of failure, Elastic constants (atomistic origin), State of stress in 2D/3D, Transformation of stress, Principal stresses, Mohr Circle, Stress-strain relationships in isotropic and anisotropic materials, Viscoelasticity; Mechanical testing of materials : tensile tst, hardness, toughness, etc; Theoretical Strength, Concept of Dislocations, Slip, Burger Vector and Stress and Strain fields of Dislocations, Energy of Dislocations, Forces on dislocation, Line tension, Motion of Dislocations, Peierls Model, Concept of slip systems; Dislocation in crystal systems, Source of dislocations and multiplication, Stacking faults and energy; Strengthening mechanisms : Strain hardening, Solid Solution Strengthening, Precipitation and Dispersion Strengthening, Grain Boundary and Hall-Petch relation, Martensitic Strengthening; Creep, Time-dependent plasticity, Deformation mechanism maps of elastoplasticity; Fracture: Evolution of fracture models: ultimate failure, Microstructural mechanisms of fracture strengthening; Fatigue: Failure below fracture stress: insidious failure, Empirical fatigue models, Microstructural mechanisms of prolonged fatigue lifetime.

MML301 Materials Characterization – Spectroscopy and Other Analytical Tools

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Vibrational spectroscopy: Introduction to vibrational spectroscopy, FTIR Sampling Techniques and Methodology, Beyond mid-IR Spectroscopy and Multi-modal Analysis, Microanalysis using FTIR Spectroscopy, Raman spectroscopy, selection rules, applications of Raman spectroscopy; Scanning tunneling, Auger electron, photoelectron (UV and X-ray) -spectroscopies, X-ray absorption near edge fine structure spectroscopy, X-ray fluorescence, etc; NMR: Fundamentals of the NMR, 1H and 13C NMR. 1D NMR techniques: Decoupling, DEPT, relaxation measurement. 2D NMR techniques: Homo- and heteronuclear correlation (COSY, TOCSY, HSQC, HMBC), measurement of the nuclear Overhauser effect (NOESY, ROESY); Mass spectrometry and hybrid methods: Principles and ion sources, structural analysis, analysis of gas and solutions (Eg: GC-MS, LC-MS); analysis of solid samples; ambient mass spectrometry; Other analytical techniques: Thermo gravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC); dynamic mechanical analysis (DMA), Nanoindentation, BET and Langmuir surface area.

MMP301 Computational Materials Science and Engineering Lab

1 Credits (0-0-2)
Prerequisite(s): MML252
Overlap with: NA

Introduction to Linux operating system; Bash scripting; Introduction to some open source and some commercially available computational tools for Material science; Introduction to LAMMPS software; Modelling simple systems; Introduction to Gaussian and Gauss view; Modelling kinetics of simple chemical reactions, Modelling spectroscopic properties; Introduction to VASP software, Modelling various Solid-State properties; Project, developing own code for genetic algorithm for atomic clusters; Developing own code for simple Monte Carlo simulation.

MML302 Iron making And Steelmaking

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Historical Development: Introduction to history of iron making in India and World; Raw Materials: Iron ore types and properties: Strength, Reducibility, Swelling and Softening tests etc. Prepared Ore Feed: Pellet, sinter and Briquettes. Reductant types and properties: Role of coal & Coke, Coke reactivity index (CRI) and strength after reaction (CSR). Fluxes: Types, properties and its role; Reduction Mechanism of iron ore: Reduction of iron ore by CO, H2. Thermodynamic and kinetic requirements; Blast Furnace process of Iron Making: Construction, Refractories, charging, burden distribution, thermal and chemical profile. Reactions in shaft, bosh and hearth. Control of hot metal composition and temperature. Modern Practices: High top pressure, fuel injection (coal dust injection), oxygen enrichment, humidification and use of pre-reduced burden. Blast furnace operations, problems with remedies. Gas cleaning. Hot blast stove, Pig casting, Slag granulation Instrumentation and automation; Alternative Methods of Iron Making: Need and classification, Coal based rotary kiln and Gas based

shaft method of DRI production. DRI storage and passivation, Principles of smelting reduction; COREX process, Scope of renewable sources of energy in Iron making and iron making industries in India.

MMP302 Industrial Exposure to Metals Processing

1 Credits (0-0-2)
Prerequisite(s): MEL205
Overlap with: NA

Introduction to industrial systems/units involved in metal processing; Systematic study of metal processing chain including Extraction, alloying, solidification, heat treatment and preparation of primary products in the industry environment; Understanding the working principles of essential elements / units like blast furnace, coke oven, sintering plant, ESP, boiler, turbines, etc; The course will be conducted in form of Industrial visits to relevant plant / training labs and will be evaluated based on corresponding viva-voce and reports.

MML303 Polymeric Materials and Engineering

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction: Introduction to “soft” materials. Brief chemical structure/bonding/organic chemistry review. What is a polymer, Fundamental overarching concepts of polymer chemistry and material properties, nomenclature; Polymer Synthesis: Addition polymerization, Step-growth polymerization, condensation reactions, radical polymerization, ionic polymerization, polymerization mechanisms and statistics; Polymer propoerties: Structure, properties and applications of different polymers; Conducting polymers, stimuli responsive polymers and biopolymers.

MMP303 Metallurgical/Metallography Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: MMP501 (50%)

Sample preparation for optical microscopy – Ferrous alloy, Aluminium alloy, Copper alloy, Nickel alloy; Energy dispersive spectroscopy studies to understand the material composition; Etching and microstructure observation using various etchants.

MML351 Technologies of Thin-film Fabrication

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MEL253 (10%)

Brief introduction to thin films. Introduction to vacuum science and Technology, pumping systems, and pressure measurement equipment; Physics of thin film deposition, adsorption, surface deposition, nucleation, growth and structure development, surface structure, role of surfaces, epitaxial growth, lattice mismatch, strain, and growth modes; Physical techniques for thin film deposition: Thermal evaporation, Knudsen cell, Sputtering, E-beam evaporation, spin-coating. Electrospinning; Chemical techniques for thin film deposition: Atomic layer deposition, Chemical vapor deposition (CVD); Other

techniques: dry and wet etching, sol-gel, Electrodeposition, Spray pyrolysis, and Langmuir-Blodgett technique, etc.

MML401 Environmental Degradation of Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction: Corrosion principle – electrochemical and environmental aspects; Forms of corrosion: Mechanisms – characteristics – examples; Testing: Types of evaluation methods – sample preparation – results interpretation; Prevention techniques: Materials – design modification – cathodic-anodic protection – coating.

MMP401 Thin Film Fabrication and Characterization Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: NA

Fabrication of Thin films: Metal oxide thin films using e-beam, sputtering; polymer thin film using spin-coating techniques; Metal thin films using thermal deposition and sputtering techniques; Characterization of thin films; Thickness measurement using profilometer; Morphology and elemental information using SEM/EDAX; Conductivity measurement using probe method; Surface roughness measurement using AFM; Structural properties using XRD.

MML501 Characterization and Testing of Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MML252 (50%)

Introduction: Scope and methods used for materials characterization. Mechanical properties of materials. Microstructural components of materials; Metallographic preparation methods: slicing, mounting, mechanical grinding, polishing – mechanical, electrical. Ion-based. Special technique for TEM preparation; Optical Microscopy: Optical microscopy techniques including polarised light and phase contrast; Quantitative microscopy and its applications; Scanning Electron Microscopy: Working principle of SEM, image formation methods in SEM, voltage contrast, Energy Dispersive Spectroscopy (EDS) and Wavelength Dispersive Spectroscopy (WDS), electron back scattered diffraction; Transmission Electron Microscopy: Working principle of TEM, formation of image and selected area diffraction pattern. High resolution electron microscopy. Convergent Beam Electron Diffraction (CBED), Electron Energy Loss Spectroscopy (EELS) and Scanning Transmission Electron Microscopy (STEM); X-ray Diffraction: X-ray diffraction techniques, factors affecting diffracted intensity, application of X-ray diffraction to phase identification, order-disorder transformation, texture determination, dislocation density; Mechanical characterization: Indentation Hardness, Monotonic tensile and compression loading, Fracture toughness, Time and rate dependent deformation, fatigue loading. Tribological and wear testing.

MMP501 Material Characterization Laboratory

2 Credits (0-0-4)
Prerequisite(s): None

Overlap with: MMP303 (20%)

Optical Microscopy: Metallographic sample preparation through sampling, mounting, grinding, polishing and etching. One Ferrous Sample and one non-ferrous sample. quantitative metallography - volume fraction, grain size determination; X-ray Diffraction: Obtaining and Analysis of diffraction patterns for unknown material. Indexing the patterns, finding out the system and determination of lattice parameters. Determination of strain and crystallite size; Mechanical testing: Micro-indentation hardness, tensile and compressions tests. Analysing the results – obtaining YS, UTS, Ductility, etc. Obtaining true-stress strain data; Scanning Electron Microscopy: SEM observation of (i) Etched sample, (ii) Chemical Analysis by EDX, (iii) Fracture surface of the samples; operating conditions for various sample conditions to be noted and studied; Transmission Electron Microscopy: TEM sample preparation, TEM observation of thin foil of metallic samples - BF,DF, and selected area diffraction (SAED) pattern; Indexing of the SAED pattern and the determination of zone axis. The operating conditions (voltage, current, magnification, camera length etc.) to be noted and studied.

MML551 Thermodynamics and Phase Diagram

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: NA

Thermodynamic fundamentals: principles and equations for closed and open systems, criteria for equilibrium of multicomponent multiphase systems. Stable, metastable, and unstable equilibria, stability function for binary and multicomponent phases. Principle of irreversible thermodynamics, Driving force and fluxes for diffusion, laws of diffusion and their application. Kinetics: Absolute reaction rate theory and its applications to simple metallurgical reactions. Solutions: Thermodynamic formalisms for binary and multicomponent metallic solutions, compounds and ordered phases. Gibbs energy - composition diagrams. Binary Phase Diagrams and their Computation: Thermodynamics of phase equilibria: Computation of phase diagrams of unary and simple binary systems; Isomorphous systems, congruent minima and maxima, iso-Gibbs energy curves, miscibility gaps and spinodal, eutectic and peritectic type phase diagrams, phase diagrams with ordered phases, ordering spinodal, metastable extensions of phase boundaries, slopes and curvatures of phase boundaries and their consequences on the topologies of phase diagrams, retrograde solubility. Evolution of microstructures during equilibrium cooling of alloys in different types of phase diagrams. Ternary phase diagrams: Representation, lever rule, two-, three-, and four-phase equilibria, isomorphous systems, congruent minima and maxima, miscibility gaps, eutectic, peritectic and quasi peritectic phase diagrams. Interpretation of ternary phase diagrams. Scheil's scheme of representing reactions taking place in ternary alloys during equilibrium cooling.

MML552 Fundamentals of Crystallography

1 Credits (1-0-0)
Prerequisite(s): None
Overlap with: MML202 (40%)

Symmetry: Introduction, molecules and crystals, elements of symmetry, Point groups, chirality, Translation, plan groups, crystal lattice, bravais lattice, elements of periodic symmetry, Space Groups; Methods: X-rays, neutrons, diffraction principles, reciprocal space, Structure factor, Fourier synthesis, phase problem, Information obtained by diffraction, Diffraction methods: single crystals and polycrystals (powders and thin-film), Resolution of structures, identification of known and unknown

compounds, Refinement of crystalline structures, Presentation of modern software (APEX4, Olex2, Fullprof, Shelx).

MML553 Material Synthesis and Processing

2 Credits (2-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction: Definition of synthesis; historical examples of key synthetic discoveries; prospects; Basics of nucleation and growth processes, ceramic synthesis, Scale-up of synthetic processes; Self-Assembly: Supramolecular self-assembly; Gels; 3D self-assembly; Self-assembling monolayers; Sol-Gel Reactions: Synthesis from metal alkoxides; Gelation and calcination, hydrothermal methods; Polymer synthesis: Polymer Design and Synthesis, Reaction Types and Processes, Free Radical Polymerization, Controlled Radical Polymerization, Ionic Polymerization, Homogeneous and Heterogeneous Polymerization, Biomaterials Systems, Polymer Functionalization and Modification: Motivations; Synthesis of Nanomaterials: Solid-liquid interface interactions Influence of reaction conditions on morphological properties of materials; Quantum dots; Nanowires; Carbon nanotubes; combustion methods, Supramolecular Nanostructures; intercalation, and mild methods; Dendrimers; Colloids; Vapor Phase Synthesis: Gas phase reactions; solid substrate-vapor interactions in CVD, PVD. Effect of vapor deposition conditions on growth and morphology thin films; molecular beam epitaxy; Composite Synthesis: Classification of composite materials; Metal matrix systems; Ceramic matrix systems; Polymer matrix systems.

MMP553 Material Fabrication Laboratory

2 Credits (0-0-4)
Prerequisite(s): None
Overlap with: NA

Developing non-ferrous alloys: a) Sample preparation optical microscopy up to polishing b) Etching the sample and optical microscopy; Polymer synthesis using Chemical route and determination of molecular weight; Synthesis of Ceramic material (BaTiO3); Elemental analysis using spectroscopy and phase analysis using diffraction; Analysis of hardness, strength, and ductility; Study of Grain and grain boundary on above-prepared alloys, polymers, and ceramic materials.

MML554 Computational Methods in Materials Science

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Revisiting some numerical techniques – numerical differentiation and integration, curve fitting, matrix diagonalization, matrix inversion; Group theory: Symmetry elements, symmetry operations, Great Orthogonality theorem and character tables, Applications to solid structure; Quantum-Mechanical calculations: Revisiting basics of Quantum Mechanics, Revisiting Hartree-Fock Theory and its solution for single molecule, Revisiting Tight binding model and simple band structure calculations, Introduction to Density functional theory (DFT). Basics of Molecular dynamics (MD): Force field – different interactions and respective potentials, MD in different ensembles, MD algorithm; Introductory Monte Carlo techniques used in material science; Basic introduction to Genetic Algorithm used in material science.

MML555 Microstructural Engineering of Structural Materials

3 Credits (3-0-0)

Prerequisite(s): Nil

Overlap with: MML551 (5%), MEL659 (10%), MML204 (10%), MML202 (5%)

Basics of solidifications, microstructures, and solid-state phase transformation in relation to processing
Basics of solidifications
Microstructural constituents
Solid-state phase transformation
Thermo-mechanical processing

Case studies of some structural materials:
Steels: Microstructure and processing
Introduction to the history of Iron and Steel with a bird's eye view on applications over the years
Introduction to Fe-C phase diagram: Classification of Iron and Steel alloys, various phase transformations
Introduction to Ferritic, Austenitic, and Martensitic steels with their applications and various alloying additions to attain these phases
Understanding the role of kinetics in phase transformation, displacive and Reconstructive transformation in steels, and their effect on microstructure evolution and mechanical properties
Microstructural tailoring based on atomic mechanisms and phase transformation kinetics of advanced high-strength steels (TRIP, TWIP, IF, Dual-Phase, and Bainitic steels)-the interdependence of alloying addition, stacking fault energies, cooling rate, and temperatures
Understanding the effect of microstructure on the properties of various steels and focusing on tuning the microstructures for applications (Case Studies)

Light metals and alloys (Al-based and Ti-based)
History of Aluminium alloys and their classifications
Strengthening Mechanisms in Al alloys
Case studies for the application of heat-treatable and non-heat-treatable Al alloys
Introduction and classification of Titanium alloys. Phase diagrams of various Ti alloys and phase transformations involved
Properties of various phases and influence on mechanical behavior
Role of heat treatments and thermo-mechanical processing routes to attain various microstructures in different Ti alloys
Case studies for applications of various Ti alloys

Superalloys: Microstructure and high-temperature properties
Introduction to superalloys with their classification and applications
Various phases present in superalloys, the criticality of alloying additions in achieving various phases, and their stability
Defects in superalloys: Partial Dislocations, Stacking Faults, Anti Phase Boundaries, KW locks
Strengthening Mechanisms in superalloys. Yield Strength Anomaly, Creep, and Fatigue properties
Single crystal superalloys: Introduction to Bridgman route for production, advantages over directionally solidified and conventional cast alloys
Case studies: Application of superalloys as turbine disc and turbine blade materials, microstructural engineering involved in tuning the alloys
Discussion on design aspects of blade, introduction to thermal barrier coatings for improving operating temperatures.

MML556 Physics of Materials

3 Credits (3-0-0)

Prerequisite(s): Nil

Overlap with: PHL508 (10%), MML251 (15%), CYL500 (5%), MML202 (3%)

Introduction to Materials Properties: Electrical, Magnetic, and Thermal; Importance of physical properties in applications, Basics of Quantum Mechanics for materials science, Fundamentals of Electronic Structure: Atomic Structure and Bonding, Drude model for electronic and thermal conductivity, The Sommerfield theory of Metals, Fermi-Dirac distribution, Ground State of Electron, The periodic potential, Bloch's theorem, Nearly free electron approximation, The Kronig-Penney Model and tight binding approximation, Origin of bands, Energy bands in 1-D and 3-D, Conductors, Semiconductors and Insulators, Mechanism of electronic and ionic charge transport in solids.

Electronic Properties: Dielectric properties of materials, Polarization (electronic, ionic & orientational), Electrical resistivity: Two-probe, Four-Probe methods, Magnetoresistance, and Hall effect. I-V curve and Resistive switching, Ferroelectric and Piezoelectric properties of materials.

Thermal Properties: Specific heat capacity, Phonons, Thermal diffusivity, Thermal conductivity, Thermal expansion. Measurement Techniques: Thermal Conductivity, Diffusivity, Specific heat capacity, Magnetic Properties: Basic concepts of magnetism: Magnetic moment and susceptibility. Types of magnetism, Magnetic Hysteresis, Curie temperature, Soft and hard magnets and their applications. Magnetic materials in technology: magnetic sensors, magnetic data storage. Introduction to spintronics, Materials for spintronics (Heusler alloys, topological insulators). Magnetocaloric effect and refrigeration application, Measurement Techniques: VSM, SQUID,

Thermoelectric Properties: Thermoelectric and its Applications. Thermoelectric Parameters, Figure of merit and Conversion efficiency, Novel strategies to develop efficient thermoelectric materials, Materials at different temperature ranges: Low temperature (Bi-Sb based alloys, $FeSb_2$), Mid Temperature (Chalcogenides, Skutterudites, BiCuSeO), High Temperature (Lanthanum telluride, SiGe etc), Physics at Nanoscale, Size effects on physical properties

Lecture Wise Plan:

Unit I: Fundamental Understanding of Properties of Materials
Lecture 1-2: Introduction to Materials Properties: Electrical, Magnetic, and Thermal; Importance of physical properties in applications.
Lecture 3-5: Basics of Quantum Mechanics for materials science
Lecture 6: Fundamentals of Electronic Structure: Atomic Structure and Bonding,
Lecture 7: Drude model for electronic and thermal conductivity,
Lecture 8-9: The Sommerfield theory of Metals, Fermi-Dirac distribution, Ground State of Electron
Lecture 10-11: The periodic potential, Bloch's theorem, Nearly free electron approximation
Lecture 12-13: The Kronig-Penney Model and tight binding approximation
Lecture 14: Origin of bands, Energy bands in 1-D and 3-D
Lecture 15: Conductors, Semiconductors and Insulators
Lecture 16-18: Mechanism of electronic and ionic charge transport in solids.
Unit II: Addressing Specific Materials Properties using Fundamental Understanding
A. Electronic Properties:
Lecture 19-20: Dielectric properties of materials, Polarization (electronic, ionic & orientational)
Lecture 21-22: Electrical resistivity: Two-probe, Four-Probe methods, Magnetoresistance, and Hall effect.
Lecture 23: I-V curve and Resistive switching
Lecture 24: Ferroelectric and Piezoelectric properties of materials.
B. Thermal Properties
Lecture 25: Specific heat capacity, Phonons, Thermal diffusivity, Thermal conductivity, Thermal expansion.
Lecture 26-27: Measurement Techniques: Thermal Conductivity, Diffusivity, Specific heat capacity
C. Magnetic Properties:
Lecture 28: Basic concepts of magnetism: Magnetic moment and susceptibility.
Lecture 29-30: Types of magnetism, Magnetic Hysteresis, Curie temperature, Soft and hard magnets and their applications.
Lecture 31: Magnetic materials in technology: magnetic sensors, magnetic data storage.
Lecture 32-33: Introduction to spintronics, Materials for spintronics (Heusler alloys, topological insulators).

Lecture 34: Magnetocaloric effect and refrigeration application.
Lecture 35: Measurement Techniques: VSM, SQUID
D. Thermoelectric Properties
Lecture 36: Thermoelectric and its Applications.
Lecture 37: Thermoelectric Parameters, Figure of merit and Conversion efficiency.
Lecture 38: Novel strategies to develop efficient thermoelectric materials.
Lecture 39-40: Materials at different temperature ranges: Low temperature (Bi-Sb based alloys, FeSh;), Mid Temperature (Chalcogenides, Skutterudites, BiCuSeO), High Temperature (Lanthanum telluride, SiGe etc).
E. Physics of Nanoscale Materials.
Lecture 41-42: Physics at Nanoscale, Size effects on physical properties.

Courses offered in the Discipline of Mathematics

MAL100 Mathematics-I

4 Credits (3-1-0)
Prerequisite(s): None
Overlap with: NA

Real number system: Sequences: Convergence of a sequence-Sandwich theorem- Cauchy sequences- subsequence-monotone sequences-monotone convergence theorem; Series: Convergence of infinite series-comparison test-Cauchy condensation test-ratio test-root test-Leibnitz test; Functions of one variable: Limits and continuity of functions- intermediate value property-differentiability of a function-local maxima and minima-Rolle's theorem-mean value theorem and applications; Integration: Definite integrals as a limit of sums-fundamental theorems of calculus-applications of definite integrals to area, volume, surface area-improper integrals; Functions of two variables: Limit-Continuity-partial derivatives- directional derivatives-gradient-differentiability-chain rule- tangent planes and normal – maxima and minima-Lagrange multiplier method; Multiple integrals: Double and triple integrals with applications to volume - surface area-change of variables-vector fields-line integrals-Green's theorem and its applications-path independence- surface integrals evaluation-Gauss's divergence theorem and its applications-Stokes Theorem.

MAL101 Mathematics-II

4 Credits (3-1-0)
Prerequisite(s): None
Overlap with: NA

Systems of linear equations: Elementary operations-row-reduced echelon matrices-Gauss elimination-LU factorization-linear independence-rank of a matrix-solutions of linear systems-existence and uniqueness; Vector spaces: Vector space-subspaces-spanning space-bases and dimensions; Linear transformations: Linear transformation-matrix representations of linear transformations-range space and rank-null space and nullity-the rank and nullity theorem-invertibility; Eigenvalues and eigenvectors: Eigne values-eigenvectors and some applications of eigenvalue problems-Hermitian, skew-Hermitian, unitary matrices and their eigenvalues-eigen bases; Diagonalization: Annihilating polynomial-the minimal polynomial and the characteristic polynomial-Cayley-Hamilton theorem-real quadratic form; Inner product spaces: Inner product spaces-orthonormal bases- Gram-Schmidt process; Differential Equations: Review of First Order ODE- Lipschitz condition-Picard`s theorem; Linear differential equations: Linear dependence and Wronskian-linear ODE with constant coefficients of higher order-characteristic equations- Cauchy-Euler equations-method of undetermined coefficients-method of variation of parameters- solutions methods using Laplace Transform.

MAL400 Introduction to Programming

4.5 Credits (2-1-3)
Prerequisite(s): None
Overlap with: NA

Content of this course is exactly overlapping with CSL100 and the same will be offered by the discipline of Computer Science and Engineering.

MAL401 Linear Algebra

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MAL101 (25%)

Matrix: Systems of linear equations-matrices and elementary operations-row-reduced echelon matrices-solutions of linear systems: existence and uniqueness; Vector space: Vector spaces-subspaces-spanning space-bases and dimensions-ordered basis and coordinates; Linear Transformation: Linear transformations-matrix representations of linear transformations-range space and rank-null space and nullity-the rank and nullity theorem-invertibility; Inner product spaces: Cauchy-Schwarz's inequality-Gram-Schmidt orthonormalization-orthonormal basis-orthogonal projection-projection theorem-four fundamental subspaces and their relations (relation between null space and row space; relation between null space of the transpose and the column space); Eigen space: Eigenvalues and eigenvectors-the characteristic polynomial-the Cayley- Hamilton theorem-the minimal polynomial-algebraic and geometric multiplicities-diagonalization-Invariant subspaces-adjoint of an operator-normal-unitary and self-adjoint operators-Schur's Lemma, diagonalization of normal matrices-spectral decompositions and spectral theorem-applications of spectral theorem; Primary decomposition theorem-Jordon canonical form-Introduction to bilinear and Quadratic forms: Bilinear and quadratic forms-Sylvester's law of inertia.

MAL402 Real Analysis

3.5 Credits (3-0.5-0)
Prerequisite(s): MAL100 or Equivalent
Overlap with: MAL100 (20%)

Overview of Real Number system: Completeness property-Density property-Countable and Uncountable; Metric Spaces: Metric spaces-Open sets-Closed sets-sequence-series-Limit-Continuity; Completeness: Complete metric space-Nested set theorem-Baire category theorem-Applications; Compactness: Basic properties of compact set-Totally bounded-Finite intersection property-Continuous functions on compact sets-Uniform continuity; Connectedness: Basic properties of connected set-Continuous functions on connected sets-Path connected; Riemann integration: Definition and existence of integral-Fundamental theorem of calculus; Convergence of sequence and series of functions: Pointwise and uniform convergence of functions-Series of functions-Power series-Dini's theorem-Ascoli's theorem-Continuous function which is nowhere differentiable-Weierstrass approximation theorem.

MAL403 Probability and Statistics

4 Credits (3-1-0)
Prerequisite(s): MAL100 or Equivalent
Overlap with: NA

Introduction to set algebra-sigma algebra-Borel sigma algebra-sequence of sets and its limits-limsup and liminf of sequence of sets; Axiomatic definition of probability-probability space-properties of probability functions-conditional probability-Bayes' rule-independence of events-continuity of probability functions-Borel Cantelli lemmas; Random variables-distribution function and its property-probability mass and density functions-symmetric distribution and its properties-expectation-moments-moment generating function-Markov inequality- Chebyshev's inequality; Joint distributions-marginal and conditional distributions-moments-independence of random variables-covariance, and correlation-

joint moment generating functions-additive properties of random variables-functions of random variables-ordered Statistics; Special distributions: Discrete uniform-Bernoulli-binomial-geometric-negative binomial-hypergeometric-Poisson-exponential-gamma-normal-bivariate normal distribution; Population-sample-parameters-distributions of the sample mean and the sample variance for a normal population-Chi-Square-t and F distributions-law of large numbers–central limit theorem-point estimation-method of moments-maximum likelihood estimator-unbiasedness; Testing of hypothesis: Null and alternate hypothesis-Neyman Pearson fundamental lemma and its applications-tests for one sample and two sample problems for normal populations-tests for proportions-confidence interval estimation-confidence interval for parameters of normal population.

MAL404 Modern Algebra

3 Credits (3-0-0)
Prerequisite(s): MAL101 or Equivalent
Overlap with: NA

Groups: Basic notion of groups - subgroups - cosets of a subgroup - Lagrange's theorem- cyclic groups - permutation groups - normal subgroups - quotient groups - group homomorphisms, isomorphisms and automorphisms - group actions - Cayley’s theorem - Sylow's theorem - direct products of groups-finite abelian groups; Rings: definition and examples of rings - subrings - Ideals - maximal and prime ideals - quotient rings- ring homomorphisms and isomorphisms. Integral domains: division rings and fields - field of quotients of an integral domain - Euclidean domains - principal ideal domains, unique factorization domains - Polynomial ring- Irreducibility of polynomials; Fields: Subfields - extension fields - algebraic extensions- roots of a polynomial - splitting fields- algebraically closed field - normal and separable extensions - Ruler and compass constructions. Galois theory: Fundamental theorem of Galois theory - polynomials solvable by radicals.

MAL405 Differential Equations

4 Credits (3-1-0)
Prerequisite(s): (MAL100 and MAL101) or Equivalent
Overlap with: MAL101 (20%)

First order linear differential equations: Introduction to ODE, review of solution methods for linear first order differential equations; First order nonlinear differential equations: Cauchy-Picard theorem-continuation of solutions; Second order linear differential equations: Solution methods by variation of parameters and Wronskian- order reduction methods-undetermined coefficients; Series solutions-Series solutions of second order differential equations-Legendre and Bessel’s equations and properties-two point boundary value problem-Sturm-Liouville theory; Linear systems: Linear system with constant coefficients-fundamental solutions; First order linear and quasi-linear partial differential equations: Cauchy problem-method of characteristics; Second order partial differential equations: Classification of second order PDEs- physical motivation- Laplace, heat and wave equations- solutions using separation of variables, similarity methods, transform methods and power series method.

MAL406 Numerical Analysis

4 Credits (3-1-0)
Prerequisite(s): MAL100 or Equivalent
Overlap with: MEL304 (60%)

Linear systems of equations: direct and iterative schemes- computational costs of each scheme- ill conditioning and convergence analysis- sources of errors; Nonlinear equations: Solutions of nonlinear equations- Numerical Schemes for non-linear systems- bisection method-Newton's method and its variants- fixed point iterations- convergence analysis; Interpolation: Finite differences- polynomial interpolation- Hermite interpolation- spline interpolation; Numerical integration: Trapezoidal and Simpson's rules - Gaussian quadrature - Richardson extrapolation; Initial value problems: Taylor series method - Euler and modified Euler methods - Runge-Kutta methods - single step - multistep methods – order – consistency - stability and convergence analysis; Boundary value problems: Shooting and finite difference methods.

MAL500 Topology

3 Credits (3-0-0)
Prerequisite(s): MAL402 or Equivalent
Overlap with: NA

Definition of topological spaces and examples-bases-subbases; Product topology-subspace topology-metric topology-quotient topology; Closed sets-limit points-continuous functions-homeomorphisms; Connectedness-connected sets in R-path connectedness-components and path components-local connectedness; Compactness-compactness in metric spaces-local compactness-limit point compactness-sequential compactness-compactification; The separation and countability axioms; Urysohn lemma-Urysohn's metrization theorem; Tietze extension theorem-Tychonoff theorem; Completely regular spaces-Stone-Čech compactification.

MAL501 Complex Analysis

3 Credits (3-0-0)
Prerequisite(s): MAL402 or Equivalent
Overlap with: NA

Complex numbers: Basic properties of complex numbers - complex planes - topology of the complex plane; Functions of a complex variable: Limits, continuity and complex differentiability - holomorphic functions - Cauchy Riemann equations - harmonic functions - elementary functions - some application of harmonic functions; Integration in complex plane: Contour integrals- antiderivatives - path independence - Cauchy-Goursat theorem - Cauchy's integral formula - consequences of Cauchy's integral formulas- Liouville's theorem and the fundamental theorem of algebra - Morera's theorem - open mapping theorem - maximum modulus principle; Sequences and series: Power series -Taylor and Laurent series - isolated singularities - zeros and poles - residues - residue theorems - the argument principle - Rouche's theorem - evaluation of real integrals via contour integration; Conformal mappings: Mobius transformations - Schwarz lemma - automorphisms of the disc and upper half plane - Riemann mapping theorem.

MAL502 Functional Analysis

4 Credits (3-1-0)
Prerequisite(s): MAL402 or Equivalent
Overlap with: NA

Normed spaces: Normed space-Banach spaces-linear maps-boundedness-non-compactness of the unit ball in infinite dimensional normed linear spaces-Banach-Steinhaus theorem-open mapping theorem- closed graph theorem- Hahn-Banach Theorem-Introduction to compact linear maps; Hilbert

Spaces: Bessel's inequality-complete systems-Gram-Schmidt orthogonalization- Parseval's identity-projections-orthogonal decomposition-Bounded Operators and Adjoints-Normal, Unitary and Self-Adjoint Operators; Dual spaces-Riesz representation theorem-reflexivity-weak topologies-weak convergence-weak compactness-Banach-Alaoglu theorem.

MAL503 Discrete Mathematics

4 Credits (3-1-0)
Prerequisite(s): None
Overlap with: NA

The content of this course is exactly overlapping with CSL201 and the same will be offered by the discipline of Computer Science and Engineering.

MAL504 Data Structure

4 Credits (2-1-2)
Prerequisite(s): MAL400
Overlap with: NA

The content of this course is exactly overlapping with CSL202 and the same will be offered by the discipline of Computer Science and Engineering.

MAL505 Database Management Systems

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: NA

The content of this course is exactly overlapping with CSL303 and the same will be offered by the discipline of Computer Science and Engineering.

MAL510 Elementary Number Theory

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: CSL201 (10%), MA519 (100%)

Preliminaries: Well-Ordering Principle - Mathematical induction - Binomial theorem.
Divisibility theory: Division algorithm - The greatest common divisor and the least common multiple - Euclidean Algorithm - Prime numbers- Prime number theorem (statement only), Fundamental theorem of arithmetic. The linear Diophantine equation in two unknowns.
The theory of congruences: Fermat's theorem, Pseudoprimes, Wilson's Theorem, Euler's generalization of Fermat's theorem; Number Theoretic functions. Primitive roots. The quadratic reciprocity law; Brief introduction to public key cryptography.
Number of special forms: Perfect numbers - Mersenne primes - Fermat numbers - Fibonacci numbers. Some nonlinear Diophantine equations: The Pythagorean equations, A special case of Fermat's last theorem; Representation of integers as sums of squares; Continued fractions, Pell's equation.

MAL511 Additive Number Theory

3 Credits (3-0-0)

Prerequisite(s): MAL404 or equivalent
Overlap with: ME212 (20%), ME111 (10%)

Sumsets: Introduction to sumsets – Direct and inverse problems for sumsets. Sumsets in torsion-free abelian groups: Freiman homomorphisms and Freiman isomorphisms, basic lower bounds and inverse theorems for sumsets.
Sizes of Sumsets: Doubling constant – Ruzsa distance – additive energy – Ruzsa's covering lemma, Green-Ruzsa covering lemma – Sidon sets – Frieman's 3k-4 theorem – sum-product problems. Sumsets in groups: Cauchy-Davenport theorem – Pollard's theorem – Erdös-Ginzburg-Ziv theorem – Chevalley-Warning theorem – Vosper's theorem – Freiman-Vosper theorem – Kemperman's theorem – Kneser's addition theorem and its applications – Rectification principles.
The Polynomial method: Alon's combinatorial Nullstellensatz – restricted sumsets and the Erdös-Heilbronn conjecture – Dias da Silva-Hamidoune theorem – Snevily's conjecture – Kemnitz's conjecture. Sumsets in higher dimensional Euclidean space. Geometry of nimbers: Lattices and determinants – Minkowski's first theorem and Minkowski's second theorem.
Structure of sets with small sumsets: Plünnecke-Ruzsa theorem – review of Fourier analysis on groups – Bohr sets in sumsets – Bogolyubov's Lemma – generalized arithmetic progression in Bohr sets – Freiman-Ruzsa Theorem.

MAL512 Partial Differential Equations

3 Credits (3-0-0)
Prerequisite(s): MAL405 or equivalent.
Overlap with: MA606 (90%)

First order PDEs: Cauchy problems-linear, quasilinear and nonlinear partial differential equations-method of characteristics-existence of local solutions-weak solution-introduction to conservation laws-weak solutions-Rankine-Hugoniot condition- shocks-Lax-Oleinik formula-entropy condition and uniqueness of entropy solution.
Second Order PDEs: Classification-Characteristics.
Laplace and Poisson's Equation: Fundamental solutions-Mean value Property-Harmonic functions-Harnack inequality-Green's function-Maximum principle-Hopf Lemma-Perron's method-Duhamel's principle-energy methods-introduction to variational method.
Heat Equation: Fundamental solution and initial-value problem-mean value formula-maximum principle, uniqueness and regularity
Wave equation: One dimensional wave equation-solutions in odd and even dimensions.

MAL513 Topics in Fixed Point Theory

3 Credits (3-0-0)
Prerequisite(s): MAL402 or equivalent.
Overlap with: MA512 (100%)

Metric Fixed Point Theory: Banach contraction principle- Applications to integral equations- differential equations-numerical analysis-some generalizations of Banach contraction principle- multi-valued maps- examples- Hausdorff metric- Nadler's theorem.
Fixed Points in Ordered Space: Fixed points results in partially ordered metric space- applications to matrix equations.
Fixed Points in Topological Spaces: Brouwer's fixed point theorem-applications- Schauder's fixed point theorems- applications to Peano existence theorem-non-expansive maps-examples-fixed point

theorem for non-expansive maps- Kakutani fixed point theorem for mauti-valued maps-applications-Key-Fan best approximation theorem.

MAL514 Statistical Inference

3 Credits (3-0-0)
Prerequisite(s): MAL403 or equivalent.
Overlap with: MAL403 (20%), MA509 (100%)

Statistical inference problem: Parametric inference-Data collection- Statistics- Estimator-Sampling distribution. Order Statistics: Distribution of r-th order statistics-distribution of r-th and s-th order statistics, sample median- sample range-mid-range.
Sufficiency and Completeness: Sufficiency and minimal sufficient statistics-Neyman Fisher factorization theorem-Ancillary statistics- completeness-Basu's Theorem and its application-Exponential family.
Method of estimation: Maximum likelihood estimator (MLE)-properties of MLE's-Method of moments-Least Square Estimator.
Unbiased Estimation and Lower bound for variance: Unbiased estimation-uniformly minimum variance unbiased estimator (UMVUE)-Fisher information-Cramer-Rao lower bound (CRLB)- Bhattacharyya bound- Rao-Blackwell theorem-Lehman-Scheffe theorem.
Statistical Hypotheses: Simple and composite-statistical tests-critical regions-Type I and Type II errors-size and power of a test-Neyman Pearson lemma and its different applications-Most powerful test-uniformly most powerful test-unbiased test and uniformly most powerful unbiased test-Likelihood ratio test-Application to normal distribution, p-value.
Interval estimation: Confidence intervals-construction of confidence intervals-shortest expected length confidence interval-most accurate one sided confidence interval and its relation to UMP test.

MAL600 Introduction to Spectral Theory

3 Credits (3-0-0)
Prerequisite(s): MAL502 or equivalent
Overlap with: None

Introduction: Origin – spectrum and invertibility. Banach Algebra: Ideals & quotients – spectrum of an element of Banach algebra – spectral radius – Reisz functional calculus – dependence of the spectrum on the algebra. Spectral Representation: Spectrum and resolvent – various sub-divisions of spectrum – spectral projection – spectral measure – spectral representation theorem of compact operators and self-adjoint operators. Compact Perturbation & Fredholm theory: Calkin algebra – Fredholm operators – Fredholm index – Reisz theory of compact operators – Fredholm alternative – essential spectrum – further analysis of spectrum. Spectral Properties of unbounded linear operators: Unbounded linear operators and Hilbert adjoint – symmetric and self-adjoint linear operators – multiplication operator – differentiation operator.

MAL601 Operator Theory I

3 Credits (3-0-0)
Prerequisite(s): MAL502 or equivalent
Overlap with: MAL602 (8%), MA610 (100%)

Overview of Hahn-Banach theorem, open mapping theorem, closed graph theorem, uniform boundedness principles.

Banach algebras: Spectral radius formula – Gelfand-Mazur theorem – Gelfand theory.
C^*-algebra: Homomorphisms – character – maximum ideal – positive elements – approximate units-states-the GNS construction.
Spectral theorem: Compact normal operators – normal operators – the L-infinity functional calculus for normal operators. Fredholm operators.

MAL602 Operator Theory II

3 Credits (3-0-0)
Prerequisite(s): MAL502 or equivalent
Overlap with: MAL601 (15%)

Overview of Gelfand theory-C*- algebras the GNS construction-Spectral theorem for normal operator-Schatten-p-class operators. Basic Von-Neumann Algebras- Trace class operator-Hilbert Schmidt Operator-Dual of trace class operators-Commutant. Operator spaces-Contractive and complete contractive homomorphism-Function Algebra-Dilation.

MAL603 Martingale Theory

3 Credits (3-0-0)
Prerequisite(s): MAL403 or equivalent
Overlap with: MAL402 (5%), MAL403 (10%), MAL608 (100%).

Review of measure theory and conditional expectation: Sigma algebras-measurable functions-Lebesgue integrals-conditional probability-conditional expectation-conditional independence. Discrete Time Martingales: Filtrations-martingales-submartingales and supermartingales-Doob decomposition theorem-discrete stopping times-stopped martingales-optional sampling theorem-maximal and upcrossing inequalities. Continuous time martingales: Continuous stopping times-local martingales-Brownian motion-semimartingales.

MAL604 Stochastic Processes

3 Credits (3-0-0)
Prerequisite(s): MAL403 or equivalent.
Overlap with: MAL403 (2.5%), MA611 (100%)

Discrete-time Markov chains: Definition and basic properties, Markov property. class division, hitting time and absorption probabilities, strong Markov property, recurrence and transience, invariant distributions, convergence to equilibrium, time reversal. ergodic theorem.
Random walk— in dimension one, two and three, The Reflection Principle, hitting probabilities of a finite sets, Last visits and Long leads, Maxima and first passages, Duality, position of maxima.
Continuous time Markov chains: Definition and examples, Q-matrices, embedded Markov chain, Kolmogorov forward and backward equations, classification of states, limit theorems.
Poisson Process: Definition and properties, inter arrival and waiting time distributions, conditional distribution of arrival times, its different characterizations.
Markov chain mixing: Coupling and total variation distance, Mixing time, upper bound and lower bound on mixing time.

Courses offered in the Discipline of Mechanical Engineering

MEP102 Digital Fabrication

3 Credits (1-0.5-3)
Prerequisite(s): None
Overlap with: NA

Theory of projections; Orthographic projection; Isometric projection and perspective projection; Familiarization with 3D solid modelling (CAD) for the creation of engineering and freeform geometries; 3D Scanning using CMM and laser scanners and their applications and Preparatory activities for 3D Printing: Conversion of CAD model into a real part, stl format ant its importance, slicing, effect of part orientation; 3D printing of the part: Introduction to additive manufacturing process; conventional machining processes: turning, centering, drilling, and milling; CNC programming, Familiarization with machining processes using tabletop reconfigurable CNC machines; Familiarization with Casting, Welding, and molding and its inspection; Laser-based manufacturing processes (Demonstration of Laser cutting machine); Introduction to the concept of Digital manufacturing and industry 4.0

MEL211 Thermodynamics

3 Credits (2-1-0)
Prerequisite(s): None
Overlap with: MML201 (15-20%); CYL504 (15-20%)

Introductory concepts and definitions: Macroscopic and microscopic point of view, system, surroundings, boundary, thermodynamics properties, thermodynamics state and equilibrium, steady state, work interaction, various forms of work; First law of thermodynamics: Quasi-static and reversible processes; Heat interaction; Adiabatic process; Zeroth law of thermodynamics, temperature, Celsius scale of temperature, ideal gas scales of temperature, properties of fluids, internal energy, enthalpy, Carnot cycle; First law analysis for a control volume/open system, steady-state and transient processes with engineering applications; Second law of thermodynamics: Kelvin-Planck's statement, Clausius Statement and corollaries, Heat engines and refrigerators, absolute temperature scale, Second law analysis for a control volume/open system, steady-state and transient processes with engineering applications; Entropy and the Clausius inequality: Second law in terms of entropy, adiabatic-reversible-isentropic processes, entropy generation, the Gibbs equation, entropy for ideal gases, entropy change for reversible and irreversible processes, concepts of availability and exergy analysis for closed and open systems; Properties of Substances: Properties of pure substances – phase equilibrium diagrams p-v, p-T, T-s and h-s planes; dryness fraction, steam tables and Mollier diagram; Thermodynamics property relations: Maxwells relations, TdS relations, ratio of heat capacities.

MEL212 Fluid Mechanics

4 Credits (3-0-1)
Prerequisite(s): None
Overlap with: NA

Introduction: Basic ideas of continuum, fluid properties including viscosity, surface tension and vapour pressure; Fluid Statics: Hydrostatic pressure distribution, Manometry, Forces on submerged bodies, Buoyancy and Floatation, Stability of floating bodies, Pressure distribution in rigid body motion; Fluid Kinematics: Lagrangian and Eulerian descriptions, Deformation of fluid element, Strain rates, Vorticity,

Flow description using pathline, streamline and streak line; Conservation laws: Reynolds Transport Theorem, Integral form of conservation laws – mass, linear momentum, angular momentum and energy, Differential form of conservation laws, Elementary derivation of Navier-Stokes equations, Exact solution to Navier-Stokes equations: Couette flow and Poiseulle flow etc.; Inviscid flows: Bernoulli equation and applications, overview of various losses; Plane potential flows: Streamfunction-velocity potential, superposition, source, sink, Doublet, flow past a cylinder, circulation, D'Alembert's Paradox; Dimensional analysis: Buckingham Pi theorem, dimensionless groups, similitude laws and scaling, practical applications; Boundary Layer Theory: Definition of boundary layer thickness, momentum thickness and energy thickness, Blasius solution, Von-Karman Momentum integral equation; Introduction to Turbulent flows: Basic definition and characteristics of turbulent flow, Energy Cascade, Mean and Fluctuating Components, Derivations of Reynolds Averaged Navier-Stokes Equations, Turbulent Flow through a Pipe and Channel, Moody Diagram, Hydrodynamic Smooth and Rough Pipe and Example Problems; Introduction to Compressible flows: High speed gas flow, speed of sound, One-dimensional form of the governing equations, Isentropic gas relations, Velocity measurement using a pitot tube at all Mach numbers.

MEL214 Applied Thermal Engineering

3 Credits (2-1-0)
Prerequisite(s): None
Overlap with: MEL211 (5%)

Introduction to Various Thermodynamics Systems: Simple Steam Power Plant, Gas Turbines, Internal Combustion Engines, Domestic Refrigerators, Air Conditioners, Jet Propulsion, Rocket Propulsion, Gas Compressors; Vapor Power Cycles: Actual vapor power cycle processes, Rankine and Carnot Cycles, Mean temperature of heat addition, Reheating cycle, Regenerative Cycles, Reheat-Regenerative Cycles, Exergy Analysis of Vapor Power Cycles, Binary Vapor Power Cycles; Gas Power Cycles: Carnot cycles, Stirling Cycles, Ericsson Cycles, Air Standard Cycles, Otto Cycles, Diesel Cycle, Dual Cycles, Comparison of Otto, Diesel and Dual Cycles, Lenoir Cycle, Atkinson Cycle, Brayton Cycles, Aircraft Propulsion; Cogeneration and Combined Cycles: Combined gas-steam power Plant, Different arrangements in combined cycles; Basics of Refrigeration Cycles: Reversed Heat Engines Cycles, Vapor Compression Refrigeration Cycles, Gas Cycle Refrigeration; Gas Compressors: Compression Processes, Work of Compression, Reciprocating compressors, Single-Stage Reciprocating Air Compressors, Volumetric Efficiency, Multistage Compression.

MEL231 Engineering Mechanics

3 Credits (2-1-0)
Prerequisite(s): None
Overlap with: NA

Introduction: Mechanics - Method of Solving Problems - Forces and Force Equilibrium in Plane and Space; Rigid Bodies: Equivalent systems of Forces - Forces and Moments - Couple - Equilibrium in two and three dimensions; Distributed Forces: Center of Gravity and Centroids of Planes and Volumes - Moments of Inertia of Area, Parallel-axis Theorem; Analysis of Structures: Trusses and Frames - Internal forces in members – Beams - Shear Force - Bending Moment; Friction: Wedge, Screws, Belt Friction; Method of Virtual Work: Principle of Virtual Work and its application to solve problems of mechanics; Rigid-body kinematics: Absolute motion - Relative velocity - Relative acceleration - Rotation relative to rotating axes; Rigid-body kinetics: Linear Momentum - Angular momentum - Kinetic

energy - Work and energy - Impulse and momentum; Rigid body in three-dimensions: Kinematics - Kinetics – Gyroscopes.

MEL232 Mechanics of Solids

3 Credits (2-1-0)
Prerequisite(s): None
Overlap with: NA

Introduction: Deformable bodies - Analysis of deformable bodies - Solution of some statically indeterminate problems; Stress: Introduction to stress, Plane stress, Equilibrium equations - Stress transformation in plane stress - Mohr's Circle - Thin cylinders; Strain: Introduction to deformation and strain - Plane strain - Strain transformation - Measurement of strains using strain Gauge and strain rosette; Stress-strain relationship: Tension and compression test of metallic bars - Hooke's law for uniaxial and multi-axial loading - Thermal strains - Equations of elasticity, Introduction of Fatigue behavior and S-N curve - Theories of Failure - Stress concentration; Torsion: Torsion of circular shafts - Torsion of elastic hollow shaft - Introduction to torsion of rectangular shafts - Torsion of thin-walled shafts; Bending: Pure bending of beams - Moment-Curvature relationship - Stress-strain relation in bending - Elastic beams with transverse forces - Transverse shear stresses - Built-up beams - Composite beams; Deflection of beams: Governing equation - Deflection using the moment of integration - Method of superposition - Energy methods - Castigliano's theorem; Buckling of Columns: Stability of equilibrium - Elastic instability of flexible columns - Critical loads for different boundary conditions of columns.

MEL251 Casting, Forming and Welding

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Basics of manufacturing, Primary and secondary manufacturing and its types, brief overview of metals; Casting: Introduction to casting, types of patterns and its allowance, types of moulding materials, gating system and its design, riser design, types of casting such as ingot/continuous and shape casting (investment casting, die casting, sand casting, centrifugal casting etc.), casting defect, casting solidification for pure metal and alloy; Welding: Fundamentals of welding and its types, Gas welding/Cutting, Arc welding (TIG, MIG, SAW etc), Arc characteristics, modes of metal transfer, types of power source and its characteristics, Spot welding, Brazing, soldering, Solid state welding; Forming: Stress-strain curve, Yield function, Various types of bulk forming process such as rolling, extrusion, forging, wire drawing and its force analysis, sheet metal forming such as blanking, punching, deep drawing etc . Forming defects; Introduction to powder metallurgy: Basic definition, process, application.

MEL252 Fundamentals of Industrial Engineering

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Production Planning and Control: Forecasting models, aggregate production planning, scheduling, Lean manufacturing, Concurrent engineering, materials requirement planning and inventory management; Operations Research: Linear programming, simplex method etc., Transportation and Assignment Problems, network flow models, simple queuing models, PERT and CPM; TQM:

Introduction, Historical Review, TQM Principles: six sigma, Kaizen etc., Quality Function Deployment (QFD), Total Productive Maintenance (TPM), FMEA, Quality Systems: Need for ISO 9000 and ISO 14000 - Concept, Requirements and Benefits, Case Studies.

MEP302 Engineering and Machine Drawing

2 Credits (0-0-4)
Prerequisite(s): None
Overlap with: MEP102 (5%)

Engineering curves; Theory of projections: 1st and 3rd angle projection, isometric projection; Projection of line, planes, and solids; Projection of section of solids; Development of surfaces; Geometric dimensioning and tolerances: Limits, Fits, tolerances (geometric and dimensional), Tolerance stack up analysis for assembly, concept of production drawing; Keys, cotters and pin joints; Shaft coupling, Gears; 2D assembly drawing.

MEL304 Applied Numerical Methods

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MAL101 (10 %)

Error Analysis: Approximations and round-off errors, Taylor series, truncation errors, error propagations; Root finding techniques: Bracketing Methods-Bisection, False-Position methods; Open Methods-Fixed point, Secant and Newton-Raphson method, Roots of polynomials, rate of convergence; Linear Algebra: Algorithms for Gauss Elimination, LU Decomposition, Gauss-Seidel; Optimization: One and Multi-dimensional unconstrained Optimization-Golden Section search, Gradient methods, constrained optimization; Curve fitting: Least-squares regression-linear, and polynomial regression; Interpolation-Lagrange interpolating polynomial, Spline interpolation; Numerical differentiation and integration: Discretization and order to accuracy, Newton-cotes Integration-Trapezoidal, Simpson's rule; Romberg integration, Richardson extrapolation; Methods to solve Ordinary and Partial differential equations: Runge-Kutta Method, Finite difference and finite element based methods to solve Elliptic and Parabolic equations; Demonstration of few case studies.

MEL313 Heat and Mass Transfer

3.5 Credits (3-0.5-0)
Prerequisite(s): None
Overlap with: NA

Introduction: Rate equation and conservation of energy equations, modes of heat transfer; Conduction: 1D steady heat conduction with and without heat generation, Unsteady state heat conduction (lumped capacitance method and Heisler chart), heat transfer from extended surfaces; Convection: Governing equations, dimensional analysis, boundary layers, Forced convection - external and internal flows, Natural and mixed convection; Heat Exchanger: Design and types of heat exchangers: Analysis of heat exchanger: LMTD and effectiveness-NTU methods; Radiation: Processes and properties, Black and real body radiation, view factor and radiation exchanges between surfaces in an enclosure; Mass Transfer: Concept of mass transfer.

MEL333 Design of Machine Elements

3.5 Credits (3-0.5-0)

Prerequisite(s): None
Overlap with: MEL232 (10%)

Basics: Introduction to Mechanical Engineering Design, Engineering Materials - Load and Stress Analysis, Deflection and Stiffness; Failure Prevention: Failure resulting from static loading; Fatigue failure resulting from variable loading; Design of Mechanical elements: Shafts; Power Screw, Threaded Joints, Bolt, Rivet, Weld; Springs; Bearings; Gears; Clutch, Break, Belts.

MEL334 Theory of Mechanisms and Machines

3.5 Credits (3-0.5-0)
Prerequisite(s): None
Overlap with: NA

Kinematics of Mechanisms: Kinematic pairs, diagrams, and inversion; Mobility and range of movement; Displacement, velocity, and acceleration; Analysis of planar linkages; Design of Mechanisms: Dimensional synthesis for motion, path, and function generation; Gears and gear trains; Cam mechanisms, Cam profile synthesis; Dynamics of Machines: Dynamic force analysis; Inertia forces and balancing for rotating and reciprocating machines; Flywheels, Governors; Vibration: Introduction, Single degree of freedom system; Free and forced vibration; Damped, undamped, and overdamped system.

MEL351 Machining and Machine Tools

3 Credits (3-0-0)
Prerequisite(s): NA
Overlap with: NA

Machining as secondary manufacturing processes, types of machining processes, types of cutting tools, Different output characteristics in machining processes; Concept of directrix and generatrix, types of surfaces generated in machining; Determination of material removal rate and machining time in different machining processes; Cutting tool geometry, concepts of master line; Mechanics of chip formation, concept of orthogonal and oblique cutting; Analysis of cutting forces in orthogonal cutting, experimental measurement of cutting force; Cutting temperature: causes, effects, measurement and control; Cutting tool materials, Cutting fluid, tool wear and tool life, role of geometrical and process parameters and cutting fluid on machinability; Machine tools: Types, mechanisms and work holding devices; Grinding: introduction and types of grinding operations, and specifications of grinding wheels.

MEP371 Thermal and Fluid Engineering Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: NA

Experiments to demonstrate major and minor pipe losses, Bernoulli's principle, Flow regimes, flow measurement devices, performance of turbines, hydraulic/pneumatic systems will be covered under fluid mechanics and machine domain; Whereas experiments to demonstrate different modes of heat transfer (Conduction, Convection and Radiation), and the performance of refrigerator, air conditioner, internal combustion engine will be covered under the domain of thermal engineering.

MEP376 Solid Mechanics and Dynamics Lab

1 Credits (0-0-2)
Prerequisite(s): None
Overlap with: NA

Experiments on stress and strain measurements on mechanical components/structures; Experiments on measurement of material properties; Experiments on dynamics and vibration of mechanical components/structures.

MEP381 Manufacturing and Metrology Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: NA

Casting; Metal forming: Rolling, Extrusion, sheet metal forming, forging; Welding: Metal inert gas welding, TIG, gas welding, Spot welding, friction stir welding; Machining: Turning, milling, drilling; Metrology: Coordinate measuring machine, vernier callipers/screw gauge.

MEL414 Internal Combustion Engines

3 Credits (2.5-0.5-0)
Prerequisite(s): MEL111 or equivalent
Overlap with: MEL111 (5%)

Introduction: Engine Configurations and components, Engine types and classification, Reciprocating and rotary engines, Valve timing, Thermochemistry of fuel-air mixtures, Engine operative parameters, Torque and power, Efficiencies, Mean effective pressure.
Combustion in Spark-ignition Engines: Premixed charge combustion, SI Engine combustion conceptual models, Combustion rate characterization, Thermodynamics analysis of combustion, Flame propagation Phenomenon, Cycle to cycle variation, knocking combustion, Factors affecting Knock.
Combustion in Compression-ignition Engines: Fuel injection and spray structure, CI Engine combustion conceptual model, Diesel combustion process characterization, Thermodynamics analysis, Premixed and mixing controlled combustion, Fuel injection parameters.
Engine cooling, lubrication and other systems: Air-cooled Systems- Colling fins, Baffles, Liquid cooling systems – Direct, Thermosyphon, Forced circulation, Evaporative and pressure cooling, Function and mechanism of lubrication, Lubrication systems, Exhaust gas recirculation, Variable valve timing.
Formation of Engine emissions: Sources of engine emissions, Formation of carbon monoxide, NOx Formation, Unburned hydrocarbon emissions, Soot and particulate formation, Emission Measurement, NDIR technique, Flame ionization detector, Chemiluminescence technique for NOx measurement, Smoke opacity.
Exhaust Aftertreatment devices: Basics of catalytic exhaust treatment, Three-way catalytic converter, Diesel oxidation catalyst, Diesel Particulate filter, Regeneration, Gasoline particulate filter, NOx absorber, Selective catalytic converter.

MEL416 Power Plant Engineering

3 Credits (2-1-0)
Prerequisite(s): MEL211 or equivalent
Overlap with: MEL214 (15%)

Economics of Power Generation:
Introduction, Power plant economics, Types of power plants
Steam Power Plants:
Introduction, Economics of Power Generation, Reheating and regeneration, Feedwater heaters, Supercritical pressure cycle, Deaerator, Binary vapour cycle, Combined cycle plants, Coal, Coal analysis, Combustion reactions, Energy balance of steam generator
Steam Generators, Steam Turbines, Condenser:
Introduction, Basic types of steam generators, Fire tube and water tube boilers, Ash handling system, Feedwater treatment, Steam turbines, Condenser, Cooling towers.
Diesel Engine and Gas Turbine Power Plants:
Introduction, Combustion in a CL engine, Performance characteristics, Supercharging, Layout of a diesel engine power plant, Gas turbine power plant, Components of gas turbine plant, gas turbine fuels, Gas turbine Materials.
Nuclear and Hydroelectric Power Plants:
Nuclear fusion and fission, Chain reaction, Nuclear fuels, Components of nuclear reactor, Classification of reactors, Nuclear waste and its disposal, Advantages and disadvantages of Hydroelectric power plant, Classification of hydroelectric power plants, Pelton, Francis turbines and Kaplan turbines.
Non-conventional and Renewable Power Generation:
Introduction, Renewable energy sources potential, Solar power plants, Thermal energy, Wind energy, Wind power plant, Waste to power generation, Geothermal energy.

MEL501 Advanced Engineering Mathematics

3 Credits (3-0-0)
Prerequisite(s): NA
Overlap with: MEL304 (30%)

Ordinary Differential equations: Review of 2nd and Higher order ODEs, Systems of ODEs, Series solutions of ODEs; Numerical differentiation and integration techniques, Few numerical methods for solution of ODEs; Partial Differential equations: Basic concepts, Variable separation method, Solution of wave equation, Solutions by Fourier series; Linear algebra: Review of Matrices, Numerical linear algebra, Eigen value problems, QR and Singular value decomposition; Vector Calculus: Review of vector algebra, Vector transformations, Vector integral calculus and theorems; Optimization: One-dimensional constrained and unconstrained optimization, Multidimensional constrained and unconstrained optimization, Linear and quadratic programming; Regression analysis: Least-square regression, Newton's divided difference interpolation, Lagrange interpolation.

MEL558 Surface Engineering

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: Old MT503 (10%)

Introduction to surface engineering – Concept and Importance.

Surface Degradation: Causes, types and consequences of surface degradation. Classification of surface modification techniques, advantages and their limitations.
Materials for Surface Engineering: Selection of materials for engineering the surfaces for specific applications, structure and property relationship of coatings system.
Conventional surface engineering and heat treatment practices. Surface modification of ferrous and non-ferrous materials like nitriding, cyaniding, aluminizing etc.
Techniques of thin film coatings; Vapour deposition processes: Chemical Vapour Deposition of different types of coatings. Vacuum Evaporation Deposition, Cathodic Arc Evaporation Deposition, sputtering and its advancements, Characteristic properties of coatings.
Thermal Spraying methods: Classifications, Flame and plasma spraying, HVOF, cold spray techiques and its variants.
Electroplating, Electroless coating, laser, Electron beam and Microwave assisted Surface Engineering, Friction Surfacing and Friction stir processing.
Physical Characterization: Mircostructure, Surface morphology, Phase analysis, Determination of Crystallite size in coatings.
Mechanical Characterization: Determination of thickness of coating, coating hardness, Adhesion of surface coating, Surface roughness.
Performance evaluation of coating: Friction and wear performance, Evaluation of corrosion resistance, Assessment of oxidation resistance, Applications of tribological coatings, Performance of cutting tool coatings: Few case studies using hard and soft coatings, HFCVD Diamond coated tool.

MEL611 Advanced Fluid Mechanics

3 Credits (3-0-0)
Prerequisite(s): MEL212 or equivalent
Overlap with: ME212 (20 %)

Introduction: Fluid Properties, Definition of Continuum, Examples of Viscous Flow Phenomena, Laminar and Turbulent Flow, Vector and Tensor notation, Lagrangian/Eulerian Methods, Streamline, Path line, Streak line, Material Derivative and acceleration, Strain Rate, Translation, Rotation and Distortion of Fluid Element, Vorticity and Circulation; Fundamental Equations of Viscous Flow: Conservation of Mass, Momentum and Energy, Control Volume Approach, Derivation of Continuity Equation: conservative and non conservative form, Derivation of Navier-Stokes (N-S) equations for Compressible Flow, Stokes Hypothesis. Incompressible form of N-S equations; Exact Solutions: Parallel Flow in a Straight Channel, Couette Flow, Lubrication Theory, Hagen-Poiseuille Flow, Unsteady Parallel Flow, Stokes Problems, Similarity Solution and Creeping Flow; Potential flows: Stream function, velocity potentials, Kelvin's circulation theorem, Complex variable and Potential flow, principle of superposition, Magnus effect, lift and drag on two-dimensional shapes; Boundary Layer Theory: Derivation of 2-D Boundary Layer Equations, Displacement, Momentum and Energy Thickness, Order of Magnitude Analysis, Shape Factor, Momentum-Integral Approach, Boundary Layer Separation, Effect of Pressure Gradient, Boundary Layer Control by Suction and Blowing, Blassius Solution of Boundary Layer Equation, Falkner-Skan equation, Kármán-Pohlhausen Method for Non-Zero Pressure Gradient, Holsten and Bohlen Method (Modified Pohlhausen Method), Waltz's-Quadrature Formula and Example Problems; Flow Instability: Instability, Concept of Small-Perturbations, Linearized Stability of Parallel Viscous Flows, Orr-Sommerfeld Equation, Neutral Stability Curve, Boundary Layer Transition over a Flat Plate; Turbulent Boundary Layers: Introduction to Turbulent Flows, Features of Turbulence, Energy Cascade, Mean and Fluctuating Components, Derivations of Reynolds Averaged Navier-Stokes Equations, Reynolds Stress Tensor, Turbulent

Boundary Layer Equations, Eddy Viscosity and Mixing Length Hypothesis, Universal Law of Wall, Laminar Sublayer, Power Law for Turbulent Boundary Layer, Skin Friction Coefficient, Turbulent Boundary Layer with Pressure Gradient, Quadrature Formula and Example Problems, Fully Developed Turbulent Flow through a Pipe and Channel, Use of Log Law and Power Law, Derivation of Coefficient of Friction for Turbulent Pipe Flow.

MEL612 Conduction and Radiation Heat Transfer

3 Credits (3-0-0)
Prerequisite(s): MEL313 or equivalent
Overlap with: ME313 (10 %)

Conduction; Derivation of heat conduction equation; Summary of basic 1D conduction; Fins with variable cross-section; Multi-dimensional steady and unsteady problems in Cartesian and Cylindrical coordinates. Semi-infinite solids; Duhamel's Superposition Integral; Solidification and Melting; Inverse heat conduction; Microscale heat transfer; Radiation; Physical mechanism. Laws of thermal radiation. Radiation properties of surfaces; View factors for diffuse radiation. Radiation exchange in black and diffuse-gray enclosures; Radiation effects in temperature measurement. Enclosure theory for surfaces with wall temperatures that are continuous functions of space. Spectrally diffuse enclosure surfaces. Specularly reflecting surfaces; The equation of radiative properties in participating media. Radiative properties of molecular gases. Approximate solution methods for one-dimensional media: The optically thin and optically thick approximations; Radiation in participating media: Gas radiation; Combined Conduction and Radiation: Example of a spacecraft radiator. Solar radiation. Greenhouse effect.

MEL613 Convective Heat Transfer

3 Credits (3-0-0)
Prerequisite(s): MEL212, MEL313
Overlap with: MEL313 (15%)

Overview of continuity and momentum equations and derivation of energy equation; Solutions for laminar external forced convection; Solutions for Laminar internal forced convection; Transition flow - Heat transfer in transition flow; Turbulent flow - Reynolds averaged equations of motion, Averaged energy equations; Turbulent flow and heat transfer over a flat plate; Turbulent flow and heat transfer in pipes and channels; Laminar and turbulent natural convection - laminar and turbulent mixed convection; Boiling heat Transfer-Pool boiling, nucleate boiling, film boiling, flow boiling; Condensation-dropwise condensation, film condensation; Combined convection and radiation; Some special topics (subjected to availability of time)- Convective heat transfer with nanofluids, Heat transfer in impinging continuous/pulsating jets, Double diffusive convection, conjugate heat transfer.

MEL614 Computational Fluid Dynamics

3 Credits (3-0-0)
Prerequisite(s): MEL212 (or equivalent); MEL313 (or equivalent)
Overlap with: MEL212 (2%), MEL313 (2%), ME615 (100%)

Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations, Differential vs integral forms of general transport equations
Classification of physical behaviours, classification method for simple PDEs; Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method;

Finite volume method for diffusion problems;
Finite volume method for convection-diffusion problems: differencing schemes; Solution of discretized equations: TDMA, Iterative methods; Solution algorithms for pressure-velocity coupling in steady flow: SIMPLE and SIMPLER algorithm;
The finite volume method for unsteady flows: Explicit scheme, Crank-Nicolson scheme, fully implicit scheme; Stability, Feasibility Criterion and Error Analysis of a Solution,
Unstructured grid formulation, Application of CFD to analyze advanced engineering problems.

MEL616 Advances in Interfacial Sciences

3 Credits (3-0-0)
Prerequisite(s): MEL212 (or equivalent)
Overlap with: ME616 (Old curriculum course)

Introduction:
Scope of the course and Basic concepts of interfaces and fundamentals of governing equations.
Liquid-fluid interface science and governing equations
Solid-liquid interface science and governing equations
Special phenomena at solid-liquid and liquid-fluid interfaces
Capillarity: Deformable interfaces
Emphasis on the effect of surface tension, liquid at interfaces, Surface curvature, Contact Angles and measurement.
Surface wettability:
Hydrophilic, hydrophobic, superhydrophobic surfaces, and variable wettability gradient surfaces for bio-applications.
Hydrodynamics of wetting:
Thin film wetting, droplets, bubbles, puddles and waves, Instability of fluid films.
Droplet impact: Fluid dynamics aspect
Spreading, receding, bouncing, nonbouncing, partial bouncing, splashing. The partial differential equations and their solutions for these problem. Scaling approximations. Experimental and Numerical methods that can be used for these problems.
Droplet evaporation: Fluid dynamics and heat transfer
Conduction, convection, mass transfer via diffusion. The partial differential equations and their solutions for these problem. Experimental and Numerical that can be used for two-phase flow and heat transfer problems.
Surfactants:
Application: Soap films and bubbles in detail.
Microfluidics:
Basics of manipulation of fluids in a microchannel and its applications. Boiling and heat transfer in microchannel.
Colloids:
Colloidal Deposits and its interfacial science
Special Topics:
Applications in Forensic science, biotechnology, energy and sustainable environment. Some lab demonstration on Solid-Liquid-Fluid interface characterization, Water droplet impact on micropillared substrates, Water droplet evaporation: Coffee-ring effect and inner deposit effect.

MEL617 Microfluidics

3 Credits (3-0-0)
Prerequisite(s): MEL212 or equivalent
Overlap with: MEL212 (7%), BML611 (27%)

Introduction: Significance in fundamental and applications of microdevices, scaling laws.
Transport laws and boundary conditions: overview of conservation of mass, momentum and energy equations, momentum/thermal accommodation coefficients, Maxwell's slip model, few exact solutions with slip and temperature jump boundary conditions, scaling and microscale effects such as compressibility and refraction.
Channel flow: Hydraulic resistance, equivalent circuit theory, pressure drive flows, Stokes flow, compliance due to soft wall and entrapped gasses in the channel.
Surface tension driven flows: Dynamic contact angle, themocapilarity, Electrowetting, Concept of Debye layer, Electrokinetic phenomena.
Microfabrication: Functional materials, Lithography, Subtractive and additive techniques, laser microfabrication, bonding, Polymer based fabrication techniques.
Microdevices: Design parameters and fabrication steps for fabricating Micropumps, Microvalves, Micro flow sensors, Lab-on-a-chip devices, Microneedles, Micromixers.
Demonstration sessions of some fabrication techniques.

MEL618 Thermal Management of Electronics Systems

3 Credits (3-0-0)
Prerequisite(s): MEL313 or equivalent
Overlap with: MEL313 (15%)

Introduction: heat transfer modes, thermal spreading and contact resistance, microscale heat transfer; Fin analysis, heat sink design optimization, Air and liquid jet impingement, heat pipes, vapour chambers, thermosyphons;
Pump fluid loops (single and two phase), Immersion cooling, phase change energy storage, multi-mode heat transfer;
Thermal systems analysis, cold plates and heat exchangers, flow network modelling, compact models, acoustic and mechanical design issues;
Data Centre Energy Flow and thermal management, Battery thermal management, Emerging technologies

MEL622 Experimental methods in Fluids and Thermal Science

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: ME653 (100%)

Analysis of Experimental Data: Causes and types of experimental error, uncertainty analysis, statistical analysis of data, probability distributions and curve fitting; Dynamic performance characteristics; Input types; Instrument types-zero order instrument, first-order instrument, second-order instrument.
Measurement of pressure: Design of Pitot and Pitot static tubes, factors affecting the measurements of Pitot/Pitot Static Tubes: Alignment, wall effects, turbulence etc., the effect of flow compressibility on pressure measurements of PST, methods of measuring static and Pitot/stagnation pressure in the compressible flow. Flow measurements: 3 hole and 5 hole probes, directional sensitivity of 3 hole and five-hole probes.

Hotwire anemometry (HWA): Detail analysis of constant current anemometer (CCA) and constant temperature anemometer (CTA), comparison of CCA and CTA, measurements of fluctuating velocity in turbulent flow
Laser Doppler Velocimetry/Anemometry (LDV/LOA), Particle Image Velocimetry (PIV), micro-PIV, Flow visualization methods.
Temperature Measurements: Details of Thermocouple measurements and its calibration; Liquid crystal thermography (LCT), InfraRed Thermography (IRT)
Optical methods for temperature and density measurements: Qualitative and quantitative analysis through Interferometer, Schlieren and Shadowgraph.

MEL623 Engine Management System and Alternative Fuels

3 Credits (3-0-0)
Prerequisite(s): MEL414 or equivalent
Overlap with: MEL414 (5%)

Introduction: History, Charge preparation in gasoline engines, Fuel-air mixture in diesel engine, Power-torque characteristic curve.
Gasoline engine management: Cylinder charge control systems, Manifold fuel injection, Gasoline direct injection, Operation of gasoline engine on natural gas, Ignition system. Inductive ignition systems, Ignition Coils, Spark Plugs, Sensors for IC Engines- temperature sensors, Engine speed sensors, Hot film air mass sensors, Piezoelectric knock sensor, high-pressure fuel sensor, Lambda sensor, Electronic control unit, Electronic management of catalytic devices.
Diesel engine management: Cylinder charge control systems, Principles of diesel fuel injection, Mixture distribution, Diesel fuel injection systems, Single plunger fuel injection pumps. Unit injector systems and Unit pump systems, Common rail systems, Injection nozzles, Minimizing emissions inside the engine, Micromechanical pressure sensors, Hall-effect sensors, accelerator pedal sensor, Hot-film air-mass meter, Electronic diesel control (EDC), Electronic control unit (ECU).
Alternative fuels: Liquid Alternative Fuels, Straight vegetable oils, Biodiesels. Emulsified Fuels, Hydrotreated vegetable oil, Methanol, Ethanol and higher versions of alcohols, Second generation liquid alternative fuels, Gaseous alternative fuels, Hydrogen, Liquefied petroleum gas, Di-methyl ether, Hythane. Emission characteristics of alternative fuels, dilution and measurement.

MEL624 Energy Conservation and Management

3 Credits (3-0-0)
Prerequisite(s): MEL211, MEL313.
Overlap with: NA

Introduction: National and international status of energy and power, environmental aspects associate with energy utilization; Energy audits and surveys-concept, significance, types, methodology, Energy conservation acts and policies. Energy Economics: Investment appraisal indexes, cost benefit analysis, fixed and variable costs, interest charges, payback period, net present value, internal rate of return, life cycle costing. Energy conservation in Stream generator and distribution network: Efficiency testing, control mechanism, steam traps, condensate recovery, use of insulation and refractories. Energy conservation in pumping system: Pumps, fans, blowers, compressor, and associated supply system. Waste heat recovery: Recuperative and regenerative heat exchangers, Cogeneration/Combined heat and power unit (CHP), economics of CHP. Energy conservation in building heating/cooling: Building envelope, human thermal comfort, HVAC systems, problems with traditions design and alternate approaches, Passive heating/cooling, thermal energy storage.

MEL631 Continuum Mechanics

3 Credits (3-0-0)
Prerequisite(s): MEL232 (or equivalent)
Overlap with: NA

Introduction to vectors and tensors: Indicial notations - Tensor Algebra - Higher order tensors - Transformation laws-Integral theorems; Kinematics: Motion-Various measures of Deformation; Concept of Stress: Traction vector and stress tensor - Cauchy's stress theorem - State of Stress; Balance principles: Conservation of Mass - Momentum, Energy - Reynolds' Transport Theorem, Objectivity; Linear elasticity: Small strains, Compatibility equations - Equations of elasticity - Boundary value problems.

MEL633 Finite Element Method

3 Credits (2-1-0)
Prerequisite(s): MEL232 (or equivalent)
Overlap with: NA

Introduction and historical background; Development of Weak forms of governing equations: Elasticity and Heat transfer; Finite element formulation (static/steady-state and time dependent); One Dimensional Problems: Bar element – Beam element – Application to trusses and frames; Two and Three dimensional FEM: Plane Problems, Axisymmetric problems - Isoparametric elements - Trianglular, Quadrilaterial, Tertrahedra and Hexahedral Elements; Vibration, and stability problems.

MEL636 Structural Dynamics

3 Credits (3-0-0)
Prerequisite(s): MEL231
Overlap with: MEL334 (10%)

Introduction: DOF, Harmonic motion, Periodic motion- Introduction to spring, mass and damper, fundamental definitions and assumptions.
Single degree of freedom system: Equation of motion - Free vibration without and with viscous damping – Logarithmic decrement.
Forced vibrations: Without and with viscous damping – Vibration isolation – Base excitation, Response due to general periodic loading, Impulse response function, Duhamel integral.
Two degrees of freedom system: Free vibrations without and with damping, Natural modes – Forced vibration without and with damping.
Multi-degree of freedom system: Free vibration without and with damping, normal modes, natural frequencies – Forced vibrations without and with damping – Mass normalization, stiffness normalization – Variable separable solution.
Vibration of continuous systems: Vibrating strings – Longitudinal and Torsional vibration of rods – Vibration of beams

MEL637 Wave Propagation in Structures

3 Credits (3-0-0)
Prerequisite(s): MEL232 or equivalent
Overlap with: Nil

Introduction: Structural dynamics and wave propagation; Basics of non-destructive testing, structural health monitoring, practical examples of wave propagation in elastic structures; continuous and discrete Fourier transform, FFT.
Fundamentals of wave propagation: sample waveforms, spectral analysis of wave motion; propagating and reconstructing waves, phase velocity, group velocity, dispersion relations, wavenumbers, signal processing and spectral estimation.
Waves in 1D: longitudinal wave propagation in rods, mode conversions, torsional waves in 1D; D'Alembertz solutions, Viscoelastic rod, higher order rod theory; coupled thermos elastic waves.
Waves in 2D: flexural wave propagation in beams, mode conversion; waves in curved beams; higher order beam theories, wave guides; wave propagation in composite beams.
Three-dimensional waves: Wave propagation in complex structures, wave propagation in plates (review of elasticity, Navier's equation of motion, boundary and initial conditions, Helmholtz decomposition, dilation and shear waves); plane waves, slowness diagram; Scattering of flexural waves; wave propagation in composite plates.

MEL651 Additive Manufacturing Technology

3 Credits (3-0-0)
Prerequisite(s): (MEP102 and MEL251) or Equivalent
Overlap with: ME251 (15%)

Additive and subtractive manufacturing, History of additive manufacturing, Introduction and additive manufacturing process chain: CAD model preparation, slicing, build file preparation; Additive manufacturing mechanism: sheet lamination, Material Extrusion, Direct energy deposition, powder bed fusion; Arc based additive manufacturing; Solid state additive manufacturing etc.; Post-processing; Numerical modeling; Economic analysis, and application in various industries.

MEL652 Advances in Metal forming and welding

3 Credits (3-0-0)
Prerequisite(s): MEL251
Overlap with: MEL251 (15%)

Metal Forming: Introduction: Metal forming processes, definition, advantages, disadvantages, forming equipment. Theory of plasticity: stress-strain relation, strain-displacement, incompressibility, strain compatibility, yield criteria, flow rule. Theories in Metal forming: slip line field, upper bound and lower bound theorem, slab analysis. Bulk Forming Processes and sheet metal forming application.
Welding: Advanced fusion welding technique (Magnetically impelled arc welding, GTAW, electron beam welding). Welding metallurgy: Solidification, Recrystallization mechanism. Defects in welding, Residual stresses, Inspection and testing of weldments, formability of welded material.

MEL655 Automation in Production Systems

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction to manufacturing, Manufacturing system concept. Production concept, Production/Product relationship and mathematical models, Principles of automation and strategies, Basic elements of an automated system, Advanced automation functions and levels of automation; Introduction to NC, CNC technology, DNC, Control systems in CNC system, CNC programming techniques: Word address

format and Computer-assisted part programming; Introduction to Robotics; Group Technology and cellular manufacturing, Opitz System and GT benefits; Flexible manufacturing systems (FMS); Process planning and computer-assisted process planning; Automated materials handling and storage systems.

MEL656 Material Processing with Laser

3 Credits (3-0-0)
Prerequisite(s): MEL251 or equivalent
Overlap with: NA

Introduction to laser, basics of laser, laser properties, advantages and disadvantages, application. Working principle of different industrial laser, CO_2 Laser, Nd-YAG laser, Diode laser, Excimer laser, Fiber laser etc. Laser interaction with materials. Laser Safety. Physical demonstration of laser material processing. Laser cutting, drilling, welding and forming. Laser based surface engineering techniques. Laser assisted manufacturing processes.

MEL658 Mechanical Behaviour and Testing of Materials

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MML501 (15%), MEL232 (5%), MEL659 (5%), MML204 (10%), ME559 (40%), ME151 (15%)
Introduction: Crystals — lattice — Elastic deformation - Theoretical strength— Real strength — defects — slip mechanism— slip system.
Mechanical testing: Uniaxial monotonic tensile and compression loading— stress-strain relationship — mechanisms of deformation — Role of strain-rate —strengthening factors. Creep mechanism — Effect of load and temperature— Creep mechanism maps. Cyclic loading— Low-cycle and High-cycle fatigue- S-N curve.
Tribology: Introduction - wear and friction - test methods — data processing.
Corrosion: Introduction — types— test methods— data processing.

MEL659 Advanced Materials and Processing

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MML204 (15%)

Introduction: Crystal structure – defects – dislocations – plastic deformation. Equilibrium Phase diagram Fe-Fe_3C phase diagram – TTT diagrams. Heat treatment: Types – effect on materials microstructure and performance. Reference of Ferrous and non-ferrous alloys. Metallography: Sample preparation methods – Microscopy – Diffraction – Spectroscopy. Strengthening Mechanisms: Dislocation-based – Grain boundary based – solid-solution – based – precipitation-based. Softening Mechanisms: Recovery – Recrystallization – Grain-growth. Physical metallurgy of advanced materials: Ferrous alloys – light -weight alloys – Super-alloys. Advanced Processing techniques: Severe plastic deformation – Advanced coating – Additive Manufacturing. Case studies on advancement in development and application of advanced materials shall be discussed by students.

Courses offered in the Discipline of Mechatronics Engineering

MTL201 Fluid Power Systems

4 Credits (3-0-2)
Prerequisite(s): None
Overlap with: NA

Introduction: Types of power systems – Physical properties of fluids – Types of fluids and fluid power systems – Application of fluid power systems; Hydraulic systems: Pumps – Actuators – valves – circuits design and analysis – Ancillary hydraulic devices; Pneumatic systems: Compressors – Air preparation units – circuit design; Advanced systems: Servo-hydraulics – Electro-pneumatics – Digital systems; Lab-practise: computer simulation of hydraulic and pneumatic circuits – design development and deployment of pneumatic systems.

MTL202 Industry 4.0

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: DSL250 (10%)

Introduction: Sensing & actuation, Communication, Networking; Industry 4.0: Globalisation and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories; Basic principles and technologies of a Smart Factory: Internet of Things (IoT) & Industrial Internet of Things (IIoT), Big Data, Cyber-Physical Systems, Value chains in manufacturing companies, Customization of products, Digital Twins, Cloud Computing / Cloud Manufacturing; Industrial IoT: Big Data Analytics and Software Defined Networks, Machine Learning and Data Science, Data Management with Hadoop, Security in IIoT, Fog Computing; Industrial IoT-Application Domains: Factories and Assembly Line, Food Industry, Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management, Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries.

MTL301 Fundamentals of Robotics

3 Credits (3-0-0)
Prerequisite(s): MEL334
Overlap with: EEL208 (10%) and EEL205 (10%)

Introduction, transformations, DH Parameters, Forward and Inverse Kinematics, redundancy resolution; Velocity kinematics and Jacobian, Singular value decomposition, singularity, and manipulation ability; Trajectory planning, dynamics; Multi finger grasping – form, force closures, grasp matrix; Locomotion – active and passive walkers, concepts of balance, Biped Gait and Balance using ZMP, kinematics and dynamic modelling of walk. Design and Optimization of legged mechanisms; Sensors and actuators as used in robotics, Basics of linear control – PD, PID controller, model-based control, stability.

MTP301 Mechanism Lab

1.5 Credits (0-0-3)
Prerequisite(s): None

Overlap with: NA

Rigid link mechanism: Analysis, synthesis and fabrication; Path planning for mechanism labs; Fabrication of robotic linkage; Evaluation material properties: Hardness, tensile strength, coefficient of friction etc; Actuation of mechanisms; Measurement of torque and forces in mechanism.

MT302 Mechatronics Lab II

2 Credits (0-0-2)
Prerequisite(s): NA
Overlap with: EEP308 (23%), EEP501 (83%)

Modelling of PMDC motor: Modelling – identification – Disturbance observer.
Speed and Position control of PMDC motor: Ziegler-Nichols tuning.
Close loop control of power converter: PID tuning using GA, PSO and MA based optimization.
Emulation flight dynamics of aerial vehicles: Course and Elevation
Non-Linear control of cart pendulum system and Maglev System
Digital state feedback control for PMDC motor
Evaluation.

MTP302 Mechatronics Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: EEP307 (25%)

Rigid link mechanism: Analysis, synthesis and fabrication; Path planning for mechanism labs; Fabrication of robotic linkage; Evaluation material properties: Hardness, tensile strength, coefficient of friction etc; Actuation of mechanisms; Measurement of torque and forces in mechanism.

MT303 Mechatronics Lab III

2 Credits (0-0-2)
Prerequisite(s): NA
Overlap with: NA

Material testing for tensile, compressive, torsion and bending strengths, measurement of strain, stress and modulus.
Use of piezoelectric sensor / dynamometer in mechanical systems for force and torque measurement and their signal processing.
Pneumatic training Kit – training for pneumatic actuators, Robot programming for simple pick and place operations and simulation.
Hand-on experiments for Path planning and synthesis of mechanism, measurement of motion parameters in mechanism and corresponding Velocity and acceleration analysis / analysis of real time mechanisms with sensor integration
Lab Project: 3D printing of working mechanism and demonstration.

MTQ401 Minor Project

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: NA

Research and system development oriented projects based on problems of practical interest. Students are generally expected to work towards the goals set by the project supervisor. Evaluation would be done based on regular presentations, written reports, and demo of the system developed.

MTL501 Fundamentals of Mechatronics

3 Credits (2-0-2)
Prerequisite(s): None
Overlap with: MEL333 (25%), EEL208 (25%), and MEL231 (25%)

Basics of measurement and Instrumentation: Characteristics, calibration and Error Analysis; Electrical Measurements: (i) bridge circuits for measurements, (ii) wattmeter and energy meter (iii) dynamometers, potentiometers and instrument transformers; An introduction to sensors: (i) temperature sensors (ii) force and pressure sensors (iii) motion sensors and LVDT, (iv) flow sensors (v) Hall effect sensors. Signal conditioning circuit, design (bridge and filter circuits, instrument amplifier) and microcontroller based signal processing and display (using Arduino board); Forces and Moments transmitted by Slender Members: Axial force distribution - Shear force distribution - Bending moment distribution, Stress and Strain: Stress - Plane stress - Strain -Plane strain - Mohr's circle, Stress-Strain Relations: Tensile test - Elastic Stress-Strain relation - Stress concentration - Stress due to torsion - Stress due to bending, Column buckling; Basics of Mechanisms: Kinematic pairs, diagrams, and inversion, Analysis of Mechanisms: Displacement, velocity, and acceleration - Analysis of planar linkages - Dynamic force analysis; Inertia forces, Basics of Dynamic components: Gears and gear trains - Cam - Flywheel -Gyroscope; Lab module: Material property testing [2], Manufacturing methods [3], Development of mechanisms.

MTL602 Design and Analysis of Robotic System

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MTL301 (25 %)

Introduction to robotics- History, growth; Robot applications- Manufacturing industry, defense, rehabilitation, medical etc., Laws of Robotics; Robot mechanisms; Kinematics- coordinate transformations, DH parameters; Forward kinematics, Inverse Kinematics, Jacobians, Statics, Trajectory Planning; Actuators: electrical, pneumatic, etc.; Sensors, sensor integration; Control – PWM, joint motion control, feedback control, Computed torque control; Perception, Localisation and mapping, Simultaneous Localization and Mapping; Probabilistic robotics, Path planning, Breadth-first & Depth-first search; Dijkstra; A-star; D-star; Voronoi; Potential Field; Hybrid approaches; Introduction to Reinforcement Learning.

MTL603 Digital Manufacturing

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction to manufacturing techniques: casting, welding, forming, machining etc; Introduction to CAD/CAM: Computer graphics, CNC, CNC coding etc; Introduction to DM- History, development, applications, components; Theory System of Digital manufacturing Science: Operation reference mode and architecture of the digital manufacturing system, modelling theory and method of the digital manufacturing, the macro integrity theory of the digital manufacturing system and the meta theory

constructing digital manufacturing; Manufacturing Informatics in Digital Manufacturing Science: The principle and properties of manufacturing information, the measurement and materialization of manufacturing information, self-assembling and the synthesis of manufacturing information and information security.
Digital twin for smart manufacturing: Background, concept etc; Cyber-Physical Fusion in Digital twin Shop-Floor: Discussion on fusion of physical elements in physical shop-floor (PS), model fusion in virtual shop-floor (VS), data fusion in shop-floor digital twin data (SDTD), and fusion of services in shop-floor service systems (SSS).
Digital Twin-Driven Prognostics and Health Management: How DT is use to emulate physical equipment thoroughly with high fidelity and how it can help digital continuous monitoring; Digital Twin and Virtual Reality and Augmented Reality/Mixed Reality: How to integrate VR, AR and MR with the DT will be discussed to provide more immersive and interactive services to users.

MTL655 Automation in Production Systems

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: MEL655 (100%)

Introduction to manufacturing, Manufacturing system concept. Production concept, Production/Product relationship and mathematical models, Principles of automation and strategies, Basic elements of an automated system, Advanced automation functions and levels of automation; Introduction to NC, CNC technology, DNC, Control systems in CNC system, CNC programming techniques: Word address format and Computer-assisted part programming; Introduction to Robotics; Group Technology and cellular manufacturing, Opitz System and GT benefits; Flexible manufacturing systems (FMS); Process planning and computer-assisted process planning; Automated materials handling and storage systems.

Courses offered in the Discipline of Physics

PHL101 Physics for Engineers

4 Credits (3-1-0)
Prerequisite(s): None
Overlap with: NA

Mechanics -generalized coordinates, Lagrangian and Hamiltonian formulation, simple, damped, forced –oscillations; Optics -interference, diffraction, polarization, LASER; Electromagnetism -Maxwell equation, dielectrics, metals, theory of radiation; Modern physics –atomic structure, quantum mechanics, photoelectric effect, relativity, nuclear physics; Astrophysics -Kepler's problem, stars, white-dwarfs, neutron stars, black holes, geometry of the universe, Materials property -electrical, thermal, magnetic, mechanical properties.

PHP102 Physics Lab

1.5 Credits (0-0-3)
Prerequisite(s): None
Overlap with: NA

Error Analysis, Newton rings, Bandgap of a semiconductor, Characteristics of a n-p-n transistor, Hall effect, Diffraction, Stefan's law and Zener diode, Cathode Ray Oscilloscope, Gouy's method: Measurement of the magnetic susceptibility.

PHL403 Mathematical Physics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Vector space, orthogonality, matrices, Cayley-Hamilton Theorem, eigenvalues, eigenvectors. Complex variable, Singularities, Taylor and Laurent series, residue theorem, contour integration; Fourier series, Fourier transformation, Laplace transformation. Special function: Gamma, Hermite, Bessel, Legendre, Laguerre and Green functions; Introduction of tensor and group theory, representation of O(N), SU(N).

PHL404 Electronics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Network theorems and related theories of electronic circuits/devices; application to simple circuits; p-n junction devices, diode, transistors; biasing schemes; small signal amplifiers; feedback; oscillators. Power supply; wave shaping circuits; Bipolar junction transistor: configurations, small signal amplifier, oscillators; JFET and MOSFET: characteristics, small signal amplifier. OP-AMP: Differential amplifiers; Op-Amp (741) circuits (amplifiers; scalar; adder; subtractors; comparator; logarithmic amplifiers; etc.); Number systems and their inter-conversion; Boolean algebra; Logic gates; De-Morgan's theorem. Logic Families: TTL, MOS and CMOS; Combinational Circuits: Adders, subtractors, Encoder, etc.; Sequential Circuits: Flip-flops, Registers, Counters, Memories; A/D and D/A conversion Microprocessor and microcontroller basics.

PHL501 Classical Mechanics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Review of Newtonian mechanics, Lagrangian mechanics, generalized coordinates, constraints, principle of virtual work. Lagrange's equation, calculus of variations, central forces, collisions, scattering small oscillations, anharmonic oscillators. perturbation theory, forced oscillators. Hamilton's equations, phase space & phase trajectories, canonical transformations, Poisson brackets. Hamilton-Jacobi theory, rigid body dynamics, nonlinear dynamics; Special Theory of Relativity: Relativistic Kinematics, Mass Energy equivalence, Continuous System.

PHL502 Quantum Mechanics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: PHLXXX, Physics for engineer (5%)

Origins of quantum theory, Schrödinger equation, wave mechanics, one and three-dimensional problems, Harmonic and other potentials; hydrogen atom, general treatment of angular momentum; spin. Time Independent Perturbation Theory, Variational Methods, WKB Approximation Method, Time Dependent Perturbation Theory, Fermi's Golden Rule. Scattering Theory: Scattering Amplitude and Cross Section. Born Approximation, Partial Wave Analysis, Optical Theorem, Hard-Sphere Scattering, Resonance Scattering from a Square Well Potential.

PHL505 Electrodynamics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Vector Analysis, Electrostatics: Coulomb's law, Electric Field, Gauss's law, Electric Potential, Poisson's and Laplace equations, Boundary conditions, Work and Energy in Electrostatics, Conductors, Multipole expansion. Electric field in matter: Dielectrics, Polarization and Bound charge, Electric Susceptibility and Permittivity. Magnetostatics: Lorentz force, Biot-Savart law, Ampere's law, Magnetic Vector potential, Boundary conditions, Multipole expansion. Magnetic field in matter: Magnetic materials, Magnetization and Bound currents, Ampere law in magnetized materials, Magnetic Susceptibility and Permeability. Electrodynamics: Faraday's law, Self and mutual inductance. Maxwell's equations. Conservation laws: Continuity equation, Poynting theorem. Electromagnetic waves: Wave equations, Energy and momentum of Electromagnetic waves, Propagation in linear media, Reflection and transmission of Electromagnetic waves, Electromagnetic waves in conductor. Potentials and Field: Scalar and vector potential, Gauge transformations, Coulomb and Lorentz gauges.

PHP506 Electronics Laboratory

3 Credits (0-0-6)
Prerequisite(s): None
Overlap with: NA

P-N junction diode characteristics, Study of diode circuit and power supply, Special diode (SCR and TRIAC) characteristics. Bipolar junction transistor (BJT) - characteristics, JFET characteristics, MOSFET characteristics, Study of Logic gates, Study of De Morgan's Laws. Applications of Operational Amplifier.

PHL507 Statistical Mechanics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Classical Statistical Mechanics: Postulate of classical statistical mechanics, Liouville's theorem, micro canonical ensemble, Derivation of equipartition theorem, classical ideal gas, Gibb's Paradox. Canonical ensemble and energy fluctuation, grand canonical ensemble and density fluctuation, Equivalence of canonical and grand canonical ensemble. Quantum Statistical Mechanics: The density matrix, ensembles in quantum statistical mechanics; Ideal gas in micro-canonical and grand canonical ensembles; Equation of state for ideal Fermi gas, Theory of white dwarf stars. Ideal Bose Gas, Photons and Planck's law, Phonons, Bose-Einstein condensation; Phase Transition: Thermodynamic description of phase transitions, phase transitions of second kind, Discontinuity of specific heat, change in symmetry in a phase transition of second kind. Ising model: Definition of Ising model, One Dimensional Ising model; Ideal Bose Gas, Photons and Planck's law Phonons, Bose- Einstein condensation; Thermodynamics description of phase transitions, phase transitions of second kind, Discontinuity of specific heat, change in symmetry in a phase transition of second kind.

PHL508 Solid State Physics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Crystal structure: Miller indices and reciprocal lattice, Bragg and von Laue diffraction, structure factor; Lattice vibration and thermal properties: harmonic approximation, monatomic and diatomic lattices, Brillouin zone, density of states, acoustic and optical modes, phonons, crystal momentum, Debye model of specific heat, thermal expansion, thermal conductivity. Free electron theory: Fermi gas, specific heat, Ohm's law, magnetoresistance, thermal conductivity; Band theory: Bloch theorem, nearly free electron model, motion of electron in energy bands, effective mass; Semiconductor: Intrinsic and extrinsic semiconductors, mobility and electrical conductivity, Fermi level, Hall effect. Magnetism: Diamagnetism, Hund's rules, Lande g-factor, quantum theory of paramagnetism, Pauli paramagnetism, exchange interaction, ferromagnetism, hysteresis; Superconductivity: Meissner effect, London equations, type-I and type-II superconductors; Ginzburg-Landau theory, outlines of BCS theory.

PHL509 Nuclear and Particle Physics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Ground state of Deuteron, Mesons and nuclear force field (Field theory of Nuclear forces); Liquid drop model and Weissacker's mass formula, Shell model of the nucleus, Fermi gas model Single particle shell model, Collective model of nucleus, rotational motion of the nucleus, vibration of spherical Nuclei; Description of nuclear Reactions, Q-value, derivation of elastic and reaction cross section, description

by partial wave analysis, Resonances, Breit-winger one level formula; Accelerators and Detectors. The Standard model of particle physics, particle classification, Spin and parity determination, Isospin, strangeness, hypercharge, and baryon number, lepton number, Gell-Mann-Nishijima Scheme, Quarks in hadrons: Meson and baryon octet, Elementary ideas of SU(3) symmetry, charmonium, charmed mesons and B mesons, Quark spin and colour.

PHL510 Atomic and Molecular Physics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Review of one and two-electron atoms; Many electron atoms: central field approximation, Thomas-Fermi model, Hartree-Fock and self-consistent field methods, Hund's rule, L-S and j-j coupling, Equivalent and nonequivalent electrons, Spectroscopic terms, Lande interval rule. Interaction with Electromagnetic fields: Zeeman, Paschen Back and Stark effects; Hyperfine structure and isotope shift, selection rules; Lamb shift; Molecular spectra: rotational, vibrational, electronic, Raman and Infra-red spectra of diatomic molecules; Hund's rule, Frank–Condon principle. Molecular structure: molecular potential, Born-Oppenheimer approximation, diatomic molecules, electronic angular momenta; Modern developments: optical cooling and trapping of atoms, Bose- Einstein condensation, Introduction of LASER physics.

PHP511 General Physics Laboratory

3 Credits (0-0-6)
Prerequisite(s): None
Overlap with: NA

Gamma Ray spectrometer, GM Counter, Frank Hertz Experiment. Optical Fiber characterization, Michelson Interferometer. Zeeman effect, Magnetic Hysterisis loop, Electron Spin resonance. Magnetoresistance using Four Probe Method. Confocal Raman Spectrometer-1, Confocal Raman Spectrometer-2.

PHL601 Computational Physics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

C Programming language: Algorithms, flow charts, constants, expressions, conditional statements, loops, arrays, logical expressions, control statements, functions, structures, pointers, bit operation, files in C.
Solving problems using C programming. Numerical Analysis: Interpolation by Lagrange method, Numerical solution of simple algebraic equation by Newton- Raphson method, Least Square fit using rational functions.
Numerical integration: Trapezoidal method, Simpson's method, Romberg integration, Gauss quadrature method, Eigenvalues and eigenvectors of a matrix, Solution of linear homogeneous equations, Trace of a matrix, Matrix inversion, Solution of ordinary differential equation by Runge-Kutta Method, Introductory Monte Carlo techniques.

PHL602 Astrophysics and Cosmology

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: PH660 (10%)

Astrophysics: basics, spectra, radiative transfer, stars, end-states of stars (white dwarfs, Chandrasekhar's mass limit, neutron stars, supernovae, black holes), quasars, gamma ray bursts, astrophysical fluids& plasmas, applications to stars/galaxies and the Universe.
Einstein's relativity: special relativity, equivalence principle, basics of general relativity.
Cosmology: redshift, FRLW models of the Universe, expansion, Hubble's law, the early Universe, big-bang model, inflation, nucleosynthesis, matter and radiation dominated era.
Dark matter, dark energy, cosmic microwave background, baryon acoustic oscillations, formation of galaxies and stars, current forefront of research, supermassive black holes, first stars, epoch of reionization, 21 cm cosmology, N-body simulations.

PHL603 Quantum Field Theory

3 Credits (3-0-0)
Prerequisite(s): Nil
Overlap with: PH600 (15%)

Relativistic quantum mechanics – Klein-Gordon equation, Dirac equation, free-particle, Solutions Lagrangian formulation of Klein-Gordon, Dirac and Maxwell equations, Symmetries (Noethers theorem), Gauge field, Actions.
Canonical quantization of scalar and Dirac fields. Interacting fields – Heisenberg picture, perturbation theory, Wick's theorem, Feynman diagram.
Cross-section and S-matrix. Quantization of gauge field, gauge fixing. QED and QED processes. Radiative corrections – self-energy, vacuum polarization, vertex correction. optical theorem. Introduction to renormalization.

PHL604 Particle Physics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

The Standard model of particle physics, particle classification, fermions and bosons, lepton flavors, quark flavors, electromagnetic, weak and strong processes, Spin and parity determination, Isospin, strangeness, hypercharge, and baryon number, lepton number, Gell- Mann-Nishijima Scheme.
Quarks in hadrons: Meson and baryon octet, Elementary ideas of SU(3) symmetry, charmonium, charmed mesons and B mesons, Quark spin and colour. Dirac equation, scattering processes of spin-1/2 particles (Feynmans rules as thumb rule).
Propagators Current-current interactions, weak interaction, Fermi theory Gauge symmetries, spontaneous symmetry breaking, Higgs mechanism Electroweak interaction, Glashow-Salam-Weinberg model Introduction to QCD, structure of hadrons (form factors, structure functions), parton model, Deep inelastic scattering.

PHL605 Relativistic Matter at Finite Magnetic Field

3 Credits (3-0-0)
Prerequisite(s): Nil
Overlap with: Nil

Two-body to N-body coupled oscillators to Continuous System, Relativistic ideal and dissipative Hydrodynamics, Magneto Hydrodynamics.
Kinetic Theory in presence of magnetic field, quantum aspect of magnetic field, Landau quantization, quantum Hall effect, quantum field theory at finite temperature and magnetic field.
Propagators at finite temperature, Propagators at finite magnetic field, Application towards High Energy Nuclear Physics and Astro Physics.

PHL606 Physics of Galaxies and Interstellar Medium

3 Credits (3-0-0)
Prerequisite(s): Nil
Overlap with: PH660 (10%)

Basics of gas dynamics, instabilities, shocks, supernovae, super bubbles, ionization fronts, basic magnetohydrodynamics, cosmic rays.
Interstellar medium: phases of interstellar medium, molecular clouds and star formation, radiative processes in interstellar medium, Magnetic field in interstellar medium and galaxies.
Galaxies: types of galaxies, components of galaxies, dynamics of gas and stars in galaxies, rotation curves of galaxies, cosmological perturbations and their growth, dark matter haloes, formation and evolution of galaxies, intergalactic medium, supermassive blackholes.

PHL607 Experimental and Measurement Techniques

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction to structure properties, basic crystallography, Normal and Reciprocal lattice, X-ray diffraction, Ewald Sphere; X-ray Characterization: X-ray diffraction (XRD) technique and analysis methods.
Electron Microscopy: Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), Electron Backscattered Diffraction (EBSD), Electron Probe Microanalysis (EPMA), Transmission Electron Microscopy (TEM) and diffraction pattern analysis.
Surface Probe Microscopy: Atomic Force Microscopy (AFM), Scanning Tunnelling Microscopy (STM); Electron Emission spectroscopies: X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Ultraviolet Photoelectron Spectroscopy (UPS).
Vibrational Spectroscopy: Raman Spectroscopy, Infra-red Spectroscopy, FTIR; Optical Techniques: Absorbance, Fluorescence, and Photoluminescence spectroscopy; Resonance techniques: Nuclear Magnetic Spectroscopy (NMR), Electron Paramagnetic Resonance (EPR); Chromatography: gas and liquid; Time of Flight (TOF) secondary ion mass spectroscopy.

PHL608 Quantum Theory of Solids

3 Credits (3-0-0)
Prerequisite(s): Nil
Overlap with: Nil

Quasi particles-Acoustic Phonons, Plasmons, Optical Phonons, and polarization waves, magnons, polarons, Fermion Fields and the Hartree-Forck approximation.
Correlated quasi particles-Many-Body Techniques and the Electron Gas, electron-phonon Interaction, superconductivity, Bloch Functions-General Properties, Brillouin Zones and Crystal Symmetry, Dynamics of Electrons in a Magnetic Field: de Hass-van Alphen Effect and Cyclotron Resonance.
Magnetoresistance, Calculation of Energy Bands and Fermi Surfaces, Semiconductor Crystals-Energy Bands, Cyclotron Resonance and Impurity States, Optical Absorption and Excitons, Green's Functions--Application to Solid State Physics.

PHL609 Advanced Quantum Mechanics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: PH600 (15%)

Unit-I: Klein-Gordon equation and its drawbacks, Dirac equation, Properties of Dirac matrices, non-relativistic reduction of Dirac equation, magnetic moment, Darwins term, Spin-Orbit coupling, Poincare transformation, Lorentz group, Covariant form of Dirac equation, Bilinear covariants, Gordon decomposition.
Unit-II: Free particle solution of Dirac equation, Projection operators for energy and spin, Physical interpretation of free particle solution, Zitter bewegung, Hole theory, Charge conjugation, space reflection and time reversal symmetries of Dirac equation. Continuous systems and fields. Transition from discrete to continuous systems, Lagrangian and Hamiltonian Formulations, Noether's theorem.
Unit-III: Second quantization, Equal Time Commutators, Normal Ordering, covariant quantization of electromagnetic field, Quantization of scalar, electromagnetic, and Dirac fields, Propagators for scalar, spinor and vector fields.

PHL610 Science and Technology of Thin Films

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Introduction to thin films and their relevance. Introduction to vacuum science and Technology, gas transport and pumping systems, pressure measurements.
Physics of thin film deposition, adsorption, surface deposition, nucleation, growth and structure development, surface structure, role of surfaces, epitaxial growth, lattice mismatch, strain, and growth modes.
Various thin film fabrication techniques: Thermal evaporation, Knudsen cell, Sputtering, E-beam evaporation, Atomic layer deposition, electrospinning, dry and wet etching, Chemical vapor deposition (CVD), sol-gel, Electrodeposition, Spray pyrolysis, spin-coating,
and Langmuir-Blodgett technique, etc.
Phase transformations in thin films, Overview of various properties of thin films and their relation to their microstructures.

PHL611 Applied Optics

3 Credits (3-0-0)
Prerequisite(s): None
Overlap with: NA

Brief history and basics of light: wave motion, electromagnetic waves, photons. Geometrical optics: Reflection, Refraction, Total internal reflection, lenses, prism. Physical optics: waves and wavefront, Coherence, Interference, Diffraction, Polarization, Scattering. Fourier optics: Fourier Transformation, Diffraction Theory, Propagation of light waves. Optical systems: Human Eye, Microscopes, Telescope, Laser, Light Emitting Diodes, Camera, Spectrometers, Spatial light modulators. Applications of optical techniques: Interferometers, Laser in industry, Optical imaging, Singular optics, Optical information processing, Fiber optics communication.