Rules and Regulations

College Timings:
The college timing is from 8:45 AM to 4:45 PM. The students must follow the college timing.

Academic calendar and Time table:
The details of academic curriculum and activities are mentioned in the academic book. The students are required to strictly follow the class Time table and academic calendar.

Attendance:
All students are hereby informed that attendance for lectures/practical/tutorials is compulsory. Mumbai University does not allow students to appear for examination if their attendance is less than 75%. But for the good academic performance of the students, the department expects 100% attendance in theory and practical separately.

Defaulters:
Defaulters list will be displayed monthly. The defaulter students are required to bring their parents/guardians within four days after the display of defaulters list. If students remain defaulter consistently he/she has to face the consequences as laid by the Mumbai University.

Assembly/prayer:
The Assembly/Prayer starts at 8:50 AM. The student must remain present in their respective classes for the prayer. The students reporting the college late will be treated as late comers and their attendance will be noted in the separate register. After three late marks the students are expected to bring their parents/guardians to the college.

Identity card:
Student must wear ID during college hours in the campus.

Mobile Phone:
Use of cell phone is strictly prohibited in the college premises.

Examination:
As per the university norms, there will be two term test i.e Mid Term test and End Term test in the semester which is an integral part of Internal Assessment for every subject. Both the examination will be based on 40% and 70% of theory syllabus respectively for each subject and will be conducted as per the dates mentioned in the academic calendar.
Attendance for both internal examination IS COMPULSORY. As per the university norms, no retest will be conducted under any circumstances. Separate passing heads is compulsory for internal and external examination for individual subjects. If the student fails in any of the exam he/she has to reappear in the concerned subject after the declaration of the result.

**Practicals/tutorials/Assignments:**

The Student should compulsory bring their rough and fair journal for the concerned subject for every practical and tutorials and get it checked regularly. Failing to do so, they will not be allowed for the practical. The Assignments for every subject should be submitted on regular basis. The student must abide by the above mentioned rules and regulations laid down by the department for their better and brighter future.
UNIVERSITY OF MUMBAI

ELECTRONICS
TELECOMMUNICATION

Bachelor of Engineering
Second Year (Semester - Ann IV), Revised Course
(Rev2012) Academic Year 2013-14
Electronics Telecommunication Engineering
(Second Year - Sem. III & IV), Revised course

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)
Preamble:

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation processes is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO’s) and give freedom to affiliated Institutes to add a few (PEO’s) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated Institutes understand the depth and approach of course to be taught, which will enhance learner’s learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester based Credit and Grading system enables a much required shift in focus from teacher-centric to learner-centric education since the workload is estimated based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner’s performance. Credit and grading based system was implemented for First Year of Engineering from the academic year 2012-2013. Subsequently, this system will be carried forward for Second Year Engineering in the academic year 2013-2014, for Third Year and Final Year Engineering in the academic years 2014-2015 and 2015-2016 respectively.

Dr. S. K. Ukarande
Dean,
Faculty of Technology,
Member Management Council, Senate, Academic Council
University of Mumbai, Mumbai
Preamble:

The engineering education in India has significantly expanded and diversified. Now, the challenge is to ensure its quality to the stakeholders along with the expansion. To meet this challenge, the issue of quality needs to be addressed, debated, and taken forward in a systematic manner. Accreditations are the principal means of quality assurance in higher education and reflect the fact that in achieving recognition, the institution or program of study is committed to open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially the range of skills and knowledge a student will have at the time of graduation from the program. An engineering program must ensure that its graduates understand the basic concepts of science and mathematics, have gone through one engineering field in depth of appreciate and use its methodologies of analyses and design, and have acquired skills for lifelong learning.

An engineering program must therefore have a mission statement which is in conformity with program objectives and program outcomes that are expected of the educational process. The outcomes of a program must be measurable and must be assessed regularly through proper feedback for improvement of the programme. There must be a quality assurance process in place within the Institute to make use of the feedback for improvement of the programme. The curriculum must be constantly refined and updated to ensure that the defined objectives and outcomes are achieved. Students must be encouraged to comment on the objectives and outcomes and the role played by the individual courses in achieving them. In line with this, the Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

I, as Chairman, Board of Studies in Electronics and Telecommunication Engineering, University of Mumbai, happy to state here that, Program Educational Objectives were finalized in a meeting where more than 20 members from different Institutes were attended, who were either Head of their representatives of Electronics and Telecommunication Engineering Department. The Program Educational Objectives finalized for undergraduate program in Electronics and Telecommunication Engineering are listed below;

- To provide students with a strong foundation in the mathematical, scientific and engineering fundamentals necessary to formulate, solve, and analyze engineering problems and to prepare them for graduate studies.
- To prepare students to demonstrate an ability to formulate and solve electronics and telecommunication engineering problems.
- To prepare students to demonstrate an ability to design electrical and electronic systems and conduct experiments, analyze and interpret data.
- To prepare students to demonstrate success for a successful career in industry to meet needs of Indian and multi-national companies.
- To develop the ability among students to synthesize data and technical concepts from applications to product designs.
- To provide opportunities for students to work as part of teams on multidisciplinary projects.
- To promote awareness among students for the life-long learning and to introduce them to professional ethics and codes of professional practice.

In addition to the above Program Educational Objectives, for each course of undergraduate program, objectives and expected outcomes from learner’s point of view are also included in the curriculum.
to support the philosophy of outcome-based education. I believe strongly that small steps taken in the right direction will definitely help in providing quality education to the stakeholders.

Dr. Udhav Bhosle  
Chairman, Board of Studies in Electronics and Telecommunication Engineering
# Programme Structure B.E. (Electronics & Telecommunication)

**S.E. (Electronics & Telecommunication) Sem III**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Scheme (Hrs.)</th>
<th>Credits Assigned</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Theory</td>
<td>Practical</td>
</tr>
<tr>
<td>ETS301</td>
<td>Applied Mathematics III</td>
<td>04</td>
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<tr>
<td>ETC302</td>
<td>Analog Electronics</td>
<td>04</td>
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</tr>
<tr>
<td>ETC303</td>
<td>Digital Electronics</td>
<td>04</td>
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</tr>
<tr>
<td>ETC304</td>
<td>Circuits and Transmission Lines</td>
<td>04</td>
<td>--</td>
</tr>
<tr>
<td>ETC305</td>
<td>Electroni Instruments and Measurements</td>
<td>04</td>
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</tr>
<tr>
<td>ETS306</td>
<td>Object Oriented Programming Methodology</td>
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<tr>
<td>ETL301</td>
<td>Analog Electronics Laboratory</td>
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<td>02</td>
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<td>Digital Electronics Laboratory</td>
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<td>02</td>
</tr>
<tr>
<td>ETL303</td>
<td>Circuits and Measurements Laboratory</td>
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<td>02</td>
</tr>
<tr>
<td>ETS304</td>
<td>Object Oriented Programming Methodology</td>
<td>--</td>
<td>*04</td>
</tr>
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</table>

Total: 20 10 01 20 04 01 2

*Out of four hours, 2 hours theory shall be taught to entire class followed by 2 hrs. practical in batches.

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<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Theory Marks</th>
<th>Examination Scheme</th>
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<td>Internal Assessment</td>
<td>Term Work</td>
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<td>Test 2</td>
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<td>ETC305</td>
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<td>ETS306</td>
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<tr>
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<td>Subject Code</td>
<td>Subject Name</td>
<td>Teaching Scheme (Hrs.)</td>
<td>Credits Assigned</td>
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<td></td>
<td>Theory</td>
<td>Practical</td>
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<td></td>
<td>Theory Marks</td>
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</tbody>
</table>

Course pre-requisite:
FES101: Applied Mathematics
FES201: Applied Mathematics

Course objectives:
- To provide students with a sound foundation in Mathematics and prepare them for graduate studies in Electronics and Telecommunication Engg.
- To provide students with mathematics fundamentals necessary to formulate, solve, and analyze engineering problems.
- To provide an opportunity for students to work as part of teams on multidisciplinary projects.

Course outcomes:
- Students will demonstrate basic knowledge of Laplace Transform, Fourier series, Bessel Functions, Vector Algebra, and Complex Variables.
- Students will demonstrate an ability to identify, formulate, and solve electronics and telecommunication Engg. problems using Applied Mathematics.
- Students will show the understanding of impact of Engineering Mathematics in Telecom Engg.
- Students who can participate and succeed in competitive exams like GATE, GRE.
<table>
<thead>
<tr>
<th>Module No.</th>
<th>Unit No.</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.1</td>
<td><strong>Laplace Transform (LT) of Standard Functions:</strong> Definition of unilateraland bilateral Laplace Transform, LT of $\sin(at), \cos(at), e^{at}, \sinh(at), \cosh(at), \text{erf}(t)$, Heaviside unit step, Dirac-delta function</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td><strong>Properties of Laplace Transform:</strong> Linearity, first shifting theorem, second shifting theorem, multiplication by $t^n$, division by $t$, Laplace Transform of derivatives and integrals, change of scale, convolution theorem, initial and final value theorem, Parseval's identity</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td><strong>Inverse Laplace Transform:</strong> Partial fraction method, long division method, residue method</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td><strong>Applications of Laplace Transform:</strong> Solution of ordinary differential equations</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>2.1</td>
<td><strong>Introduction:</strong> Definition, Dirichlet's conditions, Euler's formulae</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td><strong>Fourier Series of Functions:</strong> Exponential, trigonometric functions, even and odd functions, half range sine and cosine series</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Complex form of Fourier series, orthogonal and orthonormal set of functions, Fourier integral representation</td>
<td>1</td>
</tr>
<tr>
<td>3.0</td>
<td>3.1</td>
<td><strong>Solution of Bessel Differential Equation:</strong> Series method, recurrence relation, properties of Bessel function of order $+1/2$ and $-1/2$</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>Generating function, orthogonality property</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>Bessel–Fourier series of functions</td>
<td>0</td>
</tr>
<tr>
<td>4.0</td>
<td>4.1</td>
<td><strong>Scalar and Vector Product:</strong> Scalar and vector product of three and four vectors, and their properties</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td><strong>Vector Differentiation:</strong> Gradient of scalar point function, divergence, curl of vector point function</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td><strong>Properties:</strong> Solenoidal and irrotational vector fields, conservative vector field</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4.4</td>
<td><strong>Vector Integral:</strong> Line integral, Green's theorem in a plane, Gauss' divergence theorem, Stokes' theorem</td>
<td>2</td>
</tr>
<tr>
<td>5.0</td>
<td>5.1</td>
<td><strong>Complex Variable:</strong> Analytic Function: Necessary and sufficient conditions, Cauchy–Reimann equations in polar form</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5.2</td>
<td>Harmonic function, orthogonal trajectories</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5.3</td>
<td><strong>Mapping:</strong> Conformal mapping, bilinear transformations, cross ratio, fixed points, bilinear transformation of straight lines and circles</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total:** 5
Textbooks:

Reference Books:
1. B. S. Tyagi, “Functions of a Complex Variable”, Kedarnath Ram Nath Publication

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average mark of both the tests will be considered for final Internal Assessment.

End Semester Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be selected from all the modules.

Term Work/Tutorial:
At least 08 assignments covering entire syllabus must be given during the ‘class wise tutorial’. The assignments should be students’ centric and an attempt should be made to make assignments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every assignment graded from time to time. The grades will be converted to marks as per ‘credit and grading system’ manual and should be added and averaged. Based on above scheme grading and term work assessment should be done.
<table>
<thead>
<tr>
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<th>Subject Name</th>
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<th>Credits Assigned</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Theory</td>
<td>Practical</td>
</tr>
<tr>
<td>ETC302</td>
<td>Analog Electronics</td>
<td>4</td>
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<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Examinations Scheme</th>
<th>Theory Marks</th>
<th>Internal</th>
<th>End Sem.</th>
<th>Term Work</th>
<th>Practical</th>
<th>Oral</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Test 1</td>
<td>Test 2</td>
<td>Test 1 and Test 2</td>
<td>End Sem. Exam</td>
<td>Term Work</td>
<td>Practical and Oral</td>
</tr>
<tr>
<td>ETC 302</td>
<td>Analog Electronics</td>
<td></td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>80</td>
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</tr>
</tbody>
</table>

**Course pre-requisite:**
- FEC102: Applied Physics
- FEC105: Basic Electrical and Electronics Engineering

**Course Objectives:**
- To understand the operation of semiconductor devices
- To understand DC and AC models of semiconductor devices
- To apply concepts of DC and AC modeling of semiconductor devices for the design and analysis
- To verify the theoretical concepts through laboratory and simulation experiments.

**Course Outcomes:**
After completion of this course, students will be:
- Able to understand the current-voltage characteristics of semiconductor devices.
- Able to understand and related DC and AC models of semiconductor devices with their physical operation.
- Able to perform design and analysis of electronic circuits.
- Able to design analog systems and components.
Module No. | Unit No. | Topics | Hrs.
--- | --- | --- | ---
1.0 | 1.1 | PN Junction Diode: Diode current equation, effect of temperature on diode characteristics, breakdown mechanism, diode as a switch, small-signal model | 8
1.2 | Clusters and Clampers: Voltage transfer characteristics, series and shunt clippers, single diode series and shunt clamp circuits | 8
1.3 | Other PN junction devices: Construction and operation of Varactor diode, photodiode, Schottky diode | 0
2.0 | Field Effect Transistors | 0
2.1 | Junction Field Effect Transistor (JFET): Construction, working, regions of operation, transfer (V<sub>GS</sub>, V<sub>T</sub>, I<sub>B</sub>) and output (V<sub>DS</sub>, V<sub>DS</sub>, I<sub>B</sub>) characteristics, Schottky equation | 8
2.2 | Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET): E-MOSFET: MOS capacitor, energy band diagram of MOS capacitor, accumulation, depletion, and inversion region, threshold voltage, operation of MOSFET, derivation of threshold voltage and drain current, body effect, channel length modulation, D-MOSFET construction and working | 8
3.0 | DC Analysis of Transistor Circuits | 1
3.1 | Bipolar Junction Transistor: Review of BJT characteristics, DC load line and regions of operation, transistors as a switch, DC analysis of common BJT circuits, analysis and design of fixed bias, collector-to-base bias and voltage divider bias, stability factor analysis | 1
3.2 | Junction Field Effect Transistor: Analysis and design of self bias and voltage divider bias | 1
3.3 | MOSFET: DC load line and region of operation, common MOSFET configurations, analysis and design of biasing circuits | 1
4.0 | Small Signal Analysis of BJT Amplifiers | 1
4.1 | BJT CE Amplifier: Understanding of amplification concept with reference to input/output characteristics, AC load line analysis, definition of amplifier parameters Z<sub>0</sub>, Z<sub>0</sub>, A<sub>0</sub> and A<sub>0</sub>, graphical analysis to evaluate parameters | 1
4.2 | Small Signal Mid-Frequency Models: Hybrid-pi model, early effect, h-parameter model | 1
4.3 | Small Signal Analysis: Small signal analysis of mid-frequency (Z<sub>0</sub>, Z<sub>0</sub>, A<sub>0</sub> and A<sub>0</sub>) of CE, CB, and CC configurations of hybrid-pi model, comparison between CE, CB, and CC configurations with reference to parameters | 1
5.0 | Small Signal Analysis of FET Amplifiers | 0
5.1 | JFET CS Amplifier: Small signal equivalent circuit, analysis (mid-frequency) of Z<sub>0</sub>, Z<sub>0</sub>, A<sub>0</sub>, and A<sub>0</sub> | 8
5.2 | E-MOSFET Amplifier: Graphical analysis to evaluate parameters, AC load line, small signal model, small signal (mid-frequency) analysis of CS, CD, and CG amplifiers | 8
6.0 | Oscillators (numerical, non-numerical) | 0
6.1 | Concept of Oscillator: Concept of negative and positive feedback and conditions for oscillation | 8
6.2 | RC Oscillators: Phase shift and Weinbridge | 0
6.3 | LC Oscillators: Hartley, Colpitts, and Clapps | 0
6.4 | Tuned Oscillator: Twin-T oscillator and crystal oscillator | 0

Total: 5
**TextBooks:**

**Recommended Books:**

**Internal Assessment (IA):**
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

**End Semester Examination:**
1. Question paper will comprise of 6 questions each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining question (Q. 2 to Q. 6) will be selected from all the modules.
**Course Objectives:**
- To introduce the fundamental concepts and methods for design of various digital circuits.
- To build the skill of digital system design and testing used in various fields of computing, communication, automation, control mechanism and instrumentation.

**Course Outcomes:**
After completion of course, students will be
- Able to distinguish between analog and digital signals and data.
- Able to analyze, transform and minimize combination logic circuits.
- Able to understand basic arithmetic circuits.
- Able to design and analyze sequential circuits.
- Able to design digital systems and components.
<table>
<thead>
<tr>
<th>Module No</th>
<th>Unit No</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.1</td>
<td>Arithmetic codes: Review of number system, BCD code, Octal code, Hexa-decimal code, EX-3 code, Gray code, ASCII code</td>
<td>4</td>
</tr>
<tr>
<td>2.0</td>
<td>2.1</td>
<td>Logic Gates and Combination Logic Circuits: Transfer characteristics, noise margin, fan-in, fan-out, introductory to their logic families, their transfer characteristics and noise margin</td>
<td>6</td>
</tr>
<tr>
<td>2.2</td>
<td></td>
<td>Universal Gates and Combination Circuits: Realization of basic gates using NAND and NOR gates, Boolean algebra, De Morgan’s theorem, SOP and POS representation, K-map up to five variables, Quine-McCluskey method, variable entered mapping</td>
<td></td>
</tr>
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</table>
TextBooks:

ReferenceBooks:

InternalAssessment(I.A):
Two tests must be conducted which should cover at least 80% of syllabus. The average mark of both the tests will be considered or final Internal Assessment.

End SemesterExamination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining question (Q. 2 to Q. 6) will be selected from all the modules.
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<tr>
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<td>Test 2</td>
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<td></td>
<td>Term Work</td>
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</tr>
<tr>
<td>ETC304</td>
<td>Circuits and Transmission Lines</td>
<td>20 20 20 80 -- -- --</td>
<td>100</td>
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</tbody>
</table>

Course pre-requisite:
FEC105: Basic electrical and electronics engineering

Partial fraction expansion matrices, determinants, calculus and differential equations,

Course objectives:
- To analyze and synthesize circuits and to become familiar with the propagation of signals through transmission lines.
- To analyze the circuits in time and frequency domain.
- To study network functions, inter relationships among various circuit parameters, solve more complex network using these parameters.

Course outcomes:
- Through test, laboratory exercises and home assignment, students will be able to apply their knowledge in solving complex circuits.
- Students will be able to evaluate the time and frequency response which is useful in understanding the behavior of electronic circuits and control system.
- Student will be able to understand how the information in terms of voltage and current is transmitted through the transmission lines and importance of matching.
<table>
<thead>
<tr>
<th>Module No.</th>
<th>Unit No.</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td></td>
<td><strong>Electric circuit analysis</strong></td>
<td>1</td>
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<tr>
<td>1.1</td>
<td></td>
<td><strong>Analysis of DC circuits</strong>: Analysis of circuits with and without controlled sources using generalized loop and node matrix methods and Source Transformation Superposition Thevenin, Norton, Millman theorems</td>
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<tr>
<td>1.2</td>
<td></td>
<td><strong>Magnetic circuits</strong>: Self and mutual inductances, coefficient of coupling, dot convention, equivalent circuit, solution using loop analysis</td>
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<tr>
<td>1.3</td>
<td></td>
<td><strong>Tuned coupled circuits</strong>: Analysis of tuned coupled circuits</td>
<td></td>
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<tr>
<td>2.0</td>
<td></td>
<td><strong>Time and frequency domain analysis</strong></td>
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<tr>
<td>2.1</td>
<td></td>
<td><strong>Time domain analysis of R-L and R-C circuits</strong>: Forced and natural response, time constant, initial and final values</td>
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<tr>
<td></td>
<td></td>
<td><strong>Solution using first order equation for standard input signals</strong>: Transient and steady state time response, solution using universal formula</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td></td>
<td><strong>Time domain analysis of R-L-C Circuits</strong>: Forced and natural response, effect of damping</td>
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<tr>
<td></td>
<td></td>
<td><strong>Solution using second order equation for standard input signals</strong>: Transient and steady state time response</td>
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<td>2.3</td>
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<td><strong>Frequency domain analysis of RLC Circuits</strong>: S-domain representation, applications of Laplace Transform, solving electrical networks, driving point and transfer function, poles and zeros, calculation of residues by analytical and graphical method, analysis of ladder and lattice network</td>
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<tr>
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<td><strong>Response to standard signals</strong>: Transient and steady state time response of R-L-C circuits</td>
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<tr>
<td>3.0</td>
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<td><strong>Synthesis of RLC Circuits</strong></td>
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<tr>
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<td><strong>Positive real functions</strong>: Concepts of positive real function, testing for Hurwitz polynomials, testing for necessary and sufficient conditions for positive real functions</td>
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<tr>
<td>3.2</td>
<td></td>
<td><strong>Synthesis of RC, RL, LC and RLC circuits</strong>: Properties and synthesis of RC, RL, LC driving point functions</td>
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<tr>
<td>4.0</td>
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<td><strong>Two port circuits</strong></td>
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<td>4.1</td>
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<td><strong>Parameters</strong>: Open circuits, short circuit, transmission and hybrid parameters, relationships among parameters, reciprocity and symmetry conditions</td>
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<td><strong>Interconnection of two-port circuits</strong>: T and π representation.</td>
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<td><strong>Terminated two-port circuits</strong>:</td>
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<tr>
<td>5.0</td>
<td></td>
<td><strong>Radio frequency transmission lines</strong></td>
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<td>5.1</td>
<td></td>
<td><strong>Transmission Line Representation</strong>: T and π representation, terminated transmission line, infinite line</td>
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<tr>
<td>5.2</td>
<td></td>
<td><strong>Parameters of radio frequency lines</strong>: Propagation constant, attenuation constant, phase constant, group velocity, input impedance, characteristic impedance, reflection coefficient, standing wave ratio, VSWR, ISWR, S-parameters</td>
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<tr>
<td>5.3</td>
<td></td>
<td><strong>Smith Chart</strong>: Impedance locus diagram, impedance matching</td>
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<tr>
<td><strong>Total</strong></td>
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</table>
TextBooks

Reference Books

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:
1. Question paper will comprise of 6 questions each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining question (Q. 2 to Q. 6) will be selected from all the modules.
Pre-requisites:
- Students are expected to have basic knowledge of analog and digital electronics.

Course Objectives:
- To understand basic functions and principle of working of sensors and components used in Electronic Measurement.
- To understand principles of advanced electronic instruments and applications in measurement of electronic parameters.

Course Outcomes:
- Students will learn measurement of physical parameters using various transducers and working of sensors.
- They will become familiar with basics of instruments and details of operation of measuring instruments and their applications.
<table>
<thead>
<tr>
<th>Module No.</th>
<th>Unit No.</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
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<tbody>
<tr>
<td>1.0</td>
<td>1.1</td>
<td><strong>Introduction to basic instruments</strong>: Component of generalized measurement systems, applications of instruments, systems, static and dynamic characteristics of instruments, concepts of accuracy, precision, linearity, sensitivity, resolution, hysteresis, calibration</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td><strong>Errors in measurement</strong>: Errors in measurement classification of errors, remedies to eliminate errors</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td></td>
<td><strong>Sensors and transducers</strong>: Active and passive transducers, characteristics and selection criteria of transducers, working principle of Eddy-current sensors, Pzoelectric transducers, photoelectric and photo voltaic sensors, capacitive sensors</td>
<td>1</td>
</tr>
<tr>
<td>2.1</td>
<td></td>
<td><strong>Basics of sensors and transducers</strong>: Active and passive transducers, characteristics and selection criteria of transducers, working principle of Eddy-current sensors, Pzoelectric transducers, photoelectric and photo voltaic sensors, capacitive sensors</td>
<td>2</td>
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<tr>
<td>2.2</td>
<td></td>
<td><strong>Displacement and pressure</strong>: Potentiometers, pressure gauges, Linear Variable Differential Transformer (LVDT) for measurement of pressure and displacement, strain gauges</td>
<td></td>
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<tr>
<td>2.3</td>
<td></td>
<td><strong>Temperature transducers</strong>: Resistance Temperature Detectors (RTD), thermistors and thermocouples, their ranges and applications</td>
<td></td>
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<tr>
<td>3.0</td>
<td></td>
<td><strong>Testing and measuring instruments</strong>: Operating principles and applications</td>
<td>1</td>
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<tr>
<td>3.1</td>
<td></td>
<td><strong>Analog multi-meter</strong>: Multi-range measurement of voltage, current and resistance specifications</td>
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<tr>
<td>3.2</td>
<td></td>
<td><strong>Measurement of resistance</strong>: Kelvin’s double bridge, Wheatstone bridge, and Megohmmeter bridge</td>
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<tr>
<td></td>
<td></td>
<td><strong>Measurement of inductance</strong>: Maxwell bridge and Hey bridge</td>
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<tr>
<td></td>
<td></td>
<td><strong>Measurement of capacitance</strong>: Schering bridge, Q-Meter: Operating principles and applications</td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td></td>
<td><strong>Energy and power meters</strong>: Working of energy and power meter</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td><strong>Data Acquisition and Digital Instruments</strong>: Data acquisition and converters</td>
<td>1</td>
</tr>
<tr>
<td>4.1</td>
<td></td>
<td><strong>Data acquisition and converters</strong>: Single channel, multichannel and PC based DAS, A/D and D/A converters: Types and specifications of A/D and D/A converters, Significance of X1/2 digit display</td>
<td>0</td>
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<tr>
<td>4.2</td>
<td></td>
<td><strong>Digital multi-meter</strong>: Block diagram, multi-range measurement of voltage, current and resistance specifications</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td><strong>Oscilloscopes</strong>: Block diagram based Study of CRO, specifications, controls, sweep modes, role of delay line, single and dual-beam dual trace CROs, chop and alternative modes</td>
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<tr>
<td>5.1</td>
<td></td>
<td><strong>Cathode ray oscilloscope</strong>: Block diagram based Study of CRO, specifications, controls, sweep modes, role of delay line, single and dual-beam dual trace CROs, chop and alternative modes</td>
<td>8</td>
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<tr>
<td>5.2</td>
<td></td>
<td><strong>Measurement using oscilloscope</strong>: Measurement of voltage, frequency, rise time, fall time and phase difference, Lissajous figures, detection of frequency and phase</td>
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<tr>
<td>5.3</td>
<td></td>
<td><strong>Digital storage oscilloscope (DSO)</strong>: Block diagram based study of DSO, study of features like roll, refresh, storage mode and sampling rate, applications of DSO</td>
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<tr>
<td>6.0</td>
<td></td>
<td><strong>Signal analyzers</strong>: Introduction to harmonic total harmonic distortion analyzer, block diagram and applications of wave analyzers</td>
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<tr>
<td>6.1</td>
<td></td>
<td><strong>Wave analyzers</strong>: Introduction to harmonic total harmonic distortion analyzer, block diagram and applications of wave analyzers</td>
<td>6</td>
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<tr>
<td>6.2</td>
<td></td>
<td><strong>Spectrum and network analyzers</strong>: Block diagram and applications</td>
<td>5</td>
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<td></td>
<td></td>
<td><strong>Total</strong>:</td>
<td>2</td>
</tr>
</tbody>
</table>
TextBooks:

Reference Books:

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered for final Internal Assessment.

End Semester Examination:
1. Question paper will comprise of 6 questions each carrying 20 marks.
2. The student needs to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining question (Q. 2 to Q. 6) will be selected from all the modules.
<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Scheme (Hrs.)</th>
<th>Credits Assigned</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Theory</td>
<td>Practical</td>
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<tr>
<td>ETS306</td>
<td>Object Oriented Programming Methodology</td>
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<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Examination Scheme</th>
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<tr>
<td></td>
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<td>TheoryMarks</td>
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<td>Theory</td>
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<tr>
<td>ETS306</td>
<td>Object Oriented Programming Methodology</td>
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</tr>
</tbody>
</table>

**Pre-requisites:**
Course in Structured Programming Approach/Any Programming Language

**Course Objectives:**
- To understand the concept of Object Oriented Programming
- To help student to understand the use of programming language such as JAVA to resolve problems.
- To impart problems understanding analyzing skills in order to formulate algorithms.
- To provide knowledge about JAVA fundamentals data types, variables, keywords and control structures.
- To understand methods, arrays, inheritance, Interface, package and multithreading and concept of Applet.

**Course Outcomes:**
- Students will be able to code a program using JAVA constructs.
- Given an algorithm, student will be able to formulate a program that correctly implements the algorithm.
- Students will be able to generate different patterns and flows using control structures and use recursion in their programs.
- Students will be able to use thread methods, thread exceptions, and thread priority.
- Students will implement method overloading in their code.
- Students will be able to demonstrate reusability with the help of inheritance.
- Students will be able to make more efficient programs.
<table>
<thead>
<tr>
<th>Module No</th>
<th>Unit No</th>
<th>Topic</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1</td>
<td>Fundamentals of object-oriented programming</td>
<td>4</td>
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<td></td>
<td></td>
<td>Overview of programming</td>
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<tr>
<td></td>
<td>1.2</td>
<td>Introduction to the principles of object-oriented programming: classes, objects, messages, abstraction, encapsulation, inheritance, polymorphism, exception handling, and object-oriented containers</td>
<td></td>
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<tr>
<td></td>
<td>1.3</td>
<td>Differences and similarity between C++ and JAVA</td>
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<tr>
<td>2</td>
<td>2.1</td>
<td>Fundamentals of Java</td>
<td>4</td>
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<td></td>
<td>2.2</td>
<td>Features of Java</td>
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<td></td>
<td>2.3</td>
<td>JDK Environment and tools</td>
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<tr>
<td></td>
<td>2.4</td>
<td>Keywords, data types, variables, operators, expressions</td>
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<tr>
<td></td>
<td>2.5</td>
<td>Decision making, popping, type casting</td>
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<td></td>
<td>2.6</td>
<td>Input/output using scanner class</td>
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<tr>
<td>3</td>
<td>3.1</td>
<td>Classes and objects</td>
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<tr>
<td></td>
<td>3.2</td>
<td>Creating classes and objects</td>
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<tr>
<td></td>
<td>3.3</td>
<td>Memory allocation for objects</td>
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<td></td>
<td>3.4</td>
<td>Passing parameters to methods</td>
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<tr>
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<td>3.5</td>
<td>Returning parameters</td>
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<td>3.6</td>
<td>Method overloading</td>
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<td>3.7</td>
<td>Constructor and finalize()</td>
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<td></td>
<td>3.8</td>
<td>Arrays: Creating an array</td>
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<tr>
<td></td>
<td></td>
<td>Types of array: One-dimensional arrays, Two-dimensional array, string</td>
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<tr>
<td>4</td>
<td>4.1</td>
<td>Inheritance, interface, and package</td>
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<tr>
<td></td>
<td>4.2</td>
<td>Types of inheritance: Single, multilevel, hierarchical</td>
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<td></td>
<td>4.3</td>
<td>Method overriding super keyword, final keyword, abstract class</td>
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<tr>
<td></td>
<td>4.4</td>
<td>Interface</td>
<td></td>
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<td>Packages</td>
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<td>Multithreading</td>
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<td>Lifecycle of thread</td>
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<tr>
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<td>5.3</td>
<td>Methods</td>
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<td>Priority in multithreading</td>
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<td>6</td>
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<td>Applet lifecycle</td>
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<td>6.3</td>
<td>Creating applet</td>
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<td>Applet tag</td>
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<td><strong>6</strong></td>
</tr>
</tbody>
</table>
TextBooks:
1. RajkumarBuyya, "Object-orientedprogrammingwithJAVA",McgrawHill

ReferenceBooks:
<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Scheme(Hrs.)</th>
<th>Credits Assigned</th>
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<tbody>
<tr>
<td>ETL301</td>
<td>Analog Electronics Laboratory</td>
<td>Theory: -- Practical: 02 Tutorial: --</td>
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<th>Examination Scheme</th>
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</table>

**Term Work:**
At least 10 experiments covering entire syllabus should be set to have well-defined inference and conclusion. Computation/simulation based experiments are also encouraged. The experiments should be students' centric and attempts should be made to make experiments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades will be converted to marks as per the *credit and grading* scheme manual and should be added and averaged. Based on the above scheme, grading and term work assessment should be done.

*The practical and oral examination will be based on entire syllabus.*
<table>
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<th>Subject Code</th>
<th>Subject Name</th>
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<tr>
<td>ETL302</td>
<td>Digital Electronics Laboratory</td>
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<th>Subject Code</th>
<th>Subject Name</th>
<th>Examination Scheme</th>
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<tr>
<td></td>
<td></td>
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<td>Digital Electronics Laboratory</td>
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</table>

**Term Work:**
At least 10 experiments covering entire syllabus should be set to have well predefined inference and conclusion. Computation/simulation based experiments are also encouraged. The experiments should be students’ centric and attempts should be made to make experiments more meaningful, interesting, and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades will be converted to marks as per ‘credit and grading’ system manual and should be added and averaged. Based on the above scheme grading and term work assessment should be done.

The practical and oral examination will be based on entire syllabus.
Subject Code | Subject Name                        | Teaching Scheme (Hrs) | Credits Assigned |
-------------|-------------------------------------|-----------------------|-----------------|
            |                                     | Theory | Practical | Tutorial | Theory | Practical | Tutorial | Total |
ETL303      | Circuits and Measurement Laboratory | --     | 02        | --       | --     | 01        | --       | 0     |

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<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Theory Marks</th>
<th>End Sem. Exam</th>
<th>Term Work</th>
<th>Practical and Oral</th>
<th>Oral</th>
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<td>--</td>
<td>25</td>
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</table>

**Term Work:**

At least 10 experiments on Circuits and Transmission lines and 5 on Electronics Instruments and Measurements over the entire syllabus should be set to have well defined inference and conclusion. Computation/simulation based experiments are also encouraged. The experiments should be student-centric and attempts should be made to make experiments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades converted into marks as per credit and grading system. Manuals should be added and averaged. Based on this final term work grading and term work assessment should be done.
Subject Code | Subject Name | Teaching Scheme (Hrs) | Credits Assigned
--- | --- | --- | ---
ETSL 304 | Objec Oriented Programming Methodology Laboratory | -- 02+02* -- -- 01 -- 0 1

*-Out of four hours, 2 hour theory shall be taught to entire class followed by 2 hrs. practical in batches.

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Examination Scheme</th>
<th>Theory Marks</th>
<th>Term Work</th>
<th>Practical and Oral</th>
<th>Oral</th>
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<tr>
<td>ETSL 304</td>
<td>Objec Oriented Programming Methodology Laboratory</td>
<td></td>
<td>Test 1 Test 2</td>
<td>Avg. O Test 1 and Test 2</td>
<td>End Sem. Exam</td>
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<td>--</td>
<td>25</td>
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</tbody>
</table>
| | | | | | | 7 5

**Term Work:**
At least 10 experiments covering the entire syllabus should be set to have well-defined inference and conclusion. The experiments should be student-centric and attempt should be made to make experiments more meaningful, interesting, and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades will be converted to marks as per **Credit and Grading** System manual and should be added and averaged. Based on the above scheme grading and term work assessment should be done.

**The Practical and Oral Examination will be based on the entire syllabus.**
<table>
<thead>
<tr>
<th>Sub Code</th>
<th>Subject Name</th>
<th>Teaching Scheme (Hrs)</th>
<th>Credits Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Theory</td>
<td>Practical</td>
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<tr>
<td>ETS401</td>
<td>Applied Mathematics IV</td>
<td>04</td>
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<td>Analog Electronics II</td>
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<tr>
<td>ETC403</td>
<td>Microprocessor and Peripherals</td>
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<tr>
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<td>Wave Theory and Propagation</td>
<td>04</td>
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<td>ETC405</td>
<td>Signals and Systems</td>
<td>04</td>
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<td>04</td>
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<td>Analog Electronics II Laboratory</td>
<td>--</td>
<td>02</td>
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<td>Microprocessor and Peripherals Laboratory</td>
<td>--</td>
<td>02</td>
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<tr>
<td>ETL403</td>
<td>Software Simulation Laboratory</td>
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<td>Subject Code</td>
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<td>Teaching Scheme (Hrs)</td>
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<th>Subject Code</th>
<th>Subject Name</th>
<th>Examination Scheme</th>
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<tr>
<td>ETS401</td>
<td>Applied Mathematics IV</td>
<td>20, 20, 20, 80</td>
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</tbody>
</table>

Course Pre-requisite:
- FEC 101: Applied Mathematics
- FEC 201: Applied Mathematics
- SES 301: Applied Mathematics

Course Objectives:
This course will present the method of calculus of variations (CoV), basic concepts of vector spaces, matrix theory, concepts of ROC and residue theory with applications.

- To provide students with a solid foundation in mathematics and prepare them for graduate studies in Electronics & Telecommunication Engineering.
- To provide students with the mathematics fundamental necessary to formulate, solve and analyze engineering problems.
- To provide opportunity for students to work as part of teams on multidisciplinary projects.

Expected Outcomes:
- Students will be able to apply the method of calculus of variations to specific systems, demonstrate the ability to manipulate matrices and compute eigenvalues and eigenvectors, identify and classify zeroes, singular points, residues and their applications.
- Students will demonstrate an ability to identify and solve Telecommunication Engineering problems using applied mathematics.
- Students who can participate and succeed in competitive exams like GATE, GRE.
<table>
<thead>
<tr>
<th>Module No.</th>
<th>Unit No.</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.1</td>
<td>Calculus of variation, Euler Langrange equation, solution of Euler’s</td>
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<tr>
<td></td>
<td></td>
<td>Langrange equation (only results for different cases for function)</td>
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<tr>
<td></td>
<td></td>
<td>independent of a variable, independent of another variable, independent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>of differentiation of a variable and independent of both variables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Isoperimetric problems, several dependent variables</td>
<td></td>
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<tr>
<td></td>
<td>1.3</td>
<td>Functions involving higher order derivatives, Rayleigh-Ritz method</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>2.1</td>
<td>Vectors in n-dimensional vector space, properties, dot product, cross</td>
<td>2</td>
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<tr>
<td></td>
<td></td>
<td>product, norm and distance properties in n-dimensional vector space</td>
<td></td>
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<tr>
<td></td>
<td>2.2</td>
<td>Metric spaces, vector spaces over real field, properties of vector spaces</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>over real field, subspaces</td>
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<tr>
<td></td>
<td>2.3</td>
<td>Norms and normed vector spaces</td>
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<tr>
<td></td>
<td>2.4</td>
<td>Inner products and inner product spaces</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>The Cauchy-Schwarz inequality, orthogonal Subspaces, Gram-Schmidt process</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>3.1</td>
<td>Linear Algebra, Matrix Theory, characteristic equation, Eigenvalues and</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eigenvectors, properties of Eigenvalues and Eigenvectors</td>
<td></td>
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<tr>
<td></td>
<td>3.2</td>
<td>Cayley-Hamilton theorem, examples based on verification of Cayley-Hamilton</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>theorem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>Similarity of matrices, Diagonalisation of matrix</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td>Functions of square matrix, derogatory and non-derogatory matrices</td>
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<tr>
<td></td>
<td>3.5</td>
<td>Quadratic forms over real field, reduction of quadratic form to a</td>
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<tr>
<td></td>
<td></td>
<td>diagonal canonical form, rank, index, signature of quadratic form,</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Sylvester’s law of inertia, value-class of a quadratic form,</td>
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<td></td>
<td></td>
<td>definite, semi-definite and indefinite</td>
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<td></td>
<td>3.6</td>
<td>Singular Value Decomposition</td>
<td></td>
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<tr>
<td>4.0</td>
<td>4.1</td>
<td>Complex Integration, Line Integral, Cauchy’s Integral theorem for simply</td>
<td>5</td>
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<tr>
<td></td>
<td></td>
<td>connected regions, Cauchy’s integral formula</td>
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<tr>
<td></td>
<td>4.2</td>
<td>Taylor’s and Laurent’s series</td>
<td></td>
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<tr>
<td></td>
<td>4.3</td>
<td>Zeros, singularities poles of f(z), residues, Cauchy’s Residue theorem</td>
<td></td>
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<tr>
<td></td>
<td>4.4</td>
<td>Applications of Residue theorem to evaluate real integral of different</td>
<td></td>
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<tr>
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<td>types</td>
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</table>

| Total     |                      |                                                                        | 2    |
Textbooks:
3) Higher Engg. Mathematics by Dr. B.S. Grewal, Khanna Publication

Reference Books:
1) Todd K. Moon and Wynn C. Stirling, Mathematical Methods and algorithms for Signal Processing Pearson Education.
3) Linear Algebra Hoffman & Kunze (Indian edition) 2002
5) Complex Analysis – Scham Series

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average mark of both the tests will be considered for final Internal Assessment.

End Semester Examination:
1. Question paper will comprise of 6 questions each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining questions (Q. 2 to Q. 6) will be selected from all the modules.

Term Work / Tutorial:
At least 08 assignments covering entire syllabus must be given during the Class Wise Tutorial. The assignments should be students’ centric and an attempt should be made to make assignments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every assignment graded from time to time. The grades will be converted to marks as per Credit and Grading System manual and should be added and averaged. Based on above scheme, grading and term work assessment should be done.
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<td></td>
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<td>Practical</td>
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<td>ETC402</td>
<td>Analog Electronics I</td>
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<th>Examination Scheme</th>
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<td></td>
<td>Internal Assessment</td>
<td>Term Work</td>
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<td></td>
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<td>Test 1</td>
<td>Test 2</td>
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<tr>
<td>ETC402</td>
<td>Analog Electronics II</td>
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<td>20</td>
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</table>

**Course Pre-requisite:**
ETC: 302 – Analog Electronics

**Course Objective:**
- To deliver the core concepts and reinforce the analytical skills learned in Analog Electronics.
- To motivate students to use MOS devices for designing and analyzing electronic circuits which will help them to understand the fundamentals of VLSI design.

**Expected Outcomes:**
After completion of the course, students will be able to
- Analyze and design multi-stage electronic circuits.
- Differentiate between discrete and integrated biasing techniques.
- Differentiate between small signal and large signal amplifiers.
<table>
<thead>
<tr>
<th>Module No</th>
<th>Unit No</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.1</td>
<td><strong>Frequency Response of Amplifiers</strong></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
<td><strong>High Frequency Model</strong>: High frequency hybrid-piequivalent circuits of BJT and MOSFET, Miller effect and Miller capacitance gain bandwidth product</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
<td><strong>Single Stage Amplifiers</strong>: Effect of capacitors (coupling, bypass, load) on frequency response of single stage BJT (CE, CC, CB configurations), MOSFET (CS, CG, CD configuration) amplifiers, low and high frequency response of BJT (CE, CB, CC) and MOSFET (CS, CG, CD) amplifiers</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td><strong>Multistage Amplifier</strong>: Low and high frequency response and mid-frequency analysis of multistage (CE-CE, CS-CS), cascode (CE-CB, CS-CG) Amplifiers, Darlington pair, design of two stage amplifiers</td>
<td>4</td>
</tr>
<tr>
<td>2.0</td>
<td>2.1</td>
<td><strong>BJT Differential Amplifiers</strong>: Terminology and qualitative description of DC transfer characteristics, small signal analysis, differential and common mode gain, CMRR, differential and common mode input impedance</td>
<td>0</td>
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<tr>
<td></td>
<td>2.2</td>
<td><strong>MOSFET Differential Amplifiers</strong>: DC transfer characteristics, small signal analysis, differential and common mode gain, CMRR, differential and common mode input impedance</td>
<td>0</td>
</tr>
<tr>
<td>3.0</td>
<td>3.1</td>
<td><strong>Integrated Circuits Biasing Techniques</strong>: Two transistor (BJT, MOSFET) current source, current relationship output resistance</td>
<td>0</td>
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<tr>
<td></td>
<td>3.2</td>
<td><strong>Improved Current Source</strong>: Three transistor (BJT, MOSFET) current source</td>
<td>8</td>
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<tr>
<td></td>
<td>3.3</td>
<td><strong>Special Current Source</strong>: Cascode (BJT, MOSFET) current source, Wilson and Widlar current sources</td>
<td>8</td>
</tr>
<tr>
<td>4.0</td>
<td>4.1</td>
<td><strong>Power Amplifiers</strong>: Power BJTs, power MOSFETs, heat sinks</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td><strong>Classification</strong>: Class A, Class B, Class AB and Class C operation, and performance parameters</td>
<td>8</td>
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<tr>
<td></td>
<td>4.3</td>
<td><strong>Transformer and Transformerless Amplifiers</strong>: Transformer coupled Class A Amplifier, Class AB output stage with diode biasing, $V_{BE}$ multiplied by biasing input buffer transistors Darlington configuration</td>
<td>8</td>
</tr>
<tr>
<td>5.0</td>
<td>5.1</td>
<td><strong>Fundamentals of Op-amp</strong>: characteristics of op-amp, high frequency effect on op-amp gain and phase-slew rate limitation</td>
<td>8</td>
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<tr>
<td></td>
<td>5.2</td>
<td><strong>Applications of Op-amps</strong>: Inverting and non-inverting amplifier, adder, subtractor, integrator, differentiator, active filters (first order, low and high pass)</td>
<td>8</td>
</tr>
<tr>
<td>6.0</td>
<td>6.1</td>
<td><strong>DC Regulated Power Supply</strong>: Regulator Performance parameters, Zener, shunt regulator, transistorized series and shunt regulator</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong></td>
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</table>

University of Mumbai SE (Electronics & Telecommunication) R-2012
TextBooks:

Recommended Books:

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:
1. Question paper will comprise of 6 questions each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining questions (Q. 2 to Q. 6) will be selected from all the modules.
**Course Pre-requisite:**
ETC303: Digital Electronics

**Course Objectives:**
- To develop background knowledge and core expertise in microprocessor.
- To study the concepts and basic architecture of 8085, 8086, 80286, 80386, 80486 Pentium processor and Co-processor 8087.
- To know the importance of different peripheral devices and their interfacing to 8086.
- To know the design aspects of basic microprocessor.
- To write assembly language programs in microprocessor for various applications.

**Course Outcomes:**
Students will learn
- The architecture and software aspects of microprocessor 8086
- Assembly language programs in 8086 for various applications.
- Co-processor configurations.
- Various interfacing techniques with 8086 for various applications.
- Basic concepts of advanced microprocessors.
<table>
<thead>
<tr>
<th>Module No.</th>
<th>Unit No.</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td></td>
<td>Architecture of 8085 and 8086 Microprocessor</td>
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<tr>
<td>1.1</td>
<td></td>
<td>8085 Architecture and pin configuration</td>
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</tr>
<tr>
<td>1.2</td>
<td></td>
<td>8086 Architecture and organization pin configuration</td>
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<tr>
<td>1.3</td>
<td></td>
<td>Minimum and Maximum modes of 8086</td>
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<tr>
<td>1.4</td>
<td></td>
<td>Read and Write bus cycle of 8086</td>
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<tr>
<td>2.0</td>
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<td>Instruction set and programming of 8086</td>
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<td>8086 Addressing modes</td>
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<tr>
<td>2.2</td>
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<td>8086 Instruction encoding formats and instruction set</td>
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<td>Assembler directives</td>
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<td>8086 programming and debugging of assembly language program</td>
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<td>3.0</td>
<td></td>
<td>Peripherals interfacing with 8086 and applications</td>
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<td>3.1</td>
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<td>8086-Interrupt structure</td>
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<td>3.2</td>
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<td>Programmable interrupt controller 8259A</td>
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<tr>
<td>3.3</td>
<td></td>
<td>Programmable peripheral interface 8255</td>
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<td>3.4</td>
<td></td>
<td>Programmable interval timer 8254</td>
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<td>3.5</td>
<td></td>
<td>DMA controller 8257</td>
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<tr>
<td>3.6</td>
<td></td>
<td>Interfacing 8259A, 8255, 8254, 8257 with 8086 and their applications</td>
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<tr>
<td>4.0</td>
<td></td>
<td>ADC, DAC interfacing with 8086 and its applications</td>
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<td>4.1</td>
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<td>Analog to Digital Converter (ADC) 0809</td>
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<tr>
<td>4.2</td>
<td></td>
<td>Digital to Analog Converter (DAC) 0808</td>
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</tr>
<tr>
<td>4.3</td>
<td></td>
<td>Interfacing ADC 0809, DAC 0808 with 8086 and their applications</td>
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<tr>
<td>4.4</td>
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<td>8086 based data acquisition system</td>
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<td>5.0</td>
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<td>8086 Microprocessor interfacing</td>
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<td>5.1</td>
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<td>8087 Math coprocessor its datatypes and interfacing with 8086</td>
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<tr>
<td>5.2</td>
<td></td>
<td>Memory interfacing with 8086 microprocessor</td>
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<tr>
<td>6.0</td>
<td></td>
<td>Advanced Microprocessors</td>
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<tr>
<td>6.1</td>
<td></td>
<td>Basic architectures of 80286, 80386, 80486 and Pentium processor</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total** | | | **5** | **2** |
TextBooks:

ReferenceBooks:
4. National SemiconductorData AcquisitionLinear Device DataBook
5. IntelPeripheralDevices: DataBook.

InternalAssessment(IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered for final InternalAssessment.

EndSemesterExamination:
1. Question paper will comprise of 6 questions each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining questions (Q.2 to Q.6) will be selected from all the modules.
Course Pre-requisite
Vector Algebra, Vector Integral

Course Objective:
- To understand basic laws of electrostatic and magnetostatic in vector form.
- To understand the propagation of wave in different media like dielectric and conducting media by solving wave equation and find parameters of media.
- To calculate energy transported by means of electromagnetic waves from one point to another and to study polarization of waves.
- To solve electromagnetic problems using different numeric methods.
- To extend the student's understanding about the propagation of the waves by different types such as ground waves and space waves.
- To study the factors affecting the wave during its propagation.
- To understand sky wave propagation related parameters such as MUF, skip distance and critical frequency.

Expected Outcomes:
- Ability to find nature of electric or magnetic field produced due to different charge distributions.
- Ability to understand working of different equipments based on electromagnetic定律 in daily life.
- Knowledge of behavior of EM waves and travelling of waves in free spaces as well as media.
- Able to find conditions for loss of signal.
- Able to apply numerical methods for designing antennas.
- An ability to select proper parameters for propagation of the waves by considering the factors affecting.
- Any ability to identify and solve problems related to the propagation of waves.
- To understand the basics of wave propagation required for the study of antennas.
<table>
<thead>
<tr>
<th>Module No</th>
<th>Unit No</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.1</td>
<td><strong>Fundamental laws of electromagnetic fields:</strong> Coulomb’s law, Gauss’ law, Bio-Savart’s law, Ampere’s law, Poisson’s and Laplace equations</td>
<td>3</td>
</tr>
<tr>
<td>1.0</td>
<td>1.2</td>
<td><strong>Boundary conditions:</strong> Static electricity and magnetism</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>1.3</td>
<td><strong>Maxwell’s equations:</strong> Integral and differential form for static and time varying fields and its interpretations</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>1.4</td>
<td><strong>Applications of electromagnetic fields:</strong> Ink-jet printer, CRO, electromagnetic pump</td>
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<tr>
<td>2.0</td>
<td>2.1</td>
<td><strong>Uniform plane wave equation and power balance</strong></td>
<td>0</td>
</tr>
<tr>
<td>2.0</td>
<td>2.2</td>
<td><strong>Solution of wave equations:</strong> Partially conducting media, perfect dielectrics and good conductors concept of skin depth</td>
<td>8</td>
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<tr>
<td>3.0</td>
<td>3.1</td>
<td><strong>Plane Wave Propagation</strong></td>
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<td>3.0</td>
<td>3.2</td>
<td><strong>Propagation in different mediums:</strong> Behavior of waves for normal and oblique incidence in dielectrics and conducting media, propagation in dispersive media</td>
<td>6</td>
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<tr>
<td>4.0</td>
<td>4.1</td>
<td><strong>Finite Difference Method (FDM):</strong> Neumann type and mixed boundary conditions, Iterative solution of finite difference equations, solutions using hand matrix method</td>
<td>8</td>
</tr>
<tr>
<td>4.0</td>
<td>4.2</td>
<td><strong>Finite Element Method (FEM):</strong> Triangular mesh configuration, finite element discretization, Element governing equations, Assembling all equations and solving result equations</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>5.1</td>
<td><strong>Types of wave propagation:</strong> Ground, space and surface wave propagation tilt and surface waves, impact of imperfect earth and earth’s behavior at different frequencies</td>
<td>0</td>
</tr>
<tr>
<td>5.0</td>
<td>5.2</td>
<td><strong>Space wave propagation:</strong> Effect of imperfection of earth, curvature of earth, effect of interference zone, shadowing effect of hills and building, atmospheric absorption, Super-refraction, scattering phenomena, tropospheric propagation and fading</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>6.1</td>
<td><strong>Reflection and Refraction of waves:</strong> Ionosphere and Earth magnetifield effect</td>
<td>7</td>
</tr>
<tr>
<td>6.0</td>
<td>6.2</td>
<td><strong>Measures of Ionosphere Propagation:</strong> Critical frequency, Angle of incidence, Maximum unstable frequency, Skip distance, Virtual height, Variations in ionosphere and Attenuation and fading of waves in ionosphere</td>
<td></td>
</tr>
</tbody>
</table>

**Total:** 5

2
TextBooks:

ReferenceBooks

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of the syllabus. The average marks of both the tests will be considered for final Internal Assessment.

End Semester Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining questions (Q. 2 to Q. 6) will be selected from all the modules.
<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Scheme (Hrs.)</th>
<th>Credits Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Theory</td>
<td>Practical</td>
</tr>
<tr>
<td>ETC405</td>
<td>Signals and Systems</td>
<td>04</td>
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</tr>
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<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Examination Scheme</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Theory Marks</td>
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<tr>
<td></td>
<td></td>
<td>Internal Assessment</td>
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<tr>
<td></td>
<td></td>
<td>Test 1</td>
</tr>
<tr>
<td>ETC405</td>
<td>Signals and Systems</td>
<td>20</td>
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</table>

**Course Pre-requisite**

ETS: 301 - Applied Mathematics II  
ETC: 304 - Circuits and Transmission Lines

**Course Objectives:**
- To introduce students to the idea of signal and system analysis and characterization in time and frequency domain.
- To provide foundation of signal and system concepts to areas like communication, control, and comprehending applications of signal processing in communication systems.

**Course Outcomes:**
- Students will be able to understand the significance of signals and systems in the time and frequency domains.
- Students will be able to interpret and analyze signal and report results.
- Students will be able to evaluate the time and frequency response of continuous and discrete time systems which is useful in understanding behavior of Electronics circuits and communication systems.
<table>
<thead>
<tr>
<th>Module No.</th>
<th>Unit No.</th>
<th>Topics</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.1</td>
<td><strong>Overview of signals and systems</strong></td>
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<td></td>
<td></td>
<td><strong>Introduction</strong>: Signals, systems, examples of systems for</td>
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<tr>
<td></td>
<td></td>
<td>controls and communications, sampling theorem, sampling of</td>
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<tr>
<td></td>
<td></td>
<td>continuous time signals, elementary signals, exponential,</td>
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<tr>
<td></td>
<td></td>
<td>sine, step, impulse, ramp, rectangular, triangular and</td>
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<td></td>
<td></td>
<td>operation on signals</td>
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<td></td>
<td></td>
<td><strong>Classification of signals</strong>: Continuous and discrete time,</td>
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<tr>
<td></td>
<td></td>
<td>deterministic and non deterministic periodic and aperiodic</td>
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<td></td>
<td></td>
<td>symmetric (even) and asymmetric (odd), energy and power</td>
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<td></td>
<td></td>
<td>causal and anti-causal signals</td>
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<td>2.1</td>
<td><strong>Classification of systems</strong>: Static and dynamic, time</td>
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<td></td>
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<td>invariant and time variant, linear and nonlinear, causal and</td>
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<td>non-causal, stable and unstable systems</td>
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<td>2.2</td>
<td><strong>Linear Time Invariant (LTI) systems</strong>: Representation of</td>
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<td>systems using differential / difference equation, impulse,</td>
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<td>step and exponential response, system stability, examples</td>
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<td></td>
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<td>on applications of LTI systems, convolution, impulse response</td>
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<td>on inter-connected systems, auto-correlation, cross</td>
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<td>correlation, properties of correlation, analogy between</td>
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<td></td>
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<td>correlation and convolution, total response of a system</td>
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<td>3.0</td>
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<td><strong>Overview of Laplace Transform</strong>: Laplace Transform and</td>
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<td></td>
<td></td>
<td>properties, relation between continuous time Fourier</td>
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<td>Transform and Laplace Transform, unilateral Laplace</td>
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<td></td>
<td>Transform</td>
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<td>3.2</td>
<td>**Analysis of continuous-time LTI systems using Laplace</td>
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<td></td>
<td></td>
<td>Transform**: Transfer Function, causality and stability of</td>
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<td>systems, solution of differential equation using Laplace</td>
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<td>Transform</td>
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<td>z-Transform of finite and infinite duration sequences,</td>
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<tr>
<td></td>
<td></td>
<td>relation between discrete-time Fourier Transform and z-</td>
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<td>Transform properties, Inverse z-Transform, one-sided z-</td>
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<td></td>
<td></td>
<td>Transform</td>
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<td></td>
<td>4.2</td>
<td><strong>Analysis of discrete-time LTI systems using z-Transform</strong>:</td>
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<td></td>
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<td>Transfer Function, causality and stability of systems,</td>
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<td>frequency response, relation between Laplace Transform and</td>
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<td></td>
<td></td>
<td>z-Transform</td>
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<tr>
<td>5.0</td>
<td>5.1</td>
<td><strong>Fourier series of continuous and discrete-time signals</strong></td>
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<td></td>
<td><strong>Review of Fourier series</strong>: Trigonometric and exponential</td>
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<td></td>
<td>Fourier series representation of signals, magnitude and</td>
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<td></td>
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<td>phase spectra, power spectral density and bandwidth, Gibbs</td>
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<td></td>
<td></td>
<td>phenomenon</td>
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<td>5.2</td>
<td><strong>Properties of Fourier Series</strong>: linearity, time shifting,</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>time reversal, frequency shifting, time scaling,</td>
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<td>differentiation, symmetry, Parseval’s relation. Examples</td>
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<td>based on properties of analogy between Continuous Time Fourier</td>
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<td>Series (CTFS) and Discrete Time Fourier Series (DTFS)</td>
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<tr>
<td>6.0</td>
<td>6.1</td>
<td>**Continuous Time Fourier Transform (CTFT) and Discrete Time</td>
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<tr>
<td></td>
<td></td>
<td>Fourier Transform (DTFT)**: Fourier Transform and Inverse</td>
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<td></td>
<td>Fourier Transform, non-periodic signals, limitations of</td>
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<tr>
<td></td>
<td></td>
<td>Fourier Transform and need for Laplace and z-Transform</td>
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<tr>
<td></td>
<td>6.2</td>
<td><strong>Properties of Fourier Transform</strong>: linearity, time shifting,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>time reversal, frequency shifting, time and frequency</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>scaling, modulation, convolution in time domain,</td>
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<tr>
<td></td>
<td></td>
<td>differentiation in time domain, differentiation in frequency</td>
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<tr>
<td></td>
<td></td>
<td>domain, symmetry, Parseval’s relation, Energy, power</td>
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<td></td>
<td></td>
<td>spectral density and bandwidth. Definition and problems on</td>
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<td></td>
<td></td>
<td>DTFT</td>
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<tr>
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<td><strong>Total</strong></td>
<td>52.0</td>
</tr>
</tbody>
</table>
Textbooks

Referencebooks

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered as final IA marks.

End Semester Examination:
1. Question paper will comprise of 6 questions each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining question (Q. 2 to Q. 6) will be selected from all the modules.

Term Work:
At least 08 assignments covering entire syllabus must be given during the “Class Wise Tutorial”. The assignments should be students’ centric and an attempt should be made to make assignments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every assignment graded from time to time. The grades will be converted to marks as per “Credit and Grading System” manual and should be added and averaged. Based on above scheme grading and term work assessment should be done.
Subject Code | Subject Name | Teaching Scheme Hrs | Credits Assigned |
--- | --- | --- | ---

Examination Scheme |
--- |
Theory Marks: 80 |
Internal Assessment: Test 1: 20, Test 2: 20, Avg. Of Test 1 and Test 2: 20 |

Course pre-requisite:
Dynamics, Differential Equations, Laplace Transforms.

Course objectives:
Objectives of this course are:
- To teach the fundamental concepts of Control systems and mathematical modeling of the system.
- To study the concept of time response and frequency response of the system.
- To teach the basics of stability analysis of the system.

Course outcomes:
The outcomes of this course are:
- Students will be able to derive the mathematical model of different type of the systems.
- Students will understand the basic concepts of control system.
- Students will understand the analysis of systems in time and frequency domain.
- Students will be able to apply the control theory to design the conventional controllers widely used in the industries.
<table>
<thead>
<tr>
<th>Module No</th>
<th>Unit No</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.1</td>
<td>Introduction to Control System Analysis: Open loop and closed loop systems, feedback and feedforward control, examples of control systems</td>
<td>8</td>
</tr>
<tr>
<td>1.0</td>
<td>1.2</td>
<td>Modeling: Types of models, impulse response model, state variable model, transfer function model</td>
<td>8</td>
</tr>
<tr>
<td>1.0</td>
<td>1.3</td>
<td>Dynamic Response: Standard test signals, transient and steady state behavior of first and second order systems, steady state errors in feedback control systems and their types</td>
<td>8</td>
</tr>
<tr>
<td>2.0</td>
<td>2.1</td>
<td>Mathematical Modeling of Systems: Models of mechanical systems, model of electrical systems, block diagram reduction, signal flow graph, and the Mason's gain rule</td>
<td>8</td>
</tr>
<tr>
<td>3.0</td>
<td>3.1</td>
<td>State Variable Models of Various Systems: State variable models of mechanical systems, state variable models of electrical systems</td>
<td>2</td>
</tr>
<tr>
<td>3.0</td>
<td>3.2</td>
<td>State Transition Equation: Concept of state transition matrix, properties of state transition matrix, solution of homogeneous systems, solution of non homogeneous systems</td>
<td>2</td>
</tr>
<tr>
<td>3.0</td>
<td>3.3</td>
<td>Controllability and Observability: Concept of controllability, controllability analysis of LTI systems, concept of observability, observability analysis of LTI systems</td>
<td>2</td>
</tr>
<tr>
<td>4.0</td>
<td>4.1</td>
<td>Concept of Stability: Concept of absolute, relative and robust stability, Routh stability criterion</td>
<td>8</td>
</tr>
<tr>
<td>4.0</td>
<td>4.2</td>
<td>Root Locus Analysis: Root-locus concepts, general rules for constructing root-locus, root-locus analysis of control systems, design of lag and lead compensators</td>
<td>8</td>
</tr>
<tr>
<td>5.0</td>
<td>5.1</td>
<td>Stability Analysis in Time Domain: Frequency domain specifications, response, peak and peak resonating frequency, relationship between time and frequency domain specifications of system stability margins</td>
<td>8</td>
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<tr>
<td>5.0</td>
<td>5.2</td>
<td>Bodeplot: Magnitude and phase plot; Method of plotting Bodeplot; Stability margin on the Bodeplot; Stability analysis using Bodeplot</td>
<td>8</td>
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<tr>
<td>5.0</td>
<td>5.3</td>
<td>Nyquist Criterion: Polar plots, Nyquist stability criterion; Nyquist plot; Gain and phase margins</td>
<td>8</td>
</tr>
<tr>
<td>6.0</td>
<td>6.1</td>
<td>Optimal and Adaptive Control Systems: Performance measure for optimal control problems, the principle of optimality, concept of dynamic programming, fundament ab single function, functions involving several independent functions, constrained minimization of functions</td>
<td>8</td>
</tr>
<tr>
<td>6.0</td>
<td>6.2</td>
<td>Adaptive Control Systems: Model reference adaptive control approach to controller design; Neuro-Fuzzy adaptive control (only concept)</td>
<td>5</td>
</tr>
</tbody>
</table>

Total: 5 Hrs.
Textbooks:

Reference Books:
5. Sastry S. S., “Adaptive Control” PHI.

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered as final IA marks.

End Semester Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No. 1 will be compulsory and based on entire syllabus.
4. Remaining question (Q.2 to Q.6) will be selected from all the modules.
<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>TeachingScheme(Hrs)</th>
<th>CreditsAssigned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Theory</td>
<td>Practical</td>
</tr>
<tr>
<td>ETL401</td>
<td>Analog Electronics Laboratory</td>
<td>01</td>
<td>02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>ExaminationScheme</th>
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<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Test 1</td>
</tr>
<tr>
<td>ETL401</td>
<td>Analog Electronics Laboratory</td>
<td>01</td>
</tr>
</tbody>
</table>

**Term Work:**
At least 10 experiments covering entire syllabus should be set to have well predefined inference and conclusion. Computation/simulation based experiments are also encouraged. The experiments should be student-centric and attempts should be made to make experiments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades converted into marks as per Credit and Grading System manual should be added and averaged. Based on this final term work grading and term work assessment should be done.

**The Practical and Oral examination will be based on entire syllabus.**
<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Scheme (Hrs)</th>
<th>Credits Assigned</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>Theory</td>
<td>Practical</td>
</tr>
<tr>
<td>ETL402</td>
<td>Microprocessors and Peripherals Laboratory</td>
<td>--</td>
<td>02</td>
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<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Examination Scheme</th>
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<td></td>
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<td></td>
<td></td>
<td>Internal Assessment</td>
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<td></td>
<td></td>
<td>Test 1</td>
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<tr>
<td>ETL402</td>
<td>Microprocessors and Peripherals Laboratory</td>
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</table>

**Term Work:**

At least 10 experiments covering the entire syllabus should be set to have well-defined inference and conclusion. Computation/simulation-based experiments are also encouraged. The experiments should be student-centric and attempts should be made to make experiments more meaningful, interesting, and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades will be converted to marks as per the 'credit and grading' system manual and should be added and averaged. Based on the above scheme grading and term work assessment should be done.

**The Practical and Oral examination will be based on the entire syllabus.**
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<td>Software Simulation Laboratory</td>
<td>Theory: 00, Practical: 02, Tutorial: 00</td>
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Students will demonstrate:
- an ability to design system and processes per needs/specifications.
- an ability to visualize and work on laboratory and multidisciplinary tasks.
- skills to use modern engineering tools, software and equipment to analyze problems.

**Term Work**:
At least 10 simulation-based experiments from Analog Electronics, Digital Electronics, Circuits and Transmission, Microprocessor, Signals and Systems and Wave Theory and Propagation should be set to have well-defined reference and conclusion. The experiments should be students-centric and attempts should be made to make experiments more meaningful, interesting and innovative.

Term work assessment must be based on the overall performance of the student with every experiment graded from time to time. The grades converted into marks as per Credit and Grading System manual should be added and averaged. Based on this final term work grading, and term work assessment should be done. It is advisable to use required application software for simulation based experiments. Use of opensource software should be encouraged.

**Practical and oral examination will be based on simulation experiments.**
Analog Electronics –I

**Overview:** A E-I course intends to provide an overview of principles, operation and application of various Electronics Devices for performing various functions. It relies on elementary treatment and qualitative analysis. AE-I course makes use of simple models and equations to illustrate the concepts involved. It provides students with detailed knowledge of various devices structure, working, characteristics also it provides detailed knowledge of various basic electronics circuits.

**Pre-requisite:**
1) Applied Physics
2) Basic Electrical & Electronics Engg.

**Objectives:**
1) To study working, construction & characteristics of different types of Diode, BJT & FETs
2) To study & analyze different types of BJT and FET biasing Circuits.
3) To apply concept of DC & AC Modelling.
4) To study small signal BJT, JFET & MOSFET amplifier in depth.
5) To Study various clipper & clamper circuits using diodes
6) To verify the theoretical concept through Laboratory & simulation.

**Outcomes:** Upon completion of course students will be able to:

a) Student will understand characteristics of various Electronic Devices
b) Analyze electronic circuits (BJT, FET and Diode)
c) Use simulation software
d) Build, Design, Make measurements, Test and Troubleshoot Electronic circuits (BJT, JFET and Diode)
e) Gain foundation for advance course.
f) Grasp fundamental knowledge of various applications of electronic circuits.
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Module 1

Diodes and Their Applications

1) Find $I_1$, $I_1$, and $I_2$ for Si diode $V_0 = 0.7V$
   for Ge diode $V_0 = 0.3V$.

2) Find $V_0$, if
   for Si diode $V_0 = 0.7V$
   for Ge diode $V_0 = 0.3V$.

3) Explain Zener and Avalanche Breakdown
   Mechanism of PN Junction

4) Explain the V-I characteristics of Zener Diode.
57. Find the value of I_s for Si diode. 
V_D = 0.7 V.

67. For the given circuits, draw the OLP waveform for the given i/p. Assume the diode is ideal.

a) 

b)
Draw the op-amp waveform for the given circuits.

[Diagram of op-amp circuits with 10μF capacitors and diodes and resistors labeled with voltages.]
* Module - 2
* Field Effect Transistor.

1. Draw and explain V-I Characteristics of JFET and explain the same.

2. Explain how to find JFET Parameters graphically.

3. Explain Construction and Working of N-channel Enhancement MOSFET.

4. Explain Construction and Working of N-channel Depletion MOSFET.

5. Derive the Equation for Threshold Voltage of N-channel Enhancement MOSFET.

6. Give the Difference Between N-channel Enhancement and N-channel Depletion MOSFET.
Module 2 - DC Analysis of TV Circuits

For the given circuit find the operating point of JFET.

a) 10V

b) 12V

For the JFET
I_{ds} = 8mA

\( g_m = 5600 \mu A/V \)

\( V_P = -4V \)
Design the DC Bias of a JFET with an n-channel JFET, for the circuit shown in Fig. The transistor parameters are

\(I_{DSS} = 5\, mA\), \(V_P = -4\, V\), \(I_{DG} = 2\, mA\), \(V_{DS} = 6\, V\).

Design a JFET circuit with a Voltage Divider Biasing. The transistor parameters are

\(I_{DSS} = 12\, mA\), \(V_P = -3.5\, V\), \(R_1 + R_2 = 100\, k\Omega\).

Design the circuit such that \(I_D = 5\, mA\), \(V_{DS} = 5\, V\).
(10) In the ckt shown below, $V_{IN} = 0.8\, V$, $k_n = 0.5\, mA/V^2$. Calculate $V_{GS}$, $I_D$, $V_{DS}$.

(11) For N-MOS Enhancement MOSFET, $V_{IN} = 1.2\, V$, $k_n = 0.2\, mA/V^2$, $\tau = 0.01\, V^{-1}$. Calculate $V_D$ for $V_{GS} = 2\, V$ and $V_{GS} = 4\, V$. What is the value of $V_A$?

(12) Calculate the Drain Current of N-MOS with $V_{IN} = 0.8\, V$, $k_n' = 80\, mA/V^2$, $W = 10\, \mu\text{m}$, $L = 1.2\, \mu\text{m}$ and with applied voltages of $V_{DS} = 0.1\, V$ and (a) $V_{GS} = 0$, (b) $V_{GS} = 1\, V$, (c) $V_{GS} = 2\, V$, (d) $V_{GS} = 3\, V$.

(13) For N-Channel depletion MOSFET the parameters are $V_{IN} = -2.5\, V$, $k_n = 1.1\, mA/V^2$. Determine $I_D$ for (a) $V_{GS} = 0\, V$ and (b) $V_{DS} = 0.5\, V$, (c) $V_{DS} = 2.5\, V$, (d) $V_{DS} = 5\, V$. Repeat the same for $V_{GS} = 2\, V$. 
(9.14) For the given circuit, \( V_{TP} = -0.8\, \text{V}, \, k_p = 0.02\, \text{mA/\text{V}^2} \).
Determine \( V_S \) and \( V_{SD} \).

\[ +5\, \text{V} \rightarrow \quad +0.4\, \text{mA} \rightarrow \quad -5\, \text{V} \]

\[ R_G = 50\, \text{k\Omega}, \quad R_D = 5\, \text{k\Omega} \]

(9.15) Determine \( V_{GS} \) and \( V_{DS} \) for MOSFET

When i) \( I_G = 5\, \text{mA} \), ii) \( I_G = 1\, \text{mA} \).

\( k_n = 1.5\, \text{mA/\text{V}^2}, \, V_{TN} = 1.2\, \text{V} \)

\[ +15\, \text{V} \rightarrow \quad +0.1\, \text{mA} \rightarrow \quad -9\, \text{V} \]

\[ 24\, \text{k\Omega} \]
9.16) For the given circuit, find the operating point of BJT. If $\beta = 100$, $V_{BE} = 0.6V$. 

a) 

\[V_{BE} = 0.6V, V_C = 10V, R_1 = 200k, R_2 = 2k, R_3 = 1k\]

b) 

\[V_{BE} = 0.6V, V_C = 10V, R_1 = 250k, R_2 = 2.5k\]

c) 

\[V_{BE} = 0.6V, V_C = 12V, R_1 = 150k, R_2 = 2k, R_3 = 0.5k\]

d) 

\[V_{BE} = 0.6V, V_C = 10V, R_1 = 40k, R_2 = 2k, R_3 = 10k, R_4 = 0.5k\]
(9.17) For the BJT $\beta = 100$, determine $V_o$ for

1) $I_Q = 0.1\text{mA}  \quad 2) I_Q = 0.5\text{mA}  \quad 3) I_Q = 2\text{mA}$.

(9.18) Calculate the Q point if $R = 75\,\Omega$, $V_{BE} = 0.6$.
Module 4
Small Signal Analysis of BJT Amplifier

9.1) Explain the following AC models for the BJT
   i) Ye model
   ii) Hybrid model.
   iii) Hybrid - II Model.

9.2) Derive the equation for $A_v$, $A_i$, $Z_i$ and $Z_o$ for CE and CE Amplifier employing
    VDR Biassing, use Hybrid - II Model.

9.3) For the given circuit calculate $A_v$, $Z_i$, $Z_o$
    for the BJT. $V_{BE} = 0.7V$, $R = 1000$, $V_A = 200V$
Q4) For the given circuit \( \beta = 100, V_A = 100V \), find:
   a) DC voltage at the base and emitter
   b) find \( R_C \) such that \( V_{CEQ} = 3.5V \)
   c) Assuming \( C_c \) and \( C_e \) are shorted, determine \( A_v \)

Q5) For the given circuit, determine \( A_v, A_i, Z_i, Z_o \)
   For BJT \( \beta = 100, V_{BE} = 0.6V, V_A = 20V \).
   For MOSFET \( \beta = 10, V_{BE} = 0.6V, V_A = 20V \).
Module 5

Small Signal Analysis of FET Amplifiers

9.1 Using Small Signal AC model, Determine the Equations for $A_v$, $Z_i$, $Z_o$ of
   a) Common-Source Amplifier
   b) Common-Drain Amplifier
   c) Common-Gate Amplifier

Using N-Channel Enhancement MOSFET and use VDR Biasing.

9.2 Calculate the small-signal voltage gain of CS Amplifier such that
   $g_m = 1 \text{mA/V}$, $R_0 = 50 \text{kHz}$, $R_d = 10 \text{kHz}$,
   Assume $R_{si} = 2 \text{k}\Omega$ and $R_{il} R_2 = 50 \text{kHz}$.

9.3 For the given circuit, find $i_{ds}$ and $A_v$:
   For MOSFET $V_{TH} = 1V$, $K_n = 0.5 \text{mA/V^2}$
   $k = 0.01 \text{V}^{-1}$

\[ i_{ds} = g_m v_{gs} \]

Diagram:

- $V_S$ (power supply)
- $C_1$, $C_2$ (capacitors)
- $R_a = 200 \text{k}\Omega$
- $R_1 = 10 \text{k}\Omega$
- $R_2 = 10 \text{k}\Omega$
- $I_g = 2 \text{mA}$
- $+9V$, $-9V$ (power supplies)

Diagram showing the circuit configuration for the problem described.
(Q4) For the given circuit determine:
  \( A_v, \, Z_i, \, Z_0.\)

\[ V_i \]
\[ C_{c1} \]
\[ 2k \]
\[ 1M \]
\[ -2 \]

\[ 10V \]
\[ C_{c2} \]
\[ 0V \]
\[ 10k \]
\[ \frac{1}{2} \]

For the JFET: \( I_{DSS} = 8mA \), \( V_P = -2\,V.\)

(Q5) For the given circuit calculate:
  \( A_v, \, Z_i, \, Z_0.\)

\[ \frac{I_{DSS} = 8mA}{V_P = -2.5\,V} \]
* Module 6 *

* OSCILLATOR *

(9.1) Explain Barkhousen Criteria.

(9.2) Draw and explain RC phase shift osc using BST and derive the expression for frequency of oscillation.

(9.3) Draw and explain Wien bridge osc using BST and derive the expression for frequency of oscillation.

(9.4) With the help of General Topology Derive the expression for freq of oscillation for Tank Ckt.

(9.5) Write the Short Notes on:

a) Hartely osc using BST
b) Colpitt osc using BST.
c) Crystal osc.
d) Twin-T osc.
ENGINEERING MATHEMATICS III

Overview: This course covers Laplace transform, Fourier series, Vectors, Fourier Transform, Z Transform, Fourier Integral, and Matrices.

Pre-requisite: Students should have knowledge of derivatives, definite and indefinite integral.

Objectives:
1. To learn about Laplace Transform, Inverse Laplace Transform and its application to differential equation and boundary value problems.
3. To learn Fourier series expansion of a function in the given interval.
4. To understand Fourier Transform and Z-Transform and its properties.

Outcome:

a) To improve analytical skills of students.
b) To develop and optimize computer algorithm.
c) After studying this subject students will be able to apply it in subjects like
   1. Electric networks,
   2. Principles of control system.
   3. Signal and System.
   4. Discrete and Continuous time signal processing.
d) To prepare students to excel in post graduate exams.
e) To apply knowledge of matrices in MATLAB software.

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BESSEL FUNCTIONS

01) Reduce Laplace’s equation in Cartesian co-ordinates to Bessel’s equation by changing to cylindrical co-ordinates.

\[ J_{1/2}(x) = \sqrt{\frac{2}{\pi x}} \sin x \quad (M-09) \quad \text{and} \quad J_{-1/2}(x) = \sqrt{\frac{2}{\pi x}} \cos x \]

02) Prove that \( J_{1/2}(x) = \sqrt{\frac{2}{\pi x}} \sin x \) is a solution of \( \frac{d^2y}{dx^2} + (2n + 1) \frac{dy}{dx} + xy = 0 \)

03) Show that (a) \( y = x^{-n} J_n(x) \) is a solution of \( \frac{d^2y}{dx^2} + (2n + 1) \frac{dy}{dx} + xy = 0 \)

(b) \( y = x J_n(x) \) is a solution of \( x^2 \frac{d^2y}{dx^2} - xy' + (x^2 - n^2 + 1)y = 0 \)

04) When \( n \) is a positive integer prove that \( J_n(-x) = (-1)^n J_n(x) \) and deduce that \( J_n(x) \) is even function when \( n \) is even & an odd function when \( n \) is odd.

05) Find \( J_0(x) \) and \( J_1(x) \)

08) When \( n \) is a positive integer prove that \( J_{-n}(x) = (-1)^n J_n(x) \)

Recurrence Relations

Problems

11) Find \( J_2(x), J_3(x), J_4(x), J_5(x) \) in terms of \( J_0(x) \) and \( J_1(x) \)

12) P.T. \( J_{3/2}(x) = -\sqrt{\frac{2}{\pi x}} \left[ \frac{\sin x}{x} - \cos x \right] \quad \text{and} \quad J_{5/2}(x) = \sqrt{\frac{2}{\pi x}} \left[ \frac{(3-x^2)\sin x - 3xcos x}{x^2} \right] \)

13) Show that (a) \( \frac{d}{dx} (J_n^2 + J_{n+1}^2) = 2\left(\frac{n}{x} J_n^2 - \frac{n+1}{x} J_{n+1}^2 \right) \)

(b) \( \frac{d}{dx} (x J_n J_{n+1}) = x \left( J_n^2 - J_{n+1}^2 \right) \)

14) S.T. (a) \( 2J_n^2 = J_{n-1} J_{n+1} \)

(b) \( 2^2 J_n^2 = J_{n-2} J_n + J_{n+2} \quad (M-09) \) and hence \( J_2 - J_0 = 2J_0^2 \)

(c) \( 2^3 J_n^3 = J_{n-3} J_{n-1} J_{n+3} + 3J_{n+1} - J_{n+3} \) and hence \( 3J_1 - J_3 = 4J_0^3 \)

15) Show that (a) \( J_0'(x) = -J_1(x) \)

(b) \( J_2'(x) = \frac{2}{x} J_0(x) + \left(1 - \frac{4}{x^2}\right) J_1(x) \)
16) Show that
(a) \[ \int_0^{5/2} J_{3/2} (ax) \, dx = \frac{1}{a} J_{5/2} (a) \] (D-10)
(b) \[ \int x^3 J_3 (x) \, dx = -x^3 J_2 (x) - 5x^2 J_1 (x) - 15x J_0 (x) + 15 J_1 (x) \, dx \]
(c) \[ \int x^4 J_1 (x) \, dx = (4x^3 - 16x) J_1 (x) - (x^4 - 8x^3) J_0 (x) + C \]
(d) \[ \int J_3 (x) \, dx = -2 \frac{J_1 (x)}{x} - J_2 (x) \] (D-10)

17) Prove that
(a) \[ J_{-3/2} (x) = -\sqrt{\frac{2}{\pi x}} \left[ \frac{\cos x}{x} + \sin x \right] \] (D-09)
(b) \[ J_{-5/2} (x) = \sqrt{\frac{2}{\pi x}} \left[ \frac{(3 - x^2) \cos x + 3x \sin x}{x^2} \right] \]
(c) \[ J_4 (x) = \left( 1 - \frac{24}{x^2} \right) J_0 (x) + \left( \frac{48}{x^3} - \frac{8}{x} \right) J_1 (x) \]
(d) \[ J_3' (x) = \left( \frac{12}{x^2} - 1 \right) J_0 (x) + \left( \frac{5}{x} - \frac{24}{x^3} \right) J_1 (x) \]
(e) \[ \int x^4 J_0 (x) \, dx = x^2 (x^2 - 9) J_1 (x) + 3x(x^2 - 3) J_0 (x) + 9 J_1 (x) \, dx \]

**Generating Function for** \( J_n (x) \)**

**Problems**

18) Show that
(a) \[ \cos (x \sin \theta) = J_0 (x) + 2x \cos \theta J_1 (x) + 2x^2 \cos 2 \theta J_2 (x) + ... \]
(b) \[ \sin (x \sin \theta) = 2 \sin \theta J_1 (x) + 2x \sin \theta J_3 (x) + 2x^2 \sin 3 \theta J_4 (x) + ... \]
(c) \[ \cos x = J_0 (x) - 2x J_2 (x) + 2x^2 J_4 (x) + ... \]
(d) \[ \sin x = 2x J_1 (x) - 2x^2 J_3 (x) + 2x^3 J_5 (x) + ... \]
(e) \[ x = 2 \{ J_1 (x) + 3J_3 (x) + 5J_5 (x) + ... \} \]
(f) \[ J_0^2 + 2J_1^2 + 2J_2^2 (x) + ... = 1 \]

19) Prove that the Bessel’s integral
(a) $J_n(x) = \frac{1}{\pi} \int_0^\pi \cos(x\theta - x\sin\theta) d\theta$

(b) $J_0(x) = \frac{1}{\pi} \int_0^\pi \cos(x\sin\theta) d\theta$

**Fourier-Bessel Series**

**Problems**

20) (a) Expand $f(x) = 4x - x^3$ in $0 < x < 2$ as $4x - x^3 = 8 \sum \frac{J_2(2\lambda_n)}{\lambda_n^2} J_1(\lambda_n x)$

where $\lambda_n$'s are the positive roots of $J_1(2\lambda) = 0$ (D-10)

(b) Show that the Fourier- Bessel series in $J_2(\lambda_i x)$ for $f(x) = x^2$ in $0 < x < a$

where $\lambda_i$ are the positive roots of $J_2(\lambda a) = 0$ is $x^2 = \sum_{i=1}^\infty \frac{2a}{\lambda_i J_3(\lambda_i a)} J_2(\lambda_i x)$

21) (a) Expand $f(x) = 1$ in $0 < x < 1$ in a series as $1 = \sum_{i=1}^\infty \frac{2}{\lambda_i J_1(\lambda_i)} J_0(\lambda_i x)$ (D-09)

(b) Show that $x = \sum_{i=1}^\infty \frac{2}{\lambda_i J_2(2\lambda_i)} J_1(\lambda_i x)$
Analytic Functions

Problem

01. Show that the functions $z^2$, $\sin z$, $\cosh z$, $\log z$ and $ze^{-z}$ are analytic.

02. Show that the following functions are analytic
   
   (a) $(x^3 - 3xy^2) + i(3x^2y - y^3)$  
   (b) $\frac{x - iy}{x^2 + y^2}$  
   (c) $\sin x \cosh y + i \cos x \sinh y$

03. Show that the following functions satisfy Cauchy-Riemann equations at the origin but are not analytic at the origin.
   
   (a) $f(z) = \begin{cases} \frac{x^3(1+i) - y^3(1-i)}{x^2 + y^2}, & z \neq 0 \\ 0, & z = 0 \end{cases}$
   
   (b) $f(z) = \begin{cases} \frac{xy^2(x + iy)}{x^2 + y^4}, & z \neq 0 \\ 0, & z = 0 \end{cases}$
   
   (c) $f(z) = |z|^2$
   
   (d) $f(z) = \begin{cases} e^{-z^4}, & z \neq 0 \\ 0, & z = 0 \end{cases}$

Sufficient Conditions

04. Show that the functions $z$ (M-11) and $\frac{z}{Z}$ are not analytic.

05. Find the constant $a$ in the analytic function $\frac{1}{2} \log(x^2 + y^2) + i \tan^{-1} \frac{ay}{x}$

Harmonic Functions

06. S.T. $u = x^2 - y^2$ and $v = \frac{-y}{x^2 + y^2}$ are harmonic but $u + iv$ is not analytic (M-11,D-08)

07. Prove that there does not exist any analytic function whose real part is $x^2 + 3x + y^2 - 4y + 6$

Polar Form
8. If \( f(z) = (r^3 \cos k\theta + iv^k \sin k\theta) \) is analytic find \( k \) (D-09)

9. Show that \( u = (r - \frac{a^2}{r})\sin\theta \) is harmonic.

**Milne-Thomson Method**

10. S.T. the following functions are harmonic and find the harmonic conjugate of the following functions & the corresponding analytic function \( f(z) = u + iv \) in terms of \( z \)

   (a) \( u = x^3 - 3xy^2 + 3x^2 - 3y^2 + 2x + 1 \) \( \Rightarrow \) \( v = \frac{\sinh 2y}{\cosh 2y + \cos 2x} \) (D-08)

   (b) \( u = e^{-2xy} \sin(x^2 - y^2) \) (D-10)

   \( (r - \frac{a^2}{r})\sin\theta \) (D-09)

**Orthogonal Family of Curves**

12. Find the family of curve orthogonal to

   (a) \( e^{-x} \sin y - y \cos y \geq c \) (D-08)

   (b) \( 3x^2y + 2x^2 - y^3 - 2y^2 = c \)

   (c) \( x^3y - xy^3 = c \) (M-09)

13. Find the analytic function \( f(z) = u + iv \), in terms of \( z \), if

   (a) \( u - v = e^x (\cos y - \sin y) \) (M-08)

   (b) \( u - v = (x - y)(x^2 + 4xy + y^2) \) (D-09)

   (c) \( \frac{u}{v} = \tan y \)

14. If \( f(z) = u + iv \) is analytic then show that it is a constant function if

   (a) \( f(z) \) is analytic

   (b) \( f(z) \) has constant modulus
(c) $f(z)$ has constant amplitude

15. If $f(z) = u + iv$ is analytic then show that

(a) \[ \left( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right) |f(z)|^2 = 4|f'(z)|^2 \] (M-10)

(b) \[ \left( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right) u^2 = 2|f'(z)|^2 \]

(c) \[ \left( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right) \log|f(z)| = 0 \] (D-10)

16. Show that $V = e^{-x} \cos y + y \sin y$ is harmonic and the corresponding analytic function $f(z) = u + iv$ (M-09)

17. Find the analytic function $f(z)$ whose real part is $(r^2 \cos 2\theta - r \sin \theta)$

18. Show that $f(z) = e^{3 - 3xy^2 + 2xy} + i \left( x^2y - x^2 + y^2 - y^3 \right)$ is analytic and hence find $f'(z)$ (M-09)

19. Show that the following functions are analytic

(a) $x^2 - y^2 + i2xy$    
(b) $e^x (\cos y + i\sin y)$

20. Find $a, b, c, d$ if $(x^2 + 2axy + by^2) + i(cx^2 + 2dxy + y^2)$ is analytic. (D-08)

21. Find the value of $a$ if $u = x^2 - y^2$ is a harmonic & its harmonic conjugate (M-11)

22. Show that $u = e^x \cos y + x^3 - 3xy^2$ is harmonic (M-08)

23. If $\phi$ and $\psi$ are harmonic functions in $x$ and $y$ then show that $u + iv$ is analytic

\[ u = \frac{\partial\phi}{\partial y} - \frac{\partial\psi}{\partial x} \text{ and } v = \frac{\partial\phi}{\partial x} + \frac{\partial\psi}{\partial y} \] (M-09)

24. Find the harmonic conjugate of the following functions and the corresponding analytic function $f(z) = u + iv$ in terms of $z$
25. Find the analytic function \( f(z) = u + iv \), in terms of \( z \), if

(a) \( u + v = \frac{2\sin 2x}{e^{2y} + e^{-2y} - 2\cos 2x} \)  
(b) \( u + v = \frac{\sin 2x}{\cosh 2y - \cos 2x} \)  

(D-10)

26. If \( f(z) = u + iv \) is analytic then show that it is a constant function if

(a) \( v + iu \) is analytic  
(b) \( u - iv \) is analytic

27. If \( f(z) = u + iv \) is analytic then S.T. \( \left( \frac{\partial}{\partial x} |f(z)|^2 \right) + \left( \frac{\partial}{\partial y} |f(z)|^2 \right) = |f'(z)|^2 \)

Conformal Mapping

1. If \( w = f(z) \) is analytic and \( f'(z) = 0 \) in a region \( R \) then prove that \( w = f(z) \) is conformal in that region.

2. Find image of circle \( |z| = 2 \) under

(i) \( w = z + (3 + 2i) \)  (ii) \( w = 3z \)  (iii) \( w = \sqrt{2} e^{4z} \)  
(iv) \( w = (1 + 2i)z + (3 + 4i) \)  (v) \( w = 1/z \)

3. Show that under the transformation \( w = 1/z \)

(a) circles in the \( z \)-plane are mapped into circles in the \( w \)-plane  
(b) circle \( |z - 1| = 1 \) is mapped into the line \( u = 1/2 \)  
(c) circle \( |z - 3| = 5 \) is mapped into the line \( \left| w + \frac{3}{16} \right| = \frac{5}{16} \)  
(d) line \( y - x + 1 = 0 \) is mapped into the circle \( u^2 + v^2 - u - v = 0 \)  
(e) hyperbola \( x^2 - y^2 = 1 \) is mapped into the lemnicate \( \rho^2 = \cos 2\phi \)

4. Under the transformation \( w = z^2 \) find the image of

(a) the region between the lines \( x = 0, x = 1, y = 0 \) and \( y = 1 \)  
(b) the region between the lines \( x = 1, y = 1, x = 2 \) and \( y = 2 \)  
(c) the region between the lines \( x = 1, y = 1 \) and \( x + y = 1 \)

5. Show that the transformation

(a) \( w = z + \frac{a^2 - b^2}{4z} \) maps the circle \( |z| = \frac{a + b}{2} \) in the \( z \)-plane into an ellipse in the \( w \)-plane with semi-axes \( a \) and \( b \).
(b) $w = z + \frac{a^2}{z}$ maps the circle $|z| = b$ in the $z$-plane into an ellipse when $b > a$
and into a line when $b < a$
(c) $w = z + \frac{1}{z}$ maps lines and $z = \text{constant}(< \frac{\pi}{2})$ and circles $|z| = \text{constant}$ into
confocal conics with foci at $w = \pm 2i$

**Bilinear transformation**
6. Prove that a bilinear transformation 
   (a) is a combination of translation, magnification, rotation & inversion; hence deduce that it maps circles in the $z$-plane into circles in the $w$-plane.
   (b) keeps the cross-ratio invariant
7. Show that the bilinear transformation
   (a) $w = \frac{5 - 4z}{4z - 2}$ maps the circle $|z| = 1$ into the circle $|w + \frac{1}{2}| = 1$
   (b) $w = \frac{2z + 3}{z - 4}$ maps the circle $|z - 2| = 2$ into the line $4u + 3 = 0$
8. Find a bilinear transformation which maps 
   (a) $z = 1, i, -1$ into $w = 1, 0, -i$ and hence find the image of the region $|z| < 1$ (M-09)
   (b) $z = -1, 1, \infty$ into $w = -i, -1, i$ and hence find the fixed points (M-11)

9. Find image of the triangular whose vertices are $i, 1+i, 1-i$ under the transformation $w = 3z + 4 - 2i$ (D-10)
10. Find image of the rectangle bounded by the lines $x = 0, y = 0, x = 2, y = 2$ under the transformations
    (a) $w = (1 + i)z$  (b) $w = (1 + 2i)z + (1 + i)$  (c) $w = z + (1 + i)$
11. Show that under the transformation $w = \frac{1}{z}$
    (a) the circle $|z - 2i| = 2$ is mapped into the line $v = -1/4$ (M-09)
    (b) the circle $(x - 3)^2 + y^2 = 2$ is mapped into the circle $(u - \frac{3}{7})^2 + v^2 = \frac{2}{49}$
    (c) the strip $\frac{1}{4} \leq y \leq \frac{1}{2}$ is mapped into the region between the two circles
        $u^2 + (v + 2)^2 = 4$ and $u^2 + (v + 1)^2 = 1$
12. Show that under the transformation $w = \frac{iz + 2}{4z + i}$ maps the real axis in the $z$-plane
into a circle in the $w$-plane. Find the centre and radius of the circle. Find the point in the $z$-plane which is mapped onto the centre of the circle in the $w$-plane.

13. Under the transformation $w = z^2$ find the image of

(a) the region between $0 \leq r \leq 1$ and $0 \leq \theta \leq \frac{\pi}{4}$

(b) the circle $|z - 1| = 1$ as the car diode $\rho = 2(1 + \cos \phi)$ (M-09)

14. Show that the transformation

(a) $w = z^2 + z$ maps the circle $|z| = 1$ in the $z$-plane into the car diode (D-08) $\rho = 2(1 + \cos \phi)$ in the $w$-plane

(b) $w = \sin z$ maps lines parallel to the co-ordinate axes in the $z$-plane into confocal conics in the $w$-plane

(c) $w = \cosh z$ maps lines $x = \text{constant}$ and $y = \text{constant}$ into confocal conics in the $w$-plane

(d) $w = z + \frac{1}{z}$ maps lines $x = \text{constant}(< \frac{\pi}{2})$ and circles $|z| = \text{constant}$ into confocal conics with foci at $w = \pm 2i$

15. Prove that a bilinear transformation can be expressed as

(a) $\frac{1}{w - \alpha} = k + \frac{1}{z - \alpha}$ if $\alpha$ is a single fixed point

(b) $\frac{w - \alpha}{w - \beta} = k \frac{z - \alpha}{z - \beta}$ if $\alpha$ and $\beta$ are two fixed points

16. Show that the bilinear transformation

(a) $w = \frac{3 - z}{z - 2}$ maps the circle in the $z$-plane with center $(5/2, 0)$ and radius $\frac{1}{2}$ into the imaginary axis in the $w$-plane

(b) $w = \frac{2}{z + i}$ maps the real axis in the $z$-plane into a circle in the $w$-plane.

17. Find a bilinear transformation which maps

(a) $z = 2, i, -2$ into $w = 1, i, -1$ (M-10, D-09)

(b) $z = 0, i, -2i$ into $w = -4i, \infty, 0$ (D-10, D-08, M-08)

And find the fixed point of the transformation

18. Find the fixed points and normal form of the bilinear transformation
Vector Algebra and Vector Calculus

**Vector Algebra**

1) Prove that \( \vec{a} \cdot (\vec{b} \times \vec{c}) \times d = \vec{c} \cdot (\vec{a} \times \vec{d}) - \vec{a} \cdot (\vec{b} \times \vec{c}) \cdot \vec{d} \).

2) Prove that \( \vec{c} \times \vec{d} + \vec{a} \times \vec{d} = \vec{b} \cdot \vec{c} - \vec{a} \cdot \vec{b} \cdot \vec{d} \) & hence deduce that \( \vec{c} \times \vec{d} + \vec{a} \times \vec{d} + \vec{b} \times \vec{d} = 0 \).

3) Prove that
   
   (i) \( \vec{a} \times \vec{b} \times \vec{c} \times \vec{d} = \vec{b} \cdot \vec{c} \cdot \vec{d} - \vec{a} \cdot \vec{b} \cdot \vec{d} \)
   
   (ii) \( \vec{a} \times \vec{b} \times \vec{c} \times \vec{d} = \vec{a} \cdot \vec{b} \cdot \vec{c} \cdot \vec{d} - \vec{b} \cdot \vec{c} \cdot \vec{d} \).

4) Expand \( \vec{a} \times \vec{b} \times \vec{c} \times \vec{d} \) in two different ways & deduce that
   
   \[ \vec{a} = \vec{c} \cdot \vec{a} + \vec{b} \cdot \vec{b} \cdot \vec{d} - \vec{b} \cdot \vec{d} \cdot \vec{c} \]

5) Prove that the three vectors \( \vec{a} \times \vec{b} \times \vec{c} \times \vec{d} \) are coplanar.

6) If \( \vec{a} \neq \vec{0} \), \( \vec{a} \cdot \vec{b} = \vec{a} \cdot \vec{c} \) and \( \vec{a} \times \vec{b} = \vec{a} \times \vec{c} \), then prove that \( \vec{b} = \vec{c} \).

7) Prove that \( \vec{a} + \vec{b} + \vec{c} + \vec{d} = \vec{b} + \vec{c} \).

8) Prove that \( \vec{i} \times \vec{j} + \vec{j} \times \vec{k} + \vec{k} \times \vec{i} = 2\vec{a} \).

9) Prove that \( \begin{vmatrix} \vec{p} & \vec{a} & \vec{b} & \vec{c} \\ \vec{a} \cdot \vec{p} & \vec{a} \cdot \vec{q} & \vec{a} \cdot \vec{r} \\ \vec{b} \cdot \vec{p} & \vec{b} \cdot \vec{q} & \vec{b} \cdot \vec{r} \end{vmatrix} = \begin{vmatrix} \vec{p} & \vec{a} & \vec{q} & \vec{b} & \vec{c} \\ \vec{a} \cdot \vec{p} & \vec{a} \cdot \vec{q} & \vec{a} \cdot \vec{r} \\ \vec{b} \cdot \vec{p} & \vec{b} \cdot \vec{q} & \vec{b} \cdot \vec{r} \end{vmatrix} \).

10) Prove that \( \begin{vmatrix} \vec{a} \cdot \vec{a} & \vec{a} \cdot \vec{b} & \vec{a} \cdot \vec{c} \\ \vec{b} \cdot \vec{a} & \vec{b} \cdot \vec{b} & \vec{b} \cdot \vec{c} \\ \vec{c} \cdot \vec{a} & \vec{c} \cdot \vec{b} & \vec{c} \cdot \vec{c} \end{vmatrix} = \begin{vmatrix} \vec{a} \cdot \vec{b} & \vec{a} \cdot \vec{c} \\ \vec{b} \cdot \vec{b} & \vec{b} \cdot \vec{c} \\ \vec{c} \cdot \vec{c} & \vec{c} \cdot \vec{c} \end{vmatrix} \).

11) Prove that \( \vec{a} \times \vec{b} \times \vec{c} \times \vec{d} = \vec{a} \cdot \vec{b} \cdot \vec{c} \cdot \vec{d} - \vec{a} \cdot \vec{b} \cdot \vec{c} \cdot \vec{d} \).

12) Prove that \( \vec{a} \times \vec{b} \times \vec{c} \times \vec{d} = \vec{a} \cdot \vec{b} \cdot \vec{c} \cdot \vec{d} - \vec{a} \cdot \vec{b} \cdot \vec{c} \cdot \vec{d} \).

13) Attempt the following:
   
   (i) If \( \vec{a} \times \vec{b} \times \vec{c} = 0 \), show that \( \vec{a} \times \vec{b} \times \vec{c} = 0 \).
   
   (ii) If \( \vec{a} + \vec{b} + \vec{c} = 0 \), prove that \( \vec{a} \times \vec{b} = \vec{b} \times \vec{c} = \vec{c} \times \vec{a} \).

14) Prove that \( \vec{a} \times \vec{b} \times \vec{c} \times \vec{d} = \vec{b} \cdot \vec{c} \).

15) Prove that \( \vec{a} \times \vec{b} \times \vec{c} \times \vec{d} = \vec{a} \cdot \vec{b} \cdot \vec{c} \cdot \vec{d} \).
16) If the vector $\vec{x}$ and the scalar $\lambda$ satisfy the equations $\vec{a} \times \vec{x} = \lambda \vec{a} + \vec{b}$ and $\vec{a} \cdot \vec{x} = 1$. Find the values of $\lambda$ and $\vec{x}$ in terms of $\vec{a}$ and $\vec{b}$. Determine them if $\vec{a} = \hat{i} - 2\hat{j}$ and $\vec{b} = 2\hat{i} + \hat{j} - 2\hat{k}$.

17) If $\vec{r}$ is coplanar with $\vec{a}$ and $\vec{b}$, then show that $\vec{r} = \frac{\vec{r} \cdot \vec{a}}{\vec{a} \cdot \vec{b}} \vec{a} + \frac{\vec{r} \cdot \vec{b}}{\vec{a} \cdot \vec{b}} \vec{b}$.

18) If the vectors $\vec{u}, \vec{v}, \vec{w}$ are non–coplanar show that the vectors $\vec{u} \times \vec{v}, \vec{v} \times \vec{w}, \vec{w} \times \vec{u}$ are also non–coplanar. Hence obtain the scalars $l, m, n$ such that $\vec{u} = l(\vec{u} \times \vec{w}) + m(\vec{v} \times \vec{w}) + n(\vec{u} \times \vec{v})$.

19) If $\vec{a}, \vec{b}, \vec{c}$ are three vectors defined by $\vec{a} = \frac{\vec{a} \times \vec{r}}{\vec{q} \cdot \vec{r}}$, $\vec{b} = \frac{\vec{r} \times \vec{p}}{\vec{q} \cdot \vec{r}}$, $\vec{c} = \frac{\vec{p} \times \vec{q}}{\vec{q} \cdot \vec{r}}$, then prove that $\vec{p} \times \vec{a} + \vec{q} \times \vec{b} + \vec{r} \times \vec{c} = 0$.

20) Solve simultaneously, $\vec{r} \times \vec{a} = \vec{a} \times \vec{b}$ & $\vec{r} \cdot \vec{a} = 0$ where $\vec{a} \cdot \vec{b} \neq 0$.

21) If $\vec{A} = \vec{i} + 2\vec{j} - 3\vec{k}$, $\vec{B} = 2\vec{i} + \vec{j} - \vec{k}$, $\vec{C} = \vec{i} + 8\vec{j} - 2\vec{k}$, Find $|\vec{A} \times \vec{C}|$.

22) If $\vec{a} = \vec{i} + 2\vec{j} + 3\vec{k}$, $\vec{b} = -2\vec{i} + \vec{j} + \vec{k}$, $\vec{c} = 10\vec{j} - 2\vec{k}$ then determine $u, v, w$ such that $\vec{a} \times \vec{b} \times \vec{c} = u\vec{a} + v\vec{b} + w\vec{c}$.

23) Prove that $\vec{a} \times \vec{i} \times \vec{b} = -\vec{a} \times \vec{b} \times \vec{i}$.

24) Find $\lambda$ such that the vectors $2\vec{i} - \vec{j} + \vec{k}, \vec{i} + 2\vec{j} + 3\vec{k}$ and $3\vec{i} + 2\vec{j} + 5\vec{k}$ coplanar.

25) Find the scalars $p$ and $q$ if $(\vec{i} \times \vec{b}) \times \vec{c} = \vec{a} \times (\vec{i} \times \vec{c})$ where $\vec{a} = 2\vec{i} + \vec{j} + p\vec{k}$, $\vec{b} = \vec{i} - \vec{j}$, $\vec{c} = 4\vec{i} + q\vec{j} + 2\vec{k}$.

26) Show that the vectors $(\vec{i} \times \vec{c}), (\vec{i} \times \vec{a}), (\vec{i} \times \vec{b})$ are coplanar of $a, b, c$ are co-planar.

27) Prove that the 4 points $4\vec{i} + 5\vec{j} + \vec{k}, -\vec{i} + \vec{j} + 3\vec{k}, 3\vec{i} + 9\vec{j} + 4\vec{k}, 4\vec{i} + \vec{j} + \vec{k}$ are co-planar.

**Vector Calculus**

1) If $\vec{r} = \vec{a} e^{2t} + \vec{b} e^{2t}$, Show that $\frac{d^2\vec{r}}{dt^2} - 4\vec{r} = 0$.

2) If $\vec{r} = 4a \sin^2 \theta \vec{i} + 4a \cos^2 \theta \vec{j} + 3b \cos 2\theta \vec{k}$,

(i) \[\frac{d\vec{r}}{d\theta} \times \frac{d^2\vec{r}}{d\theta^2}\]

(ii) \[\left|\frac{d\vec{r}}{d\theta} \frac{d^2\vec{r}}{d\theta^2} \frac{d^3\vec{r}}{d\theta^3}\right|\]

3) Evaluate (i) $\frac{d}{dt} \left(\vec{r} \times \frac{d\vec{r}}{dt}\right) \frac{d^2\vec{r}}{dt^2}$
where $\vec{r}$ is a vector function of '$t$' 

4) If $\vec{r} = \vec{a} \sinht + \vec{b} \cosh t$, where $\vec{a}$ and $\vec{b}$ are constant vectors prove that 

(i) $\frac{d^2 \vec{r}}{dt^2} = \vec{a}$ 
(ii) $\frac{d\vec{r}}{dt} \times \frac{d^2 \vec{r}}{dt^2} = \text{constant}$. 

5) Find $\frac{d}{d\theta} \left( \vec{a} \times \vec{b} \times \vec{c} \right)$ at $\theta = \frac{\pi}{2}$ 

For $\vec{a} = \sin \theta \hat{i} + \cos \theta \hat{j} + \theta \hat{k}$, $\vec{b} = \cos \theta \hat{i} - \sin \theta \hat{j} - 3 \hat{k}$, $\vec{c} = 2 \hat{i} + 3 \hat{j} - 3 \hat{k}$ 

6) If $\vec{r} = \vec{a} \cos \omega t + \vec{b} \sin \omega t$, then prove that 

(i) $\vec{r} \times \frac{d\vec{r}}{dt} = \omega \vec{c} \times \vec{b}$ 
(ii) $\frac{d^2 \vec{r}}{dt^2} = -\omega^2 \vec{r}$ 

7) If $\vec{r} = \vec{a} \sin \omega t - \vec{b} \sin \omega t + \frac{ct}{\omega^2} \sin \omega t$, prove that $\frac{d^2 \vec{r}}{dt^2} + \omega^2 \vec{r} = \frac{2\vec{b}}{\omega} \cos \omega t$. 

8) If $\vec{r} = a \cos t \hat{i} + a \sin t \hat{j} + at \tan \alpha \hat{k}$ 

(i) Find $\left| \frac{d\vec{r}}{dt} \times \frac{d^2 \vec{r}}{dt^2} \right|$ \hspace{1cm} (Dec – 10) 

(ii) Prove that $\left[ \frac{dr}{dt} \left( \frac{d^2 r}{dt^2} \right)^2 \frac{d^3 r}{dt^3} \right] = a^3 \tan \alpha$. (May – 08) 

9) If $\frac{d\vec{a}}{dt} = \vec{u} \times \vec{a}$ & $\frac{d\vec{b}}{dt} = \vec{u} \times \vec{b}$, show that $\frac{d}{dt} \left( \vec{u} \times \vec{b} \right) = \vec{u} \times \left( \vec{u} \times \vec{b} \right)$ (May – 09) 

10) Prove that $\frac{d}{dt} \left[ \vec{v} \left( \frac{d\vec{v}}{dt} \right)^2 \right] = \left[ \frac{d\vec{v}}{dt} \left( \frac{d^2 \vec{v}}{dt^2} \right)^2 \right]$ 

11) Prove that $\left| \vec{f} \times \frac{d\vec{f}}{dt} \right| = \left| \frac{d\vec{f}}{dt} \right|$ where $\vec{f}$ is an unit vector. 

12) Find $\frac{d}{dt} \left( \frac{\vec{r} \times \vec{a}}{\vec{r} \cdot \vec{a}} \right)$ where $\vec{r}$ is a vector function of scalar $t$ and $\vec{a}$ is a constant vector. 

13) Write down the formula for $\frac{d}{dt} \left( \vec{u} \times \vec{b} \right)$ and verify the same for 

$\vec{A} = 5t^2 \hat{i} + t \hat{j} - 3t^3 \hat{k}$ and $\vec{B} = \sin t \hat{i} - \cos t \hat{j}$ 

14) If $\vec{r} = t^3 \hat{i} + \left( 2t^3 - \frac{1}{5} t^2 \right) \hat{j}$, then show that $\vec{r} \times \frac{d\vec{r}}{dt} = \hat{k}$
15) Find the magnitude of the velocity and acceleration of a particle which moves along the curve \( x = 2\sin 3t, \ y = 2\cos 3t, \ z = 8t \) at any time \( t > 0 \) Find unit tangent vector to the curve.

16) A particle moves along a plane curve such that its linear velocity is perpendicular to the radius vector. Show that the path of the particle is a circle.

17) If \( \hat{\mathbf{A}} = \sin t \hat{i} + \cos t \hat{j} + t \hat{k}, \ \hat{\mathbf{B}} = \cos t \hat{i} - \sin t \hat{j} - 3\hat{k}, \ \hat{\mathbf{C}} = 2\hat{i} + 3\hat{j} - \hat{k} \).

Find \( \frac{d}{dt} \hat{\mathbf{A}} \times \hat{\mathbf{B}} \times \hat{\mathbf{C}} \) at \( t = 0 \)

Ans: \( 7\hat{i} + 6\hat{j} - 6\hat{k} \) (May – 11)

**Vector differentiation**

**(A) Gradient of a scalar point function \( \phi \).**

1) If \( \phi = 3x^2y - y^3z^2 \) find \( \nabla \phi \) at the point \( p(1, -2, -1) \) \[ \text{Ans:} \ \frac{1}{\sqrt{3}}(i + j + k) \]

2) Find \( \nabla \phi \), when \( \phi = xyz \) at \( (1, 2, 3) \).

\[ \text{Ans:} \ \hat{i} + \frac{3\hat{j}}{\sqrt{14}} \]

3) (i) If \( \phi = x^n + y^n + z^n \) show that \( r \cdot \nabla \phi = n\phi \)

(ii) If \( \phi = x^3 + y^3 + z^3 - 3xyz \), show that \( \vec{r} \cdot \nabla \phi = 3\phi \)

4) If \( \phi = \log(2 + y^2 + z^2) \), find \( \nabla \phi \) at \( (2, 1, 1) \).

\[ \text{Ans:} \ \frac{-\hat{i} + 3\hat{j} + 2\hat{k}}{\sqrt{14}} \]

5) If \( u = x + y + z, v = x^2 + y^2 + z^2, w = xy + yz + zx \) then show that \( \nabla u, \nabla v, \nabla w \) are co-planar.

6) If \( \phi = x^2 + y^2 + z^2, \psi = x^2y^2 + y^2z^2 + z^2x^2 \) then find \( \nabla(\phi \psi) \)

7) If \( \phi \) is a function of \( u, v, w \) where \( u, v, w \) are functions of \( x, y, z \) then

\[ \nabla \phi = \frac{\partial \phi}{\partial u} \nabla u + \frac{\partial \phi}{\partial v} \nabla v + \frac{\partial \phi}{\partial w} \nabla w \]

8) Prove that \( \nabla f(r) = \frac{f'(r)}{r} \hat{r} \) & hence find \( 'f \) if \( \nabla f = 2r^4 \hat{r} \) (May – 08)

9) Prove that:

(i) \( \nabla r = \frac{\hat{r}}{r} \)

(ii) \( \nabla \log r = \frac{\hat{r}}{r^2} \)

(iii) \( \nabla r^n = nr^{n-2} \hat{r} \)

(iv) \( \nabla \int r^n dr = r^{n-1} \hat{r} \)

(v) \( \nabla \cdot \hat{r} = 3 \)

10) Prove that \( \nabla \left( 2e^r \right) = \hat{r} + 2e^r \hat{r} \)

11) Prove that:

(i) \( \nabla \cdot \vec{r} = \vec{a} \)

(ii) \( \vec{a} \cdot \nabla \vec{r} = \vec{a} \)

(iii) \( \vec{a} \cdot \nabla \vec{g} = \vec{a} \cdot \nabla \phi \) where \( \vec{a} \) is an instant vector.

12) Prove that:

(i) \( \nabla f(\vec{u}) = f'(\vec{u}) \nabla u \)

(ii) \( \nabla \int f(\vec{u}) d\vec{u} = f(\vec{u}) \nabla u \)
13) Prove that $\mathbf{a} \cdot \nabla \frac{1}{r} = -\frac{\mathbf{a} \cdot \mathbf{r}}{r^3}$ where $\mathbf{a}$ is a constant vector.

14) Prove that $\nabla \left( \mathbf{a} \cdot \mathbf{r} \right) = \mathbf{a}$ where $\mathbf{a}$ and $\mathbf{r}$ are constant vectors.

15) Prove that $\nabla \cdot \mathbf{f} = \mathbf{f}(\mathbf{r}, \mathbf{r})$ where $\mathbf{f}$ is a constant vector.

16) Prove that $\mathbf{a} \cdot \mathbf{b} = \mathbf{a} \cdot \mathbf{b}$.

17) If $\mathbf{u} = 2r^4 \mathbf{r}$, find $\mathbf{u}$.

18) Find $\phi \mathbf{e}_\mathbf{r}$ such that $\nabla \phi = \frac{\mathbf{r}}{r^5}$ and $\phi \mathbf{e}_\mathbf{r} = 0$.

19) Prove that $\nabla \left[ \mathbf{a} \cdot \nabla \mathbf{r} \right] = \frac{3 \mathbf{a} \cdot \mathbf{r}}{r^5} - \frac{\mathbf{a}}{r^3}$ where $\mathbf{a}$ is a constant vector.

20) Prove that $\nabla \left( \frac{\mathbf{a} \cdot \mathbf{r}}{r^n} \right) = \frac{\mathbf{a} \cdot \mathbf{r}}{r^n} - \frac{n \mathbf{a} \cdot \mathbf{r}}{r^{n+2}}$ where $\mathbf{a}$ is a constant vector.

(B)

1) Find a unit normal to the surface $x^2 y + 2xz = 4$ at the point $(2, -2, 2)$.

Ans : $\frac{1}{\sqrt{3}} (\hat{i} + \hat{j} + \hat{k})$

2) Find the unit normal to the surface $x^2 + y^2 + z^2 = a^2$ at $\left( \frac{a}{\sqrt{3}}, \frac{a}{\sqrt{3}}, \frac{a}{\sqrt{3}} \right)$.

Ans : $\frac{1}{\sqrt{3}} (\hat{i} + \hat{j} + \hat{k})$

3) Find the unit normal to the surface $xy^3 z^2 = 4$ at the point $(-1, -1, 2)$.

Ans : $\frac{1}{\sqrt{11}} (\hat{i} + 3\hat{j} - \hat{k})$

4) Find a unit normal to the surface $x^3 + y^3 + 3xy = 3$ at $(1, 2, -1)$.

Ans : $\frac{1}{\sqrt{14}} (\hat{i} + 3\hat{j} + 2\hat{k})$

(C) Angle between the surfaces

1) What is the angle between the normal to the surface $xy = z^2$ at the points $(1, 4, 2)$ and $(-3, -3, 3)$?

Ans : $\theta = \cos^{-1} \left( \frac{1}{\sqrt{22}} \right)$

2) Find the angle between the surface $ax^2 + y^2 + z^2 - xy = 1$ and $bx^2 y + y^2 z + z = 1$ at $p(1, 1, 0)$.

Ans : $45^\circ$

3) Find the cosine of the angle between the normal to the surfaces $x^2 y + z = 3$ and $x \log z - y^2 = -4$ at the point of intersection $P(-1, 2, 1)$.

Ans : $\cos \theta = \frac{-5}{\sqrt{18}}$
4) Find the constants ‘a’ and ‘b’ so that the surface \( ax^2 - byz = \phi + 2x \) will be orthogonal to the surface \( 4x^2y + z^3 = 4 \) at the point (1, -1, 2).

\textbf{Ans:}\ a = 5/2 \& b = 1

5) Find the constants m and n such that the surface \( mx^2 - 2nyz = \phi + 4x \) will be orthogonal to the surface \( 4x^2y + z^3 = 4 \) at the point (1, -1, 2).

\textbf{Ans:}\ m = 5 \& n = 1.

6) Find the angle between the two surfaces \( x^2 + y^2 + ax^2 = 6 \) and \( z = 4 - y^2 + bxy \) at \( p (1, 1, 2) \)

\textbf{Ans:}\ \theta = \cos^{-1}\left[ \frac{6}{\sqrt{11}} \right]

7) Find the angle between surfaces \( xy^2z = 3x + z^2 \) and \( 3x^2 - y^2 + 2z = 1 \) at the point (1, -2, 1)

\textbf{Ans:}\ \theta = \cos^{-1}\left( \frac{-3}{7\sqrt{6}} \right)

8) If the angle between the surfaces \( x^2 + axz + byz = 2 \) and \( x^2z + xyz + y + 1 = z \) at \( (0, 1, 2) \) is \( \cos^{-1}\left( \frac{3}{\sqrt{3}} \right) \), find the constants ‘a’ and ‘b’.

9) Find the constants ‘a’ b & c if the normal to the surface \( ax^2 + bxz + z^2y = c \) at \( P (-1, 1, 2) \) is parallel to the normal to the surface \( x^2 - y^2 + 2z = 2 \) at \( Q (1, 1, 1) \).

\textbf{Ans:}\ a = 10, b = 8 \& c = -2

10) Find the constants ‘a’ and ‘b’ if the surface \( ax^2 - bxy + xz = 10 \) is orthogonal to the surface \( x^2 + y^2 = 4 + xz \) at \( P (1, 2, 1) \).

\textbf{Ans:}\ a = -5, b = -7.

11) Find the constants a and b such that the surfaces \( 5x^2 - 2yz - 9x = 0 \) and \( ax^2y + bz^3 = 4 \) cut orthogonally at (1, -1, 2)

\textbf{Ans:}\ a = 4 \& b = 1

12) Find the constant, a, b, c if the normal to the surface \( ax^2 + yz + bxz^3 = c \) at \( P (1, 2, 1) \) is parallel to the normal to the surface \( y^2 + xz = 61 \) at \( Q (10, 1,6) \).

\textbf{Ans:}\ a = 1, b = 1, c = 4

(D) Directional Derivatives

1) What is the directional derivative of \( \phi = xy^2 + yz^3 \) at the point (2, -1, 1) in the direction of the vector \( \hat{i} + 2\hat{j} + 2\hat{k} \).

\textbf{Ans:}\ \frac{-11}{3}

2) Find directional derivative of \( \phi = x^4 + y^4 + z^4 \) at the point \( A(1, -2, 1) \) in the direction of line \( AB \) where \( B = (2, 6, -1) \).

\textbf{Ans:}\ \frac{-260}{\sqrt{69}}
3) Find the directional derivative of \( \phi = \frac{2x - y + z}{e} \) at the point \((1, 1, -1)\) in the direction towards the point \((-3, 5, 6)\).

\[ \text{Ans : } \frac{-5}{9} \]

4) What is the directional derivative of \( \phi = xy^2 + yz^3 \) at the point \((2, -1, 1)\) in the direction of the normal to the surface \( x \log z - y^2 = -4 \) at \((-1, 2, 1)\).

\[ \text{Ans : } \frac{15}{\sqrt{17}} \]

5) For the function \( \phi = \frac{y}{x^2 + y^2} \) find the magnitude of the directional derivative making an angle of 30° with positive x-axis at the point \((0, 1)\).

\[ \text{Ans : } \frac{-1}{2} \]

6) Find the directional derivative of \( x^3 + y^3 + z^3 - xyz \) at \( P(1,1,1) \) in the direction of normal to the surface \( x \log z + y^2 = 4 \) at \( Q(1, -2, 1) \)

\[ \text{Ans : } \frac{-6}{\sqrt{17}} \]

7) Find the rate of change of the distance of \( \phi = xyz \) at \((1,1,1)\) in the direction normal to the surface \( x^2yz + 4xz^2 = 6 \) at the point \((1, -2, -1)\).

\[ \text{Ans : } \frac{-3}{\sqrt{165}} \]

8) Find the directional derivative of \( \phi = xy(x - y + 3) \) at \( P(1, 2, 1) \) in the direction of normal to the surface \( x^2 + y^2 + az^2 = 4 \) at \( Q(1, 1, 1) \).

\[ \text{Ans : } \sqrt{57} \]

9) Find the directional derivative of \( \phi = x^2y + y^2z + z^2x^2 \) at \( P(1, 2, 1) \) in the direction of normal to the surface \( x^2 + y^2 - z^2x = 1 \) at \( (1, 1, 1) \).

\[ \text{Ans : } -4\hat{i} + 4\hat{j} + 12\hat{k} \]

10) Find the directional derivation of \( \phi = e^{2x} \cos yz \) at the origin in the direction of tangent to the curve \( x = a \sin t, y = a \cos t, z = a t \) at \( t = \frac{\pi}{4} \).

\[ \text{Ans : } 1 \]

11) Find the directional derivative of \( \phi = x^2 + y^2 + z^2 \) at \((1, 2, 3)\) in the direction of the line \( \frac{x}{3} = \frac{y}{4} = \frac{z}{5} \) (Dec – 07)

\[ \text{Ans : } \frac{52}{\sqrt{50}} \]

**Divergence**

1) \( \vec{A} = x^2\hat{i} - 2y^3z^2\hat{j} + xyz\hat{k} \) Find \( \nabla \cdot \vec{A} \) at \((1, -1, 3)\).

\[ \text{Ans : } -47 \]
2) Given \( \phi = 2x^3 y^2 z^4 \). Find \( \nabla \cdot \nabla \phi \).

Ans :: - \( 12xy^2 z^4 + 2x^3 z^4 + 24x^3 y^2 z^2 \)

3) Show that \( \nabla \cdot \nabla \phi = \nabla^2 \) where \( \nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \) denotes the Laplace’s operator.

4) Prove that \( \nabla \cdot \mathbf{\alpha} = y + y + 2x = 0 \)

5) Prove that \( \nabla \cdot \mathbf{F} = 3 \)

6) Prove that :
   (i) \( \nabla \cdot (\mathbf{\alpha} \times \mathbf{F}) = 0 \) (May – 08)
   (ii) \( \nabla \cdot \left( \frac{\mathbf{\alpha} \times \mathbf{F}}{r} \right) = 0 \)
   (iii) \( \nabla \cdot (\mathbf{\alpha} \cdot \mathbf{F}) = \alpha^2 \) (May – 08)
   (iv) \( \nabla \cdot (\mathbf{\alpha} \times \mathbf{F}) = 2\alpha^2 \)

7) Prove that :
   (i) \( \nabla \cdot \mathbf{F} = \frac{2}{r} \)
   (ii) \( \nabla \cdot \left( \frac{\mathbf{F}}{r^n} \right) = \frac{3 - n}{r^n} \)

8) Prove that \( \nabla \cdot \left( \mathbf{m} \mathbf{\alpha} \right) = \mathbf{m} + 3 \mathbf{\alpha}^m \)

9) Prove that \( \nabla \left[ \nabla \cdot \mathbf{\hat{F}} \right] = -\frac{2}{r^3} \mathbf{\hat{F}} \)

10) Prove that \( \nabla^2 f(r) = f''(r) + \frac{2}{r} f'(r) \) hence find such \( f(r) \) that \( \nabla^2 f(r) = 0 \).

11) Prove that :
   (i) \( \nabla^2 \frac{1}{r} = 0 \)
   (ii) If \( \mathbf{F} = \frac{x}{r} \mathbf{i} + \frac{y}{r} \mathbf{j} + \frac{z}{r} \mathbf{k} \) and \( r = \sqrt{x^2 + y^2 + z^2} \) prove that \( \nabla \cdot \mathbf{F} = \frac{2}{r} \).

12) Prove that :
   (i) \( \nabla^2 \log r = 5 + 6 \log r \)
   (ii) \( \nabla^2 (n \log r) = \frac{n}{r} \mathbf{\nabla} \cdot \mathbf{\nabla} + 1 \log r + 2n + 1 \mathbf{\nabla}^2 r - 2 \)
   (iii) \( \nabla^2 \left( \frac{1}{r^2} \right) = \frac{2}{r^4} \) (iv) \( \nabla^2 (r^2) = 6 \)

13) Prove that \( \nabla^2 (2 e^r) = (2 + 6r + 6 e^r) \)

14) Prove that \( \nabla^2 (2 \log r - 6 e^r) \)

15) Prove that \( \nabla^4 e^r = \left[ 1 + \frac{4}{r} \right] e^r \)

16) (i) Prove that \( \nabla \cdot (r \mathbf{\nabla} \left( \frac{1}{r^3} \right) = \frac{3}{r^4} \) (ii) Prove that \( \nabla \cdot \left( \frac{1}{r^n} \right) = \frac{n}{r^{n+1}} \) (Dec – 09)

17) If \( \nabla r^n \) is solenoidal, show that \( n = -1 \).
18) If \( \vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \) & \( \vec{a} \cdot \vec{b} \) are constant vectors, prove that
\[
\vec{a} \cdot \nabla \left( \frac{\vec{b} \cdot \nabla}{r} \right) = 3 \frac{\vec{a} \cdot \vec{r}}{r^5} \frac{\vec{b} \cdot \vec{r}}{r^3} - \frac{\vec{a} \cdot \vec{b}}{r^3} \] (Dec – 07)

**Curl :**

1) If \( A = x^2z\hat{i} - 2y^3z^2\hat{j} + xy^2z\hat{k} \). Find \( \nabla \times \vec{A} \) at \((1, -1, 1)\)

**Ans.:** \(-6\hat{i}\)
2) Prove that :
   (i) \( \text{Curl} \ \text{grad} \ \phi = 0 \)
   (ii) \( \text{Div} \ \text{curl} \ \vec{A} = 0 \)
   (iii) \( \text{Curl} \ \vec{r} = 0 \)
   (iv) \( \text{Curl} \ (m \vec{r}) = 0 \).
3) Prove that \( \nabla \times (\vec{a} \times \vec{r}) = 2\vec{a} \) where \( \vec{a} \) is a constant vector. (May – 08)
4) Prove that \( \nabla \times (\vec{a} \times \vec{r}) \) \( \text{log} r \) \( = \frac{2\vec{a} \cdot \vec{r}}{r^4} \) (May – 09)
5) Prove that \( \nabla \times \left( \frac{\vec{a} \times \vec{r}}{r^n} \right) = \frac{\vec{a} \cdot \vec{r} - n\vec{a}}{r^{n+2}} + \frac{n\vec{a} \cdot \vec{r}}{r^{n+2}} \) (May – 09)
6) Prove that \( \nabla \times \left( \frac{\vec{a} \times \vec{r}}{r^3} \right) + \nabla \left( \frac{\vec{a} \cdot \vec{r}}{r^3} \right) = 0 \)
7) Prove that \( \nabla \times \left( \frac{\vec{a} \times \vec{r}}{r} \right) = \frac{\vec{a}}{r} + \frac{\vec{a} \cdot \vec{r}}{r^3} \vec{r} \)
8) Find ‘n’ such that \( \nabla \times \left( \frac{\vec{a} \times \vec{r}}{r^n} \right) = \frac{2\vec{a} \cdot \vec{r}}{r^4} \vec{r} \)
9) Find \( f(r) \) so that the vector \( f \ \vec{r} \) is both solenoidal and irrotational. (Dec – 09)

**Ans:** \( c/r^3 \)
10) If \( \vec{a} \) is a constant vector, prove that \( \nabla \times \frac{\vec{a}}{r^n} = 3 \vec{a} \times \vec{a} \).
11) If \( u = x^2 + y^2 + z^2 \) and \( \vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \) then find \( \text{div} (\vec{r} \vec{r}) \) in terms of \( u \).
12) Find the value of ‘n’ for which the vector \( r^n \vec{r} \) is solenoidal, where \( \vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \)

**Ans:** \( -n = -3 \).
13) Prove that \( \vec{F} = \vec{a} + 2y \hat{j} + az \hat{k} + \vec{b} - 3y \hat{j} - 3z \hat{k} + \vec{c} - cy + 2z \hat{k} \) is solenoidal and determine constants \( a, b \& c \) if \( \vec{F} \) is rotational.

**Ans:** \( a = 4, b = 2, c = -1. \)
14) Prove that \( \nabla \left( \frac{f \vec{r}}{r^2} \right) = \frac{1}{r^2} \frac{d}{dr} \left( 2f \vec{r} \right) \)

Hence, or otherwise prove that \( \text{div} \left( \frac{\vec{r}}{r^2} \right) = \frac{\vec{r}}{r} \) (Dec – 08)
15) Verify : \( \vec{a} \times \vec{b} \times \vec{c} = \vec{a} \cdot \vec{c} \vec{b} - \vec{b} \cdot \vec{c} \vec{a} \) and \( \vec{a} \times \vec{b} \times \vec{c} = \vec{a} \cdot \vec{c} \vec{b} - \vec{a} \cdot \vec{b} \vec{c} \).

For \( \vec{a} = 3\hat{i} - 2\hat{j} + 2\hat{k}, \vec{b} = 6\hat{i} + 4\hat{j} + 2\hat{k}, \vec{c} = 3\hat{i} + 2\hat{j} + 4\hat{k} \)

(May – 10)
16) Find \( \vec{F} \) and \( \nabla \times \vec{F} \) where \( \vec{F} = \frac{x\hat{i} - y\hat{j}}{x^2 + y^2} \) (Dec – 10)
• FOURIER SERIES

Neither Even nor Odd Functions

Problems

01. Find the Fourier series expansion of the functions in the respective intervals

(a) \( f(x) = x^2, \ 0 < x < 2 \) and hence deduce that \( \sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6} \) (M-09)

and \( \frac{\pi^2}{12} = \frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \ldots \) (D-09)

(b) \( f(x) = 4 - x^2, 0 < x < 2 \) & hence deduce that \( \frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \ldots = \frac{\pi^2}{6} \)

(c) \( f(x) = x \sin x; 0 \leq x \leq 2\pi \)

(d) \( f(x) = \begin{cases} 0 & ; -\pi \leq x < 0 \\ \sin x & ; 0 \leq x \leq \pi \end{cases} \)

and hence deduce that

\[
\begin{align*}
(i) & \quad \frac{1}{1.3} + \frac{1}{3.5} + \frac{1}{5.7} + \ldots = \frac{1}{2} \\
(ii) & \quad \frac{1}{1.3} - \frac{1}{3.5} + \frac{1}{5.7} + \ldots = \frac{\pi - 2}{4} \quad (D-07)
\end{align*}
\]

\[
(iii) \quad \frac{1}{1.3} + \frac{1}{5.7} + \frac{1}{9.11} + \ldots = \frac{\pi}{8}
\]

02. Find the Fourier series expansion of the functions in the respective intervals

(a) \( f(x) = \frac{\pi - x}{2}, x \in (0, 2\pi) \) & hence deduce that \( \frac{1}{1} - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots = \frac{\pi}{4} \) (M-11)

(b) \( f(x) = \cos ax; 0 < x < 2\pi; a \neq \text{integer} \) and hence deduce that

\[
\pi \cot a\pi = \frac{1}{a} + 2a \sum_{n=1}^{\infty} \frac{1}{a^2 - n^2} \quad \text{&} \quad \pi \cosec a\pi = \frac{1}{a} + 2a \sum_{n=1}^{\infty} \frac{(-1)^n}{a^2 - n^2}
\]

(c) \( f(x) = \begin{cases} 0 & ; -\pi < x < 0 \\ x^2 & ; 0 < x < \pi \end{cases} \) where \( f(x) \) is periodic with \( 2\pi \) (M-10, M-09)

(d) \( f(x) = \begin{cases} 2 & ; -2 < x < 0 \\ 0 & ; 0 < x < 2 \end{cases} \) (D-09)
Even Functions

Problems

03. Find the Fourier expansion for the following functions

(a) \( f(x) = x^2 \) in \((-\pi, \pi)\) and hence deduce that (M-09,D-10)

\[
\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \ldots = \frac{\pi^2}{6} \quad \frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \ldots = \frac{\pi^2}{12}
\]

\[
\frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \ldots = \frac{\pi^2}{8} \quad \frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \ldots = \frac{\pi^4}{90}
\]

(b) \( f(x) = \frac{\pi^2}{12} - \frac{x^2}{4} \) in \((-\pi, \pi)\) (M-11)

(c) \( f(x) = |\sin x| \) (D-07)

(d) \( f(x) = x \sin x \) in \((-\pi, \pi)\) & deduce that \( \frac{1}{1^2} \frac{1}{3^2} \frac{1}{5^2} \ldots \frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \ldots = \frac{\pi^2}{8} \) (D-08)

04. Find the Fourier series expansion for the following functions

(a) \( f(x) = \left( \frac{\pi - x}{2} \right)^2 \) in \((0,2\pi)\) and hence deduce that (M-08,D-10)

\[
\frac{1}{1^2} + \frac{1}{2^2} + \frac{1}{3^2} + \ldots = \frac{\pi^2}{6} \quad \frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \ldots = \frac{\pi^2}{12}
\]

(b) \( f(x) = \sqrt{1 - \cos x}, 0 < x < 2\pi \) & deduce that \( \sum_{n=1}^{\infty} \frac{1}{n^2 - 1} = \frac{1}{2} \) (M-10,D-09)
(c) \( f(x) = \begin{cases} 
\frac{1}{2} + x & ; \ -\frac{1}{2} < x \leq 0 \\
\frac{1}{2} - x & ; \ 0 < x \leq \frac{1}{2} 
\end{cases} \), \( f(x) \) is a periodic function of period 1. (D-08)

(d) \( f(x) = \begin{cases} 
x + \frac{\pi}{2} & ; \ -\pi < x < 0 \\
\frac{\pi}{2} - x & ; \ 0 < x < \pi 
\end{cases} \) (D-09)

(e) \( f(x) = \begin{cases} 
x & ; \ 0 < x < \frac{\pi}{2} \\
\pi - x & ; \ \frac{\pi}{2} < x < \pi 
\end{cases} \) & hence deduce that \( \sum_{n=1}^{\infty} \frac{1}{(2n-1)^4} = \frac{\pi^4}{96} \) (D-07, M-11)

**Odd Functions**

**Problems**

05. Find the Fourier expansion for the following functions

(a) \( f(x) = \begin{cases} 
-(\pi + x) & ; \ -\pi \leq x \leq -\pi/2 \\
x & ; \ -\pi/2 \leq x \leq \pi/2 \\
\pi - x & ; \ \pi/2 \leq x \leq \pi 
\end{cases} \)

(b) Prove that in the interval \( 0 < x < \pi \),

\[
e^{a\pi} - e^{-a\pi} = 2\pi \left[ \frac{1}{a^2 + 1} - \frac{2\sin 2x}{a^2 + 2^2} + \frac{3\sin 3x}{a^2 + 3^2} - \ldots \right]
\] (D-08)

(c) \( f(x) = x \cos x \) in \( (-\pi, \pi) \) (M-08)

(d) \( f(x) = x - x^2, -1 < x < 1 \) (D-09)

(e) \( f(x) = x^3 \) in \( \pi, \pi \) (M-09)

06. Find the Fourier expansion for the following functions

(a) \( f(x) = \begin{cases} 
\pi x & ; \ 0 < x < 1 \\
\pi(x - 2) & ; \ 1 < x < 2
\end{cases} \) & hence S.T \( 1 - \frac{1}{3} + \frac{1}{5} - \ldots = \frac{\pi}{4} \) (D-07)
Half Range Fourier Series

Problems

07. Find the half range Fourier sine/cosine series of the function

(a) \( f(x) = x \); \( 0 < x < 2 \) \( \text{(D-09)} \) and hence deduce that
\[
\sum_{n=1}^{\infty} \frac{1}{(2n-1)^4} = \frac{\pi^4}{94} \quad \text{and} \quad \sum_{n=1}^{\infty} \frac{1}{n^4} = \frac{\pi^4}{90}
\]

(b) \( f(x) = \begin{cases} 
  kx & ; 0 \leq x \leq L/2 \\
  k(L-x) & ; L/2 \leq x \leq L
\end{cases} \) and hence deduce that
\[
\frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \ldots = \frac{\pi^2}{8} \quad \text{and} \quad \frac{1}{1^4} + \frac{1}{3^4} + \frac{1}{5^4} + \ldots = \frac{\pi^2}{96}
\]

(c) \( f(x) = x(L-x) \); \( 0 < x < L \) and hence deduce that
\[
\sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{(2n-1)^3} = \frac{\pi^3}{32} \quad \text{(M-11)}
\]

(d) \( f(x) = \begin{cases} 
  1 & ; 0 < x < 1 \\
  x & ; 1 < x < 2
\end{cases} \) \( \text{(M-08)} \)

(e) Find the half range cosine series for \( f(x) = \sin x \); \( 0 \leq x \leq \pi \) and hence deduce that
\[
\frac{1}{1.3} + \frac{1}{3.5} + \frac{1}{5.7} \ldots = \frac{1}{2} \quad , \quad \frac{1}{1^2.3^2} + \frac{1}{3^2.5^2} + \frac{1}{5^2.7^2} \ldots = \frac{\pi^2 - 8}{16} \quad \text{(D-10)}
\]

08. Find the half range Fourier sine/cosine series of the function
(a) Find the half range Fourier cosine series of \( f(x) = x(\pi - x) \); \( 0 < x < \pi \) and hence deduce that (D-09)

\[
(i) \sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6} \quad \text{D - 09), \quad (ii) \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{(2n-1)^2} = \frac{\pi^2}{12} \quad \text{D - 09)}
\]

\[
(f) \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{(2n-1)^3} = \frac{\pi^3}{32}, \quad (\nu) \sum_{n=1}^{\infty} \frac{1}{(2n-1)^3} = \frac{\pi^4}{96}, \quad \sum_{n=1}^{\infty} \frac{1}{n^3} = \frac{\pi^4}{90}
\]

(b) \( f(x) = x \sin x \) in \( [0, \pi] \) and hence deduce that

\[
\frac{1}{1^2} - \frac{1}{3^2} - \frac{1}{5^2} + \frac{1}{7^2} + \frac{1}{9^2} - \frac{1}{11^2} - \frac{1}{13^2} + \ldots = \frac{\pi^2}{8\sqrt{2}}
\]

(c) \( f(x) = \frac{\pi}{4} \) in \( (0, \pi) \) and hence deduce that (M-10)

\[
(\pi^2) \left( \frac{\pi}{2} - x \right) = \frac{1}{1^2} \cos x + \frac{1}{3^2} \cos 3x + \frac{1}{5^2} \cos 5x + \ldots \text{ and }
\]

\[
(\frac{\pi}{8}) x(\pi - x) = \frac{1}{1^2} \sin x + \frac{1}{3^2} \sin 3x + \frac{1}{5^2} \sin 5x + \ldots
\]

(d) Find the half range cosine series of \( f(x) = \sin \frac{\pi x}{L} \); \( 0 < x < L \) (M-09)

**Complex Form of Fourier series**

**Problems**

09. Find the complex form of Fourier series of following functions in the respective intervals

(a) \( f(x) = e^{-x}, \ -1 < x < 1 \) \quad (b) \( f(x) = \cosh ax, (L, -L) \) \quad (D-09,D-

(c) \( f(x) = \cos ax, -\pi < x < \pi (a \neq \text{integer}) \) \quad (M-09,M-11)

**Homework**

(a) \( f(x) = e^{ax}, -L < x < L \) \quad (M-08,D-07)

(b) \( f(x) = 2x, \ 0 < x < 2\pi \) \quad (D-09)

(c) \( f(x) = \begin{cases} 0; & 0 < x < L \\ a; & L < x < 2L \end{cases} \quad (D-08) \)

**Orthogonal and Orthonormal Functions**

**Problems**

10. Determine if the following set of functions are orthogonal or orthonormal, and find the corresponding set of orthonormal functions in the case of orthogonal
functions.

(a) $x, \frac{1}{2}(3x^2 - 1), \frac{1}{2}(5x^3 - 3x)$ in $(-1, 1)$

(b) $\cos x, \cos 2x, \cos 3x, \ldots$ in $[0, \pi]$  \textbf{(M-08)}

(c) $\sin x, \sin 3x, \sin 5x, \ldots$ in $[0, \frac{\pi}{2}]$  \textbf{(D-09,D-08,D-07,D-10)}

(d) $1, \sin \frac{\pi x}{T}, \cos \frac{\pi x}{T}, \sin, \cos \frac{2\pi x}{T}, \ldots$ in $[0, 2T]

11. If the functions $x, \frac{1}{2}(ax^2 - 1), \frac{1}{2}(bx^3 - 3x)$ are orthogonal find $a$ and $b$

12. Show that the functions $1, x, \frac{1}{2}(3x^2 - 1)$ are orthogonal and find the corresponding set of orthonormal functions.

13. Show that the following set of functions is orthonormal.

$$\frac{-x}{e^\frac{x}{2}}, \frac{-x}{e^\frac{x}{2}}(1 - x), \frac{1}{2} \frac{-x}{e^\frac{x}{2}}(2 - 4x + x^2)$$

in $(0, \infty)$

14. Show that the following set of functions $\sin \left(\frac{(2n+1)\pi x}{L}\right)$, $n=0,1,2,\ldots$ is orthogonal over $[0, L]$. Hence construct an orthonormal set of functions. \textbf{(M-11)}

15. Define orthogonal and orthonormal set of functions. S.T. $\sin nx$, $n=1,2,3,\ldots$ is orthogonal set of functions over $[0, \pi]$. Hence construct orthonormal set of functions.

**Fourier Integral**

**Problems**

01. Find the Fourier integral of the function

(a) $f(x) = \begin{cases} 0, & x < 0 \\ e^{-x}, & x > 0 \end{cases}$

& deduce that

$$\int_{-\infty}^{\infty} \frac{\cos \lambda x + \lambda \sin \lambda x}{\lambda^2 + 1} d\lambda = \begin{cases} 0, & x < 0 \\ \frac{\pi}{2}, & x = 0 \\ \pi e^{-x}, & x > 0 \end{cases}$$
(b) $f(x) = \begin{cases} 1, & |x| < 1 \\ 0, & |x| > 1 \end{cases}$ & hence show that
\[ \int_0^\infty \frac{\sin \lambda \cos \lambda x}{\lambda} d\lambda = \begin{cases} \frac{\pi}{2}, & |x| < 1 \\ \frac{\pi}{4}, & |x| = 1 \ (M-11) \\ 0, & |x| > 1 \end{cases} \]

02. Using the Fourier integral representation show that
\[ \int_0^\infty \frac{\cos \lambda x + \lambda \sin \lambda x}{1 + \lambda^2} d\lambda = \begin{cases} 0, & x < 0 \\ \frac{\pi}{2}, & x = 0 \\ \pi e^{-x}, & x > 0 \end{cases} \]

03. Find the Fourier integral representation of the function
\[ f(x) = \begin{cases} 0, & x < 0 \\ \frac{1}{2}, & x = 0 \ (M-10,D-10) \\ e^{-x}, & x > 0 \end{cases} \]

04. Find the Fourier integral of the function
(a) $f(x) = \begin{cases} -e^{\lambda x}, & x < 0 \\ e^{-\lambda x}, & x > 0 \end{cases}$ & hence S.T.

(b) $f(x) = \begin{cases} e^{\lambda x}, & x \leq 0 \ (D-09) \ & \text{hence S.T.} \\ e^{-\lambda x}, & x \geq 0 \end{cases}$

05. Express the function $f(x) = \begin{cases} 1 \text{ for } |x| < 1 \\ 0 \text{ for } |x| > 1 \end{cases}$ as Fourier integral, and hence evaluate
\[ \int_0^\infty \frac{\sin \omega \cos \omega x}{\omega} d\omega, \int_0^\infty \frac{\sin \omega x}{\cos \omega} d\omega \text{ and } \int_0^\infty \frac{\sin \omega}{\omega} d\omega \]
06. If \( f(x) = \begin{cases} \sin x & \text{when } 0 < x < \pi \\ 0 & \text{otherwise} \end{cases} \) then show that

\[
f(x) = \frac{1}{\pi} \int \frac{\cos \lambda x \cos \lambda (\pi - x)}{1 - \lambda^2} \, d\lambda
\]

and hence deduce that

\[
\int_0^\infty \frac{\lambda \pi}{2(1 - \lambda^2)} \, d\lambda = \frac{\pi}{2}
\]

---

**LAPLACE TRANSFORM**

**Problems**

01) Using the definition, find the Laplace Transform of the following functions

(a) \( F(t) = \begin{cases} t & 0 < t < 4 \\ 5 & t > 4 \end{cases} \)

(b) \( F(t) = \begin{cases} \sin t & 0 < t < \pi \\ \cos t & t > \pi \end{cases} \)

02) Using the definition, find the Laplace Transform of the following functions

(a) \( F(t) = \begin{cases} 2(t-1)^2 & 0 < t < 5 \\ 1 & t > 5 \end{cases} \)

(b) \( F(t) = \begin{cases} \cos t & 0 < t < 2\pi \\ 0 & t > 2\pi \end{cases} \)

**Problems**

03) Find the Laplace Transform of following functions

(a) \( e^{2t} \) \( e^{4t} \) \( e^{6t} \)

(b) \( \cos^4 t \)

(c) \( \sin 2t \sin 4t \sin 6t \)

04) Show that

(a) \( L[\sin \sqrt{t}] = \frac{\sqrt{\pi}}{2s^{3/2}} e^{-1/4s} \)

(b) \( L[\sin^3 t] = \frac{3!}{(s^2+1)(s^2+9)} \) and hence show that \( \int_0^\infty e^{-2t} \sin^3 t \, dt = \frac{3}{65} \)

(c) \( \alpha = \frac{\pi}{4} \) Using Laplace Transform if \( \int_0^\infty e^{-2t} \sin(t+\alpha) \cos(t-\alpha) dt = \frac{3}{8} \)

05) Find the Laplace Transform of following functions

(a) \( e^{2t} - \sqrt{t} \)

(b) \( \cos 2t \cos 4t \cos 6t \)

(c) \( \cosh^4 t \) (D-07)
Show that

\[ L\left[ \frac{\cos \sqrt{t}}{\sqrt{t}} \right] = \frac{\sqrt{\pi}}{\sqrt{s}} e^{-1/4s} \]
\[ L[\sin^5 t] = \frac{5!}{(s^2 + 1)(s^2 + 9)(s^2 + 25)} \]
\[ L[J_0(t)] = \frac{1}{\sqrt{s^2 + 1}} \text{ and hence } \int_0^\infty t e^{-3t} J_0(4t)dt = \frac{3}{125} \text{ if } J_0(t) = \sum_{r=0}^\infty \frac{(-1)^r}{(r!)^2} \left( \frac{t}{2} \right)^{2r} \]

**First Shift Theorem**

**Problems**

07) Find the Laplace transform of the following functions

(a) \((1 + t e^{-t})^3\)  
(b) \(t^5 \sinh t\)  
(c) \(e^{-2t} \sin^2 4t\)  
(d) \((t^2 \sinh t)^2\)

08) Find the Laplace transform of the following functions

(a) \(e^{-3t} \sin 3t \cosh 2t\)  
(b) \(\sinh at \cos t\)  
(c) \(\left( \frac{\cos t + \sin t}{e^t} \right)^2\)

**Second Shift Theorem**

**Problem**

09) Find \(L[G(t)]\) where \(G(t) = 0\) for \(0 < t < \frac{2\pi}{3}\) and \(\cos(t - \frac{2\pi}{3})\) for \(t > \frac{2\pi}{3}\)

10) Find the Laplace transform of \((t - 1)^2 u(t - 1)\) and \(e^{-3t} u(t - 2)\) where \(u(t - a) = \begin{cases} 0; & t < a \\ 1; & t \geq a \end{cases}\) is the unit step function (M-11)

11) Find \(L[G(t)]\) where \(G(t) = 0\) for \(0 < t < \frac{2\pi}{3}\) and \(\sin^2 (t - \frac{2\pi}{3})\) for \(t > \frac{2\pi}{3}\)

**Change of Scale Theorem**

**Problem**
12) Find \( L\{F(3t)\} \) and \( L\{F\left(\frac{t}{2}\right)\} \) if given \( L\{F(t)\} = \frac{1 - 3s}{s^2 - 4s + 2} \)

13) Find \( L\{e^{-t}F(2t)\} \) if given \( L\{F(t)\} = \frac{1}{s(s^2 + 1)} \)

**Multiplication By t Theorem**

**Problems**

14) Find the Laplace transform of the following functions and hence evaluate the given integral

(a) \( t \sin^2 t \); \( \int_0^\infty e^{-2t}t \sin^2 t \, dt = \frac{1}{8} \)

(b) \( t \sqrt{1 + \sin t} \); \( \int_0^\infty e^{-t}t \sqrt{1 + \sin t} \, dt = \frac{28}{25} \)

(c) \( t^2 \sin \sqrt{3} t \); \( \int_0^\infty e^{-t^2}t \sin \sqrt{3} t \, dt = 0 \)

(d) \( t^3 \sin t \); \( \int_0^\infty e^{-t^3}t \sin t \, dt = 0 \text{ (M-10)} \)

15) Find the Laplace transform of the following functions

(a) \( te^{-2t} \sin(at - b) \text{ (D-08)} \)

(b) \( t^2 \sin at \text{ (M-11)} \)

(c) \( (t \sin 2t)^2 \text{ (M-10)} \)

(d) \( t^2 \sin^2 2t \text{ (M-08)} \)

(e) \( \frac{\sqrt{1 + \sin 4t}}{e^{2t}} \text{ (M-08)} \)

(f) \( te^{3t} \cos 2t \); and hence show that \( \int_0^\infty e^{3t}t \cos 2t \, dt = \frac{5}{169} \)

(g) \( \int_0^\infty \cos(tx^2) \, dx \) and hence evaluate \( \int_0^\infty \cos x^2 \, dx \text{ (M-10)} \)

**Division By t Theorem**

**Problems**

15) Find the Laplace transform of the following functions & hence evaluate the integral

(a) \( \frac{\sin^2 t}{t} \); \( \int_0^\infty e^{t} \frac{\sin^2 t}{t} \, dt = \frac{1}{4} \log 5 \)

(b) \( \frac{\sin 2t + \sin 3t}{t} \); \( \int_0^\infty e^{-t} \frac{\sin 2t + \sin 3t}{t} \, dt = \frac{3\pi}{4} \)

(c) \( \frac{e^{-at} - e^{-bt}}{t} \); \( \int_0^\infty \left( \frac{e^{-3t} - e^{-6t}}{t} \right) \, dt = \log 2 \)
\[
\cos at - \cos bt \quad \frac{t}{t} \quad \int_0^\infty \left( \frac{\cos 6t - \cos 4t}{t} \right) dt = \log \frac{2}{3} \quad \cos at - \cos bt \quad \frac{t}{t}
\]

(e) \[\frac{\sin t \sinh t}{t} \quad \int_0^\infty \frac{\sin t \sinh t}{t} dt = \frac{\pi}{8} \]

16) Find the Laplace transform of the following functions & hence evaluate the integral

(a) \[\sin t \quad \int_0^\infty \sin t dt = \frac{\pi}{2} \quad \text{(b)} \quad \sin t \sin t \quad \text{and} \quad \text{F}(t) = \int_0^t e^{-u} \sin 3u du \quad \text{(c)} \quad e^{-t} \sin 3t \quad \text{M-09)} \]

\[\sin 2t \cosh 2t \quad e^{-\cosh 2t - \sin 2t} \quad \text{(M-10)} \]

Laplace Transform Of Integral

Problems

17) Find Laplace Transform of the following functions

(a) \[\int_0^t e^{-u} \frac{\sin 4u}{u} du \quad \text{(b)} \quad \int_0^t 1 - e^{-u} du \quad \text{(c)} \quad \int_0^t u \cos^2 u du \quad \text{L} e^t \cosh u du \]

18) Find Laplace Transform of the following functions

(a) \[\int_0^t \frac{1 - \cos u}{u} du \quad \text{(b)} \quad \int_0^t e^{-3u} \cos 4u du \quad \text{(c)} \quad \int_0^t e^{-2u} \cos^2 u du \quad \text{(d)} \quad \int_0^t e^{-t} \frac{\sin u}{u} du dt \quad \text{M-08)} \]

Laplace Transform Of Derivative

Problems

19) (a) Find function \[L \left( \frac{\cos \sqrt{t}}{\sqrt{t}} \right) \quad \text{given} \quad L[\sin \sqrt{t}] = \frac{\sqrt{\pi}}{2s^{3/2}} e^{-1/4s} \]

(b) If \[F(t) = \begin{cases} t + 1 & \text{if } 0 \leq t \leq 2 \\ 3 & \text{if } t \geq 2 \end{cases} \quad \text{find} \quad L[F(t)] \quad \text{and} \quad L[F''(t)] \]

20) (a) If \[L \left( \sin \omega t \right) = \frac{2\omega}{(s^2 + \omega^2)^2} \quad \text{find} \quad L \left( \sin \omega t + \omega t \cos \omega t \right) \quad \text{M-11)} \]

(b) Find \[L \left( \frac{d}{dt} \left( \frac{\sin^2 t}{t} \right) \right) \]

Convolution Theorem
**Problem**
21) Verify Convolution theorem for the function $F(t) = t^2, G(t) = e^{2t}$

22) Verify Convolution theorem for the function $F(t) = \sin at, G(t) = \sin bt$

**Periodic Function**

**Problems**
23) Find the Laplace transform of the following functions with period equal to length of the given interval

(a) $F(t) = \frac{t}{T}, \ 0 < t < T$

(b) $F(t) = |\sin \omega t|$

(c) $F(t) = \begin{cases} 
1 & 0 < t < a/2 \\
-1 & a/2 < t < a 
\end{cases}$

(d) $F(t) = \begin{cases} 
\frac{t}{a} & 0 < t < a \\
\frac{2a - t}{a} & a < t < 2a 
\end{cases}$

24) Find the Laplace transform of the following functions with period equal to length of the given interval

(a) $F(t) = \begin{cases} 
\sin \omega t & 0 < t < \pi \omega \\
0 & \pi \omega < t < 2\pi \omega 
\end{cases}$

(b) $F(t) = \begin{cases} 
1 & 0 < t < 1 \\
0 & 1 < t < 2 
\end{cases}$ (M-08)

(c) $F(t) = t; \ 0 < t < 1 \text{ and } 0; 1 < t < 2 \text{ and } F(t+2) = F(t) \text{ for } t > 0$

**Heavyside’s Unit Step Function**

**Problems**
25) Prove the following results

(a) $L[F(t)H(t-a)] = e^{-as}L[F(t+a)]$

(b) $L[H(t-a)] = \frac{e^{-as}}{s}$

26) Find the Laplace transform of the following functions

(a) $L[t^4H(t-1)]$

(b) $L[(1+2t-3t^2+4t^3)H(t-2)]$
28) Evaluate \( \int_0^\infty e^{-t} (1 + 2t - t^2 + t^3) H(t - 1) dt \) \[(M-10)\]

29) Express the following function using Unit step functions and evaluate the Laplace transform
\[
F(t) = \begin{cases} 
    t^2 & 0 < t < 2 \\
    4t & t > 2 
\end{cases}
\]

30) Prove the following results
(a) \( L[F(t) H(t)] = L[F(t)] = f(s) \)
(b) \( L[F(t - a) H(t - a)] = e^{-as} L[F(t)] \)
\( \mathcal{L}[H(t)] = \frac{1}{s} \)

29) Find the Laplace transform of the following functions
(a) \( L[t^2 H(t - 3)] \)
(b) \( L[(1 + 3t - t^2 + t^3) H(t - 4)] \)

30) Express the following function using Unit step functions and evaluate the Laplace transform
\[
F(t) = \begin{cases} 
    \sin t & 0 < t < \pi \\
    \sin 2t & \pi < t < 2\pi \\
    \sin 3t & t > 2\pi 
\end{cases}
\]
(b) \( F(t) = \begin{cases} 
    2t & 0 < t < 1 \\
    3t^2 & t > 1 
\end{cases} \) \[(M-10)\]

**Unit impulse (or Dirac delta) function**

**Problems**
32) Prove the following results
(a) \( \int_0^\infty F(t) \delta(t - a) dt = F(a) \)
(b) \( L[F(t) \delta(t - a)] = e^{-as} F(a) \)

33) Find the following
34) Prove the following results
(a) \( L[\delta(t - a)] = e^{-at} \) \hspace{1cm} (b) \( L[\delta(t)] = 1 \)

35) Find the following \( L[t \ U(t - 4) - t^3 \delta(t - 2)] \)

Error Function

Problems
36) Show that
(a) \( \int_0^\infty e^{-t} \text{erf}\sqrt{t}dt = \frac{1}{\sqrt{2}} \) \hspace{1cm} (b) \( L \left\{ t^2 \text{erf}\sqrt{t} \right\} = \frac{3s + 8}{s^2 (s + 4)^2} \) (D-10)

37) Show that
(a) \( L \left( \int_0^t \text{erf}\sqrt{t} \right) = \frac{1}{s^2 + 1} \) \hspace{1cm} (b) \( L \left\{ \text{erf}\sqrt{t} \right\} = \frac{1}{(s - 3) \sqrt{s - 2}} \)
(c) \( \int_0^\infty e^{-st} \text{erf}\ 2\sqrt{t}dt \)

INVERSE LAPLACE TRANSFORM

Problems
38) Find (a) \( L^{-1} \left\{ \frac{6}{3 - 2s} - \frac{3 + 4s}{9s^2 + 16} + \frac{8 - 6s}{16s^2 - 9} \right\} \hspace{1cm} (b) L^{-1} \left\{ \frac{3s - 2}{s^2} - \frac{3 + 4s}{9s^2 + 16} + \frac{8 - 6s}{16s^2 - 9} \right\} \)

Homework
39) Find (a) \( L^{-1} \left( \frac{1 - \sqrt{s}}{s^2} \right)^2 \) (M-11) (b) \( L^{-1} \left( \frac{3s - 2}{s^{3/2}} + \frac{3(s^2 - 1)}{2s^3} \right) \) (c) \( L^{-1} \left( \frac{2s + 1}{s(s + 1)} \right) \)

Problems
40) Find the Inverse Laplace Transform of the following functions
   (a) \( \frac{1}{\sqrt{8s - 27}} \)  
   (b) \( \frac{6s - 4}{2s^2 - 12s + 26} \)  
   (c) \( \left\{ \frac{1}{(s-1)^5} + \frac{3s+1}{(s+1)^4} \right\} \)

41) Find the Inverse Laplace transform of the following functions
   (a) \( \frac{e^{-5s}}{(s + 4)^3} \)  
   (b) \( \frac{8e^{-3s}}{s^2 + 4} \)  
   (c) \( \frac{(s + 1)e^{-\pi s}}{s^2 + s + 1} \)

42) Find the Inverse Laplace Transform of the following functions using partial fraction method
   (a) \( \frac{2s^2 - 6s + 5}{s^3 - 6s^2 + 11s - 6} \)  
   (b) \( \frac{-3s^2 + 20s - 24}{(s-1)(s-2)^2} \)  
   (c) \( \frac{3s + 1}{(s-1)(s^2 + 1)} \)  
   (d) \( \frac{s + 2}{(s^2 + 2s + 1)s^2 + 2s + 3} \)  
   (e) \( \frac{s^2 + 2s + 3}{(s^2 + 2s + 2)(s^2 + 2s + 5)} \)  
   (f) \( \frac{s}{s^4 + 4} \)

43) Find the Inverse Laplace Transform of the following functions using convolution theorem
   (a) \( \frac{1}{(s^2 + 4)}(s^2 + 9) \)  
   (b) \( \left\{ \frac{s}{s^4 + 13s^2 + 36} \right\} \)  
   (c) \( \frac{s^2 + 4s + 4}{(s^2 + 4s + 8)^2} \)  
   (d) \( \frac{1}{(s^2 + a^2)^2} \)  
   (e) \( \frac{s}{(s^2 + a^2)^2} \) (M-11)  
   (f) \( \frac{s^2}{(s^2 + a^2)^2} \)  
   (g) \( \frac{s^2}{(s^2 + a^2)^2} \)  
   (h) \( \frac{s^3}{(s^2 + a^2)^2} \)

44) Find the Inverse Laplace Transform of
   a) \( \tan^{-1}(s + 1) \)  
   b) \( \tan^{-1}\frac{2}{s^2} \)  
   c) \( \frac{1}{s} \log\left(\frac{s + 2}{s + 1}\right) \)  
   d) \( \frac{1}{s} \log\left(\frac{s^2 + a^2}{s^2 + b^2}\right) \)

45) Find the Inverse Laplace Transform of the following functions
   (a) \( \frac{1}{\sqrt{2s + 3}} \)

46) Find the Inverse Laplace transform of the following functions
   (a) \( \frac{e^{4-3s}}{(s+4)^{5/2}} \)  
   (b) \( \frac{e^{-2s}}{s^2 + 8s + 25} \)  
   (c) \( \frac{e^{-11s}}{s^2 - 2s - 2} \) (M-08)

47) Find the Inverse Laplace Transform of the following functions using partial fraction method
\[
(a) \quad \frac{3s + 7}{s^2 - 2s - 3} \quad (M-10) \\
(b) \quad \frac{s + 2}{(s + 1)^3(s + 3)} \quad (M-10) \\
(c) \quad \frac{1}{s^3 + 1}
\]

\[
(d) \quad \frac{2}{(s+1)^2(s^2+4)} \quad (M-08) \\
(e) \quad \frac{1}{s^3 + 1} \\
(f) \quad \frac{2s^3 + 10s^2 + 8s + 40}{s^2(s^2 + 9)}
\]

\[
(g) \quad \frac{s^2 + 2s + 3}{(s^2 + 2s + 2)(s^2 + 2s + 5)} \\
(h) \quad \frac{s}{s^4 + 4} \\
(i) \quad \frac{s}{s^4 + s^2 + 1}
\]

\[
(j) \quad \frac{2s^2 - 1}{(s^2 + 1)(s^2 + 4)} \quad (M-11) \\
(k) \quad \frac{s}{(s^2 + 1)(s^2 + 4)(s^2 + 9)} \\
(l) \quad \frac{6s + 3}{s^4 + 5s^2 + 4}
\]

48) Find the Inverse Laplace Transform of the following functions using convolution theorem

\[
(a) \quad \frac{s^2}{(s^2 + 4)(s^2 + 9)} \\
(b) \quad \frac{s}{(s^2 + 4)^2} \quad (M-08) \\
(c) \quad \frac{1}{(s^2 - a^2)^2} \quad (M-08) \\
(d) \quad \frac{1}{(s - 4)^4(s + 3)} \\
(e) \quad \frac{s}{(s^2 - a^2)^2} \\
(f) \quad \frac{s^2}{(s^2 + a^2)(s^2 + b^2)} \\
(g) \quad \frac{s^2 + 5}{(s^2 + 4s + 13)^2}
\]

49) Find the Inverse Laplace Transform of

\[
(a) \quad \tan^{-1}(s + 1) \\
(b) \quad \cot^{-1} \frac{s - 2}{3} \\
(c) \quad \tan^{-1} \frac{2}{s^2} \\
(d) \quad \frac{1}{s} \log(1 + \frac{1}{s^2})
\]

### Application of Laplace Transform

### Problems
50) Solve the following equations
(a) $y''+2y'+5y = e^{-t} \sin t$; $y(0)=0, y'(0)=1$ (M-11)
(b) $y'+2y + \int_0^1 y \, dt = \sin t$; $y(0)=1$ (M-08)
(c) $y''+9y = \cos 2t$; $y(0)=1, y(\pi/2)=-1$
(d) $y''-3y'+2y = 4e^{-t}$; $y(0)=-3, y'(0)=5$
(e) $y''+4y = f(t)$, $y(0)=0, y'(0)=1$ where $f(t)=1$ when $0<t<1$ and $f(t)=0$ when $t>1$

(a) $y''-3y'+2y = 4e^{2t}$; $y(0)=-3, y'(0)=5$
(b) $y''-y'+2y = 20\sin t$; $y(0)=1, y'(0)=2$ (M-10)

(c) $y + \int_0^1 y \, dt = 1 - e^{-t}$
(d) $y''+9y = 18t$; $y(0)=0, y(\pi/2)=0$
(e) $y''-3y''+3y'-y = t^2e^{t}$; $y(0)=1, y'(0)=0, y''(0)=-2$
(f) $y''+3y'+2y = t\delta(t-1)$; $y(0)=0, y'(0)=1$

Vector Integration

Line Integral

Problems

01) If $\vec{A} = (3x^2 + 6y) \hat{i} - 14yz \hat{j} + 20xz^2 \hat{k}$ evaluate the line integral $\int_C \vec{A} \cdot d\vec{r}$ from $(0,0,0)$ to $(1,1,1)$ along the following paths $C$:

  a) $x = t, y = t^2, z = t^3$
  b) the line segment joining $(0,0,0)$ to $(1,1,1)$
  c) the line segment joining $(0,0,0)$ to $(1,0,0)$, then to $(1,1,0)$, then to $(1,1,1)$

02) Evaluate $\int_C \vec{A} \cdot d\vec{r}$ along the curve $C$ with
\[
\vec{r} = a \cos \theta \hat{i} + a \sin \theta \hat{j} + b \theta \hat{k} \text{ from } \theta = \frac{\pi}{4} \text{ to } \theta = \frac{\pi}{2}
\]
\[
\vec{A} = (-3a \sin^2 \theta \cos \theta) \hat{i} + a(2 \sin \theta - 3 \sin^3 \theta) \hat{j} + b \sin 2\theta \hat{k}
\]

03) Find the work done under force \( \vec{F} = (2x - y + z) \hat{i} + (x + y - z^2) \hat{j} + (3x - 2y + 4z) \hat{k} \) in moving a particle once around
   a) the circle \( x^2 + y^2 = 9, z = 0 \)  
   b) the ellipse \( 9x^2 + 4y^2 = 36, z = 0 \)

04) Evaluate \( \int_C \vec{A} \cdot d\vec{r} \) along the curve \( x^2 + y^2 = 1, z = 1 \) in the positive direction from \((0,1,1)\) to \((1,0,1)\) if \( \vec{A} = (2x + yz) \hat{i} + zx \hat{j} + (xy + 2) \hat{k} \)

05) Evaluate \( \int_C \vec{A} \cdot d\vec{r} \) along the curve \( C \) with position vector
\[
\vec{r} = a \cos \theta \hat{i} + b \sin \theta \hat{j} + c \theta \hat{k} \text{ from } \theta = 0 \text{ to } \theta = \frac{\pi}{2}
\]
\( \vec{A} = x \hat{i} + y \hat{j} + z \hat{k} \)

06) Find the work done under force \( \vec{F} = 3xz \hat{i} - 4y \hat{j} + z \hat{k} \) in moving a particle along the curve \( x = t^2 + 1, y = t^3, z = 2t + 3 \) from \((1,0,3)\) to \((2,1,5)\)

07) Evaluate \( \int_C \vec{F} \times d\vec{r} \) where \( \vec{F} = x \hat{i} - z \hat{j} + x^2 \hat{k} \) where \( C \) is the curve \( x = t^2, y = 2t, z = t^3 \)
   from \( t=0 \) to \( t=1 \) \( (D-10) \)

\section*{Conservative Vector Field}

\section*{Problems}

08) Show that \( \vec{F} = (y^2 \cos x + z^3) \hat{i} + (2y \sin x - 4) \hat{j} + (3xz^2 + 2) \hat{k} \) is conservative. Find its scalar potential \( \phi \). Hence find the work done in moving a particle in this field of force \( \vec{F} \) from the point \((0,1,-1)\) to the point \( (\frac{\pi}{2}, -1, 2) \)

09) Show that \( \vec{F} = (2xy + z^3) \hat{i} + x^2 \hat{j} + 3xz^2 \hat{k} \) is irrotational and hence find its scalar potential \( \phi \). Hence find the work done in moving a particle in this field of force \( \vec{F} \) from the point \((1,-2,1)\) to the point \((3,1,4)\) \( (M-09) \)
10) Find the constants a, b, c if \( \mathbf{F} = (x + 2y + az)\mathbf{i} + (bx - 3y - z)\mathbf{j} + (4x + cy + 2z)\mathbf{k} \) is irrotational. Find its scalar potential \( \phi \) such that \( \mathbf{F} = \nabla \phi \). Hence find the work done in moving a particle in this field of force \( \mathbf{F} \) from the point (1,2,-4) to the point (3,3,2) along the line joining these two points.

11) Show that \( \mathbf{F} = (y e^{xy} \cos z)\mathbf{i} + (xe^{xy} \cos z)\mathbf{j} - e^{xy} \sin z\mathbf{k} \) is conservative. Find its scalar potential \( \phi \). Hence find the work done in moving a particle in this field of force \( \mathbf{F} \) from the point (0,0,0) to the point (-1,2,\pi) \( \text{(M-08,D-10)} \)

12) Show that \( \mathbf{F} = xyz^2\mathbf{i} + (x^2z^2 + z \cos yz)\mathbf{j} + (2x^2yz + y \cos yz)\mathbf{k} \) is conservative. Find its scalar potential \( \phi \). Hence find the work done in moving a particle in this field of force \( \mathbf{F} \) from the point (0,0,1) to the point (1,4,2).

13) Show that \( \int_{P}^{Q} (2xy^3 - y^2 \cos x)dx + (1 - 2y \sin x + 3x^2y^2)dy = \frac{\pi^2}{4} \)
along the arc \( 2x = \pi y^2 \) from P(0,0) to Q(\( \frac{\pi}{2} \),1)

**Green’s Theorem**

**Problems**

14) Verify Green’s theorem in the plane for

a) \( \oint_{C} (3x^2 - 8y^2)dx + (4y - 6xy)dy \) where \( C \) is the boundary of the region enclosed by the curves \( y = x^2 \) and \( x = y^2 \) \( \text{(D-08)} \)

b) \( \oint_{C} (x^2 - 2xy)dx + (x^2y + 3)dy \) where \( C \) is the boundary of the region enclosed by the curves \( y^2 = 8x \) and \( x = 2 \) \( \text{(M-08)} \)

c) \( \oint_{C} (y - \sin x)dx + \cos xdy \) where \( C \) is the triangle with vertices at (0, 0), (\( \frac{\pi}{2} \),0) and (\( \frac{\pi}{2} \),1)
15) Using Green’s theorem evaluate

a) \[ \int_{C} \vec{A} \cdot d\vec{r} \text{ where } \vec{A} = \left(-\frac{y\hat{i} + x\hat{j}}{x^2 + y^2}\right) \text{ and } C \text{ is the circle with center at } (3, 3) \text{ and radius } 1 \]

b) \[ \int_{C} \vec{A} \cdot d\vec{r} \text{ where } \vec{A} = (3x + 4y)\hat{i} + (2x - 3y)\hat{j} \text{ and } C \text{ is the circle } x^2 + y^2 = 2^2 \] (May-09)

c) \[ \oint_{C} x^2y\,dx + xy^2\,dy \]

d) \[ \oint_{C} (2x^2 - y)\,dx + (2x + y^2)\,dy \] over C where C is the boundary of the region bounded by \[ y = x^2, y=1 \text{ and } x=0 \] (D-10)

e) The area A bounded by a simple closed curve C in the xy-plane and hence find the area of the ellipse

\[ \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \]

16) Verify Green’s theorem in the plane for

a) \[ \oint_{C} (x^2 - xy)\,dx + (x^2 - y^2)\,dy \text{ where } C \text{ is the boundary of the region enclosed by the curves} \]

\[ y = x^2 \text{ and } y = x \]

b) \[ \oint_{C} x^2\,dx - xy\,dy \text{ where } C \text{ is the triangle with vertices at } (0, 2), (2, 0) \text{ and } (4, 2) \]

c) \[ \oint_{C} (x^2 - \cosh y)\,dx + (y + \sin x)\,dy \text{ where } C \text{ is the rectangle with vertices at} \]

\( (0, 0), (\pi, 0), (\pi, 1) \) and \( (0, 1) \)

d) \[ \oint_{C} (2x^2 - y^2)\,dx + (x^2 + y^2)\,dy \text{ where } C \text{ is the boundary of the region enclosed by} \]

(i) the x-axis and the 3 semi-circle \[ y = \sqrt{1 - x^2} \] (ii) the lines \( x=0, x=2, y=0, y=3 \) (M-09)

17) Using Green’s theorem evaluate

a) \[ \oint_{C} \vec{A} \cdot d\vec{r} \text{ where } \vec{A} = \left(-\frac{y\hat{i} + x\hat{j}}{x^2 + y^2}\right) \text{ and } C \text{ is some circle enclosing the origin} \]
b) \[ \oint_C (e^{x^2} - xy) \, dx - (y^2 - x) \, dy \text{ where } C \text{ is the circle } x^2 + y^2 = 1 \quad (D-09) \]

c) \[ \oint_C (2x - y^3) \, dx - xy \, dy \text{ where } C \text{ is the boundary of the region enclosed by the }
\text{circles } x^2 + y^2 = 1 \text{ and } x^2 + y^2 = 9 \quad (M-09) \]

d) find the area of the asteroid \[ \frac{2}{3} + \frac{2}{2} = \frac{2}{3} \]
\[ (x^2 + y^2)^2 = a^2(x^2 - y^2) \]

f) find the area of the lemniscate

**Surface Integral**

**Problems**

14) Evaluate \[ \iint_S \vec{A} \cdot d\vec{S} \text{ where } S \text{ is that part of the plane} \]

\[ a) 2x+3y+6z=12 \text{ which is located in the first octant and } \vec{A} = 18z^2 \hat{i} - 12 \hat{j} + 3y \hat{k} \quad (D-08) \]

\[ b) 2x+y+z=6 \text{ which is in the first octant and } \vec{A} = (x + y^2) \hat{i} - 2x \hat{j} + 2yz \hat{k} \quad (M-08) \]

15) Evaluate \[ \iint_S \vec{A} \cdot d\vec{S} \text{ where } \vec{A} = yz \hat{i} + zx \hat{j} + xy \hat{k} \text{ and } S \text{ is the sphere } \]
\[ x^2 + y^2 + z^2 = 1 \text{ which is located in the first octant.} \]

16) Evaluate \[ \iint_S \vec{A} \cdot d\vec{S} \text{ where } \vec{A} = z \hat{i} + x \hat{j} - 3y^2 \hat{k} \text{ and } S \text{ is the surface of the cylinder} \]
\[ x^2 + y^2 = 16 \text{ included in the first octant between the planes } z=0 \text{ and } z=5. \]

17) Evaluate \[ \iint_S \vec{A} \cdot d\vec{S} \text{ where } \vec{A} = 2y \hat{i} - z \hat{j} + x^2 \hat{k} \text{ and } S \text{ is the surface of the parabolic} \]
\text{cylinder located in the first octant bounded by the planes } y=4 \text{ and } z=6 \]

18) Evaluate \[ \iint_S \vec{A} \cdot d\vec{S} \text{ where } \vec{A} = 4xz \hat{i} + xyz \hat{j} + 3z \hat{k} \text{ and over the entire region above the} \]
\text{xy-plane bounded by the cone } x^2 + y^2 = z^2 \text{ and the plane } z=4. \]

**Gauss Divergence Theorem**

**Problems**

19) Verify Gauss divergence theorem for
a) \[ \vec{A} = 4xz \hat{i} - y^2 \hat{j} + yz \hat{k} \] over the cube bounded by the planes \( x=0, x=1, y=0, y=1, z=0, z=1 \)

b) \[ \vec{A} = x^3 \hat{i} + y^3 \hat{j} + z^3 \hat{k} \] over the sphere \( x^2 + y^2 + z^2 = a^2 \)

c) \( \vec{A} = 4\vec{x} - 2y^2\hat{j} + z^2\hat{k} \) over the cylinder \( x^2 + y^2 = 4, z = 0, z = 3 \) (M-08)

20) Use the divergence theorem to evaluate

a) \[ \oiint_S (x^2 - yz) \hat{i} + (y^2 - zx) \hat{j} + (z^2 - xy) \hat{k} \cdot dS \] over the cube bounded by the planes \( x=0, x=1, y=0, y=1, z=0, z=1 \)

b) \[ \oiint_S \nabla r^2 \cdot dS \] where \( S \) is the sphere \( x^2 + y^2 + z^2 + 2x + 6y + 1 = 0 \)

c) \[ \oiint_S [(xz^2 \hat{i} + (x^2 y - z^3) \hat{j} + (2xy + y^2 z) \hat{k}] \cdot dS \] where \( S \) is the surface enclosing the region bounded by the hemisphere \( z = \sqrt{a^2 - x^2 - y^2} \) and the plane \( z=0 \)

21) Verify Gauss divergence theorem for

a) \[ \vec{A} = (x^2 - yz) \hat{i} + (y^2 - zx) \hat{j} + (z^2 - xy) \hat{k} \] over the surface of the parallellopiped bounded by the planes \( x=0, x=a, y=0, y=b, z=0, z=c \).

b) \[ \vec{A} = 2x^2 \hat{i} - y^2 \hat{j} + 4xz^2 \hat{k} \] over the region in the first octant bounded by the cylinder \( y^2 + z^2 = 9 \) and \( x = 2 \) (D-08)

c) \[ \vec{A} = 4xz \hat{i} + xyz \hat{j} + 3z \hat{k} \] over the closed region above the xy-plane bounded by the cone \( x^2 + y^2 = z^2 \) and the plane \( z=4 \)

d) \[ \vec{A} = 4\vec{x} + 3y \hat{j} - 2z \hat{k} \] over the closed surface bounded by the planes \( 2x+2y+z=4, x=0, y=0, z=0 \)

22) Use the divergence theorem to evaluate

a) \( \oiint_S (4x \hat{i} - 2y^2 \hat{j} + z^2 \hat{k}) \cdot dS \) where \( S \) is the region bounded by the surfaces \( y^2 = 4x, x = 1, z = 0, z = 3 \)

b) \( \oiint_S (x^2 \hat{i} + y^2 \hat{j} + z^2 \hat{k}) \cdot dS = \frac{\pi}{12} \) where \( S \) is the part of the sphere \( x^2 + y^2 + z^2 = 1 \) lying above the xy-plane (D-10)

c) \( \oiint_S \vec{r} \cdot d\vec{S} \) where \( S \) does/does not enclose the origin

d) \( \oiint_S (\phi \nabla \psi - \psi \nabla \phi) \cdot d\vec{S} \) e) div \( \vec{A} \)
Stoke’s Theorem

Problems

23) Verify Stoke’s theorem for
   a) \( \vec{A} = (x + y) \hat{i} + (2x - z) \hat{j} + (y + z) \hat{k} \) over the triangle with vertices at the points
      \((2,0,0), (0,3,0), (0,0,6) \) (D-08)
   b) \( \vec{A} = (2x - y) \hat{i} - yz^2 \hat{j} - y^2z \hat{k} \) where \( S \) is the surface of the sphere \( z = \sqrt{a^2 - x^2 - y^2} \)

24) Using Stoke’s theorem evaluate
   a) \( \iint_S \nabla \times \vec{A} \cdot d\vec{S} \) where \( \vec{A} = (x^2 + y - 4) \hat{i} + (2xz + z^2) \hat{k} \) and \( S \) is the surface
      above the xy-plane of the paraboloid \( z = 4 - (x^2 + y^2) \)
   b) \( \iint_S \nabla \times \vec{A} \cdot d\vec{S} \) where \( S \) is the part of the surface \( x^2 + y^2 + z^2 - 2ax + az = 0 \) and
      \( \vec{A} = (2y^2 + 3z^2 - x^2) \hat{i} + (2z^2 + 3x^2 - y^2) \hat{j} + (2x^2 + 3y^2 - z^2) \hat{k} \)

25) Verify Stoke’s theorem for
   a) \( \vec{A} = \sin z \hat{i} - \cos x \hat{j} + \sin y \hat{k} \) where \( C \) is the boundary of the
      rectangle \( 0 \leq x \leq \pi, 0 \leq y \leq 1, z = 3 \)
   b) \( \vec{A} = y \hat{i} + z \hat{j} + x \hat{k} \) over the surface \( x^2 + y^2 = 1 - z \) \((z > 0) \) (D-09)

26) Using stoke’s theorem evaluate \( \oint_C y\,dx + z\,dy + x\,dz \) where \( C \) is the curve of intersection of
    the sphere \( x^2 + y^2 + z^2 = a^2 \) and the plane \( x + z = a \) (D-10)
Electronic Instrumentations and measurements

**Overview:** Electronic Instrumentation intends to provide the concepts, principles and procedure of various analog and digital electronic instruments and measurement techniques for the measuring various electronic quantities. The course also highlights transducers, signal analyzers, analog to digital and digital to analog converter, various transmission techniques and its application in instrumentation. The course begins with linear AC/DC Analysis and familiarizes with standard measurement tools. The relationship between time and frequency domain measurement of circuits covers the fundamental concept of Electronic Instrumentation.

**Pre-requisite:** The basic operation of OP-AMP

**Objective:**

1) To study construction of instruments
2) To understand the principle and operation of different electronic instrument
3) To provide knowledge of appropriate selection of instruments for measurement
4) To describe reading and interpreting values from different meters
5) To learn the application of instruments
6) To understand the principles of Advanced Electronic Instruments and its applications.
7) To learn the principle of transducer, classification and characteristic of different sensor and transducers and their recent development along with practical application in communication.

**Outcome:** Upon completion of course students will be able to:

a) Understand basic principle of electronic measurement
b) Understand principle of advanced electronic instruments and their application
c) Familiarize with standard measurement tool
d) Develop relationship between time and frequency domain measurement of circuits
e) Gain ability to design a complete instrumentation system from sensing the physical variable to displaying the control state
f) Gain insights into how to deal with instrument problem and propose solution for them
g) Develop ability to explain types of sensors and make proper selection for application under consideration
h) Design and implement conditioning circuit for different types of sensors
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I) Question Bank of Module -1

Principals of Measurements :-

A) Short Answer Questions for (Oral Exam.)
1. Give the significance of measurement.
2. List out the different methods of measurement system.
3. List out the different characteristics of measuring devices.
4. Define Accuracy, Precision, Accuracy, & Sensitivity.
5. List out the static and dynamic characteristics of measurement system.

B) Long Answer Questions

1. Draw a neat functional block diagram of a general instrumentation system and explain the same briefly.
2. Write short note on static and dynamic characteristics of measurement system.

2) Question Bank of Module -2

Sensors and Transducers:-

A) Short Answer Questions for (Oral Exam.)
1. Define Transducer. Differentiate between Analog and Digital Transducers?
2. Explain the principle of piezoelectric transducers.
3. What is meant by Resistive Transducers. Why are they preferred over those employing other principles? Explain any two types.
4. Explain active and passive transducers with examples.
5. Write a note on thermocouples. Explain thermoelectric laws.
6. Explain the principle of operation of capacitive sensors.
B) Long Answer Questions

1. With the help of a neat block diagram, describe the operation of LVDT. What are its application areas?
2. Explain the working of STRAIN GAUGE with neat block diagram.
3. Explain with neat block diagram capacitive transducers.
4. Draw and explain the block diagram of RTD.
5. Draw and explain block diagram of RESISTIVE TRANSDUCERS.
7. Explain the principle of piezoelectric transducers.
8. What is meant by Resistive Transducers. Why are they preferred over those employing other principles? Explain any two types.
9. Explain active and passive transducers with examples.
10. What is a photoelectric transducer? Explain the various types giving the operating principle and applications.
11. Explain the principle of operation of capacitive sensors.
12. Write a note on thermocouples. Explain thermoelectric laws.

III) Question Bank of Module 3
Testing And Measuring Instruments

A) Short Answer Questions for (Oral Exam.)

1. What is the mean by quality factor?
2. What are the sources of errors in Q-meter?
3. What is the sensitivity of voltmeter.
4. List out the different bridges for inductance measurement.
5. List out the different bridges for capacitance measurement.
6. List out the different applications of LCR-Q-Meter.
7. What are the different test equipments?

B) Long Answer Questions

1. Explain automatic test equipment.
2. Explain Q meter.
3. Explain true RMS meter.
4. A voltmeter having a sensitivity of 1000 o./V reads 100 V on its 150 V scale when connected across an unknown resistor in series with a milliammeter. When mA reads 5 mA? Calculate the error due to loading effect of voltmeter.
5. A symmetrical square wave voltage of the type shown is applied to a 6 average responding ac voltmeter with a scale calibrate in terms of rms value of a sine wave. Calculate-
   (i) Form factor of square wave voltage.
   (ii) Error in meter indication.

C) University Exam Questions:

1. What is the role of time base generator in a CRO?
2. Draw and explain the block diagram of Digital Storage Oscilloscope. State its advantages and applications in communications.
3. Draw and explain the structure of a conventional CRT.
4. In an experiment the voltage across a 10 K ohms resistor is applied to CRO.
II) Module 3

Signal Analyzers

A) Short Answer Questions For (Oral Exam.)

1. What is principle of harmonic distortion analyzer?
2. Explain tuned circuit harmonic analyzer.
3. Write a detailed note on distortion factor meter
4. Differentiate between wave analyzer and total harmonic distortion meter
5. What are the different types of network analyzers?
6. What are the applications of a network analyzer?
7. Explain the significance of a signal analyzer. Describe the principle of operation of wave analyzer.
8. Explain total harmonic distortion.

B) Long Answer Questions

1. With the help of a neat block diagram, describe the operation of a wave analyzer. What are its application areas?
2. Explain the working of radio frequency range wave analyzer with neat block diagram.
3. Explain with neat block diagram fundamental suppression distortion analyzer.
4. Draw and explain the block diagram of a network analyzer.
5. Draw and explain block diagram of digital FFT analyzer.
6. What are the elements of a network analyzer?
7. What is distortion? What are the methods for its measurement? Describe experimental method for distortion measurement with reference to a typical distortion meter.
8. With a block diagram explain the elements of network analyzer with its application.
9. Write a short note on heterodyne wave analyzer.

10. Define harmonic distortion. How can it be measured? Draw the block diagram of Fundamental Suppression Harmonic Distortion Analyzer and explain the working.

11. Explain the elements of a digital FFT analyzer with a suitable block diagram.

12. What is the basic principle of wave analyzer? Explain heterodyne wave analyzer with applications.

C)University Exam Questions

1. Explain the significance of a signal analyzer. Describe the principle of operation of a wave analyzer. (May 2009, Mark 5)

2. Explain total harmonic distortion. (Dec 2008, Mark 5)

3. Explain the elements of a digital FFT analyzer with a suitable block diagram. (May 2009, Mark 10)

4. What is the basic principle of wave analyzer? Explain heterodyne wave analyzer with applications. (Dec 2008, Mark 10)

5. Why a wave analyzer called a frequency selective voltmeter? (Dec 2009 and Dec 2010, Mark 5)

6. Explain the type of analyzers used for optimizing microwave Network design. (Dec 2009, Mark 6)

7. What is meant by Total Harmonic Distortion? Explain fundamental suppression Harmonic Distortion Analyzer. (Dec 2009, Mark 10)

8. What is meant by network analysis? Explain the analogy of two port linear networks with microwave networks. (May 2010, Mark 6)

9. What is the basic principle of wave analyzer? Explain the heterodyne wave analyzer with applications. (May 2010, Mark 10)
III) Module 4
Measuring Instruments and Test Equipments

A) Short Answer Questions for (Oral Exam.)

1. Explain the working principle of Q-meter.
2. Draw Block Diag.of Automatic Test Equipment.
3. What are the different test equipments.
4. What is Q and how is it measured?

B) Long Answer Questions

1. Explain automatic test equipment.
2. Explain Q meter.
3. Explain true RMS meter.

C) University Exam Questions

1. Explain the working principle of Q-meter.
2. Write a short note on Automatic Test Equipment.
3. A voltmeter having a sensitivity of 1000 o./V reads 100 V on its 150 V scale. When connected across an unknown resistor in series with a milliammeter. When mA reads 5 mA? Calculate the error due to loading effect of voltmeter.
4. A symmetrical square wave voltage of the type shown is applied to an 6 average responding ac voltmeter with a scale calibrated in terms of rms value of a sine wave. Calculate-
   (i) Form factor of square wave voltage.
   (ii) Error in meter indication.
Module 4

Data Acquisition and digital Instruments

A) Short Answer Questions for (Oral Exam.)

1. Which is the fastest ADC and why?
2. Write about the various performance parameters of DAC
3. What do you understand by analog signal.
4. What do you understand by DMM.
5. What are the different types of ADC?
6. What are the applications of a DATA LOGGER?

B) Long Answer Questions

1. Explain R2R ladder technique of DAC.
2. Find the conversion time and resolution for a 8 bit counter type ADC and 8 bit successive approximation type of ADC. Assume a clock frequency of 1 MHz.
3. Explain the principle and operation of digital frequency counter..
4. What is the basic principle of ADC? Explain the operation of Successive approximation type of ADC
5. Explain Digital Multimeter.
6. Explain the operation of a binary weighted resistor technique of Digital to Analog conversion.

7. Current for digital input of 1011?
8. Find the conversion time and resolution for a 8 bit counter type ADC and 8 bit successive approximation type of ADC. Assume a clock frequency of 1 MHz.
9. Explain Rf2R ladder technique of DAC with 4 bit input. Also suggest the values of resistors if resolution required is 0.5V and reference voltage is 10V.
10. Which is the fastest ADC and why?
11. Explain the principle and operation of digital frequency counter.
12. Write about the various performance parameters of DAC.
13. What is the basic principle of ADC? Explain the operation of Successive Approximation type of ADC.
14. Write a note on Universal counter.
15. Write a short note on Automatic Test Equipment.
16. Explain Digital Multimeter.
17. The lowest range on a 4 digit digital voltmeter is 10 mV full scale. What is the resolution of the meter?
18. Write a note on automation in digital instruments.
19. Explain the operation of a binary weighted resistor technique of Digital to Analog conversion.
20. Explain the various performance parameters of ADC.
21. In a 4 bit DAC for a digital input of 0100 an output current of

V) Module-5

Oscilloscopes

A) Short Answer Questions for (Oral Exam.)

1. What is the role of time base generator in a CRO?
2. How is the electron beam focused to a fine spot on the face of a CRT?
3. State Different Operating modes of DSO.
4. What are the differences between dual trace and dual beam oscilloscopes?
5. Draw the block diagram of Dual beam Oscilloscope.
6. Draw the block diagram of Dual trace Oscilloscope.
7. Draw the block diagram of DSO.

8. What are the advantages of DSO’s over traditional CRO’s.

**B) Long Answer Questions**

1. Draw and explain the block diagram of Digital Storage Oscilloscope. State its advantages and applications in communications.

2. Draw and explain the structure of a conventional CRT.

3. In an experiment the voltage across a 10 K ohms resistor is applied to CRO.

4. How is the electron beam focused to a fine spot on the face of a CRT?

5. Draw and explain the block diagram of a general purpose CRO.

6. How does the digital storage oscilloscope differ from a conventional oscilloscope? Explain the principle, features and applications of DSO.

7. Why is phosphor screen of CRT provided with an aluminum layer?

8. Describe the various types of sweeps used in CRO.

9. Derive an expression for vertical deflection of electron beam in CRT. What is the minimum distance that will allow full deflection of 4 cm at oscilloscope screen with deflection factor of 100 V cm and with accelerating potential of 2 kV.

10. What is the role of time base generator in a CRO?

11. Draw and explain the block diagram of Digital Storage Oscilloscope. State its advantages and applications in communications.

12. Draw and explain the structure of a conventional CRT.

13. In an experiment the voltage across a 10 K ohms resistor is applied to CRO.

14. The screen shows a sinusoidal signal of total vertical occupying 3 cm and horizontal occupying of 2 cm. The front panel control is on 2 v/div and 2 ms/div respectively. Calculate rms value of voltage across resistor and its frequency.

15. How is the electron beam focused to a fine spot on the face of a CRT?

16. Draw and explain the block diagram of a general purpose CRO.

17. How does the digital storage oscilloscope differ from a conventional oscilloscope? Explain the principle, features and applications of DSO.

18. Why is phosphor screen of CRT provided with an aluminum layer?

19. Describe the various types of sweeps used in CRO.

20. Derive an expression for vertical deflection of electron beam in CRT. What is the minimum distance that will allow full deflection of 4 cm at oscilloscope screen with deflection factor of 100 V cm and with accelerating potential of 2 kV.

Draw and explain the block diagram of DSO. Describe the various modes of operation.
VI ) Module-6

Signal Analyzers

A) Short Answer Questions For (Oral Exam.)

1. What is principle of harmonic distortion analyzer?
2. Explain tuned circuit harmonic analyzer.
3. Write a detailed note on distortion factor meter
4. Differentiate between wave analyzer and total harmonic distortion meter
5. What are the different types of network analyzers?
6. What are the applications of a network analyzer?
7. Explain the significance of a signal analyzer. Describe the principle of operation of wave analyzer.
8. Explain total harmonic distortion.

B) Long Answer Questions

1. With the help of a neat block diagram, describe the operation of a wave analyzer. What are its application areas?
2. Explain the working of radio frequency range wave analyzer with neat block diagram.
3. Explain with neat block diagram fundamental suppression distortion analyzer.
4. Draw and explain the block diagram of a network analyzer.
5. Draw and explain block diagram of digital FFT analyzer.
6. What are the elements of a network analyzer?
7. What is distortion? What are the methods for its measurement? Describe experimental method for distortion measurement with reference to a typical distortion meter.
8. With a block diagram explain the elements of network analyzer with its application
9. Write a short note on heterodyne wave analyzer.

10. Define harmonic distortion. How can it be measured? Draw the block diagram of Fundamental Suppression Harmonic Distortion Analyzer and explain the working.

11. Explain the elements of a digital FFT analyzer with a suitable block diagram.

12. What is the basic principle of wave analyzer? Explain heterodyne wave analyzer with applications.
Digital Electronics

Overview: Digital logic design is concerned with digital electronic circuits. Digital circuits are employed in the design and construction of systems such as digital computers, data communication and many other applications that require digital hardware. This subject provides fundamental concepts used in design of digital system. It presents various binary signals suitable in representing information in digital systems. To also introduces various postulates of Boolean algebra and shows correlation between Boolean algebraic expression and their corresponding logic diagram. It outlines formal procedure for the analysis and design of combination and sequential digital circuits.

Pre-requisite: A basic knowledge of electronic circuits, concepts of diode, BJT and FET Switching

Objectives:
1) To realize importance of Boolean logic
2) To articulate why gates are fundamental elements of a digital systems
3) To gain ability to work with binary number system and arithmetic
4) To gain ability to analyze, design and explain uses of combinational logic networks in hierarchical and modular approach
5) To understand digital components which are building blocks of complex digital systems with an introduction to sequential circuit
6) To provide entry level knowledge and skills for a wide range of occupation in digital application
7) To introduce most common digital logic families

Outcomes: Upon completion of course students will be able to:
   a) Describe the topics generally considered within the realm of digital logic design
   b) Familiarize themselves with digital components
   c) Solve the problems of binary arithmetic and work with binary number systems.
   d) Realize the fact that gates are fundamental elements of digital system
   e) Understand key concepts of Boolean algebra
   f) Formulate a solution by applying key Boolean laws of reduction to given problem
   g) Understand key concepts of Quin Mccluskey method and K-Map method
   h) Understand the electronic circuits of common gates of different logic families
   i) Describe different combinational and sequential circuits which are building blocks of digital system design.

Mapping of course objective with course outcome

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MODULE NO:1

1: Design EX-OR and X-NOR gates using all universal gates.

2: Using 2s complement method subtract,
   \((47)_8\) from \((47)_{10}\)

3: State the rules of BCD subtraction.

4) Perform the following operations,
   (a) \(1011.11 \times 101.11\)
   (b) \((5A)_{16} \times (5B)_{16}\)
   (c) Convert \((43)_{8}\) into hexa decimal number system.
   (d) Find \((18-34)_{10}\) using 2’s complement number system.
   (e) Convert \((9CD)_{16}\) into decimal number.
   (f) Determine the value of \(x\)
       \((211)x = (152)_8\)
   (g) Convert \((43)_8 = (?)_2 = (?)_{10}\)
   (h) Find \(H\) if \((193)_{16} = (623)_8\)
        (i) Add \((52)_{10}\) to 2s complement of \((18)_{10}\)

5) Prove that a dual of exclusive OR is also its complement.

6) Justify, NAND and NOR gates are universal logic gates.

7) Prove the following using Boolean Theorems

1: \{\{(C+CD)(C+CD)\} \{AB+AB+AB+AB\} = C
2: ABC+ABC+ABC+ABC=AB+AC+BC

8) Find the 2’s complement for the given binary numbers.
   \(\text{a) } 0.0101\)
   \(\text{b) } 1101.01\)

9) Perform the following subtraction using 9’s complement method.
   (i) \((5240)_{10}-(76532)_{10}\)
   (ii) \((76532)_{10}-(4250)_{10}\)

10) Write the comparison between 1’s complement and 2’s complement.

11) Explain in brief Excess-3 code.

12) Solve the equation for \(X\).
    \((X)_{16} = (1111111111111111)_{2}\)

13) Express the following decimal numbers in Gray code form.
    (i) \(42\)
    (ii) \(340\)

14) What are the advantages of digital system?

15) What is BCD code? What are its advantages and disadvantages?

16) Explain weighted and non-weighted codes with examples.
1) Design the combinational logic circuit that has four inputs and one output. The output is equal to 1 when inputs have above 1000.

2) Given the logic function
   \[ f = ABC + BCD + ABC \]
   (i) Make the truth table.
   (ii) Simplify using a K-map.
   (iii) Realize \( f \) using NAND gates only.

3) For the following function, find the reduced Boolean equation using Quine McClusky method.
   \[ F(A, B, C, D) = m(3, 4, 9, 13, 14, 15) + d(5, 7) \]

4) For the following function implement the logic circuit using,
   (i) only NAND gates.
   (ii) only NOR gates.
   \[ F(A, B, C, D) = m(1, 3, 4, 6, 9, 11, 12, 14) + d(2, 5, 8, 15) \]

5) Minimise the expression using Quine McCluskey method.
   \[ f(A, B, C, D) = m(1, 3, 7, 9, 10, 11, 13, 15) \]

6) The circuit has four inputs and two outputs. One of the outputs is to be true when the majority of inputs are false. The other outputs are true only when there are equal number of true and false in the inputs. Design and implement combinational circuit using NAND gates only.

7) Simplify using k-maps.
   a) \( f(a, b, c, d) = \pi M(4, 5, 6, 7, 8, 12) + d(1, 2, 3, 9, 11, 14) \)
   b) \( f(a, b, c, d) = \Sigma m(0, 1, 2, 3, 5, 7, 8, 9, 11, 14) \)

8) Explain the terms minterms & maxterms.

9) Minimize the following function using k-map & realize using NAND gates only.
   \[ Y = \Sigma m(1, 3, 5, 8, 9, 11) + (2, 13) \]

10) Convert the following equations into into their canonical/standard forms.
    a) \( Y = AB + BC + AC \)
    b) \( Y = (A + C)(B + A)(C + B) \)
MODULE NO 3

1) Design the circuit for full subtractor using logic gates. (10)
2) Design the following equation using 8:1 MUX
   \[ F(A,B,C,D) = \sum_m(0,1,3,4,8,9,15) \] (10)
3) Design the circuit for 3 bit binary code to Gray code converter using 3:8 decoder
4) Design a 3 bit Gray code to binary code converter.

5) Implement 16:1 multiplexer using 4:1 multiplexers only and explain its operation.

6) Design 1:4 de-multiplexer with active high outputs and explain its operation.
7) Write short notes on
   (i) FPGA   (ii) CPLD   iii) Full Subtractor

8) Design a circuit using full adder blocks to add two 4-bit numbers.

9) Design the circuit for BCD to 7 segment display decoder driver for common cathode type using logic gates.
10) Design the circuit for 2 input EX-NOR operation using 4:1 mux.

MODULE NO 4

1) Design and explain the process of JK FF to SR FF conversion.
2) What is meant by Race Around condition? How it is avoided? Explain any one method.
3) Design & explain MOD-5 Asynchronous counter using MS-JK FFs.
4) Design & explain 3 bit bi-directional shift register using D-FFs.

5) Draw JKMS flip flop using gates and explain its operation

6) Do the following conversion of flip flops; (i) JKMS to D (ii) SR to T

7) Design Mod 6 up synchronous counter using JKMS flip flops

8) Explain D Flip-Flop.

9) Explain Master slave JK-FF.
10) Convert T FF to D FF

11) Explain Johnson counter.
12) Explain universal shift register

13) What is asynchronous preset & clear inputs of flipflops? Explain their uses.
MODULE NO 5

1) Draw a state diagram of sequence detector to detect a non overlapping sequence ---1101--- and write its state table. Find the equivalent states if they are present.
2) Explain sequence generator using suitable example.
3) Design sequence generator which go through states 1,2,4,5,3,7 and repeat. Use any FlipFlop. Draw state diagram.
4) Design a sequence detector to detect the following sequences, 1001
   draw necessary state diagram, state table, and k-maps. remove redundant states.
   design the circuit using JK FlipFlops.
5) Design the sequence detector to detect three or more consecutive 1s in a string of bits coming through an input line.

MODULE NO 6

1) Define propagation delay? What is fan-in and fan-out? What is meant by power dissipation? What is noise margin? Explain with suitable examples.
2) Explain interfacing of T.T.L. and CMOS logic families.
3) Compare different logic families.
4) Draw standard TTL inverter, discuss its operation & draw its transfer characteristics.
5) Explain following characteristics of logic families with examples.
   (i) Figure of merit  (ii) Fan out  (iii) Voltage parameters
   (iv) speed  (v) Noise margin.
6) Explain parameters of logic families.
7) Explain ECL circuit.
8) Draw a standard TTL NAND gate and explain its working.
9) Compare TTL, CMOS, ECL logic families
10) Define the following terms
    a) Propagation delay
    b) Power dissipation
    c) Fan out
    d) Fan in
    e) Noise margin
11) Mention the advantages and disadvantages of TTL, CMOS and ECL logic
12) Draw the circuit diagram of two input TTL NAND gate and explain the function of each component in it.

13) State the application of CMOS logic inverter.

14) Write note on ‘comparison of TTL and CMOS logic families.'
Circuit Theory and Transmission Line

**Overview:** Circuit theory and transmission line and synthesis a core subject for the students of Telecommunication Engineering. A good understanding of this subject helps students to grasp other subjects comfortably. In fact, network theory has revolutionized the process of analysis in all branches of engineering. It has been possible to represent electrical analog of a real physical system in terms of electric circuit elements and analysis made accurately. Network theory is all about various types of networks, behavior, analysis and applications. This subject helps us to understand principles and components of electrical, electronic circuit elements.

**Pre-requisite:** Fundamentals of DC and R-L-C AC network

**Objective:**
1) To study AC/DC network analysis
2) To study magnetic circuit & analysis.
3) To study time response of first and second order system using Laplace transform and differential equations
4) To study network functions.
5) To study different two port network parameters and relationship between them.
6) To study elements of smith chart theory.
7) To study fundamentals of transmission line.
8) To study parameters of radio frequency lines

**Outcome:** Upon completion of course students will be able to:

a) Solve different electronic and electrical circuits.
b) Demonstrate an ability to identify, formulate electronic and telecommunication engineering problems.
c) Understand basic concepts of control system and Digital signal Processing.
d) Gain foundation in mathematical, science and engineering fundamentals required to solve engineering problems.
e) Realize key concepts of electrical networks.
f) Realize key concepts of transmission line and smith chart

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Module 1

SOURCE TRANSFORMATION AND SOURCE SHIFTING

1. Find the voltage at node 2 in the network shown in Fig. by source transformation technique.

\[ V = \frac{55}{7} \text{ V} \]

2. Reduce network shown into a single source and a single resistor between terminals A and B.

\[ [3.75 \text{ V}, 1.75 \Omega] \]

3. Calculate the power dissipated across 10 \( \Omega \) resistor by using source transformation technique.
4. Use source transformation to simplify the network until two elements remain to the left of terminals a and b.

5. Calculate voltage across the resistor using source shifting technique.

MESH ANALYSIS

6. Find $I_1$ if the dependent voltage is labelled (i) $2\ V_2$ (ii) $1.5\ V_3$. 
7. For the network shown in Fig. obtain the branch currents.

\[ \begin{align*}
&\begin{array}{c}
V_3 \\
5 \Omega & 10 I_A & 10 \Omega & 5 \Omega \\
5 V & I_A & I_B & 10 V \\
20 V & + & - & + \\
I_1 & 10 V & 40 \Omega & 90 V \\
\end{array}
\end{align*} \]

\[ [1 \text{ A}, 1 \text{ A}] \]

8. Find currents in the three meshes of network shown in Fig.

\[ \begin{align*}
&\begin{array}{c}
5 V \\
1 \Omega & 1 \Omega & 1 \Omega \\
I_x & I_y & 1 \Omega \\
5 V & + & - \\
\end{array}
\end{align*} \]

\[ [0.25 \text{ A}, 0.416 \text{ A}] \]

9. Find the power supplied by the dependent voltage source.

\[ \begin{align*}
&\begin{array}{c}
5 A \\
50 \Omega \\
20 \Omega & 30 \Omega \\
+ & - \\
V_1 & 0.4 V_1 & 0.01 V_1 \\
\end{array}
\end{align*} \]

\[ 383.62 \text{ W} \]

10. Find currents \( I_x \) and \( I_y \).
11. Use mesh analysis to find $V_3$ if element A is
(a) Short circuit
(b) a $5 \, \Omega$ resistor
(c) 20 V independent voltage source, positive reference on the right.
(d) a dependent voltage source of 1.5 $i$, with positive reference on the right.
(e) a dependent current source 5 $i$, arrow directed to the right.

[0.5 A, 0.1 A]

[69.4 V, 72.38 V, 73.68 V, 70.71 V, 97.39 V]

12. Find currents $I_1$, $I_2$ and $I_3$. 

13. Find current $I_1$.

14. Find the power delivered to the 4 $\Omega$ resistor. To what voltage should the 100 V battery be changed so that no power is delivered to the 4 $\Omega$ resistor.

15. For the network shown in figure determine I current flowing through 8 $\Omega$ resistance.
16. Find current through 13 Ω resistance.

15. Find voltage $V_1$ and $V_2$ in the network of Fig.

16. For the Fig. given, find voltages $V_a$, $V_b$ and $V_c$. 

[2.5 V, 2.5 V]
17. Find voltage $V_x$.

\[4.303 \text{ V}, 3.87 \text{ V}, 3.33 \text{ V}\]

18. Find voltage $V_x$.

\[4.31 \text{ V}\]

19. Find voltage $V_x$.

\[2.09 \text{ V}\]
20. Determine $V_1$. 

\[ 6.2 \text{ V} \]

21. Find voltage $V_y$. 

\[ 140 \text{ V} \]

22. Find voltage $V_2$. 

\[ 10 \text{ V} \]
23. For the given network shown in the figure determine $V_1$ using Nodal Analysis.

SUPERPOSITION THEOREM

23. For the network shown in Fig., determine $V_A$ and $V_B$. 

[4 V, 10 V]
24. Find the current through 6 Ω resistor in the network shown in Fig.

![Image of circuit with 6 Ω resistor, 15 V, and 10 V sources]

25. Find current I_x for the network shown in Fig.

![Image of circuit with 5 Ω and 1 Ω resistors, 20 V, and 30 A source]

26. Find current I_1 in the network shown in Fig.

![Image of circuit with 10 Ω, 2 A, and other resistors]

27. Find current I_1 in the network shown in Fig.

![Image of circuit with 10 V, 2 A, and other resistors]
28. Determine current $I_2$ in the network of Fig.

![Network Diagram](image)

29. Find voltage $V_x$ in the network shown in Fig.

![Network Diagram](image) \[0.8 \text{ A}\]

30. Determine the current through 10 $\Omega$ resistor in the network of Fig.

![Network Diagram](image) \[30 \text{ A}\]

31. Find the voltage $V_x$ in the circuit shown in Fig.

![Network Diagram](image) \[8 \text{ V}\]
32. Find $V_1$ in the network shown in Fig.

![Network Diagram]

33. Find current $I$ using Superposition Theorem for the circuit shown in the figure.

![Circuit Diagram]

THEVENIN’S AND NORTON’S THEOREM

33. Determine Thevenin’s equivalent network for the Fig. shown.

(i)

![Thevenin Equivalent Circuit]

[20 V, 10 Ω]
34. Using Norton’s theorem determine current through 15 Ω resistance for the network shown in figure. Also verify the result using Thevenin’s theorem.

MAXIMUM POWER TRANSFER THEOREM
1. For the network shown in figure Find RL for maximum power transfer and maximum power transferred
2. State and prove maximum power transfer theorem for a R-L-C network excited by AC source.

Module 2

1. In the network of Fig. switch is closed at $t = 0$. With capacitor uncharged, find value for $i$, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^+$.

![Network 1](image1)

[0.1 A, 100 A/s, 10^5 A/s^2]

2. In the given network of Fig. switch is closed at $t = 0$. With zero current in the inductor, find $i$, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^+$.

![Network 2](image2)

[0, 100 A/s, 1000 A/s^2]

3. In the network shown in Fig., switch is closed. Assuming all initial conditions as zero, find $i$, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^+$.

![Network 3](image3)
4. In the network shown in Fig., at $t = 0$, switch is opened. Calculate $v$, $\frac{dv}{dt}$, $\frac{d^2v}{dt^2}$ at $t = 0^+$.

5. In the given network of Fig., switch is opened at $t = 0$. Solve for $v$, $\frac{dv}{dt}$ and $\frac{d^2v}{dt^2}$ at $t = 0^+$.

6. For the network shown in Fig., switch is closed at $t = 0$. Determine $v$, $\frac{dv}{dt}$ and $\frac{d^2v}{dt^2}$ at $t = 0^+$. 
7. In the network shown in Fig., switch is changed from position 1 to position 2 at $t = 0$, steady condition having reached before switching. Find the values of $i$, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^+$.

8. In the network shown in Fig., switch is changed from position 1 to position 2 at $t = 0$, steady condition having reached before switching. Find the values of $i$, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^+$.

9. In the network shown in Fig., switch is changed from position 1 to position 2 at $t = 0$, steady condition having reached before switching. Find the values of $i$, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^+$.
10. In the network of Fig., switch is changed from position ‘a’ to ‘b’ at $t = 0$. Solve for $i$, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^\circ$. 

11. The switch in Fig. is moved from position a to b at $t = 0$, the network having been in steady state in position a. Determine $i_1(0^\circ)$, $i_2(0^\circ)$, $i_3(0^\circ)$ $\frac{di_2}{dt}(0^\circ)$ and $\frac{di_3}{dt}(0^\circ)$.
12. Determine whether RLC series circuit shown in Fig. is underdamped, overdamped or critically damped. Also find $v_L(0^+)$ and $(\_\_\_\_\_\_\_\_)$.

![Diagram of RLC series circuit](image)

[Critically damped, 200 V, 2000 A/s, 0]

13. Determine whether RLC circuit of Fig. is underdamped, overdamped or critically damped. Also find $v_L(0^+)$, $\frac{di}{dt}(0^+)$, $\frac{d^2v}{dt^2}(0^+)$ if $v(t) = u(t)$.

![Diagram of RLC circuit](image)

[Underdamped 1 V, 1 A/s, 2 V/s²]

4. The network of Fig. is under steady state with switch at position 1. At $t = 0$, switch is moved to position 2. Find $i(t)$.

![Diagram of network](image)

[$i(t) = 0.25 + e^{-2000t}$]

15. The switch in the circuit of Fig. is moved from position 1 to 2 at $t = 0$. Find $v_C(t)$.

![Diagram of circuit](image)
16. In the network of Fig., switch is moved from 1 to 2 at t = 0. Determine $i(t)$.

\[ i(t) = 20 - 16 e^{-4t} \]

17. For the network shown in Fig., steady state is reached with the switch closed. The switch is opened at t = 0. Obtain expressions for $i_L(t)$ and $v_L(t)$.

\[ i_L(t) = 0.15 e^{-33.33 \times 10^3 t}, \quad v_L(t) = -450 e^{-33.33 \times 10^3 t} \]

18. In the network of Fig., switch is open for a long time and it closes at t = 0. Find $i(t)$.

\[ i(t) = 1.67 + 0.83 e^{-150t} \]

19. In the network shown in Fig., the switch closes at t = 0. The capacitor is initially uncharged. Find $v_C(t)$ and $i_C(t)$. 

\[ v_C(t) = 50 + 150 e^{200t} \]
20. For the network shown in Fig. switch is open for a long time and closes at \( t = 0 \). Determine \( v_C(t) \).

\[
\begin{align*}
V_c(t) &= 1 - e^{-68.02t}, \\
i_c(t) &= 204.06 \times 10^{-6} e^{-68.02t}
\end{align*}
\]

21. In Fig. switch is closed at \( t = 0 \). Find \( v_C(t) \) for \( t > 0 \).

\[
\begin{align*}
V_c(t) &= 900 + 300 e^{-266.67t}
\end{align*}
\]

22. In the network shown switch is shifted to position ‘b’ at \( t = 0 \). Find \( v(t) \) for \( t > 0 \).

\[
\begin{align*}
v(t) &= -2.5 e^{-t/100}
\end{align*}
\]
23. In the network of Fig., the switch is open for a long time and at \( t = 0 \) it is closed. Determine \( v_2(t) \).

\[ v_2(t) = 4(1 - e^{-20t}) \]

24. In the network of Fig. switch is in position ‘a’ for a long time. At \( t = 0 \) switch is moved from a to b. Find \( v_2(t) \). Assume that the initial current in 2 H inductor is zero.

\[ v_2(t) = -0.5 e^{-3/4 t} \]

25. In the network shown in Fig., a steady state condition is achieved with switch open. At \( t = 0 \) switch is closed. Find \( v_a(t) \).

\[ v_a(t) = e^{-20/3 t} \]

26. In the network shown in Fig., switch is closed at \( t = 0 \). Obtain the current \( i_2(t) \).
27. The switch in Fig. is open for a long time and closes at $t = 0$. Determine $i(t)$ for $t > 0$.

\[ i_2(t) = 5 \, e^{-100000t} \]

28. In the network shown, steady state is reached with switch open. At $t = 0$, switch is closed. Find $v_c(t)$ for $t > 0$.

\[ i(t) = 25 \, (1 - e^{-4t}) \]

29. In circuit shown has acquired steady state before switching at $t = 0$.

(i) obtain $v_c(0^+)$, $v_c(0)$, $i(0^+)$ and $i(0)$

(ii) obtain time constant for $t > 0$

(iii) find current $i(t)$ for $t > 0$.

\[ v_c(t) = 5 \, e^{20t} \]
30. In the network shown, switch is initially at position 1 for a long time. At \( t = 0 \), switch is changed to position 2. Find current \( i(t) \) for \( t > 0 \).

\[ i(t) = 2e^{-30t} \]

31. In the network shown, switch is in position 1 for long time and at \( t = 0 \), switch is moved to position 2. Find \( v(t) \) for \( t > 0 \).

\[ v(t) = 0.5e^{\frac{3}{4}t} \]

32. A series RL circuit has a constant voltage \( V \) applied at \( t = 0 \). At what time does \( v_R = v_L \).

(May 97, Dec. 97, May 99)
33. Obtain $V_c(t)$ for $t > 0$.

![Circuit Diagram](image)

34. In Fig. switch is closed at $t = 0$. Find $i(t)$ for $t > 0$.

![Circuit Diagram](image)

\[ i(t) = 2.5 (1 - e^{-2.67t}) \]

35. Find current $i(t)$ for $t > 0$.

![Circuit Diagram](image)

\[ i(t) = 17.5 e^{-50t} \]

36. The network shown in Fig. is under steady state when switch is closed. At $t = 0$ it is opened. Obtain an expression for $i(t)$.

![Circuit Diagram](image)
37. In the network shown, switch is closed at \( t = 0 \). Find \( v(t) \) for \( t > 0 \).

\[
\text{Module 3}
\]

1. Hurwitz Polynomial, Positive Real Function and Network Synthesis

Check for Hurwitz giving reasons
(i) \( P(s) = s^7 + 3s^5 + 2s^3 + 3 \)
(ii) \( s^7 + 8s^4 + 24s^3 + 28s^2 + 23s + 6 \)

2. Test whether the following polynomials are Hurwitz.
(i) \( P(S) = s^3 + 2s^2 + 4s + 2 \)
(ii) \( Q(S) = s^4 + s^3 + 4s^2 + 2s + 3 \)

3. Check for Hurwitz giving reason
(i) \( s^7 - 2s^6 + 2s^5 + 9s^2 + 8s + 4 \)
(ii) \( s^7 + 3s^5 + 2s^3 + 3 \)
(iii) \( s^5 + 8s^4 + 24s^3 + 28s^2 + 23s + 16 \)
(iv) \( -2s^2 - 4s - 12 \)

4. What are the essential properties of Hurwitz polynomials? Test the polynomial for Hurwitz.
(i) \( s^3 + s^2 + 2s + 2 \)
(ii) \( s^4 + s^2 + s + 1 \)

5. Find the range of values of ‘\( a \)’ so that \( F(s) = s^4 + s^3 + as^2 + 2s + 3 \) is Hurwitz.

6. Check for the positive real function, giving reason:
(i) \( s^4 + 3s^3 + s^2 + s + 2 / s^3 + s^2 + s + 1 \)
(ii) \( 2s^3 + 2s^2 + 3s + 2 / s^2 + 1 \)

7. Define the positive real function. State and explain properties of positive real function.

8. Give the necessary and sufficient conditions for the function to be positive real.

9. Test whether following function is positive real function:
(i) \( F(s) = s^2 + 4s + 3 / s^2 + 6s + 8 \)
(ii) \( F(s) = \frac{s^2 + 1}{s^3 + 4s} \)

(iii) \( F(s) = \frac{s^4 + 2s^3 + 3s^2 + 1}{s^4 + s^3 + 3s^2 + 2s + 1} \)

(iv) \( 7s + 2 / 2s + 4 \)

(v) \( 2s^3 + 2s^2 + 3s + 2 / s^2 + 1 \)

(vi) \( s^2 + 2s + 6 / s(s + 3) \)

10. \( z(s) \) is a positive real function whose even part is \( 4/4 - s^2 \). Find \( z(s) \).

11. \( z(s) = \frac{2(s^2 + 1)(s^2 + 25)}{s(s^2 + 4)} \) in all four forms

12. \( y(s) = \frac{4(s^2 + 4)(s^2 + 25)}{s(s^2 + 16)} \) in Foster II form

13. \( z(s) = \frac{(s^2 + 1)(s^2 + 4)}{s(s^2 + a)(s^2 + 3)} \) for \( z(s) \) to be LC, what should be the value of \( a \)?


15. RC / RL Functions

\( \frac{F(s)}{s} = \frac{2(s+1)(s + 3)}{(s + 2)(s + 6)} \) synthesize in ladder form.

\( F(s) = \frac{(s + 1)(s + 3)}{s(s + 2)} \) in C I and C II forms

\( Z(s) = \frac{s + 4}{(s + 2)(s + 6)} \) in Cauer I and Foster I form.

\( Z(s) = \frac{(s + 2)(s + 6)}{s(s + 4)} \) in Foster I and Foster II form

16. Show that in RC admittance function \( YRC(s) \), has the property \( Y(0) < Y(\infty) \).

17. A designer requires the network with following data:-

(i) Impedance function has simple poles at \(-2\) and \(-6\)

(ii) It has simple zero at \(-3\) and \(-7\)

(iii) \( Z(0) = 20 \) ohms. Find all canonical forms.

18. An RC impedance function has a pole at \( s = 0 \). What will be the first element in first Foster form of synthesis?

19. Synthesize the driving point impedance given by the expression \( Z(s) = \frac{s^2 + 2s + 2}{s^2 + s + 1} \) A designer requires the RC network with following data –

(i) Impedance function has simple poles at \(-2\) and \(-6\)

(ii) It has simple zero at \(-3\) and \(-7\)

(iii) \( Z(0) = 20\Omega \). Determine Foster I and II forms.

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**Module 4**

1. Find network functions \( \frac{V_1}{I_1} \), \( \frac{V_2}{V_1} \) and \( \frac{V_2}{I_1} \) for the network shown in Fig.
1. Find the network functions \( \frac{V_2}{V_1} \), \( \frac{I_b}{I_1} \), \( \frac{V_1}{I_1} \), and \( \frac{V_2}{I_1} \) for the network in Fig.

2. Find the network functions \( \frac{V_2}{V_1} \), \( \frac{I_b}{I_1} \), \( \frac{V_1}{I_1} \) and \( \frac{V_2}{I_1} \) for the network in Fig.

3. For the network shown in Fig., determine transfer function \( \frac{V_2}{V_1} \).

4. For the network shown in Fig., determine voltage transfer function \( \frac{V_2}{V_1} \).
5. Determine the driving point impedance \( \frac{V_1}{I_1} \), transfer impedance \( \frac{V_2}{I_1} \) and voltage transfer ratio \( \frac{V_2}{V_1} \) for the network shown.

6. For the ladder network of Fig., find driving point impedance at 1-1' terminal with 2-2' open.

7. Determine voltage transfer function \( \frac{V_2}{V_1} \) for the network shown in Fig.
8. For the network shown in Fig. determine transfer function \( \frac{I_2}{V_1} \).

9. For the network shown, determine \( \frac{V_2}{V_1} \) and \( \frac{V_2}{I_1} \).
10. Determine the voltage ratio $\frac{V_2}{V_1}$, current ratio $\frac{I_2}{I_1}$, transfer impedance $\frac{V_2}{I_1}$ and driving point impedance $\frac{V_1}{I_1}$ for the network shown in Fig.

\[ \begin{align*}
\frac{2s^2 + 4s + 2}{36s^3 + 41s^2 + 25s + 8}, & \quad \frac{(2s + 2)}{9s^3 + 8s^2 + 5s + 2} \\
\frac{2s + 2}{9s^3 + 8s^2 + 5s + 2}, & \quad \frac{36s^3 + 41s^2 + 25s + 8}{9s^4 + 17s^3 + 13s^2 + 7s + 2}
\end{align*} \]

11. Find open circuit transfer impedance $Z_{21}$ and open circuit voltage ratio $G_{21}$ for the following adder network.

\[ \begin{align*}
\frac{1}{2s^3 + 3s^2 + 4s^4 + 7s^2 + 1}
\end{align*} \]

12. For the two port network shown, determine $Z_{11}$, $Z_{21}$ and voltage transfer ratio $G_{21}$ (s).
For the network shown in Fig., determine $Z_{11}(s)$, $G_{12}(s)$ and $Z_{12}(s)$.

\[
\begin{bmatrix}
\frac{2s^3 + 4s^2 + 3s + 2}{s^2 + 2s + 1} & \frac{s}{s^2 + 2s + 1} & \frac{s}{2s^3 + 4s^2 + 3s + 2}
\end{bmatrix}
\]

13. For the network shown in Fig., determine $Z_{11}(s)$, $G_{12}(s)$ and $Z_{12}(s)$.

For the bridged T-network shown, evaluate the driving point admittance $Y_{11}$ and transfer admittance $Y_{21}$.

\[
\begin{bmatrix}
\frac{s^2 + 3s + 1}{s(2s + 1)} & \frac{s^2 + 2s + 1}{s(2s + 1)} & \frac{s^2 + 2s + 1}{s^2 + 3s + 1}
\end{bmatrix}
\]

14. For the bridged T-network shown, evaluate the driving point admittance $Y_{11}$ and transfer admittance $Y_{21}$.

\[
\begin{bmatrix}
\frac{2s^2 + 5s + 1}{s^2 + 5s + 2} & \frac{s^2 + 2s + 1}{s^2 + 5s + 2}
\end{bmatrix}
\]

15. For the network shown, plot poles and zeros of function $\frac{I_0}{I_1}$.

\[
\begin{bmatrix}
2s^2 + 5s + 2
\end{bmatrix}
\]
16. Draw the pole zero diagram of \( \frac{I_2}{I_1} \) for the network shown.

\[
\begin{align*}
\frac{s (s + 2)}{s^2 + 2s + 1}
\end{align*}
\]

17. For the network shown, find pole zero plot for \( \frac{V_c(s)}{V_i(s)} \).

18. For the network shown, determine \( \frac{V_2}{I_g} \). Plot the pole zero diagram of \( \frac{V_2}{I_g} \).

19. For the network shown, plot poles and zeros of transfer impedance and determine magnitude and phase of \( V_2(s) \), given \( V_1(s) = 2 \) \( \square \) 0 as a function of \( \Box \). Also find driving point impedance.
20. Obtain the impedance function $Z(s)$ for which pole-zero diagram is shown in Fig.

\[ Z(\ast) = 1 \]

\[ \left[ \frac{1}{s + 2}, \frac{1}{s^2 + 3s + 1}, \frac{2}{\sqrt{(1 - w^2)^2 + (3w)^2}} \tan^{-1} \frac{3w}{1 - w^2} \right] \]

21. Obtain the admittance function $Y(s)$ for which pole-zero diagram is shown in Fig.

\[ Y(\ast) = 1 \]

\[ \left[ \frac{s (s + 2)}{(s + 1) (s + 3)} \right] \]

22. Obtain the impedance function for which pole zero diagram is shown in Fig. Evaluate the impedance at $s = j1$. If a current of 10 cost is applied to the impedance. What voltage will appear across it.
23. A network and its pole-zero configuration are shown in Fig. Determine the values of R, L and C if \( Z(j0) = 1 \).

\[
\begin{bmatrix}
2 (s + 1) \\
\frac{s^2 + 2s + 2}{s^2 + 2s + 2}
\end{bmatrix}
\]

24. The pole zero diagram of the driving point impedance function of the network of Fig. is shown below. At d.c., the input impedance is resistive and equal to 2 \( \Omega \). Determine the values of R, L and C.

\[
\begin{bmatrix}
1 W, \frac{1}{3} H, \frac{1}{10} F \\
\end{bmatrix}
\]

25. A network and pole zero diagram for driving point impedance \( Z(s) \) are shown in Fig. Calculate the values of the parameters R, L, G and C if \( Z(j0) = 1 \).

\[
\begin{bmatrix}
2 W, 1 H, \frac{1}{17} F \\
\end{bmatrix}
\]
26. A series RLC circuit has for its driving point admittance, pole diagram as shown in Fig. Find the values of R, L and C.

\[
\begin{bmatrix}
\frac{9}{5} \Omega, \frac{9}{10} H, \frac{4}{9} \Omega, \frac{1}{9} F
\end{bmatrix}
\]

27. For the network shown, poles and zeros of driving point impedance are,

Poles : \((-3 \pm j3)\) ; zero : 2

If \(Z(j0) = 1\), find the values of R, L, G and C.

\[
\left[ 2 \text{ W}, 1 \text{ H}, \frac{1}{626} \text{ F} \right]
\]
28. Given the transfer function :

\[ H(s) = \frac{V_o}{V_i} = \frac{10}{s^2 + 3s + 10} \]

Realize the function using the circuit.

(i) Find L and C when R = 5 \( \Omega \)
(ii) Find L and C when R = 1 \( \Omega \)

![Circuit Diagram](image)

29. For the given network function, draw the pole-zero diagram and hence obtain the time domain voltage. Verify the result analytically.

\[ V(s) = \frac{5(s+5)}{(s+2)(s+7)} \left[ 3e^{2t} + 2e^{3t} \right] \]

30. A transfer function is given by

\[ Y(s) = \frac{10s}{(s+5-j15)(s+5+j15)} \]

Find time domain response using graphical method.

31. Draw pole-zero diagram for the given network function and hence obtain \( v(t) \).

\[ V(s) = \frac{4s(s+2)}{(s+1)(s+3)} \]

32. Write a short note on Pole Zero plot and their use to get time domain response.

**Module 5**

1. What is transmission line? Explain different kind of transmission line.
2. Explain \( \pi \) model of transmission line.
3. Short note on: Group velocity, Reflection coefficient, VSWR, S-parameters
Object Oriented Programming Methodology

Course Objective:
1) To understand the concept of the object oriented Programming
2) To help student to understand use of programming
3) To impart problems understanding, analyzing skill in order to formulate algorithms.
4) To provide knowledge about JAVA fundamentals: Data types, variables, keywords and control structure s
5) To understand methods, arrays, Interface, Package and Multithreading and concept of applet.

Course Outcomes:
1) Students will be able to code a program using JAVA constructs.
2) Given an algorithm a student will be able to formulate a program that correctly implements the algorithm.
3) Students will be able to generate different patterns and flows using control structures and
   Use recursion in their programs.
4) Students will be able to use thread methods, thread exceptions and thread priority.
5) Students will implement method overloading in their code.
6) Students will be able to demonstrate reusability with the help of inheritance.
7) Students will be able to make more efficient programs.
Experiment List

Experiment No 1:- To Study of JAVA Environment:
1. How to compile a java file?
2. How to run a class file?
3. How to debug a java file?
4. How to set classpath?
5. How to view current classpath?
6. How to set destination of the class file?
7. How to run a compiled class file?
8. How to check version of java running on your system?
9. How to set classpath when class files are in .jar file?

Experiment No 2:- Write a Java Program for (Don’t take input from user)
1. To find area and circumference of circle.
2. To find the simple interest.
3. To convert temperature from degree centigrade to Fahrenheit.
4. To calculate sum of 5 subjects & find percentage.

Experiment No 3 : Write a Java Program For Arrays
1. To sort an array and search an element inside it?
2. To sort an array and insert an element inside it?
3. To determine the upper bound of a two dimensional array?
4. To reverse an array?
5. To write an array of strings to the output console?
6. How to search the minimum and the maximum element in an array?

Experiment No 4 : Write a Java Program For Arrays
1. To merge two arrays?
2. To fill (initialize at once) an array?
3. To extend an array after initialization?
4. To sort an array and search an element inside it?
5. To remove an element of array?

Experiment No 5 : Write a Java Program For Arrays
1. To remove one array from another array?
2. To find common elements from arrays?
3. To find an object or a string in an Array?
4. check if two arrays are equal or not?
5. To compare two arrays?
Experiment No 6 : Write a Java Program For String

1. How to compare strings?
2. How to search last occurrence of a substring inside a substring?
3. How to remove a particular character from a string?
4. How to replace a substring inside a string by another one?
5. How to reverse a String?

Experiment No 7 : Write a Java Program For String

1. How to search a word inside a string?
2. How to split a string into a number of substrings?
3. How to convert a string totally into upper case?
4. How to match regions in a string?
5. How to compare performance of two strings?

Experiment No 8: Write a Java Program For Method overloading and Inheritance

1. To overload methods?
2. To use method overloading for printing different types of array?
3. To use method for solving Tower of Hanoi problem?
4. To use method for calculating Fibonacci series?
5. To use method for calculating Factorial of a number?
6. To use method overriding in Inheritance for subclasses?

Experiment No 9: Write a Java Program For Constructor

Experiment No 10: Write a Java Program For Interface

Experiment No 11: Write a Java Program For Packages

Experiment No 10: Write a Java Program For Multithreading

Experiment No 11: Write a Java Program For Applet

1. How to create a basic Applet?
2. How to create a banner using Applet?
3. How to display clock using Applet?
4. How to create different shapes using Applet?
5. How to fill colors in shapes using Applet?
6. How to goto a link using Applet?

Experiment No 12: Write a Java Program For Applet
1. How to create an event listener in Applet?
2. How to display image using Applet?
3. How to open a link in a new window using Applet?
4. How to play sound using Applet?
5. How to read a file using Applet?
6. How to write to a file using Applet?
7. How to use swing applet in JAVA?
made using the published literature as well as textbooks and student reports from previous projects if available.

- Proper Planning: Students must define the project goals and must organize a logical sequence of steps to achieve these goals. This will vary depending on the project, ability to procure materials, availability of equipment etc.
- Regular Meetings: Students must meet regularly (weekly-4Hrs in VII Semester and 8 Hrs in VIII Semester) with the project guide.
- Professional Record Keeping: Proper records are essential and are typically kept in a log book with all details of activity noted. Be sure to use standard nomenclature and work in the SI system of units. (Log-book will contain in table format: Date/ Activity/ outcome/ comment on outcome/ Resources utilized/ Next meeting date, Target/ Guide’s Remark)

<table>
<thead>
<tr>
<th>Term work</th>
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<tr>
<td>Term work should consist of the above mentioned activities which shall be evaluated and shall carry a weightage of 25 marks.</td>
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<th>Oral Examination</th>
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<td>The oral examination shall be conducted on the basis of presentation given by the students and shall carry a weightage of 25 marks.</td>
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