

**CURRICULUM
FOR
CIVIL ENGINEERING**

Semester - II (CIVIL ENGINEERING)

S.No	Paper Code	Paper Title	L	T	P	Credits
1	100203	Chemistry	3	1	3	5.5
2	101202	Mathematics -Ii (Differential Equations)	3	1	0	4
3	100204	Programming For Problem Solving	3	0	4	5
4	100205	Workshop Manufacturing Practices	1	0	4	3
5	100206	English	2	0	2	3

PAPER CODE - 100203

100203	Chemistry	L:3	T:1	P:3	Credit:5.5
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Module 1

Atomic and Molecular Structure: Failure of Classical Newtonian and Maxwell Wave Mechanics to Explain Properties of Particles at Atomic and Subatomic Level;
Electromagnetic Radiation, Dual Nature of Electron and Electromagnetic Radiation,
Plank's Theory, Photoelectric Effect And Heisenberg Uncertainty Principle. Failure Of
Earlier Theories To Explain Certain Properties Of Molecules Like Paramagnetic Properties. Principles For Combination Of Atomic Orbitals To Form Molecular Orbitals.
Formation Of Homo And Hetero Diatomic Molecules And Plots Of Energy Level Diagram Of
Molecular Orbitals. Coordination Numbers And Geometries, Isomerism In Transition
Metal Compounds, Crystal Field Theory And The Energy Level Diagrams For Transition Metal Ions And Their Magnetic Properties.

Module 2

Spectroscopic Techniques And Applications: Principles Of Vibrational And Rotational Spectroscopy And Selection Rules For Application In Diatomic Molecules. Elementary Idea Of Electronic Spectroscopy. Uv-Vis Spectroscopy With Related Rules And Its Applications. Fluorescence And Its Applications In Medicine. Basic Principle Of Nuclear Magnetic Resonance And Its Application. Basics Of Magnetic Resonance Imaging.

Module 3

Intermolecular Forces And Properties Of Gases: Ionic, Dipolar And Van Der Waals Interactions. Equations Of State Of Ideal And Real Gases, Deviation From Ideal Behaviour. Vander Waal Gas Equation.

Module 4

Use Of Free Energy In Chemical Equilibria & Water Chemistry: Thermodynamic Functions: Energy, Enthalpy Entropy And Free Energy. Equations To Interrelate Thermodynamic Properties. Free Energy, Emf. And Cell Potentials, The Nernst Equation And Applications. Corrosion. Use Of Free Energy Considerations In Metallurgy Through Ellingham Diagrams. Solubility Equilibria. Water Chemistry, Hard And Soft Water. Parameters Of Quality Of Water To Be Used In Different Industries As For Drinking Water. Calculation Of Hardness Of Water In All Units. Estimation Of Hardness Using Edta And Alkalinity Method. Removal Of Hardness By Soda Lime And Ion Exchange Method Including Zeolite Method.

Module 5

Periodic Properties: Effective Nuclear Charge, Penetration Of Orbitals, Variations Of S, P, D And F Orbital Energies Of Atoms In The Periodic Table,



Electronic Configurations, Atomic And Ionic Sizes, Ionization Energies, Electron Affinity And Electronegativity, Polarizability, Acid, Base, Principle Of Hsab Theory, Oxidation States, Hybridization And Molecular Geometries.

Module 6

Stereochemistry: Representations Of 3-D Structures, Structural Isomers And Stereoisomers, Configurations And Symmetry And Chirality, Enantiomers, Diastereomers, Optical Activity, Absolute Configurations And Conformational Analysis.

Module 7

Organic Reactions And Synthesis Of A Drug Molecule: Introduction To Intermediates And Reactions Involving Substitution, Addition, Elimination, Oxidation-Reduction, Diels Alder Cyclization And Epoxide Ring Openings Reactions. Synthesis Of A Commonly Used Drug Molecule Like Aspirin.

Suggested Text Books:

- University Chemistry, By B. H. Mahan
- Chemistry: Principles And Applications, By M. J. Sienko And R. A. Plane
- Fundamentals Of Molecular Spectroscopy, By C. N. Banwell
- Engineering Chemistry (Nptel Web-Book), By B. L. Tembe, Kamaluddin And M. S. Krishnan
- Physical Chemistry, By P. W. Atkins
- Organic Chemistry: Structure And Function By K. P. C. Vollhardt And N. E. Schore, 5th Edition
- [Http://Bcs.Whfreeman.Com/Vollhardtschore5e/Default.Asp](http://Bcs.Whfreeman.Com/Vollhardtschore5e/Default.Asp)

Course Outcomes

The Concepts Developed In This Course Will Aid In Quantification Of Several Concepts In Chemistry That Have Been Introduced At The 10+2 Levels In Schools. Technology Is Being Increasingly Based On The Electronic, Atomic And Molecular Level Modifications.

Quantum Theory Is More Than 100 Years Old And To Understand Phenomena At Nanometer Levels, One Has To Base The Description Of All Chemical Processes At Molecular Levels. The Course Will Enable The Student To: Analyse Microscopic Chemistry In Terms Of Atomic And Molecular Orbitals And Intermolecular Forces. Rationalise Bulk Properties And Processes Using Thermodynamic Considerations. Distinguish The Ranges Of The Electromagnetic Spectrum Used For Exciting Different Molecular Energy Levels In Various Spectroscopic Techniques Rationalise Periodic Properties Such As Ionization Potential, Electronegativity, Oxidation States And Electronegativity. List Major Chemical Reactions That Are Used In The Synthesis Of Molecules.

Chemistry Laboratory

Choice Of 10-12 Experiments From The Following

- Determination Of Surface Tension And Viscosity
- Thin Layer Chromatography
- Ion Exchange Column For Removal Of Hardness Of Water
- Determination Of Chloride Content Of Water
- Colligative Properties Using Freezing Point Depression
- Determination Of The Rate Constant Of A Reaction
- Determination Of Cell Constant And Conductance Of Solutions
- Potentiometry - Determination Of Redox Potentials And Emfs
- Synthesis Of A Polymer/Drug
- Saponification/Acid Value Of An Oil
- Chemical Analysis Of A Salt
- Lattice Structures And Packing Of Spheres
- Models Of Potential Energy Surfaces
- Chemical Oscillations- Iodine Clock Reaction
- Determination Of The Partition Coefficient Of A Substance Between Two Immiscible Liquids Adsorption Of Acetic Acid By Charcoal



Use Of The Capillary Viscometers To Demonstrate Of The Isoelectric Point
As The Ph Of Minimum Viscosity For Gelatin Sols And/Or Coagulation Of The White Part Of Egg.

Laboratory Outcomes

The Chemistry Laboratory Course Will Consist Of Experiments Illustrating The Principles Of Chemistry Relevant To The Study Of Science And Engineering. The Students Will Learn To: Estimate Rate Constants Of Reactions From Concentration Of Reactants/Products As A Function Of Time Measure Molecular/System Properties Such As Surface Tension, Viscosity, Conductance Of Solutions, Redox Potentials, Chloride Content Of Water, Etc Synthesize A Small Drug Molecule And Analyse A Salt Sample.

PAPER CODE - 101202

101202	Mathematics -Ii (Differential Equations)	L:3	T:1	P:0	Credit:4
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Ordinary Differential Equations

Module 3A

First Order Ordinary Differential Equations: Exact, Linear And Bernoulli's

Equations, Euler's Equations, Equations Not Of First Degree: Equations Solvable For P, Equations Solvable For Y, Equations Solvable For X And Clairaut's Type.

Module 3B

Ordinary Differential Equations Of Higher Orders: Second Order Linear

Differential Equations With Variable Coefficients, Method Of Variation Of Parameters, Cauchy-Euler Equation; Power Series Solutions; Legendre Polynomials, Bessel Functions Of The First Kind And Their Properties.

Textbooks/References:

- Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
- W. E. Boyce And R. C. DiPrima, Elementary Differential Equations And Boundary Value Problems, 9th Edition, Wiley India, 2009.
- S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
- E. A. Coddington, An Introduction To Ordinary Differential Equations, Prentice Hall India, 1995.
- E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
- G.F. Simmons And S.G. Krantz, Differential Equations, Tata Mcgraw Hill, 2007.

Partial Differential Equations

Module 3C

Partial Differential Equations - First Order: First Order Partial Differential Equations, Solutions Of First Order Linear And Non Linear Pdes.

Module 3D

Partial Differential Equations - Higher Order: Solution To Homogeneous And Non Homogeneous Linear Partial Differential Equations Second And Higher Order By Complementary Function And Particular Integral Method. Flows, Vibrations And Diffusions, Second-Order Linear Equations And Their Classification, Initial And Boundary Conditions (With An Informal Description Of Well-Posed Problems), D'Alembert's Solution Of The Wave Equation; Duhamel's Principle For One Dimensional Wave Equation. Separation Of Variables Method To Simple Problems In Cartesian Coordinates. The Laplacian In Plane, Cylindrical And Spherical Polar Coordinates, Solutions With Bessel Functions And Legendre Functions. One Dimensional Diffusion Equation And Its Solution By Separation Of Variables. Boundary-Value Problems: Solution Of Boundary-Value Problems For Various Linear Pdes In Various Geometries.

Textbooks/References:

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- S. J. Farlow, Partial Differential Equations For Scientists And Engineers, Dover Publications, 1993.
- R. Haberman, Elementary Applied Partial Differential Equations With Fourier Series
And Boundary Value Problem, 4th Ed., Prentice Hall, 1998.
- Ian Sneddon, Elements Of Partial Differential Equations, Mcgraw Hill, 1964.
- Manish Goyal And N.P. Bali, Transforms And Partial Differential Equations, University Science Press, Second Edition, 2010.

Complex Variables

Module 4a

Complex Variable - Differentiation: Differentiation, Cauchy-Riemann Equations, Analytic Functions, Harmonic Functions, Finding Harmonic Conjugate; Elementary Analytic Functions (Exponential, Trigonometric, Logarithm) And Their Properties; Conformal Mappings, Mobius Transformations And Their Properties.

Module 4B

Complex Variable - Integration: Contour Integrals, Cauchy-Goursat Theorem (Without Proof), Cauchy Integral Formula (Without Proof), Liouville's Theorem And Maximum-Modulus Theorem(Without Proof); Taylor's Series, Zeros Of Analytic Functions, Singularities, Laurent's Series; Residues, Cauchy Residue Theorem (Without Proof), Evaluation Of Definite Integral Involving Sine And Cosine, Evaluation Of Certain Improper Integrals Using The Bromwich Contour.

Module 4A

Applications Of Complex Integration By Residues: Evaluation Of Definite Integral Involving Sine And Cosine. Evaluation Of Certain Improper Integrals Using The Bromwich Contour.

Textbooks/References:

- Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
- J. W. Brown And R. V. Churchill, Complex Variables And Applications, 7th Ed., Mc- Graw Hill, 2004.
- Veerarajan T., Engineering Mathematics For First Year, Tata Mcgraw-Hill, New Delhi, 2008.
- N.P. Bali And Manish Goyal, A Text Book Of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
- B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.

Numerical Methods

Module 5A

Numerical Methods - 1: Solution Of Polynomial And Transcendental Equations -
Bisection Method, Newton-Raphson Method And Regula-Falsi Method.
Finite Differences,
Relation Between Operators, Interpolation Using Newton's Forward And Backward
Difference Formula. Interpolation With Unequal Intervals: Newton's Divided Difference
And Lagrange's Formula. Numerical Differentiation, Numerical
Integration: Trapezoidal Rule And Simpson's 1/3rd And 3/8 Rules.

Module 5B

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Numerical Methods - 2: Ordinary Differential Equations: Taylor's Series, Euler

And Modified Euler's Methods. Runge- Kutta Method Of Fourth Order For Solving First

And Second Order Equations. Milne's And Adams Predictor-Corrector Methods. Partial

Differential Equations: Finite Difference Solution Two Dimensional Laplace Equation

And Poisson Equation, Implicit And Explicit Methods For One Dimensional Heat Equation (Bender-Schmidt And Crank-Nicolson Methods), Finite Difference Explicit Method For Wave Equation.

Textbooks/References:

- P. Kandasamy, K. Thilagavathy, K. Gunavathi, Numerical Methods, S. Chand & Company, 2nd Edition, Reprint 2012.
- S.S. Sastry, Introductory Methods Of Numerical Analysis, Phi, 4th Edition, 2005.
- Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
- B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2010.

PAPER CODE - 100204

100204	Programming For Problem Solving	L:3	T:0	P:4	Credit:5
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Module 1

Introduction To Programming: Introduction To Components Of A Computer System

(Disks, Memory, Processor, Where A Program Is Stored And Executed, Operating System, Compilers Etc). Idea Of Algorithm: Steps To Solve Logical And Numerical Problems.

Representation Of Algorithm: Flowchart/Pseudocode With Examples. From Algorithms To

Programs; Source Code, Variables (With Data Types) Variables And Memory Locations,

Type Casting/Type Conversion, Run Time Environment (Static, Dynamic Location),

Storage Classes (Auto, Register, Static, Extern), Syntax And Logical Errors In Compilation, Object And Executable Code.

Module 2

Operators: Arithmetic Expressions/Arithmetic Operators/Relational Operators/Logical Operators/Bitwise Operators And Precedence

Module 3

Conditional Branching And Loops: Writing And Evaluation Of Conditionals And Consequent Branching, Iteration And Loops

Module 4

Arrays: Array Declaration & Initialization, Bound Checking Arrays (1-D, 2-D), Character Arrays And Strings.

Module 5

Basic Algorithms: Searching (Linear Search, Binary Search Etc.), Basic Sorting Algorithms (Bubble, Insertion And Selection), Finding Roots Of Equations, Notion Of Order Of Complexity Through Example Programs (No Formal Definition Required)

Module 6

Function: Introduction & Writing Functions, Scope Of Variables Functions (Including Using Built In Libraries), Parameter Passing In Functions, Call By Value, Passing Arrays To Functions: Idea Of Call By Reference

Module 7

Recursion: Recursion, As A Different Way Of Solving Problems. Example Programs, Such As Finding Factorial, Fibonacci Series, Reverse A String Using Recursion, And Gcd Of Two Numbers, Ackermann Function Etc. Quick Sort Or Merge Sort.

Module 8

Structure/Union: Structures, Accessing Structure Elements, Way Of Storage Of

Structure Element, Defining Structures And Array Of Structures, Basic Definition Of Union, Comparison B/W Structure & Union With Example

Module 9

Pointers: Idea Of Pointers, Defining Pointers, Use Of Pointers In Self-Referential Structures, Notion Of Linked List (No Implementation), Pointer To Pointer, Pointer To Array, Pointer To Strings, Array Of Pointer, Pointer To Function, Pointer To Structure.

Module 10

File Handling

(Only If Time Is Available, Otherwise Should Be Done As Part Of The Lab)

Suggested Text Books

- Byron Gottfried, Schaum's Outline Of Programming With C, Mcgraw-Hill
- E. Balaguruswamy, Programming In Ansi C, Tata Mcgraw-Hill

Suggested Reference Books

- Brian W. Kernighan And Dennis M. Ritchie, The C Programming Language, Prentice Hall Of India
- Yashwant Kanetkar, Let Us C, Bpb Publication

The Student Will Learn

- To Formulate Simple Algorithms For Arithmetic And Logical Problems.
- To Translate The Algorithms To Programs (In C Language).
- To Test And Execute The Programs And Correct Syntax And Logical Errors.
- To Implement Conditional Branching, Iteration And Recursion.
- To Decompose A Problem Into Functions And Synthesize A Complete Program Using Divide And Conquer Approach.
- To Use Arrays, Pointers And Structures To Formulate Algorithms And Programs.
- To Apply Programming To Solve Matrix Addition And Multiplication Problems And Searching And Sorting Problems.

- To Apply Programming To Solve Simple Numerical Method Problems, Namely Root Finding Of Function, Differentiation Of Function And Simple Integration.

Laboratory Programming For Problem Solving

[The Laboratory Should Be Preceded Or Followed By A Tutorial To Explain The Approach Or Algorithm To Be Implemented For The Problem Given.]

Tutorial 1: Problem Solving Using Computers:

Lab1: Familiarization With Programming Environment

Tutorial 2: Variable Types And Type Conversions:

Lab 2: Simple Computational Problems Using Arithmetic Expressions

Tutorial 3: Branching And Logical Expressions:

Lab 3: Problems Involving If-Then-Else Structures

Tutorial 4: Loops, While And For Loops:

Lab 4: Iterative Problems E.G., Sum Of Series

Tutorial 5: 1d Arrays: Searching, Sorting:

Lab 5: 1d Array Manipulation

Tutorial 6: 2d Arrays And Strings

Lab 6: Matrix Problems, String Operations

Tutorial 7: Functions, Call By Value:

Lab 7: Simple Functions

Tutorial 8: Numerical Methods (Root Finding, Numerical Numerical Integration):

Lab 8: Programming For Solving Numerical Methods Problems
Differentiation,

Tutorial 9: Recursion, Structure Of Recursive Calls

Lab 9: Recursive Functions

Tutorial 10: Pointers, Structures And Dynamic Memory Allocation

Lab 10: Pointers And Structures

Tutorial 11: File

Handling: Lab 11: File

Operations

Laboratory Outcomes

- To Formulate The Algorithms For Simple Problems
- To Translate Given Algorithms To A Working And Correct Program
- To Be Able To Correct Syntax Errors As Reported By The Compilers
 - To Be Able To Identify And Correct Logical Errors Encountered At Run Time
 - To Be Able To Write Iterative As Well As Recursive Programs.
- To Be Able To Represent Data In Arrays, Strings And Structures And Manipulate Them Through A Program
- To Be Able To Declare Pointers Of Different Types And Use Them In Defining Self- Referential Structures.
- To Be Able To Create, Read And Write To And From Simple Text Files.

PAPER CODE - 100205

Bsc	Workshop Manufacturing Practices	L:1	T:0	P:4	Credit:3
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Detailed Contents:

1. Manufacturing Methods-Casting, Forming, Machining, Joining, Advanced Manufacturing Methods (3 Lectures)
2. Cnc Machining, Additive Manufacturing (1 Lecture)
3. Fitting Operations & Power Tools (1 Lecture)
4. Carpentry (1 Lecture)
5. Plastic Moulding, Glass Cutting (1 Lecture)
6. Metal Casting (1 Lecture)
7. Welding (Arc Welding & Gas Welding), Brazing, Soldering (2

Lecture) **Suggested Text/Reference Books:**

- Hajra Choudhury S.K., Hajra Choudhury A.K. And Nirjhar Roy S.K., "Elements Of Workshop Technology", Vol. I 2008 And Vol. Ii 2010, Media Promoters And Publishers Private Limited, Mumbai.
- Kalpakjian S. And Steven S. Schmid, "Manufacturing Engineering And Technology", 4th Edition, Pearson Education India Edition, 2002.
- Gowri P. Hariharan And A. Suresh Babu, "Manufacturing Technology - I" Pearson Education, 2008.
- Roy A. Lindberg, "Processes And Materials Of Manufacture", 4th Edition, Prentice Hall India, 1998.
- Rao P.N., "Manufacturing Technology", Vol. I And Vol. Ii, Tata Mcgrawhill House, 2017.

Course Outcomes:

- Upon Completion Of This Course, The Students Will Gain Knowledge Of The Different Manufacturing Processes Which Are Commonly Employed In The Industry, To Fabricate Components Using Different Materials.

Workshop Practice: (60 Hours) [L: 0; T: 0; P: 4 (2 Credits)]

1. Machine Shop (10 Hours) And Fitting Shop (8 Hours)
2. Carpentry (6 Hours)
3. Welding Shop (8 Hours) (Arc Welding 4 Hrs + Gas Welding 4 Hrs)
4. Casting (8 Hours) And Smithy (6 Hours)
5. Plastic Moulding & Glass Cutting (6 Hours)
6. 3-D Printing Of Different Models (8 Hours)

Examinations Could Involve The Actual Fabrication Of Simple Components, Utilizing One Or More Of The Techniques Covered Above.

Laboratory Outcomes

- Upon Completion Of This Laboratory Course, Students Will Be Able To Fabricate Components With Their Own Hands.
- They Will Also Get Practical Knowledge Of The Dimensional Accuracies And Dimensional Tolerances Possible With Different Manufacturing Processes.
- By Assembling Different Components, They Will Be Able To Produce Small Devices Of Their Interest. By Assembling Different Components, They Will Be Able To Produce Small Devices Of Their Interest.

Paper Code - 100206

HMSC	English	L:2	T:0	P:2	Credit:3
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1. Vocabulary Building

- A. The Concept Of Word Formation
- B. Root Words From Foreign Languages And Their Use In English
- C. Acquaintance With Prefixes And Suffixes From Foreign Languages In English To Form Derivatives.
- D. Synonyms, Antonyms, And Standard Abbreviations.
- E. Affixes, Acronyms

2. Basic Writing Skills

- A. Sentence Structures
- B. Use Of Phrases And Clauses In Sentences
- C. Importance Of Proper Punctuation
- D. Kinds Of Sentences
- E. Use Of Tense, Use In Context And Coherence Of Tense In Writing
- F. Use Of Voice - Active/Passive In Sentences
- G. Use Of Speech - Direct And Indirect Speech
- H. Framing Questions- Direct, Using Modal Verbs

3. Identifying Common Errors In Writing

- A. Subject-Verb Agreement
- B. Noun-Pronoun Agreement
- C. Misplaced Modifiers
- D. Articles
- E. Prepositions
- F. Redundancies
- G. Clichés
- H. H. Common English Errors

4. Nature And Style Of Sensible Writing

- A. Describing
- B. Defining
- C. Classifying
- D. Providing Examples Or Evidence
- E. Writing Introduction And Conclusion
- F. Organising Principle Of Paragraphs In Documents
- G. Argument, Describing/ Narrating/ Planning, Defining, Classifying
- H. Lexical Resources, Using Suitable Language Register
- I. Coherence, Writing Introduction, Body And Conclusion, Techniques For Writing Precisely, Grammar And Accuracy

5. Writing Practices

- A. Comprehension
- B. Formal Letter Writing/ Application/ Report Writing/ Writing Minutes Of Meetings
- C. Essay Writing
- D. Formal Email Writing
- E. Resume/ Cv Writing, Cover Letter,
- F. Statement Of Purpose

6. Oral Communication

(This Unit Involves Interactive Practice Sessions In Language Lab)

- A. Listening Comprehension
- B. Pronunciation, Intonation, Stress And Rhythm
- C. Common Everyday Situations: Conversations And Dialogues
- D. Communication At Workplace
- E. Interviews
- F. Formal Presentations
- G. Acquainting Students With Ipa Symbols
- H. Phonetics (Basic)
- I. Sounds - Vowels, Consonants
- J. Clearing Mother Tongue Influence
- K. Clearing Redundancies And Common Errors Related To Indianisms
- L. Group Discussion
- M. Expressing Opinions
- N. Coherence And Fluency In Speech

7. Reading Skills

- A. Reading Comprehension,
- B. Paragraph Reading Based On Phonetic Sounds/ Intonation

8. Professional Skills

- A. Team Building
- B. Soft Skills And Etiquettes

9. Acquaintance With Technology-Aided Language Learning

- A. Use Of Computer Software (Grammarly, Ginger...)
- B. Use Of Smartphone Applications (Duolingo, Busuu...)

10. Activities

- A. Narrative Chain
- B. Describing/ Narrating
- C. Writing Essays In Relay
- D. Peer/ Group Activities
- E. Brainstorming Vocabulary
- F. Cue / Flashcards For Vocabulary
- G. Debates

Suggested Readings:

- Practical English Usage. Michael Swan. Oup. 1995.
- Remedial English Grammar. F.T. Wood. Macmillan.2007
- On Writing Well. William Zinsser. Harper Resource Book. 2001
- Study Writing. Liz Hamp-Lyons And Ben Heasley. Cambridge University Press. 2006.
- Communication Skills. Sanjay Kumar And Pushp Lata. Oxford University Press. 2011.
- Exercises In Spoken English. Parts. I-Iii. Ciefl, Hyderabad. Oxford University Press.

Course Outcomes:

The Student Will Acquire Basic Proficiency In English Including Reading And Listening Comprehension, Writing And Speaking Skills.

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