ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ
"ರಾಷ್ಟ್ರೀಯ ಅಭಿವೃದ್ಧಿ ಗುರಿಗಳ ಸಾಧನೆಯಲ್ಲಿ" ಕರ್ನಾಟಕ ಸರ್ಕಾರದಿಂದ ಸ್ಥಾಪಿತವಾದ ರಾಜ್ಯ ವಿಶ್ವವಿದ್ಯಾಲಯ
"ಜ್ಞಾನ ಸಂಗಮ", ಬೆಳಗಾವಿ-೫೯೦೦೧೮, ಕರ್ನಾಟಕ, ಭಾರತ

Visvesvaraya Technological University
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Dr. A. S. Deshpande B.E., M.Tech., Ph.D.
Registrar

Phone: (0831) 2498100
Fax: (0831) 2405467

Ref: VTU/BGM/BOS/A9/2021-22 / 4305

Date: 14 DEC 2021

CIRCULAR

Subject: Updated syllabus of 21PHY12/22, 21CHE12/22 and 21CHEL16/26 regarding...

Reference:

1. VTU/BGM/BOS/A9/2021-22/4218, dated 10.12.2021
2. The Hon'ble Vice-Chancellor's approval dated: 13.12.2021

The based on the feedback the following syllabi have been updated by the Board of Studies in Basic Sciences of VTU Belagavi.

1. 21PHY12/22 Engineering Physics
2. 21CHE12/22 Engineering Chemistry
3. 21CHEL16/26 Engineering Chemistry Laboratory

All the principals of Engineering Colleges are hereby informed to bring the content of this circular to the notice of the concerned. Please note: the updated syllabi of the above-mentioned subjects are made available @ **https://vtu.ac.in/en/b-e-scheme-syllabus/#menu05**

Sd/-
Registrar

Encl: As mentioned above.

To,

- All the Principals of the Engineering Colleges under the ambit of VTU Belagavi.

Copy to:

1. The Hon'ble Vice-Chancellor through the secretary to VC for information
2. The Registrar(Evaluation) for information and needful
3. The Registrar's Office, VTU, Belagavi, for information.
4. The Special Officer, Academic Section, VTU Belagavi, for information.
5. The Director ITI SMU CNC for information and to upload the circular on the VTU web portal

REGISTRAR

11.12.2021

I Semester

ENGINEERING CHEMISTRY			
Course Code	**21CHE12/22**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3Hour

Course Objectives: The course will enable the students to

CLO1: Impart the basic knowledge of chemistry and its principles involved in electrochemistry, energy storage devices and its commercial applications.

CLO2: Understand the basic principles of corrosion and its prevention, metal finishing and its technological importance

CLO3: Master the knowledge of synthesis, properties and utilization of engineering materials like polymers & Nano materials.

CLO4: Apply the knowledge of Green Chemistry principles for production of chemical compounds. understanding the concepts of alternative energy sources.

CLO5: Understand the basic concepts of water chemistry & theory, basic principle and applications of volumetric analysis and analytical instruments.

Pedagogy (General Instructions):

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Show Video/animation films to explain methods of synthesis of nanomaterials.
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

Module-1

Electrochemistry and energy storage systems:

Electrochemistry: Introduction, EMF of cell, Free Energy, Single electrode potential-Derivation of Nernst equation, Numerical problems based on Nernst Equation.

Reference Electrodes: Introduction, construction, working and applications of calomel electrode, ion selective electrodes: Introduction, construction, working and applications of Glass electrode, determination of pH using Glass electrode.

Energy storage Systems: Introduction, Classification of batteries (primary, secondary and reserved batteries). Construction, working and applications of Li-ion batteries. Advantages of Li-ion battery as an electrochemical energy system for electric vehicles. Recycling of Lithium-ion batteries, Introduction, brief discussion on direct cycling method, Sodium-ion battery-Introduction.

Pedagogy	Electrochemistry and energy systems-chalk and talk method, power point presentation, Practical topic: Determination of pKa value of weak acid using glass electrode. Energy storage Systems-Power point presentation, youtube videos for Li-ion battery construction and working. Recycling of Lithium-ion batteries, Introduction, brief discussion on direct cycling method Self-study material: Construction and working of classical batteries like Zn-MnO_2 and Pb-PbO_2 batteries Sodium-ion battery-Introduction.

Module-2

Corrosion and Metal finishing:

Corrosion and it's control:

Introduction, Electrochemical theory of corrosion, Factors affecting the rate of corrosion: ratio of anodic to cathodic areas, nature of corrosion product, nature of medium – pH, conductivity and temperature. Types of corrosion - Differential metal and differential aeration (pitting and water line). Corrosion control: Inorganic coating- Anodizing – Anodizing of aluminum, Cathodic protection - sacrificial anode and impressed current methods, Metal coatings – Galvanization. Corrosion Penetration Rate (CPR), numerical problems on CPR.

Metal finishing: Introduction, Technological importance. Electroplating: Introduction, Electroplating of chromium (hard and decorative). Electroless plating: Introduction, distinction between electroplating and electroless plating processes. Electroless plating of copper.

Pedagogy	Chalk and talk method and power point presentation - Electrochemical theory of corrosion, Factors affecting the rate of corrosion, Types of corrosion and corrosion control. Technological importance. Electroplating: Introduction, Videos: Electroplating of chromium, electroless plating of copper Self-learning material: Organic coatings: Paint, components of paints and their functions. Varnish, definition, differences between paints varnishes. principles governing electroplating-Polarization, decomposition potential and overvoltage.

Module-3

Engineering Materials

Polymers: Introduction, Synthesis and applications of Polyurethanes. Polymer composites-Introduction, synthesis, properties & applications of Kevlar Fibre,

Conducting Polymers: Introduction, Synthesis & Mechanism of conduction in polyaniline and factors influencing conductivity of organic polymers.

Biodegradable polymers: Introduction and their requirements. Synthesis, properties and applications of Poly lactic acid.

Nanomaterials:

Introduction, size dependent properties (Surface area, Electrical, Optical and Catalytic properties). Synthesis of nanomaterials: Top down and bottom up approaches, Synthesis by Sol-gel, and precipitation method, Nanoscale materials: Fullerenes, Carbon nanotubes and graphemes –Introduction, properties and applications.

Pedagogy	Chalk and talk method - Polymers, Conducting Polymers, Biodegradable polymers. Power point presentation on Nanomaterials: Practical topic: Synthesis of nanomaterial by Precipitation method. Self-learning material: classification of polymers. Nano materials synthesis by Chemical vapor deposition.

Module-4

Green Chemistry and Alternative energy resources

Green Chemistry: Introduction, definition, Major environmental pollutants, Basic principles of green chemistry. Various green chemical approaches – Microwave synthesis, Bio catalysed reactions, mechanism of degradation, Super critical conditions for solvent free reactions. Synthesis of typical organic compounds by conventional and green route; i) Adipic acid ii) Paracetamol

Atom economy – Synthesis of Ethylene oxide & Methyl Methacrylate. Industrial applications of green chemistry, Numerical problems on Atom economy.

Green fuel: Hydrogen-production (Photo electro catalytic and photo catalytic water splitting) and applications in hydrogen fuel cells. Construction, working and applications of Methanol-Oxygen fuel cell (H_2SO_4 as electrolyte).

Solar Energy:

Introduction, construction, working and applications of photovoltaic cell.

Pedagogy	Chalk and talk/power point presentation - Basic principles of green chemistry, Videos: Various green chemical approaches, Self-study material: Atom economy, advantages & disadvantages of photovoltaic cell.

Module-5

Water Chemistry, Methods of chemical analysis and Instrumental methods of analysis

Water chemistry:

Introduction, sources and impurities in water, Potable water; meaning and specifications (as per WHO standards), Hardness of water, types, determination of hardness using EDTA titration, numerical problems on hardness of water.

Biological oxygen demand (BOD), Definition and Chemical Oxygen Demand (COD). Definition, determination of COD of waste water sample and Numerical problems on COD.

Methods of Chemical Analysis:

Volumetric Analysis: Introduction, principles of titrimetric analysis, requirement of titrimetric analysis, primary and secondary standards. Requirement of a primary standard solution, units of standard solutions (normality, molarity, molality, mole fraction, ppm).

Instrumental methods of analysis:

Introduction, Theory, Instrumentation and applications of Colorimetry, Flame Photometry, Potentiometry, Conductometry (Strong acid with strong base, weak acid with a strong base, mixture of strong acid and a weak acid with a strong base)

Pedagogy	Chalk and talk/power point presentation – principles of titrimetric analysis, requirement of titrimetric analysis, Classification of titrimetric analysis, Ostwald's theory of acid-base indicator taking phenolphthalein and methyl orange as examples. Instrumental methods of analysis. Practical topic: Volumetric titrations, instrumental methods. Self-study material- Types of volumetric titrations (Neutralization, redox and complexometric), Equivalent weights.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

CO1: Discuss the electrochemical energy systems such as electrodes and batteries.

CO2: Explain the fundamental concepts of corrosion, its control and surface modification methods namely electroplating and electroless plating

CO3: Enumerate the importance, synthesis and applications of polymers. Understand properties and application of nanomaterials.

CO4: Describe the principles of green chemistry, understand properties and application alternative fuels.

CO5: Illustrate the fundamental principles of water chemistry, applications of volumetric and analytical instrumentation.

Assessment Details (both CIE and SEE)

(methods of CIE need to be define topic wise i.e.- MCQ, Quizzes, Open book test, Seminar or micro project)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain minimum of 40% marks individually both in CIE and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration). Based on this grading will be awarded.

Continuous Internal Evaluation:

1. Methods suggested: Test, Open Book test, Written Quiz, Seminar, report writing etc.
2. The class teacher has to decide the topic for closed book test, open book test, Written Quiz and Seminar. In the beginning only teacher has to announce the methods of CIE for the subject.

Semester End Examination:

Theory SEE will be conducted by University as per scheduled time table, with common question papers for subject

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub questions), should have a mix of topics under that module.

Suggested Learning Resources:

Books

1. Uppal M.M, Jain and Jain. Engineering Chemistry, Khanna Publishers, 35th Edition, 2013.
2. P.C. Jain and Monica Jain, A test Book of Engineering Chemistry, Dhanpat Rai Publications, New Delhi, 12th Edition, 2012.
3. SS Dara & Dr. SS Umare. -A Text book of Engineering Chemistry, S Chand & Company Ltd., 12th Edition, 2011.

4. R.V. Gadag and Nitthyananda Shetty-A Text Book of Engineering Chemistry, I.K. International Publishing house. 2nd Edition, 2016.
5. B.S. Jai Prakash, R. Venugopal, Sivakumaraiah& Pushpa Iyengar.,- Chemistry for Engineering Students", Subash Publications, Bangalore.5th Edition, 2014
6. F.W. Billmeyer, Text Book of Polymer Science, John Wiley & Sons, 4th Edition, 1999.
7. M.G. Fontana, N.D. Greene, Corrosion Engineering, McGraw Hill Publications, New York, 3rd Edition, 1996.
8. Principles of Physical Chemistry , B.R. Puri, L.R. Sharma & M.S. Pathania, S. Nagin Chand & Co., 41 Edition, 2004.
9. G.A. Ozin & A.C. Arsenault, "Nanotechnology A Chemical Approach to Nanomaterials". RSC Publishing, 2005.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=faESCxAWR9k
- https://www.youtube.com/watch?v=TBqXMWaxZYM&list=PLyhmwFtznRhuz8L1bb3X-9IbHrDMjHWWh
- https://www.youtube.com/watch?v=j5Hml6KN4TI
- https://www.youtube.com/watch?v=X9GHBdyYcyo
- https://www.youtube.com/watch?v=1xWBPZnEJk8
- https://www.youtube.com/watch?v=wRAo-M8xBHM.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- https://www.vlab.co.in/broad-area-chemical-sciences
- https://demonstrations.wolfram.com/topics.php
- https://interestingengineering.com/science

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ENGINEERING CHEMISTRY LABORATORY			
Course Code	21CHEL16/26	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2	SEE Marks	50
Credits	01	Exam Hours	3hrs

Course objectives:

CLO1	Quantitative analysis of materials by volumetric and chemical method.
CLO2	Instrumental methods for developing experimental skills in building technical competence

Sl.NO	Instrumentation Experiments
1	Estimation of FAS Potentiometrically using standard $K_2Cr_2O_7$ solution.
2	Estimation of Acids in acid mixture Conductometrically.
3	Determination of Viscosity coefficient of a given liquid using Ostwald's viscometer
4	Estimation of copper Colorimetrically.
5	Determination of pKa value of a given weak acid using pH meter
	Volumetric experiments
1	Estimation of Total hardness of water by EDTA complexometric method.
2	Determination of Nickel using EDTA by complexometric method
3	Determination of percentage of copper in brass using standard sodium thiosulphate solution.
4	Determination of Chemical oxygen demand of industrial waste water.
5	Estimation of percentage of iron in the given rust solution using standard Potassium Dichromate solution (External indicator method)
	Demonstration Experiments (For CIE only)
1	Estimation of Sodium & Potassium in the given sample of water using Flame Photometer.
2	Synthesis of nanomaterial by Precipitation method.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

CO1	Determine the pKa and coefficient of Viscosity of a given organic liquid.
CO2	Estimate the amount of substance present in the given solution using Potentiometer Conductometric and Colorimetric.
CO3	Determine the total hardness and chemical oxygen demand in the given solution by volumetric analysis method
CO4	Estimate the percentage of Nickel, copper and Iron in the given analyte solution by titration method.
CO5	Demonstrate flame photometric estimation of sodium & potassium and the synthesis of nanomaterials by Precipitation method.

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Assessment Details (both CIE and SEE)

Continuous Internal Evaluation (CIE): The CIE marks awarded in case of Practical shall be based on the weekly evaluation of laboratory journals/ reports after the conduction of every experiment and one practical test.

Semester End Evaluation (SEE): The practical examinations to be conducted as per the time table of University in a batch wise with strength of students not more than 10-15 per batch.

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Suggested Learning Resources:

Text Books:

1 Vogel's A.I. A text book of quantitative analysis, 35th edition, 2012.
2 Willard, Merit, Dean and Settle, A text book of Instrumental analysis, 6th edition 2012.

Reference books:

1. G.H Jeffery, J Bassett, J Mendham and R.C. Denney Vogel's A.I. A text book of quantitative analysis, Dorling Kindersley (India) Pvt., Ltd. 35th edition, 2012.
2. Gary D Christian, Analytical Chemistry, Wiley India, 6th edition, 2015.
3. T. Pradeep, A Text book of Nanoscience and Nanotechnology, McGraw Hill Education (India) Pvt., Ltd., 1st edition, 2015

11.12.2021

I/II Semester

Engineering Physics			
Course Code	21PHY12/22	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hours

Course objectives: This course(21PHY12/22) will enable the students to

- Learn the basic concepts of Physics which are essential in understanding and solving Engineering related challenges.
- Gain the knowledge of problem solving and its practical applications.
- Signify the application of sensitive instrumentation for Nano-scale system.

Pedagogy (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Apart from conventional lecture methods various types of innovative teaching techniques through videos, animation films may be adopted so that the delivered lesson can progress the students in theoretical, applied and practical skills in physics.
2. State the necessity of physics in engineering studies and offer real life examples.
3. Seminars and Quizzes may be arranged for students in respective subjects to develop skills.
4. Encourage the students for group learning to improve their creativity and analytical skills.
5. While teaching show how every concepts can be applied to the real world. This helps the students to expand understanding level.
6. Support and guide the students for self-study.
7. Ask some higher order thinking questions in the class, which promotes critical thinking.
8. Inspire the students towards the studies by giving new ideas and examples.

Module-1

Oscillations and Waves: **08 Hours**

Free Oscillations: Basics of SHM, derivation of differential equation for SHM, Mechanical simple harmonic oscillators (spring constant by series and parallel combination), Equation of motion for free oscillations, Natural frequency of oscillations.

Damped Oscillations: Theory of damped oscillations (derivation), over damping, critical & under damping (only graphical representation), quality factor.

ForcedOscillations: Theory of forced oscillations (derivation) and resonance, sharpness of resonance.

Shock waves: Mach number, Properties of Shock waves, Construction and working of Reddy shock tube, applications of shock waves, Numerical problems.

Pedagogy	Chalk and talk, Power point presentation, Videos **Practical Topics:** 1.Spring in series and parallel combination **Self-study Component:** Basics of SHM

Module-2

Modern Physics & Quantum Mechanics: **08 Hours**

Introduction to blackbody radiation spectrum- Wien's law, Rayleigh Jean's law, Stefan -Boltzmann law and Planck's law (qualitative), Deduction of Wien's law and Rayleigh Jeans law from Planck's law. Wave-Particle dualism, de-Broglie hypothesis, de-Broglie wavelength. Heisenberg's uncertainty principle and its physical significance, Application of uncertainty principle-Non-existence of electron in the nucleus (relativistic case), Wave function-Properties, Physical significance, Probability density, Normalization, Eigen values and Eigen functions. Time independent Schrödinger wave equation. Particle in a box- Energy Eigen values and probability densities, Numerical problems.

Pedagogy	Chalk and talk, Power point presentation, Videos **Practical Topics:** 1.Verification of Stefan's Law **Self-study Component:** Wave- Particle dualism, de-Broglie hypothesis , de- Broglie wavelength.

Module-3

Lasers & Optical Fibers: **08 Hours**

Lasers: Interaction of radiation with matter, Einstein's coefficients (derivation of expression for energy density). Requisites of a Laser system. Conditions for Laser action. Principle, Construction and working of CO_2 and semiconductor Lasers. Application of Lasers in Defence (Laser range finder) and medical applications- Eye surgery and skin treatment.

Optical Fibers: Propagation mechanism, angle of acceptance, Numerical aperture, Modes of propagation, Types of optical fibers, Attenuation and Mention of expression for attenuation coefficient. Discussion of block diagram of point to point communication, Optical fiber sensors- Intensity based displacement sensor and Temperature sensor based on phase modulation, Merits and demerits, Numerical problems.

Pedagogy	Chalk and talk, Power point presentation, Videos **Practical Topics:** 1. wavelength of LASER source 2. Optical fiber **Self-study Component:** Properties of Laser and comparison with ordinary source

Module-4

Electrical Conductivity in Solids: **08 Hours**

Classical free electron theory: Drude- Lorentz theory & Assumptions, Expression for electrical conductivity (no derivation), Failures of classical free-electron theory.

Quantum free electron theory: Assumptions, Density of states (no derivation), Fermi-energy, Fermi factor & its temperature dependence, Fermi - Dirac Statistics, Expression for electrical conductivity (derivation), Merits of Quantum free electron theory.

Physics of Semiconductors: Fermi level in intrinsic semiconductors, Expression for concentration of electrons in conduction band, Holes concentration in valance band (only mention the expression), Conductivity of semiconductors (derivation), Hall effect, Expression for Hall coefficient (derivation).

Dielectrics: Electric dipole, Dipole moment, Polarization of dielectric materials, Types of polarizations. Qualitative treatment of Internal field in solids for one dimensional infinite array of dipoles (Lorentz field). Claussius-Mossotti equation (derivation), Numerical problems.

Pedagogy	Chalk and talk, Power point presentation, Videos **Practical Topics:** 1.Fermi Energy of a material 2. Resistivity of a material **Self-study Component:** Electric dipole, Dipole moment, Polarization of dielectric materials

Module-5

Material Characterization Techniques and Instrumentation: **08 Hours**

Introduction to materials: Nanomaterials and nanocomposites. Principle, construction and working of X-ray Diffractometer, crystal size determination by Scherrer equation. Principle, construction, working and applications of -Atomic Force Microscopy (AFM), X-ray Photoelectron Spectroscopy(XPS), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) Numerical problems.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self study Component:**X-ray diffractometer.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

1. Interpret the types of mechanical vibrations and their applications, the role of Shock waves in various fields.
2. Demonstrate the quantisation of energy for microscopic system.
3. Apply LASER and Optical fibers in opto electronic system.
4. Illustrate merits of quantum free electron theory and applications of Hall effect.
5. Analyse the importance of XRD and Electron Microscopy in Nano material characterization.

Assessment Details (both CIE and SEE)

(methods of CIE need to be define topic wise i.e.- MCQ, Quizzes, Open book test, Seminar or micro project)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The student has to obtain minimum of 40% marks individually both in CIE and SEE to pass. Theory Semester End Exam (SEE) is conducted for 100 marks (3 Hours duration). Based on this grading will be awarded.

Continuous Internal Evaluation:

1. Methods suggested: Test, Open Book test, Written Quiz, Seminar, report writing etc.
2. The class teacher has to decide the topic for closed book test, open book test, Written Quiz and Seminar. In the beginning only teacher has to announce the methods of CIE for the subject.

Semester End Examination:

Theory SEE will be conducted by University as per scheduled time table, with common question papers for subject

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. A Text book of Engineering Physics- M.N. Avadhanulu and P.G. Kshirsagar, 10th revised Ed, S. Chand. & Company Ltd, New Delhi.
2. An Introduction to Lasers theory and applications by M.N.Avadhanulu and P.S.Hemne revised Edition 2012 . S. Chand and company Ltd -New Delhi.
3. Engineering Physics-Gaur and Gupta-Dhanpat Rai Publications-2017.
4. Concepts of Modern Physics-Arthur Beiser: 6th Ed;Tata McGraw Hill Edu Pvt Ltd- New Delhi 2006.
5. X-ray diffraction- B E Warren published by Courier Corporation.
6. Nano Composite Materials-Synthesis, Properties and Applications, J. Parameswaranpillai., N.Hameed, T.Kurian, Y. Yu, CRC Press.
7. Fundamentals of Fibre Optics in Telecommunication & Sensor Systems, B.P. Pal, New Age International Publishers.

Reference Books:

1. Introduction to Mechanics — M.K. Verma: 2nd Ed, University Press(India) Pvt Ltd, Hyderabad 2009.
2. Lasers and Non Linear Optics – B.B. Laud, 3rd Ed, New Age International Publishers 2011.
3. LASERS Principles, Types and Applications by K.R. Nambiar-New Age International Publishers.
4. Solid State Physics-S O Pillai, 8th Ed- New Age International Publishers-2018.
5. Shock waves made simple- Chintoo S Kumar, K Takayama and KPJ Reddy: Willey India Pvt. Ltd. New Delhi2014.
6. Materials Characterization Techniques-Sam Zhang, Lin Li, Ashok Kumar, CRC Press, First Edition, 2008.
7. Characterization of Materials- Mitra P.K . Prentice Hall India Learning Private Limited.
8. Nanoscience and Nanotechnology: Fundamentals to Frontiers – M.S.Ramachandra Rao & Shubra Singh, Wiley India Pvt Ltd .

Web links and Video Lectures (e-Resources):

https://www.britannica.com/technology/laser.k
https://nptel.ac.in/courses/115/102/115102124/
https://nptel.ac.in/courses/115/104/115104096/
http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
https://onlinecourses.nptel.ac.in/noc20_mm14/preview

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

http://nptel.ac.in
https://swayam.gov.in
https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham