MANONMANIAM SUNDARANAR UNIVERISTY,
TIRUNELVELI-12

SYLLABUS

PG - COURSES – AFFILIATED COLLEGES

Course Structure for M.Sc. Physics
(Choice Based Credit System)
(with effect from the academic year 2021-2022 onwards)

Semester-IV				
Part	**Subject Status**	**Subject Title**	**Subject Code**	**Credit**
3	Core	Quantum Mechanics II		4
3	Core	Nuclear and Particle Physics		4
3	Core	Research Methodology		3
3	Practical	Advanced Physics Experiments-II		3
3	Practical	C++ Programming		3
3	Elective	1. Elective 1A Optoelectronics (OR) 2. Elective 1B Material Science (OR) 3. Elective 1C Nano Physics (OR) 4. Elective 1D Renewable Energy Sources.		2
3	Core	Project		5

Total Marks: 100 Internal Exam: 25 marks + External Exam: 75 marks

A. **Scheme for internal Assessment**:
Maximum marks for written test: **15 marks**
3 internal tests, each of **I hour** duration shall be conducted every semester.
To the average of the **best two** written examinations must be added the marks scored in. The **assignment** for 5 marks and Seminar for 5 marks

The break up for internal assessment shall be:
Written test- 15 marks; Assignment -5 marks; Seminar-5 Marks Total - 25 marks

B. Scheme of External Examination
3 hrs. examination at the end of the semester
A – Part : 1 mark question two - from each unit
B – Part : 5 marks question one - from each unit
C – Part : 8 marks question one - from each unit

➢ Conversion of Marks into Grade Points and Letter Grades

S.No.	Percentage of Marks	Letter Grade	Grade Point	Performance
1	90 - 100	O+	10	Outstanding
2	80 - 89	O	9	Excellent
3	70 - 79	A+	8	Very Good
4	60 - 69	A	7	Good
5	55 - 59	B+	6	Above Average
6	50 - 54	B	5	Pass
7	0 - 49	RA	-	ReAppear
8	Absent	AA	-	Absent

➢ Cumulative Grade Point Average (CGPA)

$$\mathbf{CGPA} = \frac{\mathbf{\Sigma\,(GP \times C)}}{\mathbf{\Sigma C}}$$

- **GP** = Grade point, **C** = Credit
- CGPA is calculated only for Part-III courses
- CGPA for a semester is awarded on cumulative basis

➢ Classification

a) First Class with Distinction : CGPA $\geq$ 7.5*****
b) First Class : CGPA $\geq$ 6.0
c) Second Class : CGPA $\geq$ 5.0 and $<$ 6.0
d) Third Class : CGPA $<$ 5.0

QUANTUM MECHANICS - II

Preamble: This course imparts knowledge about approximation method to solve Schrodinger's equation and basic knowledge of scattering. It provides glimpse of relativistic quantum mechanics and introduction to field theory.

Unit I: Approximation Methods

WKB method: Introduction – Principle of WKB method – The connection formulas – Applications of WKB method – barrier penetration – Theory of alpha emission.

Variation method: Introduction – Theory of Variation method – Applications of Variation method – Calculation of ground state energy of helium atom – Vander Waal's interaction.

Unit II: Scattering theory

Introduction – Kinematics of scattering process – wave mechanical picture – Green's functions; formal expressions for scattering amplitude – Born approximation and its validity – Born series – The Eikonal approximation – Partial wave analysis: asymptotic behavior – phase shifts – scattering amplitude in terms of phase shifts – differential and total cross sections – optical theorem – low energy scattering – Resonant and non-resonant scattering – scattering by a square well potential – scattering by a Coulomb potential.

Unit III: Identical particles and spin

Introduction – Physical meaning of identity — Symmetric and anti-symmetric wave functions – Construction from unsymmetrized functions – Distinguishability of identical particles – The Pauli's exclusion principle – Connection with Statistical Mechanics – Collisions of identical particles – Spin angular momentum – Pauli's spin operators and commutation relations – electron spin functions – Spin matrices and Eigen functions – Electron spin functions for system of two electrons – Effect of spin on energy states of an atom.

Unit IV: Equation of Motion and Symmetries

Introduction – Schrodinger picture – Heisenberg picture – Interaction picture - Poisson bracket and commutator bracket – Evaluation of commutator bracket – Introduction to Symmetries in Quantum Mechanics – Conservation laws and degeneracy associated with symmetries – Continuous symmetries – Space and time translations – Rotations – Group theory applied to symmetries – Wigner – Eckart theorem Discrete symmetries – Parity and Time reversal.

Unit V: Relativistic quantum mechanics

Schrodinger's relativistic equation – charge and current densities – electromagnetic potentials – Energy levels in a coulomb field – Dirac's relativistic Equation – Probability density – Dirac matrices – Plane wave solution – Eigen spectrum Spin of Dirac's particle – Significance of negative energy states – concept of antiparticles – electron in a magnetic field – spin magnetic moment – spin orbit energy.

Books for Study:

1. A Text book of Quantum Mechanics – P. M. Mathews and K. Venkatesan, Tata Mc Graw Hill Edn. Pvt. Ltd. Publications, New Delhi, 2011.
2. Quantum Mechanics – Leonard I. Schiff, Mc Graw - Hill International Publication, New York,1996.
3. Quantum Mechanics – Eugen Merzbacher (3rd Edition), John Wiley and Sons, New York,2004.

Books for Reference:

1. Quantum Mechanics – G. Aruldhas, Printice Hall of India publications, New Delhi, 2009.
2. Quantum Mechanics – V. Devanathan, Narosa Publishing House, New Delhi, 2005.
3. Quantum Mechanics I: Fundamentals – S. Rajasekar and R. Velusamy, CRC Press,Taylor and Francis group – Boca Raton, London.
4. Quantum Mechanics – Satya Praash, Kedar Nath Ram Nath & Co., Meerut, 2012.
5. Quantum Mechanics – Theory and Applications, A. K. Ghatak and Lokanathan; (5thEdition) – Macmillan India Ltd. Publication.
6. Quantum Mechanics – G. R. Chatwal and S. K. Anand, Himalaya Publishing House, New Delhi, 2011.
7. Quantum Mechanics – S. Devanarayanan, Sci. Tech. Publications Pvt. Ltd., Chennai, 2005.
8. Quantum Mechanics – S. L. Gupta, V. Kumar, H. V. Sharma, R. C. Sharma, Jai Prakash Nath and Co., Meerut, India, 2005.
9. Quantum Mechanics – V. K. Thankappan, Wiley EasternLtd., New Delhi,1985.
10. Principles of Quantum Mechanics, R. Shankar, 2nd Edition, Springer,1994.

Related online resources:

1. https://youtu.be/WlmxhPCSM1w
2. https://youtu.be/H77bu3we8Mo

NUCLEAR AND PARTICLE PHYSICS

Preamble: This course imparts knowledge about the elementary particles, nuclear structure, nuclear reactions with the help of various nuclear models.

Unit I: Nuclear Forces

Introduction – Ground and excited states of deuteron – magnetic dipole and electric quadrupole moments of deuteron – n-p scattering at low energies – shape independent effective range theory of np scattering – pp scattering at low energies – saturation of nuclear forces - exchange forces –Meson theory of nuclear force.

Unit II: Nuclear Decays

Introduction –- alpha particle spectra - Gamow's theory of alpha decay – line and Continuous spectrum of β decay - Fermi theory of beta decay – Fermi and Gamow - Teller selection rules – parity violation – Gamma decay – multipole transitions in nuclei – selection rules – internal conversion – nuclear isomerism – Introduction to Cluster decay .

Unit III: Nuclear Models

Introduction - Liquid drop model – Weizsackers mass formula – nuclear stability – Bohr Wheeler theory of nuclear fission - magic numbers - evidence for magic numbers – shell model – spin orbit coupling – angular momenta and parities of nuclear ground states – magnetic moments - Schmidt line – collective model.

Unit IV: Nuclear Reactions

Types of nuclear reactions – Q-equation – solution of the equation – compound nuclear theory – reciprocity theorem – nuclear cross section – resonance scattering– Breit –Wigner dispersion formula – nuclear chain reaction – four factor formula.

Unit V: Elementary Particles

Classification of elementary particles - fundamental interactions conservations laws – CPT theorem -SU(3) multiplet – meson octet – baryon octet and baryon decouplet – Gellmann-Okubo mass formula –Quark theory.

Books for Study:

1. Nuclear Physics, D. C. Tayal, Himalaya Publications.
2. Elements of Nuclear Physics, M. C. Pandia and R. P. S. Yadav Kedarnath.

Books for Reference:

1. Concepts of Nuclear Physics, Bernard L Cohen, Tata Mc Graw-Hill
2. Nuclear Physics an Introduction, S. B. Patel, Wiley Eastern Ltd.
3. Nuclear Physics, R. R. Roy and B. P. Nigam, New Age International Ltd.

Online References:

1. https://en.wikipedia.org/wiki/Cluster_decay
2. https://www.youtube.com/playlist?list=PLbMVogVj5nJRvqw3zway7k3GzmUDte3a
3. https://nptel.ac.in/courses/115/104/115104043/
4. https://nptel.ac.in/courses/115/103/115103101 /
5. https://onlinecourses.nptel.ac.in/noc20_ph19/preview
6. https://nptel.ac.in/content/syllabus_pdf/115104043.pdf

RESEARCH METHODOLOGY

Preamble: Literature collection activities involved in research problem method of writing the thesis, knowledge about Origin and Latex are expected to learn.

Unit I: Introduction to Research and Defining Research Problem

Objectives of Research – Motivation in Research –Types of Research – Research Approaches - Significance of Research - Research Methods versus Methodology - Research and Scientific Method - Importance of Knowing How Research is Done - Research Process - Criteria of Good Research – Problems Encountered by Researchers in India – Research Problem – Selecting the Problem – Necessity of Defining the Problem – Technique Involved in Defining a Problem.

Unit II: Research Design and Experimental Method

Need for Research Design - Features of a Good Design - Important Concepts Relating to Research Design - Different Research Designs - Basic Principles of Experimental Designs –Concept of cause and effect – Types of variables – experimental control – Characteristics of an experiment – Steps of the Experimental Method - Characteristics of a good Experimental Method.

Unit III: Research Report

Need of Research Report – General format of Research Report – Mechanics of report writing – Evaluation of Research Report – Writing Research Abstract - Writing Research Papers.

Unit IV: Plotting software: Origin: (BFS–3)

Introduction – Importing your data – Designating Worksheet Columns as Error Bars - Plotting Data - Customizing the Data Plot - Customizing the Graph Axes - Adding Text to the Graph –Exploring Data: Transforming Column Values – Sorting

Worksheet Data – Plotting a Range of the Worksheet Data – Masking Data in the Graph – Performing a Linear Fit – Creating Multiple Layer Graphs –Working with Excel in Origin.

Unit V: Typesetting Software: Latex (BFS–4)

Introduction to LaTeX – TeX and LaTeX – A typical LaTeX input file – Characters and control sequences – Producing Simple Documents using LaTeX – LaTeX input file – producing ordinary text using LaTeX – Section headings in LaTeX – changing fonts in text mode – Active characters and special symbols in text – Producing Mathematical Formulae using LaTeX – Mathematics mode – characters in mathematics mode – superscripts and subscripts – Greek letters – mathematical symbols – standard functions – fraction and roots – Ellipsis – accents in mathematics mode - Matrices and other arrays in LaTeX - Derivatives, Limits, Sums and Integrals – Lists – tables – Defining your own Control Sequences in LaTeX.

Books for study:

Unit I

Research Methodology – Methods and techniques (2nd Revised Edition) – C. R. Kothari –New Age International Publishers, New Delhi (2005). Chapter 1,2.

Unit II

Research Methodology – Methods and techniques (2nd Revised Edition) – C. R. Kothari –New Age International Publishers, New Delhi (2005). Chapter 3.

Fundamental of Research Methodology and Statistics - Yogesh Kumar Singh- Kothari – New Age International Publishers, New Delhi (2006). Chapter9.

Unit III

Fundamental of Research Methodology and Statistics - Yogesh Kumar Singh - Kothari – New Age International Publishers, New Delhi (2006). Chapter16.

Academic Writing by Dr Ajay Semalty, HNB Garhwal University, India. Module 26, 27, 28 MOOC available in https://swayam.gov.in

Video links:

Academic Writing – Module 26

PART 1 https://youtu.be/vekfTuq0TDk

PART 2 https://youtu.be/03M-

Toaa0LQ Academic Writing – Module 27

PART1 https://youtu.be/vOYrszN3huU

PART 2 https://youtu.be/z3JoemPNg9I
Academic Writing – Module 28
PART1 https://youtu.be/RTJzC4yKrmY
PART 2 https://youtu.be/5cFUynl2he k

Unit IV
http://www.physics.rutgers.edu/~eandrei/389/Origin6_Tutorial.pdf

Unit V
http://www.maths.tcd.ie/~dwilkins/LaTeXPrimer/

Books for further reference:

1. Research methodology – A step by step guide for beginners - Ranjit Kumar – SAGE Publications India Pvt. Ltd, New Delhi (2011).
2. Research methodology – Dr. S. Rajasekar, Dr. P. Philominathan, Dr. V. Chinnathambi
https://arxiv.org/pdf/physics/0601009.pdf

ADVANCED PHYSICS EXPERIMENTS II

Any FIVE Experiments

1. Hall Effect

a. Definition of Hall effect and its application

Determination of

b. Hall voltage
c. Hall coefficient
d. Carrier density
e. Mobility of charge carriers
f. Resistivity

2. Four Probe

a. Four Probe principle
b. Measurement of Resistivity and Energy band gap of two given semiconductor materials

3. Ultrasonic Diffraction

Formation of acoustic grating in a given liquid using a crystal to determine the velocity of ultrasonic wave in the liquid and compressibility of the liquid.

Repeat for another liquid and hence find the ratio of compressibility and velocity.

4. LCR circuit

a. Determination of dielectric constant of two different liquids using LCR circuit
b. Determination of dielectric constant of a given crystal using LCR meter.

5. Hysteresis

Formation and tracing of magnetic hysteresis loop for the given specimen to determine

a. Coercivity
b. Retentivity and
c. Energy loss per unit volume per cycle of the specimen

6. Two Probe Determination of resistivity and band gap energy of the given samples

7. Logistic Map [xn+1 = axn (1-xn)] determination of equlibrium points

a. for two values of parameter a, 1 <a<3 from given x0
b. for two values of parameter a, 3<a<3.4 from given x0
c. for a value of a, 3.544< a< 3.56.
d. Plotting xn versus n of logistic map for the above parameter values and bifurcation diagra

C++ PROGRAMMING

Any FIVE programs with Algorithm and Flow chart

1. Curve Fitting –Fitting a straight line.

a) Principle of least square and fitting a straight line.
b) Principle of linear interpolation
c) C++ program to fit a straight line using the data obtained from Cauchy's Constant Experiment and Interpolation using the fitted equation.

2. Solution of simultaneous equations -Gauss Elimination method.

a) Procedure to solve Simultaneous equations using Gauss Elimination Method
b) Solving unknown branch currents in Wheatstone's bridge using GE method manually.
c) C++ program to solve the equations.

3. Numerical solution of ordinary Differential Equations.

a) Derivation of Exponential law of Radioactive decay.
b) RK 4th order method of solving a given 1st order differential equation.
c) Analytical computation of the mass of the given radioactive sample after a specified period (Given: half life period).
d) C++ program using RK method to solve radioactive problem – Compare output with the analytical result.

4. Area under the Curve

a) Numerical integration – derivation of Simpson's rule
b) C++ programs for Simpson 1/3 rd rule and Monte Carlo integration
c) Comparison of the program output with direct integration.

5. Matrix Multiplication

a) Multiplication of given matrices
b) Rotation matrix definition.
c) C++ program to rotate the given point about the origin using rotation matrix by the given angle.

6. Numerical Differentiation

a) Numerical differentiation – related to any physical problem
b) Derivation of Newton's law of cooling –equation
c) C++ program to verify the Newton's law of cooling from the given experimental data.

7. Solution of Algebraic and Transcendental equations.

a) Solution of the given equations using Newton Raphson Method – manual calculation.
b) C++ program to find the solution using N-R method and verification.

OPTO ELECTRONICS

Preamble: The student should gain knowledge on an optical communication system. The course permits students to measure different kinds of losses in an optical fiber. The student will be able to measure parameters related to LEDs as optical sources and coupling. The performance of different optical detectors can be evaluated by the student. The student will be able to obtain gainful employment in the telecommunication industry.

UNIT I: OPTICAL FIBERS AND OPTICAL COMMUNICATION SYSTEMS

Evolution of fiber optic systems – optic fiber transmission link – nature of light – basic laws of light – optic fiber modes and configurations: fiber types, ray optics representation, modes in step index fibers – linearly polarized modes – single mode fibers – graded index fiber – Fiber materials – Fiber fabrication – fiber optic cables.

UNIT II: SIGNAL DEGRADATION IN OPTICAL FIBERS

Attenuation: Attenuation Units - Absorption losses - Scattering Losses - Bending Losses - Core and cladding Losses – signal Distortion in Optical Waveguides: Information capacity Determination, Group Delay, Material Dispersion, Waveguide Dispersion - Signal Distortion in Single Mode Fibers.

UNIT III: OPTICAL SOURCES

Topics from Semiconductor Physics: Energy Bands, Intrinsic and Extrinsic Material, the pn junctions Direct and Indirect Band Gaps, Semiconductor Device Fabrication – Light-Emitting diodes (LED's): LED Structures, Light Source Materials - Quantum Efficiency and LED Power - Modulation of an LED – Laser Diodes: Laser diode Modes and Threshold conditions - Laser diode.

UNIT IV: POWER LAUNCHING AND COUPLING

Source – to – Fiber Power launching: Source Output Pattern, Power – Coupling Calculation - Power Launching versus Wavelength - Equilibrium Numerical Aperture – Lensing Schemes for coupling Improvement: Non-imaging Microsphere.

UNIT V: PHOTO DETERCTORS

Physical Principles of Photodiodes - The pin Photo detector- Avalanche Photodiodes – Photodetector Noise: Noise Sources, Signal-to-noise Ratio – Detector Response Time.

Book for Study:

1. Gerd Keiser, Opitcal Fiber Communication, Third Edition, Mc Graw Hill International (2000), relevant sections of chapter 1 to 6.

Book for Reference:

1. Jasprit Singh, Optoelectronics: An introduction to materials and devices, Mc Graw Hill, Singapore (1996).

Related online resources:

1. https://youtu.be/p6uMrpX8G7s
2. https://youtu.be/VfKpqFKOccE
3. https://youtu.be/4JKjqveWGlw

MATERIAL SCIENCE

Preamble: The course details about the temperature effect, elastic behavior of materials, solid structure, imperfections in the crystal, the various deformation of materials.

Unit I: Phase diagram

Phase rule - Single component systems - Binary Phase diagrams - Micro structural changes during cooling - The lever rule - Some typical phase diagrams - other applications of phase diagrams Phase transformations - Time scale for phase changes - Nucleation and growth - The growth and the overall Transformation kinetics - applications.

Unit II: Elastic behaviour

Atomic model for elastic behavior - The Modulus as a parameter in Design - Rubber like elasticity – An elastic behavior - Relaxation behaviours - Viscoelastic behavior – Spring - Dashpot models.

Unit III: Structure of solids

The crystalline and non-crystalline states - Covalent solids - Metals and alloys - Ionic Solids The structure of silica and silicate – polymers - classification of polymers - Structure of long chain polymers - Crystallinity of long chain polymers.

Unit IV: Imperfections

Crystal imperfections - Point imperfections - The geometry of dislocations - other properties of dislocations - Surface imperfections.

Unit V: Oxidation, corrosion and other deformation of materials

Mechanisms of Oxidation-Oxidation resistant materials-the principles of corrosion protection against corrosion - Plastic deformation - The tensile stress-strain curve - Plastic deformation by slip-Creep-Mechanisms of creep-Creep resistant materials - Ductile fracture - brittle fracture - methods of protection against fracture.

Book for Study:

1. Materials Science and Engineering - A First Course, V. Raghavan, Fifth Edition, Prentice Hall of India, New Delhi, 2011.

Online Reference:

1. https://chem.libretexts.org Bookshelves Physical and Theoretical Chemistry Textbook Maps Book%3A Physical Chemistry (Fleming) 08%3A Phase Equilibrium 8.02%3A Single Component Phase Diagrams
2. https://www.youtube.com/watch?v=symExnyQ49M

3. https://www.youtube.com/watch?v=lxNYAxr5lPc
4. https://www.researchgate.net publication 322892419 Experimental study of concrete beams prestressed with basalt fiber reinforced polymers Part II Stress relaxation phenomenon figures lo=1&utm source=google&utm medium=organic
5. https://www.sciencedirect.com topics engineering surface-imperfection
6. https://www.fastradius.com resources top-5-corrosion-resistant-materials
7. https://yenaengineering.nl brittle-and-ductile-fracture

NANO PHYSICS

Preamble: The course permits students to study the synthesis, characterization, properties and application of nanomaterials.

UNIT I

Synthesis of Nanostructured Materials: Idea of band structure extended to nanostructured matierials-0D nanostructures (quantum dots) - 1D nanostructures (quantum wires) - 2D nanostructures (quantum wells) - Carbon Nanomaterials: Fullerenes – CNT - Graphene

UNIT II

Introduction to Nanocomposites: composite material - Mechanical properties of nano composites - stress-strain relationship – toughness – strength – plasticity - synthesis methods for various nano composite materials: sputtering - mechanical alloying - sol-gel synthesis - thermal spray synthesis

UNIT III

Nanomaterial Characterization: Principle & Applications: X-ray diffraction - Debye-Scherer Formula – FTIR - Raman Spectroscopy – SEM – TEM - Differential Scanning Calorimetery (DSC)

UNIT IV

Properties of Nanostructured materials: Mechanical properties - Thermo physical properties - Electric properties - Electrochemical properties - Optical properties

UNIT V

Applications: Application of Nanostructured materials in biotechnology- electronics-defence - photonics

Books for Study:

1. Introduction to Nanotechnology by Charles P. Poole Jr and Frank J.Owens Wiley India Pvt. Ltd., (2003).
2. Nanostructures &Nanomaterials: Synthesis, Properties & Applications, Guozhong Cao, Imperial College Press (2004).

Books for Reference:

1. Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer (2007).
2. Physics of semiconductor nanostructures – K. P. Jain, Narosa 1997
3. Nanotechnology - Enabled Sensors, Kourosh Kalantar - zadeh and Benjamin Fry, Springer (2008).
4. Nanocomposite science and technology, Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, Wiley-VCH Verlag, Weiheim (2003).
5. Elements of X-Ray Diffraction (second edition, Addison – Wesley, London) B. D. Cullity (1977).
6. Handbook of Microscopy for Nanotechnology, Ed. By Nan Yao and Zhong Lin Wang, Kluwer Academic Press (2005).
7. Nanotechnology: Basic Science and Emerging Technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).

Related Online Sources:

1. https://youtu.be/5lvjo0rm-F0
2. https://youtu.be/qUEbxTkPIWI
3. https://youtu.be/k61wjab7iUs

RENEWABLE ENERGY SOURCES

Preamble: This course gives a brief knowledge about the types of various non-conventional energy sources. The societal application of these energy sources is studied.

Unit I: Introduction

Primary and secondary energy – Commercial and non commercial energy – renewable and non – renewable resources and their importance – World energy use – Indian energy scenario – Long term energy scenario for India.

Unit II: Solar and Biomass Energy

Introduction – extra terrestrial solar radiation – collectors – Solar cells – application of solar energy – Biomass energy – biomass conversion – bio gas production –

ethanol production – pyrolysis and gasification – application of biomass energy.

Unit III: Geothermal and Tidal Energy

Introduction – basic theory - geothermal resources types – resource base – application for heating and electricity generation – Tidal energy – Introduction – origin of tides – Power generation scheme.

Unit IV: Other Renewable Energy Sources

Thermoelectric and Thermionic energy resources – basic principles – power generation – nuclear energy – basic principle – power generation (basic ideas only).

Unit V: Chemical Energy Sources

Introduction – fuel cells – design and principle – types – advantages and disadvantages – applications – Batteries – Introduction – Theory – classification of batteries – advantages of batteries for bulk storage.

Books for Study:

1. Non-Conventional Energy Sources, G. D. Rai, Khanna Publishers, New Delhi, 1984

Books for Reference:

1. Solar Energies of thermal processer, A. Duffie and W.A. Beckmann, john – Wiley, 1980.
2. Principle of Solar Engineering, F. Kreith and J. F. Kreider, McGraw-Hill,1978
3. Alternate Energy Sources, T. N. Veziroglu, Vol.5 and 6, Mc Graw - Hill, 1978.
4. Solar energy – Principle of thermal collection and storage S P Sukhatme and J K Nayak, Tata Mc Graw Hill, Tata, 2008

Related online resources:

1. https://youtu.be/UJ8XW9AgUrw
2. https://youtu.be/qSWm_nprfqE
3. https://youtu.be/IdPTuwKEfmA

PROJECT