PHYE-412 – Electives 5 (C5) : Radiation Measurements And Nuclear Dosimetry

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning Objectives:

This course gives awareness and understanding of the applications of nuclear techniques in industry, Agriculture and Medical safety standards required. The course is very advanced course utilizing the concepts learnt in IIIrd semester in the elective course "Nuclear reactions and Nuclear energy" So this can also be only an elective course in IVth Semester. The course will help the student for preparation of NET/SET and other competitive examinations. After completion of this course the student will be able to understand the possibilities of starting one's own business, using nuclear radiations including agriculture like food preservations, improvement of seed qualities etc.

Learning Outcomes:

The student after completing M.Sc. degree with their specialization as nuclear physics will be able to do advanced diploma in using nuclear radiations for medical disorders and diseases on human-beings, animals etc. These students after completing their M.Sc. degree, will be having very good opportunities in industry like Polymers, Fault finding in metal, Polymer, equipments and components, high quality welding etc. The student will be highly beneficial to the society in his/her later life by performing many essential duties to help people to lead improved and prosperous lives.

Course Contents:

Unit I: Interaction of Nuclear Radiations with matter

Stopping power of charged nuclear particles, Range and straggling, Stopping power and range of electrons, Absorption of gamma rays, Photoelectric effect, Compton effect, Pair production.

Unit II: Nuclear radiation measurements

Crystal conduction counters, Energy resolution of the counter, Surface barrier counters, Cloud chamber, Diffusion cloud chamber, Bubble chamber, Spark chamber.

Unit III: Radiation Protections

Harms of radiation to body, Radiation safety standards, Radiation dosimetry measuring instruments, Film dosimetry principles, Experimental techniques, Applications, solid state nuclear track dosimetry, Track processing methods, Counting procedure and applications, Safe working methods of nuclear radiation.

Unit IV: Applications of Nuclear irradiations

Introduction, The technique of NMR, Seed oil mass screening by NMR technique, Mossbauer effect, Some experiments using Mossbauer effects, Activation analysis for element detection, Solid state nuclear track dosimetry (SSNTD), Radiation effects, Mutation by irradiation.

Books:

1. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
2. **Nuclear Physics,** D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).
3. **Nuclear Measurement Techniques,** K. Sri Ram, 1st edition, Affiliated East-West Press, Madras(1986) (ISBN-81-85095-56-6).
4. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
5. **Nuclear Physics,** R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN-EBK0036746).
6. **Fundamentals of Nuclear Science;** P.N. Tiwari, Wiley eastern Pvt. Ltd. New Delhi, 1974.
7. **Fundamentals of Nuclear Physics,** Jahan Singh, 1st edition, Pragati Prakashan, Meerut-(2012) (ISBN-978-93-5006-593-8)

PHYE-412 – Electives 5 (D5) : Material Synthesis and Characterization

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning objectives: Advances in technology depends more and more on the discovery and development of new materials having particular desired properties. In addition to mechanical strength, various structural, optical, electrical, magnetic and thermal properties are demanded from materials depending on the application.

Learning Outcomes: The field of Materials Science investigates different classes of materials - metals, ceramics, polymers, electronic materials, biomaterials- with an emphasis on the relationships between the underlying structure and the processing, properties, and performance of the materials. Research opportunities are offered as scientists and technologists, etc in national and international institutions

Course contents:

Unit I: Independent Electron Approximation

The Hartree equations, Thomas- Fermi and Lindhard Theory, the Hartree Fock approximation, the tight binding approximation, the Wigner and Seitz method, energy band calculations Fermi-Liquid theory, Lindhard theory.

Unit II: Synthesis and Characterization of Ferrites:

Synthesis: successive ionic layer adsorption and reaction (SILAR), solid state reaction route (SSRR), co-precipitation route (CR), properties: Electrical, Mechanical & magnetic, characterization: X-ray diffraction (XRD), Thermal electron microscopy (TEM).

Unit III: Thin Film Deposition Techniques:

Vacuum pumps: Mechanical pumps-oil sealed Rotary pumps, roots pumps, molecular-drag pumps, cryogenic pumps, vacuum seals, vacuum measurement- thin film nucleation- the capillarity model, the critical Nucleus physical vacuum deposition,

Unit IV: Synthesis and characterization of HTSC Materials:

Synthesis : solid state reaction route (SSRR), Chemical Route, Melt Grown Route, Melt Grown and Infiltration route, Co-precipitation Route, Sol-Gel Route. Properties: mechanical, electrical and magnetic, characterization: X-ray diffraction (XRD), determination of lattice parameters from XRD data, estimation of volume, density, scanning electron microscopy (SEM), Scanning tunneling microscopy (STM). Superconducting quantum interference devices system (SQUIDs).

References :

1. Hand book of Thin Film Technology (McGraw-Hill Handbooks)Leon I. Maissel, Reinhard Glang Published by Mcgraw-Hill (Tx) (1970) ISBN 10: 0070397422 ISBN 13: 9780070397422
2. Super fluidity and Superconductivity – D. R. Tilley and J. Tilley Published by INST OF PHYSICS (2015) ISBN 10: 0750300337 ISBN 13: 9780750300339
3. Superconductivity – T. V. Ramakrishan and C. N. R. Rao
4. Physical and magnetic properties of High Temperature Superconductors – S. K. Malik and S. S. Shah (Nova Science publishers. Inc.)

PHYE-413: Generic Electives - 6 (A6/ B6/ C6/ D6): Credits 4
(Research Oriented)

PHYE-413 – Generic Electives 6 (A6): Advanced Sensor Technology
(Research Oriented)

(Credits: 04 ; Contact Hours : 60)

Lectures: 48

Tutorials: 12

Learning Objectives:

1. To facilitate the students to understand
   c) the concepts of sensor science and technology
   d) the concept of Sensor materials and different principles of sensing technology which are used at laboratory as well industrial level
2. To provide an opportunity to the students to enter into sensor research and develop smart sensor devices.
3. To create enthusiasm among the students to undertake research in sensors

Learning Outcome:

1. Students will be able to -
   c) learn sensor materials and technologies,
   d) develop sensor devices and sensor networks.

2. Students will be capable to undertake the job in sensor industries.
3. Students will have option to start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well engineering discipline OR do research in sensor science.

Course Contents:

Unit I : Sensor Materials and Sensor Matrix

Materials : Material selection criteria, fulfilment of ideal sensor requisite, importance of 1-D materials in sensors, importance of surface area enhancement and enhancement in surface activity, Importance of size dependent Properties for sensing applications; Promising sensing materials: Carbon Nanotubes, Organic Conducting Polymers, Porphyrins and metal nanoparticles, Sensor Fabrication Technologies : AC Dielectrophoretic alignment of SWNTs and surface modification of SWNTs by OCP by charge controlled potentiostatic deposition and porphyrins by solid casting, for SWNTs, confirmation of coating by I-V measurements and electrochemical measurements;

Unit II : Chemical Sensors

Chemical Sensor Characteristics ; Specific Difficulties ; Classification of Chemical-Sensing Mechanisms ; Direct Sensors : Metal-Oxide Chemical Sensors, Chemiresistive and ChemFET sensors, Electrochemical Sensors, Potentiometric Sensors, Conductometric Sensors,

Amperometric Sensors, Complex Sensors: Optical Chemical Sensors Biosensor, Multisensor Arrays, Electronic Noses (Olfactory Sensors),

Unit III : Integrated circuit manufacturing techniques for Sensors

Introduction, **Photolithography:** Masks, Mask alignment, Spinning resist; **Exposure and development:** *Exposure, Development,* Resist tone, Critical dimension (CD) and resolution *(R)*, **Resist stripping**: *Wet stripping, Dry stripping*; **Subtractive techniques**: Overview, **Dry etching:** *Physical etching: sputtering or ion etching, Etching profiles for physical etching, Dry chemical etching, Physical-chemical etching;* **Wet etching:** *Anisotropic and isotropic etching, Etch stop techniques*, Comparison of dry- and wet-etch techniques;

Unit IV : Sensors Technology (Techniques for Sensor Fabrication)

Chemical Methods for preparation of sensor matrix: Chemical bath deposition, SILAR, **Physical vapor deposition :** *Evaporation, Sputtering, Molecular beam epitaxy, Laser ablation deposition;* **Chemical vapor deposition:** *AP CVD and LP CVD, PE CVD, Spray pyrolysis;* **Electrodeposition and electroless deposition**: *Electroless deposition , Electrodeposition, Potentiostatic, Galvanostatic, Cyclic voltammetry* : **Chemical sensor fabrication technology** : screen printing, spin coating, dip coating, casting

References:

1. Modern Sensors Handbook, Edited by Pavel Ripka and Alois Tipek; ISTE Ltd, USA **(2007)**, ISBN 978-1-905209-66-8.
2. Handbook of Chemical and Biological Sensors; Edited by Richard F Taylor, Arthur D Little Inc., Jerome S Schultz, University of Pittsburgh ; Institute of Physics Publishing Bristol and Philadelphia; **(1996)** ISBN 0 7503 0323 9
3. Hand Book of Modern Sensors : Physics, Designs and Applications By Jacob Fraden Third Edition (Springer-Verlag New York, Inc.) **(2004)**, ISBN 0-387-00750-4.
4. Understanding Smart Sensors By Randy Frank; Second Edition; Artech House Boston . London **(2000),** ISBN 1-58053-398-1.
5. Sensors and Transducers, Third Edition By Ian R. Sinclair; Butterworth-Heinemann publication, Woburn **(2001),** ISBN 0 7506 4932 1
6. Chemical Sensors: An Introduction for Scientists and Engineers : Grundler, Peter; Springer Berlin Heidelberg New York **(2007),** ISBN 978-3-540-45742-8
7. Principles of Chemical Sensors : Janata, Jiri 2nd Edition ; Springer Dordrecht Heidelberg London, New York **(2009),** ISBN 978-0-387-69930-1 e-ISBN 978-0-387-69931-8
8. Optoelectronics Devices and System SECOND EDITION by S. C. Gupta; Prentice Hall International **(2011)** ISBN: 978-81-203-5065-6
9. Optical Fibers and fiber optic communication Systems by Subir Kumar Sarkar; S Chand & Company Ltd **(2000),** ISBN: 9788121914598
10. Lasers and Optical Fiber Communications by P Sarah; I.K. International Publishing House Pvt Ltd, New Delhi **(2008),** ISBN : 9788189866587 / 8189866583
11. Optoelectronics by R. A. Barapate (Tech-Max Publication) **(2003)**

PHYE-413 – Generic Electives 6 (B6): X-Ray Spectroscopy
(Research Oriented)

(Credits: 04 ; Contact Hours : 60)

Lectures: 48

Tutorials: 12

PHYE-413 – Generic Electives 6 (C6): Accelerator Physics
(Research Oriented)

(Credits: 04 ; Contact Hours : 60)

Lectures: 48

Tutorials: 12

PHYE-413 – Generic Electives 6 (D6): Ferromagnetism
(Research Oriented)

(Credits: 04 ; Contact Hours : 60)

Lectures: 48

Tutorials: 12

OELE-101 : Open Elective (from other Departments)

This course is open elective course. Students will have to opt any course of 4 credits from any one the university Departments

PHYL-421 – Lab course 7 (Based on Electives A4,A5/ B4,B5/ C4,C5/ D4,D5)

PHYL-421 – Lab course 7 (A4, A5) : Fundamentals of Sensors and 8051- Microcontroller: Credits 3

A4 : Fundamentals of Sensors

Learning Objectives:

1. To facilitate the students to understand
   a) the concepts of sensor science and technology from different principles of sensing viz. Optical fiber based chemical, displacement, pressure sensors, Potentiometric sensor and gas sensors based on conducting polymers and single walled carbon nanotubes.
   b) properties of optical fiber (viz. Numerical aperture, losses in optical fiber and optical to electrical and electrical – optical characteristics of fiber optic converter)
   c) the concept of Sensor materials and different principles of sensing technology which are used at laboratory as well industrial level
2. To provide an opportunity to the students to enter into sensor research and develop smart sensor devices.
3. To create enthusiasm among the students to undertake research in sensors.

Learning Outcome:

1. Students will be able to -
   a) learn Sensors, characteristics of sensors, sensor materials and technologies, optical fiber and optical sensors, various methods of detection.
   b) develop sensor devices and sensor networks based on optical, thermal, optical fiber and chemical sensors.
2. Students will be capable to undertake job in optical fiber industries and sensor industries.
3. Students will have option to start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well engineering discipline OR do research in sensor science.

Course Contents:

1. Determination of Numerical Aperture of PMMA optical fiber
2. Losses in Optical fiber.
3. Study of Optical to Electrical (O-E) characteristics of fiber optic Phototransistor

converter.

4. Study of Electrical to Optical (E-O) characteristics of fiber optic 660nm an 850nm converter.
5. Optical fiber chemical sensor.
6. Study of Displacement sensor
7. Study of Potentiometric sensor.
8. Gas sensor based on OCP (organic Conducting Polymers)
9. Gas Sensor based on Single Walled carbon nanotubes (SWNTs)
10. Study of characteristics of photovoltaic cell
11. Study of characteristics of Phototransistor.
12. Study of characteristics of Photoconductive cell
13. Study of characteristics of PIN Photodiode
14. Study of characteristics of IC temperature sensor (LM 335)
15. Study of K (chromel – alumel) type Thermocouple
16. Characteristics of Platinum RTD (Resistance – Temperature Detector)
17. Characteristics of NTC (negative Temperature Coefficient) Thermistor
18. Study of Optical fiber Pressure sensor

Note: Students should perform at least four experiments

(A5) : 8051- Microcontroller:

1. Programs for addition using 8051 microcontroller.
2. Programs for subtraction using 8051 microcontroller.
3. Programs for multiplication using 8051 microcontroller.
4. Programs for division using 8051 microcontroller.
5. Programs for data transfer.
6. Programs for ones, twos complements.
7. Programs for counters.
8. Program for Ascending and descending numbers using 8051 microcontroller.
9. Program to find Square root of given number using 8051 microcontroller.
10. Program to find Maximum and minimum numbers using 8051 microcontroller.
11. Program for temperature control interface using 8051 Microcontroller.
12. Program for analog to digital converter using 8051 microcontroller.
13. Program to generate ramp, triangular and square waves using DAC through 8255 of 8051 microcontroller.
14. Program for stepper motor interface using 8051 microcontroller.

Note: Students must perform at least four experiments from above list.

PHYL-421 – Lab course 7 (B4, B5)

Applied Spectroscopy and Lasers, Nonlinear optical mixing and spectroscopic phenomena : Credits 3

B4 : Applied Spectroscopy

Learning Objectives:

a) Knowledge about the experimental investigation methods of dielectrics.
b) Understanding the theoretical knowledge by experiments.
c) Capacities development for establishing measurement methods.

Learning Outcomes:

a) After completing this course the student will be able to determine the vibrations for a polyatomic molecule and identify whether they are infrared-active.
b) On the basis of NMR, FTIR and ESR spectra student will able to identify the material.

List of Experiment

1. Study of dielectric relaxation phenomena using TDR.
2. Study of the temperature dependence of permittivity in water using TDR .
3. Study of the permittivity in aqueous solutions using TDR.
4. Study of the temperature dependence of permittivity in alcohol using TDR.
5. Study of FTIR spectra of alcohol using FTIR spectrometer
6. Study of FTIR spectra of dimethylacetamide using FTIR spectrometer
7. Study of FTIR spectra of water using FTIR spectrometer
8. Analysis of FTIR spectra of water using prerecorded sample spectrum
9. Analysis of FTIR spectra of dimethylacetamide using prerecorded sample spectrum
10. Analysis of FTIR spectra of alcohol using prerecorded sample spectrum
11. Study of NMR spectra of acrylic using NMR spectrometer
12. Study of NMR spectra of delrin using NMR spectrometer
13. Study of NMR spectra of HBF_4 using NMR spectrometer
14. Study of NMR spectra of $H_2O + CuSO_4$ using NMR spectrometer
15. Study of NMR spectra of rubber using NMR spectrometer
16. Study of FTIR spectra of dimethylacetamide using NMR spectrometer
17. Study of ESR spectra of acrylic using ESR spectrometer
18. Study of ESR spectra of delrin using ESR spectrometer

19. Study of ESR spectra of HBF_4 using ESR spectrometer
20. Study of ESR spectra of $H_2O + CuSO_4$ using ESR spectrometer
21. Study of ESR spectra of rubber using ESR spectrometer
22. Analysis of ESR spectra of water using prerecorded sample spectrum
23. Analysis of ESR spectra of alcohol using prerecorded sample spectrum

Note: Students should perform at least four experiments

B5 : Nonlinear optical mixing and spectroscopic phenomena

Learning Objectives:

a) Basic knowledge of optical phenomena such as interference, interference between parallel plates, polarization, birefringence, absorption in optical media, total internal reflection, etc.
b) Applications of these phenomena in determining splitting of spectral lines (high resolution spectroscopy)
c) Behavior of optical media in external electric and magnetic fields
d) Estimation of parameters of optical media
e) Applications of lasers in investigating these phenomena
f) Computer interfacing of these experiments and analysis of observations

Learning Outcomes:

a) Basic training in optics
b) Analysis of high resolution spectra
c) Analysis of Optical patterns and other observations
d) Training of spectrophotometric techniques
e) The student will get a training for using state of the art data acquisition system in spectroscopy laboratory
f) Hence the student can get a job as "Analyst" in Research labs

Advanced Optics experiments using lasers

1. Study of polarization of triplet components in transverse configuration using Zeeman effect
2. Study of polarization of doublet components in longitudinal configuration using Zeeman effect
3. Determine the thickness of Fabry-Perot interferometer by exact fraction using CCD camera setup
4. Measure the divergence of a LASER beam
5. To determine the unknown concentration of solute using spectrophotometer
6. Measure the refractive index of a liquid (Water) using hollow prism.
7. Measure the attenuation in an optical fiber
8. Verify the Malu's law
9. Setup and study the electro-optic Kerr effect
10. Setup and study the Faraday effect in solids and liquids
11. Measure the grating element of transmission grating
12. Measure the numerical aperture of an optical fiber
13. Measure the Brewster angle and hence the refractive index of a glass

14. To verify Beer and Lamberts law using spectrophotometer
15. Michelson interferometer
16. Fabry-Perot Interferometer
17. Twyman-Green Interferometer

References:

1. MEASUREMENT, INSTRUMENTATION AND EXPERIMENT DESIGN IN PHYSICS AND ENGINEERING by SAYER, MICHAEL, MANSINGH, ABHAI , ISBN: 978-81-203-1269-2 , PHI Learning, 1999.

Note: Students should perform at least four experiments

PHYL-421 – Lab course 7 (C4, C5)

Particle Physics, Nuclear forces, Cosmic rays and Radiation Measurements, Nuclear Dosimetry : Credits 3

C4 : Particle Physics, Nuclear forces, Cosmic rays

1. Pulse height gamma-ray spectrum of ^{137}Cs.
2. Pulse height gamma-ray spectrum with multichannel analyzer.
3. Energy calibration of scintillation spectrometer with SCA.
4. Energy calibration of scintillation spectrometer with MCA.
5. Least square fitting of a straight line.
6. Inverse Square law.
7. Absorption of Gamma-rays in an absorber.
8. Compton scattering from a lead target.
9. Scattering cross section measurements from plastic targets.
10. Backscattering from different targets.
11. Relative efficiency calibration of a scintillation detector.
12. Absolute efficiency calibration of a NaI(Tl) detector.
13. Activity of Gamma-ray source (Area ratio method).
14. Absolute activity of Gamma-ray source.
15. Absolute activity of a Gamma source by sum peak method.
16. Gamma-Gamma angular correlation.
17. Pair production and annihilation phenomenon.
18. Escape peaks in ^{24}Na.
19. Verification of Moseley's Law.
20. Study of X-ray proportional counter.
21. Determination of absolute activity by high resolution gamma ray spectrometer with high purity germanium (HPGe) detector.
22. Estimation of alpha activity using SSNTD.
23. Determination of radioactivity in surface soil, cement and fly ash.
24. Half-Life determination of ^{137m}Ba.
25. Fission yield determination of $^{91}Sr/^{89}Sr$.

26. Fission yield determination of iodine isotopes.
27. Determination of the solubility of a sparingly soluble salt.
28. Determination of manganese in steel by neutron activation analysis.
29. Multielement determination in soil by single comparator NAA.

Note: Students should perform at least four experiments

C5: Radiation Measurements, Nuclear Dosimetry

1. Plateau of a GM Counter.
2. Determination of Dead time of a GM Counter.
3. Statistical Aspects of Radioactivity Measurements.
4. Determination of Resolution of a NaI(Tl) Detector.
5. Determining the Activity of a Gamma Source.
6. The Absorption Coefficient as a Function of Gamma Ray Energy.
7. Beta Backscattering As a Function of Atomic Number.
8. Beta Energy Determination By Feather's Analysis.
9. Study of Scintillation Counter.
10. Study of Gamma Ray Coincidence Spectrometer.
11. Study of Beta Decay.
12. Study of G-M Counter.
13. Excitation of K-X-Ray by Beta Radiation.
14. A Micro Controller Based Machine for Lissajous Figures.

Note: Students should perform at least four experiments

PHYL-421 – Lab course 7 (D4, D5)

Magnetism, Superfluidity and Material Synthesis, Characterization : Credits 3

D4 : Magnetism, Superfluidity

1. Thin film deposition by Chemical Bath Deposition (CBD) and measure its thickness.
2. Variation of conductivity with temperature and frequency
3. Thin film deposition by chemical route (Electro deposition)
4. To study the vacuum system (production and measurement)
5. Synthesis of semiconductor nanoparticles by SILAR
6. Determination of size and position of nanoparticles using nano kit
7. Estimation of core loss and coercive force for a ferromagnetic core material of a transformer
8. Paramagnetic susceptibility temperature variation.
9. To determine the magneto resistance of Bismuth crystal / Bismuth compound thin film as a function of magnetic field.
10. Determination of Curie temperature of a ferromagnetic material.
11. Magnetic susceptibility of solids by Guoy's method.
12. Study of magnetic susceptibility in liquids
13. Variation of residual magnetization of carbon steel rod as a function of temperature.

Note: 1) **Other experiments may be added as per the availability of instruments.** 2) **Students should perform at least four experiments**

D5 : Material Synthesis, Characterization

Learning objectives of the course: Advances in technology depends more and more on the discovery and development of new materials having particular desired properties. In addition to mechanical strength, various structural, optical, electrical, magnetic and thermal properties are demanded from materials depending on the application.

Learning Outcome of the course: The field of Materials Science investigates different classes of materials -metals, ceramics, polymers, electronic materials, biomaterials- with an emphasis on the relationships between the underlying structure and the processing, properties, and performance of the materials. Research opportunities are offered as scientists and technologists, etc in national and international institutions

1. Thin film deposition by Chemical Bath Deposition (CBD) and measure its thickness.
2. Thin film deposition by thermal evaporation and measure its thickness
3. Characteristics of oil rotary pump
4. Characteristics of oil diffusion pump
5. Measurements of low and high vacuum techniques
6. Structural analysis of thin film by XRD

7. Variation of conductivity with temperature and frequency
8. To study the vacuum system (production and measurement)
9. Synthesis of semiconductor nanoparticles by SILAR
10. Determination of size and position of nanoparticles using nano kit
11. Porosity determination of semiconducting material.
12. Estimation of core loss and coercive force for a ferromagnetic core material of a transformer.
13. Characteristics of Superconducting quantum interference devices system (SQUIDs).

Note: Students should perform at least four experiments

PHYR-431 – Research Project Part III (Interpretation of Results) : Credit 3

Students are expected to do comprehensive interpretation of results

PHYR-432 – Research Project Part VII (Dissertation and Presentation) : Credit 6

Students are expected to write primary Dissertation and make presentation of the same.

PHY- 421 E8 : Renewable Energy

1. **Solar energy and its conversion:** Importance of Solar energy: Nature of Solar radiation, sun as a fusion reactor, spectral distribution of extraterrestrial radiation, Estimation of extra terrestrial solar radiation, Radiation on horizontal and tilted surfaces. Beam diffuse. Available solar radiation, measurement of beam, Various ways to convert solar energy into different forms. Sunshine duration recorder Angstron relations.
2. **Solar Photovoltaics (SPV):** Solar photovoltaics conversion: basic principle of solar photo-valtaics conversion, types of solar cell materials, fabrication of solar photovoltaic cells, solar cell parameters and characteristics.
   Solar Photovoltaic conversion system: Block diagram of general SPV conversion system and their characteristics, solar photovoltaic conversion system components and their characteristics, Application (such as street lights, water pumps, small capacity power generation).
3. **Photothermal applications of Solar Energy:** selective Coatings: ideal characteristics of selective coating for various applications. Types of selective coatings, material and techniques for selective coatings, Effect of selective coating on the efficiency of solar collectors.
   Solar thermal devices and Systems: Differential types of collectors, Flat collector (Basic principle, Energy balance equation of steady state, Testing, methods to reduce losses, solar cooker's, Domestic hot water system, solar dryers, solar furnace, solar refrigeration.
4. **Solar Hydrogen Energy:** Hydrogen Fuel: Importance of hydrogen as a future fuel, Sources of hydrogen, fuel of vechicles.Hydrogen Production: Production of hydrogen by photoelectrolysis and Photo-catalytic process.
   Hydrogen Storage: Gaseous, cryogenics and metal hybride.
   Utilization of hydrogen: fuel cell-principle, construction and applications.
5. **Wind energy:** Introduction, the wind: energy and power in the wind, wind turbines, wind turbines types, horizontal and vertical axes wind turbines, aerodynamics of wind turbines: aerodynamic forces, horizontal and vertical axes wind turbines, production of power and energy from wind turbines, estimating wind speed characteristics of a site,, electricity generation by wind energy, planning & wind energy, calculating the costs of wind energy, small scale wind turbines, wind energy potential, off shore wind energy.

Books :

1. World Energy Resources, Charles E. Brown (Springer Publication, 2002).
2. Principles of solar Engineering, F. Kreith and J. F. Kreider (McGraw Hill, 1978).
3. Energy Policy for India, B. V. Desai (Weiley Eastern Publication).
4. Solar Energy Termal Processes, J. A. Duffie and W.A. Beckman (John Wiley and Sons, 1980).
5. Principle of Solar Energy Conversion, A. W. Culp (McGraw Hill International Publication).
6. Heat and thermodynamics, M. W. Zemansky (McGraw Hill International Publication).
7. Solar Energy- Principles of thermal Collection and Storage, S. P. Sukhatme (2nd edition, Tata McGraw Hill Publication, 1976)
8. Handbook of solar Radiation, A. Mani (Appied Publishers, 1980)
9. Solar energy Fundamentals and applications, H. P. Garg and satya Prakash (Tata McGraw Hill, 1997)
10. Solar Thermal Engineering, J. A.Duffie (Academic Press)
11. TEDDY Year Book (Tata Energy Research Institute TERI Publication, 2002)
12. Treatise on Solar Energy, H. P. Garg, Vol. 1,2 and 3 (John Wiely and sons, 1982)
13. Solar Energy Utilization, G. D. Rai (Khanna Publishers, 1996).
14. Climatological and Solar data for India, Seshadri (Sarita Prakashan, 1969)
15. Energy Technology, S, Rao and B. B. Parulekar (Khanna Publishers, 1995)
16. Terrestrial Solar Photovotics, Tapan Bhattacharya (Namsa Publication House, New Delhi, 1998)
17. Solar Celle-operating principles, Technology and system applications, Martin A. Green (Prentice Inc. U.S.A.)
18. Fundamentals of solar Cells, F. A. Faherenbruch and R. H. Bube (Academic Press).
19. Thin Film Solar Cells, K. L. Chopra And S. R. Das (Plenum Press, 1983).
20. Solar Hydrogen Energy Systrems, T. Onta (Pergamon Press, 1979).
21. Hydrogen Technology for Energy, D. A. Maths (Noyes Data Corp.976).
22. Hydrogen as an Energy Carrier Tecchnologies, Systems Economy, Winter and Nitch (Eds).
23. Photoelectrichemical Solar Cells, Chandra
24. Handbook – Batteries Sources and Fuel, Linden (McGraw Hill, 1984).
25. Handbook – Batteries Sources and Conversion Technology, N. K. Bansal, M. Kleeman and S. N. Srinivas (Tata Energy Research Institute, New Delhi, 1996)
26. Wind Energy Conversion System, L. L. Feris (Prentice Hall, 1990)
27. Biomass Energy Systems, Venkata Ramla and S. N. Srinivas (Tata Energy Research Institute, New Delhi, 1996)
28. Renewable energy, Godfrey Boyle, Oxford University Press

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4. Each party will retain all right, title and interest to its Confidential Information. No license under any trademark, patent or copyright or application for same which now or hereafter may be obtained by each party is either granted or implied by the disclosure of Confidential Information.

5. None of the Confidential Information disclosed by Disclosing Party constitutes any representation, warranty, assurance, guarantee or inducement by Disclosing Party to Recipient with respect to the infringement of trademarks, patents, copyrights, any right of privacy, or any rights of third persons.

6. Recipient acknowledges that the Confidential Information disclosed by Disclosing Party under this Agreement may be subject to export controls under the laws of India. Recipient will comply with such laws and agrees not to knowingly export, re-export or transfer Confidential Information of Disclosing Party without first obtaining all required Indian authorizations or licenses:

7. Recipient will not reverse-engineer, decompile or disassemble any hardware of software disclosed to it under this Agreement and will not remove, overprint or deface any notice of confidentiality, copyrights, trademark, logo, legend or other notices of ownership or confidentiality from any originals or copies of Confidential Information it obtains from Disclosing Party.

8. The parties hereto are independent contractors. Neither this Agreement nor any right granted hereunder will be assignable or otherwise transferable.

9. If any term of this Agreement is held to be illegal or unenforceable by a court of competent jurisdiction, the remaining terms will remain in full force and effect.

10. This Agreement may be modified only by a writing signed by the Parties.

11. Recipient acknowledges and agrees that any remedy at law for a breach or threatened breach of the provisions herein would be inadequate to protect the interests of Disclosing Party in such Confidential Information and, in recognition of this fact, in the event of a breach or threatened breach by Recipient of any of the provisions herein, it is agreed that Disclosing Party will be entitled to equitable relief in the form of specific performance, a temporary restraining order, a temporary or permanent injunction, or any other equitable remedy that may be available without posting bond or other security. No remedy herein conferred is intended to be exclusive of any other remedy, and each and every such remedy will be cumulative and will be in addition to any other remedy given hereunder or not or hereinafter existing at law or in equity or by statute or otherwise.

12. Any person signing this Agreement represents that this Agreement has been fully and duly authorized by the party he or she represents, that he or she has been fully and duly authorized to sign this Agreement by the party he or she represents, and that his or her signature is binding upon the party on whose behalf he or she signs. Any notices required hereunder will be to writing and will be sent by certified mail (return receipt requested), postage prepaid, or via internationally recognized overnight courier with courier fees prepaid, to the party to be noticed at the address set forth below. Such notices will be deemed received on the earlier of that date actually received by the noticed party, when refused by the noticed party or when returned to the noticing party.

13. This Agreement will continue from the Effective Date until terminated by either party by giving thirty **(30) days** written notice to the other party of its intent to terminate this Agreement. Notwithstanding such termination, the confidentiality obligations of Recipient will remain in full force and effect following the date of termination of this Agreement for three (3) years. 3 year, **however the agreement can be renewed after three years on year to year basis. As a when the present collaborative research project materializes into commercialization and becomes ready for marketing. disclosure party shall give license or manufacture of the** product

14. **The said project on the terms and condition decided by the mutual consent. Simultaneously the disclosing party shall be free to enter into licensing arrangement with other enterprises for commercialization and marketing of the product.**

15. If any arbitration, litigation, or other legal proceeding occurs between the parties relating to this Agreement, the prevailing party will be entitled to recover (in addition to any

other relief awarded or granted) its reasonable costs and expenses, including attorneys' fees, incurred in the proceeding.

16. This Agreement represents the entire agreement of the parties hereto pertaining to the subject matter of this Agreement, and supersedes any and all prior oral discussions and/or written agreements between the parties with respect thereto.

17. The validity, constructing, interpretation, and enforceability of this Agreement will be governed by the laws of the State of India without giving effect to the choice of laws rules thereof. By execution and delivery of this Agreement, each of the parties submits to the exclusive jurisdiction of the Aurangabad High Court, as the exclusive proper forums in which to adjudicate any case or controversy arising hereunder.

18. This Agreement may be executed in any number of counterparts, each of which when so executed will be deemed to be an original and all of which when taken together will constitute one and the same agreement.

19. IN WITNESS WHEREOF, the parties have caused this Agreement to be entered into as of the Effective Date.

NAC GROUP of Industries, Aurangabad (MS)

By:
Name: Dilip
Title: Dharurkar
Date: Februray 20, 2017

RUSA Centre for Advanced Sensor Technology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (MS) India

By:
Name: Mahendra
Title: Shirsat
Date: Februray 20, 2017