<table>
<tr><td>Course Title</td><td colspan="2">Research Project</td></tr>
<tr><td>Course Code</td><td colspan="2">PHY401M6</td></tr>
<tr><td>Credit Value</td><td colspan="2">06</td></tr>
<tr><td rowspan="2">Hourly breakdown</td><td>Mentoring</td><td>Independent Learning</td></tr>
<tr><td>60</td><td>540</td></tr>
<tr><td colspan="3">Objectives</td></tr>
<tr><td colspan="3">• Develop capability of carrying out scientific research in the field of physics for solving real word problems</td></tr>
<tr><td colspan="3">Intended Learning Outcomes</td></tr>
<tr><td colspan="3">• Identify a hypothesis and/or a researchable problem
• Review the relevant literature, if any
• Formulate research plan with appropriate research methodology
• Analyse the collected data
• Compile a scientific report as per the guidelines
• Defend the results and findings
• Perform scientific communication in reputed forum and/or refereed journal</td></tr>
<tr><td colspan="3">Course Description</td></tr>
<tr><td colspan="3">• Each student is required to carry out a research study in the field of any branch of Physics under the supervision of academic(s) of the department of Physics and/or collaborators
• Students could also pursue research studies at institutions other than the University of Jaffna. Under such circumstances, the student is assigned with more than one supervisor; internal supervisor(s) from the panel of academics at the Department of Physics and/or external supervisor(s) from the institution where the research project is carried out
• The students are expected to maintain a log - book and consult the supervisor at least once in a week throughout the academic year
• After completion of the project, students should submit a soft bound copy of the project report for marking along with similarity report
• On completion of the research study, each student is required to present and defend the report in front of the panel of examiners appointed by the Senate</td></tr>
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Learning Methods / Activities	Laboratory / Modelling / Field work Writing project report Presentation	
Evaluation	Laboratory Report Book/ Field work Record Book	20 %
	Research project report	50 %
	Oral presentation	20 %
	Submission of abstract/poster/paper to a scientific forum	10%

Course Title	**Advanced Electromagnetism**		
Course Code	PHY402M3		
Credit Value	03		
Hourly breakdown	Theory	Practical	Independent Learning
	45	-	105
Objectives	• Explain propagation of electromagnetic waves in various environments using Maxwell's equations • Explain the generation and detection of electromagnetic waves • Importance of relativistic effect on electromagnetic fields		
Intended Learning Outcomes	• Apply Maxwell's equations to study the propagation of electromagnetic waves in different medium, transmission lines and wave guides • Describe different ways of generate electromagnetic waves • Describe the properties of Infrared, Ultra-violet, X-ray and γ radiation • Explain the relativistic effect on electromagnetic fields		
Contents	**Maxwell's Equation and Electromagnetic Waves:** Maxwell's equations, Derivation of Maxwell's equations, Energy in the electromagnetic field and Poynting Vector, Electromagnetic impedance of a medium, Plane waves in free space and in dielectric and conducting media, Propagation of electromagnetic waves through the ionosphere. **Interaction of Electromagnetic Waves with Matter:** Reflection, Refraction, Scattering and Absorption, Boundary conditions for the electromagnetic field vectors, Refractive index of a medium, Reflection and transmission of electromagnetic waves at boundaries, Scattering and absorption of electromagnetic waves by solids and liquids. **Transmission lines and Wave Guides:** Propagation of signals in a lossless transmission line, Transmission line terminated by a load impedance, Practical types of transmission lines, Reflections in transmission lines, Standing waves in transmission lines, the input impedance of a mismatched line, Lossy lines, Propagation of waves between conducting		

	Planes, Wave guides, rectangular wave guides, Optical fibers, Power transmission through wave guides. **Generation and Detection of Electromagnetic waves:** Retarded potentials, Lorentz gauge, Generation of electromagnetic waves, Hertzian dipole, Radiation from moving charges, Radiation resistance of a dipole, Half wave Antenna, Full wave antenna, Detection of Infrared, Ultra-violet, X-ray and γ radiation. **Relativistic electromagnetism:** Maxwell's Equations in four-vector form, Relativistic transformation of electromagnetic fields and potentials, Electric and magnetic fields due to a moving charge, Relativistic transformation of current density and charge density, Retarded potentials from relativistic standpoint.	
Teaching and Learning Methods	Lectures, Tutorial discussion, e-based teaching-learning, Open Educational Resources, Assignments, Guided Learning	
Evaluation	In-course assessments	30%
	End of course examination	70%
Recommended References	• David G., Introduction to Electrodynamics, 4 Ed., Cambridge University Press, (2017) • Grant, I. S., and Phillips, W. R., Electromagnetism, 2 Ed., John Wiley & Sons, (1990) • Duffin, W. J., Electricity and Magnetism, 4 Ed., McGraw-Hill, (1990) • Lorrain, P., Corson, D. R., and Lorrain, F., Electromagnetic Fields and Waves, 3 Ed., W.H Freeman & Co, (1988) • Jackson, J. D., Classical Electrodynamics, 3 Ed., John Wiley & Sons, (1998)	

Course Title	**Advanced Solid-State Physics**		
Course Code	PHY403M3		
Credit Value	03		
Hourly breakdown	Theory	Practical	Independent Learning
	45	-	105
Objectives	• Describe the type of symmetry present in the crystal • Make use of XRD technique to identify crystal structure • Explain the origin of the bandgap in solids • Provide theoretical insights into magnetic properties of solids, semiconductors and superconductivity		
Intended Learning Outcomes	• Deduce crystal structure of a material using XRD data • Describe bandgap formation • Compare different electron theories of solids • Classify semiconductors based on the nature of the bandgap and composition • Discuss the formation and biasing of a p-n junction • Differentiate magnetic materials based on their response to the external magnetic field • Apply Hund's rule to elements with different electronic configuration • Discuss the electrical, thermal and magnetic properties of superconductors		
Contents	**Crystallography:** Review of crystal structures, crystal symmetry, symmetry operations, point groups, reciprocal lattice, Bragg's law, Von Laue formulation, Equivalence of Bragg's law and Laue's condition, Ewald construction, X-ray diffraction experimental techniques, and structure factor. **Electron theory of Solids**: Review of free electron theory, physical origin of band gaps, nearly free electron theory, Bloch theorem, Kronig-Penney model, reduced, periodic and extended zone schemes, tight-binding approximation, concept of effective mass of electron, construction of fermi surfaces.		

	Semiconductors: Review of fundamentals of semiconductor physics, carrier concentration and Fermi levels in extrinsic semiconductors, Hall effect, carrier injection, generation and recombination, p-n junction, light emitting diode (LED), solar cells. **Magnetic properties of Solids**: Different types of magnetism in solids, classical and quantum theories of diamagnetism and paramagnetism, Brillouin function, ferromagnetism, physical origin of ferromagnetism, Weiss exchange field, Currie–Weiss law, Hund's rule, ferromagnetism and anti-ferromagnetism. **Superconductivity**: Introduction to superconductivity, Meissner effect, types of superconductors, critical field, critical current, Isotope effect, specific heat capacity in superconductors, two fluid model, London equations, London penetration length, quantization of magnetic flux, Josephson effect, Superconducting Quantum Interference Device (SQUID), Introduction to Bardeen–Cooper–Schrieffer (BCS) theory.	
Teaching and Learning Methods	Lectures, Tutorial discussion, e-based teaching-learning, Open Educational Resources, Assignments, Guided Learning	
Evaluation	In-course assessments	30 %
	End of course examination	70 %
Recommended References	• C. Kittel, Introduction to Solid State Physics, 8 Ed., John Wiley & Sons, (2004) • Ashcroft, N. W., and Mermin, N. D., Solid State Physics, Cengage Learning, (2011) • Ali O., Elementary Solid State Physics: Principles and Applications, Addison-Wesley, (1975) • Donald A. N., Semiconductor Physics and devices: Basic Principles, 4 Ed., McGraw-Hill, (2011)	

Course Title	**Nuclear Physics**		
Course Code	PHY404M3		
Credit Value	03		
Hourly breakdown	Theory	Practical	Independent Learning
	45	-	105
Objectives	• Introduce the properties of nuclear forces • Provide knowledge of the properties of nuclei, and the relevant models • Explain the principles involved in the nuclear decays and reactions		
Intended Learning Outcomes	• Describe the properties of strong nuclear forces • Estimate nuclear radius from mirror nuclei and alpha particle decays • Estimate barrier height voltage of Deuteron using Schrödinger equation • Explain the physical basis of the Bethe-Weizsa¨cker formula • Estimate the nuclear spin, parity, magnetic moment and electric quadrupole moment of nuclei using Shell model • Explain the different types of radioactivity and account for their occurrence • Explain the basic properties of the nuclear and fusion reactors • Calculate the kinematics of various reactions and decay processes by relativistic calculations		
Contents	**Nuclear Structure**: A survey of nuclear properties, Nuclear size and density: Scattering of fast electrons, Electromagnetic methods, nuclear charge distribution, distribution of nuclear matter **Nuclear forces:** Theory of the deuteron, Low energy Neutron - Proton scattering: Spin – dependence, Effective range theory, Coherent and Incoherent scattering. Proton – Proton Scattering, Neutron – Neutron Scattering, Isotropic spin, High energy n-p, n-n, p-p scattering, Exchange force model **Nuclear models**: Nuclear masses and binding energies; The liquid drop model: The semi empirical formula, magic number; Shell Model: Ground		

<table>
<tr><td></td><td colspan="2">state spin and parity of nuclei, Magnetic moments; Quadra pole moments, Introduction to Collective Model and Optical model.

Nuclear decays: Theory of nuclear decays: alpha, beta, electron capture and gamma decays, allowed and forbidden transition, nuclear stability, beta stability valley.

Nuclear reactions: Nuclear reactions: mechanisms, compound nucleus, kinematics and cross section, nuclear energy levels and their determination, Nuclear fission: Fission cross- section, chain reactions, control fission, moderations, thermal reactors, reactor control, fast breeder reactors, Nuclear fusion: Fusion cross- section; thermo nuclear fusion, magnetic field confinement, fusion reactors, hydrogen bomb, Fusion in stars</td></tr>
<tr><td>Teaching and Learning Methods</td><td colspan="2">Lectures, Tutorial discussion, e-based teaching-learning, Open Educational Resources, Assignments, Guided Learning</td></tr>
<tr><td rowspan="2">Evaluation</td><td>In-course assessments</td><td>30%</td></tr>
<tr><td>End of course examination</td><td>70%</td></tr>
<tr><td>Recommended References</td><td colspan="2">• Kamal, A., Nuclear Physics, Springer, (2014)
• Kenneth, S. K., Introductory Nuclear Physics, John Wlley & Sons (1988)
• Norman, D. C., Models of the Atomic Nucleus, 2 Ed., Springer, (2010)
• Cottingham, W. N. and Greenwood, D. A., An Introduction to Nuclear Physics, 2 Ed., Cambridge University Press, (2004)
• Samuel, S. M. W, Introductory Nuclear Physics, 2 Ed., John Wiley & Sons Inc., (1998)</td></tr>
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<tr><td>Course Title</td><td colspan="3">Laser Physics</td></tr>
<tr><td>Course Code</td><td colspan="3">PHY405M3</td></tr>
<tr><td>Credit Value</td><td colspan="3">03</td></tr>
<tr><td rowspan="2">Hourly breakdown</td><td>Theory</td><td>Practical</td><td>Independent Learning</td></tr>
<tr><td>45</td><td>-</td><td>105</td></tr>
<tr><td>Objectives</td><td colspan="3">• Introduce the basic principle of generation and properties of Laser
• Introduces high power pulsed lasers from Q switched nanosecond lasers to femtosecond lasers
• Introduce different types of modern lasers and their applications in industry, material science, medicine, telecommunications and research</td></tr>
<tr><td>Intended Learning Outcomes</td><td colspan="3">• Describe the fundamentals of a Laser
• Explain the safety responsibilities involved in working with lasers
• Analyse the laser-matter interaction
• Evaluate the types of laser based on their generation techniques
• Differentiate continuous and pulsed laser
• Compare the structure and properties of different types of laser, and intended applications</td></tr>
<tr><td>Contents</td><td colspan="3">Laser: Introduction, properties, classes, and safety
Monochromaticity, Coherence, Directionality, Brightness, Polarisation, Tunability, Principal components of laser, Laser classes and safety.
Einstein's relationship and line broadening mechanisms:
Interaction of matter: absorption, spontaneous and stimulated emission, Einstein's coefficient and relationship, Line shape function, Natural, Collision and Doppler broadenings
Laser Oscillation:
Absorption / Gain coefficient, Population inversion, Threshold population, Laser oscillation in Fabry –Perot cavity and Properties of cavity resonator, Rate equation, pumping power, Three- and Four-level lasers and Gain saturation

Modifying laser output:</td></tr>
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	Laser modes, Quality factor (Q), Mode locking, Q-switching, Electro-optic effect: Kerr and Pockel effects, Magneto-optic effects: Faraday Effect and Acoustic-optic effect, Non-linear effects and Harmonic generation **Types of Laser:** Ruby laser, Gas laser - CO_2 laser, He-Ne Laser, Semiconductor laser, Nd-YAG Laser. Quantum well laser, Dye laser and Polymer laser **Laser Applications**: Laser application in Holography, Information technology, Communication, Printing, Scanning, Industry, Military, and Medical Research	
Teaching and Learning Methods	Lectures, Tutorial discussion, e-based teaching-learning, Open Educational Resources, Assignments, Guided Learning	
Evaluation	In-course assessments	30%
	End of course examination	70%
Recommended References	• William, T. S., Laser Fundamentals, 2 Ed., Cambridge University Press (2004) • Thyagarajan, K. and Ajoy G,. Laser Fundamentals and Applications, 2 Ed., Springer US (2011) • Demtroder, W., Laser Spectroscopy, 4 Ed., Springer (2008).	

Course Title	**Atomic and Molecular Spectra**		
Course Code	PHY406M3		
Credit Value	03		
Hourly breakdown	Theory	Practical	Independent Learning
	45	-	105
Objectives	• Introduce the approximation methods used in quantum theory • Describe main features of atomic spectra. • Discuss the effect of external electric and magnetic fields on the atomic spectra • Explain the main features of molecular spectra and its application		
Intended Learning Outcomes	• Explain the purpose of using approximation methods in solving Hamiltonian in Quantum mechanics • Apply appropriate approximation methods to solve Hamiltonians in the study of atomic spectra • Explain Stark effect, Zeeman effect and Paschen Back effect splitting of spectral lines and broadening spectral lines • Discuss the features of atomic spectra observed experimentally. • Compare the intensities of spectral lines of rotational and vibrational spectra • Estimate bond length and rotational constant of rigid diatomic molecules • Estimate rotational and centrifugal distortion constants of diatomic molecule in harmonic vibration-rotation		
Contents	**Approximation Methods**: Time-independent non-degenerate perturbation theory, Time-independent degenerate perturbation theory, The variational method, Time-dependent perturbation theory and the interaction of atoms with radiation. **Atomic Spectra**: The spectra of Atomic hydrogen: Fine structure, Hyperfine structure; The spectra of Alkali metal atoms: Quantum defects, fine structure in alkali metal atoms; The spectrum of Helium: singlet and triplet		

	states, exchange force; Many electron Atoms: Central field approximation, Atomic configuration and periodic table of elements, Coupling schemes. The interaction of atomic systems with external electric fields: the stark effect; The interaction of atomic systems with external magnetic fields: Landau levels, the strong field Zeeman effect, the Paschen-Back effect, Anomalous Zeeman effect; Broadening of Spectral lines: Broadening, due to local and non-local effects. **Microwave Spectroscopy**: The rotation of Molecules, Rotational spectra, Diatomic molecules, Polyatomic molecules, Techniques and Instrumentations. **Infra-red spectroscopy**: The vibrating diatomic molecules, the diatomic vibrating-rotator, the vibration of polyatomic molecules, the influence of rotation on the spectra of polyatomic molecules, Analysis by infra-red techniques, Techniques and Instrumentations. **Raman Spectroscopy**: Pure rotational Raman spectra, Vibrational Raman spectra, Polarization of light and the Raman effect, Structure determination from Raman and Infra-red spectroscopy, Techniques and Instrumentations. Electronic spectra of molecules: Electronic spectra of diatomic molecules, Electronic structure of diatomic molecules, Electronic spectra of polyatomic molecules, Techniques and Instrumentations. **Spin resonance spectroscopy**: Spin and applied field, Nuclear Magnetic Resonance spectroscopy, Electron Spin Resonance spectroscopy, Techniques and Instrumentations.
Teaching and Learning Methods	Lectures, Tutorial discussion, e-based teaching-learning, Open Educational Resources, Assignments, Guided Learning

Evaluation	In-course assessments	30%
	End of course examination	70%

Recommended References	• Dmitry, B., Derek. F. K. and David, P. D, Atomic Physics: An Exploration through Problems and Solutions, Oxford University Press, (2008) • Svanberg, S., Atomic and Molecular Spectroscopy, Springer, (2004) • Banwell, C. N., Fundamentals of Molecular Spectroscopy, 3rd Edition, McGraw-Hill Book Company, (1972) • Brown, J. M., Molecular Spectroscopy, Oxford University Press, (1998) • Hollas, J. M., Modern Spectroscopy, 4 Ed., John Wiley & Sons, Ltd, (2004) • Anatoli V. A., Atomic Spectroscopy: Introduction to the Theory of Hyperfine Structure, Springer, (2005)

Course Title	**Particle Physics**		
Course Code	PHY407M3		
Credit Value	03		
Hourly breakdown	Theory	Practical	Independent Learning
	45	-	105
Objectives	• Introduce the physics of fundamental constituents of matter and experimental techniques used in the production and detection of high energy particles • Introduce the particle interactions and their properties based on fundamental force carriers		
Intended Learning Outcomes	• Explain the historical development of particle physics • Describe the working principle and applications of various types of particle accelerators • Describe the Standard Model of particle physics • Discuss the types of elementary particles • Differentiate fermions and bosons • Explain the characteristics of electromagnetic, strong, and weak interactions • Interpret the particle interactions using Feynman diagram		
Contents	**Introduction:** The old "elementary" particles, particle accelerators and detectors, particles and anti-particles, pion, muon, neutrinos, strange particles; Classification of particles: baryons, mesons and leptons, quark model; Different types of interaction: strong, electromagnetic and weak; Mediators, the standard model. **Conservation laws:** Energy and momentum, angular momentum, Isospin, strangeness, parity, charge conjugation, time reversal and CPT theorem. **Electromagnetic interaction:** General features, exchange particle, coupling constant, cross section;		

	Feynman diagram: First order, second order and third order processes, conservation of strangeness, non-conservation of isospin, electromagnetic interaction of hadrons. **Hadrons:** The baryon decuplet and octet, meson octet, baryon mass and magnetic moment, mass of light mesons, positronium, quarkonium, psi and upsilon mesons, OZI rule **Weak interaction:** parity violation, helicity of neutrino and antineutrino, decay of charged pions, muons and strange particles, W and Z bosons, Feynman diagram representation of leptonic, semi-leptonic and non-leptonic decay processes, decay of neutral kaon, strangeness oscillation, regeneration, CP violation. **Strong interaction:** Cross-section and decay rates, isospin in the two-nucleon system and pion-nucleon system, baryon resonance. **Quark- quark interaction:** The parton model, neutrino-nucleon collision and electron-positron annihilation cross-section, deep inelastic electron-nucleon, neutrino-nucleon scattering, electron-positron annihilation to hadrons, the quark-quark interaction and potential, quark confinement, Feynman diagram representation of hadronic processes.	
Teaching and Learning Methods	Lectures, Tutorial discussion, e-based teaching-learning, Open Educational Resources, Assignments, Guided Learning	
Evaluation	In-course assessments	30%
	End of course examination	70%
Recommended References	• Donald H. Perkins, Introduction to high energy physics, 4 Ed., Cambridge University Press (2000). • David Griffiths, Introduction to Elementary Particles, 2 Ed., Wiley (2008). • Martin B.R., Shaw G., Particle Physics, 3 Ed., John Wiley & Sons (2008)	

Course Title	**Introduction to Nanoscience and Nanotechnology**		
Course Code	PHY408M3		
Credit Value	03		
Hourly breakdown	Lectures	Practical	Independent Learning
	45	-	105
Objectives	• Introduce the physics of nanomaterial and nanodevices • Provide knowledge of the working principle and application of various nanostructured devices		
Intended Learning Outcomes	• Discuss the various physical properties of nanomaterials • Explain the working principle of nanostructured devices • Distinguish various fabrication technologies of nanomaterials and devices • Explain the basic concepts of quantum effects in nanoelectronic devices • Elucidate the principle and application of Nanobiotechnologies • Analyse the various potential applications of nanomaterials and nanodevices		
Contents	**Introduction:** Definition of nanoscience, nanotechnology and nanomaterials, timeline and milestone of nanotechnology. **Nanoscience:** **Quantum confinement vs dimensions**: Quantum wells, wires and dots, density of states vs dimensionality, surface area of nanostructures interaction at the nanoscale, **Effect of Nano-confinement on Properties**: Thermal, Optical, Mechanical, Structural, Electrical, Chemical, Biological and Magnetic properties, tunable properties by nanoscale surface design and their potential applications. **Nanomaterials and synthesis:** **Nanomaterials:** Polymers and semiconductors at nanoscale, Carbon based structures, Biomolecules: DNA, RNA, Nanocomposites: Metal-metal nanocomposites, polymer-metal nano-composites, Ceramic nanocomposites.		

	Top-down and bottom-up approach of nanomaterial synthesis: Theory of film growth: gas impingement, adsorption, surface diffusion, surface coverage, epitaxial growth, Factors Influencing Thin Film Growth Thin film fabrication techniques: Langmuir-Blodgett film deposition, Electrodeposition, Self-assembly monolayer deposition, Chemical bath deposition, Spray pyrolysis, Molecular Beam Epitaxy, Lithography, Metal Organic Chemical Vapour Deposition, Atomic layer deposition. Synthesis of nanomaterials **Carbon based nanostructures**: Semiconducting polymers, Graphite, Graphene, Carbon nanotube (CNT), single walled CNT, multiwall CNT, Properties of graphene and CNT, Device application of graphene and CNT, fullerene, electronic properties and application of fullerene **Nanoelectronics and Nanostructured devices:** nanoscale MOSFETs, Quantum tunneling diodes, Single electron and single molecule transistors, Nanowire and thin film field effect transistors, Coulomb blockade, Kondo effect in quantum systems, Polymer electronics, Introduction into spintronics, Magnetic properties of nanomaterials and applications, nano-electro-mechanical systems, Nanostructured solar cells, water splitting, fuel cells, batteries, supercapacitors. **Nanobiotechnology**: Functional and Structural Principles of Nanobiotechnology, Nanofludics, Nanobiomachines in action, Nanobiosensors, drug targeting, drug delivery, nanosurgery and other biomedical applications
Teaching and Learning Methods	Lectures, Tutorial discussion, e-based teaching-learning, Open Educational Resources, Assignments, Guided Learning

Evaluation	In-Course Assessment	30 %
	End-of-Course Examination	70 %
Recommended References	• Edward, L. W., Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, 2 Edi., WILEY-VCH Verlag GmbH &Co. KGaA, Weinheim,(2006)	

	• Tero, T. H., The Physics of Nanoelectronics, 1 Ed., Oxford University Press, (2013) • Karl, M. K., and Francis, D., Selected chapters on World Scientific Series on Carbon Nanoscience, World Scientific Publishing Co Pte Ltd, (2018) • Gabor, L. H., Tibbals, H. F., Joydeep, D., and Moore, J. J., Introduction to Nanoscience and Nanotechnology , CRC Press, (2008) • Frank, O., Owens and Poole, C., The Physics and Chemistry of Nanosolids , John Willey, (2008), • George, H., Fundamentals of nanoelectronics , Pearson (2008)

Course Title	**Energy and Environmental Physics**		
Course Code	PHY409M3		
Credit Value	03		
Hourly breakdown	Lectures	Practical	Independent Learning
	45	-	105
Objectives	• Understand the core physical concepts related to Environment • Comprehend the problems of energy demand and explain the possible contributions of renewable energy sources • Introduce various types of energy resources available in the environment		
Intended Learning Outcomes	• Describe the impacts of energy on environment • Discuss specific environmental problems such as pollution, ozone depletion and global warming • Distinguish the renewable and non-renewable energy sources • Explain the physical basis for the utilization of various energy sources • Make assessments on different energy technologies • Estimate the efficiency of an energy conversion process in the environment • Describe the different energy storage systems		

Contents	**Introduction:** Sustainable energy supply, energy and the environmental impact, Alternative energy sources **Environment:** Vertical structure of atmosphere, composition, greenhouse gases, atmospheric motion, solar spectrum, radiative equilibrium, effective temperature of earth, greenhouse effect and climate change **Solar energy:** Solar water heating, unsheltered heaters, sheltered heaters, system with separate storage, selective surfaces, evacuated collectors, other uses of solar heaters; air heaters, crop driers, space heat, space cooling, water desalination, Solar concentrators; photovoltaic generation, solar cells thermoelectric generation **Wind energy:** Turbine types and terms, Basic theory, Dynamic matching, stream tube theory, Characteristics of the wind, power extraction by a turbine, electrical and mechanical power generation **Hydropower:** Principles, assessing the resource for small installations, turbines, hydroelectric systems, hydraulic ram pump **Wave Energy**: Wave motion, wave energy and power, wave patterns and power extraction devices, Cause of tides, Enhancement of tides, tidal flow power and tidal range power **Biofuels**: Bio fuel classification, Biomass production for energy farming, direct combustion for heat, pyrolysis, thermo chemical processes; Alcoholic fermentation, anaerobic digestion for biogas, agrochemical fuel extraction. **Nuclear energy:** Nuclear fuel, Fusion and fission processes, nuclear reactors, reactor types, reactor design, nuclear radiation pollution and health effects. **Energy storage:** Importance of energy storage, Biological storage, chemical storage, heat storage, electrical storage, fuel cells, mechanical storage and distribution of energy

Teaching and Learning Methods / Activities	Lectures, Tutorial discussion, e-based teaching-learning, Open Educational Resources, Assignments, Guided Learning	
Evaluation	In-Course Assessment Examinations	30 %
	Final Written Examination	70 %
Recommended References	• Nelson V., Introduction to Renewable Energy, Energy and the Environment series, CRC Press, (2011) • Volker Q., Understanding Renewable Energy Systems, Earthscan, (2005) • Twidell, J., and Weir, T., Renewable energy resources, 2 Ed. , Tayler and Francis, (2006)	