SCHEME OF EXAMINATION

and

SYLLABUS

of

Master of Technology
(Engineering Physics)

for

Academic Session 2021-2022

UNIVERSITY SCHOOL OF BASIC AND APPLIED SCIENCES

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
Sector 16C, Dwarka, Delhi- 110078

Approved in the 50th meeting of the academic Council of GGS IP University held on 11/06/2021 vide agenda item AC 50.23

Programme Education Objectives (PEO)

PEO1. To provide a broad base which integrates physics and engineering sciences for students from B.Tech and M.Sc (Physics) or equivalent backgrounds.

PEO2. To provide relevant theoretical and experimental knowledge at the frontiers of innovations and research and skill sets for professional jobs, industry and research labs of global technology companies.

PEO3. To provide hands on experimental training on the physics of materials, applications in alternate energy industries (solar, nuclear, thermo-electrics, embedded systems, laser technology and novel materials etc.) with an aim towards academic and industrial employment.

PEO4. To provide skill sets in theoretical disciplines, basic foundations and methods in computation, data and information sciences, futuristic subjects like quantum information, alternate energies, photonics and nanotechnology with applications in industries and academia.

Programme Outcomes (PO)

PO1. Students get the basic training to bridge the gap between physics and engineering, gain exposure to skill sets and areas of research and innovation for future career choices.

PO2. Summer/six months project work in industry/academia expose students to placement opportunities. Hands on experience in alternate energy technologies, material science, engineering, nanotechnology, electronics etc provide adequate project mode training for industry and academia.

PO3. Students learn theoretical methods in physics, computation, modelling and simulations with an eye on applied sciences, technology and research. The use of modern scientific computing and programming software MATLAB, MATHEMATICA, LABVIEW, GAUSSIAN, VASP, etc. give an edge in industry & research related careers.

PO4. Students learn the art of presenting scientific work and results through intensive seminars and projects upgrading their communication skills for industry and academia

Mapping between PEO and PO
(on a scale of 1-10, with 10 excellent)

	PEO1	PEO2	PEO3	PEO4
PO1	8	8	8	8
PO2	8	8	8	8
PO3	8	8	8	6
PO4	8	8	6	8

Master of Technology (Engineering Physics)

FIRST SEMESTER

CODE No.	Paper Name	L	T/P	Credits
BAEPC 601	Applied Mathematical Physics	4	-	4
BAEPC 603	Experimental Techniques in Physics	4	-	4
BAEPE 605	*Program Specific Elective 1	4	-	4
BAEPE 607	**Program Specific Electives 2	4	-	4
EMES 611	Environment Studies (mandatory course)	2	-	2
	Practicals			
BAEPL 651	Computational Methods Lab.	0	4	2
BAEPL 653	Experimental Physics Lab -I	0	4	2
BAEPL. 611	***Minor Project/Seminar - I	0	4	2
	Total	18	12	24

*BAEP (C= Programme Core Theory), (E= Programme Elective Theory), (L= Programme Core Lab)

*List of Program Specific Electives (will be modified/ updated/increased from time to time)

*Program Specific Elective-1	**Program Specific Elective-2
1. Statistics and Data Science 2. Applied Quantum & Statistical Physics	1. Laser Physics 2. Green & Renewable Energy Technologies 3. Introduction to Machine Learning

***Minor Project/Seminar: Each student will be required to prepare a technical paper and make a 30 minute oral presentation on a current research topic relevant to Physics / Applied Physics / Technology to the rest of the class and Faculty. The oral presentation and a final technical report will be evaluated internally and by an external examiner.

All courses (theory & lab) will be open to other programmes of USBAS like M.Tech(NST), Ph.D course work etc.

All Programme Specific Electives will be open to programmes of other schools, wherever relevant.

Master of Technology (Engineering Physics)

SECOND SEMESTER

CODE No.	Paper Name	L	T/P	Credits
BAEPC 602	Photovoltaic Technologies	4	-	4
BAEPC 604	Embedded systems:design, modelling and analysis	4	-	4
BAEPC 606	Nuclear Technology	4	-	4
BAEPC 608	Nanoscale Physics for Advanced Materials	4	-	4
USMS 112	Entrepreneurial Mindset (mandatory course)	2	-	2
	Practicals			
BAEPL 652	Experimental Physics Lab -II	0	4	2
BAEPL 654	Embedded Systems Lab	0	4	2
BAEPL. 610	**Minor Project/Seminar-II	0	4	2
BAEPL. 655	***Summer Project (NUES)	0	4	2
	Total	18	16	26

*BAEP (C= Programme Core Theory), (E= Programme Elective Theory), (L= Programme Core Lab)

**Minor Project/Seminar -II: Each student will be required to prepare a technical paper and make a 30 minute oral presentation on a current research topic relevant to Physics / Applied Physics / Technology to the rest of the class and Faculty. The oral presentation and a final technical report will be evaluated internally and by an external examiner.

***Summer Project will be done for a period of 40 days during the summer vacation period and will be evaluated completely internally (NUES)
All courses (theory & lab) will be open to other programmes of USBAS like M.Tech(NST), Ph.D course work etc.

All Programme Specific Electives will be open to programmes of other schools, wherever relevant.

Master of Technology (Engineering Physics)

THIRD SEMESTER

CODE No.	Paper Name	L	T/P	Credits
BAEPC 701	Computer oriented operation research	4	-	4
BAEPE 703	**Programme Specific Elective 3	4	-	4
BAEPE 705	**Programme Specific Elective 4	4/2	0/4	4
BAEPOE 709	***Open Elective 1	4/2	0/4	4
BAEPOE 709	***Open Elective 2	4/2	0/4	4
CHVE 115	Human Values & Ethics (mandatory course)	2	-	2
	Practicals			
BAEPOEL 719	***Open Electives Lab	0	4	2
	Total	22/16	4/16	24

*BAEP (C= Programme Core Theory), (OE= Open Elective Theory), (OEL= Open Elective Lab)

*List of Program Specific Electives (Will be modified/ updated/ increased from time to time)

Program Specific Elective-3	Program Specific Elective-4
1. Photonics and Optoelectronics 2. Quantum Information Processing 3. Machine Learning in Material Science 4. Fundamentals of Attosecond Optics	1. Accelerator Physics and Applications 2. Wind Power Generation and RE Hybrid Systems 3. Physics of Thermoelectric Materials 4. Computational Techniques with MATLAB

***Open Elective courses will be chosen from the Programmes of Study offered in other University Schools of Study which have an appropriate relevance to the M.Tech (EP) programme. Some Open electives could have both theory and Lab components depended on the nature of the subject/topics

All courses (theory & lab) will be open to other programmes of USBAS like M.Tech(NST), Ph.D course work etc.

All Programme Specific Electives will be open to programmes of other schools, wherever relevan

Approved in the 50th meeting of the academic Council of GGS IP University held on 11/06/2021 vide agenda item AC 50.23

Master of Technology (Engineering Physics)

FOURTH SEMESTER

CODE No.	Paper Name	L	T/P	Credits
BAEPC 702	*Major project/Dissertation.	0	50	25
BAEPC 704	**Comprehensive Viva	0	10	5
	Total	0	60	30

***Major project/Dissertation: This will be a major project undertaken in either theoretical, computational or experimental work. It could be carried out either in house, i.e., involving the University schools and facilities or in industry/research labs/companies/ carried out for a period of 6 months along with the preparation of a dissertation. In both cases an internal mentor/supervisor from the USBAS is mandatory and an external collaborating supervisor can be involved in addition. The project will be examined for internal evaluation followed by an external examination involving a presentation and defence and final submission of dissertation. Original work leading to a publication will be encouraged**

****Comprehensive Viva- an internal and external evaluation via a viva voce covering all aspects of the programme of study including the major project.**

Note:

1. **Total No. of credits of the program is equal to 106 credits**
2. **Each Student shall be required to appear for examinations in all courses.**
3. **Programme Specific Electives and Open Electives will be governed by the available course being floated in the relevant semester by USBAS and other USS**
4. **For the award of the degree a student should secure at least 100 credits. The dropping of Programme Core courses will not be permitted.**
5. **Three courses namely (a) Entrepreneurship Mindset (b) Human Values (c) Environmental Sciences are mandated for all programmes run by the GGS IP University.**

Scheme of Exams/Evaluation

All Theory Papers will have continuous internal evaluation (based on minor exams, quiz, attendance, regularity, presentations etc.) and a final end semester exam conducted by the examination. All Practical papers will also have continuous internal evaluation and a final end semester exam. While the current division is of 25% internal and 75% for theory papers and 40% internal and 60% final end semester examination for practicals, this division will change as per the policies adopted by the university/university schools from time to time on the continuous evaluation process and end term examinations.

Semester-I

Master of Technology (Engineering Physics)

FIRST SEMESTER

CODE No	Paper Name	L	T/P	Cred-its
BAEPC 601	Applied Mathematical Physics	4	-	4
BAEPC 603	Experimental Techniques in Physics	4	-	4
BAEPE 605	*Program Specific Elective 1	4	-	4
BAEPE 607	**Program Specific Elective 2	4	-	4
EMES 113	Environment Sciences (mandatory course)	4	-	4
	Practicals			
BAEPL 651	Computational Methods Lab	0	4	2
BAEPL 653	Experimental Physics Lab -I	0	4	2
BAEPL. 611	***Minor Project/Seminar - I	0	4	2
	Total	20	12	26

***List of Program Specific Electives (will be modified/ updated/increased from time to time)**

*Program Specific Elective-1	**Program Specific Elective-2
1. Statistics and Data Science 2. Applied Quantum & Statistical Physics	1. Laser Physics 2. Green & Renewable Energy Technologies 3. Introduction to Machine Learning

*****Minor Project/Seminar: Each student will be required to prepare a technical paper and make a 30 minute oral presentation on a current research topic relevant to Physics / Applied Physics / Technology to the rest of the class and Faculty. The oral presentation and a final technical report will be evaluated internally and by an external examiner.**

All courses (theory & lab) will be open to other programmes of USBAS like M.Tech(NST), Ph.D course work etc. All Programme Specific Electives will be open to programmes of other schools, wherever relevant.

APPLIED MATHEMATICAL PHYSICS

Course Code : BAEPC-601 **L - 04** **Credits – 04**

Course Objectives

CO_1	**To provide a foundation for basic concepts in applied mathematics**
CO_2	**To expose students to techniques in mathematics widely used in physics and engineering**
CO_3	**To address examples and applications of problem solving in physics and engineering**
CO_4	**To enable students to use mathematics in formulating/solving problems in physics and engineering**

UNIT-I: First & second order ordinary differential equations and their solutions: Application problems of linear differential equations from Physics and Engineering: radioactive decay, rate equations, projectile motion, damped and driven harmonic oscillators, Van der pol oscillator, LCR circuit; series solutions of linear differential equations-Frobenius method; Strum-Liouville equations; Partial Differential Equations and applications from physics: the wave equation, the heat equation, the Schrödinger equation in quantum mechanics

[10]

UNIT-II: Fourier and Laplace Transforms: Fourier Transform: Parseval and convolution theorem, applications to problems in Physics (Optics/Astronomy) and Engineering (Signal and Image Processing); Laplace Transforms: convolution theorem and applications.

[12]

UNIT-III: Beta & Gamma functions, Dirac -Delta function and Green's function with applications (examples from quantum and classical mechanics).

[10]

UNIT-IV Special Functions: Hermite, Legendre, Laguerre, and Bessel functions of 1st and 2nd kind, differential equations and generating functions, recurrence relations; Airy functions and applications in physics (examples from quantum mechanics and optics) **[12]**

References/suggested books

1. Mathematical Physics, P.K. Chattopadhyay (2008) New Academic Science Ltd
2. A.K.Ghatak, I.C.Goyal and S.J.Chua, Mathematical Physics: Differential Equations and Transform Theory, 1st edition (1995).
3. V. Balakrishnan, Mathematical Physics with applications, problems and solutions, Ane books (2017)
4. Hans J.Weber and George B.Arfken, Essential Math. methods for physicists, Elsevier 6th edition (2005)
5. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley,INC, 10th edition (2011)

Course Expected Outcomes

CEO_1	**Get a grounding of the basic concepts in applied mathematics**
CEO_2	**Learn techniques in mathematics widely used in physics and engineering**
CEO_3	**Solve example problems with applications in physics and engineering**
CEO_4	**Learn to use mathematics in formulating/solving problems in physics and engineering**

EXPERIMENTAL TECHNIQUES IN PHYSICS

BAEPC-603 **L - 04** **Credits – 04**

Course Objectives

CO_1	**To give the student an over view of fundamentals of synthesis and characterization techniques**
CO_2	**To expose students to various synthesis processes and characterization technique for materials.**
CO_3	**The student will learn techniques relevant in emerging areas of industry and research**
CO_4	**Students will learn to work with their hands and learn skills required in experiments**

Unit I: Fabrication of Methods: Synthesis Methods and Strategies, Top-down and bottom-up approaches, Ball Milling , Laser ablation, Pulsed Laser Deposition, e-beam, Thermal Evaporation ,Spin Coating, RF & DC Sputtering etc.and its applications and limitations.

[12]

Unit II: X-ray Diffraction: Introduction, Powder X-ray diffraction, X-ray Source, Specimen, Detector, X-ray safety, Sample Preparation of powder X- ray diffraction sample, indexing, comparing the standard data base, determination of impurity phase, estimation of crystal size, calculation of different phases and applications. **[10]**

UNIT III : Electron Diffraction: Introduction, Scanning Electron Microscopy, Samples Preparation for SEM samples, SEM image analysis, Transmission Electron Microscopy, Sample Preparation for TEM, TEM images analysis and particles size distribution, EDAX and applications.

[12]

Unit IV: Spectroscopy: Introduction, UV-Visible spectroscopy, Photoluminescence spectroscopy, FTIR, Raman spectroscopy, and its applications.

[10]

References/suggested readings

1. ASM Hand Book Volume 10- Material Characterization (1986); Hand book of Nanotechnology edited by B Bushan; Wendlandt, W.W., Thermal Analysis, 3rd ed., John Wiley & Sons, NY, (1986), Materials characterization techniques (ed) by Sridhar, G., Ghosh Choudhary, S., and Goswami, N. G.NML, Jamshedpur.
2. Diffraction Physics by J. Cowley, North Holand PL,(1990);High Resolution Transmission Microscope and Associated Techniques by P Buseck, J Cowley and L Eyring Oxford (1992);Nanomaterials:
3. Elements of X- Ray diffraction by Cullity, B.D., Addison Wesley ;Transmission electron microscopy: A Text Book of Materials Science by3. Williams, D.B., and Carter, C.B.,
4. Advanced techniques for microstrutural characterization (ed), by Krishna, R., Anantraman, T.R., Pande, C.S., Arora, O.P., Trans Tech Publication.
5. Synthesis properties and Applications Edited by AS Edelstein and R C Cammarata(1998); Physical properties of materials. by Lovell, M.C., Avery, A.J, and Vernon, M.W,
6. Nanotechnology: Principles and Practices by Sulabha K. Kulkarni Springer

Course Expected Outcomes

CEO_1	**Students learn and understand concepts of experimental techniques**
CEO_2	**Students familiarize themselves with various synthesis process of materials and characterization techniques.**
CEO_3	**Students learn to interpret and analyse experimental results**
CEO_4	**Students are trained to take up real projects and challenges in the industry and R & D.**

STATISTICS AND DATA SCIENCE (PSE1-1)

Course Code : BAEPE-605 **L - 04** **Credits – 04**

Course Objectives

CO_1	**To provide students with an overview of fundamental statistical concepts**
CO_2	**To introduce a practical working knowledge of the basic statistical techniques encountered in applied research**
CO_3	**To introduce the basic concepts of data science**
CO_4	**To initiate programming with R and Python on real problems/case studies**

Unit-I Introduction: Sample Spaces, Events, Probability, Conditional Probability, Total Probability, Bayes Rule; example problems; Random Variables, Discrete Random Variables Binomial Distribution, Poisson Distribution, Continuous Random Variables; the Normal Distribution, Applications of the Normal Distribution, the Central limit Theorem and its applications **[12 Hrs]**

Unit-II Introduction to Data Science: What is data science? Types of data, collecting data, Frequency Distributions and Histograms, exploring and summarising data, scatterplots, graphical displays of Data: dotplots, stemplots, histograms: Absolute Frequency, Relative Frequency, Density, Measures of Center: Mode, Median, Mean, Shapes of Distribution, Measures of Spread: Range, Quartiles, Variance, Standard Deviation **[10 Hrs]**

Unit-III Basics of Statistical Inference and Hypothesis Testing on: (i) One Sample Mean (Z- and t-tests, Type I and II Error, Power & Sample Size) Variance (Chi-squared Test) Proportion (Z-test) ; Correlation and Regression; introduction to statistical machine learning, supervised and unsupervised learning. **[10 Hrs]**

Unit-IV Examples and Case Studies: [Using R and Python] based on Units-I-III. [12 Hrs]

References/suggested books:

1. Introduction to Statistics and Data Analysis With Exercises, Solutions and Applications in R Authors: Heumann, Christian, Schomaker, Michael, Shalabh, Publisher" Springer 2016
2. Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 2018, Wiley (Low price edition available)
3. Introduction to. Mathematical. Statistics. Robert V. Hogg. Allen T. Craig,, Low price Indian edition by Pearson Education
4. Probability and Statistics for Engineers. Richard A. Johnson, Irwin Miller, John Freund
5. Mathematical Statistics with Applications. Irwin Miller, Marylees Miller, Pearson Education
6. The R Software-Fundamentals of Programming and Statistical Analysis -Pierre Lafaye de Micheaux, Rémy Drouilhet, Benoit Liquet, Springer 2013; A Beginner's Guide to R (Use R) By Alain F. Zuur, Elena N. Ieno, Erik H.W.G. Meesters, Springer 2009

Course Expected Outcomes

CEO_1	**Students learn fundamental statistical concepts for future applications**
CEO_2	**Students get a practical working knowledge of basic statistical techniques encountered in applied research**
CEO_3	**Students are introduced to the basic concepts of data science**
CEO_4	**Students get familiar with R and Python programming applied to real problems/case studies**

APPLIED QUANTUM AND STATISTICAL PHYSICS (SEM-1 : PSE1-2)

Course Code : BAEPE-607 **L - 04** **Credits – 04**

Course Objectives

CO_1	To make students appreciate the crucial role of quantum mechanics in modern science and technology
CO_2	To emphasis the importance of quantum effects in conventional electronic circuits and applications in nanoscience and technology
CO_3	To emphasis the importance of the study of quantum statistics to understand the functioning of devices
CO_4	To teach students problem solving in quantum mechanics

Unit I : **Review of fundamental concepts**: Schrödinger equation, simple quantum systems; quantum harmonic oscillator; uncertainty principle, 1D, 2D and 3D quantum confinement, the electron wave packet and dispersion, introduction to electronic properties of bulk semiconductors and heterostructures

[10 hours]

Unit II: The matrix formulation of quantum mechanics: Dirac notation, state vectors, superpositions, unitary & hermitian operators, Hamiltonian evolution, quantum measurement, two level systems, Pauli spin matrices, introduction to quantum information; qubits, quantum registers and quantum gates.

[10 hours]

Unit III: Review of concepts in quantum statistics: identical particles, Maxwell-Boltzmann statistics, indistinguishable particles; Fermi–Dirac & Bose Einstein statistics; Application to (a) ideal Bose gas, Debye theory of specific heat, Black-body radiation, Bose-Einstein Condensation; (b) ideal Fermi gas, simple metals, electronic specific heat; Fermi degeneracy, white dwarf stars**.**

[10 hours]

Unit IV: Problem solving (analytical/numerical with Matlab) based on Units I-III: Examples: (i) Energy eigenvalues & eigenstates of a confined electron **(ii)** Study of an electron confined in a harmonic potential **(iii)** Dispersion of a quantum wavepacket for a free particle and in a harmonic potential **(iv)** Time dynamics of a quantum two-level system (qubit) **(v)** Calculate and plot density of states for a quantum well and quantum wire.

[10 hours]

Suggested Books and References

1. Applied Quantum Mechanics , A. F. J. Levi (Cambridge University Press) (2006)
2. Quantum Mechanics: An Introduction, Walter Greiner, Springer (2000)
3. Concepts of Modern Physics, Arthur Beiser & Shobit Mahajan, McGraw Hill Education; (2017)
4. Introduction to Quantum Mechanics (2016) David J. Griffiths

Course Expected Outcomes

CEO_1	Students learn to appreciate the crucial role of quantum mechanics in modern science and technology
CEO_2	Students appreciate quantum effects in conventional electronic circuits, transistors, and future applications of nanoscience and technology
CEO_3	Students learn the importance of quantum statistics to understand the functioning of devices
CEO_4	Students learn problem solving in quantum mechanical systems

LASER PHYSICS (SEM-1 : PSE2-1)

Course Code : BAEP -609 **L - 04** **Credits – 04**

Course Objectives:

CO_1	To provide students basic concept of modern laser physics
CO_2	To understand the design parameters of laser systems
CO_3	To evolve the understanding of laser resonator and ultrashort pulse generation
CO_4	To develop the ability to comprehend various laser systems

UNIT-I Properties of laser beams: Monochromaticity, Coherence: spatial and temporal coherence; directionality, brightness. Homogeneous and inhomogeneous broadening. Einstein coefficient A & B and Laser rate equations.

[10]

UNIT-II: Population inversions, gain and gain saturation; Laser oscillations above threshold; Requirements for obtaining population inversions; Laser pumping requirements and techniques.

[10]

UNIT-III: Laser cavity modes; Longitudinal and Transverse laser modes, properties of laser modes; Stable laser resonators and Gaussian beams; Special Laser Cavities and Cavity Effects: Unstable Resonators, Q-Switching, Gain Switching, Mode Locking; Pulse-Shortening Techniques, Cavities for Producing Spectral Narrowing of Laser Output.

[12]

UNIT-IV: Carbon Dioxide Laser, Nd:YAG and Nd:Glass Lasers, Titanium Sapphire Laser, Semiconductor Lasers: Quantum Well Diode Laser, Vertical cavity surface emitting laser, Free Electron Laser (FEL); high intensity laser matter interaction, industry applications: laser cutting, welding, drilling & micromachining; laser in medicine: light-tissue interaction, Optical Coherence Tomography(OCT); satellite Laser ranging and Lasers in astronomy.

[12]

References:

[1] William T. Silfvast, Laser Fundamentals, 2nd edition, Cambridge University Press, (2004)

[2[John Hawkes and John Wilson, Optoelectronics: An Introduction, 3rd edition, Prentice Hall Europe, (1998)

[4] A.Corney, Atomic and Laser Spectroscopy, 1st edition, Oxford: Clarendon Press, (1977)

[5] Orazio Svelto, Principles of Lasers, 5th edition, Springer, (2010)

[6] W.Koechner, Solid State Laser Engineering, 5th edition, Springer, (1999); Ajoy Ghatak and K.Thyagarajan, Optical Electronics, Cambridge University Press, 2004

Course Expected Outcomes:

COE_1	To apply the knowledge acquired of laser fundamentals to technological uses
COE_2	To apply the gained skills of optics and quantum optics into development of laser systems
COE_3	To develop laser physics concepts into ultrashort laser pulse generation technology
COE_4	To apply the concepts of laser physics to develop and working of various laser systems

GREEN & RENEWABLE ENERGY TECHNOLOGIES (SEM-1 : PSE2-2)

Course Code : BAEPE 613 **L - 04** **Credits – 04**

Course Objectives

CO1	To learn the present energy scenario and the need for energy conservation.
CO2	To understand concepts of renewable energy sources like wind, solar, bio and other renewable energy resources.
CO3	To analyse the environmental aspects of renewable energy resources
CO4	To understand concepts of solar radiation

Unit I : Introduction : Energy needs of India, classification of energy sources, energy efficiency and energy security, Energy scenario current, environmental effects of energy sources, cheap energy versus environment, Importance of renewable energy resources, solar day, equation of time, local and solar time, sun earth angles, shadow angles, sunrise and sunset **[12 hours]**

Unit II : Solar Radiation: Basics, Thermal radiation fundamentals, Solar radiation and electromagnetic spectrum, solar radiation entering the earth system, Solar radiation using satellite, Instruments for measuring solar radiation: Pyranometer, Pyrheliometer, Sunshine recorder, Solar radiation on horizontal and inclined surface, Liu and Jordan Formula, Daily and monthly solar radiation, simulations to calculate sun earth angles and hourly solar radiation on tilted surface **[12 hours]**

Unit III: Solar thermal and solar photovoltaics: Basic concepts, types of collectors, collection systems, photo voltaic (PV) technology: solar thermal effect, solar cells, characteristics of PV systems, equivalent circuit, and array design, building integrated PV system and efficiency calculations, applications. **[10 hours]**

Unit IV: Other Renewable Energy Resources: Wind Energy, Bio Energy, Geothermal energy, ocean thermal energy, wave energy, Tidal energy, waste to energy, heat to energy, Fuel cells: types and applications. **[10 hours]**

Suggested Readings and References

1. Rai G.D, “Non conventional Energy Sources” Khanna Publishers, 2006.
2. A.Duffie and W.A.Beckmann, Solar Engineering of Thermal Processes-John Wiley (1980)
3. Understanding renewable energy systems, Volker Quaschning, 2006, Replika Press Pvt. Ltd., India.; Alternative Energy, Vol 1-3, Neil Schlager and Jayne weisblatt, 2006, Thompson Gale Generating electricity from the sun, Fred C Treble, 1991, Pergramon Press.
4. F.Kreith and J.F.Kreider, Principles of Solar Engineering, McGraw-Hill (1978).
5. Handbook of Energy Engineering , Albert Thumann ,D. Paul Mehta, 2008 Fairmont Press, Inc

Course Expected Outcomes

CEO1	Learn about Renewable Energy resources and its importance
CEO2	Understand the process of solar thermal and solar photovoltaic power generation
CEO3	Understand the concept of solar radiation, calculation of direct, diffuse and total solar radiation both theoretically and experimentally.
CEO4	Summarize the fundamentals of other renewable energy resources like wind, bio, geothermal, ocean etc.

AN INTRODUCTION TO MACHINE LEARNING : (PSE2-3)

Course Code : BAEPE 615 **L - 04** **Credits – 04**

Course Objectives

CO1.	**To understand the basic concepts of Machine Learning**
CO2.	**To understand the difference between supervised, unsupervised learning.**
CO3.	**To choose the appropriate machine learning tool for different real world problems.**
CO4.	**To analyze tons of data, extract value and glean insight from it.**

UNIT I: Introduction to: Machine Learning, Supervised Learning, Unsupervised Learning, Regression and classification, Examples, Applications, Scope, etc.

[12]

UNIT-II: Linear Regression (One Variable): Model Representation, Cost Function, Intuition of Cost Function, Gradient Descent for Linear Regression and is intuitions, Housing Prices Prediction Problem

[10]

UNIT-III: Linear Regression (Multivariable): Multiple Features, Gradient Descent for multivariable, Parameters(Learning Rate), Feature Scaling, Features and Polynomial Regression, Normal Equation, Normal Equation Invariability.

[10]

UNIT IV Classification: Binary (Two-Class) Pattern Classification Problems, Logistic Regression and the cost function, Optimal Separation For Linearly Separable Data Sets, Hard Margin Classifier, Soft Margin Classifier, Nonlinear Support Vector Machines.

[12]

Use Python programming language to implement the studied ML models

References:

1. Numerical Optimization with Applications by *Suresh Chandra, Jayadeva, Aparna Mehra*, Narosa, 2009
2. Pattern recognition and machine learning by *Christopher Bishop,* Springer Verlag, 2006
3. Introduction to Machine Learning by *Alpaydin, E.,* MIT Press, 2004.
4. Support vector machines: Optimization based theory, algorithms and extensions by Deng, N., Tian, Y., and Zhang, C., New York: Chapman & Hall, CRC Press (2012)

Course Expected Outcomes

CEO_1	The end of the course the students are able to have good hold on basics of Machine Learning techniques
CEO_2	This course will help to understand practical aspects of Machine learning models,
CEO_3	The students will study Python for Machine Learning
CEO_4	The students will develop Machine Learning models for simple real world problems

(For Post Graduate Programmes in USS)

ENVIRONMENTAL STUDIES

Paper Code: EMES-611 **L-02** **Credits-02**

Course Objectives

CO_1	**The course is designed to impart basic knowledge of the environment and its components.**
CO_2	**The course deals in creating awareness about the environment, existing organisms, the energy resources and current environmental problems faced by the world.**
CO_3	**To understand and explore different approaches of conserving and protecting environment for the benefit of society.**

Course Contents

Unit I: Fundamentals: The Multidisciplinary nature of environmental studies: Definition, scope and importance, need for public awareness:

Ecosystems: Structure and function of an ecosystem, energy flow in ecosystems, food chain, food web, ecological pyramids, ecological succession; Introduction to types & characteristics.

Biodiversity: Introduction to biodiversity-definition, genetics, species, ecosystem diversity, value of biodiversity-consumptive uses, productive, social, ethical, aesthetic and option values, biodiversity at global and national level, hot spots of biodiversity in India, threats to biodiversity, in-situ and ex-situ conservation.

[7 hours]

Unit II: Renewable and non renewable resources:Energy resources: Growing energy needs, renewable and non renewable energy sources, sustainable development

Water Resources: Use and over-utilization of surface and ground water, conflicts over water

Forest resources: Use and over-exploitation, deforestation, case studies

Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies

Food resources: World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems

Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. **[5 hours]**

Unit III: Environment Pollution: Air Pollution: Types of pollutants, sources, effects & control of air pollutants.

Water Pollution: Classification of Pollutants, their sources, waste water treatment

Soil Pollution: Composition of soil, classification and effects of solid pollutants and their control.

Solid Waste Management: Classification, waste treatment and disposal methods; compositing, sanitary land filling, thermal processes, recycling and reuse methods.

Hazardous wastes - Classification, treatment and disposal processes.

Marine Pollution: Causes, effects and control of marine pollution, coastal zone management.

Thermal pollution: Causes, effects and control of Thermal pollution **[5 hours]**

Unit IV: Social Issues, Human Population and Environment Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents, Environmental Impact Assessment; Some important Environmental laws, Green bench; population growth and variation among nations, environment and human health, human rights, value education, women and child welfare, Role of government and non government organizations in environment improvement. **[6 hours]**

Field work

Suggested Readings:

1. Textbook of environmental studies, Erach Barucha, UGC, 2013
2. Fundamental concepts in environmental studies, DD Mishra, S Chand & Co Ltd, 2014
3. A textbook of environmental studies, R Gadu, S Rattan, S Mohaptra, Kataria Publication, 2016
4. Basics of Environment and Ecology, A. kaushik & C.P.Kaushik, New Age International Publishers, 2010.
5. Elements of environmental sciences & engineering, P Meenakshi, PHI Learning Pvt Ltd, 2014
6. Environmental studies, B Joseph, Tata McGraw-Hill Publishing Company Ltd., 2012
7. Environmental chemistry, Sharma & Kaur, Goel Publishing House, 1995
8. Environmental Studies, Franky Varah, Mahongnao P., Khashimwo P. and Shimrah. T. Heritage Publishers, New Delhi, 2020

Course Outcomes

CO_1	Environmental Studies course will provide necessary information and knowledge about the various aspects of environment, ecosystems and related biodiversity.
CO_2	Students will be able to learn and understand about the availability and sustainable use of resources, environmental problems and their short term and long term impacts to humans.
CO_3	Course will help them to learn about various social issues and role of human in conservation and protection of our environment.

COMPUTATIONAL METHODS LAB-I

Course Code : BAEPL-651 **P - 04** **Credits – 02**

Course Objectives

CO_1	To introduce students to computational methods in Physics with MATLAB. And also introduce the use of MATHEMATICA, GAUSSIAN, LAB VIEW, VASP AND R
CO_2	To expose students to introductory topics and basics of numerical techniques and programming. To learn to solve problems in tune with the needs of industry/research and topical subjects.
CO_3	To educate students on the logic behind solving problems related to real physical examples, simulation, modelling and designing algorithms that translate into codes
CO_4	To appreciate the role of computing as an invaluable tool in research and problem solving in both academia and industry

List of experiments [To be updated and modified from time to time]

1. Introduction to the Matlab programming language; Operations in Matlab: basic mathematical operations with matrices & arrays
2. Plotting with Matlab: line plots, 1-D, 2-D, 3-D, meshgrid, labeling axes, legends, importing and plotting data files in Matlab, Learning to use if, while, elseif commands; Simple animations
3. Numerical methods for Solving Ordinary Differential Equations (ODEs); Programming in Matlab to solve 1st order and 2nd order ODEs ; Solving ODEs using inbuilt matlab solvers
4. The Newton Raphson method for root finding; Programming in Matlab to find roots using Newton Raphson method; Using direct matlab solvers for root finding
5. Numerical methods for Integration – Rectangular Method; Trapezoidal and Simpson's method; Programming in Matlab for integration using the above methods
6. Curve Fitting

Specific examples: Classical Mechanics: Newton's laws, Projectile Motion, Simple Harmonic Oscillator, Damped & Driven Harmonic Oscillator, Van der Pol Oscillator, Lorenz Equations, I D cellular automata, Simple Fractals; etc; **Quantum mechanics;** Particle in a box: 1D, 2D; Energy levels & density of states; Schrödinger equation for simple quantum systems; Plotting & visualisation of various potentials; Radioactive Decay, wave packet dynamics:

Course Expected Outcomes

CEO_1	Students learn to work on computational methods in Physics with MATLAB.
CEO_2	Students learn to solve real life problems encountered in industry/research and topical subjects.
CEO_3	Students understand the logic behind simulation, modelling and designing algorithms that translate into codes
CEO_4	Students learn to appreciate the role of computing as an invaluable tool in research and problem solving in both academia and industry

Suggested References/Books

1. MATLAB Programming for Engineers, 6E Stephen J. Chapman, Cengage Learning India Pvt. Ltd.(2019)
2. Getting Started with MATLAB , Rudra Pratap, Oxford University Press; 7E (2019)

EXPERIMENTAL PHYSICS LAB -I

Course Code : BAEPL-653 **P - 04** **Credits – 02**

CO_1	To introduce students to various experiments in the area of material science, laser and solar photovoltaics
CO_2	To expose students to skills in designing their own experiments using basic infrastructure
CO_3	To educate students on hands on training with instruments and experimental techniques
CO_4	To help appreciate the role of practical problems and solutions in real life experimental scenarios

List of experiments [To be updated and modified from time to time]

1. To demonstrate the I-V and P-V characteristics of PV module with varying radiation and temperature level.
2. To demonstrate the I-V and P-V characteristics of series and parallel combination of PV modules.
3. To show the effect of variation in tilt angle on PV module power.
4. To determine density of the sample and study the sintering effect on it .
5. Familiarization of powder X-ray diffraction set up ; writing the XRD pograms for powder diffraction ; preparing the powder samples for XRD and do the measurement for the standard samples Al, ZnO, Ag.
6. Measure the electrical conductivity of the given sample and compare with standard data and estimate the error in the samples
7. Writing the LabVIEW programming for electrical conductivity and data acquisition.
8. Synthesis various thick ness of ZnO films on different substrate using spin coater.
9. Synthesis of bismuth telluride system by hydrothermal and microwave method.
10. To study Laser beam characteristics and measure the spot size of He-Ne Laser
11. To study Spatial and Temporal Coherence of He-Ne Laser
12. To study Zeeman effect with He-Ne Laser
13. Study the GM Counter

Course Outcomes

CO_1	Students learn various experiments in the area of material science, laser and solar photovoltaics
CO_2	Students acquire skills in designing their own experiments using basic infrastructure
CO_3	Students get hands on training with instruments and experimental techniques
CO_4	Students appreciate the role of practical problems and solutions in real life experimental scenarios

MINOR PROJECT-I

Course Code : BAEPC-611 **P - 04** **Credits – 02**

Course Objectives (CO)

Students will be required to prepare a technical paper and make an oral presentation on a current research topic relevant to Physics / Applied Physics / Technology to the rest of the class and Faculty. This presentation and report will be evaluated internally and by an external examiner.

CO1	To initiate the student to take up a research topic in which a small theoretical/numerical or experimental project can be done, written up and presented in a seminar
CO2	To help the student to gain confidence in approaching a research topic/problem and learning the methodology, thinking critically and coming up with problem solving techniques.
CO3	To teach the student how to write up a piece of work in a technical report as well as to make a presentation and communicate a topic and results in a clear, comprehensive and effective manner as well as to tackle questions from a critical audience
CO4	To instil students with a sense of confidence when facing interview/evaluations

Course Expected Outcomes (CEO)

CEO1	The student will be in a position to approach a new topic or research problem and understand it through self study making her/him ever ready to learn new things and take on challenges in their career.
CEO2	The exercise of doing these projects will take the student to working with researchers in research labs, industry, companies etc. giving them both exposure and an opportunity for future placements and careers.
CEO3	The student will learn to write technical papers and reports, make seminar presentations well and communicate ideas and results with clarity, making them well prepared for future jobs.
CEO4	**S**tudents develop a sense of confidence when facing interview/evaluations and learn to speak clearly and defend their presentations and work

Semester-II

Master of Technology (Engineering Physics)

SECOND SEMESTER

CODE No.	Paper Name	L	T/P	Credits
BAEPC 602	Photovoltaic Technologies	4	-	4
BAEPC 604	Embedded systems:design, modelling and analysis	4	-	4
BAEPC 606	Nuclear Technology.	4	-	4
BAEPC 608	Nanoscale Physics for Advanced Materials	4	-	4
USMS 112	Entrepreneurial Mindset (mandatory course)	2	-	2
	Practicals			
BAEPL 652	Experimental Physics Lab -II	0	4	2
BAEPL 654	Embedded Systems Lab	0	4	2
BAEPL. 610	**Minor Project/Seminar-II	0	4	2
BAEPL. 655	***Summer Project (NUES)	0	4	2
	Total	18	16	26

**Minor Project/Seminar -II: Each student will be required to prepare a technical paper and make a 30 minute oral presentation on a current research topic relevant to Physics / Applied Physics / Technology to the rest of the class and Faculty. The oral presentation and a final technical report will be evaluated internally and by an external examiner.

***Summer Project will be done for a period of 40 days during the summer vacation period and will be evaluated completely internally (NUES)

All courses (theory & lab) will be open to other programmes of USBAS like M.Tech(NST), Ph.D course work etc.

All Programme Specific Electives will be open to programmes of other schools, wherever relevant.

PHOTOVOLTAIC TECHNOLOGIES

Course Code: BAEPC-602 **L - 04** **Credits – 04**

CO1	To recognize the physics of semiconductors behind solar cells.
CO2	To develop a comprehensive understanding of solar Photovoltaic (PV) components
CO3	To provide in-depth understanding to design and simulate the performance of a solar PV power plant
CO4	To learn planning, project implementation and operation of solar PV power generation

Course Objectives:

Unit I : Introduction : Physics of solar cells: Review of semiconductor properties, dynamics and densities of electrons and holes, Fermi level in doped semiconductors, carrier transport, interaction of light with semiconductor, Absorption of light in direct and Indirect Band gap Semiconductors, recombination processes, electrostatics of p-n junctions, junction capacitance, carrier injection, minority carriers in Quasi Neutral Regions under dark and illuminated conditions, saturation current density, light generated current, solar cell output parameters: Isc, Voc, FF,Efficiency,Efficiency limit, Effect of Temperature.

[12 hours]

Unit II : PV Systems: PV cell, module, Array, Energy storage, brief study of associated system electronic components: charge controller, battery, inverter, wiring, stand etc.

[10 hours]

Unit III: PV System examples: Designing, modeling and simulation; Stand alone Systems, hybrid systems, utility interactive system, designing of PV system: components, load evaluation system design, Example of PV remote cabin

[10 hours]

Unit IV: Present and future scope in SPV: Status of SPV in industry and research labs in India and abroad, emerging technologies: Organic Solar cells, Bilayer and bulk heterojunction organic solar cell, dye sensitized solar cells, perovskite solar cells, Quantum dot sensitized solar cells, etc.

[12 hours]

Suggested Readings/References

1. Solar Energy: Fundamentals, Design, Modeling and Applications: G.N. Tiwari, 2002, Narosa Pub. house

2. **Understanding renewable energy systems**, Volker Quaschning, 2006, Replika Press, India

3. **Alternative Energy**, Vol 1-3, Neil Schlager and Jayne weisblatt, 2006, Thompson Gale; Generating electricity from the sun, Fred C Treble, 1991, Pergramon Press.

4. **Solar Cells: Operating principles, technology and system Applications**, Martin A. Green, Prentice Hall (1982)

5. **Physics of solar cells**, Peter Wurfel, Wiley VCH Verlag GmbH & Co. KGaA, 2016.

6. T**errestrial solar photovoltaics,** Tapan Bhattacharya, Narosa Publishing House, 1998.

Course Expected Outcomes

CEO1	Students will be able to understand the operation of a silicon PV cell.
CEO2	Students will be able to understand and explain the operation and performance characteristics of various solar power plant components and select them to meet specific criteria
CEO3	Students will be able to perform a solar resource assessment of a potential site and develop understanding on the PV plant design
CEO4	Students will be able to design and simulate a PV power plant

EMBEDDED SYSTEMS:DESIGN, MODELLING AND ANALYSIS

Course Code :BAEPC-604 **L - 04** **Credits – 04**

Course objectives

CO1	To familiarize students with basic hardware components differentiate between microprocessors and micro-controllers.
CO2	To understand the architecture of ARM processor with its instruction set.
CO3	To appreciate and Identify the applicability of the embedded system.
CO4	To comprehend real time operating systems used for embedded systems.

Unit-I Introduction : Embedded vs General computing systems, Classification of Embedded systems(ES), Applications, Core of ES, Microprocessors and microcontrollers, RISC and CISC controllers, Applications, specific ES - washing machine, domain specific -automotive, Programmable logic devices, CISC Examples Motorola (68HC11), 8051, RISC example ARM, DSP Processors, Harvard Architecture, PIC, Simulator, Emulator. **[10 hrs]**

Unit-II Design, Development and Programming ES : OS for ES, RTOS and IDE for ES Design, Choosing an RTOS, Types of OS, Tasks, process and threads, Preemptive Task scheduling techniques, Interprocess Communication, Task synchronization issues – Racing and Deadlock, Binary and counting semaphores (Mutex example without any program), Integration & testing of Embedded hardware & firmware, Integrated development environment (IDE), Structure of embedded program, compiling, linking, downloading & debugging, embedded product development life-cycle. **[12 hrs]**

Unit-III ARM Embedded Systems: The RISC design philosophy, The ARM Design Philosophy, ARM Processor Fundamentals: Registers, Current Program Status Register, Pipeline, Exceptions, Interrupts, and the Vector Table, ARM Processor Families, Introduction to ARM Instruction Set-Data Processing Instructions, Branch Instructions, Load Store Instructions, Program Status Register Instructions. **[12 hrs]**

Unit-IV Embedded hardware : Memory map, Memory -RAM, ROM, UVROM, EEPROM, Flash Memory DRAM, Watchdog Timers, A/D and D/A Converters, Sensors, Actuators, LED, LCD, Keyboard, Communication Interface- I^2C bus**,** JTAG**.** **[10 hrs]**

Course Expected Outcomes

CEO1	To be able to interpret basic hardware components and their selection methods based on characteristics and attributes of an embedded system.
CEO2	To be able to implement programming ARM for different applications and to interface external devices and I/O with ARM microcontroller and to describe the architectural features and instructions of ARM microcontroller.
CEO3	To develop the hardware -software co-design approaches.
CEO4	To demonstrate the need of real time operating system for embedded system applications

Suggested Readings/References

1. Andrew N Sloss, Dominic Symes and Chris Wright, ARM system developers guide, Elsevier, Morgan Kaufman publishers, 2008
2. K V Shibu, Introduction to Embedded Systems, Tata McGraw Hill Education, Private Limited, 2nd Edition
3. Paul Horowitz, Art of Electronics, Winfield Hill, Cambridge University press, 3rd Edition
4. Joseph Yiu, System - on - chip architecture with ARM Cortex Processor, ,Addison Wesley, 2000

NUCLEAR TECHNOLOGY

Course Code :BAEPC-606 **L-04** **Credits – 04**

Course Objectives

CO_1	To expose students to the future of nuclear power as an alternative to carbon-centric power
CO_2	To help students develop a basic understanding of fundamental concepts of properties of nuclei, radioactive decay, radiation units, nuclear instrumentations and their applications in science and technology.
CO_3	To teach students to basic concepts and knowledge of protective measures against the radiation exposure.
CO_4	To teach students to develop problem based skills.

Unit I: Basics of Nuclear Technology: Basic concept of atomic structure; The composition of nucleus and its properties, mass number, Isotopes, Isobars, stable and unstable isotopes, binding energy, law of radioactive decay, introduction of accelerators and types of accelerators, details of accelerator facilities in India, overview of department of atomic energy (DAE) and centers in India, nuclear reaction, cross-section, Q-value, elementary idea of fission and fusion reactions, introduction of nuclear reactors, nuclear energy and uses. **[12]**

Unit II: Nuclear Detectors: Basic concept and working principle of gas detectors (Ionization Chambers, Geiger Muller Counter), Scintillation Detectors, Solid States Nuclear Track Detectors and their applications and Introduction of HPGe detector & applications, NaI detector & applications & Pocket dosimeter, Thermo luminescent dosimetry. **[12]**

Unit III: Radiation Quantities and Units: Basic idea of different units of activity, rad, gray, KERMA, exposure, absorbed dose equivalent dose, effective dose- Rem & Sievert, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Dose Limits for Occupational workers and Public. Overview and functionary of Atomic Energy Regularity Board (AERB): Existence and Purpose. **[10]**

Unit IV: Applications of Nuclear Technology: Application in medical science (e.g., MRI, PET, radiation therapy etc.), Archaeology, Industrial Uses: Tracing, Sterilization, Food preservation, Research applications etc., interaction with industry. **[10]**

Reference Books

1. Introductory Nuclear Physics by K. S. Krane, Wiley-India Publication, 2008.
2. Nuclear Physics by R. Prasad, Pearson, 2014.
3. R.R. Roy and B. P. Nigam : Nuclear Physics, Theory and Experiment (John-Wiley and Sons, INC.)
4. Radiation Detection and Measurements by Glenn F. Knoll, 4th Edition, John Wiley & Sons, 2010.
5. Nuclear Radiation Detectors by S.S. Kapoor and V.S. Ramamurthy, 1993.
6. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.

Course Expected Outcomes

CEO_1	Students understand the concept of nuclear structure, radioactive decay, accelerators, reactors & applications, nuclear energy, DAE.
CEO_2	After completion of this course the students will be familiar with skills in modern nuclear technology.
CEO_3	Students will learn to detect nuclear radiations using gas filled detectors, G.M counter, ionization chambers, scintillation detectors, HPGe detector and NaI detector.
CEO_4	On completion of this course, the student will be ready for assignments and placement in accelerator technology in nuclear energy, health care, medicines, reactor technology and accelerator based research and industry.

Course Code :BAEPC-608 **L-04** **Credits – 04**

NANOSCALE PHYSICS FOR ADVANCED MATERIALS

Course Objectives

CO1	To give students an overview of fundamental concepts of nano and advanced materials.
CO2	To expose students to applications of nanoscale phenomena and materials
CO3	To expose students to emerging areas of nanoscience & materials in industry and research.
CO4	To expose students to nanoscale devices and their applications

Unit 1: Basic introduction of Nano Scale Physics The nano scale and its importance and significance in Science, Engineering and Technological aspects. Physics of low dimensional materials, quantum effects, weak confinement, moderate confinement, strong confinement, Density of states for zero dimensions, one dimension, two dimensions and three dimensions, Coherence length, penetration depth, Bohr excitation radius. Surface to volume ratio and its importance in engineering and technology. Quantum size effects in nanoparticles and its properties, optical, magnetic, electronic properties, band gap and their applications. **[12 hrs.]**

Unit II: Brief Review of magnetic material Fundamentals of magnetic materials, Dia, Para, Ferro, Antiferro, Ferri, Superpara magnetic materials, Spin glass and giant and colossal magneto-resistance, super fluidity and superconductivity. **[10 hrs.]**

Unit-III: Magnetisam in Nano Structures Single-Domain vs Multi-Domain Behavior, Coercivity of Fine Particles, Superparamagnetism in Fine Particles ,Superparamagnetism in Alloys. Ferro Magnetisam in semi-conduction quantum dots, and its applications. **[10 hrs]**

UNIT IV Thermo Electric Material and device Modelling Basic concepts of the thermoelectric materials Classification of thermoelectric materials, Bulk nanostructure thermoelectric materials , nano structure thermoelectric materials, environmental thermoelectric material, fabrication thermoelectric device single pair and multi stage device, thermoelectric module of cooling applications. **[12 Hrs.]**

References

1. **ASM Hand Book Volume 10- Material Characterization (1986)**
2. **Hand book of Nanotechnology edited by B Bush-an**
3. **CRC Hand Book of thermoelectric- DM Rowe**
4. **Introduction to Magnetic Materials by B D Culity C D Graham**
5. **Introduction to Solid State Physics by Kittel, John Wiley,(1996)**

Course Expected Outcome

CEO1	Students learn basic concepts, critical thinking, and fundamental ideas of nanoscale physics and its potential applications
CEO2	Students learn basic concepts and understanding of advanced materials and their potential applications
CEO3	Students learn to apply their learning to emerging areas of nanoscience & materials in industry and research.
CEO4	Students learn about nanoscale devices and their applications in industry & research

ENTREPRENEURIAL MINDSET (MANDATORY COURSE)

Course Code :USMS112 **L-02** **Credits – 02**

CO_1	To provide a foundation for basic entrepreneurial skills and to acquaint them with the world of entrepreneurship and inspire them to set up and manage their businesses.
CO_2	To expose students to ideas of creativity and innovation
CO_3	To expose students to various aspects of entrepreneurship and business
CO_4	To expose students to case studies on successful entrepreneurs

Course Objectives

Unit I: Introduction: The Entrepreneur; Theories of Entrepreneurship; Characteristics of successful entrepreneurs, myths of entrepreneurship; entrepreneurial mindset- creativity and innovation **Role of Entrepreneur:** Factors affecting entrepreneurial growth; Role of Entrepreneurs in Economic Growth **[7hrs]**

Unit II: Promotion of a Venture and Writing a business plan: Opportunity Analysis; External Environment Analysis Economic, Social and Technological Analysis. Business plan- What is business plan, parts of a business plan. Writing a Business Plan **[7hrs]**

Unit III: Entrepreneurship Support: Entrepreneurial Development Programmes (EDP): EDP, Role of Government in Organizing EDPs. Institutions supporting small business enterprises: central level, state level, other agencies, industry associations. **[7hrs]**

Unit IV Practicals:

- Presenting a business plan
- Project on Startup India or any other government policy on entrepreneurship
- Discussion on why startup fails, role of MSME etc.
- Discussion on role of entrepreneur in economic growth.
- Discussion on technology park.
- Case study discussion on successful Indian entrepreneurs.

Course Expected Outcomes

CEO_1	Students form a foundation for basic entrepreneurial skills
CEO_2	Students learn the importance of creativity and innovation
CEO_3	Students tstudy various aspects of entrepreneurship and business
CEO_4	Students to are inspired by examples of successful entrepreneurs.

Suggested Readings:

1. Charantimath (8th Ed., 2014), Entrepreneurship Development and Small Business Enterprise, Pears Education.
2. Bamford C.E (1st Ed 2015), Entrepreneurship: A Small Business Approach, McGraw Hill Education.
3. Hisrich et al. (2013) Entrepreneurship, McGraw Hill Education
4. Balaraju, Theduri (2012), Entrepreneurship Development: An Analytical Study, Akansha Publishing House.
5. David, Otis, (2014), A Guide to Entrepreneurship, Jaico Books Publishing House, Delhi.
6. Kaulgud, Aruna, (2012), Entrepreneurship Management, Vikas Publishing House, Delhi.
7. Chhabra, T.N. (2014), Entrepreneurship Development, Sun India.

EXPERIMENTAL PHYSICS LAB -II

Course Code : BAEPL-652 **P - 04** **Credits – 02**

Course Objectives:

CO_1	To introduce students to various experiments in the area of material science, laser and solar photovoltaics
CO_2	To expose students to skills in designing their own experiments using basic infrastructure
CO_3	To educate students on hands on training with instruments and experimental techniques
CO_4	To help appreciate the role of practical problems and solutions in real life experimental scenarios

List of experiments [To be updated and modified from time to time]

1. To show the effect of variation in tilt angle on PV module power.
2. To demonstrate the effect of shading on module output power.
3. To Workout power flow calculations of stand-alone PV system of DC load with battery.
4. To measure Solar radiation using Solarimeter, sunshine recorder and pyranometer
5. To calculate total solar radiation on a tilted surface.
6. Synthesis various thick ness of ZnO films on different substrate using spin coater.
7. Synthesis of CZTS system by ball mill method
8. Design the low temperature electrical conductivity set up
9. Design , fabricate and calibration of muffle furnace
10. Detection of nature of radiation using SSNTD
11. Designing of GAS sensing setup
12. Method for testing Li-ion battery
13. Designing and developing supercapacitor for energy storage.
14. Thermoelectric samples will be prepared sputtering and thermal evaporation method.
15. Micro Raman, UV-IR will be used to study the samples.
16. Surface Morphology will be studied by AFM.
17. Structure and particle size will be estimated by powder XRD.
18. To demonstrate the effect of shading on module output power.
19. To Workout power flow calculations of stand-alone PV system of DC load with battery.
20. To measure Solar radiation using Solarimeter, sunshine recorder and pyranometer. To calculate total solar radiation on a tilted surface.

Course Outcomes:

CO_1	Students learn various experiments in the area of material science, laser and solar photovoltaics
CO_2	Students acquire skills in designing their own experiments using basic infrastructure
CO_3	Students get hands on training with instruments and experimental techniques
CO_4	Students appreciate the role of practical problems and solutions in real life experimental scenarios

EMBEDDED SYSTEMS LAB

Course Code :BAEPC-654 **P - 04** **Credits – 02**

Course Objectives:

CO_1	Understand the Building Blocks of Embedded Systems.
CO_2	Learn the working of ARM processor.
CO_3	Familiarization with IDE like Keil and learn to write programs to interface memory, peripherals with processor.
CO_4	Learn to download and Run program using Flash Magic into the ARM hardware.

List of experiments [To be updated and modified from time to time]

1. Study of ARM evaluation system
2. Write program for Interfacing7-segment display interface
3. Write program for Interface circuit for on board Buzzer and Relay
4. Write program for Interfacing LED
5. Write program for Interfacing ADC and DAC
6. Write program for Flashing of LEDS
7. Write program for Interfacing 4X4 matrix keyboard with ARM
8. Write program for interfacing LCD
9. Write program for Interfacing EPROM
10. Write program for Interfacing real time clock and serial port
11. Interfacing stepper motor and temperature sensor.

Course Expected Outcomes:

CEO_1	Able to identify all peripherals in the ARM Embedded system kit.
CEO_2	Able to write programs using IDE for ARM processor for a specific application like interfacing keyboard, display,LED, LCD, motor DAC, ADC and sensor etc.
CEO_3	Able to Interface memory and write programs related to memory operations.
CEO_4	Formulate a mini project using embedded system.

Suggested Reference/Books

1. Andrew N Sloss, Dominic Symes and Chris Wright, ARM system developers guide, Elsevier, Morgan Kaufman publishers, 2008
2. Steve Furber, ARM System-on-Chip Architecture, Second Edition, Pearson, 2015;
3. Daniel W. Lewis Fundamentals Of Embedded Software With The Arm Cortex-M3, 2nd Edition by, Pearson India

MINOR PROJECT/SEMINAR-II

Course Code : BAEPC-610 **P - 04** **Credits – 02**

Course Objectives (CO)

Students will be required to prepare a technical paper and make an oral presentation on a current research topic relevant to Physics / Applied Physics / Technology to the rest of the class and Faculty. This presentation and report will be evaluated internally and by an external examiner.

CO1	To initiate the student to take up a research topic in which a small theoretical/numerical or experimental project can be done, written up and presented in a seminar
CO2	To help the student to gain confidence in approaching a research topic/problem and learning the methodology, thinking critically and coming up with problem solving techniques.
CO3	To teach the student how to write up a piece of work in a technical report as well as to make a presentation and communicate a topic and results in a clear, comprehensive and effective manner as well as to tackle questions from a critical audience
CO4	To instil students with a sense of confidence when facing interview/evaluations

Course Expected Outcomes (CEO)

CEO1	The student will be in a position to approach a new topic or research problem and understand it through self study making her/him ever ready to learn new things and take on challenges in their career.
CEO2	The exercise of doing these projects will take the student to working with researchers in research labs, industry, companies etc. giving them both exposure and an opportunity for future placements and careers.
CEO3	The student will learn to write technical papers and reports, make seminar presentations well and communicate ideas and results with clarity, making them well prepared for future jobs.
CEO4	Students develop a sense of confidence when facing interview/evaluations and learn to speak clearly and defend their presentations and work

SUMMER PROJECT

Course Code : BAEPC-656 P - 04 Credits – 02

Course Objectives (CO)

Students will be required to prepare a technical paper and make an oral presentation based on 40 days of training/project work with industry or academia and will be evaluated internally by the faculty members

CO1	To initiate the student to take up a research topic in which a small theoretical/numerical or experimental project can be done, written up and presented in a seminar
CO2	To help the student to gain confidence in approaching a research topic/problem and learning the methodology, thinking critically and coming up with problem solving techniques.
CO3	To teach the student how to write up a piece of work in a technical report as well as to make a presentation and communicate a topic and results in a clear, comprehensive and effective manner as well as to tackle questions from a critical audience
CO4	To instil students with a sense of confidence when facing interview/evaluations

Course Expected Outcomes (CEO)

CEO1	The student will be in a position to approach a new topic or research problem and understand it through self study making her/him ever ready to learn new things and take on challenges in their career.
CEO2	The exercise of doing these projects will take the student to working with researchers in research labs, industry, companies etc. giving them both exposure and an opportunity for future placements and careers.
CEO3	The student will learn to write technical papers and reports, make seminar presentations well and communicate ideas and results with clarity, making them well prepared for future jobs.
CEO4	Students develop a sense of confidence when facing interview/evaluations and learn to speak clearly and defend their presentations and work

Semester-III

Master of Technology (Engineering Physics)

THIRD SEMESTER

CODE No.	Paper Name	L	T/P	Credits
BAEPC 701	Computer oriented operation re search	4	-	4
BAEPE 703	**Programme Specific Elective 3	4	-	4
BAEPE 705	**Programme Specific Elective 4	4/2	0/4	4
BAEPOE	***Open Elective 1	4/2	0/4	4
BAEPOE 709	***Open Elective 2	4/2	0/4	4
CHVE 115	Human Values and Ethics (mandatory course, NUES)	2	-	2
	Practicals			
BAEPOEL 719	***Open Electives Lab	0	4	2
	Total	22/16	4/16	24

List of Program Specific Electives(will be modified/ updated/increased from time to time)

Program Specific Elective-3	Program Specific Elective-4
1. Photonics and Optoelectronics 2. Quantum Information Processing 3. Machine Learning in Material Science 4. Fundamentals of Attosecond Optics	1. Accelerator Physics and Applications 2. Wind Power Generation and RE Hybrid Systems 3. Physics of Thermoelectric Materials 4. Computational Techniques with MAT-LAB

*****Open Elective courses will be chosen from the Programmes of Study offered in other University Schools of Study which have an appropriate relevance to the M.Tech (EP) programme. Some Open electives could have both theory and Lab components depended on the nature of the subject/topics**

COMPUTER ORIENTED OPERATION RESEARCH

Course Code : BAEPC-701 **L-04** **Credits-04**

Course Objectives

CO1	Translate the problem given in descriptive form into a mathematical model.
CO2	Classify the various optimization problems according to their characteristics
CO3	Develop the scientific approach to analyze the problems and making decisions
CO4	Learning various optimization methods for solving linear models

UNIT I Introduction to Operations Research, Linear Programming Problems: basic concepts, general and standard forms of LPP, Mathematical formulation, Convex feasible region, extreme points and basic feasible solutions, Optimal solution determination by using Graphical method and Simplex method, Two phase method, Big M method. **[12 Hrs.]**

UNIT II: Duality in LPP: Dual problem, Duality theorems, Complementary slackness, Economic interpretation of duality, Dual simplex method. **[12 Hrs.]**

UNIT-III Transportation and assignment models: Transportation Problem, Duality of Transportation problem, Degeneracy in transportation problem, Solution of Transportation problem (by VAM and modified distribution methods), assignment problem, Hungarian method. **[10 Hrs.]**

UNIT-IV Network Scheduling: Network and basic components, Network construction, Critical path method (CPM), Program evaluation and review techniques (PERT), Cost of completing project. Use mathematical software as Python or Mat Lab to solve the proposed models.

[10 Hrs]

References:

1. Operations Research: An Introduction by Hamdy A. Taha, Pearson Education Inc., 2007
2. Numerical Optimization with Applications by *Suresh Chandra, Jayadeva, Aparna Mehra*, Narosa, 2009
3. Practical Optimization and Engineering Application by Antonions amd L.W. Sheng, New Age Publications, 2010
4. Introduction to Operations Research by Frederick S. Hiller & Gerald J. Lieberman, McGraw Hill, 2009.
5. Linear Programming by G Hadley, Narosa Pub, 1963.

Course Expected Outcomes:

CEO1	An economic interpretation of the optimization problem
CEO2	It gives executives the power to make effective decisions and build more productive systems
CEO3	Students will acquire knowledge of a wide range of mathematical techniques and of mathematical methods/tools in other scientific and engineering domains applications
CEO4	Students will learn to apply theories and concepts in a creative and industry-oriented project work.

PHOTONICS & OPTOELECTRONICS (PSE3-1)

Course Code : BAEPE-703 **L - 04** **Credits – 04**

Course Objectives:

CO_1	To provide students with a working knowledge of fundamentals of lasers and photonics
CO_2	To expose various components of integrated photonics
CO_3	To present fundamental principles for understanding and applying optical fiber technology
CO_4	To learn various applications of photonics

UNIT-I Properties of laser beam: monochromaticity, spatial and temporal coherence, directionality. Einstein coefficients A & B, light amplification, threshold condition, laser rate equations, line broadening mechanism, variation of laser power around threshold, optimum output coupling, modes of a rectangular cavity, the quality factor, the ultimate linewidth of the laser; mode selection: transverse and longitudinal mode selection. **[10 Hrs]**

UNIT-II Integrated optics: Introduction, guided wave devices, phase modulator, Mach-Zehnder interferometer modulator and switch, optical directional coupler, comparison of bulk and integrated optic modulator; the electro-optic effect: longitudinal and transverse mode in KDP crystals; Acousto-optic effect: Raman-Nath diffraction and Bragg diffraction, Acoustic-optic devices; self-focussing phenomenon. **[10 Hrs.]**

UNIT-III Optical Fibers: Structure, Waveguiding and Fabrication; Losses and dispersions phenomena of optical fibers; Digital transmission systems; WDM: concepts and components, Erbium Doped Fiber Amplifiers (EDFA), Semiconductor laser diodes and photodetectors; optical networks; Measurements: Attenuation and dispersion measurements, numerical aperture measurements, refractive index profile measurements, Optical Time Domain Reflectometry (OTDR). **[10 Hrs.]**

UNIT-IV Laser cooling and trappings, optical tweezers. Photonic switching and computing, Introduction to metamaterials; Modern applications of photonics: information processing, optical data storage, Photonic Crystal Optics(1-D,2-D & 3-D), Fourier transform and its applications.

[12 hrs]

References:

[1] A.Ghatak & K. Thyagarajan, Optical Electronics, Cambridge University Press, 2004
[2] Amon Yariv, Optical Electronics, Saunders College Publishing 1991
[3] John M senior, Optical fiber communications PHI, 1992.
[4]B.E. A. Saleh and M.C. Teich Fundamentals of Photonics, John Wiley & Sons, 1991.
[5] Gerd Keiser. Optical Fiber Communications, Mc Graw Hill, 2000
[6] J Wilson and JFB Halkes Optoelectronics: an introduction PHI, l996; S.C. Gupta, Optoelectronic Devices and Systems, PHI, 2005

Course Expected Outcomes

COE_1	To understand basic concepts related to Laser Science & Technology
COE_2	To analyse the physics of various components of integrated optics
COE_3	To learn the various concepts of optical fiber technology
COE_4	To understand the mechanism of applications of photonics

Course Code : BAEPE-705 **L - 04** **Credits – 04**

QUANTUM INFORMATION PROCESSING (PSE3-2)

Course Objectives

CO 1	**The course introduces students to a topical and exciting areas in the frontiers of technology and physics - quantum information and computation, which is expected to revolutionise information technology soon.**
CO 2	**Students are exposed to and educated in a multidisciplinary area that demands an unusual combination of theoretical computer science and quantum mechanics.**
CO 3	**Students are initiated in an area where the government of India has announced a National Mission on Quantum Technologies & Applications (NM-QTA) with a total budget outlay of Rs 8000 Crore for 5 years in 20202, opening up a huge job market in academia and industry in the future.**
CO 4	**This course will introduce students to the important concepts of this exciting new field and cover its main ideas, current developments and future trends.**

Unit-I. Introduction: What is Information ? Information Entropy of Discrete Variables, Shannon's source coding and channel coding Theorems; Complexity classes, the factoring problem and the RSA algorithm, Turing Machines, The Church-Turing Thesis, Moore's law and the future of transistors and computing hardware, why quantum computing? **[10hrs]**

Unit-II:Quantum Physics and Computers: Review of quantum mechanics: state vectors, superpositions, unitary operators, hermitian operators, (linear algebra& vector spaces), Schrödinger equation, Hamiltonian evolution, quantum two-level systems, entangled states the concept of quantum measurement, qubits, quantum registers and quantum gates with examples. **[10hrs]**

Unit-III: Quantum Algorithms: quantum circuits, transfer matrices, the C-NOT gate, the no-cloning theorem, quantum circuits for creating Bell states, Quantum algorithms, Deutsch's algorithm, the Deutsch-Josza algorithm, the discrete Forurier transform, the quantum Fourier transform, Shor's algorithm and its implementation in a quantum circuit, Grover's search algorithm **[12hrs]**

Unit-IV: Quantum Cryptography and Quantum Teleportation and quantum hardware: Heisenberg uncertainty principle, polarization states of photons, quantum cryptography using polarized photons, entanglements, introduction to the EPR paradox, Bell's theorem, Bell basis, teleportation of a single qubit, review of some current experiments and candidate physical systems, technological feasibility of a quantum computer and the limitations imposed by noise. **[12hrs]**

References/Suggested texts

1. Elements of Information Theory, Thomas M. Cover and Joy A. Thomas (Wiley Series in Telecommunications and Signal Processing) 2006
2. Information Theory: A Tutorial Introduction February 2015, James V. Stone
3. Quantum Computation and Quantum Information, Nielsen and Chuang, (Cambridge Univ. Press 2010)

CEO_1	**Students learn about quantum information, an area expected to revolutionise information technology.**
CEO_2	**Students train in a multidisciplinary area combining computer science & quantum mechanics.**
CEO_3	**Students get a grounding in an area in which National Mission on Quantum Technologies & Applications (20202) has invested Rs 8000 Cr. for 5 years, opening a huge job market in future**
CEO_4	**Students learn the main ideas, current developments and future trends in this area, giving them a definitive edge in future careers in academia and industry**

Course Expected Outcomes

MACHINE LEARNING IN MATERIAL SCIENCE (PSE3-3)

Course Code : BAEPE-707 **L - 04** **Credits – 04**

Course Objectives

CO1	To appreciate the need of advanced ML algorithms
CO2	To understand the basics of Neural Networks
CO3	To be able to debug an ML algorithm and evaluate the performance
CO4	Apply machine learning algorithms in Materials Science domain.

UNIT I Neural Networks: Significance of Neural Networks (NN), Neuron Model, I/O layers and Hidden layers in NN and the cost function, Binary classification (optional: Logical gates with simple NN, Back propagation). **[10]**

UNIT II Practical consideration for ML model: Debugging an algorithm, Train/test/cross-validation, Model selection, Bias vs variance (Optional: Learning curves). **[10]**

UNIT-III Overview of advanced ML algorithms: Introduction to the algorithms used often in Materials Science such asDecision trees and Random Forest algorithm (optional: Discussion of ML related research papers in Materials Science field)

[12]

UNIT-IV ML model for Physics and Materials Science problems: Exploring Materials Science databases, Data extraction and curation, Model training for Materials Science Problem (E.g. classifying materials as half-Heuslers and non-half-Heuslers)

[12]

References

1. Pattern recognition and machine learning by *Christopher Bishop,* Springer Verlag, 2006
2. An introduction to neural networks for beginners, by Dr. Andy Thomas.
3. Deep Materials informatics: Applications of deep learning in materials science, Ankit Agrawal et al., MRS Communications, 9, 779 (2019).

Course Expected Outcomes:

CEO_1	Students should be comfortable with some advanced ML algorithms
CEO_2	Students should be able to handle Materials Science databases
CEO_3	Developing and debugging the models for a simple Materials Science problem.
CEO_4	Learn to apply machine learning algorithms in Materials Science domain.

FUNDAMENTALS OF ATTOSECOND OPTICS (PSE3-4)

Corse Code:BAEPE-709 **Credit:04**

Course Objectives:

CO_1	**To introduce students to basic concepts of attosecond optics and research**
CO_2	**To focus on driving lasers as key tools used in attosecond pulse generation**
CO_3	**To evolve the understanding of theoretical foundations for single atom response**
CO_4	**To develop the ability to comprehend measurement techniques and applications**

UNIT-I High power applications, high speed imaging, time scale of electron dynamics, Attosecond light pulses: mathematical description of optical pulses, propagation of optical pulse in linear dispersive media; overview of attosecond pulse generation and properties of attosecond XUV pulses, challenges and opportunities in attosecond pulses; Femtosecond driving Lasers.

[10 Hrs.]

UNIT-II Stabilisation of Carrier-Envelope Phase: carrier envelope phase in Laser Oscillator & dispersion, measurement of the carrier envelope phase of amplified pulses, carrier envelope phase measurements after hollow core fibers; Semiclassical model: three step model, chirp of attosecond pulses, tunneling ionisation and multiphoton ionisation-Keldysh theory, Isolated attosecond pulse generation **[10 Hrs.]**

UNIT-III Strong field approximation: analytical solution of the Schrodinger equation; phase matching-wave propagation equation, phase matching for plane waves, Gaussian beams and pulsed lasers; attosecond pulse trains and electron time of flight spectrometer; Single attosecond pulses: phase retrieval by omega oscillation filtering, complete reconstruction of attosecond bursts for isolated attosecond pulses**.**

[10 Hrs.]

UNIT-IV Attosecond pump probe experiments and requirement on the attosecond pulse energy, direct measurement of the temporal oscillation of light and spatial variation of field in Bessel beams, controlling two electron dynamics in Helium atoms**.** **[10 Hrs.]**

References:

[1] Eugene Gamaly, Femtosecond Laser Matter Interaction: Theory, Experiments and Applications, CRC press (2011)
[2] Zenghu Chang, Fundamentals of Attosecond Optics, CRC Press (2011)
[3] Shuntaro Watanabe, Katsumi Midorikawa, Ultrafast Optics V, Springer (2007)
[4] C.D.Lin, Anh-Thu Lee, Cheng Jin, Hui Wei, Attosecond and Strong Field Physics: Principles and Applications, Cambridge University Press (2018)
[5] Bernhard W.Adams, Nonlinear Optics, Quantum Optics, and Ultrafast Phenomena with X-Rays: Physics with X-Rays Free Electron Lasers, Springer Science (2003)
[6] Luis Plaja, Ricardo Torres, Amelle Zair, Attosecond Physics: Attosecond measurements and Control of Physical Systems, Springer (2013)

Course Expected Outcomes:

CEO_1	**To apply acquired knowledge for the development of attosecond pulse laser**
CEO_2	**To apply the gained skills in formulating and solving theoretical problems**
CEO_3	**To develop an understanding of attosecond pulse techniques**
CEO_4	**To enable students to use attosecond lasers for measurement and applications**

ACCELERATOR PHYSICS AND APPLICATIONS (PSE4-1)

Course Code: BAEPE-711 **L- 04** **Credits**

Course Objectives

CO_1	**To train students on accelerator technology, theoretical designs and their applications in research, health care, industry**
CO_2	**To expose students to Ion beam technology/ion beam processes**
CO_3	**To expose students to the basics of nuclear science and technology**
CO_4	**To teach the physics behind swift heavy ions for synthesis and modifications of nanostructured materials.**

Unit I: Instrumentation and beam lines: Introduction, instrumentation for ion beam technology, overview of accelerators, types of accelerators, beam lines, pelletron, linear accelerator, Cyclotron, Synchrotron, status of accelerators in India and abroad and overview about the Department of Atomic Energy (DAE) and its centers. **Ion interface with matter:** Ion stopping, energy losses, high energy and low energy losses, elastic and inelastic collisions. [2]

[12]

Unit II: Vacuum Technology: Basic principles of vacuum technology and brief overview, Elements of a vacuum system, Vacuum coating system and their importance, Types of vacuum pumps and applications, Rotary pump, Diffusion pump, Pirani gauge, Thermocouple gauge, Ultra high vacuum technology, Leak detection techniques and applications. **[12]**

Unit III: Ion source: Introduction of ion source, classification of ion sources, Positive and negative ion sources, Radio frequency ion sources, sputter ion source, ECR source. **Ion Beam cryogenics and its applications:** Ion Beam-an overview and applications, Introduction to cryogenics and its applications to accelerator. **[10]**

Unit IV: Swift heavy ions for synthesis and modifications of nanostructured materials: Introduction, Synthesis of nanostructured materials under electronic excitation and nuclear energy loss, ion track formation and applications, modification in materials: Thin films/bulk, nanomaterials, nanocomposite materials, Radiation damage and structure change: defects formation, points defects, line defects, columnar defects and applications.

[10]

References:

1. Accelerator Based Research in Basic and Applied Sciences, 2002, Amit Roy and D K Avasthi, Phoenix Publishers.
2. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
3. Introductory Nuclear Physics by K. S. Krane, Wiley-India Publication, 2008.
4. Nuclear Physics by R. Prasad, Pearson, 2014.
5. R.R. Roy and B. P. Nigam: Nuclear Physics, Theory and Experiment New Age International (P) Limited (2017).

Course Expected Outcomes:

CEO_1	Students become e familiar with the basic tools required to work with accelerators, ion sources, beam optics, vacuum technology, ion implantation and latest accelerators
CEO_2	Students become familiar with DAE and its centers in India
CEO_3	Students are exposed to future technology & Applications like: (a) Free Electron Laser (FEL) (b) Superconducting Linacs & Cyclotrons.
CEO_4	On completion of this course, the student will be ready for assignments and placement in accelerator technology in many fields like, health care, medicines, reactor technology, nuclear technology and accelerator based research and industry.

WIND POWER GENERATION AND RE HYBRID SYSTEMS (PSE4-2)

Course Code : BAEPE 713 **L - 04** **Credits – 04**

Course Objectives

CO1	To understand wind energy resource assessment techniques
CO2	To develop a comprehensive technological understanding in wind energy system components
CO3	To develop an intuitive understanding of wind turbine design criterion and its conversion system.
CO4	To know about applications of wind energy and hybrid systems

Unit I : Introduction : Basic principles of wind energy conversion, Status, Advantages and disadvantages of wind energy systems, Wind statistics- Measurements and data Presentation, Historical developments, latest developments, state of art of wind energy technology, turbine rating, economic analysis of wind turbine, Indian scenario and worldwide developments, present status and future trends. **[10 Hrs.]**

Unit II : Wind energy characteristics and design: Nature of atmospheric winds; wind resource characteristics and assessment; anemometry; wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography, Design of wind turbine blade; effect of stall and blade pitch on coefficient of power vs tip speed ratio and cut-out wind speeds, blade materials, design characteristics, multiple stream tube theory, vortex wake structure; tip losses; rotational sampling, wind turbine design programs, aerodynamic loads, tower shadow, wind shear, blade coning, gyroscopic, transient and extreme loads. **[12 Hrs.]**

Unit III: Control Mechanism: Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Case study of design of wind mill. **[10 Hrs.]**

Unit IV: Wind energy application and hybrid systems Wind pumps - Performance analysis, design concept and testing, Principle of WEG- Stand alone, grid connected and hybrid applications , wind diesel hybrid system, system with no storage-, system with battery backup, Wind - photovoltaic systems, economic evaluation, Wind energy in India- Case studies, environmental impacts of wind farms. **[12 Hrs.]**

References

1. Paul Gipe, Wind Energy Comes of Age, John Wiley & Sons Inc.
2. Ahmed: Wind Energy Theory and Practice, PHI, Eastern Economy Edition, 2012
3. L.L. Freris, Wind Energy Conversion System, Prentice Hall, 1990.
4. Tony Burton et al, Wind energy Hand Book, John Wiley & Sons Inc.
5. Steve Parker, “Wind power”, Gareth Stevens Publishing, 2004.
6. Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.

Course Expected Outcomes:

CEO1	Students learn to explain the existing wind energy potential.
CEO2	Students learn to explain the operation and performance characteristics of various wind power plant components and select them to meet specific criteria
CEO3	Students learn to analyze the control mechanism of wind turbine
CEO4	Students understand the application of wind energy and hybrid systems with case studies and its environmental impacts

PHYSICS OF THERMOELECTRIC MATERIALS (PSE4-3)

Course Code : BAEPE 715 **L - 04** **Credits – 04**

Course Objectives

CO1	To understand basic requirement of thermoelectric material
CO2	To understand electronic and transport properties of the system
CO3	To choose the right selection of the materials for optimization of thermoelectric material performance.
CO4	To know about applications of thermoelectric devices

Unit-I Electronic Structure of Materials Statistical equilibrium of free electrons : density of states for bulk and low dimensional system , distributions: Maxwell Boltzmann, Fermi Dirac, carrier concentration , impurity semiconductors.

[10 Hrs.]

Unit-II Static Properties Specific heat of metals and semiconductors, thermionic emission. **Transport properties of materials :** Boltzmann transport equation, Particle diffusion, electrical and thermal conductivity, Isothermal Hall effect

[12 Hrs.]

Unit-III Thermo Electric Materials (TEM): Electrical conductivity, Seeback effect, Peltier effect, Figure of Merit, Selection of the material for TEM, Different types of TEM and recent development in low dimensional TEM, doping, alloying and size effects and its Applications.

[10 Hrs.]

Unit – IV Thermoelectric Module and Device Introduction, Segment thermoelectric model , Modeling and Optimization of Segmented Thermoelectric Unicouples, Optimum Conversion Efficiency, summary. **[12 Hrs.]**

References:

1.Statistical Physics: Patheria (Butterworth-Heinemann, Oxford,1972).
2. Statistical Physics: K.Huang (Wiley Eastern, New Delhi,1975).
3.B.K.Aggarwal & Melvin Eisner: Statistical Physics (Wiley Eastern, New Delhi).
4. CRC Handbook of Thermoelectrics, Ed. CR Rowe

Course Expected Outcomes:

CEO1	Explain the existing thermoelectric materials advances
CEO2	This course will give clear cut over view transport properties of the materials
CEO3	Students will get clear knowledge about the thermoelectric materials and devices
CEO4	Students will be able to choose their carrier in R &D in this area

COMPUTATIONAL TECHNIQUES WITH MATLAB (PSE4-4)

Course Code : BAEPE-751 **L-02, P-02 [2 hrs theory, 4 hrs lab]** **Credits - 04**

Course Objectives

CO_1	To carry forward from the previous semester to advanced computational methods in physics with MATLAB as the programming language.
CO_2	To expose students to solving from a selected list of higher level problems which involve concepts of random numbers, Monte Carlo methods, Molecular dynamics and other techniques tune with the needs of industry/research and topical subjects.
CO_3	To educate students on the logic behind solving problems related to real physical examples, simulation, modelling and designing algorithms that translate into codes
CO_4	To appreciate the role of computing as an invaluable tool in research and problem solving in both academia and industry

List of experiments [To be updated and modified from time to time]

1. Introduction to the concept of random numbers; Matlab commands rand, randn, randint and examples problems based on random numbers – tossing of coin, rolling of dice, mean, variance, standard deviation, histogram plotting, uniform and normal distributions
2. Simulation of Brownian motion by MC method; Simulation of Radioactive Decay by using random numbers
3. Generation of random numbers through computer programs (mid square method, linear congruence method); Testing the quality of generated random numbers (Uniformity test, Autocorrelation test)
4. Simulating a Fractal Fern using random numbers
5. Introduction to the Monte Carlo method; Estimating the value of pi by Monte Carlo method
6. Integration using Monte Carlo method– single, double, triple integrals
7. Introduction to Molecular Dynamics; The Verlet Algorithm, The Velocity Verlet Algorithm
8. Implementation to simple systems using the Lennard Jones potential
9. Small projects based on the above techniques from classical and quantum mechanics and mathematics and relevant physical examples are given to the students

Course Expected Outcomes

CEO_1	Students learn to apply techniques learnt o real physical problems from classical mechanics, quantum mechanics and many interesting problems and situations.
CEO_2	Students get familiar with operations to visualisation techniques and techniques like Monte Carlo and Molecular Dynamics which have a wide range of applications
CEO_3	Students understand the logic behind simulation, modelling and designing algorithms that translate into codes
CEO_4	Students learn to appreciate the role of computing as an invaluable tool in research and problem solving in both academia and industry. They learn to think critically and apply the techniques learnt to real problems in projects/research/industry/academia

Suggested References/Books

1. MATLAB Programming for Engineers, 6E. Stephen J. Chapman, Cengage Learning India Pvt. Ltd.(2019)
2. Getting Started with MATLAB, Rudra Pratap, Oxford University Press; 7E (2019)

OPEN ELECTIVE 1

BAEPOE **L-04** **Credits -04**

LIST OF OPEN ELECTIVES OFFERED BY OTHER UNIVERSITY SCHOOLS OF STUDY WILL BE CIRCULATED TO STUDENTS AT THE BEGINNING OF THE SEMESTER

OPEN ELECTIVE 2

BAEPC 701 **L-04** **Credits -04**

LIST OF OPEN ELECTIVES OFFERED BY OTHER UNIVERSITY SCHOOLS OF STUDY WILL BE CIRCULATED TO STUDENTS AT THE BEGINNING OF THE SEMESTER

OPEN ELECTIVE LAB

BAEPOEL719 **P-04** **Credits -0**

LIST OF OPEN ELECTIVES OFFERED BY OTHER UNIVERSITY SCHOOLS OF STUDY WILL BE CIRCULATED TO STUDENTS AT THE BEGINNING OF THE SEMESTER

HUMAN VALUES AND ETHICS (NUES)

Course Code: HVE-102 **L – 02** **Credits -02**

Course Objectives:

CO_1	**To develop a universal approach towards human values**
CO_2	**To be able to strike a balance between aspirations and happiness**
CO_3	**To understand that humans are a part of nature and how being close to nature bring in joy and satisfaction**
CO_4	**Select classical short stories from Indian context will expose the students to diverse and multifaceted subsections in Indian society**

Unit I The Problem and Paradox of Happiness: Twin goals: happiness and just order; role of value education. Concept of good life-quality of life and subjective well-being; happiness, life satisfaction and positive affect; studying quality of life through surveys; and findings of quality of life surveys. Moral and Institutional approaches; and the inherent conflict between the two. Man and Society. **[6 hrs]**

Unit II Happiness and Nature: Biophilia hypothesis- connections with nature and co-existence with other forms of life, Deep Ecology, Importance of meaningful contact with the natural world, solutions for a healthier, greener tomorrow, Indigenous and traditional knowledge system and its intellectual-roots. **[6hrs]**

Unit III Basics of Professional Ethics, Ethical Human Conduct: Human Conduct- based on acceptance of basics Human Values, Humanistic Constitution and Universal Human Order-skills, sincerity and fidelity. To identify the scope and characteristics of people-friendly and eco-friendly production systems. **[6hrs]**

Unit IV Encompassing Different Stories/ narratives on Human Values from Indian Context.

[6hrs]

References:

1. Gaur, R.R., Sangal, S.and Bagaria, G., "A Foundation Course in Human Values and Professional Ethics", New Delhi: Excel Books, 2010.
2. Mike, W. Martin, "Paradoxes of Happiness", Journal of Happiness Studies, 2008, pp. 171-184.
3. Giddens, Anthony, "Sociology", 5th edition, Cambridge: Polity Press, 2006.
4. Ambedkar, B.R., Buddha and his dhamma, http://www.scrubd.com/doc/16634512/Buddha-and-His-Dhamma-by-B-R-Ambedkar-Full [accessed on 21 October, 2010]
5. Beteille Andre, "Antinomies of Society: Essays on Ideologies & Institutions", New Delhi: Oxford University Press, 2000.
6. Fikret Berkes, "Sacred Ecology", Second Edition Routledge Taylor & Francis Group, 2008.
7. Richard Louv, "Last Child in the Woods", Algonquin Books, 2008.
8. Ramakrishnan, E.V., "Indian Short Stories": (18700-200). Sahitya Akademi, 2012.
9. Davidar, David., "Cluch of Indian Masterpieces", Aleph Book Company, 2016.
10. "Contemporary Indian Short Stories", Sahitya Akademi, 2014.

Course Outcomes

CO_1	**The students will get sensitized about the role of value education and learn to balance ambition & happiness**
CO_2	**The students will be able to understand the importance of living in harmony with nature**
CO_3	**The students will be able to see the relevance of Professional behavior and ethics**
CO_4	**They will draw inspiration from the classical Indian literature narrated to them in the form of select short stories**

Semester-IV

Master of Technology (Engineering Physics)

FOURTH SEMESTER

CODE No.	Paper Name	L	T/P	Credits
BAEPC 702	*Major project/Dissertation.	0	50	25
BAEPC 704	**Comprehensive Viva	0	10	5
	Total	0	60	30

***Major project/Dissertation: This will be a major project undertaken in either theoretical, computational or experimental work. It could be carried out either in house, i.e., involving the University schools and facilities or in industry/research labs/companies/ carried out for a period of 6 months along with the preparation of a dissertation. In both cases an internal mentor/supervisor from the USBAS is mandatory and an external collaborating supervisor can be involved in addition. The project will be examined for internal evaluation followed by an external examination involving a presentation and defence and final submission of dissertation. Original work leading to a publication will be encouraged**

****Comprehensive Viva- an internal and external evaluation via a viva voce covering all aspects of the programme of study including the major project.**

Note:

1. **Total No. of credits of the program is equal to 106 credits**
2. **Each Student shall be required to appear for examinations in all courses.**
3. **Programme Specific Electives and Open Electives will be governed by the available course being floated in the relevant semester by USBAS and other USS**
4. **For the award of the degree a student should secure at least 100 credits. The dropping of Programme Core courses will not be permitted.**
5. **Three courses namely (a) Entrepreneurship Mindset (b) Human Values (c) Environmental Sciences are mandated for all programmes run by the GGS IP University.**

Scheme of Exams/Evaluation

All Theory Papers will have continuous internal evaluation (based on minor exams, quiz, attendance, regularity, presentations etc.) and a final end semester exam conducted by the examination. All Practical papers will also have continuous internal evaluation and a final end semester exam. While the current division is of 25% internal and 75% for theory papers and 40% internal and 60% final end semester examination for practicals, this division will change as per the policies adopted by the university/university schools from time to time on the continuous evaluation process and end term examinations.

SEMESTER-I	
COURSES	**PROPOSED TEACHING FACULTY**
BAEPC 601 **Applied Mathematical Physics**	Prof Shruti Aggarwal Prof Anu Venugopalan Dr Kriti Batra Dr Anjana Bagga Mr Mukesh Kumar
BAEPC 603 **Experimental Techniques in Physics**	Prof Shruti Aggarwal Dr Rajesh Kumar Dr S Neeleshwar Mr Mukesh Kumar
***Program Specific Elective 1**	
BAEPE-605 Statistics and Data Science	Prof Anu Venugopalan Dr Abha Aggarwal
BAEPE-607 Applied Quantum and Statistical Physics	Prof Shruti Aggarwal Prof Anu Venugopalan Dr Kriti Batra Dr Anjana Bagga Mr Mukesh Kumar
***Program Specific Elective 2**	
BAEPE-607 **Laser Physics**	Prof Shruti Aggarwal Prof Anu Venugopalan Dr Anjana Bagga Mr Mukesh Kuma
BAEPE-609 **Green and Renewable Energy Technologies**	Prof Shruti Aggarwal
BAEP-613 **Introduction to Machine Learning**	Dr.Abha Aggarwal Dr Anjana Bagga
EMES 113 **Environment Sciences (mandatory course)**	Faculty from USEM
BAEPL 651 **Computational Methods Lab**	Prof Anu Venugopalan Dr Kriti Batra Dr Anjana Bagga

SEMESTER-I	
BAEPL 653 **Experimental Physics Lab-I**	Prof Shruti Aggarwal Dr Rajesh Kumar Dr S Neeleshwar Mr Mukesh Kumar
BAEPL. 611 **Minor Project/Seminar - I**	All Faculty

SEMESTER-II	
COURSES	**PROPOSED TEACHING FACULTY**
BAEPC 602 **Solar Photovoltaic Technologies**	Prof Shruti Aggarwal Dr Anjana Bagga
BAEPC 604 **Embedded systems:design, modelling and analysis**	Dr Kriti Batra Mr Mukesh Kumar
BAEPC 606 **Nuclear Technology**	Dr Rajesh Kumar
BAEPC 608 **Nanoscale Physics for Advanced Materials**	Dr S Neeleshwar Dr Anjana Bagga
USMS 112 **Entrepreneurial Mindset (mandatory course)**	USMS Faculty
BAEPL 652 **Experimental Physics Lab-II**	Prof Shruti Aggarwal Dr Rajesh Kumar Dr S Neeleshwar Mr Mukesh Kumar
BAEPL 654 **Embedded Systems Lab**	Dr Kriti Batra Mr Mukesh Kumar

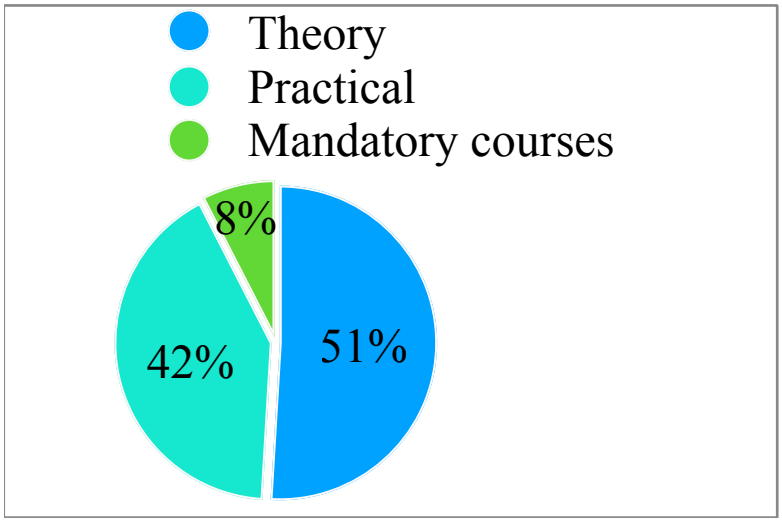
SEMESTER-II	
BAEPL. 610 **Minor Project/Seminar - II**	All Faculty
BAEPL. 655 **Summer Project (NUES)**	All Faculty

SEMESTER-III	
COURSES	**PROPOSED TEACHING FACULTY**
BAEPC 701 **Computer oriented operation research**	Dr Abha Aggarwal Dr Anjana Bagga
***Program Specific Elective 3**	
BAEPE-703 **Photonics and Optoelectronics**	Prof Anu Venugopalan Dr Abha Aggarwa
BAEPE-705 **Quantum Information Processing**	Prof Anu Venugopalan
BAEPE-707 **Machine Learning in Material Science**	Dr Abha Aggarwal Dr Anjana Bagga
BAEPE-709 **Fundamentals of Attosecond Optics**	Mr Mukesh Kumar
***Program Specific Elective 4**	
BAEPE-711 **Ion Beam Technology**	Dr Rajesh Kumar
BAEPE-713 **Wind Power Generation and RE Hybrid System**	Prof Shruti Aggarwal
BAEPE-715 **Physics of Thermoelectric Materials**	Dr Anjana Bagga
BAEPE-751 **Computational Techniques with MATLAB**	Prof Anu Venugopalan Dr Kriti Batra Dr Anjana Bagga
CHVE **Human Values & Ethics** **(mandatory course)**	CHVE
BAEPOE **Open Elective 1**	From any other USS
BAEPOE **Open Elective 2**	From any other USS

SEMESTER-III	
BAEPOE **Open Elective Lab**	From any other USS

	I	II	III	IV	Total	% of total 106 credits
Theory	**16 credits 16 hrs**	**16 credits 16 hrs**	**20/14 credits 20/14 hrs**	**5 credits 5 hrs**	**57/51 credits 57/51 hrs**	**53.77% (48.11%)**
Practical	**6 credits 12 hrs**	**8 credits 16hrs**	**2/8 credits 4/ 16hrs**	**25 credits 50 hrs**	**41/47credits 82/94 hrs**	**38.67% (44.33%)**
Mandatory courses	**4 credits 4 hrs**	**2 credits 2 hrs**	**2 credits 2 hrs**		**8 credits 8 hrs**	**7.55%**
Total credits	**26**	**26**	**24**	**30**	**106 credits**	
Total hours	**32**	**34**	**26/32 hrs**	**55 hrs**	**147 /153 hrs**	

% of Mandatory Courses= 7.55%
Average % of Theory Content = 50.94%
Average % of Lab/Project Content= 41.5%



Approved in the 50th meeting of the academic Council of GGS IP University held on 11/06/2021 vide agenda item AC 50.23