MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

Programme: B.Tech.

List of Open elective courses for B. Tech. programme

S. No.	Course Type	Course Code	Title of the course	L-T-P	Credits
1.	OE	24PHTXXX	Surface Science and Technology	3-0-0	3
2.	OE	PHT419	Physics of Nanomaterials	2-1-0	3
3.	OE	21PHT401	Solar Energy and Photovoltaics	4-1-0	4
4.	OE	PHT415	Introduction to Theory of Relativity and Cosmology	2-1-0	3

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
OE	24PHTXXX	Surface Science and Technology	3	3	0	0	0

PREREQUISITE – None

COURSE OBJECTIVE(s)

The aim of this course is to give a basic introduction of solid surfaces, chemical and physical properties of surfaces, surface characterization techniques, vacuum technology and various technological applications of surfaces. The surface applications include functional coatings using semiconducting, optical, catalytic and other electrochemical properties, bio applications, mechanical, hard coatings etc.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Fundamentals of Surfaces and interfaces - Importance of surfaces and interfaces, why are surfaces different? Transition from solid to surface, Applications of surface and interfaces in modern technology, surface lattice, reciprocal lattice to surfaces, surface relaxation and reconstruction, methods of surface cleaning **(No. of lectures - 8)**

Chemistry of surfaces - Adsorption **(**Physisorption & Chemisorption), Desorption, Mechanisms of Adsorption and desorption, Thermodynamics and kinetics of thin film growth, homogeneous and heterogeneous nucleation kinetics, catalysis. **(No. of lectures - 8)**

Vacuum Technology - Basics of vacuum, high vacuum, ultra high vacuum (UHV), Why UHV is required? How to attain UHV? UHV Setups, Vacuum Pumps, Vacuum Gauges, Surfaces in UHV, Sample preparation in UHV **(No. of lectures - 5)**

Surface characterization techniques - Auger Electron Spectroscopy, X-ray Photoelectron Spectroscopy, Scanning Probe Microscopy; Scanning Tunnelling Microscopy, Atomic Force Microscopy, Surface

structure determination by electron diffraction (LEED, RHEED).

(No. of lectures - 6)

Surfaces engineering applications - Surface functional coatings, Advanced Coating Practices, properties of nanostructured coatings, physical properties and applications of surfaces; semiconducting, optical, catalytic, electrochemical energy, bio applications, mechanical, hard coatings, hardness measurements techniques (indentation etc.), wear and friction, corrosion, lubrication,

(No. of lectures - 12)

TEXT/ REFERENCE BOOKS: -

1. Surface Science- An Introduction, K Oura (Springer).
2. Physics at Surfaces, Andrew Zangwill (Cambridge University Press).
3. Materials Degradation and its control by surface engineering, Imperial College Press, (2006)
4. Surface Analysis: The Principal Techniques, John C. Vickerman, Ian S. Gilmore (Wiley).
5. P hysics of Surfaces and Interfaces, Haralad Ibach (Springer)
6. Surface engineering in metals, CRC Press (1999) London
7. Solid Surfaces, Interfaces and Thin Films, Hans Luth (Springer).

Lecture Plan

Lecture No.	Topics to be covered
1	What are surfaces and interfaces and their importance
2	why are surfaces different?
3	Transition from solid to surface
4	Introduction to applications of surface and interfaces in modern technology
5	Surface lattice
6	reciprocal lattice to surfaces,
7	surface relaxation and reconstruction
8	Surface Creation and Surface cleaning
9	Adsorption **(**Physisorption & Chemisorption)
10	Mechanisms of Adsorption and desorption
11	Thermodynamics of interfaces
12	Kinetics of thin film growth
13	Homogeneous and heterogeneous nucleation
14	Catalysis
15	Physical and chemical methods for thin film growth
16	Physical and chemical methods for thin film growth
15	Concepts related to vacuum and significance to surface science
16	Ultra High Vacuum for surface science
17	UHV Setups, Vacuum Pumps (rotary vane, diaphragm)
18	Vacuum Pumps (turbomolecular, ion pump, Ti sublimation et.)
19	Vacuum Gauges (Thermocouple, Pirani, Ionization Gauges etc.)
20	Significance of vacuum for surface studies
21	Vacuum pumps and vacuum gauges
22	Electron energy analysers
23	Auger Electron Spectroscopy
24	X-ray Photoelectron Spectroscopy
25	X-ray Photoelectron Spectroscopy
26	Scanning Probe Microscopy (Scanning Tunnelling Microscopy)
27	Scanning Probe Microscopy (Atomic Force Microscopy)

28	Surface functional Coatings
29	Advanced Coating Practices
30	Properties of nanostructured coatings
31	Applications of Nano-coatings
32	Physics properties and applications of surfaces
33	…… continued Semiconducting, optical
34	…… continued catalytic and electrochemical energy
35	…… continued bio applications
36	…… continued mechanical applications
37	Hard coatings
38	Hardness measurements techniques
39	Wear & Corrosion, lubrication

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DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
OE	PHT419	Physics of Nanomaterials	3	2	1	0	0

PREREQUISITE
None

COURSE OBJECTIVE(s)
This course aims to familiarize and equip the students with fundamental knowledge of nanotechnology, nanomaterials, and its applications. The learned knowledge would enable the students to tackle the engineering problems.

COURSE OUTCOMES:

CO1	Impart fundamental knowledge to B.Tech. students in the field of nanoscience and nanotechnology.
CO2	Capability to use the fundamental knowledge in application
CO3	Developing the ability to use these concepts in nanotechnology, and to solve problems based on these concepts.
CO4	To explain the interdisciplinary nature of concepts in the course material during lectures.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade) will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Basics of nanomaterials - Introduction to nanomaterials, fundamental concepts and properties of nanomaterials, classification of nanomaterials, quantum confinement, quantum wells, quantum wires, quantum dots, density of states, effect of reduction of dimensions, size dependent properties of nanomaterials: Optical, chemical and electrical. **(No. of lectures- 9)**

Synthesis of Nanomaterials - Synthesis of nanomaterials using top-down & bottom-up approaches, thin film deposition methods, RF/DC sputtering, electron beam evaporation, pulsed laser deposition, lithography, sol-gel method, chemical vapor deposition, Ball milling. **(No. of lectures- 8)**

Characterization of Nanomaterials - Characterization of nanomaterials using atomic force microscopy, X-ray diffraction, scanning electron microscopy, transmission electron microscopy, Dynamic light scattering, and Raman spectroscopy. **(No. of lectures- 6)**

Application of Nanomaterials: Applications of nanomaterials in energy, electronics and medicine. Future challenges and limitations of Nanoscience and Nanotechnology. **(No. of lectures- 3)**

TEXT BOOKS/ REFERENCE BOOKS: -

1. Nanostructures and Nanomaterials Synthesis, Properties and Applications: G. Cao (Imperial College Press-2006).
2. Introduction to Nanotechnology: Charles P. Poole Jr. and Frank J. Owens (Wiley Publications-2003).
3. Introduction to Nanoscience and Nanotechnology, K K Chattopadhyay & A N Banerjee (PHI, EEE, October 2012)
4. Thin Film Phenomena by K L Chopra, McGraw Hill

Lecture Plan

Lecture No.	Topics to be covered
1	Introduction to nanomaterials
2	Fundamental concepts and properties of nanomaterials
3	Classification of nanomaterials
4	Quantum confinement
5	Quantum wells, quantum wires, quantum dots
6	Density of states
7	Effect of reduction of dimensions on various properties
8-9	Size dependent properties of nanomaterials: Optical, chemical and electrical
10	Synthesis of nanomaterials using top-down & bottom-up approaches
11	Thin film deposition methods, RF/DC sputtering
12	Electron beam evaporation
13	Pulsed laser deposition
14	Lithography
15	Sol-gel method
16	Chemical vapor deposition
17	Ball milling
18	Characterization of nanomaterials using atomic force microscopy
19	X-ray diffraction

20	Scanning electron microscopy
21	Transmission electron microscopy
22	Dynamic light scattering
23	Raman spectroscopy
24-25	Applications of nanomaterials in energy, electronics and medicine
26	Future challenges and limitations of Nanoscience and Nanotechnology

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Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
OE	21PHT401	Solar Energy and Photovoltaics	**4**	**3**	**1**	**0**	**0**

PREREQUISITE – Solid State Physics, Materials Science

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of solar energy resource, solar energy conversion techniques, basics of semiconductor junction, design and operation of solar cells, performance testing and analyses.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
d)	Internal assessment (based upon assignments, quizzes and attendance)	20%
e)	Mid-term examination	30%
f)	End Semester Examination	50%

COURSE CONTENTS

Renewable and non-renewable energy resources, solar energy: origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation, measurement of solar radiation, solar to thermal conversion, types of solar energy collectors, concentrating/non-concentrating solar collectors, collector efficiency and its dependence on various parameters, solar fuels: electrolysis of water, photoelectrochemical splitting of water. **(No. of lectures: 12)**

Fundamentals of solar cells: photo voltaic effect, p-n junction photodiodes, depletion region, electron and holes transports, absorption of photons, excitons and photoemission of electrons, band engineering, charge carrier generation, charge separation, recombination and other losses

(No. of lectures: 10)

I-V characteristics, output power, efficiency, fill factor and optimization for maximum power, metal-semiconductor heterojunctions, surface structures for maximum light absorption, operating temperature vs conversion efficiency. **(No. of lectures: 10)**

Device physics, device structures, device construction, solar cell properties and design, materials for solar cells, silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells, organic solar cells, organic-inorganic hybrid solar cells, advanced concepts in photovoltaic research, nanotechnology applications, plasmonic based solar cells. **(No. of lectures: 7)**

TEXT/ REFERENCE BOOKS: -

1. Nelson, J. The Physics of Solar Cells. Imperial College Press, 2003. ISBN: 9781860943409.
2. Solar Engineering of Thermal Process: Duffie and Beckman, John Wiley, 2013. ISBN: 9780470873663
3. Solar Energy: S. P. Sukhatme, Tata McGraw Hill, 1996. ISBN: 1259081966, 9781259081965.
4. Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis, 2015. ISBN: 9781138569478.
5. Wenham, S., M. Green, et al., eds. Applied Photovoltaics. 2nd Ed. Routledge, 2006. ISBN: 9781844074013.
6. Green, M. A. Solar Cells: Operating Principles, Technology, and System Applications. Prentice Hall, 1981. ISBN: 9780138222703.

Lecture Plan

Lecture No.	Topics to be covered
1	Renewable and non-renewable energy resources
2	Introduction to Solar energy: origin
3	Solar resource
4	Spectral distribution of solar radiation, absorption in atmosphere
5	Concept of Air Mass, quantification of solar radiation
6	Seasonal and daily variation of solar radiation, long- and short- term constants
7	Solar irradiation measurement techniques: space based and ground based;
8	Solar to thermal energy conversion systems
9	Solar concentrators and types
10	Collector efficiency and its dependence on various parameters
11	Solar to thermal to electrical energy conversion
12	Solar fuels: hydrogen, Hydrogen production processes
13	Hydrogen generation: Electrolysis of water
14	Hydrogen generation: Photoelectrochemical (PEC) splitting of water
15	Fundamentals of solar cells: photo voltaic effect
16	p-n junction photodiodes, Depletion region, electron and holes transports
15	Absorption of photons

16	Surface structures for maximum light absorption
17	Thermalization losses
18	Concept of multijunction solar cells
19	Review of classes, resolving queries
20	Semiconductor band engineering
21	Charge carrier generation and transport
22	Charge separation
23	Recombination and other losses, and time constants
24	I-V characteristics of a diode: under dark and illumination
25	Output power, types of efficiencies
26	Fill factor and optimization for maximum power
27	Metal-semiconductor junctions
28	Operating temperature vs conversion efficiency
29	Introduction to device physics: Device structures
30	Introduction to device physics: Device construction
31	Solar cell properties and design
32	Materials for solar cells
33	Silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells
34	Advanced concepts in PV: Organic solar cells, organic-inorganic hybrid
35	Advanced concepts in photovoltaic research: perovskite based solar cells
36	Nanotechnology applications and quantum dots
37	Plasmonic based solar cells
38	Renewable and non-renewable energy resources
39	Introduction to Solar energy: origin

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Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
OE	PHT415	Introduction to Theory of Relativity and Cosmology	**3**	**2**	**1**	**0**	**0**

PREREQUISITE
None

COURSE OBJECTIVE(s)
Objective of the course title "Introduction to theory of relativity and cosmology" is to introduce the concept of relativity and early universe cosmology to various branches of Engineering students. This subject will be very much fascinating and Interesting to the students as they will learn the mysteries of the early universe. They will also learn the concept of relativity both in special and as well as general case.

COURSE OUTCOMES:

CO1	To introduce the Special theory of relativity and relativistic mechanics
CO2	To introduce the General theory of relativity briefly and its applications
CO3	To introduce the Cosmology in a more scientific way

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS
Galilean transformations, principle of relativity, transformation of force from one inertial system to another, covariance of the physical laws, principle of relativity and speed of light, Michelson-Morley experiment, ether hypothesis, postulates of special theory of relativity, Lorentz transformations, Inverse Lorentz transformations, Length contraction, Time dilatation and Relativistic addition of velocities.

(No. of lectures- 7)

Relativistic energy: mass-energy relation, examples of mass-energy conversion, relation between momentum and energy, transformation of momentum and energy, particles with zero rest mass, force in relativistic mechanics. **(No. of lectures- 6)**

Four-vector formalism, introduction to tensor analysis, Euclidean and non-Euclidean geometry, basic idea of general theory of relativity, principle of equivalence, geodesics, space-time curvature.
(No. of lectures- 6)

Composition of the universe, the expanding universe, mapping the universe. Cosmological principle, homogeneous, isotropic space times, cosmological red-shift, FRW models, matter, radiation and vacuum evolution of the flat FRW Models, the big-bang and age and size of the universe.
(No. of lectures- 7)

TEXT BOOKS/ REFERENCE BOOKS: -

1. Theory of relativity: P.G.Bergman (Dover)
2. Gravitation and Cosmology: principals and application of general theory of relativity S.Weinberg (John Wiley and Sons)
3. Gravity: An introduction to Einstein's general relativity J. B. Hartle (Pearson Education)
4. Introduction to Cosmology:J.V.Narlikar (Cambridge University Press)
5. Introduction to Relativity: J.V.Narlikar (Cambridge University Press)
6. Cosmology and particle astrophysics: A Goobar (Springer)
7. General relativity: R.M.Wald (The University of Chicago Press)
8. Cosmology: S.Weinberg (Oxford University Press)
9. Introducing Einstein's Relativity: Ray D'Inverno (Oxford University Press)
10. Principles of Physical Cosmology by P.J.E. Peebles (Princeton University Press)

Lecture Plan

Lecture No.	Topics to be covered
1	Galilean transformations, principle of relativity
2	Transformation of force from one inertial system to another inertial system
3	Covariance of the physical laws
4	Michelson-Morley experiment
5	Ether hypothesis, postulates of special theory of relativity
6	Lorentz transformations
7	Inverse Lorentz transformations, Length contraction, Time dilatation
8	Relativistic addition of velocities
9	Problems solving on Length contraction and Time dilation etc.,
10	Relativistic energy: mass-energy relation
11	Examples of mass-energy conversion
12	Relation between momentum and energy
13	Transformation of momentum and energy
14	Particles with zero rest mass, force in relativistic mechanics
15	Four-vector formalism
16	Introduction to tensor analysis
17	Euclidean and non-Euclidean geometry
18	Basic idea of general theory of relativity
19	Principle of equivalence

20	Non-local lift experiments
21	Geodesics,
22	Space-time curvature
23	Composition of the universe, the expanding universe, mapping the Universe
24	Cosmological principle, homogeneous and isotropic space times
25	Cosmological red-shift and FRW models
26	Matter, radiation and vacuum evolution of the flat FRW Models, the big-bang and age and size of the universe