



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Mechanical, Energy Engineering)

Subject Code: 3723921

Semester – II

Subject Name: Fission and Fusion Energy

Type of course: Program Elective

Prerequisite: Basic knowledge of nuclear energy

Rationale: The course intends to provide knowledge of nuclear energy, nuclear reactor, importance of radiation protection and shielding, nuclear fusion and applications to graduate students.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE (E)	PA (M)	ESE (V)	PA (I)		
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Nuclear Reactor and Nuclear Power: Introduction to nuclear physics, Neutron interaction, attenuation and flux, Energy loss in scattering collisions, Fission chain reaction, Nuclear reactor fuels, Component of nuclear reactor, Non-nuclear component of nuclear power plant, Power reactor and nuclear steam supply systems, Nuclear cycle, Isotope separation, Fuel reprocessing, Radioactive waste disposal, Fick's law, Equation of continuity, Diffusion equation, Boundary condition and solution, Heat generation in reactors, Heat flow by conduction, Heat transfer to coolant, Boiling heat transfer, Thermal design of reactor.	14
2	Radiation Protection and Shielding: Introduction, Biological and quantitative effects of radiation, Calculation of radiation effect, Natural and Man-made radiation sources, Standards of radiation protection. Radiation Shielding: Introduction, Nuclear reactor shielding: Principal of reactor shielding, Reactor shield design: removal-attenuation calculations, Removal – diffusion methods, Exact methods, Shielding γ – rays.	8
3	Nuclear Fusion: Introduction, Why fusion energy?, Fusion reactions, Coulomb's law, Condition for fusion, Lawson's criteria, Occurrence of plasma in nature, Definition of plasma, Plasma parameter, criteria for plasma, applications of plasma, Laser induced fusion – uncompressed and compressed, Problems with compressed fusion, Magnetic confinement fusion, Magnetic mirrors, Toroidal machines.	7
4	Single Particle Motions: Introduction, Uniform E and B fields, Non-uniform B and E field, Time - varying B and E Field, Center drifts. Plasmas as Fluid: Introduction, Maxwell's equations in vacuum and medium, Continuity, Momentum and Euler's equation for plasma, Fluid drift perpendicular and parallel to B , Drift velocity for D.C. and A. C. field, Energy absorbed in laser induced fusion, Energy rise of electron for D.C. and A.C. field. Waves in Plasmas: Representation of waves, Phase and group velocity, Plasma Oscillations, Electron plasma waves, Sound waves, Ion waves, Comparison of Electron	13



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Mechanical, Energy Engineering)

Subject Code: 3723921

and Ion wave, Electrostatic electron oscillation and ion wave, Electromagnetic waves perpendicular and parallel to B_0 , Hydromagnetic wave, Magnetosonic wave
--

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	20	20	20	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

- 1) Introduction to Nuclear Engineering, J. R. Lamarsh, Addison Wesley Publishing Co. Inc. 1975.
- 2) Nuclear Energy: Principles, Practices, and Prospects, David Bodansky, Springer.
- 3) Introduction to Plasma Physics and Controlled Fusion, F. F. Chen, Plenum Press, 2004.
- 4) Fusion: An Introduction to the physics and technology of magnetic Confinement Fusion, Weston M. Stacey, 2nd edition, Wiley- VCH Publication.
- 5) Fusion Energy, R. A. Gross, John Wiley and Sons Inc., 2008.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To know the concept of nuclear reactor and nuclear power.	30%
CO-2	To understand the importance and theory related to radiation protection and shielding.	20%
CO-3	To know the concept of nuclear fusion - the next generation energy.	15%
CO-4	To understand the waves in plasma and its application.	35%

List of Experiments:

- 1) To study the component of nuclear reactor, non-nuclear component of reactor, supply and heat transfer systems of nuclear power plant.
- 2) To study the different types of nuclear reactor.
- 3) To study the fuel reprocessing, radioactive waste disposal and case study.
- 4) To study the radiation protections in nuclear reactor.
- 5) To study the radiation shielding in nuclear reactor.
- 6) To study the laser induced fusion and its recent applications.
- 7) To study the magnetic confinement fusion, tokamak and its recent applications.
- 8) To study the electrostatic waves in plasmas and experimental applications.
- 9) To study the electromagnetic waves in plasmas and experimental applications.
- 10) To study the hydromagnetic waves in plasmas and experiments to detect wave.

Major Equipment:

Nuclear Reactor models, nuclear fusion reactor models: initial confinement fusion, tokamak



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Mechanical, Energy Engineering)
Subject Code: 3723921

List of Open Source Software/learning website:

- 1) <http://ocw.mit.edu/courses/energy-courses/>
- 2) <https://nptel.ac.in/courses/115102020/>
- 3) <https://nptel.ac.in/courses/115106087/>
- 4) <https://nptel.ac.in/courses/115104043/35>