GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering
Level: PG
Branch: Energy Engineering
Subject Code: ME02075031
Subject Name: Fission and Fusion Energy

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

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.

Course Outcome: After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
CO-1	Apply the concept of nuclear reactor and nuclear power.	Apply
CO-2	Identify the importance and theory related to radiation protection and shielding.	Apply
CO-3	Apply the concept of nuclear fusion - the next generation energy.	Apply
CO-4	Examine the waves in plasma and its application.	Analyze

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
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	35
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	9	20
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	8	15
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 lase 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 and Ion wave, Electrostatic electron oscillation and ion wave, Electromagnetic waves perpendicular and parallel to B_o, Hydromagnetic wave, Magnetosonic wave	14	30
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
-	30	50	20	-	-

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Introduction to Nuclear Engineering, J. R. Lamarsh, Addison Wesley Publishing Co. Inc.
2. Nuclear Energy: Principles, Practices, and Prospects, David Bodansky, Springer.
3. Introduction to Plasma Physics and Controlled Fusion, F. F. Chen, Plenum Press
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.

(b) Open-source software and website:

1. https://onlinecourses.nptel.ac.in/noc21_me54/preview
2. https://www.energyencyclopedia.com/en/learning/nuclear-fusion-courses
3. https://www.coursera.org/specializations/nuclear-fuel
4. https://ocw.mit.edu/search/?q=nuclear
5. https://nptel.ac.in/courses/115102020
6. https://nptel.ac.in/courses/115106087/
7. https://nptel.ac.in/courses/115104043/35

Practical List:

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, tokomak 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.

List of Laboratory/Learning Resources Required: Nuclear Reactor models, nuclear fusion reactor models Tokomak

Suggested Project List: Industrial visit of any one of the nuclear power plants viz. Kakrapar Atomic Power Project, Kudankulam Nuclear Power Plant and Tarapur Atomic Power Plant

Suggested Activities for Students: Student can make Interactive Models for different nuclear process.

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