Ref. No.: Ex/PE/PC/B/T/322/2025

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER – 2025

NUCLEAR POWER GENERATION

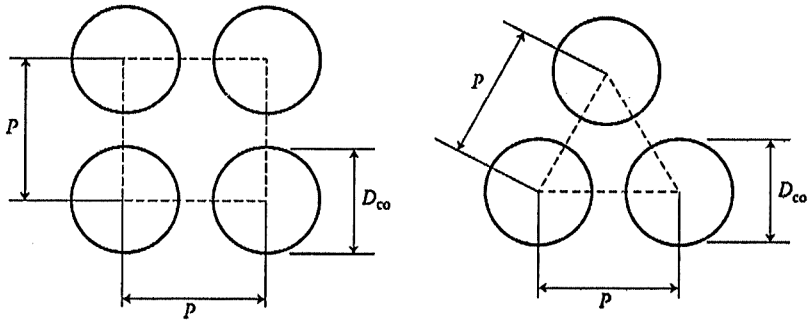
Time: 3 hrs **Full marks: 100**

Group A: CO1 (40 marks)

1. Briefly define the following terms – [2x5 = 10]
   a. Mass Defect.
   b. Fission yield
   c. Effective multiplication factor
   d. Reactor period
   e. Temperature coefficient of reactivity
2. How does reaction cross-section vary with neutron energy? [5]
3. Define reactor criticality. How can one identify if a reactor is critical? [5]
4. Considering uranium to be a homogeneous mixture of 90 weight percent of U238 ($\sigma_a = 2.70$ b) and 10 weight percent of U235 (σ_a = 681 b), determine the total macroscopic and microscopic absorption cross-sections of uranium. Assume density of uranium to be 18.7×10^3 kg/m^3. [10]
5. A fast reactor core is to be designed in the form of a bare sphere. Estimate the critical radius for the core considering the diffusion length to be 5.0 cm, infinite multiplication factor to be 1.15 and absorption reaction cross-section to be 0.03 cm^{-1}. [5]
6. What do you understand by Xenon poisoning in a nuclear reactor? [5]

Group B: CO2 (40 marks)

7. Compare the volumetric heat generation rate between a square array and a triangular array of fuel rods, having the same linear heating rate (q'), with the following configurations –



OR

Explain the operational principle of *a Pressurised Water Reactor* (PWR). How does it differ from the operation of *a Fast Breeder Reactor* (FBR)? [10]

8. Discuss the typical configuration of a fuel rod and fuel assembly. What are the different types of fuel assembly designs used in nuclear reactors? [5]

9. Derive the general heat conduction equation for (a) solid cylindrical fuel rod and (b) annular cylindrical fuel rod cooled on the outside. Hence compare the thermal performance of the solid and annular fuel rods under the constraint of same maximum temperature. [15]

10. Consider a *Pressurised Heavy Water Reactor* with the following specifications:

Core power level (MWth)	2140
% of power deposited in fuel rods	91.6
Fuel assemblies/core	12 x 380 = 4560
Assembly lateral spacing (mm)	280
Fuel rods/assembly	37
Fuel rods length (mm)	480
Fuel rod diameter (mm)	13.1

Determine (a) Equivalent core diameter and core length (b) Average core power density (c) Core-wide average linear energy generation rate of a fuel rod and (d) Core-wide average heat flux at the interface between the rod and the coolant. [10]

Group C: CO3 (20 marks)

11. (a) Discuss the progression of a typical *Loss of Coolant Accident* in a pressurised water reactor.
(b) What are the three fundamental functions of reactor safety? [5+5 = 10]

12. What do you understand by the following terms in the context of a nuclear reactor? Explain with examples.
(a) Design-basis accident
(b) Beyond-design-basis accident
(c) Severe accident [10]