

Ph. D. PHYSICS (PHDPH)

Term-End Examination

December, 2025

RPHE-007 : ELEMENTS OF REACTOR

PHYSICS—II

Time : 2 Hours

Maximum Marks : 50

***Note :** Attempt any **five** questions. The marks for each question are indicated against it. Symbols have their usual meanings. You can use a calculator.*

1. Using the general form of neutron transport equation, derive reactor kinetic equations. State the approximations in which reactor kinetic equations reduce to point reactor kinetic equations. 8+2
2. (a) Define dynamic reactivity of the system. In what units is it expressed ? Obtain its expression in terms of dynamic

multiplication factor. What would happen to the reactor if the rate of production of neutrons exceeds the rate of loss of neutrons ? 1+1+3+1

- (b) Calculate the power level and precursor density at time t , when reactivity change of -0.05 is introduced. Given $\bar{\beta} = 0.0075$, $\Lambda = 10^{-4}$ s and $\lambda = 0.08$ s $^{-1}$.

4

3. (a) Distinguish among step change in reactivity, ramp reactivity and periodic reactivity. Draw a qualitative plot of power level as a function of time for negative step reactivity change. 3+2
- (b) Define instantaneous reactor period. Obtain an expression for reactor period for (i) small positive reactivity insertion and (iii) large positive reactivities. 1+4
4. (a) Define reactivity feedback in the context of reactor physics. Differentiate between negative feedback and positive feedback and explain which of these is essential for inherent reactor safety.

1+3+1

- (b) Write two assumptions made in two lumped parameter model. Hence, write the two lumped parameter model equation in terms of temperature coefficients of reactivity of the fuel and the moderator. Why is a negative value of temperature coefficient of reactivity desirable for reactor stability. 5
5. (a) Define fuel depletion and write its consequence. 2
- (b) Suppose a reactor is fuelled with single fissile isotope. There is no fertile material. Obtain an expression of atomic number density $N_F(\vec{r}, t)$ of this isotope at point \vec{r} and t in terms of 'neutron fluence'.
- How this equation reduces : 8
- (i) Under constant flux approximation
- (ii) Under constant power approximation

6. (a) What is fission product poisoning ? Give *two* examples of poisons. 3, 1
- (b) A cylindrical control rod of diameter 7.0 cm is concentrically placed in a bare cylindrical reactor of radius 100 cm. Estimate the worth of the rod using the data :

$$K_{\infty} = 1.333, \quad B_m^2 = 3.259 \times 10^{-3} \text{ cm}^{-2},$$

$$M = 6.6 \text{ cm, and } D = 0.939 \text{ cm.} \quad 6$$

7. (a) The steady-state heat conduction in a fuel rod for an isotropic medium is given by :

$$\nabla^2 T(\vec{r}) + \frac{q'''(\vec{r})}{K} = 0$$

where K is the coefficient of thermal conductivity and $q'''(\vec{r})$ is the heat generation rate per unit volume. Obtain an expression for the temperature drop across the centre and the fuel clad interface in a plate-type fuel element. What is thermal resistance ? 6

- (b) A typical pressurized heavy water reactor has a thermal rating of 770 MW. The core contains 306 fuel bundles each of which has 19 rods. The active height of the core is 4.9 m and the fuel rod diameter is 1.5 cm. Calculate the maximum heat generation rate per unit volume. The extrapolation distance may be neglected. 4

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