

COURSE CODE: 261319

COURSE NAME: NUCLEAR REACTOR THEORY

SEMESTER & YEAR: Spring Semester (February-May), I year

INSTRUCTOR: Renato Gatto

HOURS: TBA

LOCATION: TBA

CFU (Credits): 9

TOTAL NO. OF CONTACT HOURS: $9 \times 8 = 72$

PREREQUISITES: 1st level degree (laurea triennale) in Engineering or Physics

OFFICE HOURS: After class, or by appointment (Palazzo Baleani, call 06 4991-8603 or email to renato.gatto@uniroma1.it)

COURSE AIMS: The objective of the course is to provide a general comprehension of the physical phenomena underlying the slowing-down and diffusion/transport of neutrons in media without and with nuclear fuel, and to illustrate the mathematical tools necessary to carry out criticality calculations.

LEARNING OUTCOMES: The student is expected to be able to perform and interpret analytical calculations relative to the neutronic design of a nuclear reactor, both in static and dynamic conditions.

TEXTBOOK: “The Elements of Nuclear Reactor Theory”, by S. Glasstone and M.C. Edlund. Lecture notes provided by the Instructors.

GRADING POLICY:

-ASSESSMENT METHODS: Oral final exam 90% + Numerical Project 10 %

-ATTENDANCE REQUIREMENTS: Students are strongly encouraged to attend.

COURSE DESCRIPTION

1. Introduction to reactor physics
2. Mean free path
3. Fick's law
4. Slowing down of neutrons
 - 4.1 Elastic scattering
 - 4.2 Scattering law
 - 4.3 Mean logarithmic decrement
 - 4.4 Slowing down power and moderation ratio
 - 4.5 Lethargy
5. Slowing-down in infinite, non-absorbing media
 - 5.1 Slowing-down in hydrogen
 - 5.2 Slowing-down density in hydrogen
 - 5.3 Slowing-down in media containing media with atomic mass greater than one
 - 5.4 Slowing-down in a system containing different nuclides
6. Slowing-down in infinite absorbing media
 - 6.1 Slowing-down with capture in hydrogen moderator
 - 6.2 Slowing-down in media containing nuclei with atomic mass greater than one
 - 6.3 Resonance escape probability with well-separated resonances
7. Neutron "age" theory
 - 7.1 Continuous slowing-down model
 - 7.2 "Age" equation without captures
8. Transport equation
 - 8.1 Transport theory
 - 8.2 Transport kinetic equation
9. Neutron diffusion (basic transport approximation)
 - 9.1 Transport correction
 - 9.2 Transport mean free path
 - 9.3 Diffusion equation

- 9.4 Boundary conditions
- 9.5 Solutions of the diffusion equation
- 9.6 Point-like source in an infinite media
- 9.7 Infinite plain source
- 9.8 Infinite plain source in a media of finite thickness
- 9.9 Plain source with two slabs of finite thickness
- 9.10 Diffusion length
- 9.11 Albedo
- 10. Transport approximations (more sophisticated approximations)
 - 10.1 “Pn” approximation
 - 10.2 Multigroup approximation
- 11. Multigroup libraries
 - 11.1 The “variable” library
 - 11.2 The “ABBN” library
- 12. The homogeneous thermal reactor without reflector
 - 12.1 Critical equation
 - 12.2 Approach to criticality
 - 12.3 Criticality condition
 - 12.4 Material and geometric buckling
 - 12.5 Generation time
 - 12.6 Reactors with different geometries
 - 12.6.1 Infinite slab
 - 12.6.2 Rectangular parallelepiped
 - 12.6.3 Sphere
 - 12.6.4 Finite cylinder
- 13. The homogeneous reactor with reflector
 - 13.1 One group of neutrons
 - 13.2 Infinite plane slab
 - 13.3 Reflector savings
 - 13.4 The ratio between maximum and average flux in a slab reactor

- 13.5 Two groups of neutrons
- 14 Kinetic equation
 - 14.1 The point kinetic equation
 - 14.2 Perturbative method
 - 14.3 Adjoint flux
 - 14.4 Vectorial formulation
 - 14.5 Perturbative formulation of reactivity
 - 14.6 Analysis of reactivity effects
 - 14.7 Effective mean life of prompt neutrons
- 15 Poisoning due to fission products
 - 15.1 Poisoning due to Xenon
- 16 Non-linear kinetics
- 17 Heuristically-based generalized perturbative methods (HGPT)
 - 17.1 General formulation
 - 17.2 Applications to control problems
- 18 Fuel cycle
- 19 Kinetic equation for a sub-critical reactor

Instructor: Prof. Renato Gatto

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