Nuclear Science & Engineering - Web course

COURSE OUTLINE

This course is developed primarily for the senior under- graduate and first year post-graduate students for a comprehensive knowledge in the field of nuclear science and its various engineering & technology applications. This course comprising of five modules (eight lecture hours for each module) describes

1. Fundamental properties of atomic nucleus and its structure
2. Interaction of nuclear radiation with matter and nuclear detectors
3. Nuclear reactions for generation of energy and nuclear reactors
4. Radioactivity and its applications in archeology and medicine and
5. Nuclear spectrometry and trace element analysis.

COURSE DETAIL

Modules	Topic/s	No. of Lectures
1.	**Basics of nuclear physics:**	
	Nuclear dimension, constituent particles, mass, magnetic moment, electric moment, nuclear shape, nuclear binding energy and stability.	4

NPTEL

http://nptel.iitm.ac.in

Physics

Pre-requisites:

Courses providing knowledge in classical mechanics, mathematical physics and electromagnetism.

Additional Reading:

1. A. H. Wapstra and G. Audi, *Nucl. Phys. A* 432 (1985) 1.
2. G. Dearnaley and D. C. Northrop, *Semiconductor counters for Nuclear Radiations*, E. & F. N. Spon Limited, London, 1966.
3. U. Fano, *Phys. Rev*. 72 (1947) 26.
4. E. J. Jumper *et al. Arch Chemistry-III* (ed J. B. Lambert) 447-476 (Am. Chem. Soc., Washinton, 1984).

Hyperlinks:

1. isotopes.lbl.gov/toips/greatch.pdf
2. http://www.uic.com.au/nip26.htm & *NRPB Bulletin #231, Sept 2001.*
3. http://www.medicalimagingmag.com/issues/articles/2003-07_05.asp
4. http://web.mit.edu/nrl/www/bnct/info/description/description.html

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	Structure of the nucleus: liquid drop and nuclear shell model.	4
2.	**Interaction of nuclear radiation with matter and nuclear detection technology:**	
	Interaction of charged particles (like alpha, beta, heavy ions etc.) and photons with material media, their energy loss characteristics.	3
	Different nuclear detectors like gas ionization chamber, proportional counter, G-M counter, solid-state surface barrier detectors, scintillation counter with photomultiplier tube. Basic concepts of nuclear electronics associated with these detectors for data acquisition, Application of nuclear detectors in science and technology.	5
3.	**Nuclear reactions:**	

	Q-value and a classical approach of compound nucleus formation as a possible mechanism of nuclear reaction, Different examples of nuclear reactions, Energy release in nuclear fission and fusion reactions.	2	
	Fission and fusion reactors: Fission reactor- Nuclear chain reaction, critical size, reproduction factor, design of a power reactor with fuel core, moderator, reflector, coolant, control, safety and nuclear breeding process. Fusion reactor- Lawson criteria, heating of plasma, confinement of plasma in magnetic mirror and tokamak, basic concepts of plasma instabilities, generation of nuclear power and future challenges.	6	
4.	**Radioactivity and its applications:**		
	Laws of radioactivity,	4	

	decay constant, half life, mean life, activity, Geiger-Nuttal law, theory of successive transformation, radioactive equilibrium, radioactive dating methods and accelerator mass spectrometry in geology and archeology.		
	Nuclear Medicine: Production of various radioactive isotopes, application of the isotope in therapeutic process like gamma ray therapy, boron neutron capture therapy, heavy ion therapy applications of radioisotopes in imaging process like, gamma camera, positron emission tomography and magnetic resonance imaging are discussed.	4	
5.	**Nuclear spectrometry:** Analytical process based on nuclear techniques- Rutherford back scattering spectrometry, time of flight spectrometry, nuclear reaction analysis,	8	

	neutron activation analysis for detailed composition and trace element analysis of various materials.	

References:

Chapter 1:

1. B. L. Cohen, *Concepts of Nuclear Physics*, Tata Mc Graw-Hill Publishing Company Limited, New Delhi, 2004.
2. K, Heyde*, Basic Ideas and Concepts in Nuclear Physics*, Overseas Press, Second Edition, New Delhi, 2005.

Chapter 2:

1. W. R. Leo, *Techniques for Nuclear and Particle Physics Experiments*, Narosa Publishing House, India, 1995.
2. G. F. Knoll, *Radiation Detection and Measurement,* John, Wiley & Sons, Inc, 2000.

Chapter 3:

1. S. Glasstone and A. Sesonske, *Nuclear Reactor Engineering*, D. Van Nostrand Company, INC. 1967.
2. T. A. Litlefield and N. Thorley, *Atomic and Nuclear Physics an introduction*, English Language Book Society and Van Nostrand Reinhold Company Ltd. London 1979.

Chapter 4:

1. K, Heyde*, Basic Ideas and Concepts in Nuclear Physics*, Overseas Press, Second Edition, New Delhi, 1998.
2. W. R. Leo, *Techniques for Nuclear and Particle Physics experiment*, Narosa Publishing House, India, 1995.

Chapter 5:

1. De Soete, D. R. Gijbels and J. Hoste, *Neutron Activation Analysis*. John Wiley and Sons: New York, NY. (1972).

2. L. C. Feldmen and J. W. Mayer, *Fundamentals of surface and thin films analysis*, North-Holland, Elsevier, 1986.