# B. Tech Open Electives (Engineering Physics)

## PH465: Optoelectronics (3 0 0 6)

**Basic Principles of laser**

Spontaneous and stimulated emission, Einstein coefficient, broadening of energy levels. absorption and amplification of light in a medium, population inversion and threshold condition for a laser, gain coefficient, efficiency, optical resonator, Fabry Perot resonator, spherical resonator, longitudinal & transverse modes, properties of laser, modulation of laser, semiconductor lasers.

**Optoelectronic devices**

Ideal photon detector, noise in detection process, photomultipliers, photoconductors, junction photodiodes, avalanche photodiode, charge coupled devices, energy sensitive devices, Electro-optic, magneto-optic and acousto-optic effects, applications of various optoelectronics devices.

**Optical Fibre**

Propagation of radiation in dielectric wave guides, step index and graded index fibre, modes in fibre, dispersion in multimode & monomode fibres, attenuation in fibres, signal distortion, mode coupling, power launching and coupling, fibre parameters specifications, applications of optical fibre.

**Text/References:**


1. W. T. Silfvast, *Laser Fundamentals*, 2$^{nd}$ Edn., Cambridge University Press, 2004.
2. B.E.A. Saleh and M.C.Teich, *Fundamentals of Photonics*, 2$^{nd}$ Edn., Wiley, 2007.
3. A. Ghatak and K. Thyagarajan, *Optical Electronics*, Cambridge University Press, 2009.
4. J Wilson and J Hawks, *Optoelectronics an Introduction*, 3rd Edn., Prentice Hall. 2004.
5. A Yariv and P Yeh, *Photonics*, 6$^{th}$ Edn., Oxford University press, 2007.

**<u>PH551: Non-linear dynamics and chaos (3 0 0 6)</u>**

**Dynamical systems:** Importance of concepts of chaos, Fractals, and nonlinear dynamics in different natural and engineering processes. Introduction to dynamical systems, state space: continuous state with discrete time or continuous time variable, discrete state with discrete or continous time variable.

**One-dimensional system:** Fixed points and their local and global stability analysis, converting the dynamical problem into equivalent problem of potentials.

**Two-dimensional system:** Fixed points and linear stability analysis. Nonlinear analysis with examples of pendulum. Dissipation and the divergence theorem, Poincare-Bendixon's Theorem, weakely nonlinear oscillators.

**Three-dimensional system:** Linear and nonlinear stability analysis with examples of Lorentz system, forced nonlinear oscillator, Poincare section and maps.

**Bifurcation theory:** Bifurcations in 1D and 2D flows with examples of sadle-node, transcritical, pitchfork bifurcations in different physical systems. Hopf-bifurcations. Homoclinic and hetroclinic bifurcations.

**One dimensional Maps and Chaos:** Stability of fixed point and periodic orbits, quadratic maps, bifurcation in maps, characterization of chaos using Lyapunov exponents and Fourier spectrum. Different Routes to Chaos: Quasiperiodic, intermittency, period doubling, etc.

**Fractals and attractors:** Introduction to countable and non-countable sets, Cantor set, Dimension of self-similar Fractals. Henon map, Rossler systems, Chemical chaos, forced-double well oscillators.

**A brief phenomenology of turbulent flow:** Phenomenology of Turbulent flow in classical (Kolgmogorov phenomenology for energy cascade) and quantum system (especially generation and phenomenology of turbulence in Bose-Einstein condensation and superfluid Helium).

**Text/References:**


1. Strogatz, S. *Nonlinear Dynamics and Chaos*. Reading, MA: Addison-Wesley, 2007.
2. Hilborn, Robert C. *Chaos and Nonlinear Dynamics*. Oxford University Press, Second edition, 2000.
3. Guckenheimer, J., and P. Holmes. *Nonlinear Oscillations, Dynamical Systems and Bifurcations of Vector Fields.* New York, NY: Springer-Verlag, 2002.
4. Drazin, P. G. *Nonlinear systems*. Cambridge, UK: Cambridge University Press, 1992.
5. Parker, T. S., and L. O. Chua. *Practical Numerical Algorithms for Chaotic Systems*. New York, NY: Springer-Verlag, December 20, 1991.
6. Berge, P., Y. Pomeau, and C. Vidal. *Order Within Chaos*. New York, NY: Wiley 1987.
7. Lakshmanan, M and R. Rajasekar, *Nonlinear Dynamics: Integrability, Chaos and Patterns*, Springer, 2003.

**PH552: Image Formation in Optical Systems (3 0 0 6)**

**Review of paraxial geometrical optics**: Matrix formulation of lens and mirrors, images by thin lenses; exact ray tracing;

**Wavefront aberrations**: Monochromatic aberrations, Zernike polynomial representation, Chromatic aberration; Wavefront shaping;

**Computation of Fraunhofer diffraction pattern using Fourier transform**: rectangular aperture, circular aperture and limit of resolution, periodic objects and diffraction efficiency;

**Fourier optics**: Fourier transforming properties of a lens; Diffraction limited imaging systems, Point spread functions, Airy pattern, convolution, Point spread function with aberrations; Strehl ratio. Coherent and incoherent imaging; Optical transfer function; effects of aberrations.

**Applications**: Confocal scanning microscopy, Optical super-resolution, holographic microscopy, imaging by speckle interferometry.

**Text/References**:


1. J W Goodman, *Introduction to Fourier Optics*, McGraw-Hill (2004).
2. Lipson, Lipson and Lipson, *Optical Physics,* Cambridge University Press (2011).
3. M Born and E Wolf, *Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light*, Cambridge University Press (1999).
4. E G Steward, *Fourier Optics: An introduction*, Dover Publication (2004)