Nonlinear Vibration

Swayam Prabha Course Code – M62

PROFESSOR'S NAME	Prof.S.K. Dwivedy
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INSTITUTE	Indian Institute of Technology Guwahati
COURSE OUTLINE	**Introduction:** linear and nonlinear systems, conservative and non-conservative systems; potential well, Phase planes, types of forces and responses, fixed points, periodic, quasi-periodic and chaotic responses; Local and global stability; commonly observed nonlinear phenomena: multiple response, bifurcations, jump phenomena. **Development of nonlinear governing equation of motion** of Mechanical systems, linearization techniques, ordering techniques; commonly used nonlinear equations: Duffing equation, Van der Pol's oscillator, Mathieu's and Hill's equations. **Analytical solution methods:** Harmonic balance, perturbation techniques (Linstedt-Poincare', method of Multiple Scales, Averaging – Krylov-BogoliubovMitropolsky), incremental harmonic balance, modified Lindstedt Poincare' techniques. **Stability and bifurcation analysis:** static and dynamic bifurcations of fixed point and periodic response, different routes to chaotic response (period doubling, torus break down, attractor merging etc.), crisis. **Numerical techniques:** time response, phase portrait, FFT, Poincare' maps, point attractors, limit cycles and their numerical computation, strange attractors and chaos; Lyapunov exponents and their determination, basin of attraction: point to point mapping and cell to cell mapping, fractal dimension. Application: Single degree of freedom systems: Free vibration-Duffing's oscillator; primary-, secondary-and multiple- resonances; Forced oscillations: Van der Pol's oscillator; parametric excitation: Mathieu's and Hill's equations, Floquet theory; effects of damping and nonlinearity. Multi degree of freedom and continuous systems.
COURSE DETAILS	

S. No	Module ID/ Lecture ID	Lecture Title/Topic
1.	**Module1_L1**	Introduction of Nonlinear Systems
2.	**Module1_L2**	Conservative and Non Conservative System
3.	**Module1_L3**	Commonly Observed Phenomena in Nonlinear Systems
4.	**Module1_L4**	Phenomena Associated with Nonlinear Systems
5.	**Module2_L5**	Force and Moment Based Approach
6.	**Module2_L6**	Lagrange Principle and Hamilton's Principle
7.	**Module2_L7**	Some Equation of Motion for Some Other System
8.	**Module2_L8**	Development of Equation Of Motion For Continuous System
9.	**Module2_L9**	Development of Equation of Motion for Continuous Systems and Ordering Techniques
10.	**Module2_L10**	Ordering Techniques
11.	**Module3_L11**	Straight Forward Expansions
12.	**Module3_L12**	Solution of Nonlinear Equation of Motion Using Numerical Technique and Straight Forward Expansion Method.
13.	**Module3_L13**	Lindstedt Poincare Method
14.	**Module3_L14**	Method of Multiple Scales
15.	**Module3_L15**	Method of Harmonic Balance
16.	**Module3_L 16**	Method of Averaging
17.	**Module3_L17**	Generalized Method of Averaging
18.	**Module3_L18**	KBM Method of Averaging
19.	**Module3_L19**	Incremental Harmonic Balance Method, Intrinsic Multipleharmonic Balance Method
20.	**Module3_L20**	Modified and Extendedlindstedt-Poincaretechnique
21.	**Module4_L21**	Stability and Bifurcation of Fixed-Point Response
22.	**Module4_L22**	Stability and Bifurcation Analysis of Nonlinear Fixed Point Responses
23.	**Module4_L23**	Saddle-Node, Pitchfork, Transcritical and Hopf

		Bifurcation
24.	**Module4_L24**	Static and Dynamic Bifurcation
25.	**Module4_L25**	Stability and Bifurcation Analysis of Periodic Responses
26.	**Module4_L26**	Bifurcation of Periodic Response, Introduction to Quasi-Periodic and Chaotic Response
27.	**Module4_L27**	Bifurcation of Periodic Responses-Introduction to Quasi-Periodic and Chaotic Responses
28.	**Module5_L28**	Time Response, FFT, Frequency Response Curves
29.	**Module5_L29**	Numerical Methods to Obtain Time Response
30.	**Module5_L30**	Frequency Response Curves
31.	**Module6_L31**	Single Degree of Freedom Nonlinear Systems With Cubic and Quadratic Nonlinearities
32.	**Module6_L32**	Nonlinear Vibration of Single Degree of Freedom System with Damping
33.	**Module6_L33**	Free Nonlinear Vibration of Multi-Degree-of-Freedom System
34.	**Module6_L34**	Nonlinear Forced-Vibration of Single-Degree-of-Freedom System
35.	**Module6_L35**	Nonlinear Forced-Vibration of Single and Multi Degree-of-Freedom System
36.	**Module6_L36**	Nonlinear Forced-Vibration of Single and Multi-Degree-of-Freedom System
37.	**Module6_L37**	Nonlinear Forced-Vibration of multi-Degree-of-Freedom System
38.	**Module6_L38**	Nonlinear Vibration of Parametrically Excited System
39.	**Module6_L39**	Parametrically Excited System Elastic and Magneto Beam Subjected to Periodic Base Excitation
40.	**Module6_L40**	Nonlinear Vibration of Parametrically Excited System with Internal Resonances

List of reference material/ books:

Nayfeh, A. H., and Mook, D. T., Nonlinear Oscillations, Wiley-Interscience, 1979.

Hayashi, C. Nonlinear Oscillations in Physical Systems, McGraw-Hill, 1964.

Evan-Ivanowski, R. M., Resonance Oscillations in Mechanical Systems, Elsevier, 1976.

Nayfeh, A. H., and Balachandran, B., Applied Nonlinear Dynamics, Wiley, 1995.

Seydel, R., From Equilibrium to Chaos: Practical Bifurcation and Stability Analysis, Elsevier, 1988.

Moon, F. C., Chaotic & Fractal Dynamics: An Introduction for Applied Scientists and Engineers, Wiley, 1992.

Rao, J. S., Advanced Theory of Vibration: Nonlinear Vibration and Onedimensional Structures, New Age International, 1992.

Name and contact details of two referees for the course: