Registration no: | | | | | | | | | | |

Total Number of Pages: 02 **M.TECH**
MDPE210

2nd Semester Back Examination – 2016-17
NONLINEAR VIBRATION
BRANCH(S): DESIGN AND DYNAMICS, MACHINE DESIGN, MECH. SYSTEM DESIGN
Time: 3 Hours
Max Marks: 70
Q.CODE:Z1083
Answer Question No.1 which is compulsory and any five from the rest.
The figures in the right hand margin indicate marks.

Q1 **Answer the following questions:** **(2 x 10)**

a) Differentiate between Linear and Nonlinear vibrating systems
b) What is Principle of Linear Superposition and how it is relevant to Nonlinear vibrating systems
c) What do you mean by parametrically excited vibrating systems
d) What do you mean by self-excited vibrating system
e) Differentiate between hardening and softening types of nonlinear springs
f) What do you mean by autonomous dynamic systems
g) Differentiate between conservative and non-conservative dynamic systems
h) How the stable equilibrium and unstable equilibrium are linked to the Potential energy curves in a conservative dynamic system.
i) What do you mean by negative damping.
j) What do you mean by Internal resonance in vibrating systems.

Q2 **a)** Describe the State-Space and Phase-Plane representation of dynamic systems. Define the terms singular points, centers and saddles. **(5)**
b) Derive the equation of motion of a simple pendulum and show that for large amplitude of oscillation the system is nonlinear. **(5)**

Q3 **a)** Perform a two-term straight forward expansion for the Duffing Equation with cubic nonlinearity $\ddot{x} + \omega_0^2 x + \alpha x^3 = 0$and discuss its uniformity. **(10)**

Q4 Find the solution of the equation $\ddot{x} + \omega_0^2 x + \alpha x^3 = 0$using Lindstedt Poincare's technique. Take the initial conditions at $t = 0$, $x = 0.001\, m$and $\dot{x} = 0.1\, m/s$. **(10)**

Q5 **a)** Outline the Method of Harmonic Balance as applied to study the nonlinear vibration problems. Mention its advantage and disadvantage. **(5)**
b) Outline the Method of Averaging as applied to study the nonlinear vibration problems. Mention its advantage and disadvantage. **(5)**

Q6 **a)** Write and explain the equation of motion of Vander Pol Oscillator. With the help of this, explain the phenomena of Limit Cycle. **(5)**
b) Write the Matihieu-Hill equation of motion for a parametrically excited nonlinear vibrating system and briefly outline the method to study its stability with typical stability diagram. **(5)**

Q7 **a)** Using the method of multiple scales,derive the frequency – amplitude relation for the nonlinear system represented by $\ddot{u} + \omega_0^2 u + 2\epsilon\mu\dot{u} = 0$ **(10)**

Q8 **Answer any two** **(5 x 2)**

a) With neat diagram, explain the jump up and jump down phenomena in nonlinear vibrating systems

b) Plot the phase plane trajectory for the undamped spring-mass system including the potential energy curve $U(x)$. Discuss the initial conditions associated with the plot.

c) With neat diagrams, explain the concept of fixed point response (trivial and nontrivial), periodic response, quasiperiodic response and chaotic response

d) Explain the terms primary resonance, superharmonic resonance, subharmonic resonance and combination resonance in nonlinear vibrating systems.