MASTER OF MECHANICALENGINEERING EXAMINATION, 2018
(1^{st} Year, 2^{nd} Semester)
MECHANICAL SYSTEMS AND VIBRATION CONTROL

Time: **Three hours** Full Marks: **100**

Different parts of a question must be answered together.
Provide sketches wherever applicable.
Answer any **Four (4)** questions

1.(*a*). Consider the 2-DoF spring mass system shown in Figure 1 and let the system parameters be as follows:
$$m_1 = m, m_2 = 2m, k_1 = k_2 = k$$
(*i*). Derive the equations of motion for the system and write them in matrix notation.
(*ii*). Find out the characteristic equation and evaluate the natural frequencies of the system.
(*iii*). Determine the modal vectors corresponding to the natural frequencies. [12]

1.(*b*). Determine the response of the system shown in Figure 1 following modal analysis. [05]

1.(*c*). The initial condition for the above system is given as follows: $x_1(0) = 1.0$, $x_2(0) = 0$, $\dot{x}_1(0) = 0$, $\dot{x}_2(0) = 0$. Obtain the response of the system subjected to the initial conditions. [08]

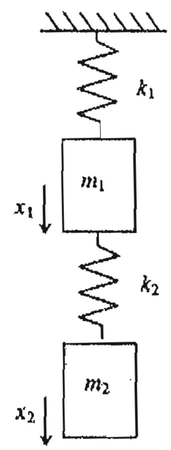

Figure 1

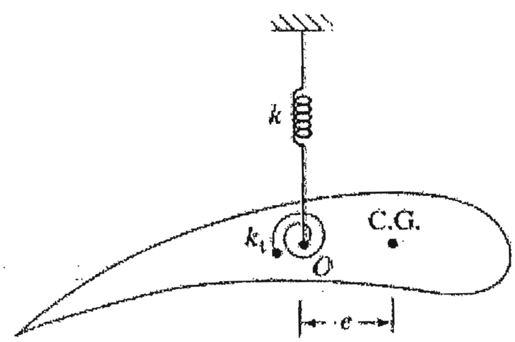

Figure 2(*a*)

2.(*a*). For the 2DoF system shown in Figure 2(*a*), derive the governing equations of motion following energy method and write them in matrix form. Comment on how the equations are coupled. Write down under what condition the governing equations become decoupled. [12+01+01]

2.(*b*). An idealized model of an automobile consists of a rigid beam of mass *m* representing the body of the car and two springs (spring stiffness = k_1 and k_2) at the two ends to simulate the suspension. Point *C* is the center of mass of the beam. A vertical force, $F(t)$, is applied at point *O*, which is at a distance of a and b from the two springs, respectively. Assuming small translation and rotation, derive the equations of motion of the system (following force and moment balance) in matrix form. What are the conditions in which the governing equations are decoupled? [09+02]

3.(*a*). A centrifugal pendulum of mass *m* and length *l* is hinged at the outer surface of a rotating crankshaft (radius *r*). Turning moment on the crankshaft is made up of two parts; a steady part that overcomes the load and generates a constant angular speed on n_0, while the second part varies harmonically to give rise to small sinusoidal oscillations of frequency ω. Angular motion of the crankshaft is denoted by θ, whereas, relative motion of the pendulum with respect to the crankshaft is given by φ.

(*i*). Derive the governing differential equation for the centrifugal pendulum.
(*ii*). Find out the steady state solution for the system and also derive the condition for which crankshaft oscillation is prevented.
(*iii*). Determine an expression for exerted torque. [16]

3.(*b*). Explain with a neat sketch what do you understand by vibration neutralizer. Draw a schematic representation of the response amplitude – excitation frequency plot of a vibration neutralizer showing the location where response amplitude is zero. Mention one disadvantage of such a vibration neutralizer. [03+04+02]

4.(*a*). With a neat schematic diagram write down the different philosophies of vibration control. What do you understand by vibration isolation? Explain with examples. [02+02]

4.(*b*). Define: Absolute Transmissibility and Relative Transmissibility. In case of a SDoF system with complex spring, prove that the expression for absolute harmonic transmissibility is same for both displacement and force excitations. [04+05]

4.(*c*). Consider a machine of mass m, which is resting on a foundation of finite mass m_f. The forces generated in the machine is harmonic in nature and is of the form, $F = Fe^{j\omega t}$. An ideal isolator of stiffness k is present in between the machine and foundation. Derive an expression for force transmissibility. [12]

5.(*a*). An undamped pendulum is represented by the equation of motion - $\ddot{\theta} + \omega_0^2 \sin\theta = 0$. Find out the equation of the trajectories and show schematic representations on the phase plane. Define separatrices. Derive the equation for the separatrices of the system and represent them in the phase plane. [05+02+04]

5.(*b*). A system is described by the following nonlinear differential equation – $\ddot{x} + x - \alpha x^2 = 0$
(*i*). Find the equilibrium positions of the system.
(*ii*). Determine the type of stability about any one of the equilibrium points.
(*iii*). Derive an integral expression for the period of motion of the system, subject to the initial conditions $x = x_0$ and $\dot{x} = 0$ at $t = 0$. [14]

6.(*a*). Mention a few characteristics of nonlinear systems that are absent for linear systems. Discuss about various sources of nonlinearity with examples. [02+06]

6.(*b*). Write down the form of undamped Duffing equation under external harmonic forcing and explain the different terms of the equation. Employ Duffing's iteration method to determine a relation between excitation frequency and amplitude of response. Use the derived relation to represent a qualitative A vs. ω plot showing the different regimes as obtained due to zero and non-zero values of excitation amplitude and nonlinear restoring force parameter. [02+05+05]

6.(*c*). Explain what is meant by jump phenomenon. [05]

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