Bengal Engineering and Science University, Shibpur
Department of Aerospace Engineering and Applied Mechanics
B.E. (AE) Part-III 6th Semester Final Examination, April-May 2013
MECHANICAL VIBRATIONS (AE-602)

Time: 3 hours

Full Marks: 70

Answer any FIVE questions.
Assume reasonable data, if not supplied with the problem.
The questions are of equal marks.

1. a) Derive an expression for the natural frequency of the system shown in fig. Q1a. The mass of each pulley is small compared with mass m and therefore, can be ignored. Furthermore, the cord holding the mass is inextensible and has negligible mass.

   b) A commercial-type vibration pick-up has a natural frequency of 4.75 cps and a damping factor $\zeta = 0.65$. What is the lowest frequency that can be measured with 1% error.

2. a) Fig. Q2a represents a simplified diagram of a spring-supported vehicle traveling over a rough road. Determine the equation for the amplitude of W as a function of the speed and determine the most unfavorable speed. If the spring is compressed 10.16 cm under the weight of the vehicle, $Y = 7.62\ cm$ and $L = 14.63\ m$, find the critical speed of the vehicle.

   b) In the arrangement shown in Fig. Q2b the sleeve M of mass $m = 0.20\ kg$ is fixed between two identical springs whose combined stiffness is equal to $k = 20\ N/m$. The sleeve can slide without friction over a horizontal bar AB. The arrangement rotates with a constant angular velocity $\omega = 4.4\ rad/s$ about a vertical axis passing through the middle of the bar. Find the period of small oscillations of the sleeve. At what values of ω will there be no oscillations of the sleeve?

3. a) A uniform cantilever beam of total mass ml has a concentrated mass M at its free end. Determine the effective mass of the beam to be added to M assuming the deflection to be that of a massless beam with a concentrated force at the end, and write the equation for its fundamental frequency.

   b) A machine of mass $1000\ kg$ is acted upon by an external force $3000\ N$ at a frequency of $1500\ rpm$. To reduce the effects of vibration, isolator of rubber having a static deflection of $2\ mm$ under the machine load and an estimated damping $\varsigma = 0.3$ are used. Determine the force transmitted to the foundation, the amplitude of vibration of the machine and the phase lag.

4. Set up the differential equation of motion for the system shown in Fig. Q4. Determine the expression for (a) the critical damping coefficient and (b) the natural frequency of damped oscillation.

5. Consider two pendulums of length l as shown in fig. Q5. Determine the natural frequencies and show mode shapes if $k = 120\ N/m,\ m_1 = 2\ kg, m_2 = 5\ kg, l = 200\ mm$, and $a = 100\ mm$.

6. Derive the differential equation of transverse vibration of a uniform beam with flexural rigidity EI, material density ρ per unit length and length l. Also, derive the natural frequency equation for a beam with one end hinged and other end free.

7. Using Rayleigh's method, determine the fundamental frequency of transverse vibration for both ends simply supported beam as shown in fig. Q7. Given: $E = 200\ GPa,\ I = 150\ cm^4,\ l = 40\ cm, W_1 = 10\ kg,\ W_2 = 40\ kg$ and $W_3 = 20\ kg$.

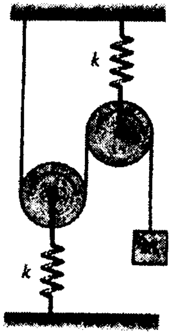

Fig. Q1a

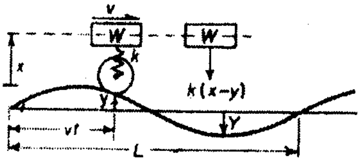

Fig. Q2a

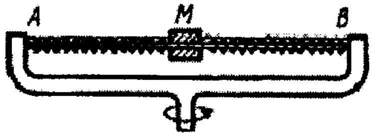

Fig. Q2b

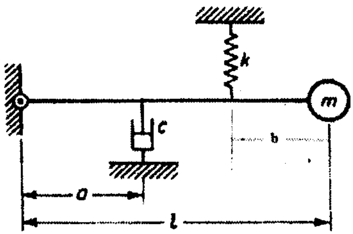

Fig. Q4

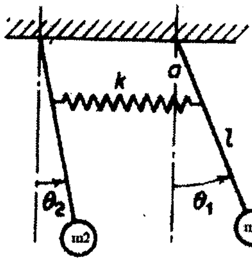

Fig. Q5

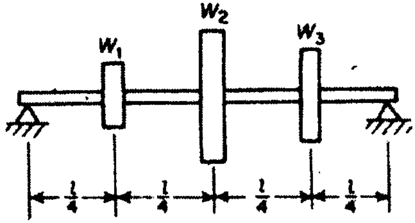

Fig. Q7