ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE, NIGERIA

DEPARTMENT OF MECHANICAL ENGINEERING

FIRST SEMESTER EXAMINATIONS

2018/2019 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE: MEE 403 – Mechanical Vibration (3 Units)

CLASS: 400 Level Mechanical Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer any **FOUR** questions

Date: March, 2019

Question 1

(a) Find the value(s) of k, such that the mass-spring system described by each of the equations below is undergoing resonance. (i) $8u'' + k\,u = 5\sin 6t$ (ii) $3u'' + k\,u = -\pi \cos t$

(3 Marks)

(b) (i) What is vibration?

(ii) Mechanical vibrations are known to have harmful effects as well as useful ones. Briefly describe three practical examples of good vibrations and also three practical examples of bad vibrations.

(5 Marks)

(c) Write the equation describing the mass-spring-damper system shown in the Figure Q.1.

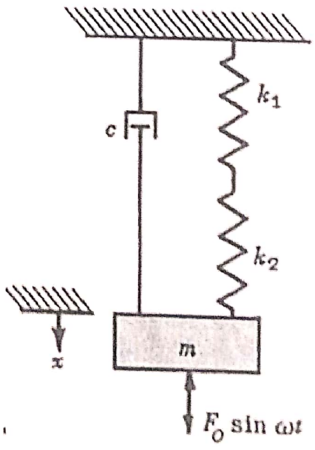

Figure Q.1

(7 Marks)

Question 2

(a) What are the necessary conditions for resonance to occur in a forced vibration?

(3 Marks)

(b) Write the differential equation for the vibratory motion shown in Figure Q.2, for a slight angular displacement θ. The angular displacement is measured from the static equilibrium position.

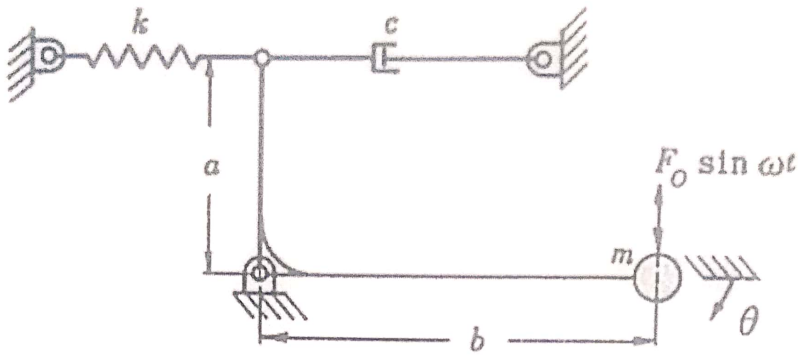

Figure Q.2

(5 Marks)

(c) Consider a mass-spring-damper system described by the equation:

$$2\ddot{x} + 3\dot{x} + kx = 0$$

What type of vibration is modelled, and what are the values of k for which the system is over-, under- and critically damped?

(7 Marks)

Question 3

(a) What is Damping Ratio, and what are the practical significance of its values

(3 Marks)

(b) In an experiment on a simple mass-spring-damper system, the damped frequency of free vibration was found to be 12 rad/s. The spring constant and mass are accurately known, from which the natural frequency was calculated to be 15 rad/s. What is the value of the damping ratio?

(5 Marks)

(c) A 4450 N vehicle, equipped with springy shock-absorber but no damper, travelling along a rough road at 96.6 km/h is modelled as shown in Figure Q.3. The sine curve representing the rough road has an amplitude of 25.4 mm and a wavelength of 6.09 m. Determine the spring constant k such that 96.6 km/h is the critical speed at which resonance occurs.

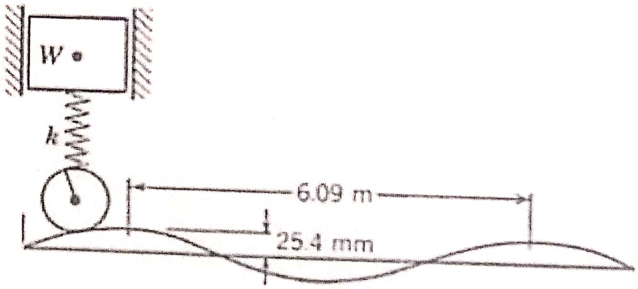

Figure Q.3

(7 Marks)

Question 4

(a) At what speeds would resonance occur, and what are the implications in machine design?

(3 Marks)

(b) Show from the first principles, using the usual but well-defined notations that, the natural frequency of undamped mass-spring system displaced from rest is given by $\omega_n = \sqrt{\frac{k}{m}}$.

(5 Marks)

(c) Given that the Transmission Ratio of a damped vibration on a platform is given by

$$TR = \sqrt{\frac{1 + \left(2\zeta\frac{\omega}{\omega_n}\right)^2}{\left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2 + \left(2\zeta\frac{\omega}{\omega_n}\right)^2}}$$

Derive the expression for vibration transmissibility of an undamped vibration.

(7 Marks)

Question 5

(a) Replace the system shown in Figure Q.5 with a single spring element.

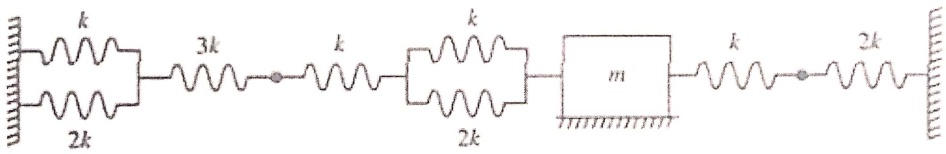

Figure Q.5

(3 Marks)

(b) In order to experimentally determine the Mass Moment of Inertia of a vehicle about its centroid, the vehicle was suspended with a very strong rope tied to its front and rear axles, so that the vehicle with mass M lies perfectly horizontal at a distance r from the pivot O to its centroid. The mass of the rope is negligible compared with the mass of the vehicle. The system is set into oscillation, and the average period T of several trials was determined. Treating the set-up as a free pendulum, derive the expression for the desired inertia. [Hint: Recall the use of Parallel Axes Theorem].

(5 Marks)

(c) Find the motion of the spring-mass-damper system modelled by the initial value problem:

$$\ddot{x} + 2\dot{x} + 26x = 13Cos3t$$
$$x(0) = 1;\ \dot{x}(0) = 0.4$$

(7 Marks)

Summary of Assessment

Attendance	10%
Home Works & Reports	20%
Class Tests	10%
Final Examination	60%
Total	100%