TECHNICAL UNIVERSITY OF MOMBASA

DEPARTMENT OF MECHANICAL AND AUTOMOTIVE ENGINEERING

FOURTH YEAR SECOND SEMESTER UNIVERSITY EXAMINATION FOR THE DEGREE IN BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING
(BSME MAY 2010 FT AND PT)

EMG 2412
VIBRATIONS

END OF SEMESTER EXAMINATIONS

SERIES: DECEMBER, 2013

TIME: 2 HOURS

INSTRUCTION TO CANDIDATES

1. You should have the following for this examination:-
   - Answer Booklet
   - Scientific Calculator
2. This paper consists of **FIVE** questions.
3. Question **ONE** is **COMPULSORY.**
4. Attempt any other **TWO** of the reaming Questions.
5. Additional Information is provided at the last page of the question paper.
6. This paper consists of **SIX** printed pages.

Question ONE (Compulsory)

(a) Differentiate between the following terms as used in vibrations:

- **(i)** Free vibration and forced vibration **(2 marks)**
- **(ii)** Damped and undamped vibration **(2 marks)**

(b) State **TWO** remedies to vibration in industrial machinery. **(2 marks)**

(c) An unloaded truck is modeled as a sprin-mass-damper system (k, m and c respectively) as shown in Figure Q.1(c). Derive the equation governing the motion. **(5 marks)**

(d) Hence or otherwise determine;

(i) The undamped natural frequency. **(3 marks)**
(ii) Damping ratio and **(3 marks)**
(iii) Damped natural frequency of the system **(3 marks)**
Given that m = 2000kg, k = 600kN/m and C = 9500Ns/m

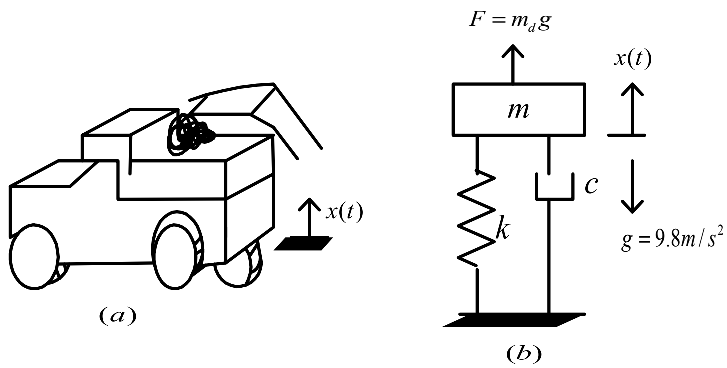

Fig. Qn 1(c)

(e) A wheel is mounted on a steel shaft (G = 83 x 10^9N/m^2) of length 1.5m and radius 0.8cm as shown in Figure Q.1(e). The wheel is rotated 5° and released. The periodic oscillation is observed as 2.3s. Derive the equation governing the motion hence or otherwise determine the mass moment of inertia of the wheel. **(10 marks)**

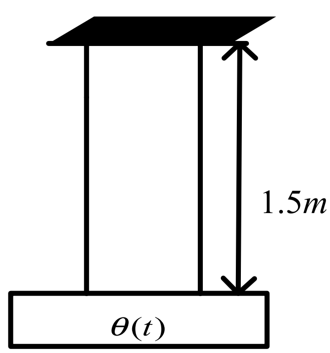

Fig. Qn. 1(e)

Question TWO

(a) State **FOUR** common causes of vibration in a system. **(4 marks)**

(b) What do you understand by the term degree of freedom of a system? **(1 mark)**

(c) State the number of degrees of freedom for the following systems shown in Figure Q.2(c). **(3 marks)**

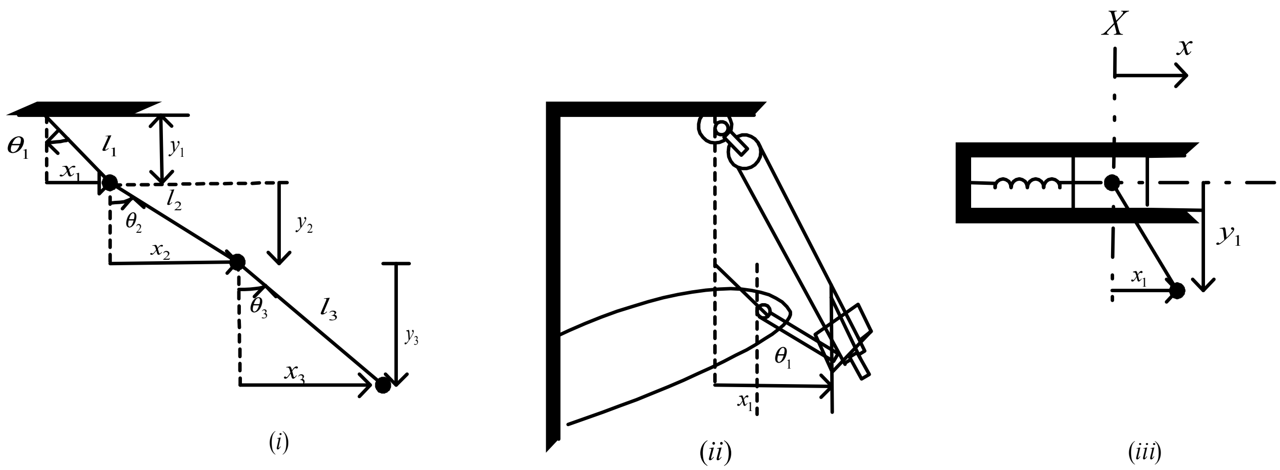

Fig. Q.2(c)

(d) The recoil mechanisms of large firearms are designed with critical damping to take advantage of the quickest return to the firing position without oscillation. A 52 kg canon is to return to within 50mm of its firing position 0.1s after maximum recoil. The initial velocity of the cannon is 2.5m/s determine:

(i) The stiffness of the recoil mechanism **(4 marks)**
(ii) Damping coefficient of the recoil mechanism. **(4 marks)**
(iii) Maximum recoil **(4 marks)**

Question THREE

The rest room door shown in Figure Q.3 is equipped with torsional springs and torsional viscous damper so that it automatically returns to its closed position after being opened. The door has a mass of 60kg and a centroidal moment of inertia about an axis parallel to the axis of the doors' rotation of $7.2 kg.m^2$. The torsional spring has a stiffness of 25N.m/rad.

(a) What is the damping coefficient such that the system is critically damped? **(5 marks)**

(b) A man with an arm load of packages, but in a hurry, kicks the door to cause it to open. What angular velocity must his kick impart to cause the door to open to 70° **(5 marks)**

(c) How long after the kick will the door return to within 5° of completely closing? **(5 marks)**

(d) It the door is designed with a damping ratio of $\zeta = 1.3$, how long after the kick with the door return to within 5° of completely closing? **(5 marks)**

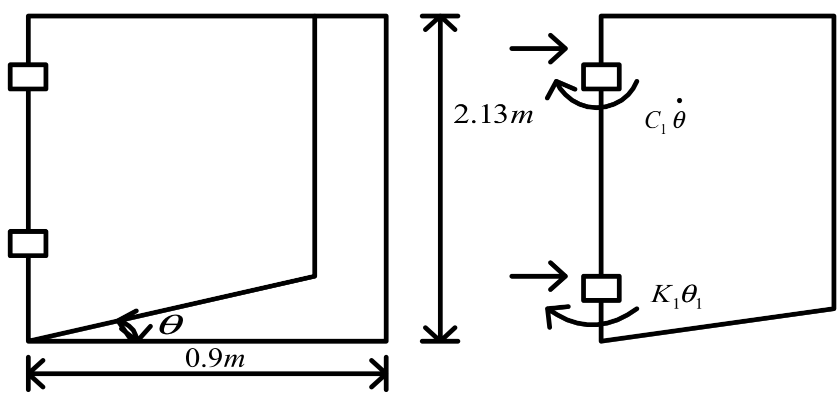

Fig. Q.3

Question FOUR

(a) State **THREE** benefits of vibration in the industry. **(3 marks)**

(b) Describe the whirling phenomenon in rotating shafts. **(5 marks)**

(c) Determine the natural frequencies and mode shapes for the degree-of-freedom system in the Figure Q.4(c). **(12 marks)**

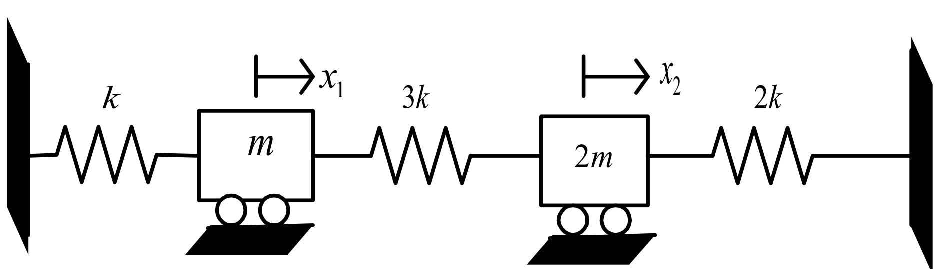

Fig. Qn. 4(c)

Question FIVE

(a) What is vibration? **(2 marks)**

(b) Vibration control involves eliminating or reducing vibration in machines or structures, briefly explain **FOUR** main ways in which this is attained. **(8 marks)**

(c) For the system shown in Figure Q.5(c), write the matrix equation based flexibility and determine the lowest natural frequency by iteration. **(10 marks)**

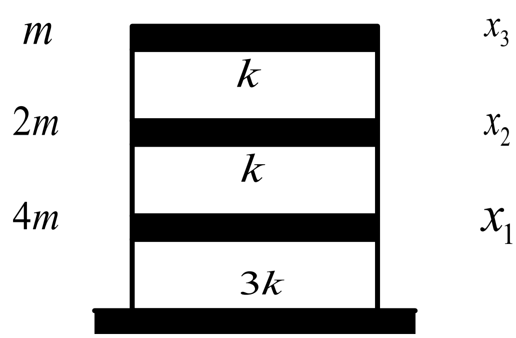

Fig. Q.5(c)

ADDITIONAL INFORMATION

The following equations are to be used where necessary.

g = 9.81m/s[2]

$$Kt = \frac{JG}{Z}$$

Torsional stiffness of shaft

$$x(t) = \frac{e^{\rho w_{nx} t}}{\sqrt[2]{\rho^2 - 1}} \left\{ \left[\frac{\overset{\circ}{x}_o}{w_n} + x_o\left(\rho + \sqrt{\rho^2 - 1}\right) \right] e^{wn} \sqrt{\rho^2 - 1t} + \left[-\frac{\overset{\circ}{x}_o}{w_n} + x_o\left(-\rho + \sqrt{x^2 - 1}\right) \right] e^{-wn\sqrt{\rho^2 - 1t}} \right\}$$

For an overdamped system and attains a maximum for t = 0 or

$$t = -\frac{1}{2w_n\sqrt{\rho^2 - 1}} In \left[\frac{\rho - 1\sqrt{\rho^2 - 1}}{\rho + \sqrt{\rho^2 - 1}} \bullet \frac{\frac{\dot{x}_o}{w_n} + x_o\left(\rho + \sqrt{\rho^2 - 1}\right)}{\frac{\dot{x}_o}{w_n} + x_o\left(\rho - \sqrt{\rho^2 - 1}\right)} \right]$$