# MACHAKOS UNIVERSITY

**University Examinations 2018/2019**

**SCHOOL OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING**

**THIRD YEAR SECOND SEMESTER EXAMINATION FOR**

**BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING**

**EMM 311: MECHANICS OF MACHINES 11**

**DATE: 20TH MAY 2019** **TIME: 8.30 – 10.30 AM**

**INSTRUCTIONS:**

***This paper contains FIVE questions.***

***Question ONE is compulsory and carries 30 marks.***

***Four remaining questions carry 20 marks each.***

***Attempt question ONE and any other TWO.***

**QUESTION ONE (30 MARKS)**

a) Differentiate between longitudinal, transverse and torsional free vibrations (3 marks)

b) i Show that the angular acceleration of a compound pendulum under simple harmonic motion is given by $\alpha = \frac{gh\theta}{k_G^2+h}$ (4 marks)

ii A flywheel of mass 120 kg is suspended in a vertical plane as a compound pendulum. The distance of centre of gravity from the knife edge support is 115 mm and the flywheel makes 120 oscillations in 165 seconds. Find the moment of inertia of the flywheel through the centre of gravity. (6 marks)

c) Name 3 applications where forced vibrations are necessary. (3 marks)

d) State two ways in which a vibrational receiver may be modified to isolate it from a vibration problem (2 marks)

e) What are lumped parameter models? (1 mark)

f) Show that the equation of a free damped vibration of a mass attached to a spring is given by:

$\lambda^2 + 2\zeta\omega_n\lambda + \omega_n^2 = 0$ (6 marks)

g) Distinguish between static and dynamic balancing (2 marks)

h) Differentiate between hydrodynamic, solid-film and hydrostatic lubrication (3 marks)

**QUESTION TWO (20 MARKS)**

a) The composite spring shown in Fig. 1 has two springs A and B in series. A has a stiffness, $k_1 = 2000\ N/m$ and B has a stiffness, $k_2 = 800\ N/m$. The composite spring carries a mass of weight 50 N and oscillates freely in the vertical direction. Calculate the frequency of longitudinal oscillation (hint: $\delta = \delta_A + \delta_B$) (7 marks)

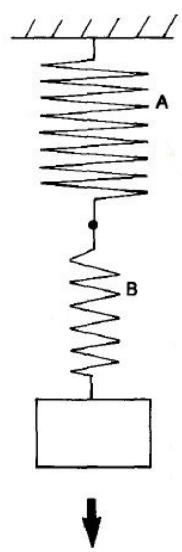


Fig. 1

b) A vertical shaft of 50 mm diameter and 1.2 m long is made from a metal whose modulus of rigidity, $G = 80\ Gpa$. The shaft has a flywheel of moment of inertia, $I = 50\ kgm^2$ mounted on the end. Determine the frequency of the torsional oscillations. (7 marks)

c) Explain how you would mount a bearing to support a radial load (6 marks)

## QUESTION THREE (20 MARKS)

a) The 8 kg body shown in Fig. 2 is moved 0.2 m from the right of the equilibrium position and released from rest at a time t = 0. If the viscous damping coefficient, c = 20 Ns/m and the spring stiffness k = 32 N/m, Determine:

i. The damped natural frequency of the body (4 marks)

ii. The displacement of the body at t = 2s (8 marks)

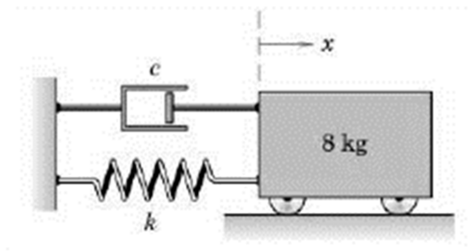


Fig. 2

b) i Show that the amplitude of a body undergoing undamped forced vibrations is given by: $X = \frac{F/k}{1-\left(\frac{\omega n}{\omega}\right)}$ (5 marks)

ii An 800g machine component mounted on springs is known to have a natural frequency of 25 $rad/s$ and little damping (from observation of its natural vibration). Its base is expected to be vibrated at a frequency of 30 $rad/s$ with amplitude 2 mm. Estimate the spring stiffness and the frequency ratio (3 marks)

## QUESTION FOUR (20 MARKS)

Four masses $m_1$,$m_2$,$m_3$ and $m_4$ are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m:

a) Using the analytical method (10 marks)

b) using the graphical method (10 marks)

**QUESTION FIVE (20 MARKS)**

a) Name two benefits of using sliding-contact bearing over rolling contact bearings to support loads (2 marks)

b) Using sketches, describe 5 types of ball bearings (10 marks)

c) List 4 steps that you can take to ensure bearings achieve their theoretical life (2 marks)

d) Find the natural frequency of transverse vibration for the shaft shown in Fig. 3. The modulus of elasticity of the shaft, $E = 200\ GPa$ and shaft diameter = 50 mm.

(Hint: $\delta = \frac{Wa^2b^2}{3EIL}$) (6 marks)

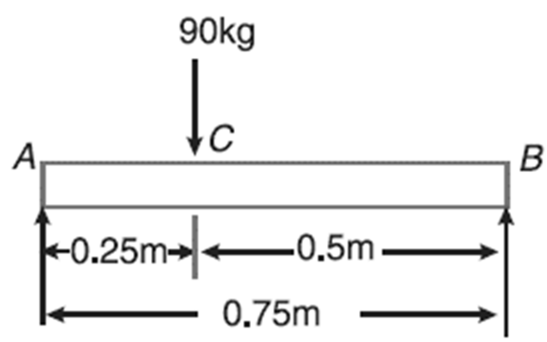


Fig. 3