MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM311: MECHANICS OF MACHINES II

DATE: 13/4/2023 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS

i) This paper contains FIVE questions

*ii) Question ONE is **compulsory** and carries 30 Marks.*

iii) The rest of the questions carry 20 Marks each.

iv) Answer question and any other two.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) i) What is damping in vibrations? (1 mark)

ii) Explain three types of damping. (3 marks)

b) i) What is the purpose of a seal in design of bearings? (1 mark)

ii) SKF Ball bearings are rated at 1 million revolutions. If you desire a life of 5000 h at 1725 rev/min with a load of 2 kN and a reliability of 90 percent, from which SKF catalogue rating would you search for the bearing? (2 marks)

c) i) What is the effect of unbalance in rotors? (2 marks)

ii) State two ways you can balance a rotor? (1 mark)

iii) A milling machine has rotational imbalance caused by a faulty flywheel. If $\boldsymbol{M}$ is the total mass of the machine, $\boldsymbol{m}$ is the eccentric mass and $\boldsymbol{\omega}$ is the speed of rotation and the machine is mounted on materials of stiffness $\mathbf{k}$ and damping coefficient **c**, model the machine as spring mass system and derived its equation of motion. (6 marks)

d) A steel shaft of diameter 26 mm and length 1.5 m carries a disc of mass moment of inertia 0.05 kgm^2 at the end, Fig. Q1 d).

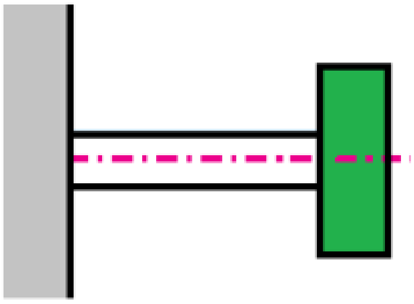


Fig. Q1 d)

If the rotor torsionally vibrates with simple harmonic motion with a maximum displacement of 4 mm, determine;

i) The maximum velocity of the system in m/s (3 marks)

ii) The maximum acceleration m/s^2 (2 marks)

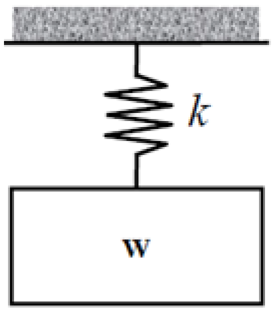
Take G = 79 GPa for steel.

e) Starting from the response equation of an undamped system, show that the logarithmic decrement cam also be given by;

$$\delta = \frac{1}{n} ln\left(\frac{y_1}{y_{n+1}}\right)$$

Where n is the number of oscillations. (5 marks)

f) A load of 50 kg is suspended from a spring whose stiffness is 5 kN/m, and its motion is damped by a force proportional to the velocity of magnitude 75 N at 1 m/s. If the load is displaced from its equilibrium position and then released, find the number of complete vibration cycles that it will execute before its amplitude is reduced to less than one tenth of the original displacement. (4 marks)



Fid Q1 f)

QUESTION TWO (20 MARKS)

a) Distinguish between static and dynamic rotor balancing (2 marks)

b) A shaft carries three masses A, B and C. Planes B and C are 60 cm and 120 cm from A. The masses A, B and C are 50 kg, 40 kg and 60 kg respectively at a radius of 2.5 cm. The angular position of mass B and mass C with A are 90^0 and 210^0 respectively. By suing the analytical method, determine the:

i. unbalanced force

ii. unbalanced couple

iii. position and magnitude of balancing mass required at 10 cm radius in planes L and M midway between A and B, and B and C. (18 marks)

QUESTION THREE (20 MARKS)

a) Fig. Q3 a) shows a Single Degree of Freedom that is forced to vibrate by a harmonic force.

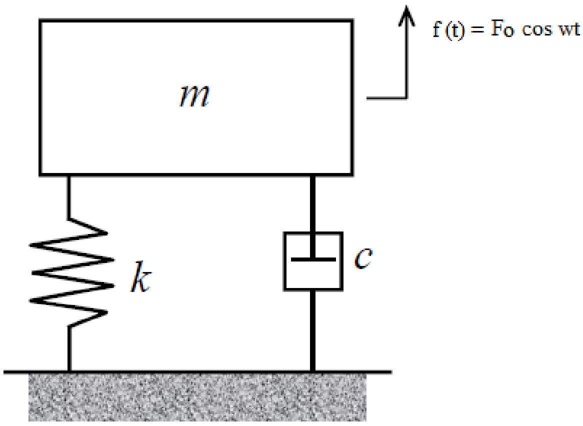


Fig. Q3 a)

Derive an expression for the steady state response of the system. (14 marks)

b) The compound pendulum illustrated in Fig. Q3 b) having a mass of 10 kg and mass moment of inertia of 0.3848 kg-m^2 is given an angular displacement of $\boldsymbol{\theta}$. By first deriving the equation of motion, determine its natural cyclic frequency when it is left to freely vibrate. Take $g = 9.81$ m/s^2 and $L = 20$ cm (6 marks)

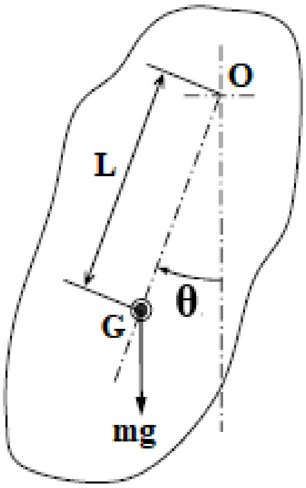


Fig. Q3 b)

QUESTION FOUR (20 MARKS)

a) Using equilibrium method, show that, the natural cyclic frequency of longitudinal vibration of a cantilever beam of negligible mass and carrying a weight W at the free end is given by;

$$f_n = \frac{0.4985}{\sqrt{\delta}}$$

Where δ = static deflection (9 marks)

b) A flywheel is mounted on a vertical shaft as shown in Fig Q4 b). The both ends of the shaft are fixed and its diameter is 50 mm. The flywheel has a mass of 500 kg. Find the natural frequency of longitudinal and transverse vibrations. Take l_1 =0.9 m, l_2 =0.6 m and E = 200 GN/m^2. (11 marks)

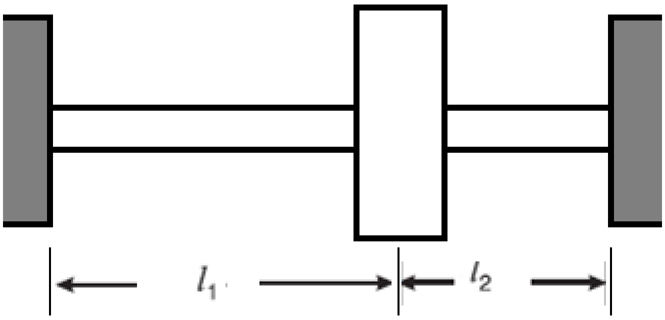


Fig. Q4b)

QUESTION FIVE (20 MARKS)

a) Study Figure Q5 a) shown below.

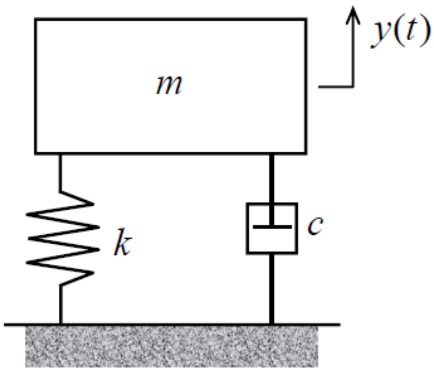


Fig. Q5 a)

For an overdamped system, derive the response equation of the system clearly defining the symbols used. Sketch the response and explain its implications (15 marks)

b) The mass of an electric motor is 120 kg and it runs at 1500 r.p.m. The armature mass is 35 kg and its C.G. lie 0.5 mm from the axis of rotation. The motor is mounted on five springs of negligible damping so that the force transmitted is one-eleventh of the impressed force. Assume that the mass of the motor is equally distributed among the five springs.

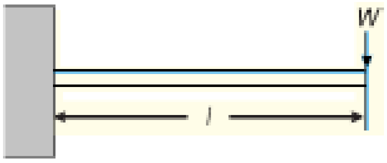
Determine**:**

i) stiffness of each spring (3 marks)

ii) dynamic force transmitted to the base at the operating speed (2 marks)

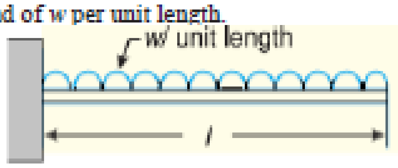
Values of static deflection (δ) for the various types of beams and under various load conditions.

1. Cantilever beam with a point load W at the free end



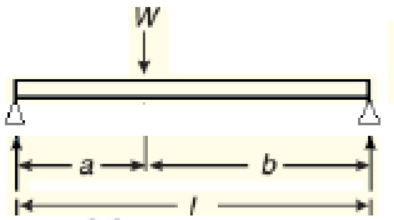
$\delta = \frac{Wl^3}{3IE}$ at the free end

2. Cantilever beam with a uniformly distributed load of w per unit length.



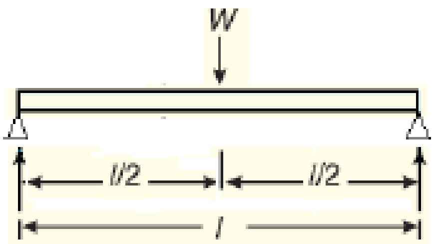
$\delta = \frac{Wl^4}{8IE}$ at the free end

3. Simply supported beam with an eccentric point load W.



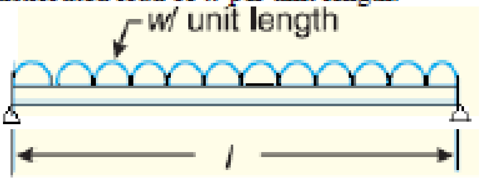
$\delta = \frac{Wa^2b^2}{3EIl}$ at the point load

4. Simply supported beam with a central point load W.



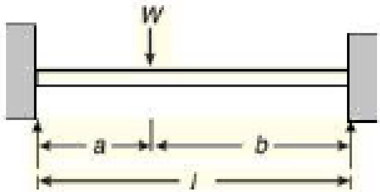
$\delta = \frac{Wl^3}{48IE}$ at the centre

5. Simply supported beam with a uniformly distributed load of w per unit length.



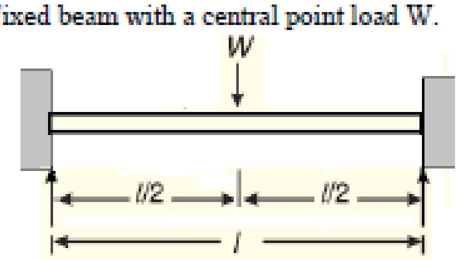
$\delta = \frac{5}{384}\frac{Wl^4}{IE}$ at the centre

6. Fixed beam with an eccentric point load W.



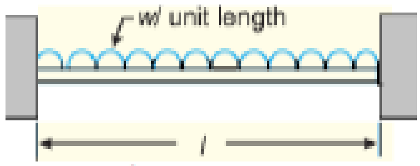
$\delta = \frac{Wa^3b^3}{3EIl^3}$ at the point load

7. Fixed beam with a central point load W.



$\delta = \frac{Wl^3}{192IE}$ at the centre

8. Fixed beam with a uniformly distributed load of w per unit length.



$\delta = \frac{Wl^4}{384IE}$ at the centre