MACHAKOS UNIVERSITY

University Examinations for 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATIONS FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM311: MECHANICS OF MACHINES II

DATE: **TIME:**

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) Define the following terms as used in design of bearings

- Catalog Load Rating (1 mark)
- Basic Load Rating (1 mark)
- Static Load Rating (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)

b) i) What causes unbalance in rotors and what is its effect? (2 marks)

ii) What is rotor balancing? (1 mark)

c) 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 c).

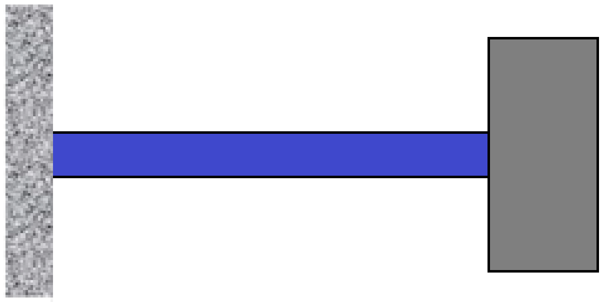


Fig. Q1 c)

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 (4 marks)

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

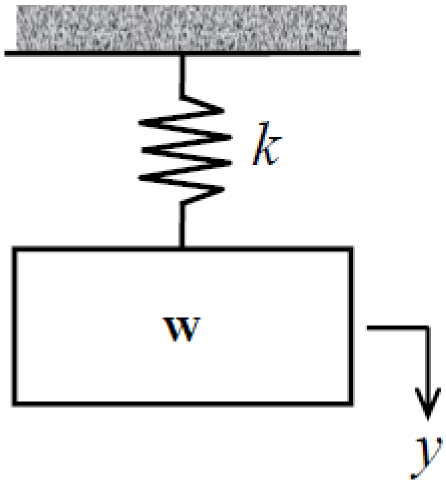
Take G = 79 GPa for steel.

d) Starting from the response equation of an undamped system, show that the logarithmic decrement is given by;

$$\delta = \frac{2\pi\zeta}{\sqrt{1-\zeta^2}}$$

Where ζ is the damping ratio (6 marks)

e) An unknown weight of W Newtons attached to the end of an unknown spring of stiffness K N/m has a natural frequency of 100 cycles per minute (cpm). When a 4.5 N weight is added to W, the natural frequency is reduced to 70 cpm. Determine the unknown weight W and the spring constant K. (4 marks)



Fid Q1 e)

f) A milling machine has rotational imbalance caused by a faulty flywheel, see Fig. Q3 a).

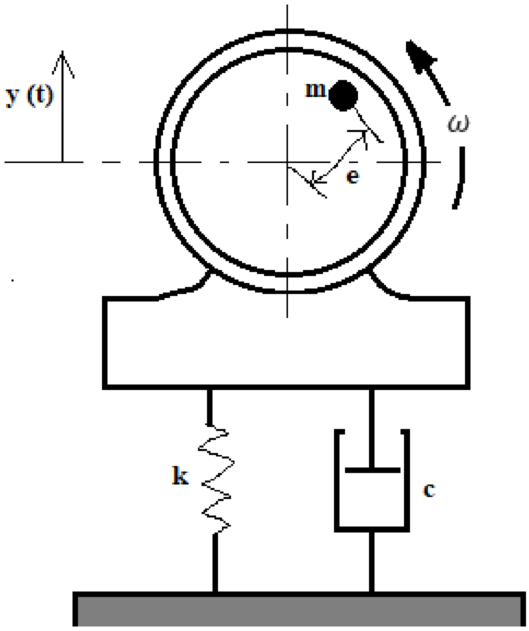


Fig. Q3 a)

If $\boldsymbol{M}$ is the total mass of the machine, $\boldsymbol{m}$ is the eccentric mass and $\boldsymbol{\omega}$ is the speed of rotation, model the machine as spring mass system and derived its equation of motion. (6 marks)

QUESTION TWO (20 MARKS)

a) Using suitable sketches, describe three types of damping (6 marks)

b) Figure Q2 b) shows a model of a single degree of freedom system that was over-damped.

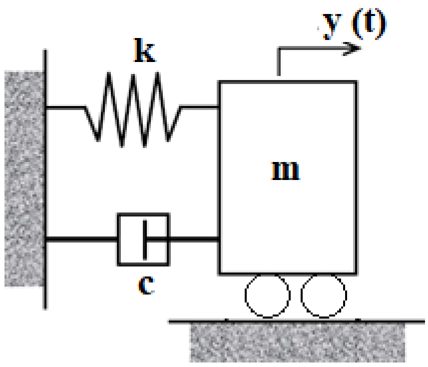


Fig. Q2 b)

Staring from the free body diagram of the system, derive the response equation of the system clearly defining the symbols used. Sketch the response and explain its implications

(14 marks)

QUESTION THREE (20 MARKS)

a) The compound pendulum illustrated in Fig. Q3 a) 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)

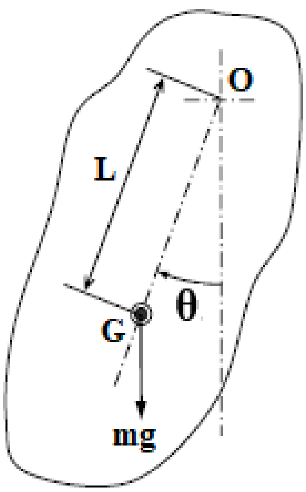


Fig. Q3 a)

b) Staring from the particular response equation of SDOF system excited by a harmonic force, $f\ (t) = F_0 \cos \sin(\omega t)$, show that the maximum magnification factor of the system is given by the following equation;

$D_{max} = \frac{1}{2\zeta\sqrt{1-\zeta^2}}$ where ζ is the damping ratio (14 marks)

The particular response is reproduced below;

$y_p(t) = \frac{F_0}{\sqrt{(k-m\omega^2)^2+(c\omega)^2}} \cos(\omega t - tan^{-1}\frac{c\omega}{k-m\omega^2})$

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;

$$f_n = \frac{997}{2000}\sqrt{\frac{WL}{EA}}$$

Where:

W = Load attached to the free end
L = Length of the beam
E = Young's modulus
A = Cross-sectional area (10 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 E = 200 GN/m^2.

(10 marks)

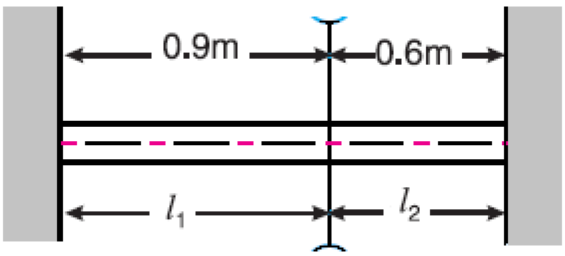


Fig. Q4b)

QUESTION FIVE (20 MARKS)

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

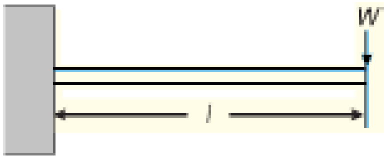
b) A shaft carries three masses A, B and C. Planes B and C are 60 cm and 120 cm from A. The masses A, B and C are 50 kg, 40 kg and 60 kg respectively at a radius of 2.5 cm. The angular position of mass B and mass C with A are 90^0 and 210^0 respectively. By suing the analytical method, determine the:

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)

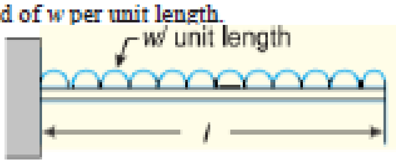
Values of static deflection (δ) for the various types of beams and under various load conditions.

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



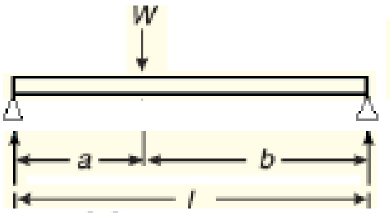
$\delta = \frac{Wl^3}{3IE}$ at the free end

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



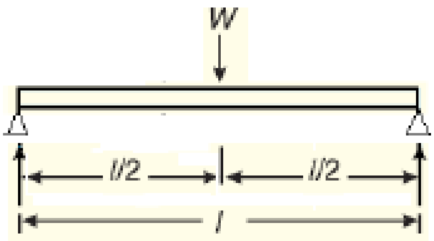
$\delta = \frac{Wl^4}{8IE}$ at the free end

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



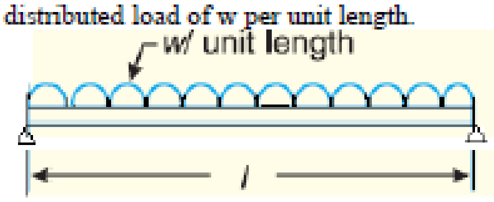
$\delta = \frac{Wa^2b^2}{3IEl}$ at the point load

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



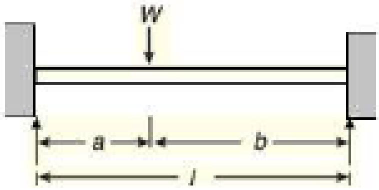
$\delta = \frac{Wl^3}{48IE}$ at the centre

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



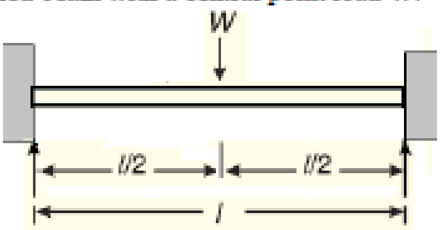
$\delta = \frac{5}{384}\frac{Wl^4}{IE}$ at the centre

6. Fixed beam with an eccentric point load W.



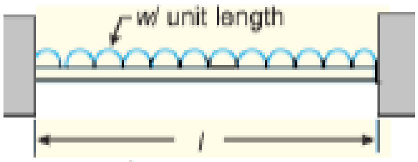
$\delta = \frac{Wa^3b^3}{3IEl^3}$ at the point load

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