



TECHNICAL UNIVERSITY OF MOMBASA

SCHOOL OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF BUILDING & CIVIL ENGINEERING
UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECV 4517: THEORY OF STRUCTURES VI

END OF SEMESTER EXAMINATION

SERIES: JANUARY 2025

TIME: 2 HOURS

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, calculator, examination pass and student ID

This paper consists of **five** questions.

Attempt question ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

QUESTION ONE (30 marks)

- (a) Determine the natural frequency and mode of vibration of the system shown in Figure Q1(a). (15 Marks)

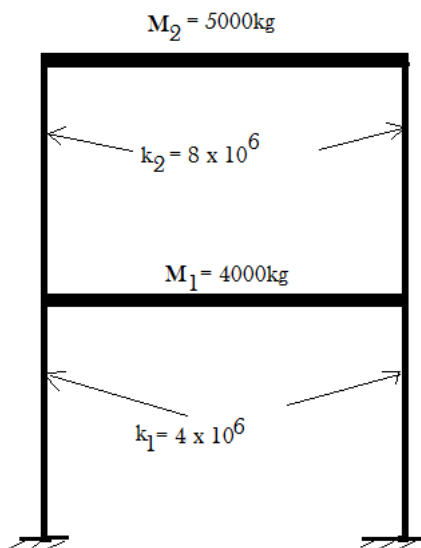


Figure Q1(a)

- (b) An air conditioning unit of mass 1600 kg is placed in the middle of an 8 m long simply supported beam ($EI = 8 \times 10^3 \text{ kNm}^2$) of negligible mass. The motor runs at 300 rpm and produces an unbalanced load of 120 kg. Assuming a damping ratio of 5%, determine the steady-state amplitude and deflection at the midpoint. What rpm will result in resonance and what is the associated deflection? **(15 Marks)**

QUESTION TWO (20 Marks)

- (a) Clearly discuss any three passive seismic control systems that can be used to reduce the magnitude of an earthquake on storey structures **(12 Marks)**
- (b) Assume that a seismograph, located 1200 km from the epicentre of an earthquake, records a maximum ground displacement of 15.6 mm from surface waves having a period of 20 seconds. Based on these assumptions, determine the surface wave magnitude. **(8 Marks)**

QUESTION THREE (20 Marks)

- (a) Briefly describe the following types of seismic waves:
- (i) Shear waves (5 Marks)
 - (ii) Love and Rayleigh waves (5 Marks)
- (b) A 3 m high, 8 m wide single-bay single-storey frame is rigidly jointed with a beam of mass 5,000 kg and columns of negligible mass and stiffness of $EI_c = 4.5 \times 10^3 \text{ kNm}^2$. Calculate the natural frequency in lateral vibration and its period. Find the force required to deflect the frame 25 mm laterally. **(10 Marks)**

QUESTION FOUR (20 Marks)

- (a) A SDOF system ($m = 20 \text{ kg}$, $k = 350 \text{ N/m}$) is given an initial displacement of 10 mm and initial velocity of 100 mm/s. Find;
- (i) the natural frequency (2 Marks)
 - (ii) the period of vibration; (2 Marks)
 - (iii) the amplitude of vibration; and (4 Marks)
 - (iv) the time at which the third maximum peak occurs. (4 Marks)
- (b) With clear illustrations describe the two major categories of dynamic loading. **(8 Marks)**

QUESTION FIVE (20 Marks)

A machine of weight $W = 1750.87 \text{ kg}$ is mounted on simply supported steel beams as shown in Figure Q5. A piston that moves up and down in the machine produces a harmonic force of magnitude $F_o = 3175.15 \text{ kg}$ and frequency $\omega_n = 60 \text{ rad/sec}$. Neglecting the weight of the beam assuming 10% of the critical damping, determine;

- (i) The amplitude of the motion of the machine (10 Marks)
- (ii) The force transmitted to the beam supports (5 Marks)
- (iii) The corresponding phase angle (5 Marks)

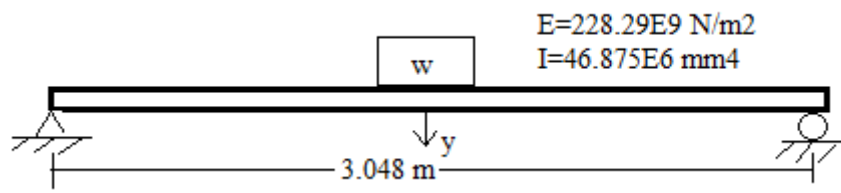


Figure Q5