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***)*

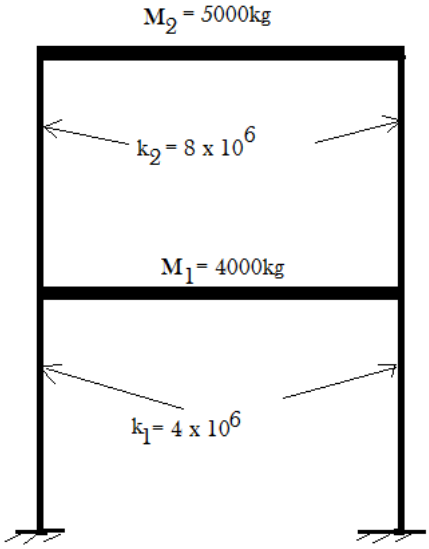

Figure Q1(a)

(b) *An air conditioning unit of mass 1600 kg is placed in the middle of an 8 m long simply supported beam (EI = 8 x 10^3 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 x 10^3 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 kg, k = 350 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 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 kg and frequency $\omega_n = 60$ 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)

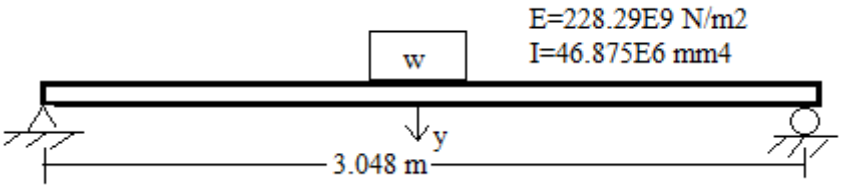

Figure Q5