**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**

SPECIAL/SUPPLEMENTARY EXAMINATION

**SERIES:** MARCH 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) Briefly discuss the following types of seismic waves as they occur in earthquake engineering
   i. Compressional waves (4 marks)
   ii. Secondary waves (4 Marks)
   iii. Rayleigh waves (4 Marks)

(b) A simple beam supports at its centre a machine having a mass of 7257.48 kg. The beam is made of standard sections with a clear span L = 3.66 m with stiffness of $11.0574 \times 10^6$ N/m. The motor runs at 300 rpm, and its rotor is out of balance to the extent of producing unbalance load of 18.14 kg at a radius of $e_0$ = 254 mm. What will be the amplitude of the steady-state response if the equivalent viscous damping for the system is assumed 10% of the critical? (18 Marks)

QUESTION TWO (20 Marks)

(a) Assume that during a major earthquake, the depth of fault rapture is estimated to be 15 km, the length of surface faulting is determined to be 600 km, and the

average slip along the fault is 2.5 m. Based on these assumptions, determine the moment magnitude. Use a shear modulus of $3x10^{10}$ N/m$^2$. (10 Marks)

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 $EI_c = 4.5 \times 10^3$ 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 THREE (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) Using clear illustrations describe the two major categories of dynamic loading. (8 Marks)

QUESTION FOUR (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)

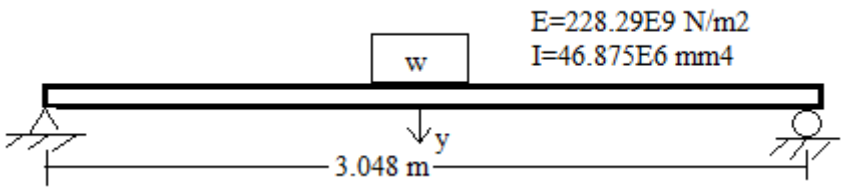
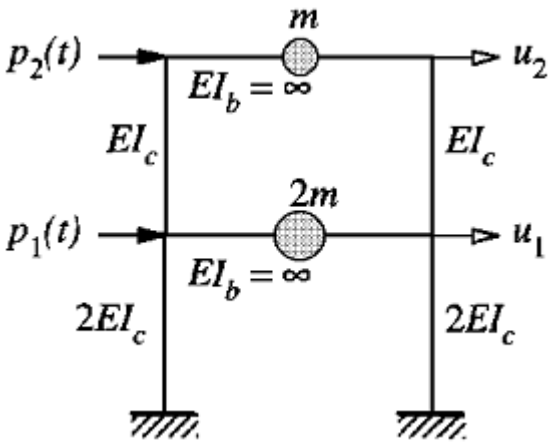



Figure Q5

QUESTION FIVE (20 Marks)

Formulate the equations of motion for the two storey shear frame shown in figure Q5.


m
$p_2(t)$
$u_2$
$EI_b = \infty$
$EI_c$
$EI_c$
2m
$p_1(t)$
$u_1$
$EI_b = \infty$
$2EI_c$
$2EI_c$