



MACHAKOS UNIVERSITY

UNIVERSITY EXAMINATIONS 2024/2025

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

**FOURTH YEAR FIRST SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE IN CIVIL ENGINEERING**

ECV 405: THEORY OF STRUCTURES V

Date:

Time :

INSTRUCTIONS

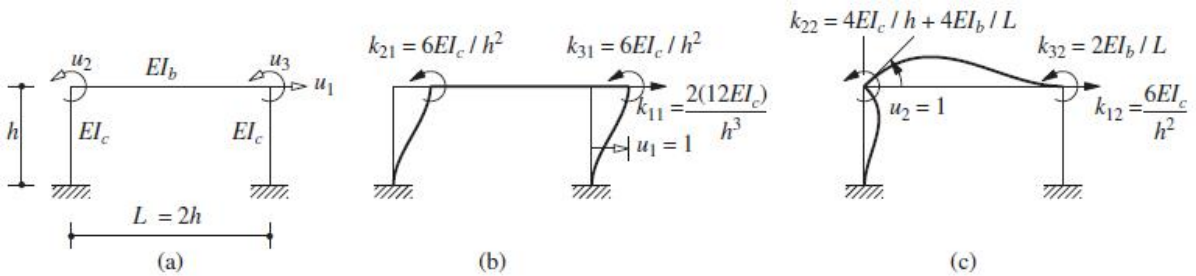
- *This paper comprises of **FIVE** questions. Answer **THREE** questions*
- *Question one is **Compulsory** and carries 30 marks*
- *Answer any other **TWO** questions*

QUESTION ONE

1. (i) With the aid of sketches/equations explain the following terms in structural dynamics (5 marks)
 - (a) Damping.
 - (b) Logarithmic increment
 - (c) Forced vibrations
 - (d) Free vibrations.
 - (e) Resonance
- (ii) Giving examples, how is the principle of lumped mass used to model structural vibrations? (3 marks)

(iii) Differentiate between damped and undamped systems. (2 Marks)

(iv) Calculate the lateral stiffness for the frame shown in Fig.Q1a, assuming the elements to be biaxially rigid. **Note: Hints are given Fig.Q1b & c** (5 marks)



(v) Using sketches elucidate how to identify the epicenter of an earthquake. (5 marks).

(vi) What is static condensation? (3 marks)

(vii) As an engineer explain the factors you would consider in coming up with a value for the damping coefficient in structural dynamics (3 marks)

(viii) Using sketches describe any possible modes of foundation vibrations. (4 marks).

2. (i) Given the setup in Fig. Q2. Use Newton's second law to derive the expression;

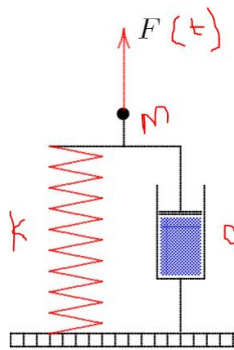


Fig. Q2

$$m \frac{d^2 u}{dt^2} + c \frac{du}{dt} + ku = F(t)$$

Where m is mass, u is displacement, t is time, c is damping coefficient, and k is springs constant.

Also, provide a solution in the case of free vibrations, showing clearly the process through which a solution can be derived for an underdamped system. (16 marks)

(ii) Differentiate between SDOF & MDOF (4 marks)

3. (i) With sketches define the underdamped system, overdamped system and critically damped system. (6 marks)

(ii) Giving examples, differentiate between free vibrations and forced vibrations. (4 marks)

(iii). For a machine foundation, given weight = 60 kN, spring constant = 11000 kN/m, and $c = 200$ kN-sec/m, determine:

a. Whether the system is overdamped, underdamped, or critically damped. Explain your answer.

(4 marks)

b. The logarithmic decrement. (3 marks)

c. The ratio of two successive amplitude. (3 marks)

4.(i) (a). A machine and its foundation weigh 140 kN. The spring constant and the damping ratio of the soil supporting the soil may be taken as 12×10^4 kN/m and 0.2, respectively. Forced vibration of the foundation is caused by a force which can be expressed as Q (kN) = $46 \sin \omega t$, $\omega = 157$ rad/sec.

Determine:

a. The undamped natural frequency of the foundation. (3 marks)

b. Amplitude of motion. (3 marks)

c. Maximum dynamic force transmitted to the subgrade. (3 marks)

(b) With the aid of sketches differentiate between hysteretic damping and Coulomb damping. (4 marks)

(ii) Find an expression for the angular natural frequency of the following system in Q4ii. Calculate the maximum amplitude of vibration of the system with a mass of $m = 10$ kg, and a

spring's constant of $k = 200 \text{ N/m}$ when given an initial displacement of $x_0 = 0.1 \text{ m}$ and an initial velocity of 0.3 m/s . (7 marks)

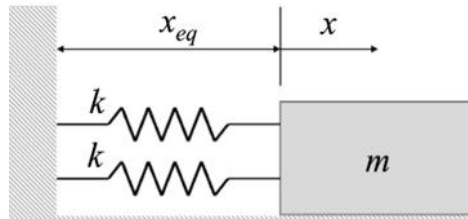


Fig. Q4ii

5. (a) (i) A foundation of mass m is supported by two springs attached in series. Determine the natural frequency of the undamped free vibration in Fig Q5ai. (5 marks)

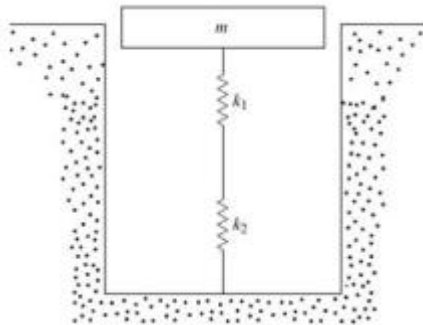


Fig. Q5ai

(ii) For the system shown in the Fig. Q5aai, calculate the natural frequency and period given $k_1 = 100 \text{ N/mm}$, $k_2 = 200 \text{ N/mm}$, $k_3 = 150 \text{ N/mm}$, $k_4 = 100 \text{ N/mm}$, $k_5 = 150 \text{ N/mm}$, and $m = 100 \text{ kg}$. (5 marks)

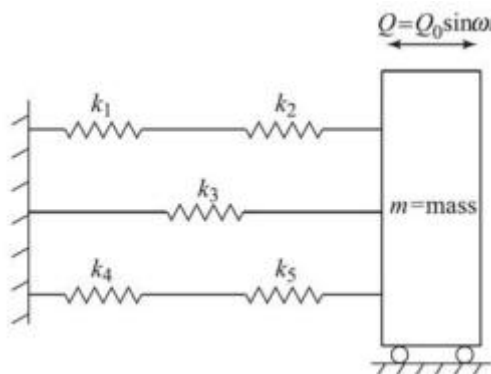


Fig. Q5aai

(b) Develop an equation for the system shown in Fig. Q5b

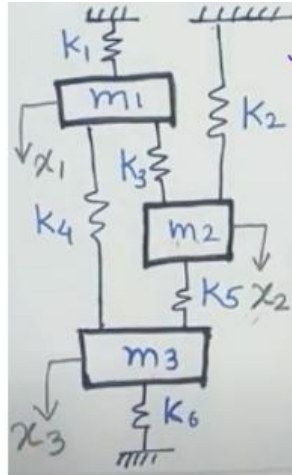


Fig. Q5b