THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING – 3rd YEAR DEGREE

SECOND SEMESTER FINAL EXAMINATIONS - 2023

CE 323 – Structural Dynamics and Earthquake Engineering

DATE: MONDAY, 23rd OCTOBER 2023 – 8:20 A.M

VENUE: CALC

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES

1. You have 10 minutes to read the paper before the examination starts. You must **not** begin writing during this time.
2. **Answer any 5 questions out of 7. All questions are of equal marks.**
3. Use only ink. Do not use pencils for writing except for drawings and sketches.
4. Only Calculator is allowed in the examination room. MOBILE PHONE is not allowed (**Switch your Mobile Phones OFF**). Notes and textbooks are not allowed.
5. Start each question on a new page and show all your calculations in the answer book provided. No other material will be accepted.
6. **Write your NAME and clearly on the front page. Do it now.**
7.

QUESTION 1 [20 MARKS] SLO 4 Analysis and design of earthquake resistant structures.

(a) A single room masonry building with inner dimension 4.0 m X 5.5 m has 200 mm thick outer walls built in 1:6 cement and sand mortar and modular bricks. The roof (other than RCC or RB slab), weighs 600kg/m³. The plinth to lintel height is 2 m and height of brickwork from bottom of lintel to bottom of roof is 1.4 m. The weight 0f 200 mm thick wall is 384kgf/m². There are two doors in front wall, four windows in 4 walls and two ventilators in two adjacent walls. Design the bands required for a design earthquake coefficient of 0.16.

Given:

Allowable bending compression in concrete = 5N/mm²

Allowable shearing stress in concrete = 0. 5N/mm²

Allowable tensile stress in steel = 140 N/mm²

Modular ratio = 18

Permissible increase in stress due to earthquake = 33.5% 10 marks

b) Differentiate between magnitude and intensity scale. 2 marks

c) Write the name of an instrument for recording earthquake. 2 marks

d) Define seismic risk map. 2 marks

e) Name tree types of floating floors used for vibration isolation. 2 marks

f) What is the basic difference between vibration absorber and vibration isolator? 2 marks

QUESTION 2 [20 MARKS] SLO 3 Evaluate methods of controlling vibrations

a) Mention several methods of determining the natural frequencies and mode shapes of multi degree-of-freedom systems. Whether the fundamental frequencies calculated from Dunkerley's formula give larger or smaller value compared to the exact value? On which fact the derivation of Dunkerley's formula is based? **2 + 1 + 2 = 5 marks**

b) Whether the value of fundamental natural frequency calculated from Rayleigh's method is smaller or larger than the exact value? Write two forms of approximate equation which is known as Dunkerley's formula explaining the notations used. **1+4 = 5 Marks**

c) Estimate the fundamental natural frequency of a simply supported beam carrying three identical equally spaced masses, as shown in Fig. 1. **10 Marks**

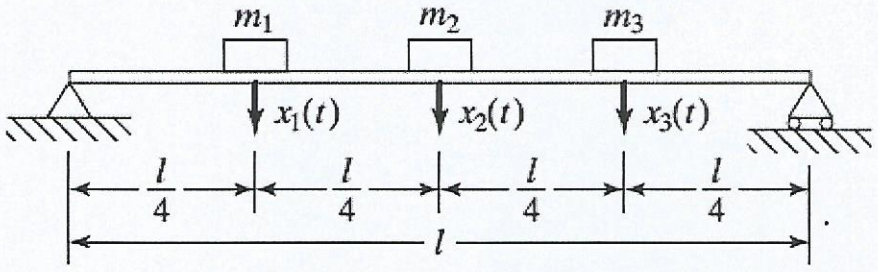


Figure 1

QUESTION 3 [20 MARKS] SLO 1 Apply the fundamental concepts and equations for analysis of a system subjected to dynamic loadings.

(a) What is meant by damping ratio? 2 Marks

(b) Define underdamped, critically damped and over damped system based on the values of damping ratio (ξ). 2 Marks

(c) Define Resonance and dynamic magnification. 2 Marks

(d) What is meant by first and second mode of vibration? 2 Marks

(e) Write down the formula for free vibration response of single degree freedom system. Explain the notations used. 2 Marks

(f) Derive the dynamic equation for SDOF system without damping. 5 Marks

(g) An undamped structural system with stiffness (k) = 25 k/ft and mass (m) = 1 k-sec^2/ft is subjected to an initial displacement (u_0) = 1 ft and an initial velocity (v_0) = 4 ft/sec.

Calculate the natural frequency and natural period of the system. 5 marks

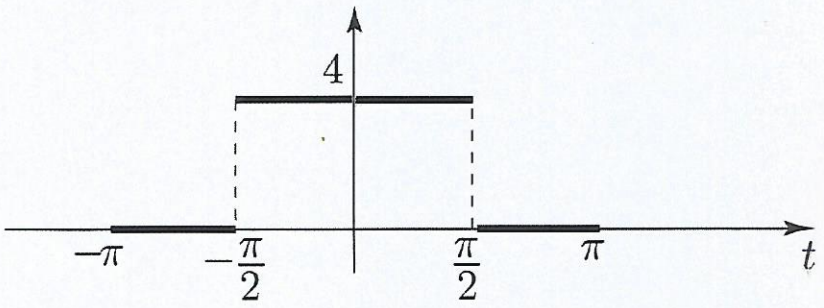
QUESTION 4 [20 MARKS] SLO2 Analyze forced vibrations under general conditions and earthquake load.

i) Write the Fourier Series expansion for a periodic sinusoidal function $f(t)$ of period 2π. Explain the notations used in the expansion. **1+2 = 3 marks**

ii) Derive a simple finite Fourier series expansion of $f(t) = cos^2 t$ with period π. **2 marks**

iii) Define Fourier coefficients and Fourier analysis with general form of Fourier series representation. **2 marks**

iv) Consider the square wave of period 2π one period of w is shown in Figure



(a) Write down the analytic description of this function,

(b) State whether you expect the Fourier series of this function to contain a constant term,

(c) List any other possible features of the Fourier series that you might expect from the graph of the square-wave function.

1+1+1 = 3 marks

v) Derive the dynamic equation of a damped single degree of freedom (SDOF) system. **10 marks**

QUESTION 5 [20 marks] SLO 1 + SLO 2 + SLO 3

a) derive the dynamic equation for SDOF system without damping. **5 marks**
b) Derive the dynamic equation of a two degree of freedom system without damping. **6 marks**
c) Write short notes on the three mechanisms used for vibration control. **9 marks**

QUESTION 6 [20 marks] SLO 2

(a) Write down the equation of motion for an undamped system under harmonic force.
(b) Derive the expression for response of the undamped damped system.
(c) Define the magnification factor and write down the expression for that.

2+6+2 = 10 Marks

(d) A reciprocating pump having a weight of 68 kg, is mounted at the middle of a steel plate of thickness 1 cm, width 50 cm and length 250 cm, clamped along two edges as shown in Figure 2. During operation of the pump, the plate is subjected to a harmonic force, $F(t) = 220\cos 62.832t$ N. Find the amplitude of vibration of the plate. **10 Marks**

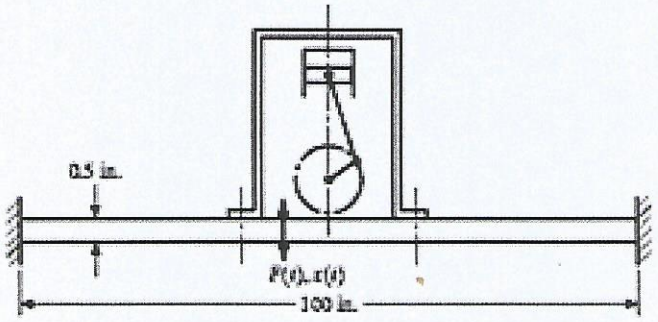


Figure 2

QUESTION 7 [20 marks] SLO 4

(a) What causes an earthquake?
(b) What are an earthquake's characteristics?
(c) How do we measure earthquakes? ← **3+3+4 = 10 Marks**
(d) Define Ring of Fire. ← **2 Marks**
(e) Write short notes on P-wave, S-wave and Love wave. ← **3+3+2 = 8 Marks**