UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2022

Module Number: CE 6252 **Module Name: Dynamics and Control of Structures**

[Three Hours]

[Answer **all questions.** Each question carries **12 marks]**

Q1. a) Explain two different methods of conducting the free vibration test.

[2 Marks]

b) What is the free vibration response of a structural system having a low damping property?

[2 Marks]

c) A reinforced concrete overhead water tank with a capacity of 120 m^3 is supported by a reinforced concrete column of 9.5 m height. The column is having a tubular cross section with an inner diameter of 3.6 m and outer diameter of 5.2 m. Modulus of elasticity of concrete is 25 GPa and unit weight of water is 9.81 kN/m^3 .

i) Idealize the structure for dynamic analysis in the lateral direction.

ii) Derive the equation of motion for the idealized structure.

iii) Determine the natural frequency and the period of motion of the system for lateral vibration.

iv) What is the force required to be applied at the tank to deflect the system by 0.05 mm laterally?

[8 Marks]

Q2. a) What are the sources of vibration?

[2 Marks]

b) Discuss the effect of four different sources of vibration on structures with examples.

[4 Marks]

c) A structure that can be idealised as a single degree of freedom system was renovated for the requirement of improvement in resistance to dynamic forces. The dynamic responses of the structure were measured before the renovation and after the renovation and recorded as shown in Figure Q2.

i) Determine the natural frequency of the structure before the renovation.

ii) Determine the damped natural frequency and damping ratio of the structure after the renovation.

[6 Marks]

Q3. Dynamic analysis is needed to be carried out for a two storey frame structure, which is proposed as a hotel complex in the coastal region. For the analysis, the structure can be idealized as two-dimensional frame and considered as a "shear frame structure" as shown in Figure Q3.

a) Identify the degree of freedom for lateral vibration and formulate the equation of motion for the system. Clearly state any assumptions you may made.

[3 Marks]

b) Determine the natural frequency and the mode shape associated with each vibration mode of the structure. Assume $k/m = 150$ (in the units of radian$^2/s^2$), where k and m are as shown in Figure Q3.

[5 Marks]

c) Assess the dynamic response of the structure for possible machine induced vibration at 5 Hz, and 7.5 Hz.

[4 Marks]

Q4. a) Explain briefly,

i) Harmonic force
ii) Total response
iii) Steady-state response
iv) Half-power band width

[4 Marks]

b) Plot the total response and steady-state response of an un-damped system having a natural frequency of 5 Hz to forcing frequency of 10 Hz. Use scaled graphs to support the answer. Clearly state any assumptions you may made.

[4 Marks]

c) The steady-state acceleration amplitude of a structure caused by vibration generator was measured for several excitation frequencies. The measurements are summarized in Table Q4.

i) Plot the acceleration amplitude with frequency.
ii) Determine the natural frequency and damping ratio of the structure.

[4 Marks]

Q5. a) Explain briefly the followings for an earthquake

i) Magnitude
ii) Intensity
iii) Epi-center
iv) Hypo- center

[4 Marks]

b) What are the vibration controlling devices and associated mechanisms that can be used to reduce dynamic responses of high-rise building structures for earthquake loadings?

[4 Marks]

c) Compare the characteristics of different types of seismic waves. Explain in detail, with neat sketches, how these characteristics can be used to determine the magnitude and epi-center of an earthquake.

[4 Marks]

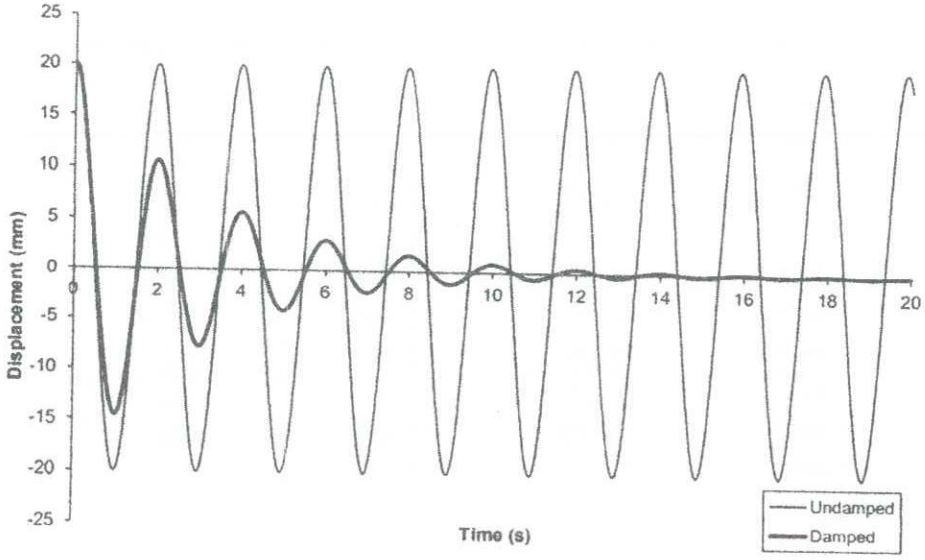

Figure Q2: Vibration measurements of a structure

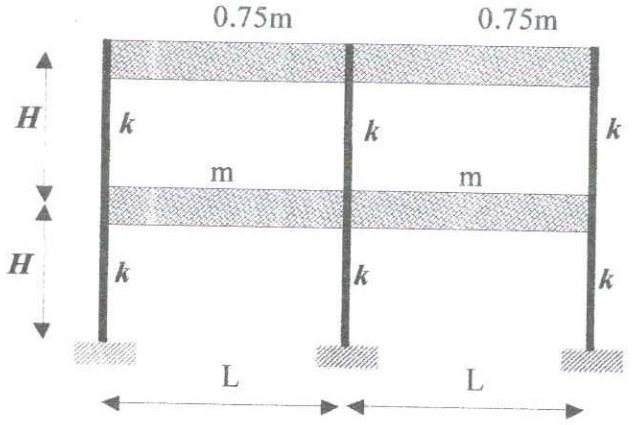

Figure Q3: Shear Frame structure

Table Q4. Steady-state acceleration amplitude of a structure at several excitation frequencies

Frequency (Hz)	Acceleration (10^{-3}g)	Frequency (Hz)	Acceleration (10^{-3}g)
1.338	1.36	1.500	13.9
1.377	1.80	1.513	10.80
1.400	2.30	1.520	9.40
1.414	3.00	1.530	7.60
1.438	4.40	1.540	6.80
1.453	6.10	1.550	6.20
1.462	8.00	1.567	5.20
1.477	13.00	1.605	3.90
1.487	15.50	1.628	3.40
1.493	16.50	1.658	3.00
1.497	15.20		