TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF BUILDING & CIVIL ENGINEERING
UNIVERSITY EXAMINATION FOR:
BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECE 2416: THEORY OF STRUCTURES VI
SPECIAL/SUPPLEMENTARY EXAMINATION
SERIES: SEPTEMBER 2018
TIME: 2 HOURS

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

-Drawing instruments.

This paper contains FOUR questions

Answer question ONE and any TWO questions.

Marks for each question are indicated in the parenthesis.

Question One (30 marks) COMPULSORY

(a) (i) Define seismic mass of the building. (2 marks)

(ii) Discuss the factors influencing Natural Period of a building. (15 marks)

(b) A machine of mass 1000 kg is supported on a vertical flexible mounting, modelled as a single degree-of-freedom system. The mounting has a total stiffness 50 kNm^{-1} but negligible damping. Any horizontal motion of the system should be ignored. In normal operation the machine is subjected to a vertical force $F = F_0 \sin\Omega t$ where the amplitude F_0 is 2500 N. Calculate the response amplitude and the force transmitted to the foundations when the driving
frequency is (a) 20 Hz and (b) 2 Hz.

(13 marks)

ANSWER ANY TWO QUESTIONS

Question Two (20 marks)

(a) Define the following terms as applied in structural dynamics

- Free vibration
- Forced vibration

- Damped vibration
- Undamped vibration
- Linear vibration
- Non-linear vibration
- Degrees of freedom
- Resonance

(8 marks)

(b) Determine the response of the system under the given initial conditions.

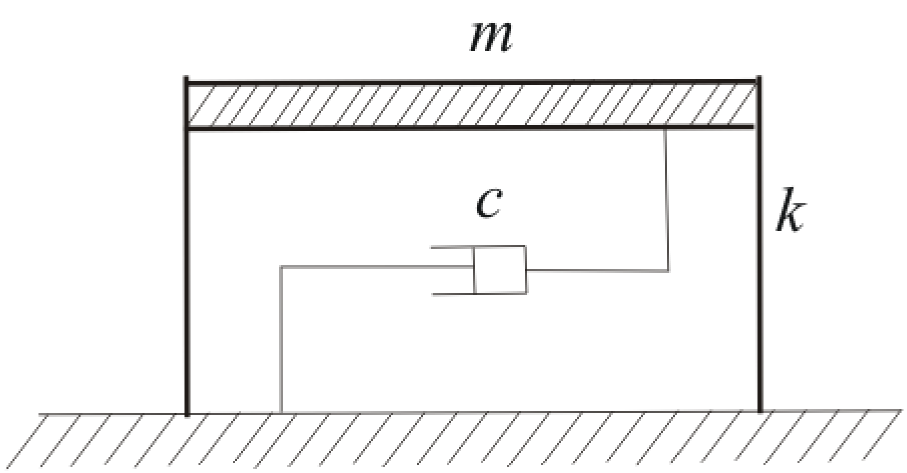

Figure 1 (8marks)

(c)Using sinusoidal graph illustrate the following types of damping

- Undamped
- Under damped
- Over damped
- Critically damped

(4 marks)

Question Three (20 marks)

(a) (i)Using Newton's second law of motion outline the procedure of deriving equation of motion of undamped single degree of freedom system.

(4 marks)

(ii) Derive the equation of motion using Newton's second law of motion for the undamped single degree of freedom system given in figure 2

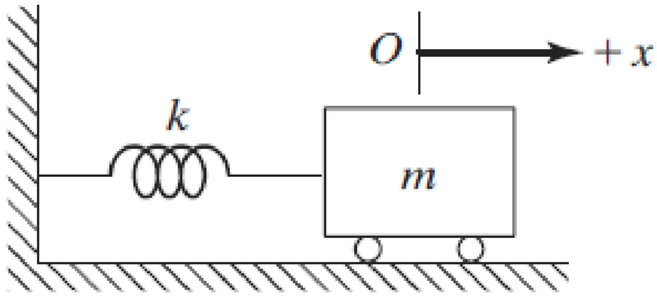

Figure. 2

(6 marks)

(b) Figure 3 shows two degree of freedom frame used in the construction of engineering workshops at TUM. Derive the equation of motion of the system subjected to the ground acceleration $\ddot{x}_g$

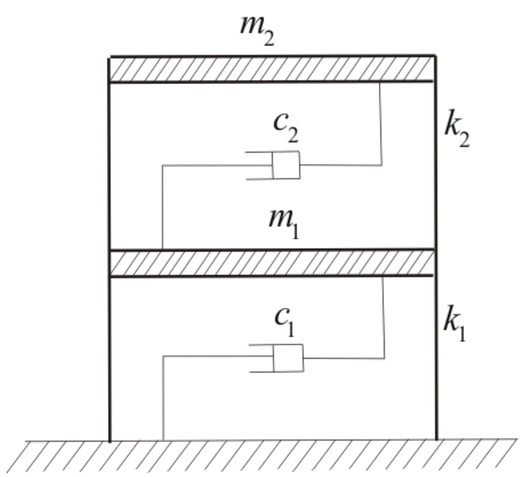

Figure.3

(10 marks)

Question Four (20 marks)

(a) The vibration on the third floor in a Marine building at Technical University of Mombasa is single harmonic motion at a frequency in the range 20-80 Hz. It is desired to install sensitive equipment in the building which must be insulated from floor vibration. The equipment is fastened to a small platform which is supported by three similar springs resting on the floor, each carrying an equal load. Only vertical motion occurs. The combined mass of the equipment and platform is 60 kg, and the equivalent viscous damping ratio of the suspension is 0.3.Find the maximum value for the spring stiffness, if the amplitude of transmitted vibration is to be less than 12% of the floor vibration over the given frequency range.

(10 marks)

(b) Consider the transverse vibration of a bridge structure. For the fundamental frequency it can be considered as a single degree of freedom system. The bridge is deflected at midspan (by winching the bridge down) and suddenly released. After the initial disturbance the vibration was found to decay exponentially from an amplitude of 10 mm to 5.8 mm in three cycles with a frequency of 1.62 Hz. The test was repeated with a vehicle of mass 40 000 kg at mid-span, and the frequency of free vibration was measured to be 1.54Hz. Find the effective mass, the effective stiffness, and the damping ratio of the structure. Let *m* be the effective mass and k the effective stiffness.

(10 marks)

Question Five (20 marks)

a) Elastic springs may be arranged either in series or in parallel to transmit axial forces. Formulate the equivalent spring stiffness in each of the two cases for any number of springs

b) Hence otherwise, calculatethe shear forces, bending moments and deflections at column ends for the frame loaded as shown in figure Q5(b). sketch he shear force and bending moments

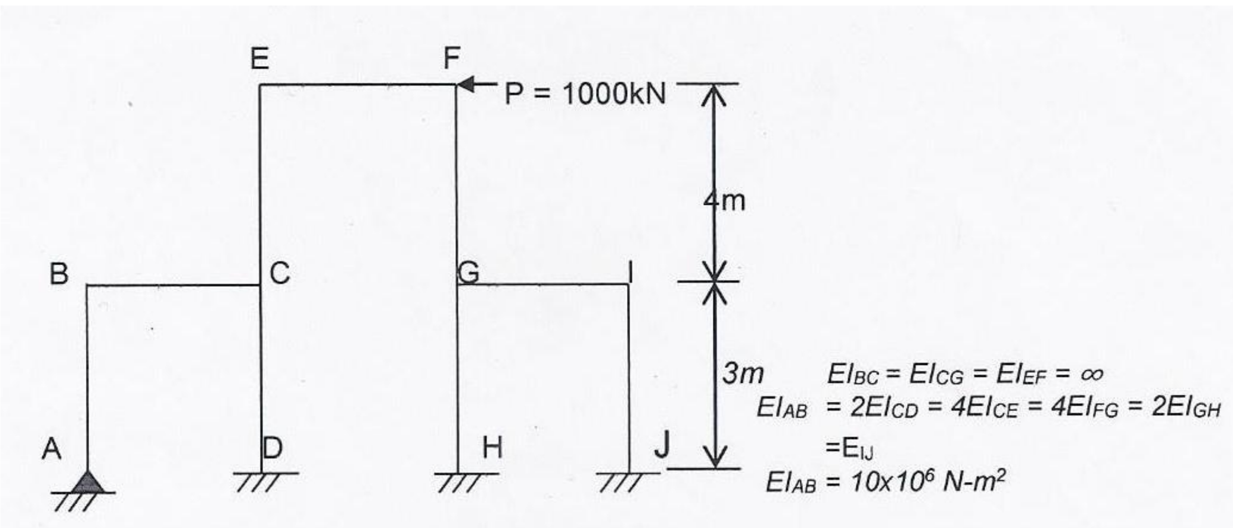

Figure Q5 (b)