Second Semester Examination
2020/2021 Academic Session

July/August 2021

EAS456 – Advanced Structural Analysis

Duration : 1 hour

Please ensure that this examination paper contains **FIVE (5)** printed pages before you begin the examination.

Instructions: This paper contains **THREE (3)** questions. Answer **TWO (2)** questions.

All questions **MUST BE** answered on a new page.

...2/-

1. (a). Using an appropriate example, explain the procedures to conduct free vibration test on a real structure in order to analyse the dynamic properties of the structure.

[10 marks]

(b). Formulate the equation of motion for a single degree of freedom system as shown in **Figure 1**. The mass *m* is connected to a viscous damper with the damping coefficient of *c* and three springs with spring constants of k_1, k_2 and k_3.

[15 marks]

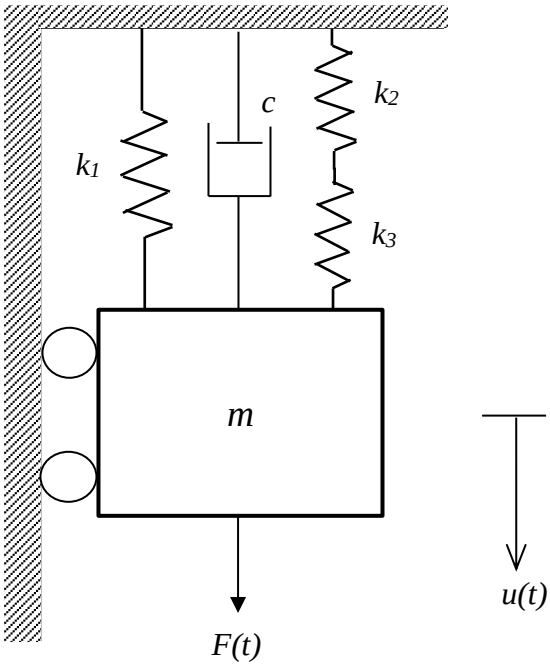

Figure 1

(c). If the system as shown in **Figure 1** is set into free vibration with an initial displacement of 30 mm and initial velocity of 4 cm/s, *m* = 150 kg, damping coefficient, *c* = 20 N.s/m, k_1 = 350 N/m, k_2 = 100 N/m and k_3 = 250 N/m, determine:

...3/-

(i). the natural frequency of undamped vibration,

(ii). the damping ratio,

(iii). the number of cycles required for the displacement amplitude to decrease to 15 mm, and

(iv). the displacement and velocity of the mass at t = 2.5 seconds. Sketch the displacement time history for the time up to 5 seconds.

The displacement response of a damped single degree of freedom system under free vibration is given by

$$u(t) = e^{-\xi\omega_n t}\left[u(0)\cos\omega_D t + \frac{\dot{u}(0) + \xi\omega_n u(0)}{\omega_D}\sin\omega_D t\right]$$

where ξ is the damping ratio,
ω_n is the natural circular frequency of undamped system,
ω_D is the natural circular frequency of damped system,
$u(0)$ is the initial displacement, and
$\dot{u}(0)$ the initial velocity.

[25 marks]

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2. (a). **Figure 2** shows three carts connected to each other by six springs. Derive the global system matrix [K][q] = [F] of the spring system by using the principle of minimum potential energy.

[35 marks]

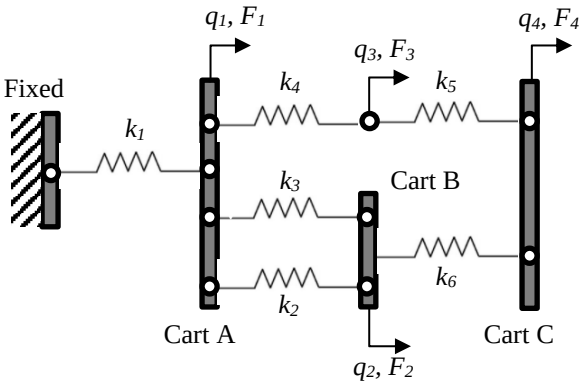

Figure 2

(b). The spring system in Part (a) has been changed to a new spring system as shown in **Figure 3**. Cart A is fixed.

(i) Write the new global system matrix of the system.

[5 marks]

(ii). Given, spring stiffnesses k2, k3 and k6 are 4 N/m, 8 N/m and 2 N/m, respectively. While F2 and F4 are 30 N and 60 N, respectively. Determine the displacement of Carts B and C.

[10 marks]

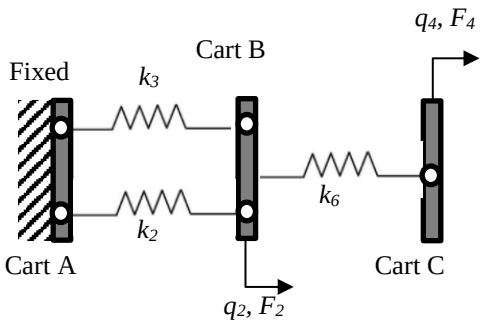

Figure 3

...5/-

3. (a). A historical multi-storey rigid frame building as shown in **Figure 4** is located in Zone I with terrain category 4. The total height of the building is 30 m and the frames are spaced at 8 m with total length of 40 m. The width of the building is 14 m. Estimate the value of the design wind pressure on the wind ward direction at the top floor of the frame according to MS1553:2002. Indicate all assumed values used in the calculations. Design data can be extracted from MS1553:2002.

[40 marks]

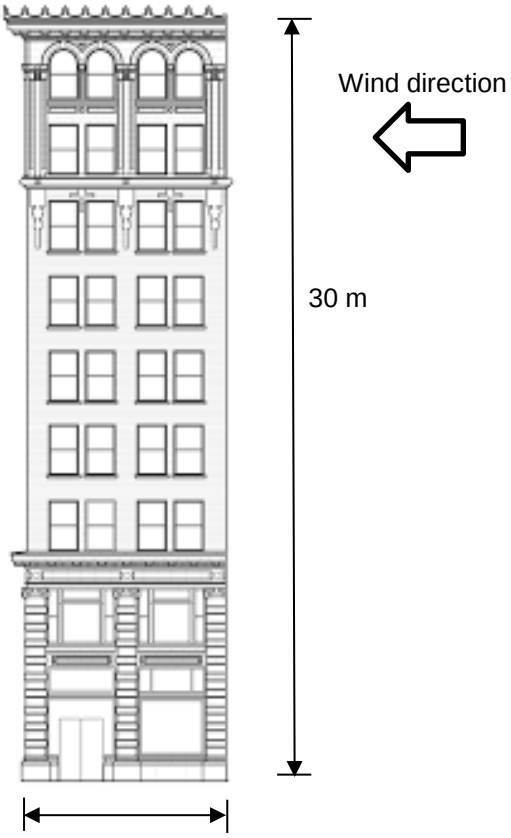

Figure 4

(b). Determine the new design wind pressure if the building is located in Zone I with new terrain Category 2.

[10 marks]

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