Second Semester Examination
2021/2022 Academic Session

July/August 2022

# EAS456 – Advanced Structural Analysis

Duration : 1 hour

Please ensure that this examination paper consists of **SIX (6)** pages of printed material before you begin the examination.

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

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

1. (a) Discuss **TWO (2)** fundamental differences between static and dynamic analyses. State the importance of carrying out dynamic analysis.

[10 marks]

(b) An undamped single degree of freedom system with mass *m* and stiffness of each column *k* as shown in **Figure 1 (a)** has the natural period $T_0$ and natural frequency $F_0$. When an additional column with the stiffness 2 kN/m is added to the system as shown in **Figure 1 (b)**, the natural period and natural frequency of the system have changed to $T_1$ and $F_1$, respectively.

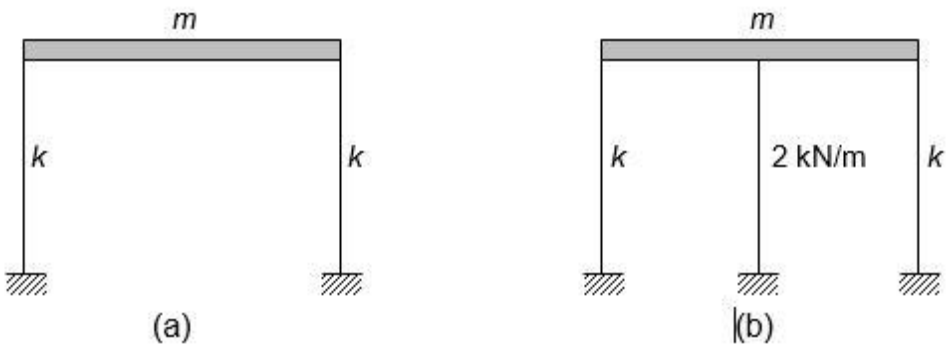


**Figure 1**

i) Given $F_1 = 1.1F_0$, determine the stiffness of the column *k*.

[4 marks]

ii) If both systems in **Figure 1** are excited with the same initial displacement *u(0)*, sketch the displacement response of both systems under free vibration in the same plot. Label clearly the response of each system in the plot with the initial displacement *u(0)* and the natural periods of system $T_0$ and $T_1$.

[8 marks]

**…3/-**

iii) If both systems in **Figure 1** are excited with the same initial velocity $\dot{u}(0)$, sketch the displacement response of both systems under free vibration in the same plot. Label clearly the response of each system in the plot with the initial velocity $\dot{u}(0)$ and the natural periods of system $T_0$ and $T_1$.

[8 marks]

(c) If the system in **Figure 1 (a)** has a damping of 5% and a weight of 2.5 kN, determine:

i) The damped natural period.

ii) The damped natural cyclic frequency.

iii) The damping coefficient.

iv) The displacement and velocity at t = 1.2 seconds if the system is excited by an initial displacement of 5 cm and an initial velocity of 25 mm/s.

[20 marks]

**…4/-**

The displacement response of an undamped single degree of freedom system under free vibration is given by

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

where $\xi$ is the damping ratio,

$\omega_n$ is the natural circular frequency of undamped system,

$\omega_D$ is the natural circular frequency of damped system,

$u(0)$ is the initial displacement, and

$\dot{u}(0)$ is the initial velocity

2. (a) Define discretization in Finite Element Method (FEM) and identify **THREE (3)** applications of FEM in structural engineering.

[8 marks]

(b) **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.

[30 marks]

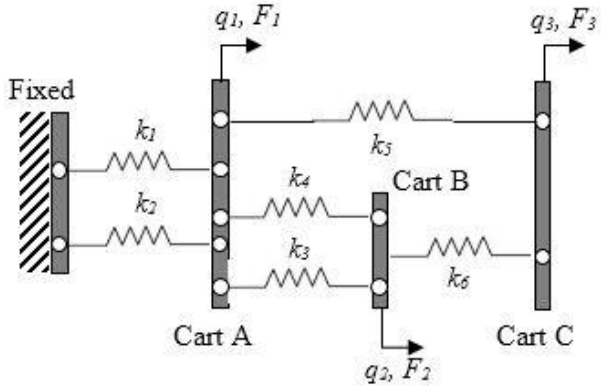


**Figure 2**

**…5/-**

(c) The spring system in Part (b) 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.

[4 marks]

ii)[ Given the spring stiffnesses $k_3$, $k_4$ and $k_6$ are 5 N/m, 10 N/m, and 4 N/m, respectively, determine the displacement of Carts B and C if $F_2$ and $F_3$ are 40 N and 50 N, respectively.

[8 marks]

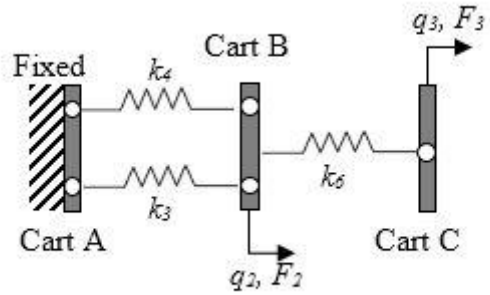


**Figure 3**

3. (a) A multi-storey rigid framed 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 24 m. The width of the building is 14 m. Calculate the value of the design wind pressure on the windward direction at the top floor of the frame according to MS1553:2002/2013. Indicate all assumed values used in the calculations. Design data can be extracted from MS1553:2002/2013.

[40 marks]

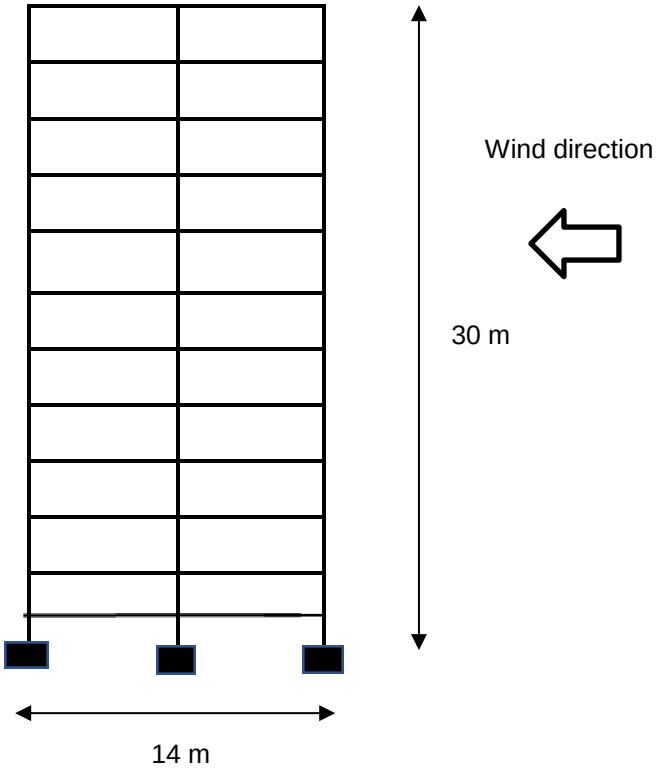


**Figure 4**

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

[10 marks]

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