UNIVERSITI SAINS MALAYSIA

1st Semester Examination
2010/2011 Academic Session

November 2010

EAS 663/4 – Dynamics and Stability of Structures

Duration : 3 hours

Please check that this examination paper consists of……….. printed pages before you begin the examination.

[Instructions: This paper contains ____( ) questions. Answer ______( ) questions only.

You must answer the questions in English.

All question **MUST BE** answered on a new sheet.

1. a) Sketch frequency-response curves for a damped single degree of freedom system subjected to a harmonic excitation under three different damping ratios. The system has a natural frequency of ω_n while the forcing frequency of the excitation is ω. Explain the relation of static and dynamic deformation responses for

    i. $\omega/\omega_n << 1$
    ii. $\omega/\omega_n >> 1$
    iii. $\omega/\omega_n = 1$

    Also state whether the dynamic response is controlled by the mass, stiffness or damping of the system for each case.

    [6 marks]

    b) A single degree of freedom building system is excited by a sinusoidal force as shown in Figure 1. Assume that the girder is rigid whereas the columns are flexible to the lateral deformation but rigid in the vertical direction. Use E = 30 GPa, I = 60 x 10^6 mm^4 and 5 % damping and neglect the mass of columns. Determine

    i. the steady state amplitude of vibration,
    ii. the maximum shear force in the column,
    iii. the maximum bending moment.

    [14 marks]

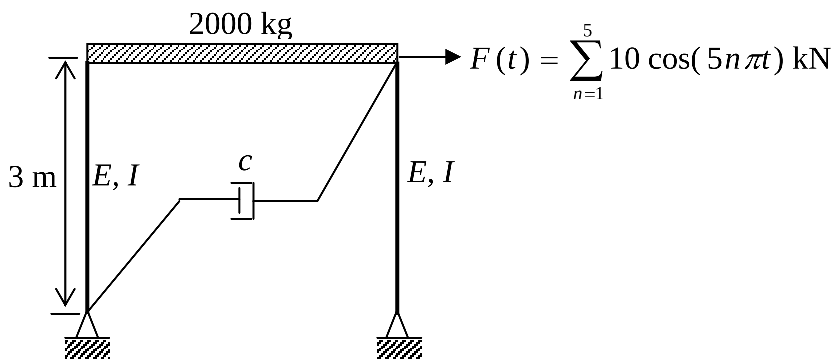

Figure 1

2. Figure 2 shows a reinforced concrete framed building subjected to earthquake ground motion. The floor is rigid with the mass of each floor is shown in the figure. Formulate the equation of motion for this building. Prove that the natural frequencies for modes 1, 2 and 3 are 5.664 rad/s, 15.512 rad/s and 21.462 rad/s, respectively, and solve the equation of motion in order to obtain the generalized mass, damping, stiffness and force. Use the stiffness of column, *k* = 200 kN/m and the damping coefficient, *c* = 10 kN.s/m.

[20 marks]

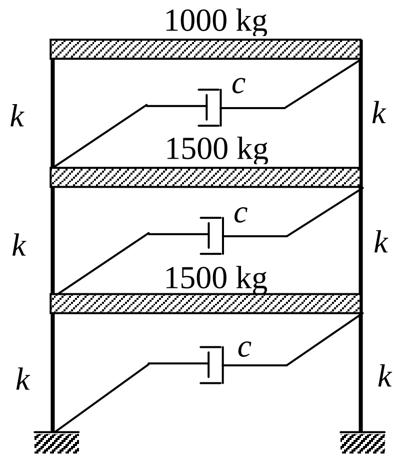

Figure 2

3. a) i. Formulate the equation of motion for the system shown in Figure 3. List **TWO (2)** assumptions made in this formulation.

[4 marks]

ii. Find the response of this system at *t* = 3s. The system is started with the displacement of 5 cm and velocity of 3 cm/s. Given *m* = 300 kg, *k* = 5 kN/m and *c* = 150 Ns/m. Sketch the displacement response time history.

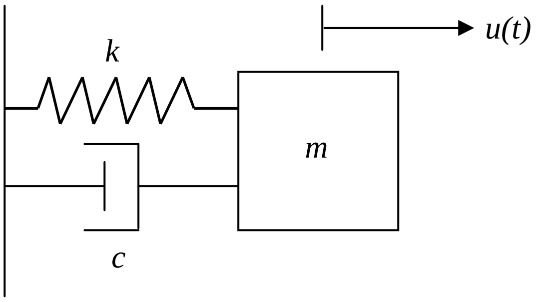

Figure 3

[6 marks]

4. a) Using Runge Kutta method, solve $y'' = y + xy'$, $y(0) = 1$, $y'(0) = 0$, to find $y\ (0.2)$ and $y'(0.2)$.

b) Determine the natural frequencies and modes of vibration of a system having mass and stiffness matrices as follows :

$$m = \begin{bmatrix} 3m & 0 \\ 0 & m \end{bmatrix} \text{ and } k = \frac{6EI}{7L^3}\begin{bmatrix} 8 & -3 \\ -3 & 2 \end{bmatrix}$$

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Question 2: a) A motor boat starts its motion with rest with initial position y=1. If the motion of the motor boat is given by $\frac{d^2y}{dt^2} = y + t\frac{dy}{dt}$, then using Runge Kutta method find its displacement and velocity at t=0.2.

b) Determine the natural frequencies and modes of vibration of a system having mass and stiffness matrices

as follows: $m = \begin{bmatrix} 3m & 0 \\ 0 & m \end{bmatrix}$ and k=$\frac{6EI}{7L^3}\begin{bmatrix} 8 & -3 \\ -3 & 2 \end{bmatrix}$.