UNIVERSITI SAINS MALAYSIA

1st. Semester Examination
2004/2005 Academic Session

October 2004

EAS 663/4 – Dynamics and Stability of Structures

Duration: 3 hours

Instructions to candidates:

1. Ensure that this paper contains **EIGHT (8)** printed pages, including appendices, before you start your examination.
2. This paper contains **FIVE (5)** questions. Answer **ALL (5)** questions.
3. All questions **MUST B** answered in English.
4. All questions **MUST BE** answered on a new sheet.
5. All questions carry equal marks.
6. Write the answered question numbers on the cover sheet of the answer script.

1. (a) List two characteristics that distinguish structural dynamic problems from static ones.

(4 marks)

(b) Define viscous damping. Sketch the displacement response, (v) versus (t) of undamped and damped SDOF systems for free vibration. Does the natural period of vibration, T, change with the present of damping?

(6 marks)

(c) Figure 1.0 shows a model of spring-mass SDOF system that is subjected to a harmonic excitation, p(t) = 50 cos 10t N. The weight of the mass block is 150 kN and the spring stiffness, k = 7000 N/m. Assume the damping of the system is equal to 5% of the critical damping. Determine the total displacement response of the system which is given by the following equation:

$$v(t) = V\cos(\Omega t - \alpha) + e^{-\zeta\omega t}(A_1\cos\omega_d t + A_2\sin\omega_d t)$$

$$V = \frac{v_r}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}}$$

where ω : natural circular frequency of the system and v_0 : static displacement due to p_o.

(10 marks)

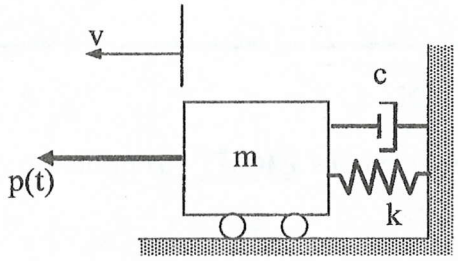

Figure 1.0

2. (a) Duhamel Integral is normally used for the evaluation of a linear SDOF system subjected to arbitrary time varying force. Define the underlined term with the help of a graph Force, (P) versus (t).

(5 marks)

(b) Figure 2.0 shows a spring-mass model for 2DOF system under free vibration. Derive the equations of motion for the system.

(5 marks)

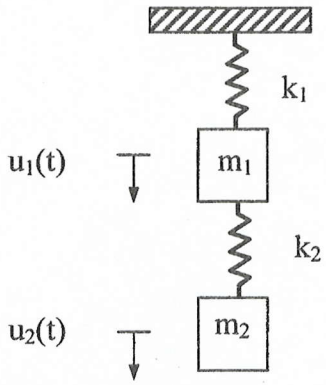

Figure 2.0 (a)

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(c) The water tower as shown in Figure 2.0 (b) weighs 700kN when filled with water is subjected to step force with rise time [Figure 2.0 (c)]. It is observed that a horizontal jack force of 30kN is required to displace the tower top by a distance of 20mm. Estimate the maximum lateral displacement response due to dynamic forces. The constant phase is given by the following equation:

$$v(t) = v_0\left\{1 + \frac{1}{\omega t_r}\left[A\sin\langle\omega(t - t_r) + \alpha\rangle\right]\right\}$$

$$A = \sqrt{(1 - \cos\omega t_r)^2 + (\sin\omega t_r)^2} \quad , \quad \tan\alpha = -\frac{\sin\omega t_r}{(1 - \cos\omega t_r)}$$

where ω : natural circular frequency of the system , v_0 : static displacement due to p_o , v_{max} : maximum response and T_n : natural period of vibration. A plot of $R_d (= v_{max} / v_0)$ versus t_r / T_n is shown in Figure 2.0 (d). Comment on the effect of ratio t_r / T_n on R_d , without carrying out any "exact" dynamic analysis.

(10 marks)

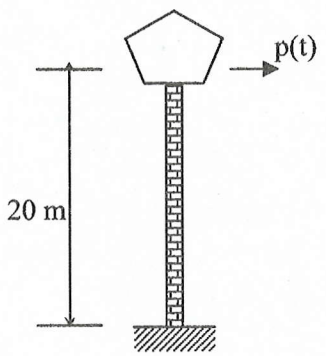

Figure 2.0 (b)

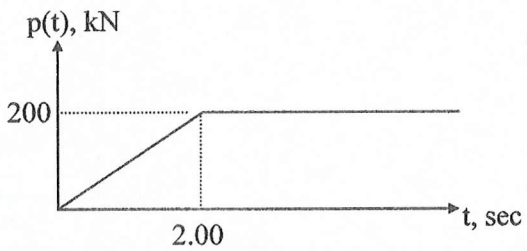

Figure 2.0 (c)

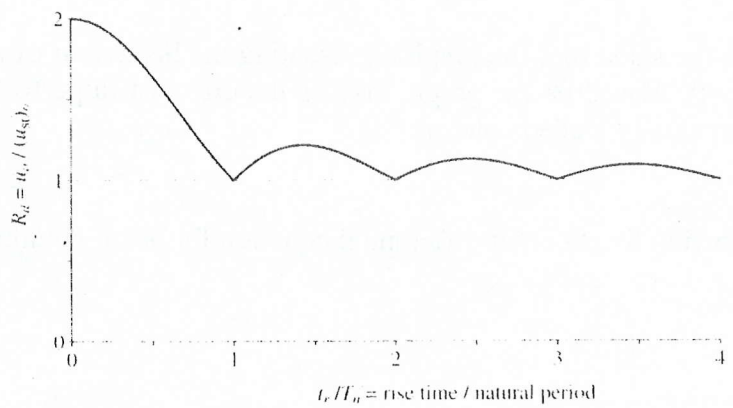

Figure 2.0 (d)