คณะวิศวกรรมศาสตร์
มหาวิทยาลัยสงขลานครินทร์

การสอบปลายภาค ประจำภาคการศึกษาที่ 1 ประจำปีการศึกษา 2546
วันศุกร์ที่ 3 ตุลาคม พ.ศ. 2546 เวลา 13.30-16.30 น.
วิชา 216-351 : การสั่นสะเทือนเชิงกล ห้อง R201

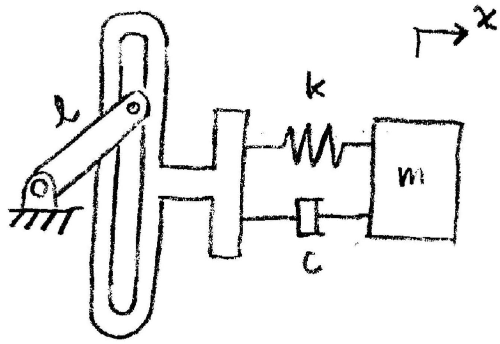
<u>คำสั่ง</u>

1. ข้อสอบมีทั้งหมด 5 ข้อ ให้ทำในสมุดคำตอบทุกข้อ และทุกข้อมีคะแนนเท่ากัน
2. อนุญาตให้ใช้เครื่องคิดเลขได้
3. ห้ามนำเอกสารใดใดเข้าห้องสอบ

ผศ.ดร. วรวุธ วิสุทธิ์เมธางกูร
ผู้ออกข้อสอบ

1. What is the maximum allowable stiffness of an isolator of damping ratio 0.05 that provides 81 percent isolation to a 40-kg printing press operating at 850 rpm?

2. A Scotch yoke mechanism provides a harmonic base excitation for the mass-spring-dash pot system as shown. The crank arm is 80 mm long. The speed of the crank is 1000 rpm. The mass of the system is 14.73 kg, the stiffness of the spring is 2.04×10^5 N/m and the coefficient of damping is 1420 N.s/m. Determine the amplitude of vibration of the mass.



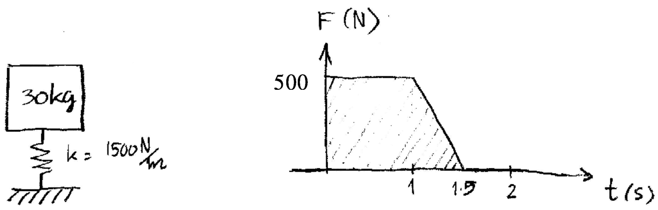
$l = 80$ mm

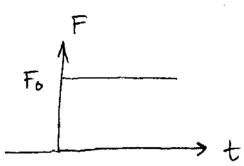
$k = 2.04 \times 10^5$ N/m

$C = 1420$ N.s/m

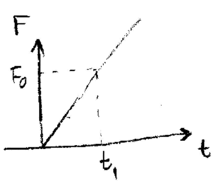
$m = 14.73$ kg

3. A machine tool of mass 30 kg is mounted on an undamped foundation of stiffness 1500 N/m. It is subject to the force shown. Determine the response of the system. The response of an undamped system to the step and ramp functions are as shown below.



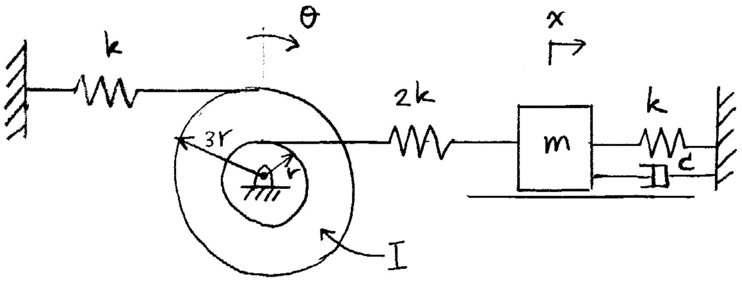


$$\Rightarrow \quad x(t) = \frac{F_0}{k}\left[1 - \cos \omega_n t\right]$$



$$\Rightarrow \quad x(t) = \frac{F_0}{k}\left(\frac{t}{t_1} - \frac{\sin \omega_n t}{\omega_n t_1}\right)$$

4. Determine the equations of motion of the system in the figure with x and θ as the unknown variables. Write the equations in matrix form.



5. The equations of motion of a system is

$$\begin{bmatrix} 3 & 0 \\ 0 & 2 \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} 30 & -15 \\ -15 & 10 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

Determine the natural frequencies and mode shapes of this system. And write the form of its general solution with constants from initial conditions left undetermined.

Given formula for all the problems:

Free vibration :

$$\ddot{x} + 2\xi\omega_n\dot{x} + \omega_n^2 x = 0$$

$$x(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

For $\xi = 0$: $x(t) = A_1 \sin\omega_n t + A_2 \cos\omega_n t$

For $\xi < 0$: $x(t) = e^{-\xi\omega_n t}\left[A_1 \sin\omega_d t + A_2 \cos\omega_d t\right]$

$$\omega_d = \sqrt{1-\xi^2}\,\omega_n$$

$$\ln\left(\frac{x_1}{x_{p+1}}\right) = \frac{2p\pi\xi}{\sqrt{1-\xi^2}}$$

For $\xi = 1$: $x(t) = e^{-\omega_n t}\left[x_0 + (\dot{x}_0 + \omega_n x_0)t\right]$

For $\xi > 1$: $x(t) = e^{\omega_n t}\left(A_1 e^{-\xi+\sqrt{\xi^2-1}} + A_2 e^{-\xi-\sqrt{\xi^2-1}}\right)$

Forced vibration :

$$\ddot{x} + 2\xi\omega_n\dot{x} + \omega_n^2 x = \frac{F_o \sin\omega_f t}{m_{eq}}$$

$$X = \frac{\left(F_o / m_{eq}\right)/\omega_n^2}{\sqrt{\left[1-\left(\omega_f/\omega_n\right)^2\right]^2 + \left(2\xi\frac{\omega_f}{\omega_n}\right)^2}}$$

$$\tan\phi = \frac{2\xi\frac{\omega_f}{\omega_n}}{1-\left(\omega_f/\omega_n\right)^2}$$

Rotating Unbalance :

$$\ddot{x} + 2\xi\omega_n\dot{x} + \omega_n^2 x = \frac{m_u e\,\omega^2}{m}\sin\omega t$$

$$\frac{mX}{m_u e} = \frac{(\omega/\omega_n)^2}{\sqrt{\left[1-\left(\omega/\omega_n\right)^2\right]^2 + \left(2\xi\frac{\omega}{\omega_n}\right)^2}}$$

$$\tan\phi = \frac{2\xi\frac{\omega}{\omega_n}}{1-\left(\omega/\omega_n\right)^2}$$

Vibration Isolation

$$TR = \sqrt{\frac{1 + (2\xi r)^2}{(1 - r^2)^2 + (2\xi r)^2}}$$

Response to General Function

$$x(t) = \int_0^t F(\tau)h(t-\tau)d\tau = \int_0^t F(t-\tau)h(\tau)d\tau$$

$$h(t) = \frac{1}{m\omega_d}e^{-\xi\omega_n t}\sin(\omega_d t)$$

Lagrange's Equation

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{x}_i}\right) - \frac{\partial L}{\partial x_i} = Q_i$$

$$\delta W = \sum Q_i \delta x_i$$

Equation of Motion

$$[M]\{\ddot{x}\} + [C]\{\dot{x}\} + [K]\{x\} = \{F\}$$

System Characteristic Equation

$$det([M]^{-1}[K] - \omega^2[I]) = 0$$