คณะวิศวกรรมศาสตร์
มหาวิทยาลัยสงขลานครินทร์

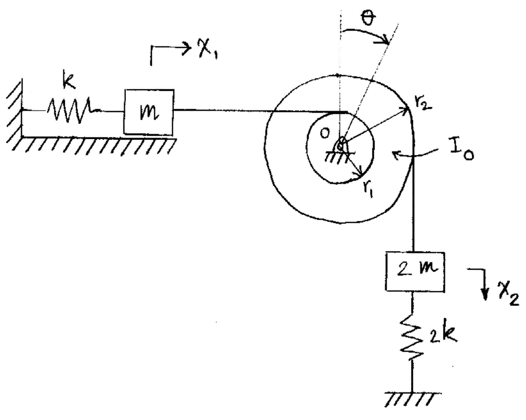
การสอบกลางภาค ประจำภาคการศึกษาที่ 1 ประจำปีการศึกษา 2546
วันพุธที่ 30 กรกฎาคม พ.ศ. 2546 เวลา 13.30-16.30 น.
วิชา 216-351 : การสั่นสะเทือนเชิงกล ห้อง A400

คำสั่ง

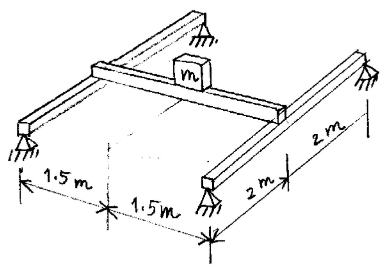
1. ข้อสอบมีทั้งหมด 5 ข้อ ให้ทำในสมุดคำตอบทุกข้อ และทุกข้อมีคะแนนเท่ากัน
2. อนุญาตให้ใช้เครื่องคิดเลขได้
3. ห้ามนำเอกสารทุกชนิดเข้าห้องสอบ

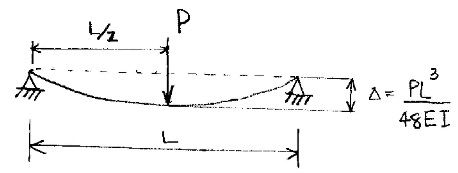
ผศ.ดร. วรวุธ วิสุทธิ์เมธางกูร
ผู้ออกข้อสอบ

1. Use energy method to determine the equation of motion of the system shown, in terms of θ. Also find the natural circular frequency, ω_n .

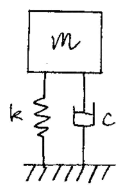


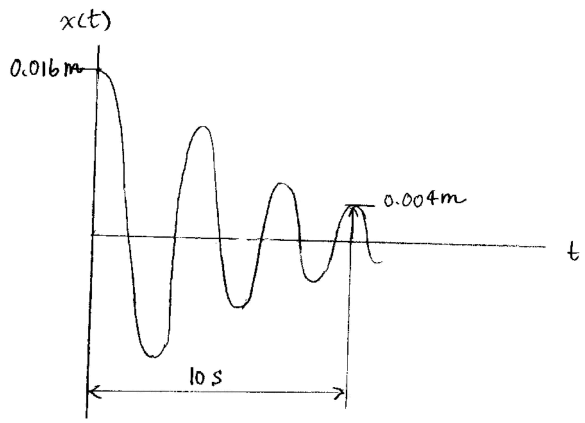
2. Compute the equivalent spring stiffness of the system shown. Given the properties of all three beams are E = 30×10^6 N/m^2 and I = 2.6×10^{-4} m^4. And if the mass m = 200 kg, what is the frequency of free vibration of this system?



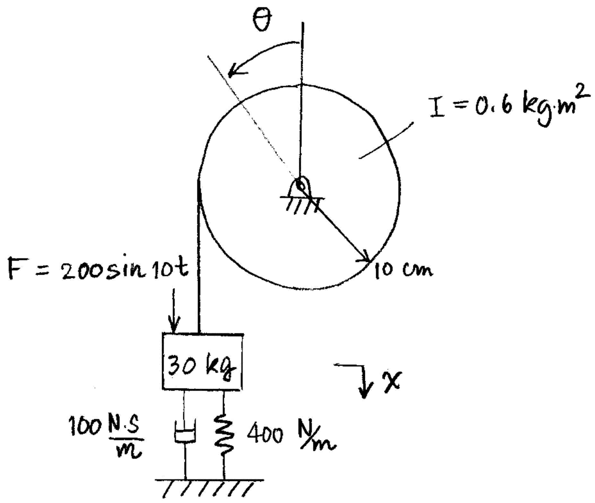


3. The simple mass-spring-damper system shown has the response after initial displacement of 0.016 m and let go as the graph shown the right. Determine the stiffness of the spring and the damping coefficient of the damper, if m = 200kg.

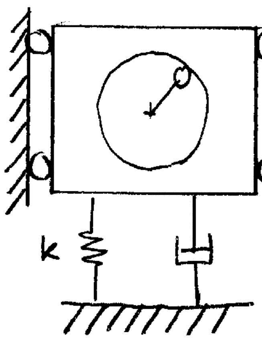




4. In the system shown determine the equation of motion in terms of x, and compute the steady state amplitude of the motion of the 30 kg mass.



5. A machine is mounted on a spring of stiffness k = 1×10^9 N/m, and has mass m = 200 kg, as shown. Assume the damping ratio is 0.3. The rotor of this machine has an unbalance of 0.5 kg-m, and it is operated at 1000 rpm. Determine the steady state vertical vibration of this machine.



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 :

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

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

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