คณะวิศวกรรมศาสตร์
มหาวิทยาลัยสงขลานครินทร์

การสอบกลางภาค ประจำภาคการศึกษาที่ 1 ประจำปีการศึกษา 2545
วันพุธที่ 31 กรกฎาคม พ.ศ. 2545 เวลา 13.30-16.30 น.
วิชา 216-351 : การสั่นสะเทือนเชิงกล ห้อง R300

คำสั่ง

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

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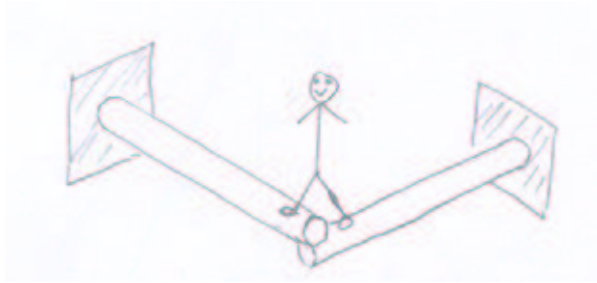
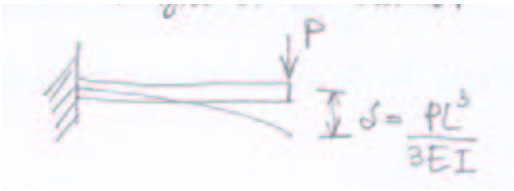
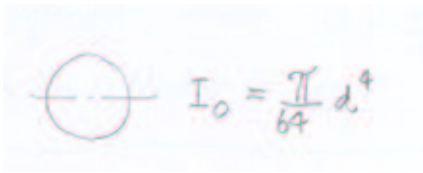
ผู้ออกข้อสอบ

1. Two cantilever beams made of steel shaft (E = 200×10^9 N/m^2) of the same size with the length of 3 m. The free end of one beam is on top of the free end of the other beam as shown. If a man weighing 80 kg stands on the free ends of the beams and feels the period of vibration to be 2 seconds, determine the diameter of the beams, neglecting the weight of the beams.





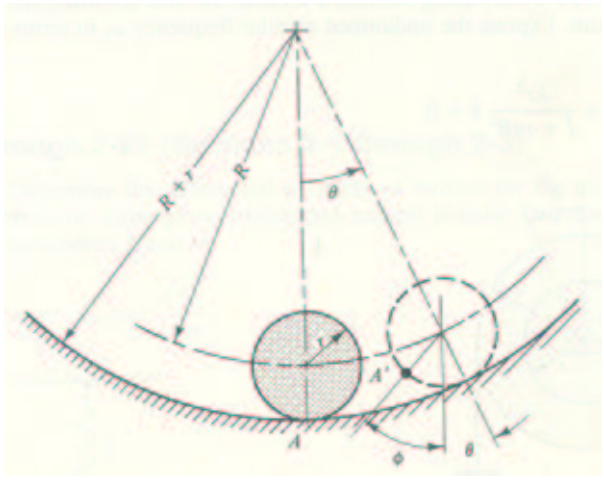


2. A cylinder of mass m and radius r rolls without slipping on a cylinderical surface as shown. For small angle of θ, determine

   (a) the differential equation of motion using energy method,

   (b) the natural frequency f_n in terms of the parameters.

Note that the point A on the cylinder moves to A', and the angle Φ is the absolute angular displacement of the cylinder, which $\phi = \frac{R}{r}\theta$. The centroidal mass moment of inertia I of the cylinder is $\frac{mr^2}{2}$.

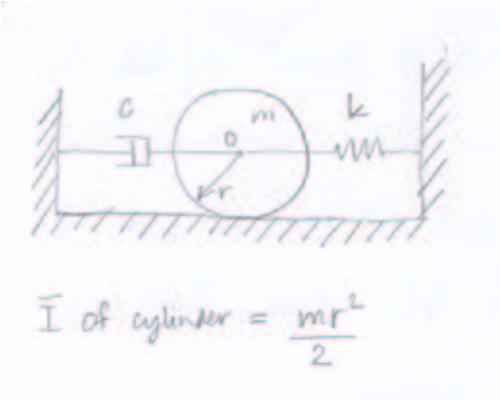


3. In the system shown, the cylinder rolls without slipping on the floor, back and forth after initial displacement from equilibrium position. Determine, in terms of the given parameters,

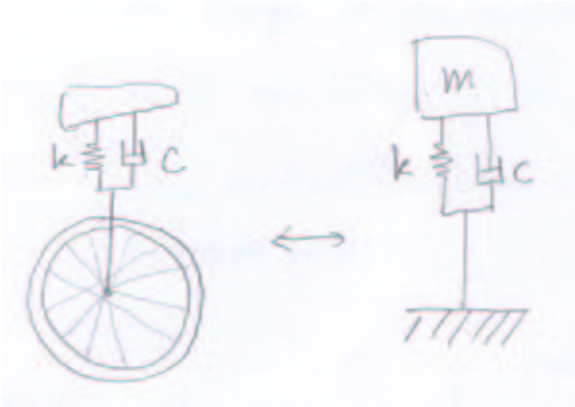
   (a) the differential equation of motion

   (b) critical damping c_c of this system

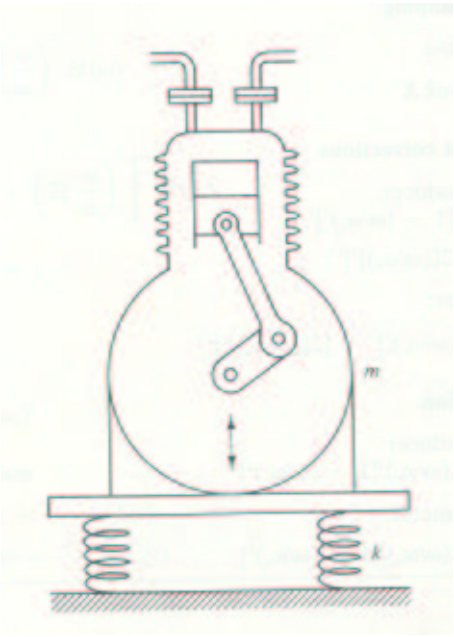
   (c) the frequency of this motion, ω_d .



4. A designer wants to design a spring-damper shock absorbing system for his unicycle. The unicycle and its simplified model neglecting the mass of the unicycle are as shown. If the mass of the rider is 65 kg, and he designs to allow for 10% overshoot, and also wants the amplitude to reduce to 1% after 2 seconds, what are the values of the stiffness *k* and damping coefficient *c* he needs? (Hint : the ratio of two adjacent amplitudes are constant.)



5. A refrigeration compressor is mounted on four springs of stiffness k = 200 N/m each, and has mass m = 55 kg, as shown. The mounts are made of spring steel with very low damping. Due to the design of the compressor, there is a vertical harmonic force of 12 N oscillating at the operating frequency of 1750 rpm. Determine the steady state vertical vibration of the compressor.



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

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

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

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 :

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

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

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