UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCEINCE AND ENGINEERING

FINAL EXAMINATION, DECEMBER 2001

Second Year – Program 3

MIE200F – DYNAMICS

Exam Type: C

Examiner – A.N. Sinclair

Answer all five questions.

All types of calculators are permitted in this examination.

Each student is permitted a single 8 ½ x 11 inch aid sheet.

All answers must include very **CLEAR, NEAT** rough work.

Use a very **DARK, BLACK** pencil or a pen.

Final answers must include the appropriate S.I. units (meter, second, kg, Newton, etc.).

Vectors must include the appropriate direction, in the coordinate system specified in the question.

Useful formulas for moments of inertia:

$I_{c\ of\ g}$ for a rod = $m\ L^2/12$

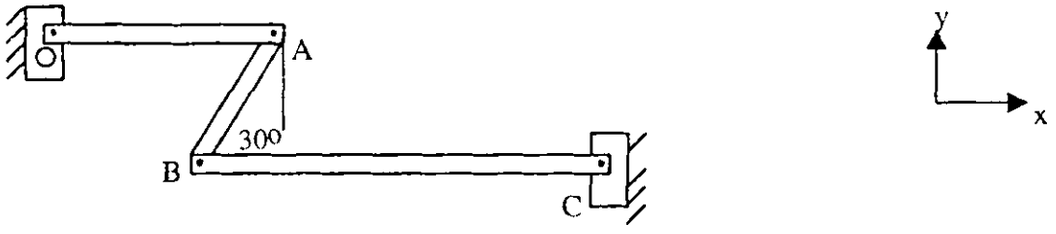
$I_{c\ of\ g}$ for a uniform disk = $m\ R^2/2$

1. Three bars are pinned together. OA has length 5 meters; AB has length 3 meters, and BC has length 10 meters. At the instant shown bar OA has $\omega = 4\ s^{-1}$ counterclockwise, and $\alpha = 6\ s^{-2}$ counterclockwise. (15)

(a) At the instant shown, find the acceleration of point "A" in x-y coordinates.

(b) At the instant shown, find the angular velocity ω of bar "AB".

(c) At the instant shown, find the angular acceleration α of bar "AB".



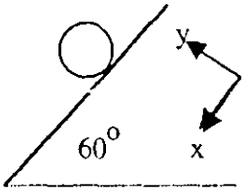
2. A 5-kg cylinder with radius R = 2 meters, and radius of gyration equal to 1.7 meters is on a steep hill as shown. The velocity of the center of gravity of the cylinder at the instant shown in the diagram is $\vec{v}_{c\ of\ g} = 3$ m/s $\hat{i}$. Coefficients of friction are $\mu_s = 0.90$ and $\mu_k = 0.30$. (20)

(a) Find the magnitude and direction of the frictional force exerted by the ground on the cylinder, if the cylinder is rolling down the hill ***without*** *slipping*.

(b) Find the kinetic energy of the cylinder assuming that it is rolling ***without*** *slipping*

(c) Find the angular acceleration of the disk assuming that it is ***slipping*** (skidding).

$g = 9.81\ m/s^2 \downarrow$

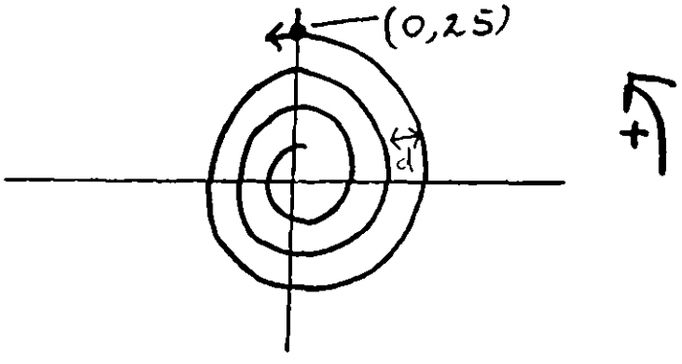


3. Dorothy is walking along a yellow brick road that is in the shape of a spiral, indicated by the black line in the accompanying diagram. The distance d between adjacent arms of the spiral is 5 m. Her speed is constant at 2 m/s. At the instant shown in the diagram, she is at the position (x, y) = (0, 25 meters), walking in the direction indicated by the arrow. (10)

(a) At the instant shown in the diagram, determine $\dot{r}$.

(b) At the instant shown in the diagram, determine the tangential component of her acceleration.

(c) At the instant shown in the diagram, is the value of $\ddot{\theta}$ positive, negative, or zero? You must CLEARLY justify your answer, either with mathematics or a logical argument, to earn any credit for this question.



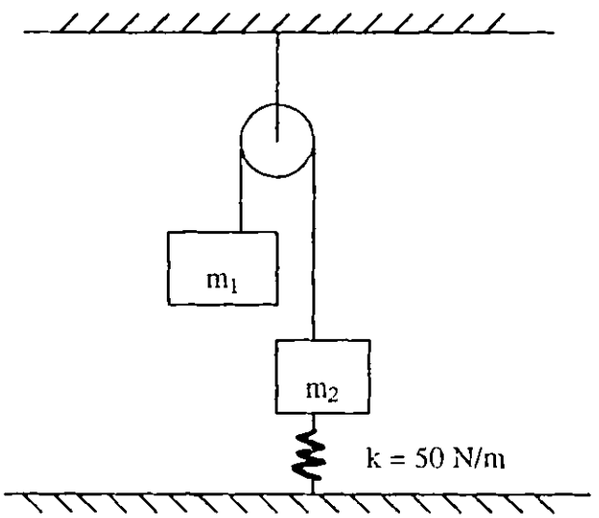
4. Two blocks are suspended from the ceiling by a rope and pulley as shown. Block m_1 is 25 kg, and m_2 is 10 kg. A spring with stiffness k = 50 N/m links m_2 to the floor, as shown in the diagram. At time t = 0, block m_1 is descending at 7 m/s, and the spring is stretched by 3 meters beyond its relaxed length..

(15)

(a) Find the acceleration of the block m_1 at time t = 0.

(b) Find the speed of block m_2 when it has traveled upwards 2 meters.

$g = 9.81\ m/s^2 \downarrow$



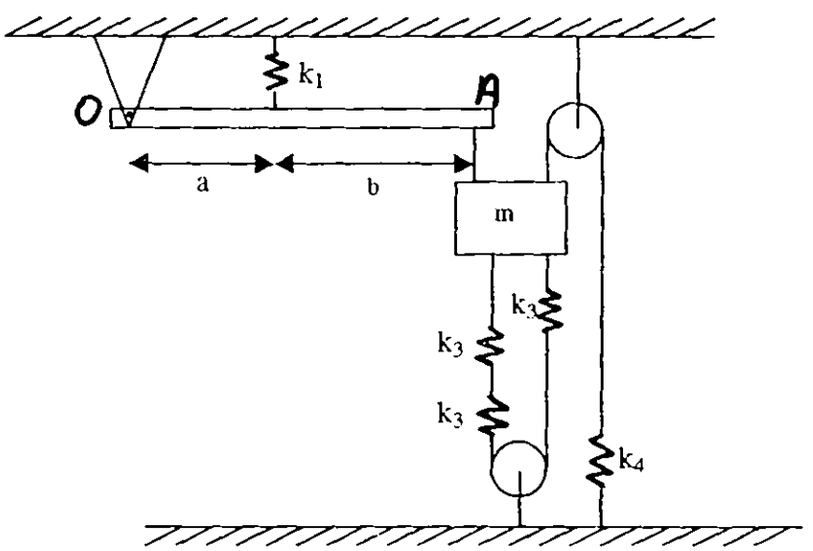
5. A block of mass m is suspended by systems of springs, pulleys, and a massless bar OA which is pinned at point "O". Assume that all springs remain stretched at all times, and that the mass moves along a vertical line without rotation.

(10)

(a) Find the natural frequency of oscillation ω_n, in terms of k_1, k_3, k_4, m, a, and b.

(b) Suppose that an earthquake causes the ceiling and floor to shake such that their displacements $\delta(t)$ from their normal elevations are given by: $\delta(t) = 0.02 \sin(\omega t)$ meters, where, $\omega = 3\omega_n$. Find the peak-to-peak amplitude of oscillation of the mass.

$g = 9.81\ m/s^2 \downarrow$



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