

Université d'Ottawa
Faculté de génie

Département de
Génie Mécanique



uOttawa

L'Université canadienne
Canada's university

University of Ottawa
Faculty of Engineering

Department of
Mechanical Engineering

MCG 2108 Mechanics II

FINAL EXAMINATION

Length of Examination: 3 hours

December 13, 2009

Professor: Natalie Baddour

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Family Name: _____

Other Names: _____

Student Number: _____

Signature _____

Closed book.

If you do not understand a question, clearly state an assumption and proceed.

Only non-programmable calculators are allowed.

Marks are given for diagrams, so draw clear diagrams!

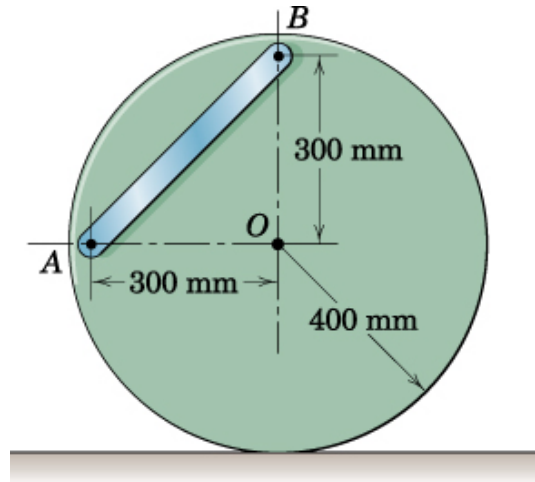
There are SIX questions. All questions carry equal weight.

At the end of the exam, when time is up:

- Stop working and turn your exam upside down.
- Remain silent.
- Do not move or speak until all exams have been picked up, and a TA or the Professor gives the go-ahead to leave.

Question 1

The 45-kg uniform circular disk with its attached 9-kg slender bar is released from rest in the position shown and rolls without slipping on the horizontal surface. Calculate the velocity v_0 of the center O when the mass center of the bar is directly below the center O of the disk.

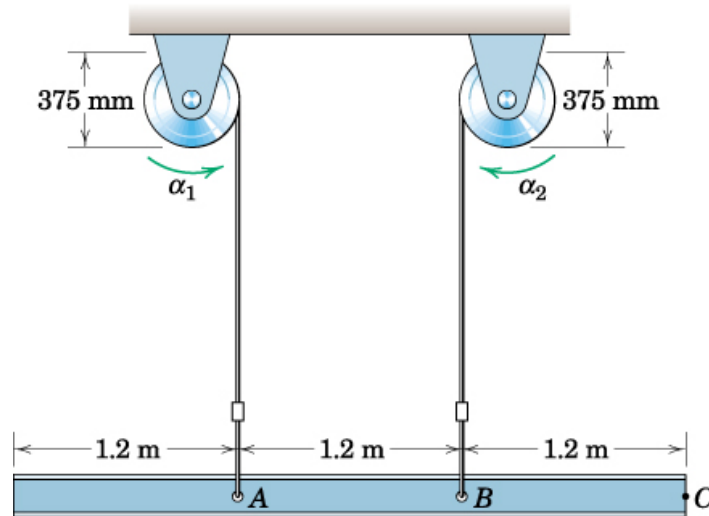


Answer:

$$\underline{v_0 = 0.954 \text{ m/s}}$$

Question 2

The 3.6-m steel beam has a mass of 125-kg and is hoisted from rest where the tension in each of the cables is 613 N. If the hoisting drums are given initial angular accelerations $\alpha_1 = 4 \text{ rad/s}^2$ and $\alpha_2 = 6 \text{ rad/s}^2$, calculate the corresponding tensions T_A and T_B in the cables. The beam may be treated as a slender bar.



Answer

$$\underline{T_A = 637 \text{ N}, T_B = 707 \text{ N}}$$

Question 3

The phenomenon of vehicle “tripping” is investigated here. The mass of the SUV is 2300-kg and its mass moment of inertia through its mass centre G is $900 \text{ kg} \cdot \text{m}^2$. The sport-utility vehicle is sliding sideways with speed v_1 and no angular velocity when it strikes a small curb. Assume no rebound of the right-side tires when it strikes the curb.

- Find the angular velocity (in terms of v_1) of the SUV after it hits the curb.
- Find the minimum speed v_1 which will bring the vehicle to the brink of rolling over.

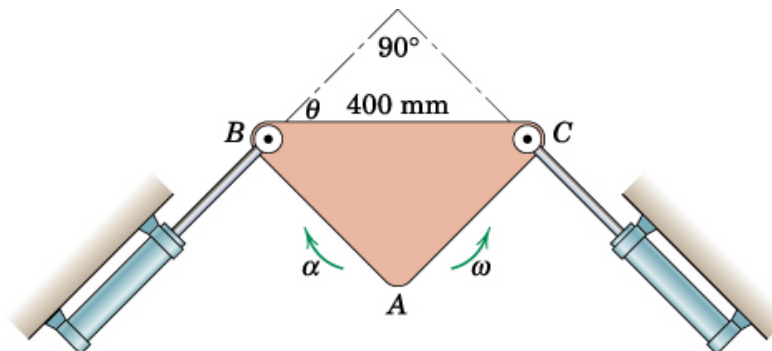


Answer :

$$\omega_2 = 0.436 v_1 \quad \underline{v_1 = 4.88 \text{ m/s}} \quad (\text{not very fast!})$$

Question 4

At the instant shown $\theta = 45^\circ$ and the triangular plate ABC has a counterclockwise angular velocity 20 rad/s and a clockwise angular acceleration of 100 rad/s^2 . Determine the magnitudes of the corresponding velocity and acceleration of the piston rod of the hydraulic cylinder attached to C .



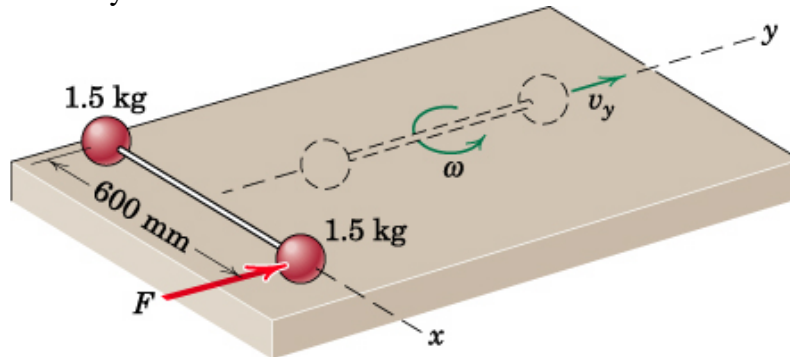
Answers

$$v = v_c = \frac{8}{\sqrt{2}} \quad \alpha = \frac{160}{\sqrt{2}} - \frac{40}{\sqrt{2}}$$

$$= \underline{5.66 \text{ m/s}} \quad = \underline{84.9 \text{ m/s}^2}$$

Question 5

Two spheres are rigidly connected to the rod of negligible mass and are initially at rest on the smooth horizontal surface. A force F is suddenly applied to one sphere in the y direction and imparts an impulse of 10-Ns during a negligibly short period of time. As the spheres pass the dashed position shown in the diagram, calculate the velocity of each one.



Answer :

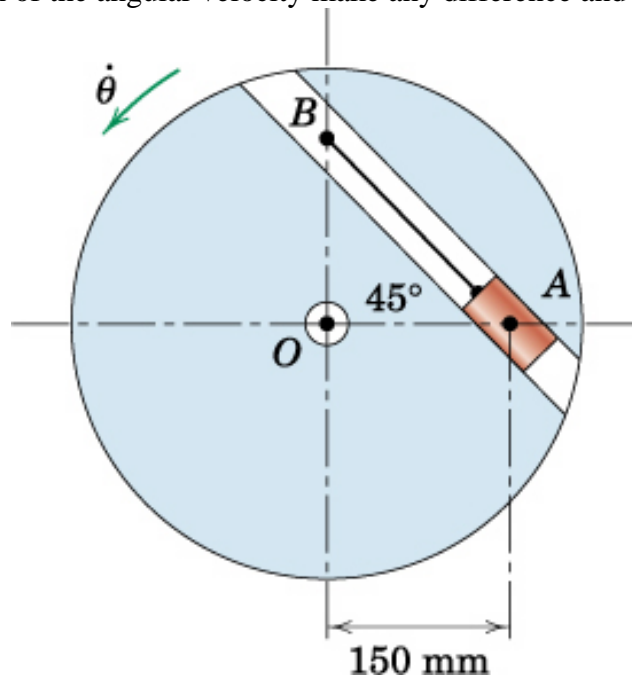
$$v_y = 3.33 \text{ m/s} \quad v_x = 3.33 \text{ m/s}$$

$$v = 3.33\sqrt{2} = 4.71 \text{ m/s both spheres}$$

Question 6

The 3-kg slider A fits loosely in the smooth 45° slot in the disk, which rotates in a horizontal plane about its center O . If A is held in position by a cord secured to point B ,

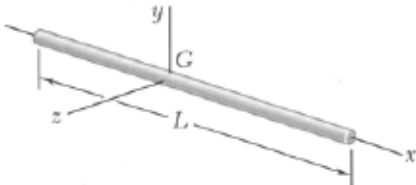
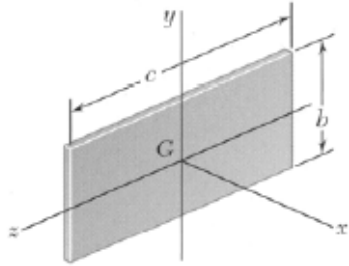
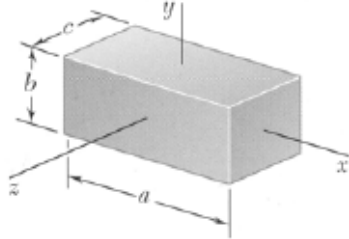
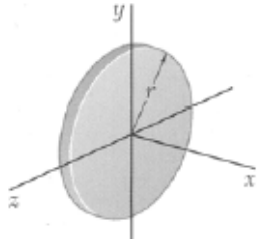
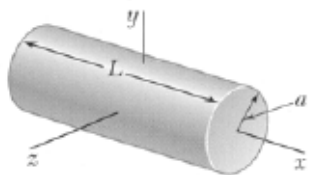

- Determine the tension T in the cord for the constant rotational velocity $\dot{\theta} = 300 \text{ rpm}$.
- Would the direction of the angular velocity make any difference and why?



Answer :

$T=314 \text{ N}$ Direction of rotation does not change acceleration hence has no influence on T .

**Mass Moments of Inertia of
Common Geometric Shapes**

<p>Slender rod</p> $I_y = I_z = \frac{1}{12}mL^2$	
<p>Thin rectangular plate</p> $I_x = \frac{1}{12}m(b^2 + c^2)$ $I_y = \frac{1}{12}mc^2$ $I_z = \frac{1}{12}mb^2$	
<p>Rectangular prism</p> $I_x = \frac{1}{12}m(b^2 + c^2)$ $I_y = \frac{1}{12}m(c^2 + a^2)$ $I_z = \frac{1}{12}m(a^2 + b^2)$	
<p>Thin disk</p> $I_x = \frac{1}{2}mr^2$ $I_y = I_z = \frac{1}{4}mr^2$	
<p>Circular cylinder</p> $I_x = \frac{1}{2}ma^2$ $I_y = I_z = \frac{1}{12}m(3a^2 + L^2)$	
<p>Circular cone</p> $I_x = \frac{3}{10}ma^2$ $I_y = I_z = \frac{3}{8}m(\frac{1}{4}a^2 + h^2)$	
<p>Sphere</p> $I_x = I_y = I_z = \frac{2}{5}ma^2$	