University of Toronto

Faculty of Applied Science and Engineering

Department of Mechanical and Industrial Engineering

FINAL EXAMINATION

May 01, 2009 2:00pm

Exam Duration: 2.5 hours

First Year – Mechanical and Industrial Engineering

MIE100 – Dynamics

Calculator Type: 3

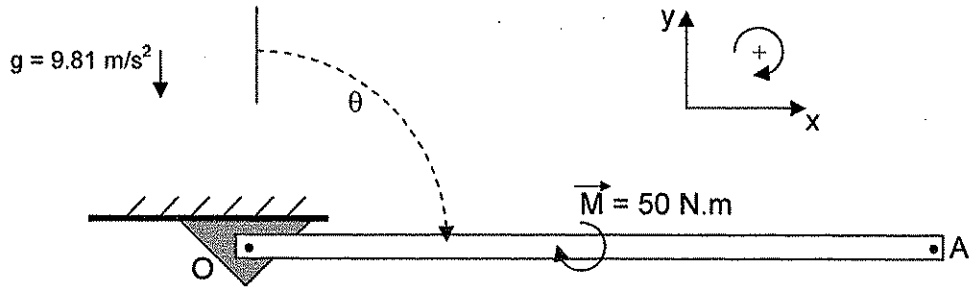
Exam Type: C

Examiners: R. Ben Mrad, C. A. Simmons, A. N. Sinclair, L. A. Sinclair

ANSWER ALL FIVE QUESTIONS
(100 MARKS TOTAL)

1. The slender uniform bar OA of length 3 meters and mass 7 kg is pinned to the ceiling at point "O". The angle θ is measured with respect to the vertical as shown in the diagram. There is no friction. In addition to the force of gravity, there is a constant external torque of $\vec{M}$ = 50 N·m applied to the center of the bar in the positive direction as shown. At the instant shown in the diagram, θ is 90°, and the velocity of point "A" is -2$\hat{j}$ m/s.

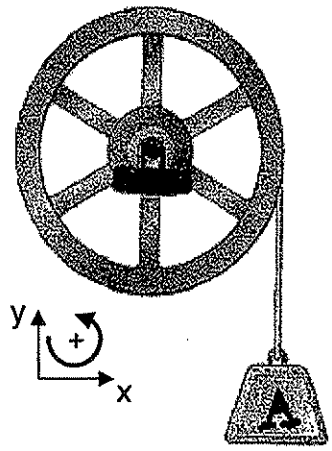
   (a) Find the angular acceleration α of the bar at the position shown in the diagram. [5 marks]
   (b) Find the velocity of the center of gravity of the bar in x-y coordinates when θ first reaches 180°.[10 marks]
   (c) Find the acceleration of point "A" in x-y coordinates when θ first reaches 180°. [10 marks]



2. The flywheel shown has a radius of 0.5 m, a radius of gyration of 0.3 m, and a mass of 100 kg. The flywheel is pinned at its centre. The 25 kg block A is attached to a wire wrapped around the flywheel. At the instant shown, the block is traveling up at a velocity of 7.5$\hat{j}$ m/s. The acceleration of A is constant and is equal to 5$\hat{j}$ m/s².

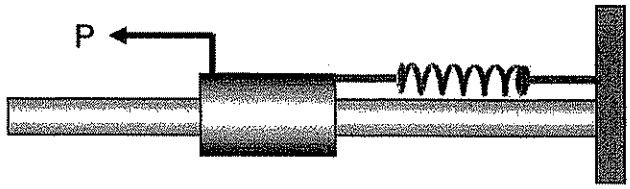
   (a) Find the velocity of block A once it has moved up 0.5 m. [10 marks]
   (b) Find the average torque exerted by the motor driving the flywheel as block A moves 0.5 m up from its position at the instant shown. [10 marks]

   Assume the wire is sufficiently long such that the block A does not touch the flywheel as it travels upward.



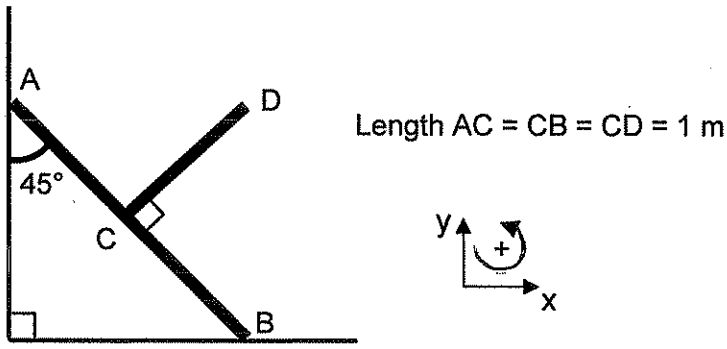
3. A 4 kg collar slides without friction on a horizontal rod. The collar is attached to a linear spring with spring constant 450 N/m. An external force P = (13 sin 5t) N acts on the mass.

   Find the amplitude of the resulting motion and indicate whether it is in phase or out of phase with the forcing function. [10 marks]

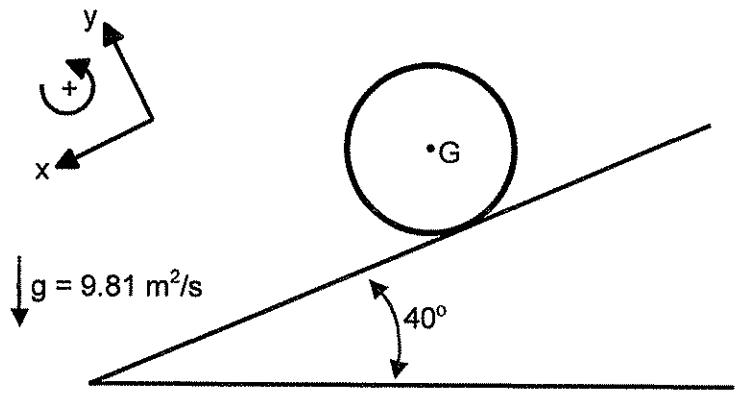


4. At the instant shown in the figure, point B on the T-shaped bar has a velocity of $1\hat{\imath}$ m/s and an acceleration of $2\hat{\imath}$ m/s^2.

   (a) Find the velocity of point D in x-y coordinates. [5 marks]
   (b) Find the angular velocity of the T-shaped bar. [6 marks]
   (c) Find the angular acceleration of the T-shaped bar. [7 marks]
   (d) Find the acceleration of point D in x-y coordinates. [7 marks]



5. A uniform circular disk with radius 0.5 m and mass 10 kg is released from rest on the incline shown. Find its angular velocity after G has moved 0.75 meters. [20 marks]



$\mu_s = 0.25$

$\mu_k = 0.20$