University of Toronto

Faculty of Applied Science and Engineering

MIE100 – Dynamics

Final Examination

April 18, 2011, 2:00pm to 4:30pm

Instructors: *J. Postma, C. Simmons, A. Sinclair and L. Sinclair*

Aids Permitted: One non-programmable calculator
One 8 1/2" by 11" sheet of paper, any colour, with any writing on both sides

Do all work in the answer booklet
This exam has six pages

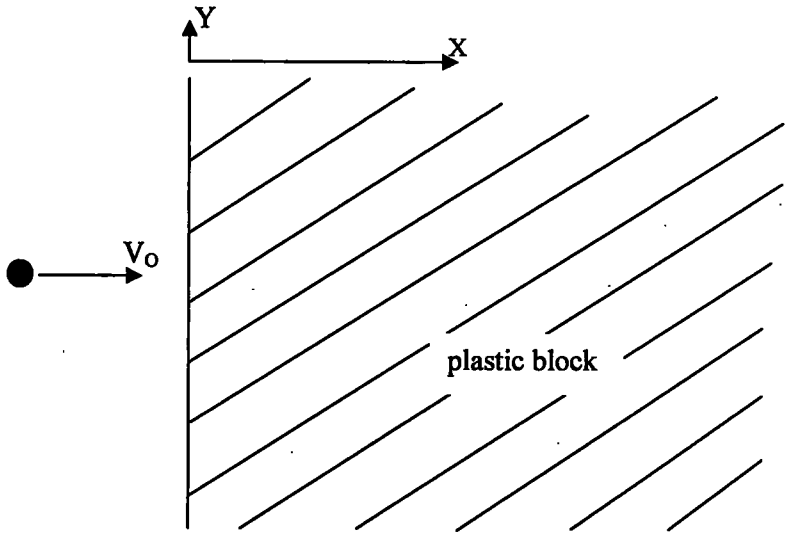
Complete all five questions

Total Marks: 100

1(a). A projectile enters a plastic block at $x = 0$ with an initial speed $v_o = 270$ m/s and travels 100 mm before coming to rest. Assume that the speed of the projectile is defined by the relation $v = v_o - Kx$, where v is expressed in m/s, x is in meters, and K is a constant.

(10) Find the initial acceleration of the projectile, just as it enters the plastic block.

Figure 1a

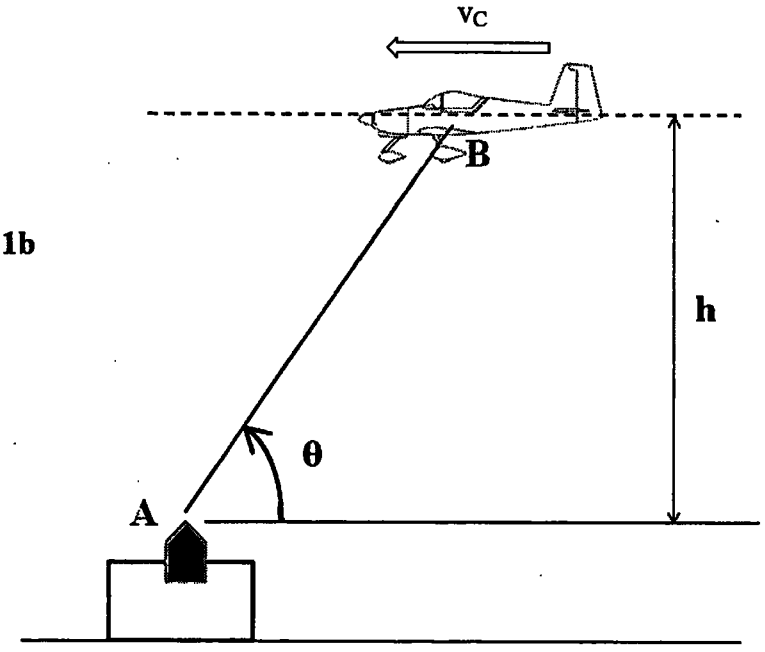


1(b). The flight path of airplane B is a horizontal straight line that passes directly over a radar tracking station at A. Knowing that the airplane moves to the left with a constant speed v_C, determine $d\theta/dt$ in terms of v_C, h and θ.

(10)

20 marks

Figure 1b



2. A wheel on a 40° degree ramp is released from rest. The wheel has mass m = 5.00 kg, radius R = 1.00 m, and radius of gyration, k_G = 0.800 m. The static and kinetic coefficients of friction between the wheel and ramp are μ_s = 0.300 and μ_k = 0.280, respectively. Use the rectangular coordinates aligned with the ramp as shown.

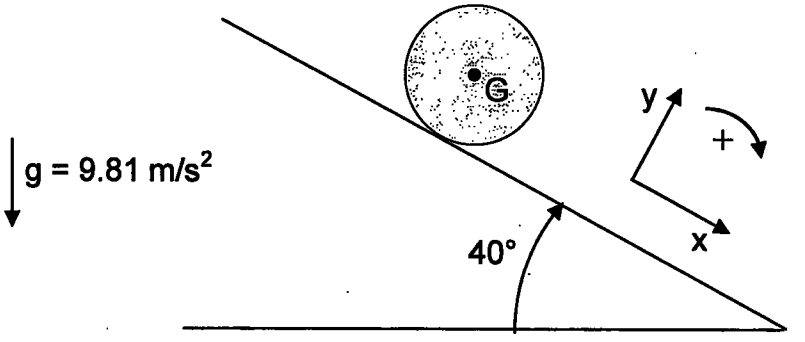


Figure 2

(10) (a) Show that the wheel slips as it rotates.

(5) (b) Determine α, the angular acceleration of the wheel.

(5) (c) Determine $\vec{a}_G$, the acceleration of the centre of mass of the wheel.

20 marks

3. The oil pumping rig is driven by wheel OA which has radius R = 0.750 m and rotates about a fixed axis at point O. Link AB is 2.50 m long. The distance from B to the fixed axis at C is also 2.50 m. At the instant shown, wheel OA has angular velocity ω_{OA} = -1.00 rad/s and angular acceleration α_{OA} = - 0.500 rad/s^2.

(4) (a) Determine the angular velocity of link AB, ω_{AB}, at the instant shown.

(4) (b) Determine the angular velocity of rod BCD, ω_{BCD}, at the instant shown.

(4) (c) Determine the acceleration of point A, $\vec{a}_A$, at the instant shown. Express your answer in the given x-y coordinate system.

(8) (d) Determine the angular acceleration of rod BCD, α_{BCD}, at the instant shown.

20 marks

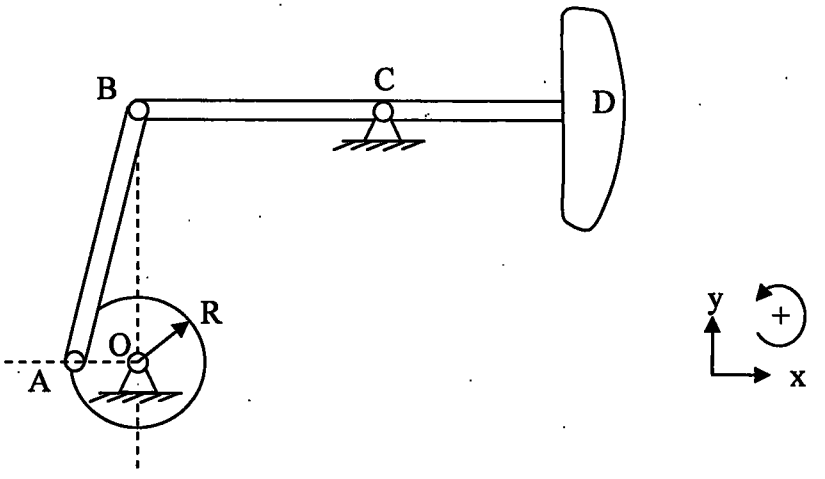


Figure 3

4. ABC is a slender, uniform rod of length 10.0 meters and mass 15.0 kg. It is pinned at point B. At the instant shown in the diagram where $\theta = 90^o$, the velocity of point C is $-12.0\,\hat{\jmath}\ m/s$.

(8) (a) Find the acceleration of point C in x-y coordinates at the instant shown.

(4) (b) Find the angular momentum about point B of the rod at the instant shown.

(8) (c) Find the velocity of point C when the bar first reaches a vertical position, where $\theta = 180^o$.

20 marks

Note: The pinned bar rotates without friction.

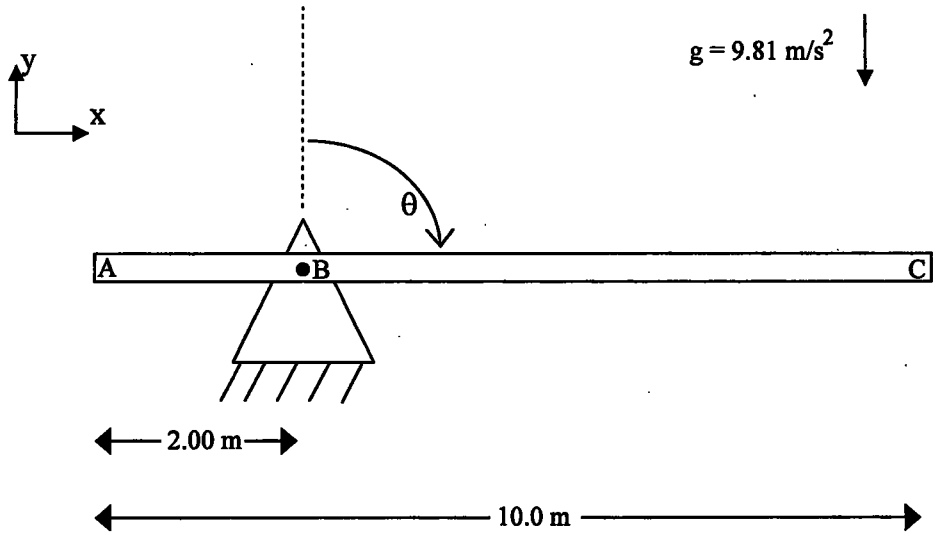


Figure 4

5. A mass is assembled with two springs and one damper as shown. A force $\vec{P} = 45.0\,\hat{j}$ N has been applied to the mass such that a static equilibrium has been reached. It is this static equilibrium position that is shown in the diagram. Neglect any rotational motion of the mass.

(3) (a) How far are the two springs stretched beyond their relaxed length in the position shown? (Both springs have the same relaxed length.)

At time t=0, the force $\vec{P}$ is removed.

(3) (b) Draw a Free Body Diagram of the mass just after $\vec{P}$ has been removed. Indicate the numerical magnitudes and proper directions of all forces on the Free Body Diagram.

(3) (c) Find the undamped natural frequency of the system, ω_n.

(3) (d) Find the damping ratio of the system, c/c_c.

(3) (e) Find the damped frequency of the system, ω_d.

(5) (f) After the force $\vec{P}$ is removed at time t=0, find the maximum displacement of the mass relative to y = 0 as indicated on the diagram.

20 marks

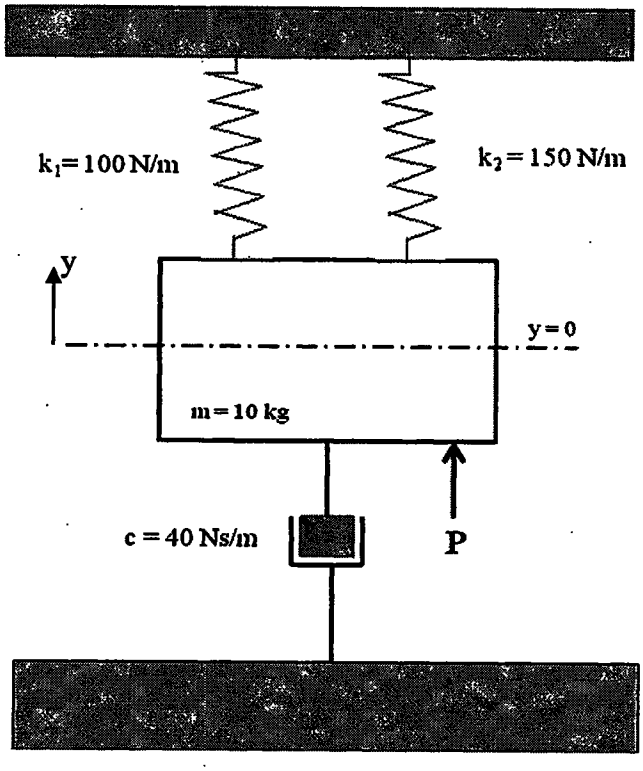


Figure 5