SJPO Training
Circular & Angular Motion Problem Set

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May 7, 2016

1 General Round

1.1 Centripetal Force

1. A particle moves at a constant speed in a circular path with a radius of 2.06 cm. If the particle makes four revolutions each second, what is the magnitude of its acceleration?

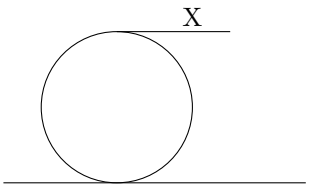
2. A carnival Ferris wheel has a 15 m radius and completes five turns about its horizontal axis every minute. What is the acceleration of the passenger at his lowest point during the ride?

3. A tether ball is on a 2.1 m string which makes an angle of 22° with the vertical as it moves around the pole in a horizontal plane. If the mass of the ball is 1.3 kg, what is the ball's speed?

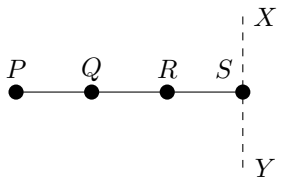
4. A tractor moving forward at uniform speed on horizontal ground has a front wheel diameter of 0.8 m and back wheel diameter of 1.25 m. The horizontal distance between the axles of the two wheels is 2 m. During a trip a pebble stuck to the front wheel flew off the wheel at the highest point. 0.2 s later, another pebble flew off the back wheel at its highest point too. The two pebbles landed on the same spot on the ground. Find the speed of the tractor.

1.2 Position-dependent Quantities

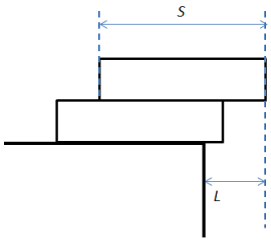
1. A large spool of rope lies on the ground, as shown in the diagram below. The end, labelled X, is pulled a distance S in the horizontal direction. The spool rolls without slipping. In terms of S, determine the distance the spool's center of mass moves.



2. $PQRS$ is a light, rigid rod with masses attached to it as shown in the diagram, where $PQ = QR = RS = l$. Determine the moment of inertia of the system about XY.

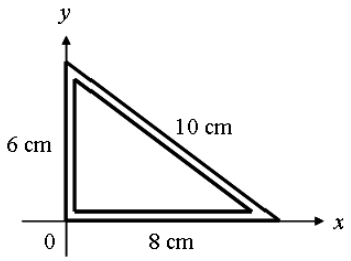


3. Two identical rectangular bricks of length S are piled with one on top of the other on a table. What is the maximum distance L (see the figure below) that the top brick can be extended beyond the edge of the table for the system to remain balanced? (Note that the figure is not drawn to scale.)



4. A diatomic molecule consists of two point masses, m_1 and m_2, separated by a distance r. If x is the distance from m_1 to the center of mass, what is the moment of inertia about an axis parallel to the molecular axis and passes through the center of mass. Note that the molecular axis is the line joining the two atoms in the diatomic molecule.

5. In the figure below, a 24 cm length of uniform wire, is bent into a right-angled triangle. The two shorter sides lies on the x and y axes as shown below. You may neglect the thickness of the wire. Determine the x- and y-coordinates of the centre of mass, in cm.

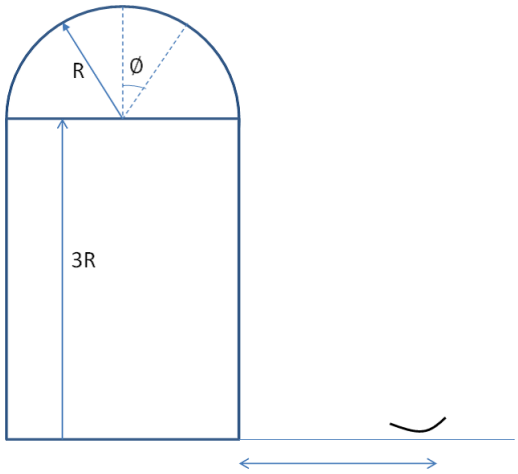


1.3 Rigid Body Mechanics

1. A drum has a radius of 0.40 m and a moment of inertia of 4.5 kgm^2. The frictional torque of the drum axle is 3.0 N m. A 15 m length of rope is wound around the rim. The drum is initially at rest. A constant force is applied to the free end of the rope until the rope is completely unwound and slips off. At that instant, the angular velocity of the drum is 13 rad/s. The drum then decelerates and comes to a halt. Determine the constant force applied to the rope.

2 Special Round

1. (8 points) A daredevil astronomer stands at the top of his observatory dome wearing roller skates and starts with negligible velocity to coast down over the dome surface.



   1. Neglecting friction, at what angle ϕ does he leave the dome's surface?
   2. If he were to start with an initial velocity v_0, at what angle ϕ would he leave the dome?
   3. For the observatory shown above, how far from the base should his assistant position a net to break his fall, as in the situation in 1? Evaluate your answer for $R = 8.0\,\text{m}$.