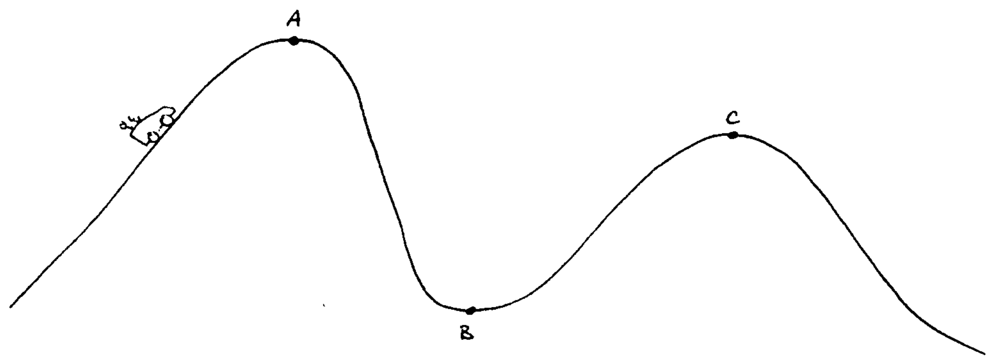
Problem 1.



A roller coaster is loaded with 2 people and taken to the top of the first hill of a ride. The car and the people combined have a mass of 300 kg. The heights at point A = 100m, point B = 0m, and point C = 75m. Ignore the effects of friction.

a) What potential energy does the car with both people have at the top of the first hill (Point A)? (4)

b) What is the speed of the car at the bottom of the first hill (Point B)? (7)

c) What is the speed of the car when it reaches the top of the second hill (point C)? (7)

d) Is energy conserved in the problem? Why or why not? If friction was considered in the problem, would energy be conserved? (2)

a) $P.E. = Mgh = 300\ Kg\ (9.80\ \frac{M}{S^2})(100M) = 2.94 \times 10^5\ J$

b) SINCE ENERGY IS CONSERVED (NO NON-CONSERVATIVE FORCES)
THE K.E. AT THE BOTTOM OF THE HILL = P.E AT THE TOP.

$\therefore\ K.E = \frac{1}{2} MV^2 = 2.94 \times 10^5\ J$

$\therefore\ V = \sqrt{\frac{2(2.94 \times 10^5\ J)}{300\ Kg}} = 44.3\ \frac{M}{S}$

c) $E_T = P.E. + K.E. = Mgh + \frac{1}{2}MV^2 = (300\ Kg)(9.80)(75M) + \frac{1}{2}(300\ Kg) \times V^2$

$2.94 \times 10^5 J = 2.21 \times 10^5\ J + 150\ Kg \times V^2$

$\therefore\ V = \sqrt{\frac{(2.94 \times 10^5 - 2.21 \times 10^5)}{150}} = 22.1\ M/S$

d) ENERGY IS CONSERVED SINCE NO N.C. FORCES. WHEN YOU ADD FRICTION, ENERGY IS NOT CONSERVED.

Problem 2.

Two skateboarders collide. Before the collision, one is moving at 10 m/s and the other at 5 m/s. The mass of the person and skateboard moving at 10 m/s is 70 kg. The other board and person is 75 kg.

a) Can you use conservation of linear momentum to solve this problem? Why or why not? (5)

b) What is the momentum of each (board + person) before the collision? (5)

c) If the two skateboarders hold onto each other after the collision, what is their final velocity? (10)

a) You may use conservation of linear momentum to solve this since there are no external forces in the problem.

b) #1: $P_1 = M_1 V_1 = (70\ Kg)(10\ \frac{M}{S}) = 700\ Kg\ \frac{M}{S}$

#2: $P_2 = M_2 V_2 = (75\ Kg)(5\ \frac{M}{S}) = 375\ Kg\ \frac{M}{S}$

c) $P_f = P_i$

$M_1 V_{1f} + M_2 V_{2f} = M_1 V_{1i} + M_2 V_{2i}$

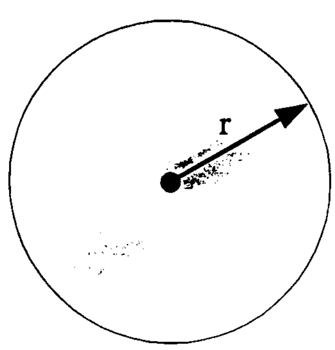
But the final velocity is the same for both.

$\therefore (M_1 + M_2) V_f = M_1 V_{1i} + M_2 V_{2i}$

$(145\ Kg) V_f = 700\ Kg\ \frac{M}{S} + 375\ Kg\ \frac{M}{S}$

$\therefore V_f = 7.41\ M/S$

Problem 3.



A flywheel whose mass is 20 kg and radius is 0.2 m is at rest. It is then brought to 3000 rev/min in 20 seconds.

a) What is the final angular speed in rad/s? (4)

b) During the time the flywheel is changing its speed, what is its average angular acceleration? (6)

c) What is the angular distance the flywheel rotates during this 20 seconds? (10)

a) $$3000 \frac{\text{REV}}{\text{MIN}} \times \frac{1 \text{ MIN}}{60 \text{ SEC}} \times \frac{2\pi \text{ RAD}}{1 \text{ REV}} = 314.2 \frac{\text{RAD}}{\text{SEC}}.$$

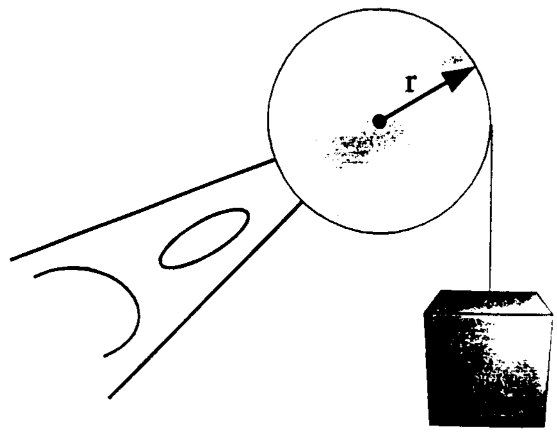
b) $$\bar{\alpha} = \frac{\omega_f - \omega_i}{t} = \frac{\left(314.2 \frac{\text{rad}}{\text{s}} - 0 \frac{\text{rad}}{\text{s}}\right)}{20.0 \text{ s}}$$

$$= 15.7 \frac{\text{rad}}{\text{s}^2}$$

c) $$\theta = \omega_0 t + \tfrac{1}{2}\alpha t^2 = (0)(20_s) + \tfrac{1}{2}\left(15.7 \frac{\text{rad}}{\text{s}^2}\right)(20.0_s)^2$$

$$\theta = 3.14 \times 10^3 \text{ radians}$$

Problem 4.



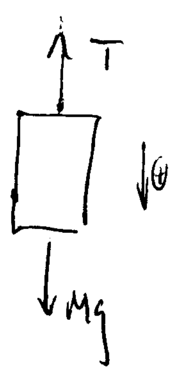
A flywheel whose mass is 20 kg. and has a radius of 0.30 m, has a light cord wrapped around the outside of it. Attached to the other end of the cord is a mass of 10 kg. The moment of inertia of the flywheel is $I = \frac{1}{2} M R^2$ where M is the mass of the flywheel and R is the radius. The hanging mass is released and causes the flywheel to spin.

a) What is the torque the hanging mass applies to the flywheel? (6)

b) What is the angular acceleration of the flywheel while this torque is applied? (10)

c) When the flywheel is spinning at an angular speed of 5 rad/sec, what is the kinetic energy of the flywheel? (4)

a) You NEED to draw a free-body diagram for the overhanging block.



$$\Sigma F_y = Ma_y$$

$$\therefore \quad Mg - T = Ma_y$$

$$\therefore \quad T = Mg - Ma_y$$

THE torque Applied to the flywheel is the Same AS this tension.

$$\therefore \quad \tau = Mg - Ma_y.$$

b) For a rotating mass:

$$\sum \tau = I\alpha$$

$$\therefore (Mg - Ma_y) = \left(\tfrac{1}{2}MR^2\right)\alpha$$

Since the cord is wrapped about outer radius of the flywheel, we can rewrite the acceleration of the hanging mass in terms of the angular acceleration of the flywheel.

$$a_y = a_T = r\alpha$$

$$\therefore Mg - MR\alpha = \left(\tfrac{1}{2}MR^2\right)\alpha$$

$$\therefore \cancel{M}(g - R\alpha) = \cancel{M}\left(\tfrac{1}{2}R^2\alpha\right)$$

$$\tfrac{1}{2}R^2\alpha + R\alpha = g$$

$$\alpha\left(\tfrac{1}{2}R^2 + R\right) = g$$

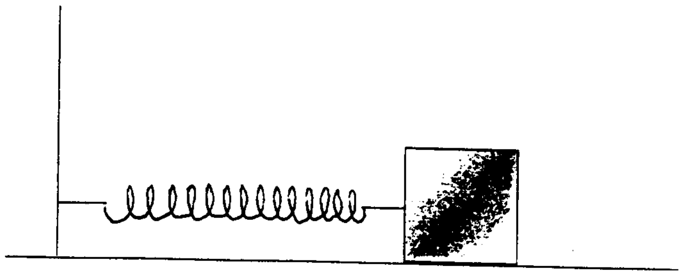
$$\alpha = \frac{g}{\left(\tfrac{1}{2}R^2 + R\right)} = \frac{9.80\,\mathrm{m/s^2}}{\left(\tfrac{1}{2}(0.30\,\mathrm{m})^2 + (0.30\,\mathrm{m})\right)}$$

$$\alpha = 28.4\ \mathrm{rad/s^2}$$

c). $$K.E. = \tfrac{1}{2}I\omega^2 = \tfrac{1}{2}\left(\tfrac{1}{2}MR^2\right)\omega^2 = \tfrac{1}{4}(20.0\,\mathrm{kg})(0.3\,\mathrm{m})^2\left(5\,\tfrac{\mathrm{rad}}{\mathrm{s}}\right)^2$$

$$K.E = 11.3\ \mathrm{J}$$

Problem 5.



A mass of 15 kg. is attached to a spring whose spring constant k is 300 N/m. The mass is pushed so the spring is now compressed by 10 cm. Ignore friction between the mass and the table top.

a) What is the force needed to compress the spring? (4)

b) What is the potential energy stored in the spring when it is compressed 10 cm? (6)

c) If the spring is now released, what is the maximum speed of the mass and where does this occur? (10)

a) $F = Kx = \left(300 \frac{N}{m}\right)(0.1\,m) = 30\,N$

b) $P.E._{SPRING} = \frac{1}{2}Kx^2 = \frac{1}{2}\left(300\frac{N}{M}\right)(0.10\,M)^2 = 150\,(0.10)^2\,J$

$= \cancel{15.0\,J}\ \ 1.5\,J$

c) Since there is no Friction in the problem, Energy is Conserved. This means: $P.E._{MAX} = K.E._{MAX}$

$\therefore\ \cancel{15.0}\ 1.5\,J = \frac{1}{2}MV_{MAX}^2 = \frac{1}{2}(15\,Kg)(V_{MAX})^2$

$\therefore\ V_{MAX} = \sqrt{\frac{2(1.5\,J)}{15.0\,Kg}} = \cancel{\ \ }\ \ 0.45\,\frac{M}{S}$

And V_{MAX} occurs where $P.E. = 0$ So this occurs at $\Delta X = 0$.