Name:____

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles shown on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

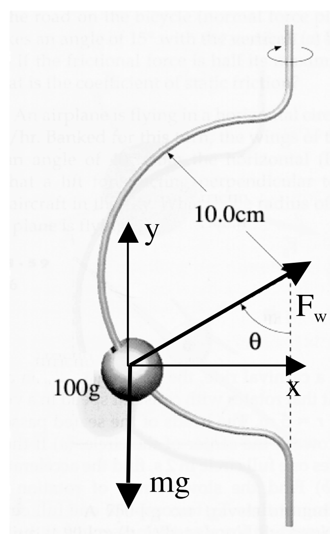
1. Looking at the apples in the grocery store, the following questions enter your (physics obsessed) mind: (a)Which has a larger mass, an apple or a watermelon? (b)Which feels a larger gravitational force when dropped? (c)Which accelerates toward Earth at a higher rate? Fortunately, your instructor asks you to answer these very questions on exam. Unfortunately, he expects you to explain your answers and cite appropriate physical principles.

(a)The watermelon has a larger mass because it is harder to accelerate (or it has more inertia) than an apple.

(b)The force of gravity is proportional to the mass according to the mass/weight rule, so the watermelon feels more gravitational force.

(c)Using Newton's Second Law, they both wind up having the same acceleration. The watermelon has a bigger mass, but more force while the apple has less mass and less force. Rule of Falling Bodies could also be cited.

3. The device shown at the right consists of a 100g bead that is free to move along a frictionless wire bent in the shape of a circle of radius 10.0cm. The device is rotated at just the right rate so that the angle is 37.0˚. Find (a)the magnitude of the force that the wire exerts on the bead and (b)the speed of the bead.



Using the Second Law and centripetal acceleration,

$$\Sigma F_x = ma_x \Rightarrow F_w \sin\theta = m\frac{v^2}{r}$$

$$\Sigma F_y = ma_y \Rightarrow F_w \cos\theta - mg = 0 \Rightarrow F_w \cos\theta = mg$$

(a)Solving the y equation,

$$F_w = \frac{mg}{\cos\theta} = \frac{(0.100)(9.80)}{\cos 37.0^\circ} \Rightarrow \boxed{F_w = 1.23N}.$$

(b)Note that $r = R\sin\theta$. The x equation becomes,

$$F_w \sin\theta = m\frac{v^2}{r} = m\frac{v^2}{R\sin\theta} \Rightarrow v = \sqrt{\frac{F_w R}{m}}\sin\theta$$

Plugging in the numbers,

$$v = \sqrt{\frac{F_w R}{m}}\sin\theta = \sqrt{\frac{(1.23)(0.100)}{(0.100)}}\sin 37.0^\circ \Rightarrow \boxed{v = 0.668 m/s}.$$

3. A top fuel dragster has a mass of 1000kg and it can accelerate from zero to 100mph (44.0m/s) in 0.840s. Find (a)the minimum amount of work done by the engine and (b)the average power output of the engine.

(a) Using the Work-Energy Theorem and the definition of kinetic energy,

$$W_{net} = \Delta K \Rightarrow W_e = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_o^2 = \tfrac{1}{2}mv^2 - 0$$

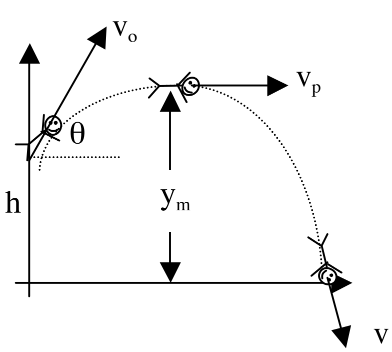
Plugging in the numbers,

$$W_e = \tfrac{1}{2}(1000)(44.0)^2 \Rightarrow \boxed{W_e = 9.68x10^5 J}.$$

(b)Using the definition of power,

$$P \equiv \frac{dW}{dt} = \frac{9.68x10^5}{0.840} \Rightarrow \boxed{P = 1.15MW}.$$

4. A 60.0kg person jumps off a 10.0m high platform. They leave with a speed of 7.00m/s at an angle of 60.0° above horizontal. Find (a)their speed that peak of their flight, (b)their maximum height, and (c)their speed when they strike the water below.



Given:
m = 60.0kg
θ = 60.0°
v_v = 7.00m/s
h = 10.0m

Find:
v_p = ?
y_m = ?
v = ?

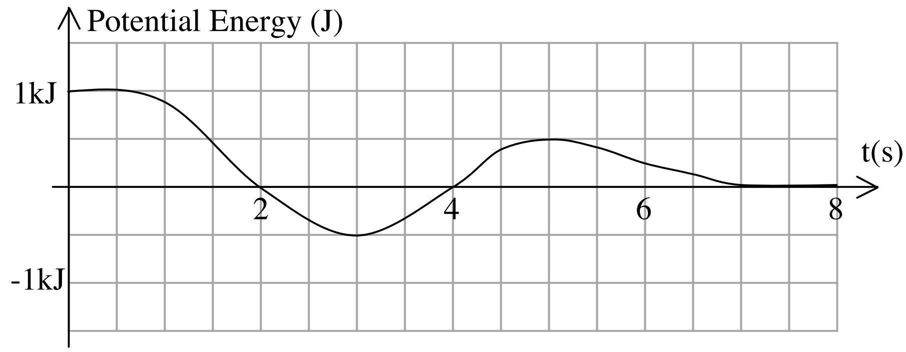
Initially,
$U_o = mgh$ and $K_o = \tfrac{1}{2}mv_o^2$

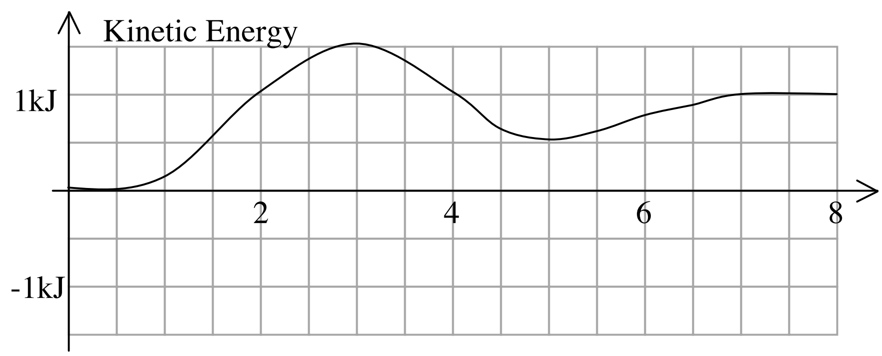
(a)At the peak the velocity is just the x component of the initial velocity since there is no acceleration along x.
$v_p = v_o\cos\theta = 7.00\cos 60.0° \Rightarrow$
$\boxed{v_p = 3.50m/s}$.

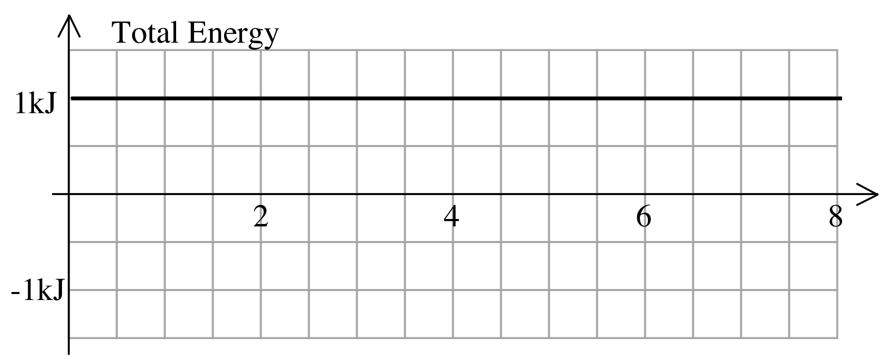
(b)At the maximum height, $U_p = mgy_m$ and $K_p = \tfrac{1}{2}mv_p^2$.
Applying the Law of Conservation of Energy, $\Delta K + \Delta U = 0 \Rightarrow (K_p - K_o) + (U_p - U_o) = 0$
$(\tfrac{1}{2}mv_p^2 - \tfrac{1}{2}mv_o^2) + (mgy_m - mgh) = 0 \Rightarrow y_m = h - \tfrac{1}{2g}(v_p^2 - v_o^2)$
$y_m = 10.0 - \tfrac{1}{2(9.80)}\left[(3.50)^2 - (7.00)^2\right] \Rightarrow \boxed{y_m = 11.9m}$.

(c)At the water, $U = 0$ and $K = \tfrac{1}{2}mv^2$.
Applying the Law of Conservation of Energy, $\Delta K + \Delta U = 0 \Rightarrow (K - K_o) + (U - U_o) = 0$
$(\tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_o^2) + (0 - mgh) = 0 \Rightarrow v = \sqrt{v_o^2 + 2gh}$
$v = \sqrt{(7.00)^2 + 2(9.80)(10.0)} \Rightarrow \boxed{v = 15.7m/s}$.

5. A person at the top of the first hill on a rollercoaster has a speed of essentially zero. Starting at this instant, their potential energy varies with time according to the graph shown below. Sketch the graphs of their kinetic energy and total energy versus time. Be sure to Explain your thinking for full credit.







The key idea is the Law of Conservation of Energy. Since the initial speed is zero, then total energy must always equal the initial potential energy. Therefore, the kinetic energy must grow when the potential energy drops and vice-versa.