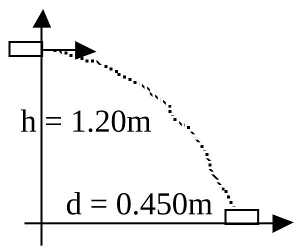
Name:____ Posting Code _____ _____ _____

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 10 points. You must show your work in a logical fashion starting with the correctly applied physical principles which are on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. A coin slides off a 1.20m high horizontal counter and strikes the floor 45.0cm from the base of the counter. Find (a)the time the coin is in the air and (b)the speed that the coin left the counter.



$x_o = 0$	$y_o = 1.20m$
$x = 0.450m$	$y = 0$
$v_{ox} = ?$	$v_{oy} = 0$
$v_x =$	$v_y = ?$
$a_x = 0$	$a_y = -9.80m/s^2$
$t = ?$	$t = ?$

(a)The time can be found using the kinematic equation for y,

$$y = y_o + v_{oy}t + \tfrac{1}{2}a_y t^2 \qquad y_o = -\tfrac{1}{2}a_y t^2 \qquad t = \sqrt{\frac{-2y_o}{a_y}}.$$

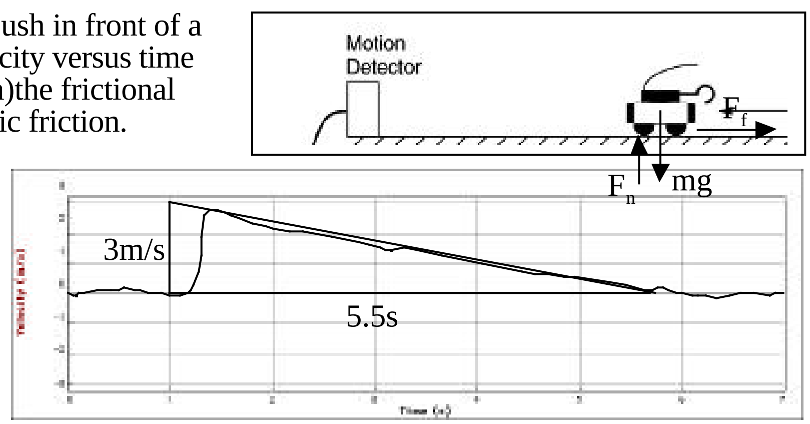
Putting in the numbers, $t = \sqrt{\dfrac{-2(1.20)}{-9.80}}$ $\boxed{t = 0.495s}$.

(b)Using the kinematic equation for x to solve for the initial speed,

$$x = x_o + v_{ox}t + \tfrac{1}{2}a_x t^2 \qquad x = v_{ox}t \qquad v_{ox} = \frac{x}{t}.$$

Putting in the numbers, $v_{ox} = \dfrac{0.450}{0.495}$ $\boxed{v_{ox} = 0.909\,m/s}$.

2. A cart of mass 350g is given a push in front of a motion detector. The resulting velocity versus time graph for the cart is shown. Find (a)the frictional force and (b)the coefficient of kinetic friction.



(a)The acceleration can be found by estimating the slope,

$$a \equiv \frac{\Delta v}{\Delta t} \approx \frac{3}{5.5} \qquad a \approx 0.545\,m/s^2.$$

Since the only horizontal force acting on the cart is friction, the Second Law requires,

$$\Sigma F_x = ma_x \qquad F_f = ma = (0.350)(0.545) \qquad \boxed{F_f = 0.191N}.$$

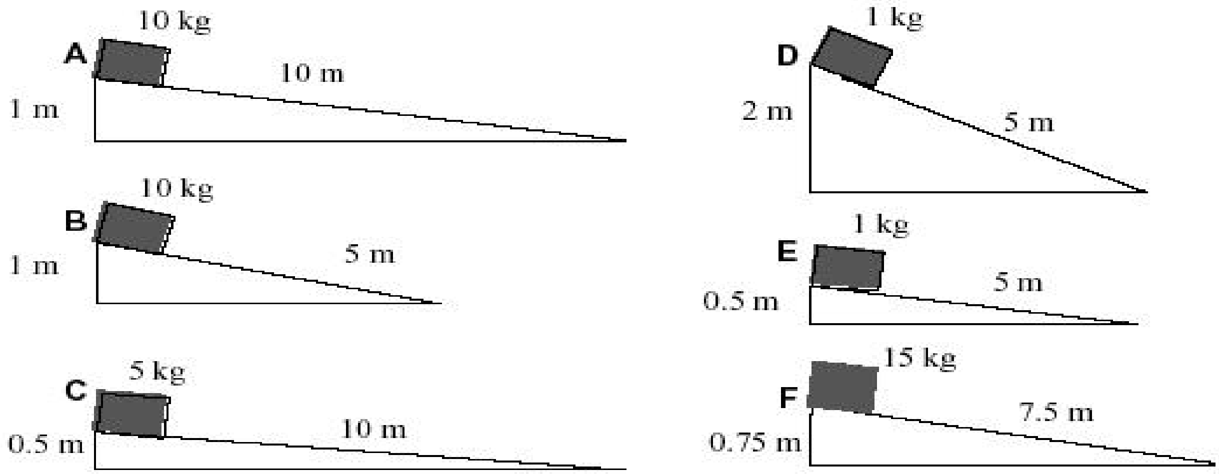
(b)Applying the Second Law to the vertical forces,

$$\Sigma F_y = ma_y \qquad F_n - mg = 0 \qquad F_n = mg.$$

The definition of the coefficient of friction is,

$$F_f \equiv \mu F_n \qquad \mu = \frac{F_f}{F_n} = \frac{ma}{mg} = \frac{a}{g} = \frac{0.545}{9.80} \qquad \boxed{\mu = 0.0556}.$$

3. Rank, in order from greatest to least, the final kinetic energies of the sliding masses the instant before they reach the bottom of the incline. All surfaces are frictionless. All masses start from rest. For full credit, you must explain your reasoning.

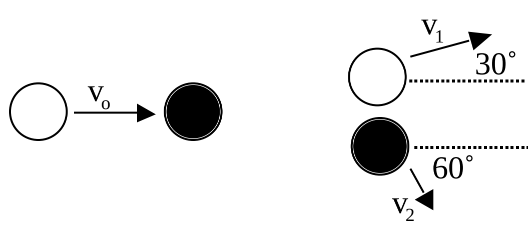


According to the Law of Conservation of Energy, the potential energy at the top will be converted into the kinetic energy at the bottom. The initial gravitational potential energy is given by U=mgh.

U_A=(10)(9.8)(1)=98J
U_B=(10)(9.8)(1)=98J
U_C=(5)(9.8)(0.5)=24.5J
U_D=(1)(9.8)(2)=19.6J
U_E=(1)(9.8)(0.5)=4.9J
U_F=(15)(9.8)(0.75)=110J

Now they can be ranked, F > A = B > C > D > E

4. A billiard ball traveling at 5.00m/s collides with a stationary ball of the same mass. The incoming ball heads off at 30.0˚ to the original direction of motion while the other ball heads off at a 60.0˚ angle. Find (a)the speeds of each of the balls after the collision and (b)determine if the collision is elastic.



before
$p_x = mv_o$
$p_y = 0$

after
$p_x = mv_1\cos30^\circ + mv_2\cos60^\circ$
$p_y = mv_1\sin30^\circ - mv_2\sin60^\circ$

(a)Using the Law of Cons. of Momentum,
$mv_o = mv_1\cos30^\circ + mv_2\cos60^\circ$
$0 = mv_1\sin30^\circ - mv_2\sin60^\circ$
Canceling the mass and solving the second equation for v_2,
$v_o = v_1\cos30^\circ + v_2\cos60^\circ$
$0 = v_1\sin30^\circ - v_2\sin60^\circ \qquad v_2 = v_1\dfrac{\sin30^\circ}{\sin60^\circ}$
Substituting and solving for v_1,

$$v_o = v_1\cos30^\circ + v_1\tfrac{\sin30^\circ}{\tan60^\circ}\cos60^\circ = v_1(\cos30^\circ + \tfrac{\sin30^\circ}{\tan60^\circ}) \qquad v_1 = \frac{v_o}{\cos30^\circ + \frac{\sin30^\circ}{\tan60^\circ}} = \frac{5}{\cos30^\circ + \frac{\sin30^\circ}{\tan60^\circ}} = \boxed{4.33 m/s}$$

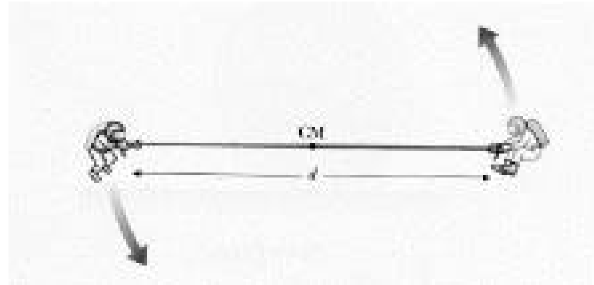
Back substituting for v_2, $v_2 = v_1\dfrac{\sin30^\circ}{\sin60^\circ} = 4.33\dfrac{\sin30^\circ}{\sin60^\circ}$ $\quad \boxed{v_2 = 2.50 m/s}$

(b)The initial kinetic energy is, $K_o = \frac{1}{2}mv_o^2 = \frac{1}{2}m(5)^2 \qquad K_o = 12.5m$.

The final kinetic energy is, $K = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 = \frac{1}{2}m(4.33)^2 + \frac{1}{2}m(2.50)^2 \qquad K = 12.5m$.

Since the kinetic energy is conserved, the collision is elastic.

5. Two astronauts each have a mass of 75.0kg are initially connected by a 10.0m long rope of negligible mass. They are isolated in space and orbit their center of mass with a speed of 5.00m/s. Find (a)the acceleration of each astronaut and (b)the tension in the rope.



(a)Using the centripetal acceleration,

$$a_c = \frac{v^2}{r} = \frac{(5.00)^2}{5.00} \qquad \boxed{a = 5.00 m/s^2}.$$

(b)The only force on an astronaut is the tension in the rope, so according to the Second Law,

$$\Sigma F = ma \qquad F_t = ma = (75.0)(5.00) \qquad \boxed{F_t = 375N}.$$

6. The two astronauts from problem 5 begin to pull in on the rope until they are only 5.00m apart. Find (a)their final speed, (b)their initial kinetic energy (c)their final kinetic energy and (d)the work they have done.

(a)Using the Law of Conservation of Angular Momentum and the angular momentum of point masses,

$$L_o = L \qquad mv_o r_o = mvr \qquad v = v_o \frac{r_o}{r} = (5.00)\frac{5.00}{2.50} \qquad \boxed{v = 10.0 m/s}.$$

(b)Using the definition of kinetic energy,

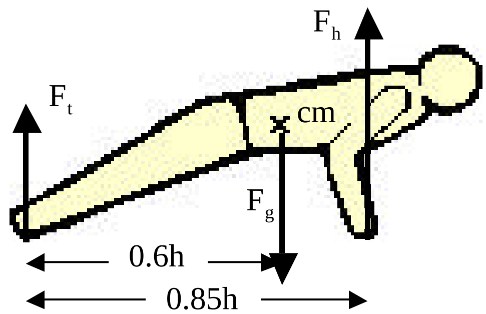
$$K_o = \tfrac{1}{2} mv_o^2 + \tfrac{1}{2} mv_o^2 = mv_o^2 = (75.0)(5.00)^2 \qquad \boxed{K_o = 1880J}.$$

(c)Again, using the definition of kinetic energy,

$$K = \tfrac{1}{2} mv^2 + \tfrac{1}{2} mv^2 = mv^2 = (75.0)(10.0)^2 \qquad \boxed{K = 7500J}.$$

(d)Applying the Work-Energy Theorem,

$$W_{net} = \Delta K = K - K_o = 7500 - 1880 \qquad \boxed{W_{net} = 5620J}.$$



7. A 50.0kg athlete about to do a push-up lies horizontally with only her hands and toes touching the ground. Her center of mass is 60% of the way from her toes to her head and her hands are 85% of the way. Find (a) the force that ground exerts on her hands and (b)the force that her hands must exert on the ground.

(a)Applying the Second Law for Rotation about an axis through her toes,

$$\Sigma\tau = I\alpha \qquad F_h(0.85h) - F_g(0.6h) = 0$$

Solving for the force on her hands,

$$F_h = \frac{0.6h}{0.85h}F_g = \frac{0.6}{0.85}mg = \frac{0.6}{0.85}(50.0)(9.80) \qquad \boxed{F_h = 346N}.$$

(b)By the Third Law, the force that the ground exerts on her hands is equal and opposite to the force that her hands exert on the ground, $\boxed{F_{gr} = 346N}$.

8. A friend wants to make a pendulum with a period of 0.500s. Find (a)the length of string that she needs and (b)the mass she wants on the end.

(a)The angular frequency for a simple pendulum is, $\omega = \sqrt{\frac{g}{\ell}}$.

The period is related to this angular frequency, $T = \frac{1}{f} = \frac{2\pi}{\omega} \qquad T = 2\pi\sqrt{\frac{\ell}{g}}$.

Solving for the length, $\ell = \frac{gT^2}{4\pi^2} = \frac{(9.80)(0.500)^2}{4\pi^2} \qquad \boxed{\ell = 0.0621\text{m} = 6.21\text{cm}}$.

(b)Since the mass doesn't affect the period **any mass substantially larger than the mass of the string** will work.

9. Dish Network provides television signals from their satellites to homes equipped with small fixed dish antennas. Since the antennas are fixed, the satellite must be at the same point in the sky at all times, so it must orbit with the same period that the earth spins (24h). Find (a)the radius of orbit of these satellites and (b)explain why the dish antennas around Chico all point toward south.

(a)Applying the Second Law and the Law of Universal Gravitation to the satellite,

$$\Sigma F = ma \qquad G\frac{mM}{r^2} = ma.$$

Using the centripetal acceleration, $G\frac{mM}{r^2} = m\frac{v^2}{r} \qquad G\frac{M}{r} = v^2.$

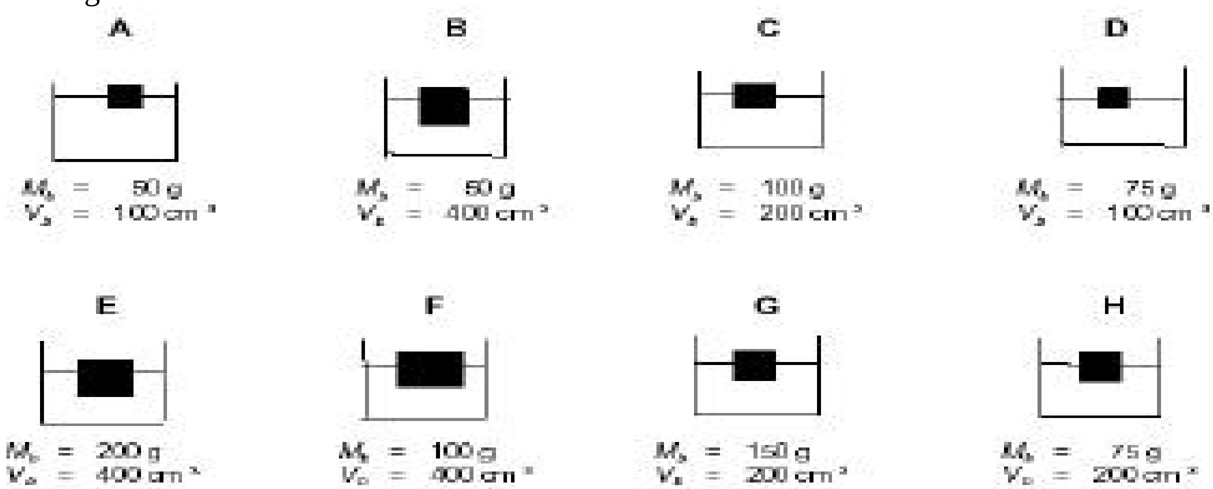
Using the definition of speed and the fact that the satellite is in circular orbit,

$$v = \frac{2\pi r}{T} \qquad G\frac{M}{r} = \left(\frac{2\pi r}{T}\right)^2 \qquad r = \left(\frac{GMT^2}{4\pi^2}\right)^{\frac{1}{3}}$$

Plugging in the numbers, $r = \left(\frac{(6.67x10^{-11})(5.98x10^{24})(24x60x60)^2}{4\pi^2}\right)^{\frac{1}{3}}$ $\boxed{r = 4.22x10^7\,m}$.

(b)This satellite must orbit around the equator in order to appear stationary. The equator is south of Chico.

10. Shown below are eight containers that have the same volume of the same liquid in them. Blocks of various solids are floating on top of the liquid. The blocks vary in both size and mass. Specific values for the masses labeled as M_b and volumes labeled as V_b of the blocks are given in each figure. Rank these situations, from greatest to least, on the basis of the buoyant force by the liquid on the blocks. That is, put first the situation that has the greatest buoyant force by the liquid on the block, and put last the situation that has the lowest buoyant force by the liquid on the block. Explain your reasoning for full credit.



Applying the Second Law to each block, requires that the buoyant force exactly equal the weight in each case. Therefor,

$\boxed{E > G > C = F > D = H > A = B}$.