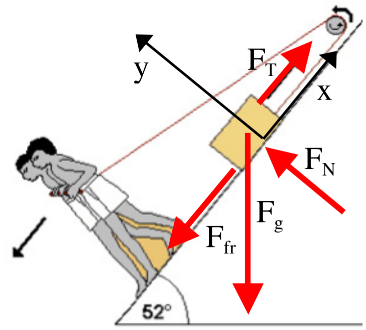
Name:_________________________________

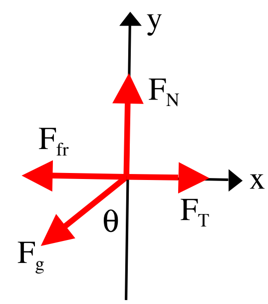
Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied and clearly stated physical principles. The equations you need are on the equation sheet. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. Who knows if this is how the pyramids were really built? Let's suppose it was. A 500kg block is pulled up the incline at a slow but constant speed by a rope with a tension of 4500N. (a)Find the acceleration of the block and (b)the coefficient of kinetic friction between the block and the ramp.



(a)The problem states that the speed is constant, so the acceleration must be zero.

(b)Given: a = 0, m = 500kg, F_T = 4500N, and θ = 52°.
Find: μ = ?



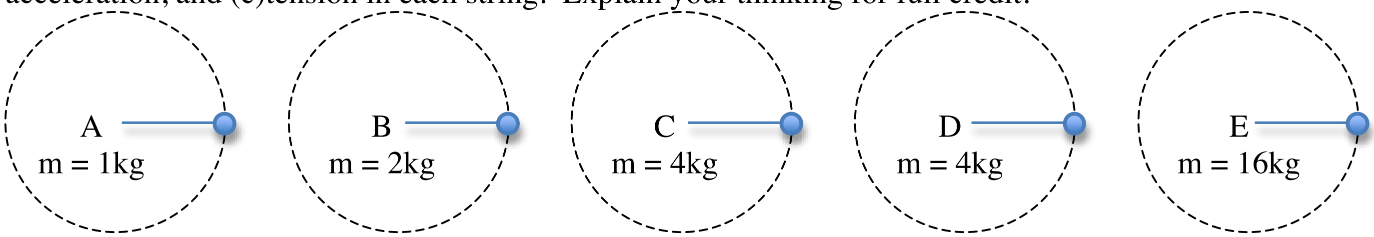
Using the free body diagram at the right we can apply the Second Law,
$\Sigma F_x = ma_x \Rightarrow F_T - F_{fr} - mg\sin\theta = 0$ and
$\Sigma F_y = ma_y \Rightarrow F_N - mg\cos\theta = 0$.

Solving the x equation for the friction and the y equation for the normal force,
$F_{fr} = F_T - mg\sin\theta$ and $F_N = mg\cos\theta$.

Substituting into the definition of the coefficient of friction, $\mu \equiv \dfrac{F_{fr}}{F_N} \Rightarrow \mu = \dfrac{F_T - mg\sin\theta}{mg\cos\theta}$.

Plugging in the numbers, $\mu = \dfrac{4500 - 500(9.8)\sin 52^\circ}{500(9.8)\cos 52^\circ} \Rightarrow \boxed{\mu = 0.212}$.

2. Below are depictions of five balls on the ends of light strings spinning in circles at identical constant speeds. The systems are out in empty space. The speed is large enough to keep the balls in circular motion. The strings are all the same length, but the masses of the balls are different as indicated. Rank these situations from greatest to least based upon the (a)centripetal acceleration, (b)tangential acceleration, and (c)tension in each string. Explain your thinking for full credit.

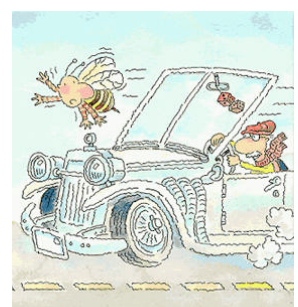


(a)The centripetal acceleration is $a_c = \frac{v^2}{r}$. Since they all have the same radius and tangential speed the centripetal accelerations are equal. So, A = B = C = D = E.

(b)Since the balls are moving at a constant speed, they all have a tangential acceleration of zero. A = B = C = D = E.

(c)Using the Second Law, $\Sigma F = ma \Rightarrow F_T = ma_c$. Since the centripetal accelerations are equal, larger masses must have larger tensions in their strings. So, E > D = C > B > A.

3. A bug flying northward at 8.00m/s collides with the windshield of a car traveling southward at 20.0m/s. Answer the following questions. For full credit, you must explain your thinking. Be sure to cite any relevant principles of physics. Which object, the bug or the car (a)feels the greater force during the collision? (b)has the greater acceleration during the collision? (c)feels the greater impulse on it during the collision? (d)has the greater change in momentum during the collision? (e)has the greater momentum after the collision?



(a)The bug and the car both feel the same force according to Newton's Third Law.

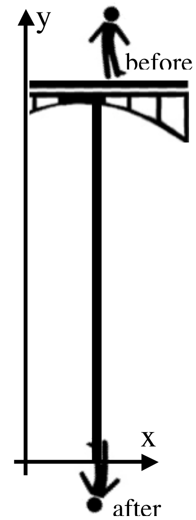
(b)Since both feel the same force, Newton's Second Law tells us the smaller mass must have the larger acceleration. So, the bug has the larger acceleration.

(c)Impulse is defined to be the force times the collision time. Since the forces are equal and the collision time is the same, they both feel the same impulse.

(d)The Impulse-Momentum Theorem says the impulse is equal to the change in momentum, so they also have the same change in momentum.

(e)The momentum is the product of mass and velocity. Since they likely have the same speed after the collision, the car has the greater momentum because it has more mass.

4. A 60.0kg bungee jumper steps off a 55.0m high bridge. The unstretched length of the cord is 30.0m and it stretches an additional 20.0m when the jumper is at the lowest point. Find the spring constant of the cord assuming both air resistance and the mass of the cord can be neglected.



Given: m = 60.0kg, h = 55.0m, y_o = 50.0m, x_o = 30.0m, and x = 20.0m.
Find: k = ?

At the top there is no kinetic energy but there is gravitational potential energy.

$$K_o = 0 \text{ and } U_o = mgy_o$$

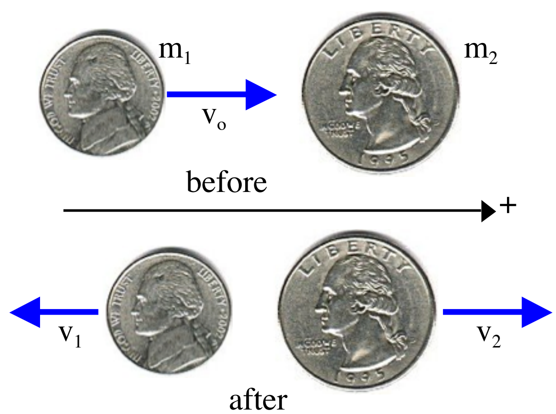
At the bottom there is also no kinetic energy, the gravitational potential energy is zero, and there is now spring potential energy.

$$K = 0 \text{ and } U = \tfrac{1}{2}kx^2$$

Applying the Law of Conservation of Energy,

$$K_o + U_o = K + U \Rightarrow 0 + mgy_o = 0 + \tfrac{1}{2}kx^2 \Rightarrow k = \frac{2mgy_o}{x^2} = \frac{2(60)(9.8)(50)}{(20)^2} \Rightarrow \boxed{k = 147\tfrac{N}{m}}.$$

5. A nickel (m = 5.00g) slides along a smooth counter at 3.00m/s and collides head-on with a quarter (m = 5.67g) originally at rest. The speed of the quarter just after the collision is 2.75m/s. (a)Find the speed of the nickel just after the collision and (b)determine if the collision is elastic.



Given: m_1 = 5.00g, m_2 = 5.67g, v_o = 3.00m/s, and v_2 = 2.75m/s.
Find: v_1 = ? and is the collision elastic?

(a)The initial momentum is, $p_o = m_1v_o$.

The final momentum is, $p = m_2v_2 - m_1v_1$.

Applying the Law of Conservation of Linear Momentum,

$$m_1v_o = m_2v_2 - m_1v_1 \Rightarrow v_1 = \frac{m_2v_2 - m_1v_o}{m_1}.$$

Plugging in the values, $v_1 = \dfrac{(5.67)(2.75) - 5(3)}{5} \Rightarrow \boxed{v_1 = 0.119\tfrac{m}{s}}$.

(b)The initial kinetic energy is $K_o = \tfrac{1}{2}m_1v_o^2 = \tfrac{1}{2}(5)(3)^2 = 22.5mJ$.
The final kinetic energy is $K = \tfrac{1}{2}m_1v_1^2 + \tfrac{1}{2}m_2v_2^2 = \tfrac{1}{2}(5)(0.119)^2 + \tfrac{1}{2}(5.67)(2.75)^2 = 21.5mJ$.
Since the kinetic energy is not conserved, the collision is inelastic.