Energy and Work Practice Name: Key

1. A 66-kg baseball player slides into third base. He starts his slide at a speed of 4.4 m/s and his speed is zero just as he reaches the base. If the coefficient of friction between his clothes and the surface of the baseball infield is 0.60, determine the following.

$V_o = 4.4\,m/s$ $\quad m = 66\,kg$

$V_f = 0$ $\quad \mu = 0.6$

(a) Initial and final kinetic energy

$KE_o = \frac{1}{2}mv_o^2$ $\quad K_f = \frac{1}{2}mV_f^2$

$= \frac{1}{2}(66)(4.4)^2$ $\quad = \frac{1}{2}(66)(0)^2$

$= 638.88\ J$ $\quad = 0$

(b) energy lost due to friction acting on the player

$\Delta E = K_f - K_o$

$0 - 638.88\,J$

$= -638.88\,J$ → 638.88 J lost

(c) distance he slides (look at work done by friction)

$W = \Delta E = dF\cos\theta$

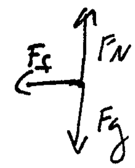
$\frac{638.88}{396} = d$

$\boxed{1.61\,m = d}$

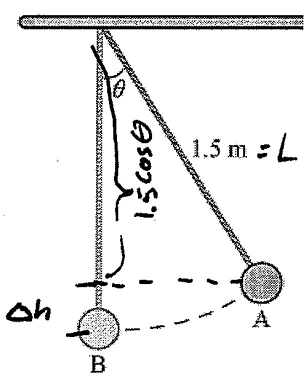
$F = F_f = \mu F_N = \mu F_g$

$F = (.6)(66)(10)$

$F = 396$



2. A pendulum bob with a mass of 0.48 kg is attached to a 1.5 m long string as shown. As the pendulum bob swings from point A, where the angle $\theta = 36°$, to point B at the bottom of its arc, determine the change in its gravitational potential energy.



$\Delta h: 1.5 - 1.5\cos(36)$

$\Delta h: 0.28647$

$\Delta U_g = mg\Delta h$

$= (66)(10)(0.28647)$

$\boxed{\Delta U_g = 189.1\ J}$

3. A car's bumper is designed to withstand a 1.9-m/s collision with an immovable object without damage to the body of the car. The bumper cushions the shock by absorbing the force over a distance. Calculate the average force on a bumper that collapses 0.270 m while bringing a 860-kg car to rest from an initial speed of 1.9 m/s. (Hint what are the initial and final KE? Remember Einitial+W=Efinal)

$V_o = 1.9\,m/s$

$V_f = 0$

$m = 860\,kg$

$\Delta x = 0.27\,m$

$F = ?$

$W = \Delta E = \Delta x \cdot F\cos(\theta)$

$K_f - K_o = \Delta x \cdot F$

$F = \frac{K_f - K_o}{\Delta x}$

$F = \frac{\frac{1}{2}m(V_f^2 - V_o^2)}{\Delta x}$

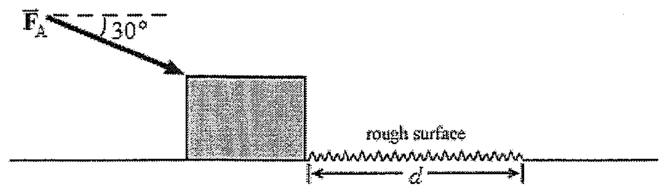
$F = \frac{\frac{1}{2}(860\,kg)(1.9\,m/s)^2}{0.27}$

$\boxed{F = 5749.2\ N}$

4. As shown in the figure below, a box of mass m = 53.0 kg (initially at rest) is pushed a distance d = 96.0 m across a rough warehouse floor by an applied force of F_A = 246 N directed at an angle of 30.0° below the horizontal. The coefficient of kinetic friction between the floor and the box is 0.100 (it is able to overcome static friction). Determine the following.

$m = 53\,kg$
$V_0 = 0$
$\Delta x = 96\,m$
$F_A = 246\,N$
$\mu_K = .1$

(a) work done by the applied force



$W = d \cdot F \cdot \cos(\theta)$

$W_a = 96\,m \cdot 246\,N \cdot \cos(30)$

$\boxed{W_a: 20452\,J}$

(b) work done by the force of gravity

Δx F_g

$\cos(\theta) = \cos(90) = 0$

because They are perpendicular no work is done. gravity is really bad at moving The block.

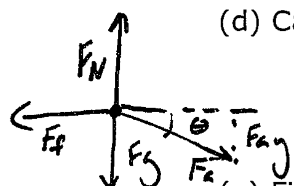
(c) work done by the normal force

F_N Δx

$\cos(\theta) = \cos(90) = 0$

Same as

(d) Calculate the normal force, and hence the frictional force. (use FBD)



$a_y = \frac{\Sigma F_y}{m}$

$0 = F_N - F_g - F_{ay}$

$F_N = F_g + F_{ay}$

$= mg + F_a \sin(30)$

$= (53)(10) + (246)\sin(30)$

$\boxed{F_N = 653\,N}$

(e) Find the work done by friction as the box slides right.

$F_f = \mu F_N = (.1)(653\,N)$

$\boxed{F_f = 65.3\,N}$

$W_f = d\,F_f \cos\theta$

$W_f = (96\,m)(65.3\,N)\cos(180)$

$\boxed{W_f = -6268.8\,J}$

(f) Calculate the net work on the box by finding the sum of all the works done by each individual force.

$W_{net} = W_a + W_f$

$= 20452\,J + (-6268.8\,J)$

$= 14183.2\,J$

(g) Now find the net work by first finding the net force on the box, then finding the work done by this net force.

$\Sigma F_x = F_{ax} - F_f$

$\Sigma F_x = F_a \cos\theta - F_f$

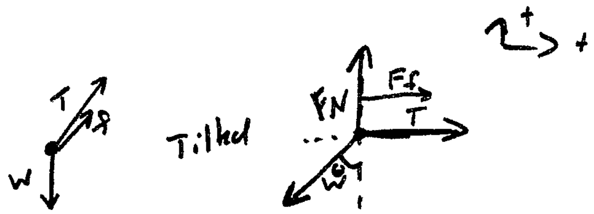
$\Sigma F_x = 246\,N \cos(30) - 65.3\,N$

$\Sigma F_x = 147.7\,N$

$W_{net} = d \cdot F_{net} \cos\theta$

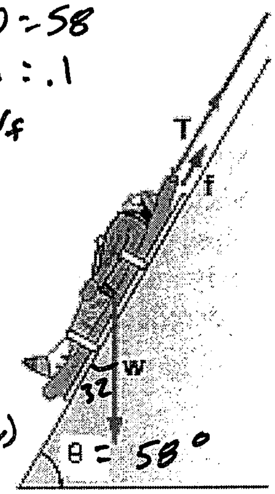
$W_{net} = 96\,m \cdot 147.7\,N$

$W_{net} = 14183.2$



5. Suppose the ski patrol lowers a rescue sled and victim, having a total mass of 95.0 kg, down a θ =58.0° slope at **constant speed**. The coefficient of friction between the sled and the snow is 0.100.

$m = 95\text{ kg}$
$\theta = 58$
$\mu = .1$
$V_0 = V_f$



(a) Draw a FBD, tilt it for this problem.

(b) What is the y-accel? Calculate the normal force, and hence the force of friction as he slides.

0: constant velocity

$a_y = \frac{\Sigma F_y}{m}$

$0 = F_N - F_{wy}$

$F_N = W\cos(58)$

$F_N = 95 \cdot 10\cos(58) = \boxed{503.4\text{ N}}$

(c)What is the x-accel? Calculate the tension in the rope.

$a_x = \frac{\Sigma F_x}{m}$

$0 = \Sigma F_x = T + F_f - F_{wx}$

$T = F_w \sin(\theta) - F_f$

$T = (10)(95)\sin(58) - (.1)(503.4N)$

$\boxed{T = 755.3N}$

(d) How much work is done by friction as the sled moves 30.0 m along the hill?

$W_f = \Delta x \cdot F_f \cos(180)$

$W_f = 30m \cdot (.1)(503.4N)\cos(180)$

$\boxed{W_f = 1510.2\text{ J}}$

(e) How much work is done by the rope on the sled in this distance?

$W_T = \Delta x \cdot T$

$W_T = 30m \cdot 755.3N$

$\boxed{W_T = 22659\text{ J}}$

(f) What is the work done by gravity on the sled?

$W_g = d \cdot F_g \cos(\theta) = 30 \cdot 95 \cdot 10\cos(32°) = \boxed{24169.4\text{ J}}$

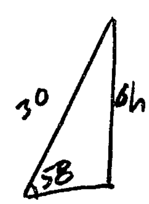
(g) What is the total work done on the skier?

(h) How much gravitational potential energy did the skier lose from the top down to the bottom?

$\Delta U_g = mg\Delta h$

$\Delta U_g = (95\text{kg})(10)(30)\sin(58)$

$\boxed{\Delta U_g = 24169.4\text{ J}}$



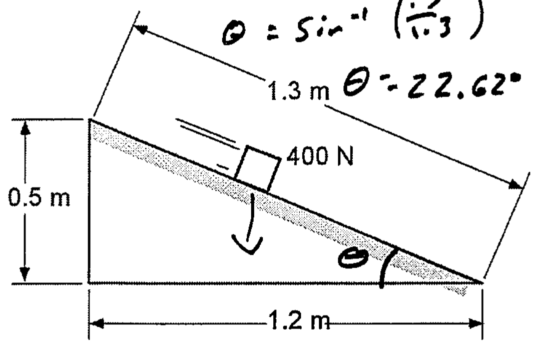
$h = 30\sin(58)$

$\sin\theta = \frac{.5}{1.3}$

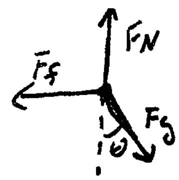
$\theta = \sin^{-1}\left(\frac{.5}{1.3}\right)$

$\theta = 22.62°$

6. A 40 kg (or 400-N) box starts from rest from the top of a ramp that has a length of 1.3 m and a height of 0.5 m. The box slides to the bottom of the ramp where the gravitational potential energy is zero. The speed of the box at the bottom of the ramp is 2 m/s. There is friction on the box by the ramp.



(a) Draw a FBD for the setup.



(b) Determine the normal force acting on the block.

$a_y = 0 \Rightarrow \Sigma F_y = 0 \Rightarrow F_N = F_{gy}$

$F_N = mg\cos\theta$

$F_N = (400N)\cos(22.62)$

$\boxed{F_N = 369.2\,N}$

(c) Find the change in kinetic energy and find the change in gravitational energy. Are they equal? $\Delta k = K_f - K_o$

$\Delta k = \frac{1}{2}m(V_f^2 - V_o^2)$

$\Delta k = \frac{1}{2}(40)(2^2 - 0^2)$

$\boxed{\Delta k = 80\,J}$

$\Delta U_g = mg\Delta h$

$\Delta U_g = 400N(0.5)$

$\boxed{\Delta U_g = 200N}$

(d) If there were no friction, what should the velocity have been at the bottom?

$\Delta U_g = \Delta k$

$\Delta U_g = k_f - K_o$

$\Delta U_g = \frac{1}{2}m(V_f^2 - V_o^2)$

$V_f = \sqrt{\frac{\Delta U_g \cdot 2}{m}}$

$V_f = \sqrt{\frac{200N \cdot 2}{40}}$

$\boxed{V_f = 3.16\,m/s}$

(e) How much work must friction have done on the block?

$W_f = F_f \cdot d = \Delta E$

$W_f = K_{potential} - K_{actual}$

$= \frac{1}{2}mV_p^2 - \frac{1}{2}mV_{actual}^2$

$= \cancel{\frac{1}{2}(40)((2)^2 - (3}\ = \frac{1}{2}(40)((3.16)^2 - (2)^2) = 119.712\,J$

(f) What is the force of friction on the block?

$W_f = F_f \cdot d$

$F_f = \frac{W_f}{d}$

$F_f = \frac{119.712\,J}{1.3m} = 92.086\,N$