Worksheet 3.3

1. A crane is lowering a box of mass 50 kg with an acceleration of 2 m/s^2.
   a. Find the tension T in the cable.

   F_T ; $F_g = 500N$

   $F_{net} = (50kg)(2 m/s^2) = 100 N$

   $F_{Net} = F_g - F_T$ $500N - F_T = 100N$ $F_T = 400N$

   b. If the crane lowers the box at a constant speed, what is the tension FT in the cable?

   $F_T = F_g$ b/c $F_{Net} = 0$

   $F_T = 500N$

2. Laura and Alan are pulling a wagon. Laura is pulling with a force of 50 N towards the northeast. Alan is pulling with a force of 50 N directly east. The wagon has a mass of 23 kg.

   50N ; 45° ; 50N ; $F_g = 230N$

   y: $50 \sin 45 = 35.4 N$ x: $35.4N$

   $212.5 = 23a$ $a = 9.24 m/s^2$

   What are the acceleration and direction of motion of the wagon?

   Total in y: $35.4 - 230 = 194.6 N$ ↓ In x: $35.4 + 50 = 85.4N$

   194.6 ; 85.4 ; $F_{net} = 212.5N$ $\emptyset = 66.3°$

3. Consider a large box of mass 24 kg at rest in the hallway of SI. A rope is attached to the top of the box. For each part, draw a free body diagram & be sure to properly label the forces on the FBD and draw them to correct relative scale.

a. A teacher tries to lift the box by pulling up on the rope with a tension force of 140 N. Obviously, this isn't enough to lift the box, so the box remains at "rest". Draw a free body diagram for the box in this situation and calculate the normal force acting on the box.

   $F_T + F_N$; $F_g = 240N$

   $F_T + F_N = F_g$ b/c it doesn't move.

   $140 + F_N = 240N$ $F_N = 100N$

b. The teacher then pulls the box horizontally to the right with a force of 60 N, so that it slides along the floor at constant speed. Draw a free body diagram for the box as it slides at constant speed; then, calculate the coeff. of friction acting on the box.

   F_{fk} ; 60N

   $F_{fk} = 60N$ $\mu_K (240N) = 60N$ $\mu_K = .25$

   $F_N = 240N$ now, b/c no longer pulling upward

c. The teacher then pulls the box horizontally to the right (again with 60 N of force, but on a different floor) so that it slides along the floor with an acceleration of 0.5 m/s^2. Draw a free body diagram for the box as it accelerates; then, calculate the coefficient of kinetic friction between the box and the ground. Be sure to show all your intermediate steps in this problem.

   F_N ; F_{fk} ; 60N ; F_g

   $F_{Net} = (24kg)(.5 m/s^2) = 12 N$

   $12N = 60 - F_{fk}$

   $48 = F_{fk} = F_N \mu_K$

   $48 = 240(\mu_K)$ $\mu_K = .2$

4. You have attached a rope to your 15 kg strongbox in order to drag it across the ground. The rope makes a 30° angle with respect to the ground. For the first few parts of this problem, please neglect friction.

30°
150 N

a. You are pulling hard enough to generate a tension of 100 N in the rope. Draw a properly scaled free body diagram for the strongbox Label each force with a name, and as usual be sure to include an appropriate length for each vector. Again, we are neglecting friction for this part.

F_N 100N = F_T
150N = F_g

b. Calculate and write in the magnitude of the normal force acting on the box next to the vector in your FBD above.

$F_g = F_N + F_{Ty}$

$150 = F_N + 100\sin 30$

$F_N = 100N$

c. What are the net force and acceleration of the box?

$F_{Tx} = 100\cos 30 = 86.6N$

$F_{net} = 86.6 = 15kg(a)$

$a = 5.77 m/s^2$

d. Starting from rest, how long would you have to pull on the box with this tension to accelerate it to a speed of 5 m/s? Kinematics! Again!

$5m/s = 5.77t + 0$

$t = .87s$

e. Ok now we're going to consider friction. What is the highest coefficient of static friction the strongbox-floor system could have and still move as a result of this 100 N force applied at 30°?

$F_{fs} < 86.6N$

$F_N(\mu_s) = 86.6$

$100\mu_s = 86.6$

$\mu_s = .866$

5. The rising concern among athletic trainers and health advocates (and parents) regarding concussions and multiple concussions among high school football players has prompted numerous studies of the effectiveness of protective head gear and the forces and accelerations experienced by players. One study suggested that there is a 50% chance of concussions for impacts rated at 75 g's of acceleration (i.e., 75 multiplied by 9.8 m/s/s). (The average head impact results in 22 to 24 g's of acceleration.) If a player's head mass (with helmet) is 6.0 kg and considered to be a ***free body***, then what net force would be required to produce an acceleration of 75 g's (~740 m/s/s)?

$m = 6kg$

$F = (6kg)(740 m/s^2)$

$F = 4440N$

6. An 80 kg sprinter kneels on the ground waiting for the starting gun to fire. The coefficient of static friction between the sprinter's feet and the ground is 0.5. How much horizontal force can the runner push off with before her feet begin to slide backward on the ground?

$m = 80kg$

$\mu = .5$

$F_N = 800N$

$F_{f_s} = 800N(.5) = 400N$

Max horizontal force = 400N

7. A .22 rifle bullet, traveling at 350 m/s, strikes a block of soft wood, which it penetrates to a depth of 0.130 m. The block of wood is clamped in place and doesn't move. The mass of the bullet is 1.80 g. Assume a constant retarding force. How much time is required for the bullet to stop? What force, does the wood exert on the bullet?

$V_i = 350m/s$ $\Delta x = .13m$ $V_f = 0$

$m = .0018kg$

$0 = (350m/s)^2 + 2a(.13m)$

$a = -471153 m/s^2$

time

$0 = -471153t + 350$

$t = .00074s$

$F = (.0018kg)(471153 m/s^2) = 848.1N$