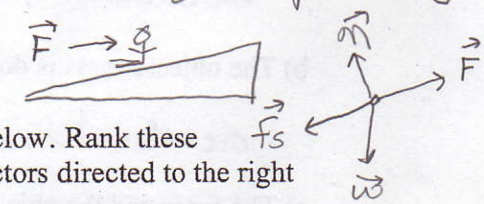
Questions and Example Problems from Chapter 4

Question 1
Why do you lung forward when your car suddenly comes to a halt? Why are you pressed backward against the seat when your car rapidly accelerates?

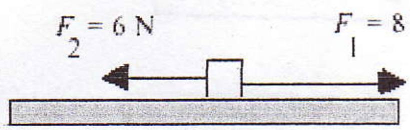
In both cases, it is $\boxed{\text{because of your inertia}}$ (Newton's 1st Law). Your tendency is to continue to move at a constant speed (+ straight line) while the car halts or rapidly accelerates.

Question 2
A person sits on a sloped hillside. Is it ever possible to have the static friction force on this person point down the hill? Explain.

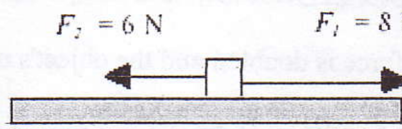
$\boxed{\text{Yes,}}$ if the object would move uphill if there were no friction. This could happen if there was a force pushing the person up the sloped hillside.



Question 3
Two forces act on an object that is on a frictionless surface, as shown below. Rank these situations from greatest acceleration to least acceleration. (Note: All vectors directed to the right are positive, and those to the left are negative. Also, 0 m/s^2 > -10 m/s^2.)



A

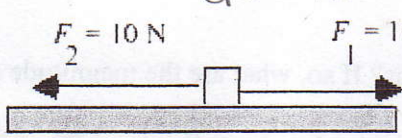


B

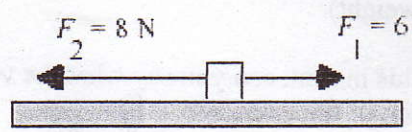
$a = 2N/4Kg = 0.5\ m/s^2$

$a = 2N/2Kg = 1\ m/s^2$

$a = 0\ m/s^2$



C



D

$a = -2N/4Kg = -0.5\ m/s^2$

Greatest 1 $\boxed{B}$ 2 $\boxed{A}$ 3 $\boxed{C}$ 4 $\boxed{D}$ Least

Problem 1.
A baseball player is sliding into second base. Identify the forces on the baseball player.

$\Rightarrow$ forces on the baseball player are:

$$\boxed{\begin{array}{l}\text{weight } \vec{w} \\ \text{normal force } \vec{n} \\ \text{kinetic friction } \vec{f}_k\end{array}}$$

Problem 2
A constant force is applied to an object, causing the object to accelerate at 8.0 m/s^2. What will the acceleration be if

$\vec{a} = \vec{F}_{net}/m = 8.0\ m/s^2$

a) The force is doubled?

acceleration is doubled $\longrightarrow$ $\boxed{a = 16\ m/s^2}$

b) The object's mass is doubled?

acceleration is cut in half $\longrightarrow$ $\boxed{a = 4.0\ m/s^2}$

c) The force and the object's mass are both doubled?

acceleration doesn't change $\longrightarrow$ $\boxed{a = 8.0\ m/s^2}$

d) The force is doubled and the object's mass is halved?

acceleration is quadrupled $\longrightarrow$ $\boxed{a = 32\ m/s^2}$

Problem 3
Two children fight over a 200 g stuffed bear. The 25 kg boy pulls to the right with a 15 N force and the 20 kg girl pulls to the left with a 17 N force. Ignore all other forces on the bear (such as its weight).

a) At this instant, can you say what the velocity of the bear is? If so, what are the magnitude and direction of the velocity?

No, you can not say what the velocity of the bear is.

b) At this instant, can you say what the acceleration of the bear is? If so, what are the magnitude and direction of the acceleration?

$\leftarrow \vec{F}_{net}$

17N $\longleftarrow \bullet \longrightarrow$ 15N

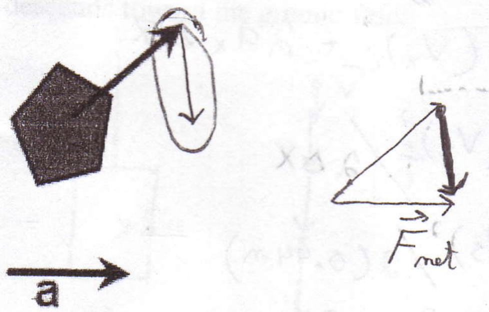
$\vec{F}_{net} = 15N - 17N$
$= -2N$

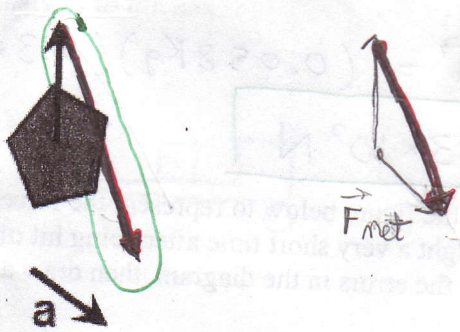
$$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{-2N}{0.200Kg} = -10\ m/s^2$$

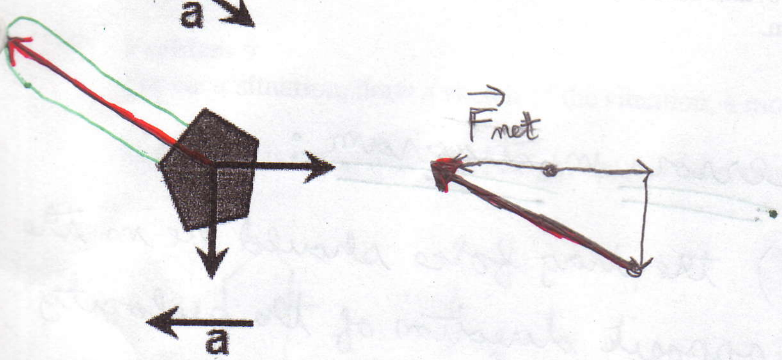
$\boxed{\vec{a} = 10\ m/s^2 \text{ to the left}}$

Problem 4
In the figures below, one force is missing. Use the given direction of acceleration to determine the missing force and draw it on object.

note: acceleration is in the same direction as the net force $\vec{F}_{net}$







Problem 5
Very small forces can have tremendous effects on the motion of very small objects. Consider a single electron, with a mass of 9.1×10^{-31} kg, subject to a single force equal to the weight of a penny, 2.5×10^{-2} N. What is the acceleration of the electron?

$m = 9.1 \times 10^{-31}$ Kg

$\vec{F}_{net} = 2.5 \times 10^{-2}$ N

$\vec{a} = ?$

$$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{2.5 \times 10^{-2}\ N}{9.1 \times 10^{-31}\ Kg} = 2.75 \times 10^{28}\ m/s^2$$

$\cancel{\vec{a} = (9.1 \times 10^{-31} Kg)(2.5 \times 10^{-2} N)}$

$\boxed{\cancel{\vec{a} = 3.6 \times 10^{-29}\ N \text{ in direction of force}}}$

Problem 6.
When a 58-g tennis ball is served, it accelerates from rest to a speed of 45 m/s. The impact with the racket gives the ball a constant acceleration over a distance of 44 cm. What is the magnitude of the net force acting on the ball?

$(V_x)_i = 0\,m/s$ $\qquad (V_x)_f^2 = \underbrace{(V_x)_i^2}_{=0} + 2a_x \Delta X$

$(V_x)_f = 45\,m/s$ $\qquad a_x = (V_x)_f^2 / 2\Delta X$

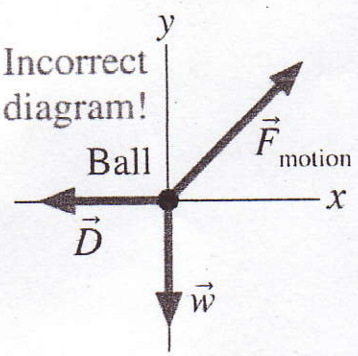
$\Delta X = 0.44\,m$ $\qquad a_x = (45\,m/s)^2 / 2(0.44\,m)$

$a_x = ?$ $\qquad = 2.3 \times 10^3\,m/s^2$

$$\vec{a} = \frac{\vec{F}_{net}}{m} \longrightarrow \vec{F}_{net} = m\vec{a} = (0.058\,Kg)(2.3\times10^3\,m/s^2)$$

$$\boxed{\vec{F}_{net} = 1.3\times10^2\,N}$$

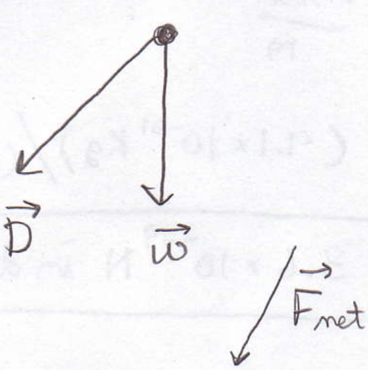
Problem 7
A student draws the flawed free-body diagram shown in the figure below to represent the forces acting on a golf ball that is traveling upward and to the right a very short time after being hit off the tee. Air resistance is assumed to be relevant. Identify the errors in the diagram, then draw a correct free-body diagram for this situation.



errors in diagram:

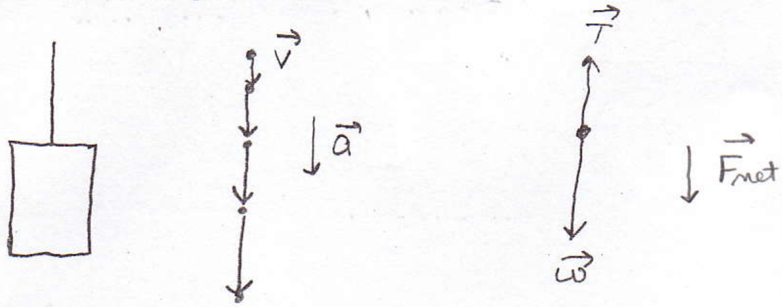
1) the drag force should be in the opposite direction of the velocity

2) there is no such force as $\vec{F}_{motion}$

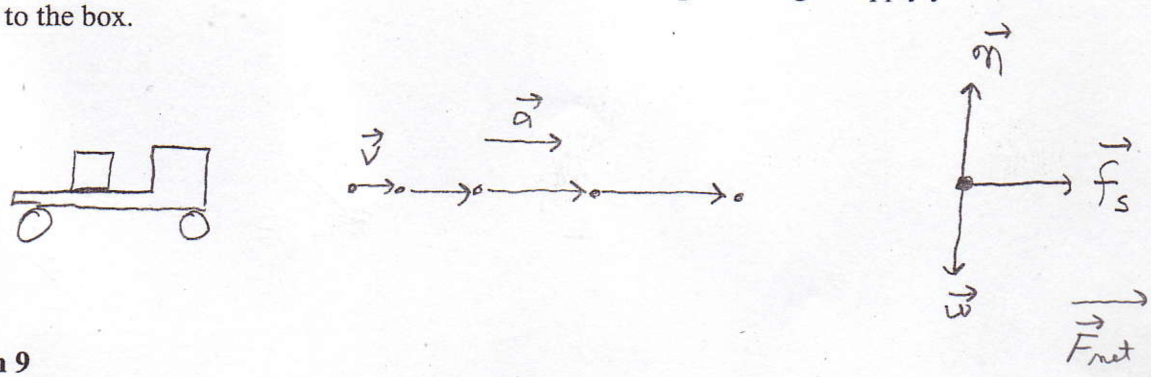


Problem 8
For each situation, draw a sketch of the situation, a motion diagram, and a FBD.

a) An elevator, suspended by a single cable, has just left the tenth floor and is speeding up as it descends toward the ground floor.

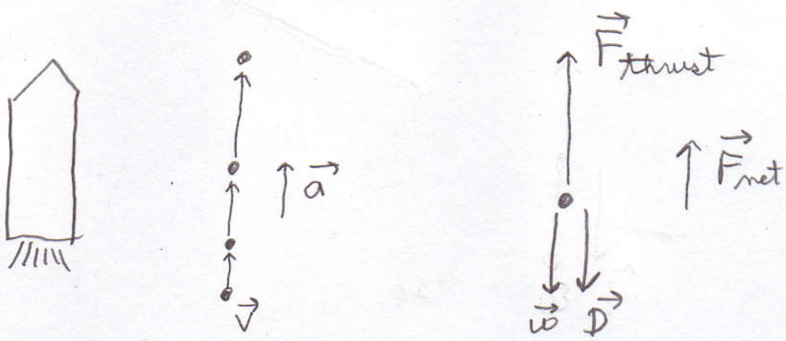


b) A heavy box is in the back of a truck. The truck is accelerating to the right. Apply your analysis to the box.



Problem 9
For each situation, draw a sketch of the situation, a motion diagram, and a FBD.

a) A rocket is being launched straight up. Air resistance is not negligible.



b) You've slammed on the brakes and your car is skidding to a stop while going down a 20° hill.