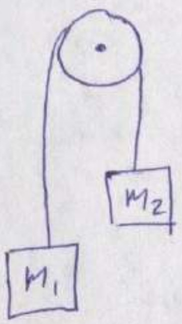
B6 #1

An atwood machine is a simple pulley



$m_1 = 8$ kg
$m_2 = 5$ kg

What is the acceleration of the system?

① Start with $F = ma$ or $a = \frac{F_{net}}{m_T}$

② Calculate net force

$F_{net} = m_1 g - m_2 g$ why?

③ Next divide by the sum of the masses.

$$\frac{F_{net}}{m_1 + m_2} = \frac{m_1 g - m_2 g}{m_1 + m_2} = a$$

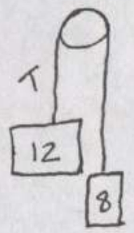
④ Complete the problem by substituting values.

⑤ What is the tension in the string?

$T_{1 or 2} = mg \pm m_1 a$ Should we add or subtract?

⑥ Does T_1 equal T_2? Yes, No or Impossible to know

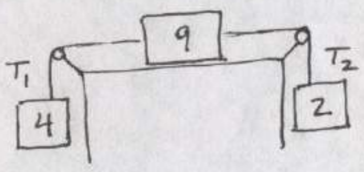
1. An atwood machine has an 8kg block hanging on one side and a 12 kg block hanging on the other side.



A.) Find the magnitude of the acceleration of the blocks.

B.) What is the tension in the string? (ignore the mass of the string)

2. Find the tension in each string for the 3-box system:



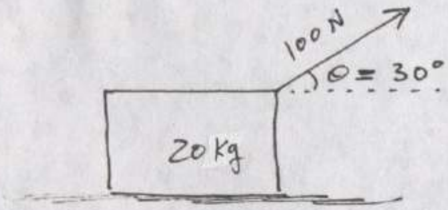
a.) if there is no friction

b.) if $\mu_K = .2$ for the surfaces of the table and 9kg block.

B6

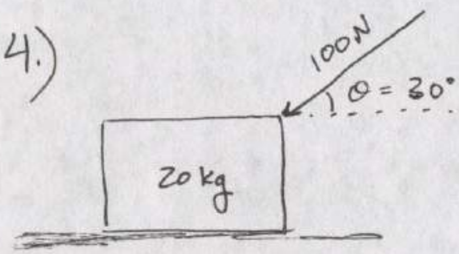
#3

3.)



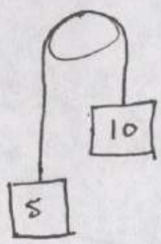
A box is being pulled along the ground with a slanted force as shown. The coefficient of kinetic friction between the box and the ground is $\mu_k = .3$ a.) Find the acceleration of the box. b.) Find force normal.

4.)



A box is being pushed along the ground with a slanted force as shown. The coefficient of kinetic friction between the box and the ground is $\mu_k = .3$ a.) Find the acceleration of the box. b.) Find force normal.

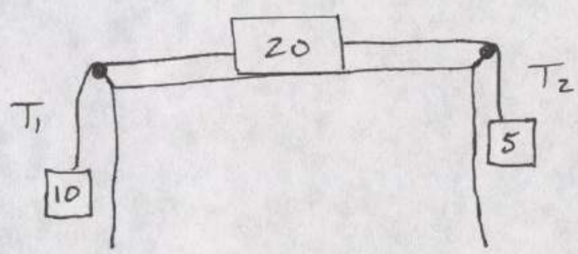
5.) An atwood machine has a 10 kg block hanging on one side and a 5 kg block on the other side.



A.) Find the magnitude of the acceleration of the blocks.

B.) what is the tension in the string?

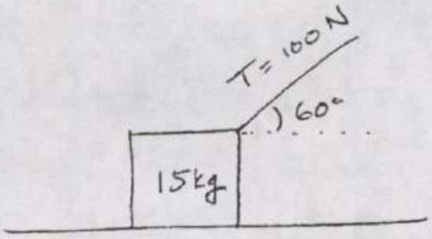
6.) Find the tension in each string for the 3 box system:



a.) if there is no friction

b.) if $\mu_k = .15$ between the 20 kg block and table.

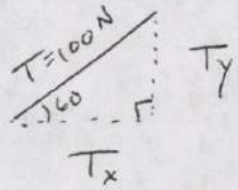
7.) Stationary Block



Label the Free body diagram

a.) What is the normal force exerted by the table? F_N = normal force

b.) In what direction is the normal force?



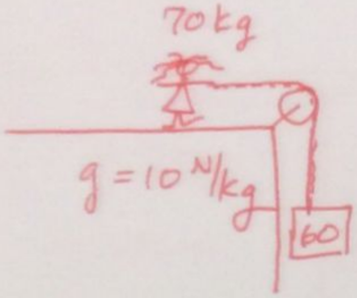
c.) In what direction is the tension?

d.) In what direction is the gravitational force?

$$\Sigma \vec{F}_y = m\, a_y$$

Solve for $\vec{F}_N$

$$\vec{F}_N + T_y - mg = m(0)$$

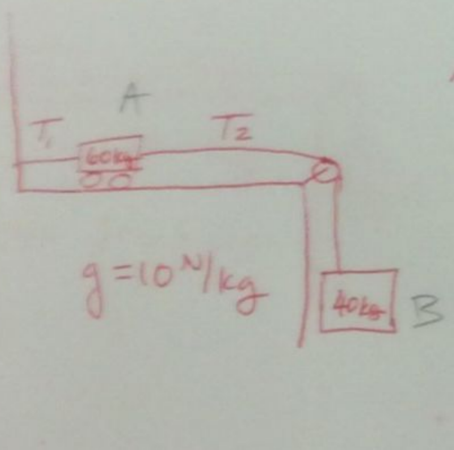


Dynamic

Frictionless Surface

1. Draw the force diagrams for
   (a) the woman
   (b) the 60kg object
2. Determine acceleration (two ways).
3. Find tension.

Static



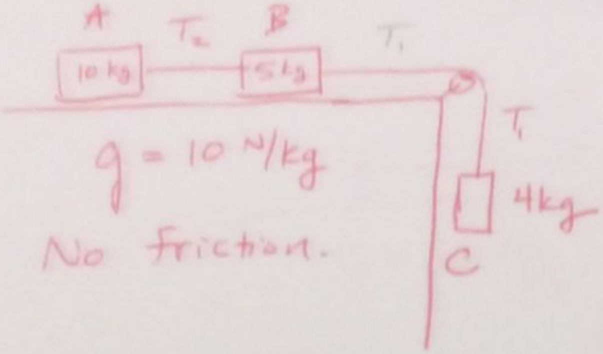
Assume no friction.

4.) What is the acceleration of the system?

5.) What is the tension in T_1?

6.) What is the tension in T_2?

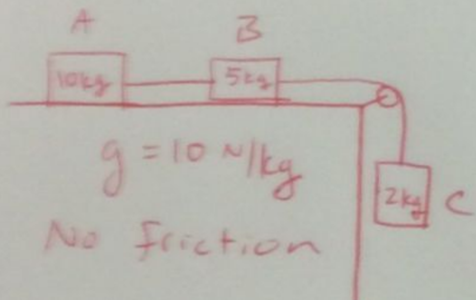
B6



g = 10 N/kg

No friction.

1. What is the acceleration of the system?
2. What is T_1?
3. What is T_2?



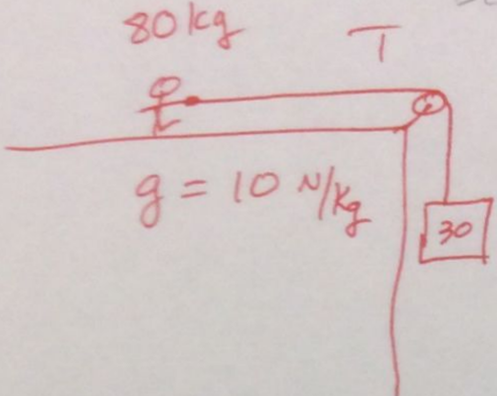
g = 10 N/kg

No friction

4. What is the acceleration of the system?
5. What is T_1?
6. What is T_2?

Dynamic

Begin by drawing the force diagrams.



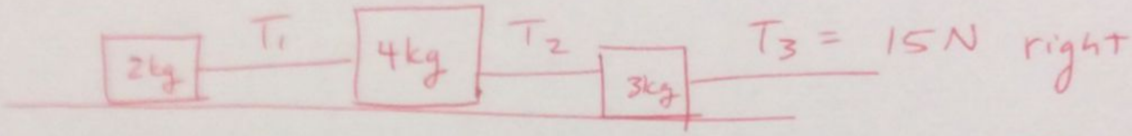
Part A $\mu_K = \mu_s = 0$

1. What is the acceleration of the system?
2. What is the tension?

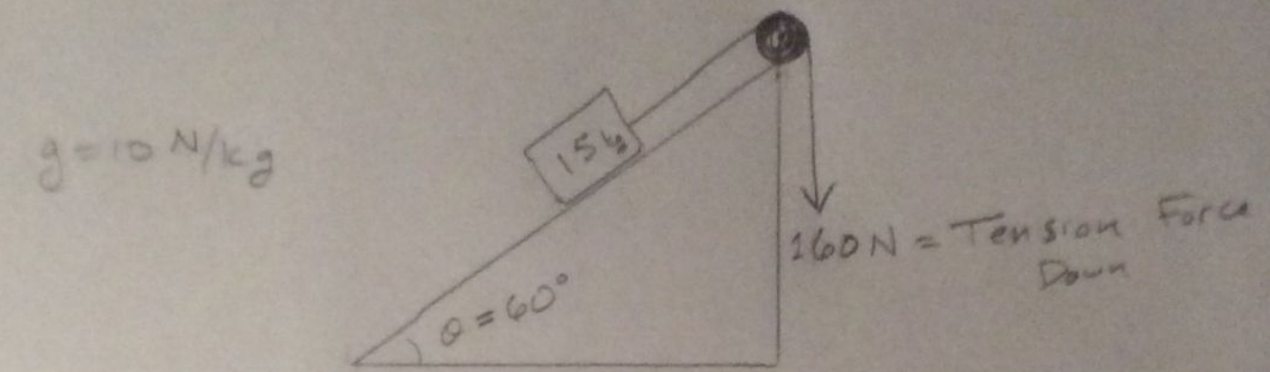
Part B $\mu_K = .2$, Assume $T > F_{static\ friction}$

1. What is the acceleration of the system?
2. What is the tension?

Assume no Friction.



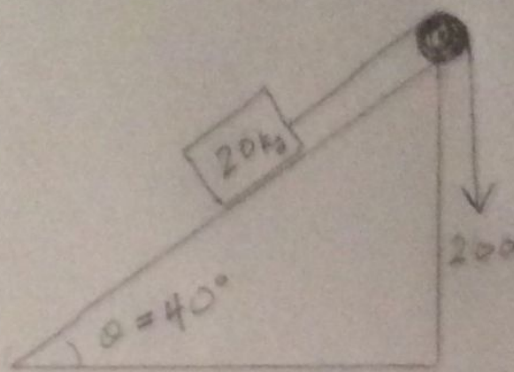
1. What is the acceleration of the system?
2. What is T_1?
3. What is T_2?



1. Assuming no friction: $\mu_K = \mu_s = 0$
   a.) what is $W_\perp$ for the block?
   b.) what is $W_\parallel$ for the block?
   c.) Write an equation for the net force on the block.
   d.) what is the acceleration of the block? Direction of motion?
   e.) If the block starts at rest, how much time is required for it to reach a velocity of 10 m/s?

2. Assume $\mu_s = .15$ and $\mu_K = .1$ between the block and ramp.
   a.) Determine static friction force. What direction is static friction?
   b.) Determine kinetic friction force. what direction is kinetic friction
   c.) write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If the block starts at rest, how much time is required for it to reach a velocity of 10 m/s?

3. Assume the tension force dissapears and the block begins at rest.
   a.) what direction is static friction?
   b.) what direction is kinetic friction?
   c.) write an equation for the net force on the block.
   d.) what is the acceleration of the block? Direction of motion?
   e.) If $V_i = 0$ and $V_f = 10$ m/s, what is the time?

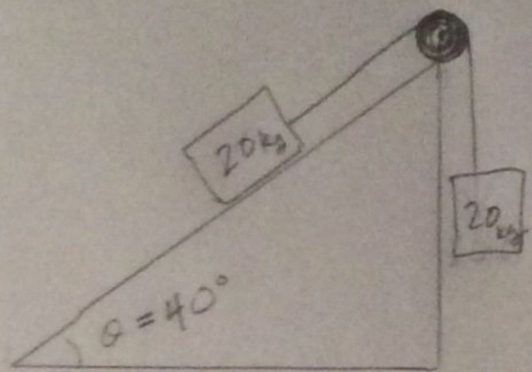


1. Assuming no friction: $\mu_K = \mu_S = 0$
   a.) what is $W_\perp$ for the block?
   b.) what is $W_\parallel$ for the block?
   c.) Write an equation for the net force on the block.
   d.) what is the acceleration of the block? Direction of motion?
   e.) If the block starts at rest, how much time is required for it to reach a velocity of 10 m/s?

2. Assume $\mu_S = .16$ and $\mu_K = .11$ between the block and ramp
   a.) Determine static friction force. What direction is static friction?
   b.) Determine kinetic friction force. what direction is kinetic friction
   c.) Write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If the block starts at rest, how much time is required for it to reach a velocity of 10 m/s?

3. Assume the tension force dissapears and the block begins at rest.
   a.) what direction is static friction?
   b.) what direction is kinetic friction?
   c.) Write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If $V_i = 0$ and $V_f = 10$ m/s what is the time?

$g = 10$ N/kg



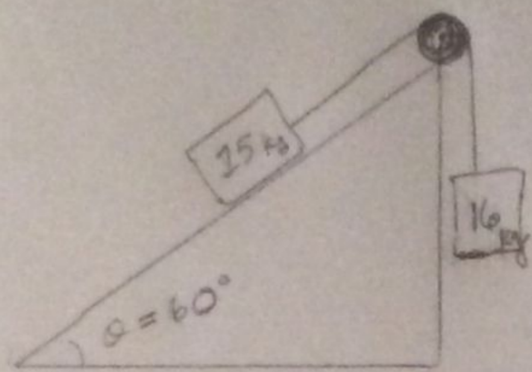
1. Assuming no friction: $\mu_K = \mu_S = 0$
   a.) What is $W_\perp$ for the block?

   b.) What is $W_\parallel$ for the block?
   c.) Write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If the block starts at rest, how much time is required for it to reach a velocity of 10 m/s?

2. Assume $\mu_S = .16$ and $\mu_K = .11$ between the block and ramp.
   a.) Determine static friction force. What direction is static friction?
   b.) Determine kinetic friction force. What direction is kinetic friction
   c.) Write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If the block starts at rest, how much time is required for it to reach a velocity of 10 m/s?

3. Assume the tension force dissapears and the block begins at rest.
   a.) What direction is static friction?
   b.) What direction is kinetic friction?
   c.) Write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If $V_i = 0$ and $V_f = 10$ m/s, what is the time?

$g = 10\ N/kg$



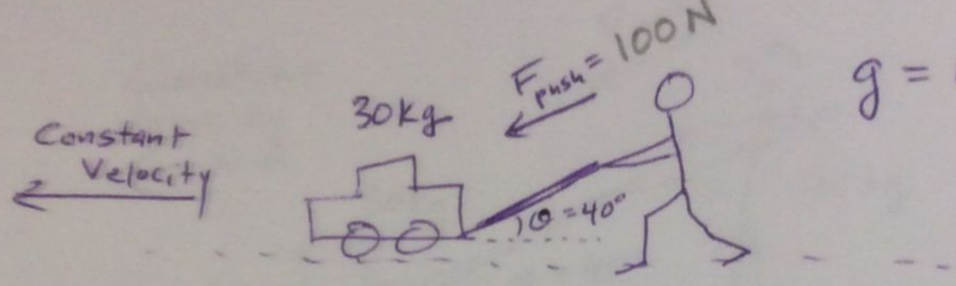
4. What is the tension in the rope?

1. Assuming no friction : $\mu_K = \mu_s = 0$
   a.) what is $W_\perp$ for the block?
   b.) what is $W_\parallel$ for the block?
   c.) Write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If the block starts at rest, how much time is required for it to reach a velocity of 10 m/s?

2. Assume $\mu_s = .15$ and $\mu_K = .1$ between the block and ramp.
   a.) Determine static friction force. What direction is static friction?
   b.) Determine kinetic friction force. what direction is kinetic friction
   c.) Write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If the block starts at rest, how much time is required for it to reach a velocity of 10 m/s?

3. Assume the tension force dissapears and the block begins at rest.
   a.) What direction is static friction?
   b.) what direction is kinetic friction?
   c.) Write an equation for the net force on the block.
   d.) What is the acceleration of the block? Direction of motion?
   e.) If $V_i = 0$ and $V_f = 10\ m/s$, what is the time?

Lawn Mower Problem 1



$g = 10 N/kg$

1. Draw a force diagram for the lawn mower.

2. what is the horizontal component of the F_{push}?

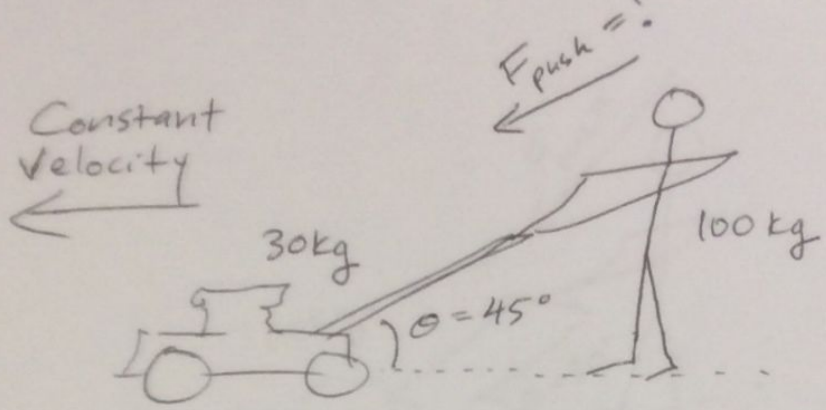
3. How does the horizontal component of F_{push} compare to the force friction on the lawn mower?

4. Write an equation for the vertical forces acting on the lawn mower.

5. Calculate force normal.

6. The horizontal component of Fpush depends on what two variables?
7. To maintain a constant velocity, what must occur to Fpush if θ increases?

Lawn Mower Problem 2



$g = 10\,N/kg$

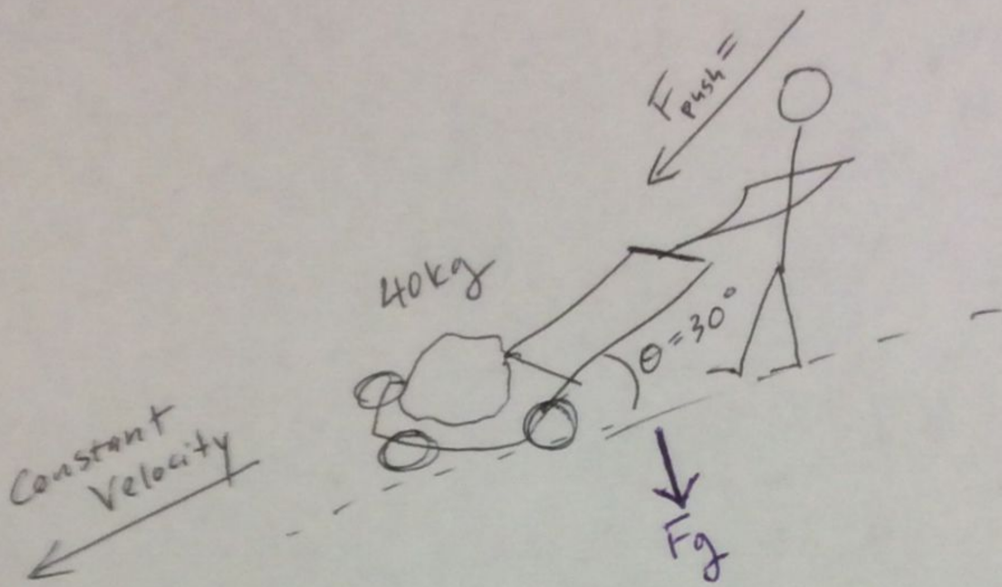
1. Draw a force Diagram for the lawn mower.

2. If $F_{Friction\ static} = 40\,N$ for the lawn mower tires and the ground, what is the $force_{push}$ required to keep the lawn mower at a constant velocity?

3. What is force normal?

4. What is μ_s?

Lawn Mower Problem 3



g = 10 N/kg

1. Draw a force diagram for the Lawn Mower.

2. What is the horizontal component of F_{push}?

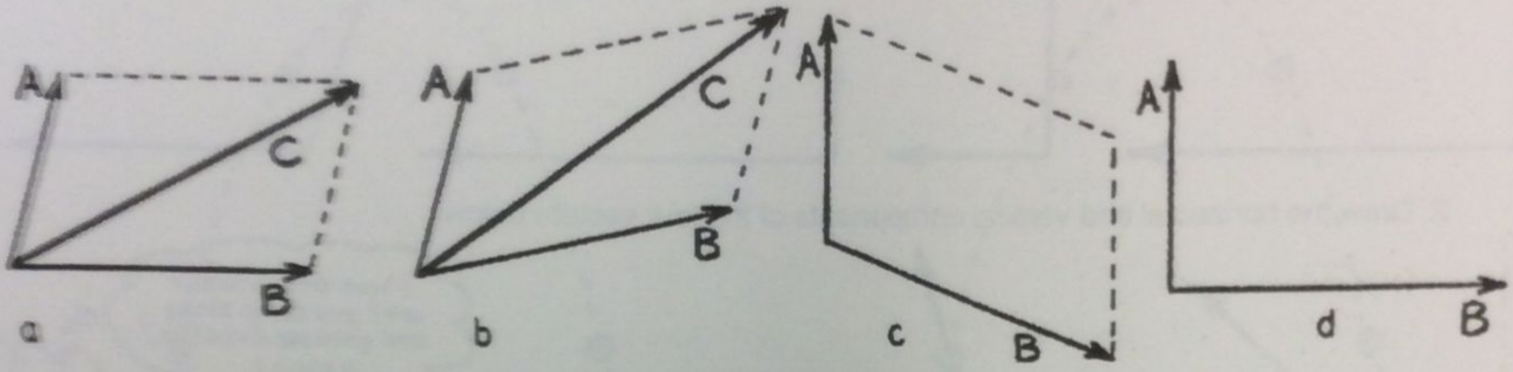
3. What is frictional force?

4. Calculate force normal.

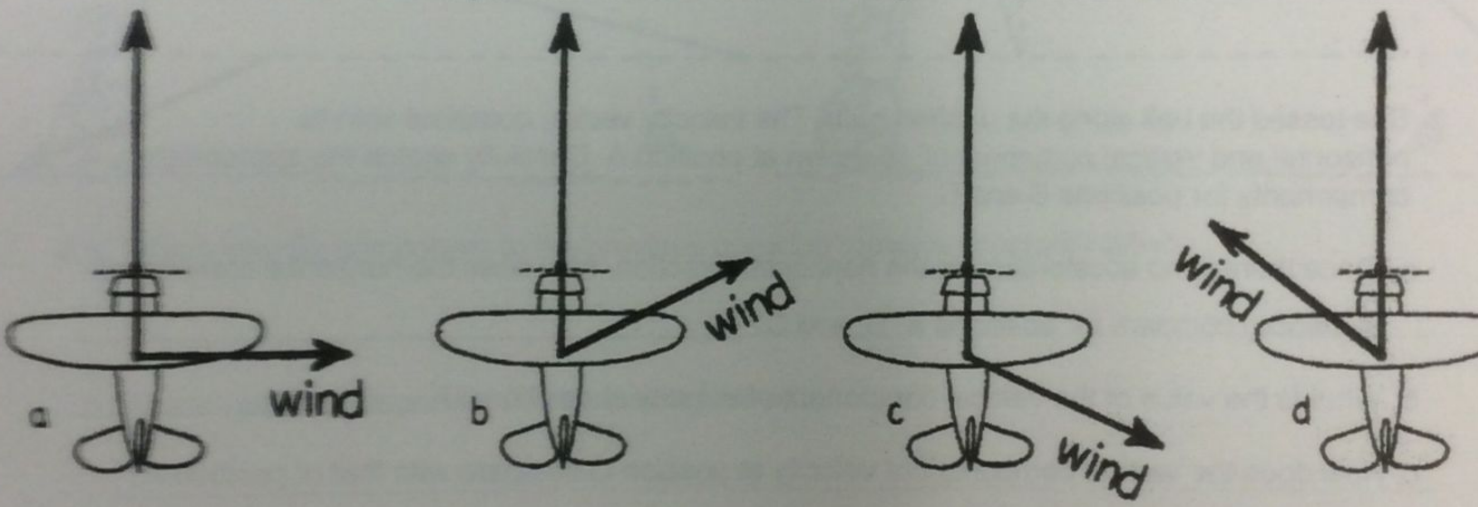
Chapter 5 Newton's Third Law of Motion

Vectors and the Parallelogram Rule

1. When two vectors **A** and **B** are at an angle to each other, they add to produce the resultant **C** by the *parallelogram rule*. Note that **C** is the diagonal of a parallelogram where **A** and **B** are adjacent sides. Resultant **C** is shown in the first two diagrams, *a* and *b*. Construct resultant **C** in diagrams *c* and *d*. Note that in diagram *d* you form a rectangle (a special case of a parallelogram).



2. Below we see a top view of an airplane being blown off course by wind in various directions. Use the parallelogram rule to show the resulting speed and direction of travel for each case. In which case does the airplane travel fastest across the ground? __________ Slowest? __________



3. To the right we see the top views of 3 motorboats crossing a river. All have the same speed relative to the water, and all experience the same water flow.

Construct resultant vectors showing the speed and direction of the boats.

a. Which boat takes the shortest path to the opposite shore?

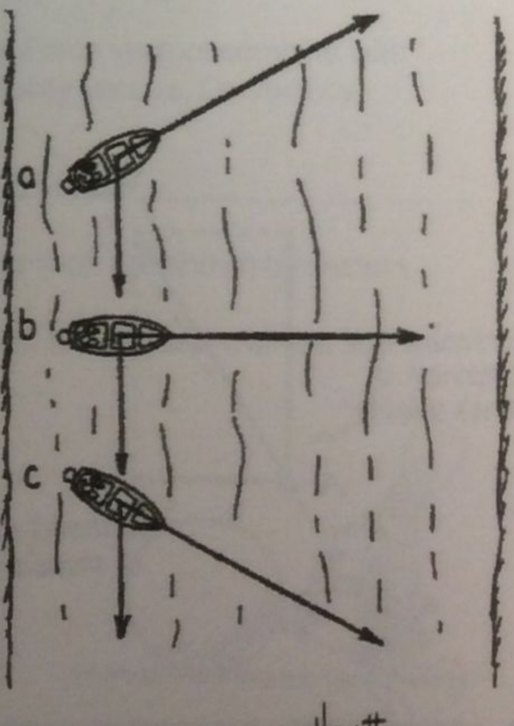
____

b. Which boat reaches the opposite shore first?

____

c. Which boat provides the fastest ride?

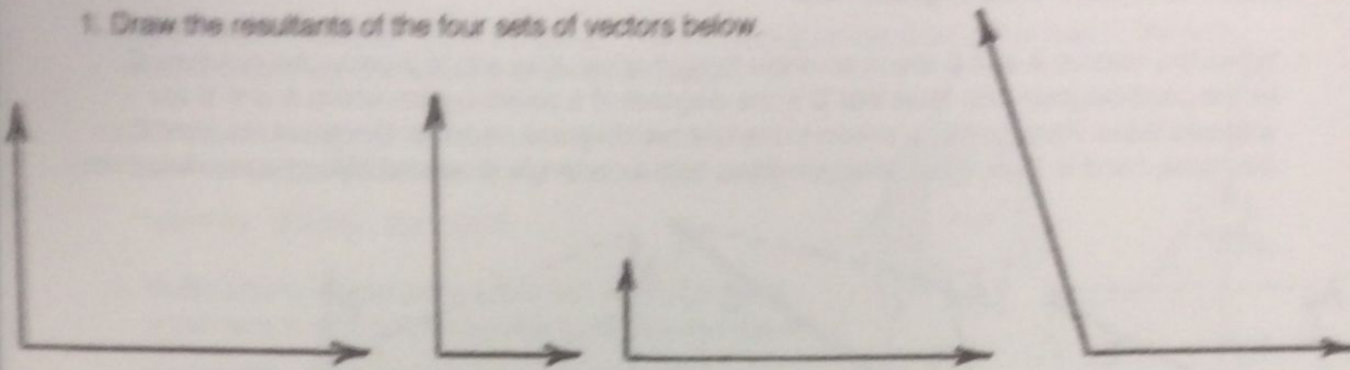
____



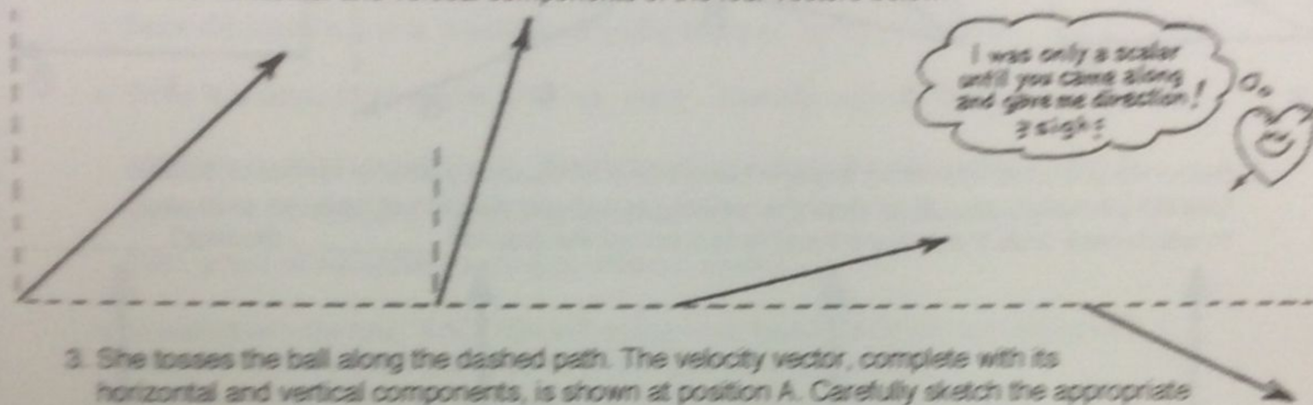
Chapter 5 Newton's Third Law of Motion

Velocity Vectors and Components

1. Draw the resultants of the four sets of vectors below.



2. Draw the horizontal and vertical components of the four vectors below.



3. She tosses the ball along the dashed path. The velocity vector, complete with its horizontal and vertical components, is shown at position A. Carefully sketch the appropriate components for positions B and C.

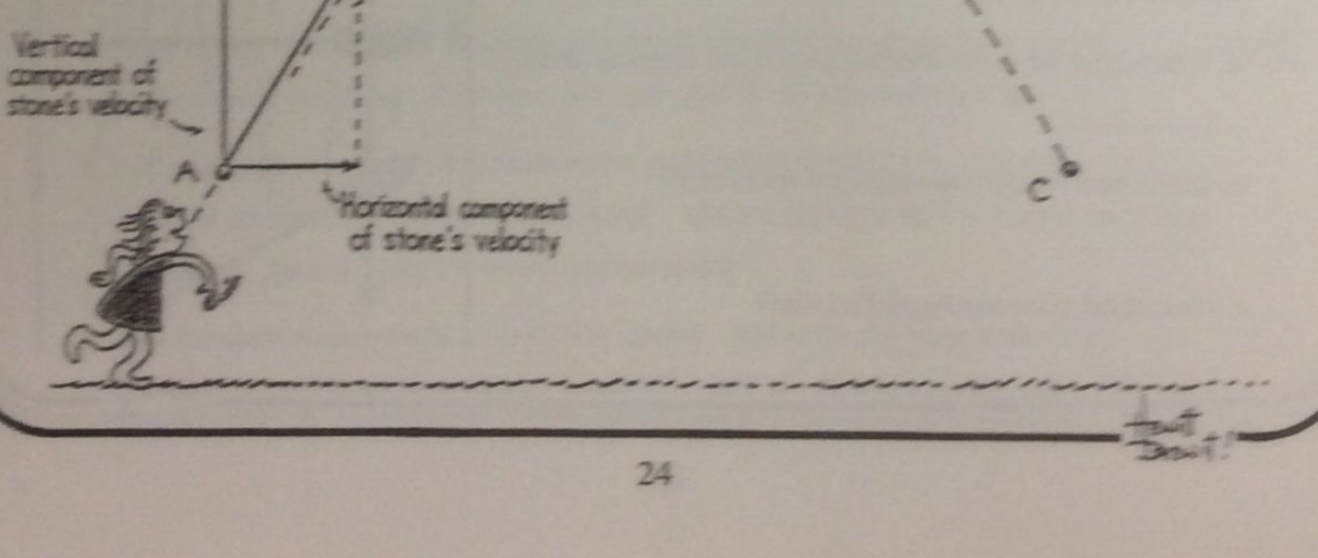
a. Since there is no acceleration in the horizontal direction, how does the horizontal component of velocity compare for positions A, B, and C? ____________________

b. What is the value of the vertical component of velocity at position B? ____________

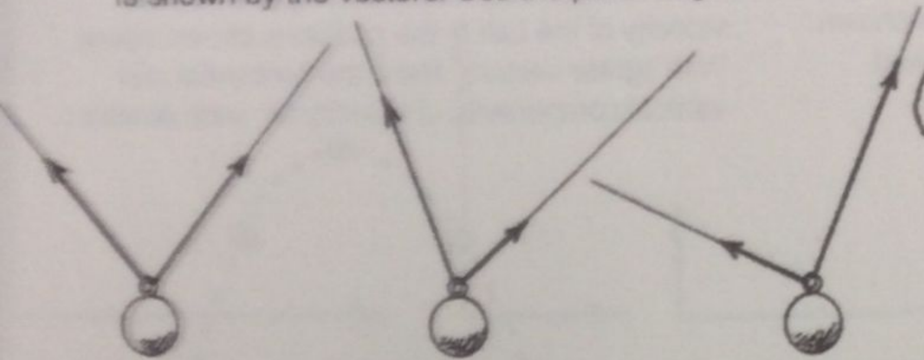
c. How does the vertical component of velocity at position C compare with that of position A?

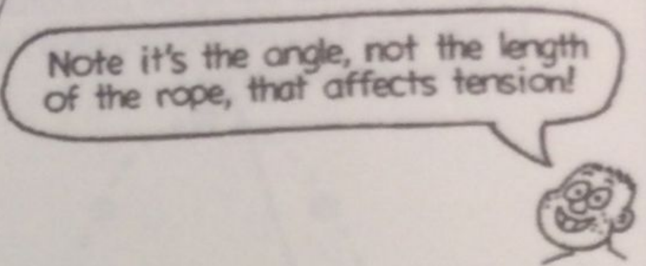
____

____



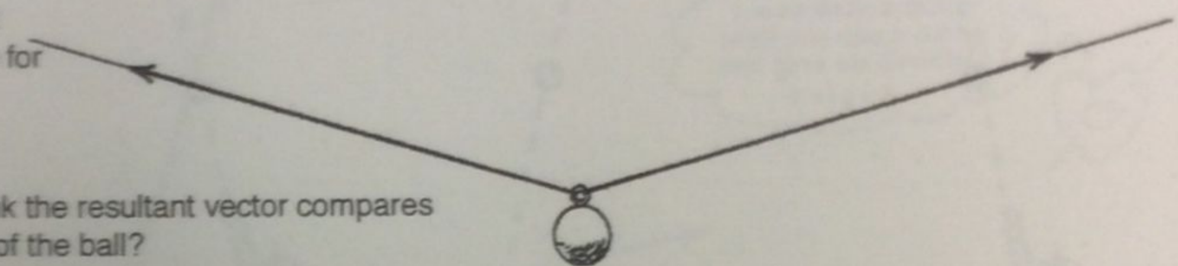
1. The heavy ball is supported in each case by two strands of rope. The tension in each strand is shown by the vectors. Use the parallelogram rule to find the resultant of each vector pair.





a. Is your resultant vector the same for each case?

____

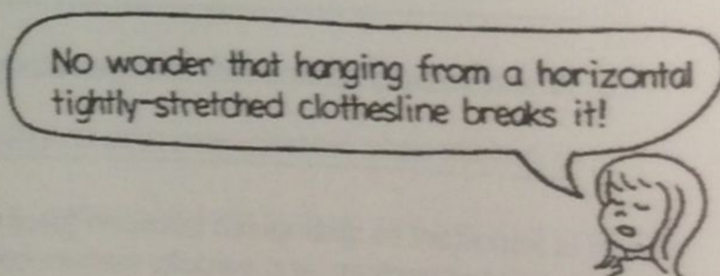


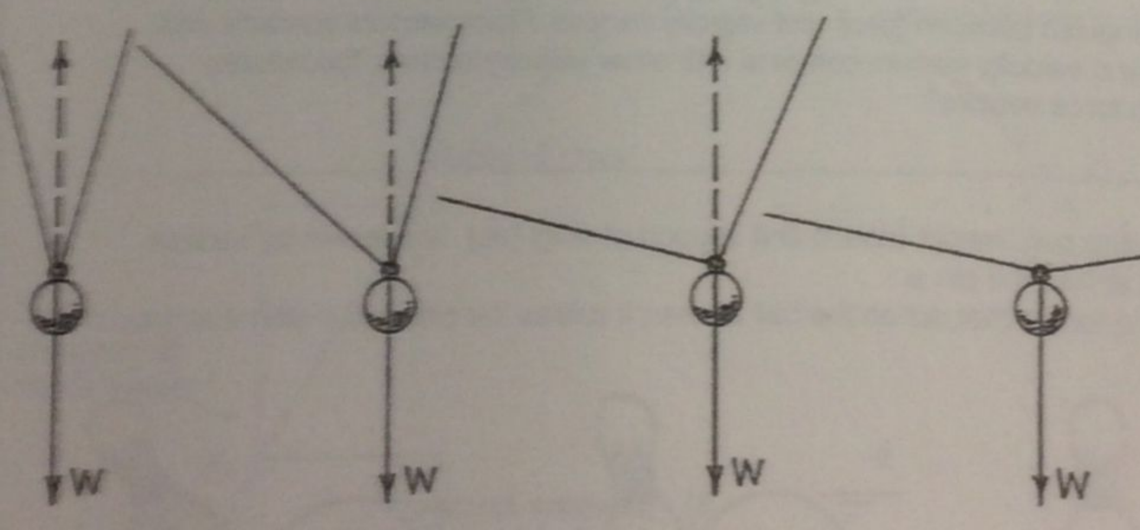
b. How do you think the resultant vector compares with the weight of the ball?

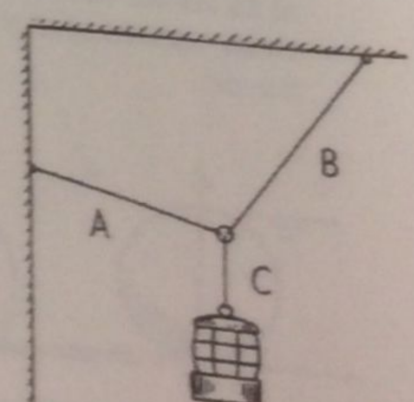
____

2. Now let's do the opposite of what we've done above. More often, we know the weight of the suspended object, but we don't know the rope tensions. In each case below, the weight of the ball is shown by the vector **W**. Each dashed vector represents the resultant of the pair of rope tensions. Note that each is equal and opposite to vectors **W** (they must be; otherwise the ball wouldn't be at rest).

a. Construct parallelograms where the ropes define adjacent sides and the dashed vectors are the diagonals.
b. How do the relative lengths of the sides of each parallelogram compare to rope tension?
c. Draw rope-tension vectors, clearly showing their relative magnitudes.







3. A lantern is suspended as shown. Draw vectors to show the relative tensions in ropes A, B, and C. Do you see a relationship between your vectors **A + B** and vector **C**? Between vectors **A + C** and vector **B**?

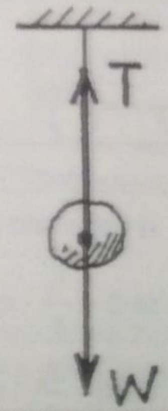
____

Chapter 5 Newton's Third Law of Motion

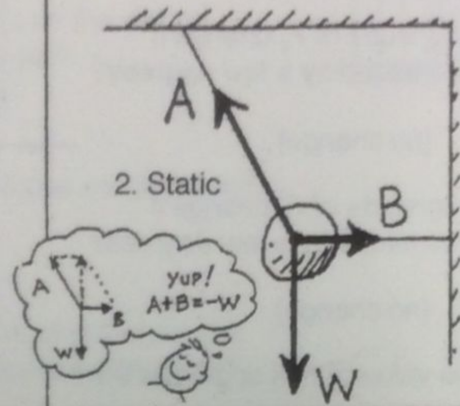
Force-Vector Diagrams

In each case, a rock is acted on by one or more forces. Using a pencil and a ruler, draw an accurate vector diagram showing all forces acting on the rock, and no other forces. The first two cases are done as examples. The parallelogram rule in case 2 shows that the vector sum of **A** + **B** is equal and opposite to **W** (that is, **A** + **B** = -**W**). Do the same for cases 3 and 4. Draw and label vectors for the weight and normal support forces in cases 5 to 10, and for the appropriate forces in cases 11 and 12.

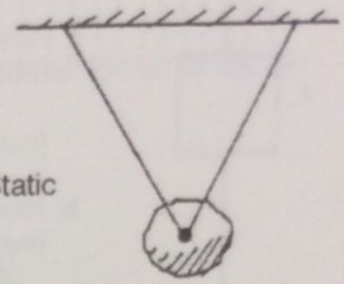
1. Static



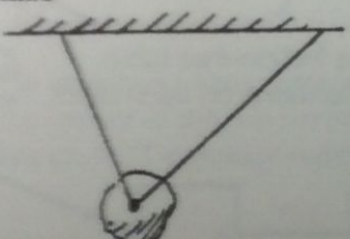
2. Static



3. Static



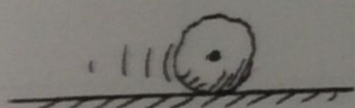
4. Static



5. Static

6. Sliding at constant speed without friction

7. Decelerating due to friction

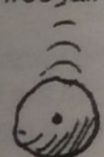


8. Static (Friction prevents sliding)

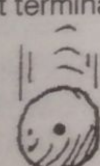
9. Rock slides (No friction)

10. Static

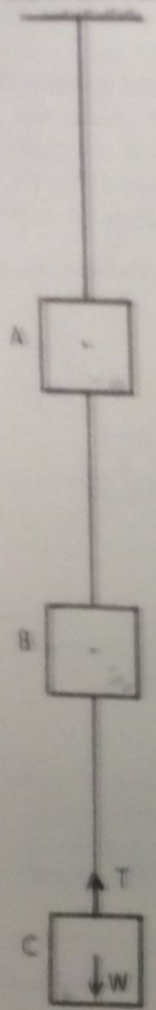
11. Rock in free fall



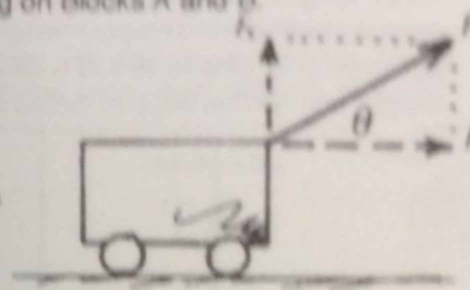
12. Falling at terminal velocity



More on Vectors



1. Each of the vertically-suspended blocks has the same weight **W**. The two forces acting on Block C (**W** and rope tension **T**) are shown. Draw vectors to a reasonable scale for rope tensions acting on Blocks A and B.



2. The cart is pulled with force **F** at angle θ as shown. F_x and F_y are components of **F**.

   a. How will the magnitude of F_x change if the angle θ is increased by a few degrees?

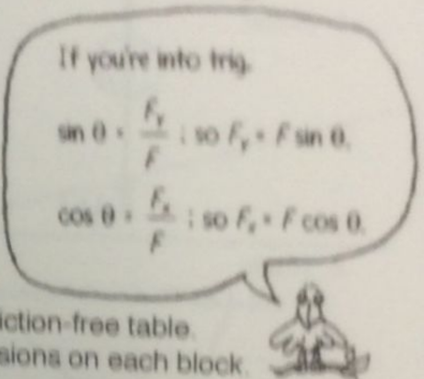
   [more] [less] [no change]

   b. How will the magnitude of F_y change if the angle θ is increased by a few degrees?

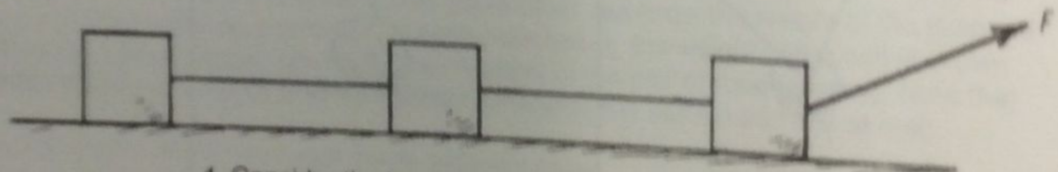
   [more] [less] [no change]

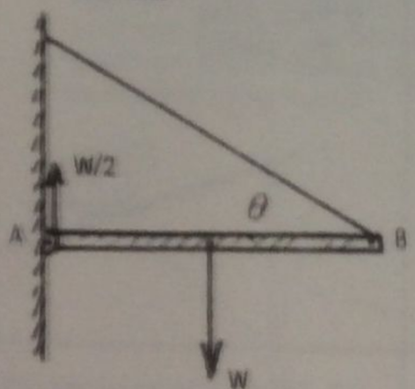
   c. What will be the value of F_x if angle θ is 90°?

   [more than **F**] [zero] [no change]



3. Force **F** pulls three blocks of equal mass across a friction-free table. Draw vectors of appropriate lengths for the rope tensions on each block.





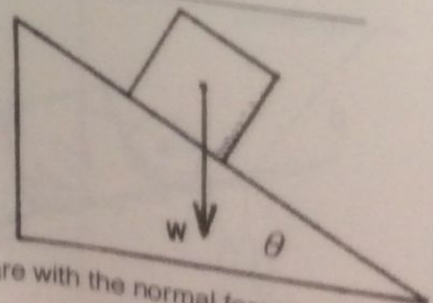
4. Consider the boom supported by hinge A and by a cable B. Vectors are shown for the weight **W** of the boom at its center, and **W**/2 for vertical component of upward force supplied by the hinge.

   a. Draw a vector representing the cable tension **T** at B. Why is it correct to draw its length so that the vertical component of **T** = **W**/2?

   ____

   b. Draw component T_x at B. Then draw the horizontal component of the force at A. How do these horizontal components compare, and why?

   ____



5. The block rests on the inclined plane. The vector for its weight **W** is shown. How many other forces act on the block, including static friction? __________ Draw them to a reasonable scale.

   a. How does the component of **W** parallel to the plane compare with the force of friction? ______________________________

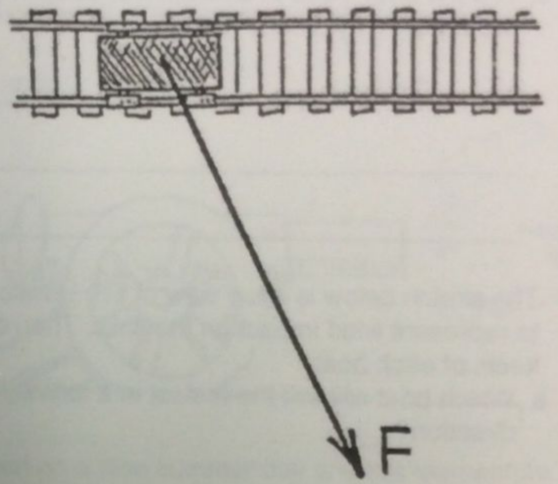
   b. How does the component of **W** perpendicular to the plane compare with the normal force?

Appendix D More About Vectors

Vectors and Sailboats

(Please do not attempt this until you have studied Appendix D!)

1. The sketch shows a top view of a small railroad car pulled by a rope. The force ***F*** that the rope exerts on the car has one component along the track, and another component perpendicular to the track.



a. Draw these components on the sketch. Which component is larger?

______

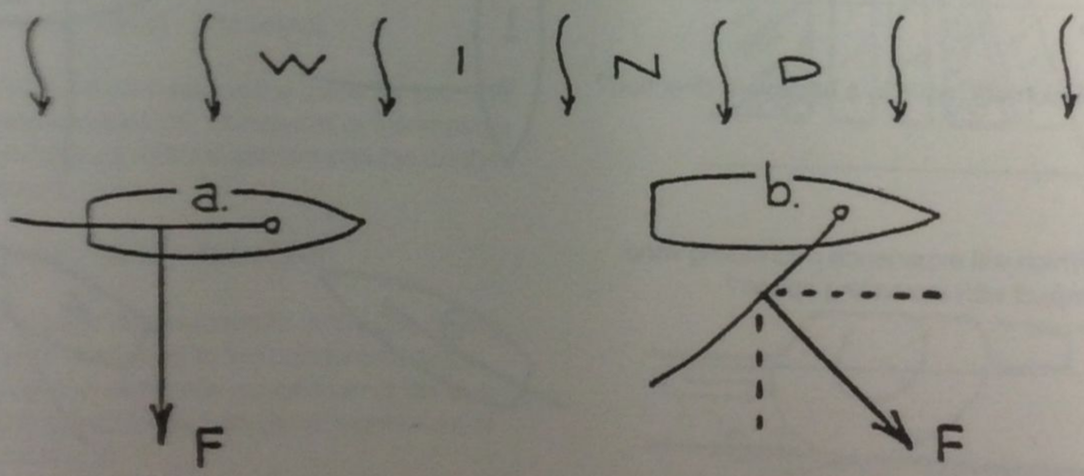
b. Which component produces acceleration?

______

c. What would be the effect of pulling on the rope if it were perpendicular to the track?

____

2. The sketches below represent simplified top views of sailboats in a cross-wind direction. The impact of the wind produces a FORCE vector on each as shown. (We do NOT consider *velocity* vectors here!)



a. Why is the position of the sail above useless for propelling the boat along its forward direction? (Relate this to Question 1.c above where the train is constrained by tracks to move in one direction, and the boat is similarly constrained to move along one direction by its deep vertical fin—the *keel*.)

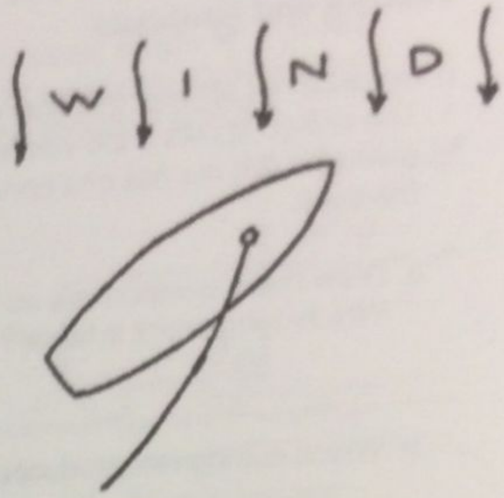
b. Sketch the component of force parallel to the to the direction of the boat's motion (along its keel), and the component perpendicular to its motion. Will the boat move in a forward direction? (Relate this to Question 1.b above.)

____

Appendix D More About Vectors

Vectors and Sailboats—continued

3. The boat to the right is oriented at an angle into the wind. Draw the force vector and its forward and perpendicular components.



   a. Will the boat move in a forward direction and tack into the wind? Why or why not?

____

____

____

4. The sketch below is a top view of five identical sailboats. Where they exist, draw force vectors to represent wind impact on the sails. Then draw components parallel and perpendicular to the keels of each boat.

   a. Which boat will sail the fastest in a forward direction?

____

   b. Which will respond least to the wind?

____

   c. Which will move in a backward direction?

____

   d. Which will experience decreasing wind impact with increasing speed?

____