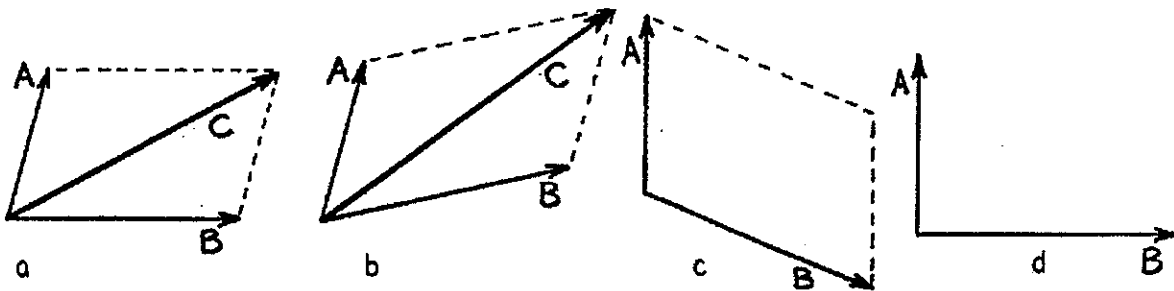


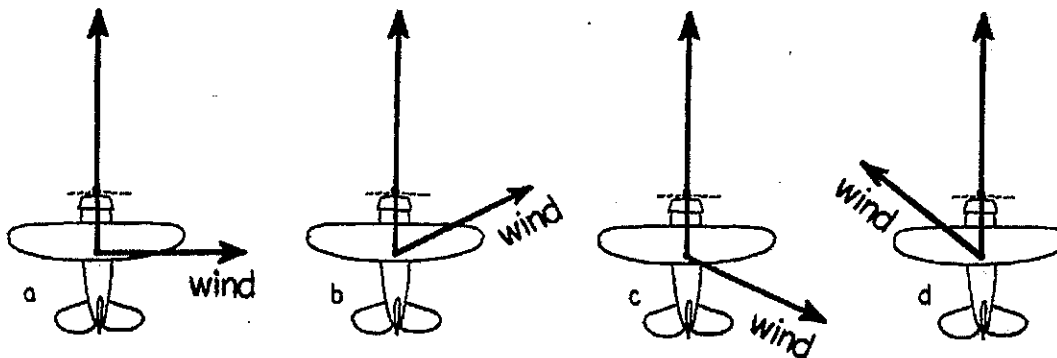
**CONCEPTUAL Physics** PRACTICE PAGE

**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? \_\_\_\_\_



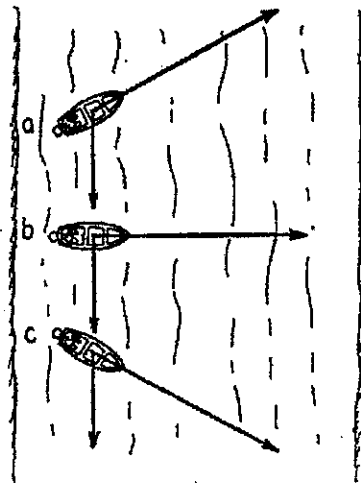
3. To the right we see the top views of 3 motorboats crossing a river. All have the same speed relative to the water, and all experience the same water flow.

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?  
 \_\_\_\_\_

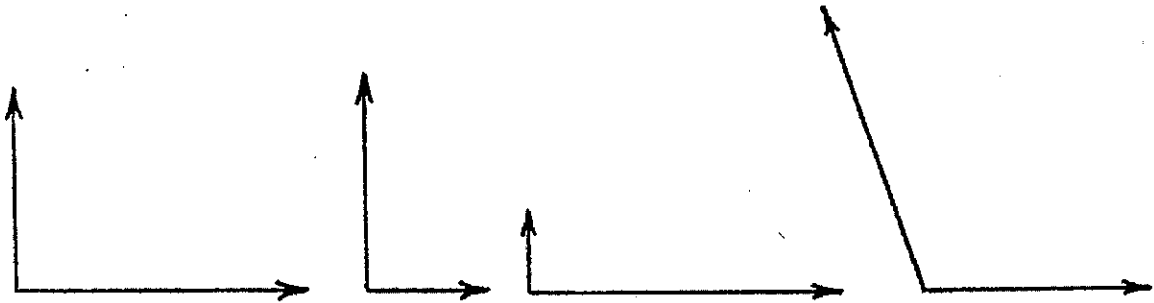
c. Which boat provides the fastest ride?  
 \_\_\_\_\_



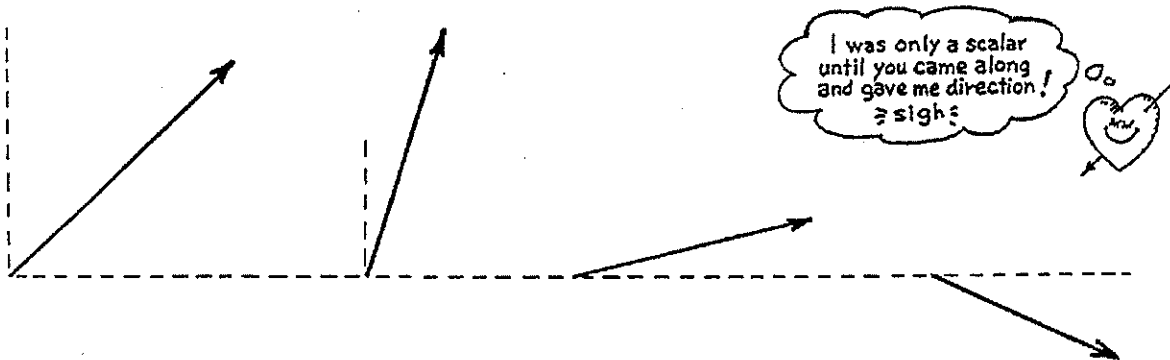
*Hewitt  
 Draw it!*

**Chapter 5 Newton's Third Law of Motion**  
**Velocity Vectors and Components**

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

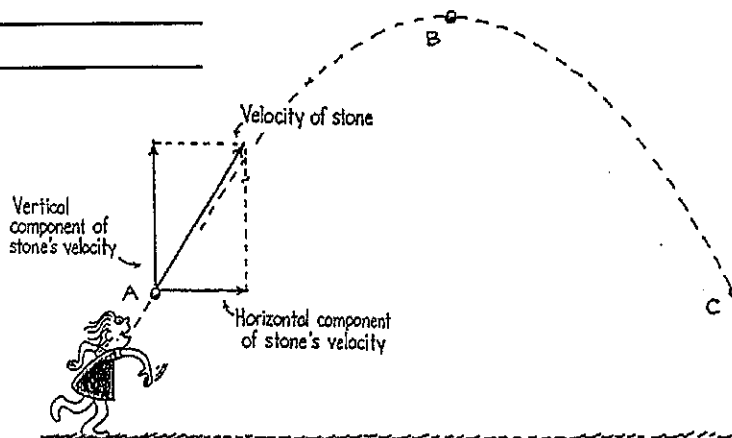


2. Draw the horizontal and vertical components of the four vectors below.



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.

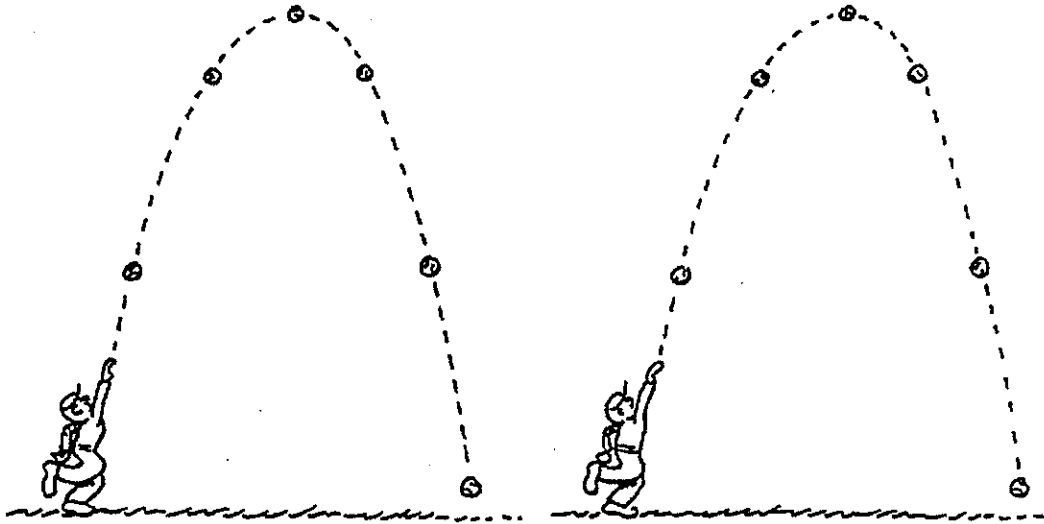
- Since there is no acceleration in the horizontal direction, how does the horizontal component of velocity compare for positions A, B, and C? \_\_\_\_\_
- What is the value of the vertical component of velocity at position B? \_\_\_\_\_
- How does the vertical component of velocity at position C compare with that of position A?  
 \_\_\_\_\_  
 \_\_\_\_\_



Hewitt  
 Draw it!

**CONCEPTUAL Physics** PRACTICE PAGE

**Chapter 5 Newton's Third Law of Motion**  
**Force and Velocity Vectors**



1. Draw sample vectors to represent the force of gravity on the ball in the positions shown above (after it leaves the thrower's hand). Neglect air resistance.
2. Draw sample bold vectors to represent the velocity of the ball in the positions shown above. With lighter vectors, show the horizontal and vertical components of velocity for each position.

3. a. Which velocity component in the previous question remains constant? Why?

\_\_\_\_\_

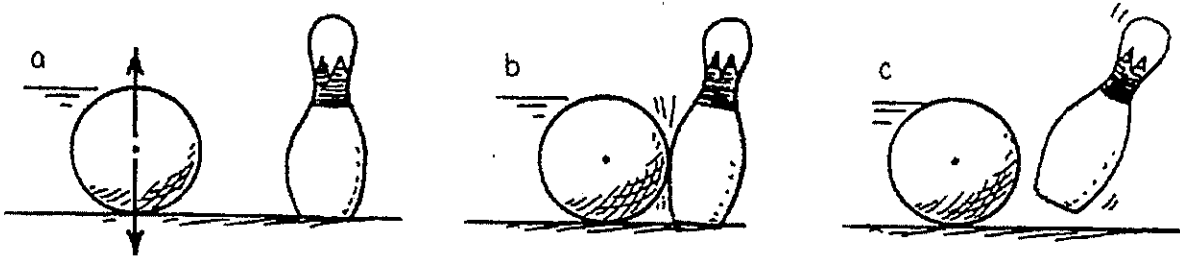
b. Which velocity component changes along the path? Why?

\_\_\_\_\_

4. It is important to distinguish between force and velocity vectors. Force vectors combine with other force vectors, and velocity vectors combine with other velocity vectors. Do velocity vectors combine with force vectors? \_\_\_\_\_

5. All forces on the bowling ball, weight (down) and support of alley (up), are shown by vectors at its center before it strikes the pin *a*.

Draw vectors of all the forces that act on the ball *b* when it strikes the pin, and *c* after it strikes the pin.

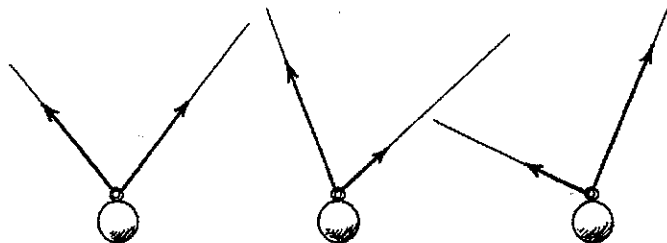


thanx to Howie Brand

Howitt  
Get it!

Chapter 5 Newton's Third Law of Motion  
Force Vectors and the Parallelogram Rule

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.



Note it's the angle, not the length of the rope, that affects tension!



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

b. How do you think the resultant vector compares to 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).

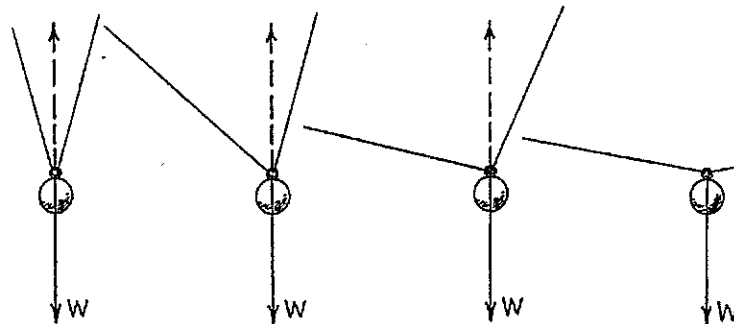
a. Construct parallelograms where the ropes define adjacent sides and the dashed vectors are the diagonals.

b. How do the relative lengths of the sides of each parallelogram compare with rope tension?  
\_\_\_\_\_

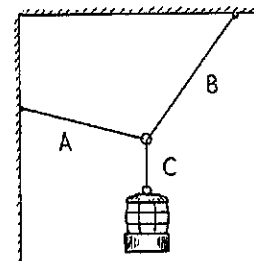
No wonder that hanging from a horizontal tightly stretched clothesline breaks it!



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**?



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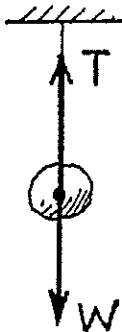
Hewitt  
Draw it!

# CONCEPTUAL *Physics* PRACTICE PAGE

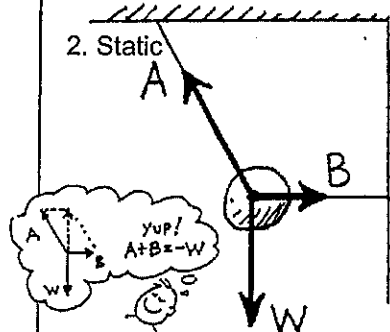
## Chapter 5 Newton's Third Law of Motion Force-Vector Diagrams

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.

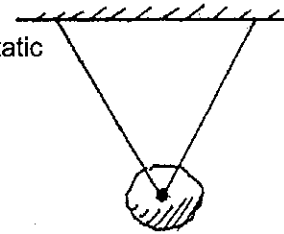
1. Static



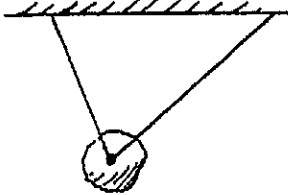
2. Static



3. Static



4. Static



5. Static



6. Sliding at constant speed without friction



7. Decelerating due to friction



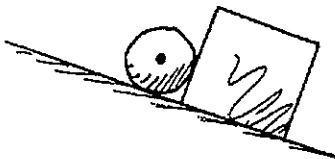
8. Static (Friction prevents sliding)



9. Rock slides (No friction)



10. Static



11. Rock in free fall



12. Falling at terminal velocity



thank to Jim Court

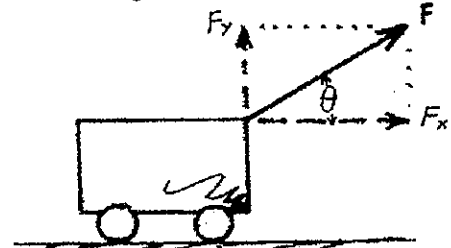
Hewitt  
Drawit!

Chapter 5 Newton's Third Law of Motion  
More on Vectors



1. Each of the vertically suspended blocks on the left 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  $\theta$  as shown.  $F_x$  and  $F_y$  are components of  $F$ .



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

[More] [Less] [No change]

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

[More] [Less] [No change]

c. What will be the value of  $F_x$  if angle  $\theta$  is  $90^\circ$ ?

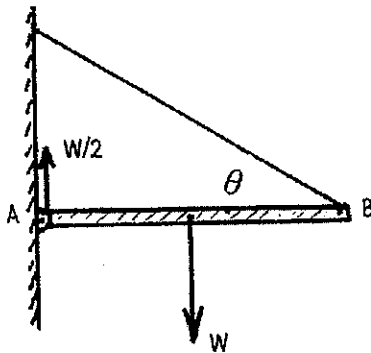
[More than  $F$ ] [Zero] [No change]

If you're into trig,  
 $\sin \theta = \frac{F_y}{F}$ ; so  $F_y = F \sin \theta$ .  
 $\cos \theta = \frac{F_x}{F}$ ; so  $F_x = F \cos \theta$ .

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



4. Consider the boom supported by hinge A and by a cable at 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  $T = W/2$ ?

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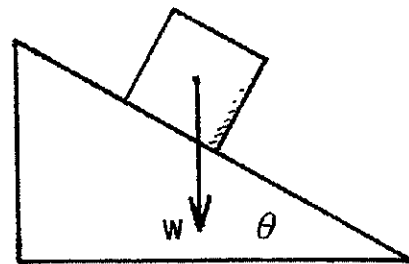
b. Draw component  $T_x$  at B. Then draw the horizontal component of the force at A. How do these horizontal components compare, and why?

\_\_\_\_\_

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? \_\_\_\_\_



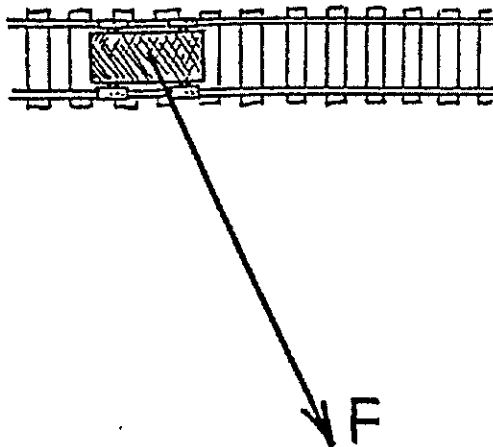
Hewitt  
Draw it!

**CONCEPTUAL Physics** PRACTICE PAGE

**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.



Draw these components on the sketch.

a. Which component is larger?

\_\_\_\_\_

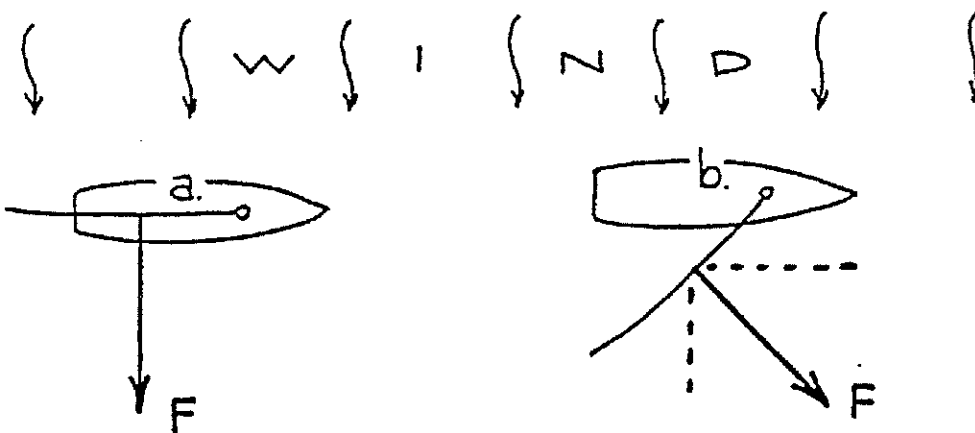
b. Which component produces acceleration?

\_\_\_\_\_

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 1c above. Where the train is constrained by tracks to move in one direction, the boat is similarly constrained to move along one direction by its deep vertical fin—the keel.)

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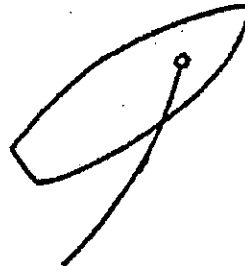
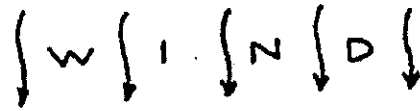
b. Sketch the component of force parallel to the direction of the boat's motion (along its keel), and the component perpendicular to its motion. Will the boat move in a forward direction? (Relate this to Question 1b above.)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Hewitt  
Drewit!

**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?

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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?

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b. Which will respond least to the wind?

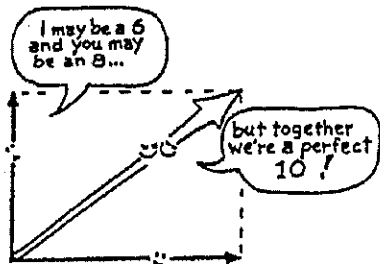
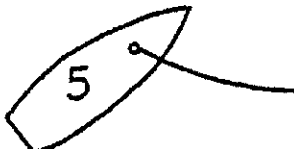
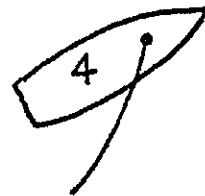
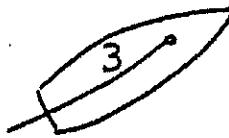
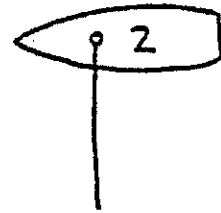
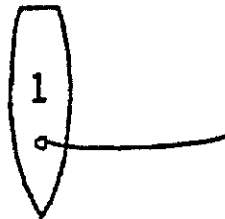
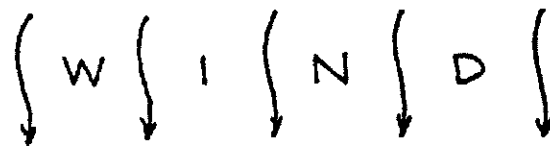
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c. Which will move in a backward direction?

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d. Which will experience less and less wind impact with increasing speed?

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Hewitt  
 Draw it!