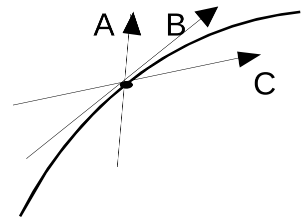
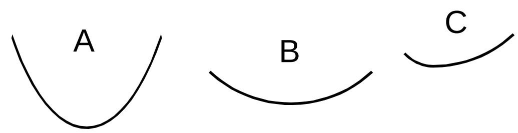
1. The curved line in the diagram at the right represents the path of a moving object. The dot on that path represents the location of the object at a certain time. At an earlier time the object was on the curve somewhere to the left of that dot, and later it is on the curve someplace to the right.



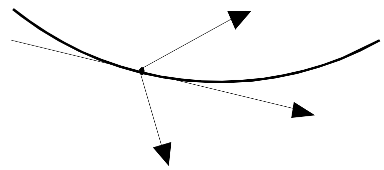
   a. The object's *velocity* can be described by an arrow through that dot. Which arrow correctly describes the object's velocity? ___ (Remember that the object moves *along* the curve, as in 7b on page 29.)
   b. Whenever an object moves along a curved path, its velocity is __________ to the curve. (See RS II.)

2. One of the curves at the right *could* be the path of a swinging pendulum bob. If the string does not stretch, the path must be a ________ar arc, like the one labelled ____.



   a. The speed of the bob ___creases whenever it is moving in a downhill direction, and ____creases whenever it is going uphill.
   b. The speed of the bob is neither increasing nor decreasing when the bob is at the ________ point of its path. *Please label that point on the bob's path sketched above.*

3. Which arrow in the diagram at the right describes the velocity of a pendulum bob just *before* it reaches the lowest point of its path? *Label it "V_1".* The other arrows are wrong because they are not ___________ to the curved path, as in 1b.



4. Draw a large arc on the back of this paper to represent the path of a swinging pendulum bob. Label the lowest point of the arc. Then make dots on the arc just before and just after that point.
   a. When the bob is passing through dot 1 (just before reaching the midpoint) its velocity is ___creasing because it is coasting *downhill*. When it passes through dot 2, just *after* passing through the midpoint, its velocity is ___creasing because it is coasting _________.
   b. Draw arrows through those dots (as in #1) to represent the velocity of the bob as it passes through them. Label the arrows "V_1" and V_2" respectively.
   c. If the second dot on the curve were *higher* than the first dot, then the new velocity would be ______ than the old velocity. If the second dot were *lower*, then V_2 would be ________ than V_1. (more, less)
   d. The second dot is really supposed to be at the *same* altitude as the first one, so the lengths of the two velocity arrows should be _______. *Please adjust them if necessary.*

5. Imagine that the V_1 arrow in #4 is a clock hand. If the "12 o'clock" direction is upward (toward the top of the paper) and the "3 o'clock" direction is eastward, then V_1 is approximately in the ___ o'clock direction, and V_2 is roughly toward ___ o'clock. (Actually, #4 says it must be *less* steep.)
   a. The 12-o'clock direction is upward, the 3-o'clock direction is eastward, and the 9-o'clock direction is ____ward. The 2 o'clock direction is ____ degrees ___ from east.
   b. The direction *opposite* to 2 o'clock is ___ o'clock, or ___ degrees ___ from _____. An arrow equal but opposite to V_1 would be roughly in the ___o'clock direction, but _____ steep. (more, less) *Draw* such an arrow in the space at the right. Label it "$-V_1$".
   c. Starting at the tip (point) of that arrow, draw and label an exact copy of the "V_2" arrow. (Remember that it points roughly in the ___ o'clock direction, but is _____ steeply tilted.)
   d. According to 4c, the lengths of those two arrows must be ______, (equal, unequal) and the absolute values of their their slopes must be ___________. Please adjust them if necessary.
   e. Draw a dotted arrow from the tail of $-V_1$ to the head of V_2. It represents the *vector sum* of $-V_1$ and ___. In other words, it describes the object's "________ in ________", as in 2b on page 41. *Label it.*
   f. If we divide that Δv by Δt (as in 2f on page 41) we see that the bob's acceleration was ______ward.

6. The **total force** on an object is the *vector sum of all the forces acting on it*. According to 4b on RS III the quotient in 5f is an ___ward vector *because* the total force on the object is _____ward. Does that theory agree with the observation you recorded in #4 on RS IV? _____ If not, which is wrong? ___

1. Vector *addition* was reviewed in #5 on page 34R. Here is a similar example involving *subtraction***:** Suppose I can paddle a canoe at 8.0 mph relative to the water. When I point the canoe eastward in a river and paddle normally I move relative to the ground at 10 mph, 37 degrees north from east.
   a. I know that V_{cg} = ___ + ___. Solving for the unknown, I get **V_{wg} = ___ - ___.**
   b. A negative velocity of 8.0 mph eastward is equivalent to a *positive* velocity of 8.0 mph ____ward, because reversing the *sign* of a vector is equivalent to reversing its __________. (clue for 3b)
   c. Reversing the direction of a relative velocity vector is also equivalent to _______ing its subscripts. For example, if V_{cw} is 8.0 mph eastward, then V_{wc} must be 8.0 mph _____ward.
   d. It would have been *incorrect* to reverse the vector called"V_{cg}" in this example because in equation 1a there is no _______tive sign in front of the V_{cg} in that equation.
   e. According to 1a-c, subtracting V_{cw} from V_{cg} is the same as *adding* ____ + ____.
   f. Use graphical vector addition (as on 34R) to determine and describe the water's velocity relative to the ground. Make your triangle big enough to get ±1% precision or better. (Use #12 on RS III.)
   g. Label each arrow clearly (using 1e) and describe the the resultant as on page 34R.

2. Suppose the price of an item was $10 yesterday and it is $11 today:
   Its *change* in price was ___ dollars. That change is calculated by ________ing the ____ price from the ____ price. (new, old) ____ - ____ = ____

3. Suppose my velocity changes from 10 m/sec east to 10 m/sec north during a 2.0-second time interval.
   a. If I *added* those two velocities, I would get 14.1 m/sec *northeast*. But to find the **CHANGE** in velocity I must _________ the ____ velocity from the ____ velocity. *Does #2 agree?* ____
   * b. Using that plan, describe the magnitude and direction of my change in velocity. Label each of the three arrows clearly, using the symbols V_1, V_2, and ΔV. *One of them must have a negative sign.*
   * c. We know that the "speed" of an object is the magnitude of its velocity. Is it correct to say that the *magnitude of the change in velocity* found in 3b is equal to the corresponding *change in speed?* Please give evidence to support your answer.

4. Suppose you are flying an airplane with a velocity "V_{pa}" relative to the air while the air is moving with a velocity "V_{ag}" relative to the ground. In flier's jargon, V_{ag} is called the "wind velocity", the magnitude of V_{pa} is the plane's "airspeed". Let "V_{pg}" represent the velocity of the plane relative to the ground. The magnitude of V_{pg} is called the aircraft's "groundspeed".
   a. Using #14 on RS II, how can V_{pg} be determined from the other two velocities? _________
   b. Is the resulting vector diagram necessarily a right triangle? ______
   * c. The wind velocity is learned from weather reports, and V_{pg} is determined from the location of your destination and your intended flying time. How can you use that information (with #1) to decide which way to point the plane and what airspeed to choose to reach the destination on schedule?

5. Suppose you intend to fly 100 miles south relative to the ground in 51 minutes. The wind is "45 mph out of the northeast". That means the air is moving southwest at 45 mph relative to the ground, or that the ground is moving ___________ at 45 mph relative to the _______, as in 1c.
   a. Describe your planned displacement relative to the ground: ____ ____ _____
   b. Describe your planned average *velocity* relative to the ground: V_{pg} = ______ mph ________
   c. According to #4, you can get V_{pa} by subtracting ____ from ____, or by *adding* ____ + _____.
   d. Do that on the back of this paper, striving for ± 1% precision. Show your method clearly. If you use a scale drawing then *describe its scale*. Then record the result here, using #2 on p. 34R.
   V_{pa} = ____ mph , ___ degrees _____ from ______.
   e. Use a protractor to measure each angle in the triangle. Record the results clearly on the diagram. Then use a ruler to measure each side of the triangle, and write those lengths (in cm.) on the arrows.
   f. Multiply each of those lengths by the scale factor that you recorded in 5d, in *mph per cm*. Record those results on the diagram also. Make sure that 5d agrees with them.