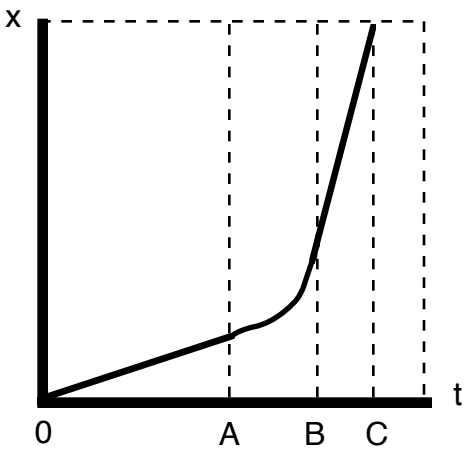
1. Position, velocity, and acceleration

Questions

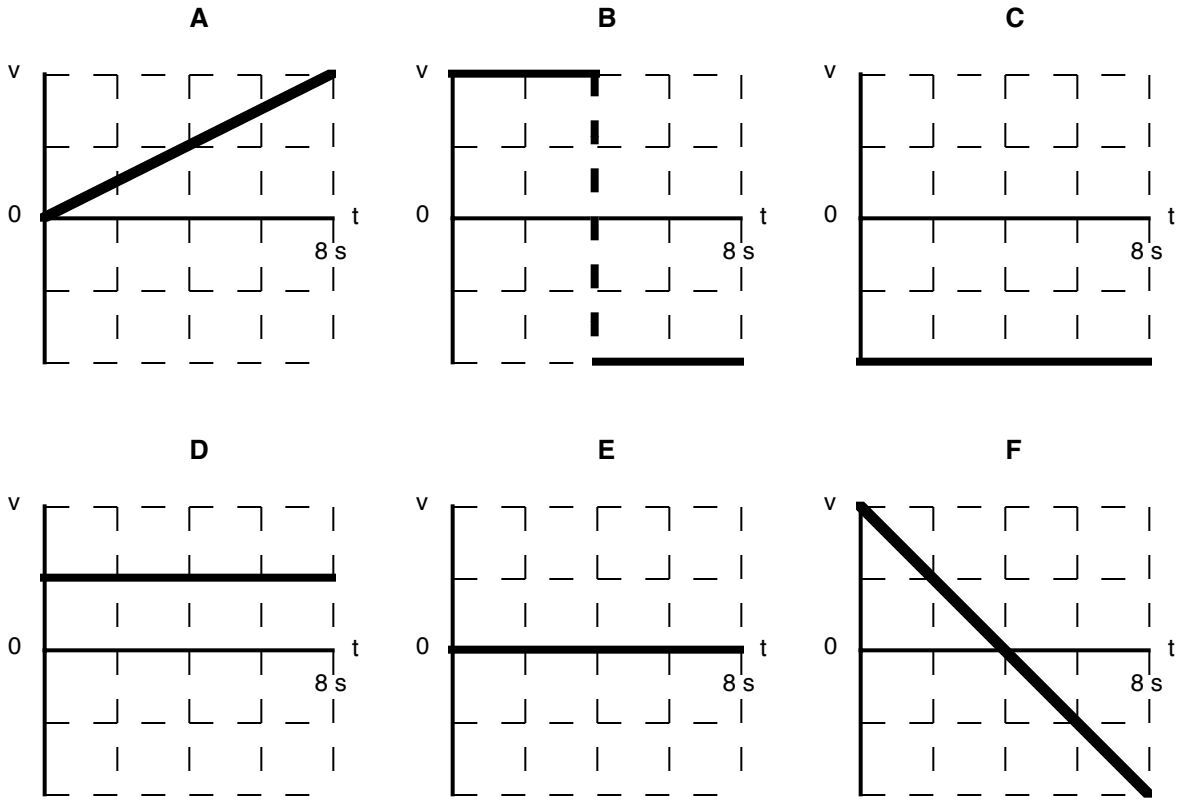
1. The diagram at right shows the position versus time graph for a car moving in a straight line.

   Describe in your own words what you would see the speedometer needle doing during the various phases of the motion: from 0 to A, from A to B, and from B to C.



2. As part of a demonstration on straight-line motion, a physics professor chooses six student "volunteers" to walk up to the front of the room. For each student, the professor draws a velocity versus time graph on the board, and the students must demonstrate the corresponding motion by walking back and forth in whatever way is required.

   On the next page are the graphs the professor used. **Each student started out from the initial position x_o at the initial time $t = 0$**. Refer to the graphs in order to answer the questions that follow. (By the way, the students' names are simply "A" through "F.")



(a) Which student(s), if any, have *returned to position* x_o *at time* $t = 8$ s?

(b) Which student(s), if any, *spend at least some time moving in the negative x direction*?

(c) Which student(s), if any, are *gradually speeding up* the entire time shown?

(d) Which student(s), if any, are *gradually slowing down* during part of the time shown?

(e) Which student(s), if any, *started* moving in the negative *x* direction and then *reversed* the direction of motion, traveling back towards the positive *x* direction?

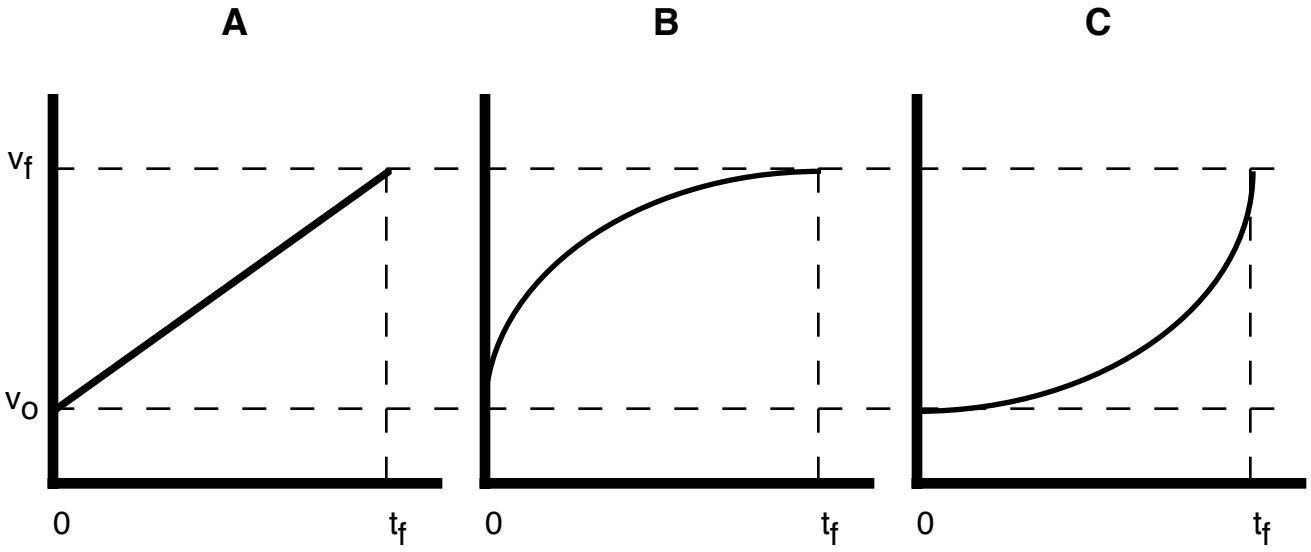
(f) Which student(s) are *farthest away from the initial position* at time $t = 8$ s?

(g) Which student(s), if any, are the *same distance from the initial position* at time $t = 8$ s?

(h) Which student(s), if any, *kept moving in the same direction* the whole time?

(i) Which student(s), if any, *stood still* at any time during the period shown?

3. Here are three different velocity versus time graphs for motion taking place between time $t = 0$ and time $t = t_f$.

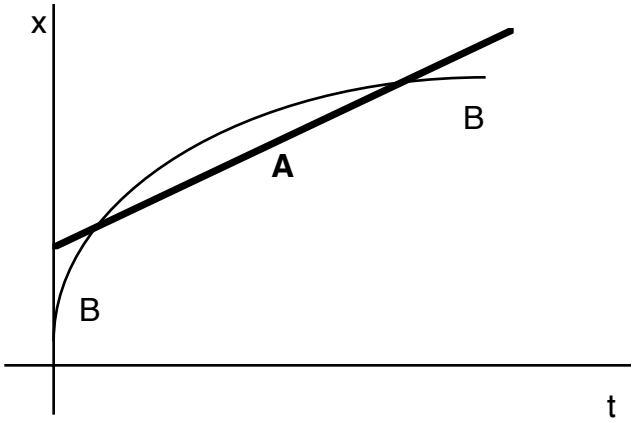


(a) In case (A) above, show that the average velocity over this time period is equal to $(v_o+v_f)/2$. [Hint: What is the definition of "average velocity"?]

(b) In case (B), will the average velocity of the time period be less than $(v_o+v_f)/2$, greater than $(v_o+v_f)/2$, or equal to $(v_o+v_f)/2$? Explain your reasoning. Try to give more than one explanation, if you can.

(c) Same question for case (C).

4. The figure shows position versus time graphs for the motion of two balls *A* and *B* rolling along parallel straight tracks.



(a) Along the *t*-axis, mark with a symbol t_p any instant or instants at which one ball is passing the other.

(b) For each t_p that you have marked, which ball, *A* or *B*, is moving faster? How can you tell?

(c) Along the *t*-axis, mark with the symbol t_{eq} any instant or instants at which the two balls have the same velocity.

(d) Finish the statement: "Over the period of time shown, ball *B* is ...

(i) ... speeding up all the time."
(ii) ... slowing down all the time."
(iii) ... speeding up part of the time and slowing down part of the time."

Explain.

(e) Over the time interval between passing points, does ball *B* travel a greater distance, a lesser distance, or the same distance, as ball *A*? Why?

Problems

Note: We expect that you will complete the "Problems" from each worksheet on your own paper. (Otherwise we have to charge lots of money just to give you blank paper that's been run through a copier.)

Be sure to save your work—you'll want to review it to study for exams!

1. A woman, driving her car west along a straight road, suddenly sees an obstacle in front of her. As quickly as possible, she applies her brakes. Her position after she applies her brakes is then described by

$$x(t) = 15\text{ m} + (20\text{ m/s})\,t - (1.3\text{ m/s}^2)\,t^2$$

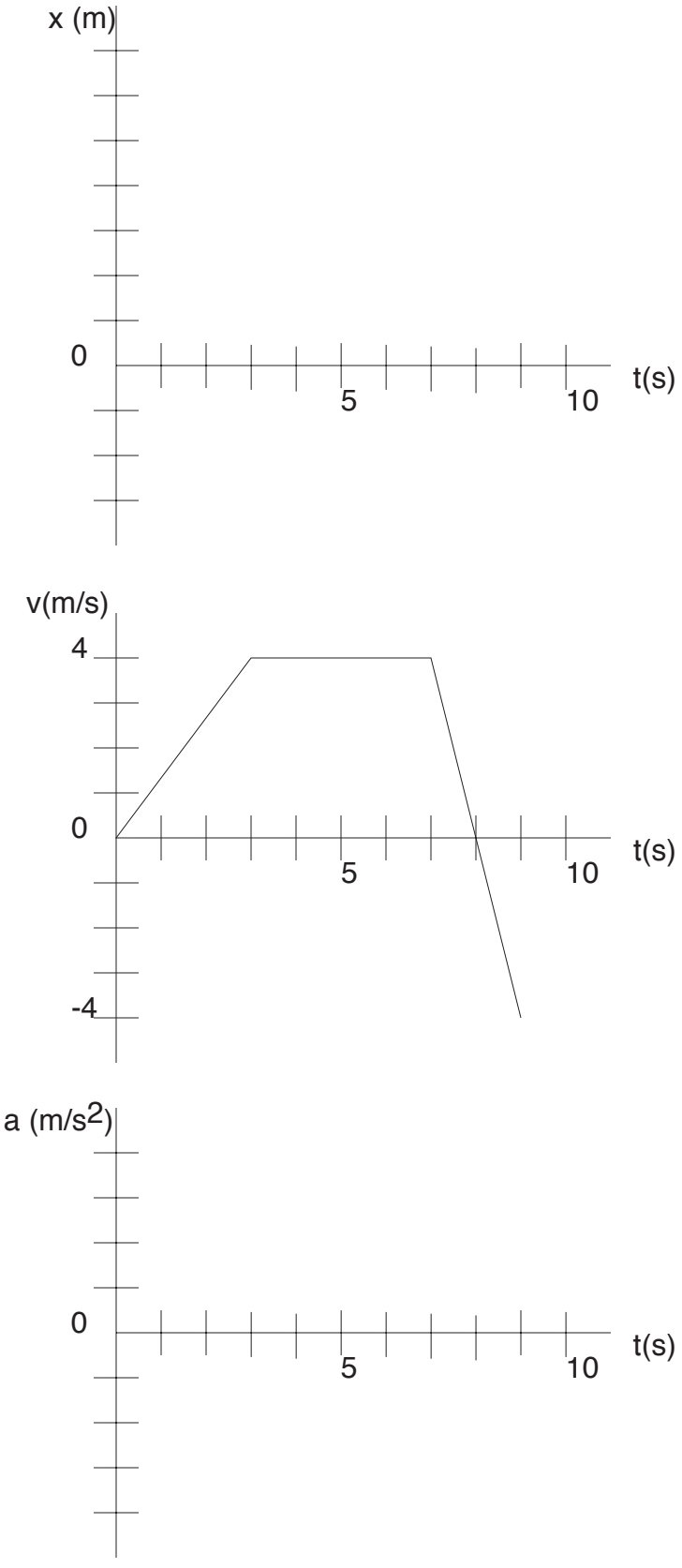
where t (in seconds) is the time elapsed since application of the brakes, and $x = 0$ was her position when she saw the obstacle.

   (a) What distance along the road does the woman travel between the instant that she sees the obstacle and the instant when she applies her brakes?
   (b) What is the velocity of the woman's car at any time t after that?
   (c) What is the velocity of the woman's car at the instant when she applies her brakes?
   (d) What time elapses between the instant when the woman applies her brakes and the time when her car comes to rest?
   (e) What is the car's acceleration at any time while the woman applies her brakes?

2. The center graph on the next page shows v versus t for a student traveling along a straight road.
   (a) Describe the motion in words.
   (b) Directly below this graph, sketch a graph of the acceleration versus time. Show numerical values for each segment.
   (c) Directly above the v versus t graph, sketch a graph of the student's position versus time. Be sure to get any curvatures correct.
   (d) How far is the student from her starting position after 4 s?
   (e) What is the student's maximum displacement from her starting position?
   (f) How far is she from her starting position after 9 s?

3. Sketch for each of the cases below a curve for x vs. t, v vs. t, and a vs. t.

   (a) Particle stays at position x_o for all time t.
   (b) Particle moves away from the origin at constant speed v_o.
   (c) Particle moves away from the origin starting from rest with increasing speed and constant acceleration.
   (d) Particle moves away from the origin starting with speed $v_o > 0$, with decreasing speed and decreasing deceleration, until it comes to rest.
   (e) [Challenge problem] A rubber ball is dropped from height H. It bounces off the ground, and then returns to height $0.8H$. From there it again falls, again bounces off the ground, and now returns to height $(0.8)^2H$. This cycle continues. Be sure your sketches include time intervals for when the ball is falling, in contact with the ground, and rising.


x (m)
0
5
10
t(s)
v(m/s)
4
0
-4
5
10
t(s)
a (m/s2)
0
5
10
t(s)