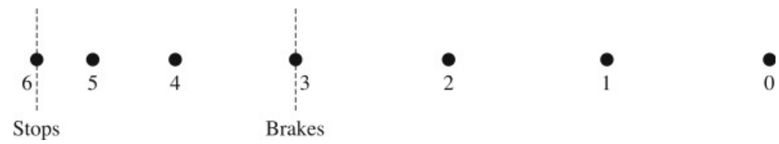
Physics 2A
Chapter 1 HW Solutions

Chapter 1
Conceptual Questions: 3, 9, 13, 16
Problems: 7, 10, 13, 14, 24, 30, 37, 44, 53, 62

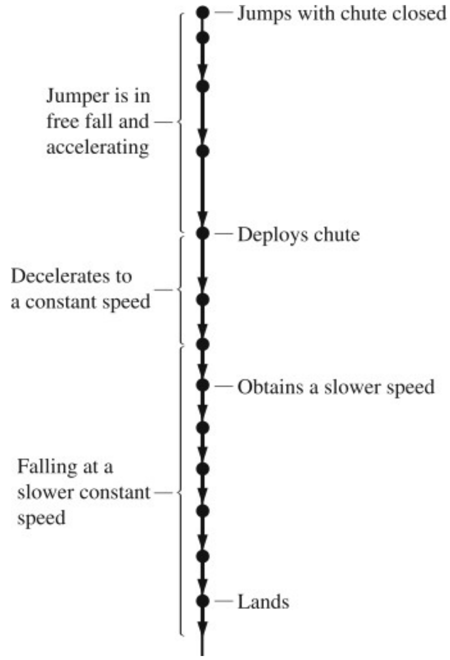
Q1.3. Reason:



Assess: The dots are equally spaced until the brakes are applied to the car. Equidistant dots indicate constant average speed. On braking, the dots get closer as the average speed decreases.

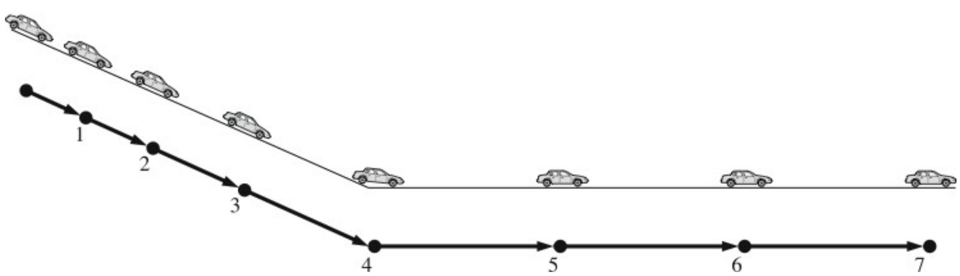
Q1.9. Reason: Yes, the velocity of an object can be positive during a time interval in which its position is always negative, such as when (in a usual coordinate system with positive to the right) an object is left of the origin, but moving to the right. For example, $x_i = -6.0$ m and $x_f = -2.0$ m. (The magnitude of Δt here is unimportant as long as time goes forward.)
However, the velocity (a vector) is defined to be the displacement (a vector) divided by the time interval (a scalar), and so the velocity *must* have the same sign as the displacement (as long as Δt is positive, which it is when time goes forward). So the answer to the second question is no.
Assess: We see again the importance of defining terms carefully and using them consistently. Students often use physics language incorrectly and then protest, "but you knew what I meant." However, incorrect word usage generally exposes incomplete or incorrect understanding.
Also note that unless stated otherwise, we assume that our coordinate system has positive to the right and that time goes forward (so that Δt is always positive).

Q1.13. Reason: The initial velocity is zero. The velocity increases and the space between position markers increases until the chute is deployed. Once the chute is deployed, the velocity decreases and the spacing between the position markers decreases until a constant velocity is obtained. Once a constant velocity is obtained, the position markers are evenly spaced. See the following figure.



Assess: Knowing the velocity of the jumper will increase until the chute is deployed and then rapidly decrease until a constant decent velocity is obtained allows one to conclude that the figure is correct.

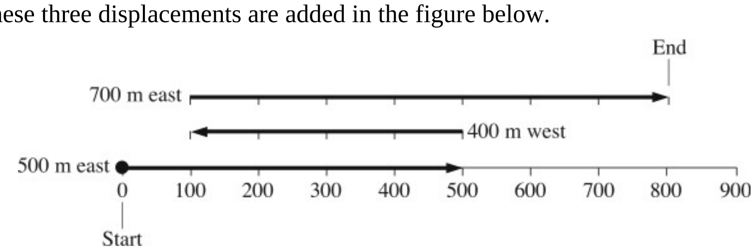
Q1.16. Reason: As the toy car rolls down the ramp, its speed increases because of the pull of gravity. In a motion diagram this is indicated by increasing length of velocity arrows. At the bottom of the ramp, the floor is horizontal. Since the floor is horizontal, gravity is no longer pulling the car to increase its velocity. At this point in the motion diagram the velocity is constant, which is indicated by arrows of constant length. The toy car continues with the speed obtained with no change in velocity. See the following diagram.



Assess: Compare to Question 1.12, which also has a motion diagram for a motion involving a part that is constant velocity and another where velocity is not constant.

P1.7. Prepare: We have been given three different displacements. The problem is straightforward since all the displacements are along a straight east-west line. All we have to do is add the displacements and see where we end up.

Solution: The first displacement is $\Delta\vec{x}_1$ = 500 m east, the second is $\Delta\vec{x}_2$ = 400 m west and the third displacement is $\Delta\vec{x}_3$ = 700 m east. These three displacements are added in the figure below.



From the figure, note that the result of the sum of the three displacements puts the bee 800 m east of its starting point.
Assess: Knowing what a displacement is and how to add displacements, we are able to obtain the final position of the bee. Since the bee moved 1200 m to the east and 400 m to the west, it is reasonable that it would end up 800 m to the east of the starting point.

P1.10. **Prepare:** We can use Equation 1.2 to calculate the horse's velocity at the different times.
Solve: Since the dots are spaced at equal intervals of time, and there is one dot between the time 10 s and 30 s, the spacing between the dots indicate a 10 s time interval. The dot between 10 s and 30 s will mark a time of 20 s. The horse is moving to the left, as time increases to the left, so the rightmost dot must be at 0 s. We will use the definition of velocity in Equation 1.2, $v = \Delta x/\Delta t$. Looking at Figure P1.10, it should be noted that you can't determine the distance information to better than 10 m and certainly not to 1 m. As a result 100 m has two significant figures (you know it is between 90 m and 110 m) and 50 m has one significant figure (you know it is between 40 m and 60 m). For this reason the answer to part (b) should have only one significant figure.
(a) Referring to the Figure P1.10 in the text, $x_\text{f} = 500\ \text{m},\ x_\text{i} = 600\ \text{m},\ t_\text{f} = 10\ \text{s},\ t_\text{i} = 0\ \text{s}$, so

$$v = \frac{\Delta x}{\Delta t} = \frac{500\ \text{m} - 600\ \text{m}}{10\ \text{s} - 0\ \text{s}} = \frac{-100\ \text{m}}{10\ \text{s}} = -10\ \text{m/s}$$

(b) Here, $x_\text{f} = 300\ \text{m},\ x_\text{i} = 350\ \text{m},\ t_\text{f} = 40\ \text{s},\ t_\text{i} = 30\ \text{s}$, so

$$v = \frac{\Delta x}{\Delta t} = \frac{300\ \text{m} - 350\ \text{m}}{40\ \text{s} - 30\ \text{s}} = \frac{-50\ \text{m}}{10\ \text{s}} = -5\ \text{m/s}$$

(c) In this case, $x_\text{f} = 50\ \text{m},\ x_\text{i} = 250\ \text{m},\ t_\text{f} = 70\ \text{s},\ t_\text{i} = 50\ \text{s}$, so

$$v = \frac{\Delta x}{\Delta t} = \frac{50\ \text{m} - 250\ \text{m}}{70\ \text{s} - 50\ \text{s}} = \frac{-200\ \text{m}}{20\ \text{s}} = -10\ \text{m/s}$$

Assess: Displacement and velocities are signed quantities. Since the *x*-axis increases to the right and the horse is traveling to the left, we should expect all the velocities to be negative.

P1.13. **Prepare:** In this problem we are given $x_\text{i} = 2.1$ m and $x_\text{f} = 7.3$ m as well as $v = 0.35$ m/s and asked to solve for Δt.
Solve: We first solve for Δt in $v = \Delta x/\Delta t$ and then apply $\Delta x = x_\text{f} - x_\text{i}$.

$$\Delta t = \frac{\Delta x}{v} = \frac{x_\text{f} - x_\text{i}}{v} = \frac{7.3\ \text{m} - 2.1\ \text{m}}{0.35\ \text{m/s}} = \frac{5.2\ \text{m}}{0.35\ \text{m/s}} = 15\ \text{s}$$

Assess: 15 s seems like a long time for a ball to roll, but it is going fairly slowly, so the answer is reasonable.

P1.14. **Prepare:** We first collect the necessary conversion factors: 1 μs = 10^{-6} s; 1 km = 10^3 m; 1 m = 10^2 cm; 1 h = 60 min; 1 min = 60 s.
Solve:

(a) $9.12\ \mu\text{s} = (9.12\ \mu\text{s})\left(\frac{10^{-6}\ \text{s}}{1\ \mu\text{s}}\right) = 9.12 \times 10^{-6}\ \text{s}$

(b) $3.42\ \text{km} = (3.42\ \text{km})\left(\frac{10^{3}\ \text{m}}{1\ \text{km}}\right) = 3.42 \times 10^{3}\ \text{m}$

(c) $44\ \text{cm/ms} = 44\left(\frac{\text{cm}}{\text{ms}}\right)\left(\frac{10^{-2}\ \text{m}}{1\ \text{cm}}\right)\left(\frac{1\ \text{ms}}{10^{-3}\ \text{s}}\right) = 4.4 \times 10^{2}\ \text{m/s}$

(d) $80\ \text{km/h} = 80\left(\frac{\text{km}}{\text{h}}\right)\left(\frac{10^{3}\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{h}}{3.6 \times 10^{2}\ \text{s}}\right) = 22\ \text{m/s}$

Assess: The conversion factors are applied in such a manner that we obtain the desired units. Scientific notation is used and the answer has no more significant figures than the starting number.

P1.24. Prepare: My barber trims about an inch of hair when I visit him every month for a haircut. The rate of hair growth thus is one inch per month. We also need the conversions 1 in = 2.54 cm, 1 month = 30 days, 1 day = 24 h, 1 h = 3600 s, 1 cm = 10^{-2} m, and $1\text{ m} = 10^6\,\mu\text{m}$.

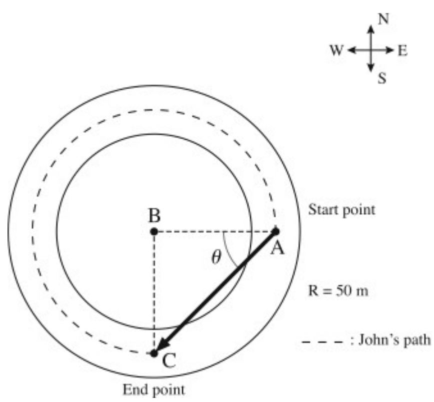
Solve: The rate of hair growth is

$$\frac{1\,(\text{in})}{(\text{month})}\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)\left(\frac{10^{-2}\text{ m}}{1\text{ cm}}\right)\left(\frac{1\text{ month}}{30\text{ d}}\right)\left(\frac{1\text{ d}}{24\text{ h}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)=9.8\times10^{-9}\text{ m/s}$$

$$=9.8\times10^{-9}\left(\frac{\text{m}}{\text{s}}\right)\left(\frac{10^6\,\mu\text{m}}{1\text{ m}}\right)\left(\frac{3600\text{ s}}{1\text{ h}}\right)=35\,\mu\text{m/h}$$

Assess: Since we expect an extremely small number for the rate at which our hair grows per hour, this figure is not unreasonable.

P1.30. Prepare: John's displacement is the vector from his starting point to his ending point.
Solve: Refer to the diagram below.



John stops at the southernmost end of the circle. His final position is 50 m west and 50 m south of his starting position since the radius of the circle is 50 m. We must find the displacement vector from the initial point to the final point.
Point *B* is at the center of the circle.
The displacement vector has a length of

$$\overline{AC}=\sqrt{\overline{AB}^2+\overline{BC}^2}=\sqrt{(50\text{ m})^2+(50\text{ m})^2}=71\text{m}$$

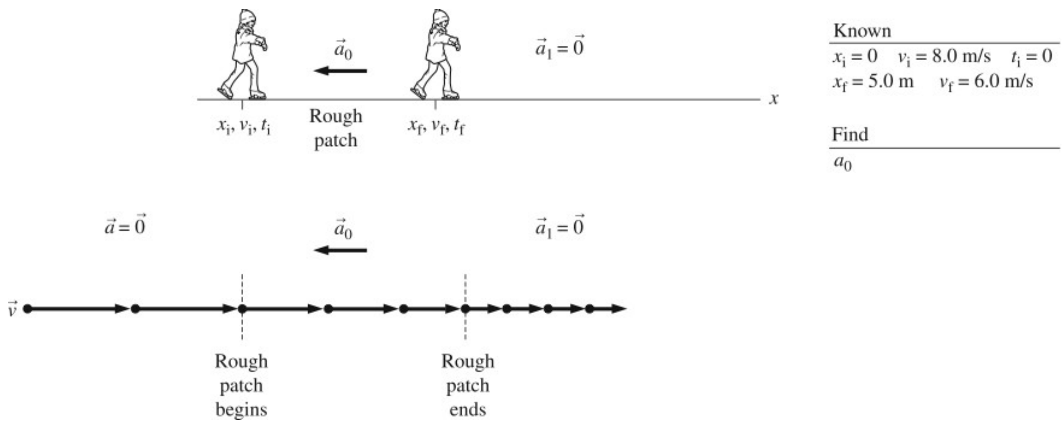
The angle in the diagram is

$$\theta=\arctan\left(\frac{1.0\text{m}}{1.0\text{m}}\right)=45°$$

So the answer in (magnitude, direction) notation would be (71 m, 45° south of west).
Assess: Compare the solution to the solution for Problem 1.28. Here it would be difficult to sum his displacement vectors along the circle, but this is not necessary since the displacement vector is always the vector from the initial position to the final position.

P1.37. Prepare: The skater moves along the *x*-axis. She slows down or has negative acceleration (decreasing velocity vectors) during a patch of rough ice. She has zero acceleration before the rough patch begins and after the rough patch ends, that is, velocity vectors are of the same length. The skater's motion diagram, a pictorial representation, and a list of values are shown in the figure below.

Solve:



Assess: Before and after the rough ice, the velocity vector is constant in length and the position dots are uniformly spaced. Since the skater is traveling slower after the rough ice than before, the velocity vectors after the rough ice are shorter than they are before the rough ice and the position dots are closer together after the rough ice than they are before the rough ice. During the rough ice section, the velocity vector decreases in length and the dot position gets closer together.

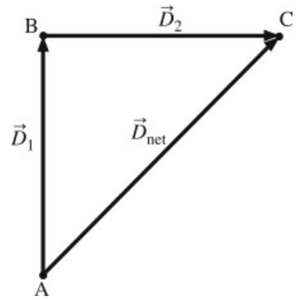
P1.44. Prepare: Knowing the dots represent the position of an object at equal time intervals and the vectors represent the velocity of the object at these times, we can construct a situation to match the motion diagram.
Solve: A bowling ball is at rest at the top of an incline. You nudge the ball giving it an initial velocity and causing it to roll down an incline. At the bottom of the incline it bounces off a sponge and travels back up the incline until it stops.
Assess: The statement that you give the ball an initial velocity is consistent with the fact that the start position dot has a velocity vector. The statement that the ball rolls down the incline is consistent with the fact that the dots are getting farther apart and the velocity vectors are increasing in length. The statement that the ball bounces off a sponge is consistent with the fact that ball does not bounce back to its original position.

P1.53. Prepare: Knowing the speed the signal travels (approximately 25 m/s) and estimating distance from you brain to your hand to be about 1.0 m, we can determine the transmission time. Some unit conversion will be required to get the answer in ms.
Solve: The transmission time for the signal may be determined by

$$t = \frac{\text{distance}}{\text{speed}} = \left(\frac{1\text{ m}}{25\text{ m/s}}\right)\left(\frac{10^3\text{ ms}}{\text{s}}\right) = 40\text{ ms}$$

Assess: When you touch something very hot, it takes a fraction of a second to remove your hand. Keeping in mind, that in this case the signal must make a round trip, the answer, while very small, seems reasonable.

P1.62. Prepare: Since during part of the motion John is traveling north and then turns east, the rules of vector addition will be used to determine the net displacement.
Solve: **(a)** The vectors form a right triangle. See the following vector diagram.



The length of the net displacement vector is

$$\overline{AC} = \sqrt{\overline{AB}^2 + \overline{BC}^2} = \sqrt{(1.00\,\text{km})^2 + (1.00\,\text{km})^2} = 1.41\,\text{km}$$

(b) Jane walks along John's net displacement vector, so she only travels 1.41 km, while John travels a total distance of 2.00 km. Since he travels at 1.50 m/s during the entire stroll, the time John takes to get to his destination is

$$\Delta t_{\text{John}} = \frac{2000\,\text{m}}{1.50\,\text{m/s}} = 1.33 \times 10^3\,\text{s}$$

For Jane to walk 1.41 km in this time, her velocity would need to be

$$v_{\text{Jane}} = \frac{1410\,\text{m}}{1.33 \times 10^3\,\text{s}} = 1.06\,\text{m/s}$$

Assess: Jane must walk slower than John to walk the shorter distance in the same time, so the answer makes sense. For displacements in different directions you must use the law of vector addition.