

Physics 4A

Chapter 1: Concepts of Motion

GENERAL STRATEGY

Problem Solving

MODEL Make simplifying assumptions.

VISUALIZE Use:

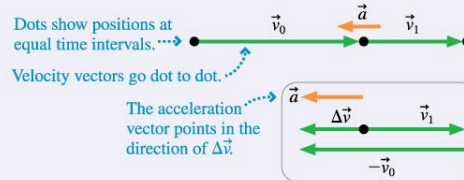
- Pictorial representation
- Graphical representation

SOLVE Use a **mathematical representation** to find numerical answers.

ASSESS Does the answer have the proper units and correct significant figures? Does it make sense?

Motion Diagrams

- Help visualize motion.
- Provide a tool for finding acceleration vectors.



► These are the *average* velocity and acceleration vectors.

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IMPORTANT CONCEPTS

The **particle model** represents a moving object as if all its mass were concentrated at a single point.

Position locates an object with respect to a chosen coordinate system. Change in position is called **displacement**.

Velocity is the rate of change of the position vector \vec{r} .

Acceleration is the rate of change of the velocity vector \vec{v} .

An object has an acceleration if it

- Changes speed and/or
- Changes direction.

Pictorial Representation

1 Draw a motion diagram.

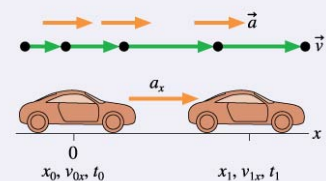
2 Establish coordinates.

3 Sketch the situation.

4 Define symbols.

5 List knowns.

6 Identify desired unknown.



| |
|---|
| Known |
| $x_0 = v_{0x} = t_0 = 0$ |
| $a_x = 2.0 \text{ m/s}^2 \quad t_1 = 2.0 \text{ s}$ |
| Find |
| x_1 |

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APPLICATIONS

For **motion along a line**:

- Speeding up: \vec{v} and \vec{a} point in the same direction, v_x and a_x have the same sign.
- Slowing down: \vec{v} and \vec{a} point in opposite directions, v_x and a_x have opposite signs.
- Constant speed: $\vec{a} = \vec{0}$, $a_x = 0$.

Acceleration a_x is positive if \vec{a} points right, negative if \vec{a} points left. The sign of a_x does *not* imply speeding up or slowing down.

Significant figures are reliably known digits. The number of significant figures for:

- **Multiplication, division, powers** is set by the value with the fewest significant figures.
- **Addition, subtraction** is set by the value with the smallest number of decimal places.

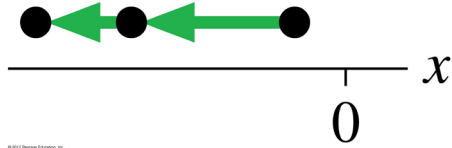
The appropriate number of significant figures in a calculation is determined by the data provided.

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Conceptual Questions and Example Problems from Chapter 1

Conceptual Question 1.6

Determine the signs (positive, negative, or zero) of the position, velocity, and acceleration for the particle in the figure below.

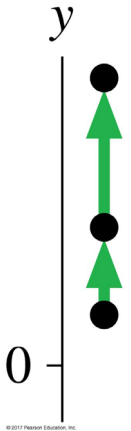


1.6. The particle position is to the left of zero on the x -axis, so its position is negative. The particle is moving to the left, so its velocity is negative. The particle's speed is decreasing as it moves to the left, so its acceleration vector points in the opposite direction as its velocity vector (i.e., to the right). Thus, the acceleration is positive.

Conceptual Question 1.8

Determine the signs (positive, negative, or zero) of the position, velocity, and acceleration for the particle in the figure to the right.

1.8. The particle position is above zero on the y -axis, so its position is positive. The particle is moving up, so its velocity is positive. The particle's speed is increasing as it moves in the positive direction, so its acceleration vector points in the same direction as its velocity vector (i.e., up). Thus, the acceleration is also positive.

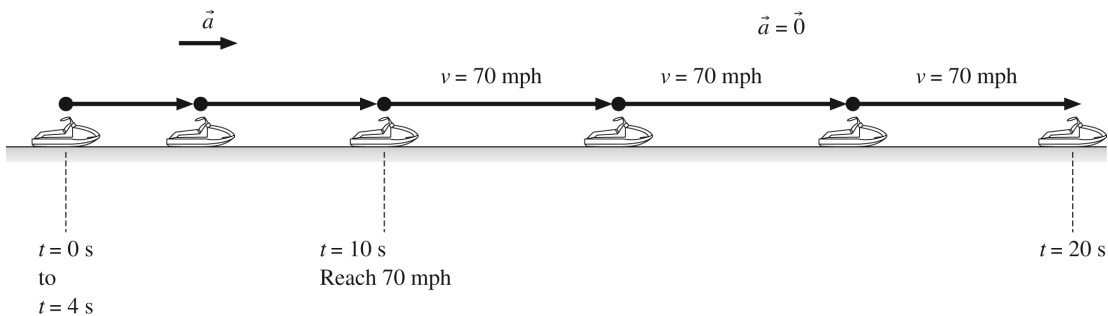


Problem 1.3

You are watching a jet ski race. A racer speeds up from rest to 70 mph in just a few seconds, then continues at a constant speed. Draw a basic motion diagram of the jet ski, using images from the video, from 10 s before reaching top speed until 10 s afterward.

1.3. Model: Model the jet ski as a particle. Assume the speeding up time is less than 10 s, so the motion diagram will show the jet ski at rest for a few seconds at the beginning.

Solve:

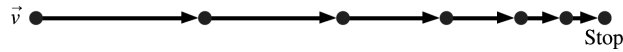


Assess: Notice that the acceleration vector points in the same direction as the velocity vector because the jet ski is speeding up.

Problem 1.7

A softball player slides into second base. Use the particle model to draw a motion diagram showing his position and his average velocity vectors from the time he begins to slide until he reaches the base.

1.7. **Solve:** The player starts with an initial velocity but as he slides he moves slower and slower until coming to rest.

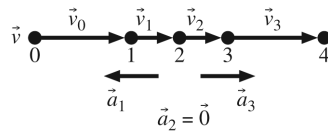


Problem 1.9

The figure below shows the first five points of a motion diagram. Use Tactics Box 1.3 to find the average acceleration vectors at points 1, 2, and 3. Draw the completed motion diagram showing the velocity vectors and acceleration vectors.



1.9. **Solve:** To find the accelerations, use the method of Tactics Box 1.3:

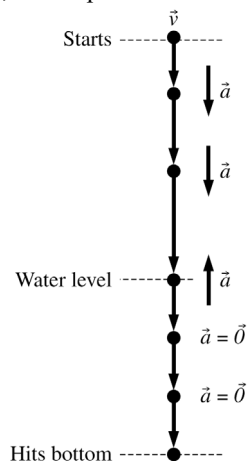


Problem 1.16

A roof tile falls straight down from a two-story building. It lands in a swimming pool and settles gently to the bottom. Draw a complete motion diagram of the tile.

1.16. **Model:** Represent the tile as a particle.

Visualize: Starting from rest, the tile's velocity increases until it hits the water surface. This part of the motion is represented by dots with increasing separation, indicating increasing average velocity. After the tile enters the water, it settles to the bottom at roughly constant speed, so this part of the motion is represented by equally spaced dots.



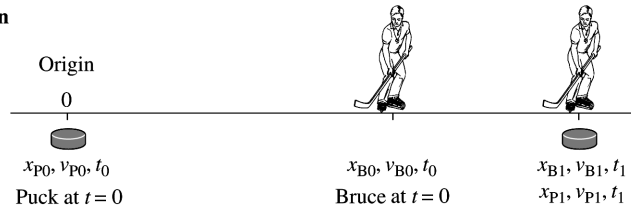
1.42. Model: Represent Bruce and the puck as particles for the motion diagram.

Visualize:

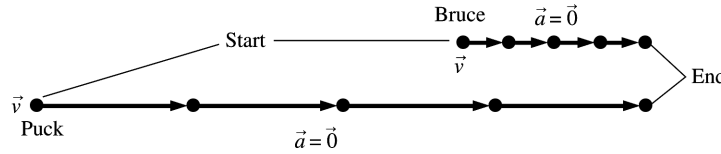
Known
 $x_{P0} = 0 \text{ m}$ $x_{B0} = 15 \text{ m}$
 $t_0 = 0 \text{ s}$ $v_{B0} = 4.0 \text{ m/s}$
 $a_P = a_B = 0 \text{ m/s}^2$
 $x_{P1} = x_{B1} = 20 \text{ m}$

Find
 v_{P0}

Pictorial representation

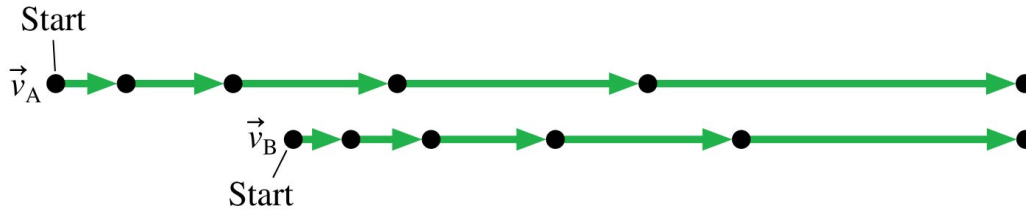


Motion diagram



Problem 1.52

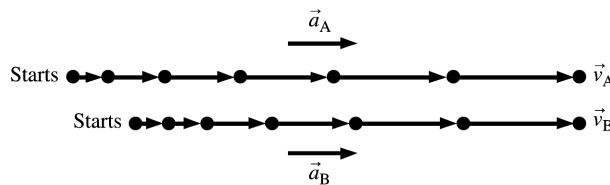
For the motion diagram shown below, (a) Complete the motion diagram by adding acceleration vectors (b) Write a physics problem for which this is the correct motion diagram. (c) Draw a pictorial representation for your problem.



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1.52. Solve:

(a)



(b) A coyote (A) sees a rabbit and begins to run toward it with an acceleration of 3.0 m/s^2 . At the same instant, the rabbit (B) begins to run away from the coyote with an acceleration of 2.0 m/s^2 . The coyote catches the rabbit after running 40 m. How far away was the rabbit when the coyote first saw it?

(c)

Known
 $x_{A0} = 0 \text{ m}$ $v_{A0} = 0 \text{ m/s}$
 $t_0 = 0 \text{ s}$ $a_A = 3.0 \text{ m/s}^2$
 $v_{B0} = 0 \text{ m/s}$ $a_B = 2.0 \text{ m/s}^2$
 $v_{A1} = x_{B1} = 40 \text{ m}$

Find
 x_{B0}

