1. Concepts of Motion

1.1 Motion Diagrams

1.2 The Particle Model

Exercises 1–5: Draw a motion diagram for each motion described below.

- Use the particle model to represent the object as a particle.
- Six to eight dots are appropriate for most motion diagrams.
- Number the positions in order, as shown in Figure 1.4 in the text.
- Be neat and accurate!

1. A car accelerates forward from a stop sign. It eventually reaches a steady speed of 45 mph.

2. An elevator starts from rest at the 100th floor of the Empire State Building and descends, with no stops, until coming to rest on the ground floor. (Draw this one vertically since the motion is vertical.)

3. A skier starts from rest at the top of a 30° snow-covered slope and steadily speeds up as she skies to the bottom. (Orient your diagram as seen from the side. Label the 30° angle.)
4. The space shuttle orbits the earth in a circular orbit, completing one revolution in 90 minutes.

5. Bob throws a ball at an upward 45° angle from a third-story balcony. The ball lands on the ground below.

**Exercises 6–9:** For each motion diagram, write a short description of the motion of an object that will match the diagram. Your descriptions should name *specific* objects and be phrased similarly to the descriptions of Exercises 1 to 5. Note the axis labels on Exercises 8 and 9.

6. **A car breaks to a stop from a speed of 40 km/hr.**
   *(Any linear motion of an object slowing down to a stop.)*

7. **Sally launches a water balloon from her second-floor window in an attempt to hit her ex-boyfriend.**
   *(Projectile motion)*

8. **Motion Starts**
   **Horizontal**
   **Vertical**

9. **Aman walks steadily along a path that turns from north towards the west and continues directly west.** *(Any turning from north to west at constant speed.)*

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**equal horizontal spacing**
1.3 Position and Time

10. The figure below shows the location of an object at three successive instants of time.

![Diagram of object's position vectors and displacement vector](image)

a. Use a red pencil to draw and label on the figure the three position vectors \( \vec{r}_0, \vec{r}_1, \) and \( \vec{r}_2 \) at times 0, 1, and 2.

b. Use a blue or green pencil to draw a possible trajectory from 0 to 1 to 2.

c. Use a black pencil to draw the displacement vector \( \Delta \vec{r} \) from the initial to the final position.

11. In Exercise 10, is the object’s displacement equal to the distance the object travels? Explain.

No, the displacement is the black arrow, \( \Delta \vec{r} \). The distance traveled is the sum of the lengths of the blue or green arrows.

12. Redraw your motion diagrams from Exercises 1 to 5 in the space below. Then add and label the displacement vectors \( \Delta \vec{r} \) on each diagram.
1.4 Velocity

13. The figure below shows the positions of a moving object in three successive frames of film. Draw and label the velocity vector $\vec{v}_0$ for the motion from 0 to 1 and the vector $\vec{v}_1$ for the motion from 1 to 2.

![Velocity Diagram]

Exercises 14–20: Draw a motion diagram for each motion described below.
- Use the particle model.
- Show and label the velocity vectors.

14. A rocket-powered car on a test track accelerates from rest to a high speed, then coasts at constant speed after running out of fuel. Draw a dashed line across your diagram to indicate the point at which the car runs out of fuel.

![Rocket Car Diagram]

15. Galileo drops a ball from the Leaning Tower of Pisa. Consider the ball’s motion from the moment it leaves his hand until a microsecond before it hits the ground. Your diagram should be vertical.
1.5 Linear Acceleration

**Note:** Beginning with this section, and for future motion diagrams, you will “color code” the vectors. Draw velocity vectors **black** and acceleration vectors **red**.

**Exercises 21–24:** The figures below show an object’s position in three successive frames of film. The object is moving in the direction $0 \rightarrow 1 \rightarrow 2$. For each diagram:

- Draw and label the initial and final velocity vectors $\vec{v}_0$ and $\vec{v}_1$. Use **black**.
- Use the steps of Tactic Box 1.3 to find the change in velocity $\Delta \vec{v}$.
- Draw and label $\vec{a}$ at the proper location on the motion diagram. Use **red**.
- Determine whether the object is speeding up, slowing down, or moving at a constant speed. Write your answer beside the diagram.

21. [Diagram showing speeding up]

22. [Diagram showing slowing down]

23. [Diagram showing slowing down]

24. [Diagram showing slowing down]
Exercises 25–29: Draw a complete motion diagram for each of the following.
- Draw and label the velocity vectors $\vec{v}$. Use \textbf{black}.
- Draw and label the acceleration vectors $\vec{a}$. Use \textbf{red}.

25. Galileo drops a ball from the Leaning Tower of Pisa. Consider its motion from the moment it leaves his hand until a microsecond before it hits the ground.

26. Trish is driving her car at a steady 30 mph when a small furry creature runs into the road in front of her. She hits the brakes and skids to a stop. Show her motion from 2 seconds before she starts braking until she comes to a complete stop.

27. A ball rolls up a smooth board tilted at a 30° angle. Then it rolls back to its starting position.