4 Kinematics in Two Dimensions

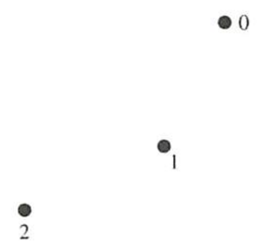
4.1 Motion in Two Dimensions

Exercises 1–2: The figures below show an object's position in three successive frames of a video. The object is moving in the direction $0 \rightarrow 1 \rightarrow 2$. For each diagram:

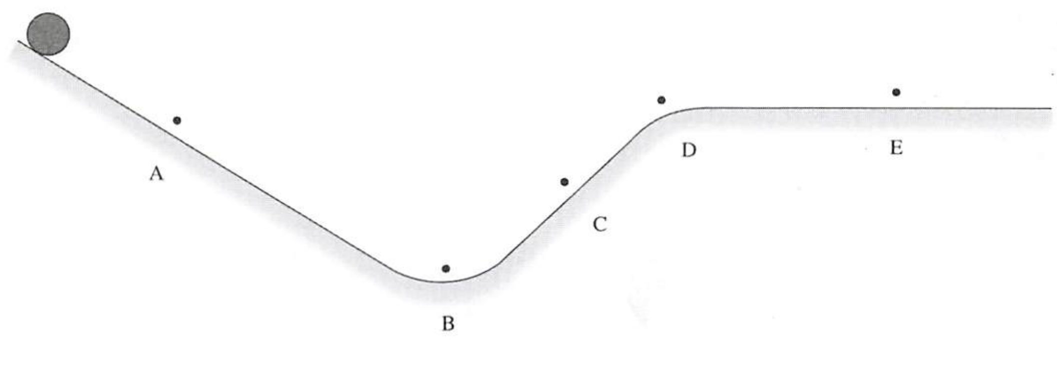
- Draw and label the initial and final velocity vectors $\vec{v}_0$ and $\vec{v}_1$ Use **black.**
- Use the steps of Tactics Box 4.1 to find the change in velocity $\Delta\vec{v}$.
- Draw and label $\vec{a}$ next to dot 1 on the motion diagram. Use **red.**
- Determine whether the object is speeding up, slowing down, or moving at a constant speed. Write your answer beside the diagram.

1.

2.



3. The figure shows a ramp and a ball that rolls along the ramp. Draw vector arrows on the figure to show the ball's acceleration at each of the lettered points A to E (or write $\vec{a} = \vec{0}$, if appropriate).
Hint: At each point is the ball changing speed, changing direction, or both? Be especially careful at point D.



4. Complete the motion diagram for this trajectory, showing velocity and acceleration vectors.

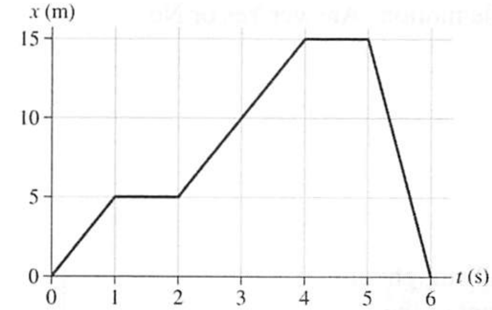
Exercises 5–6: Draw a complete motion diagram for each of the following.

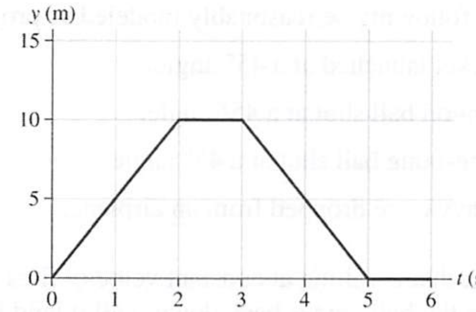
- Draw and label the velocity vectors $\vec{v}$. Use **black**.
- Draw and label the acceleration vectors $\vec{a}$. Use **red**.

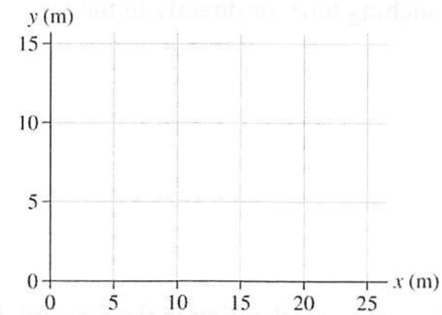
5. A cannon ball is fired from a Civil War cannon up onto a high cliff. Show the cannon ball's motion from the instant it leaves the cannon until a microsecond before it hits the ground.

6. A plane flying north at 300 mph turns slowly to the west without changing speed, then continues to fly west. Draw the motion diagram from a viewpoint above the plane.

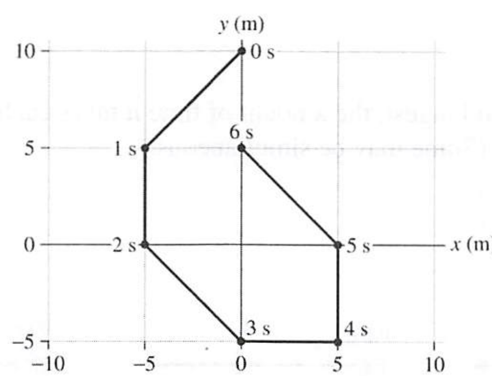
7. A particle moving in the xy-plane has the x-versus-t graph and the y-versus-t graphs shown below. Use the grid to draw a y-versus-x graph of the trajectory.

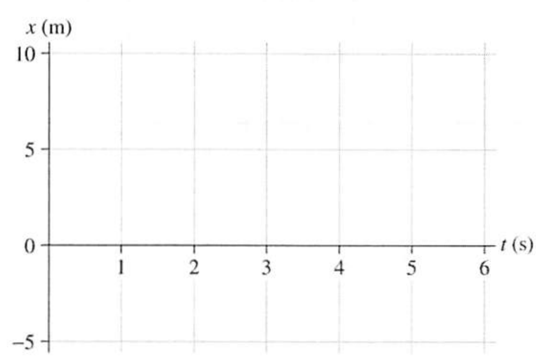


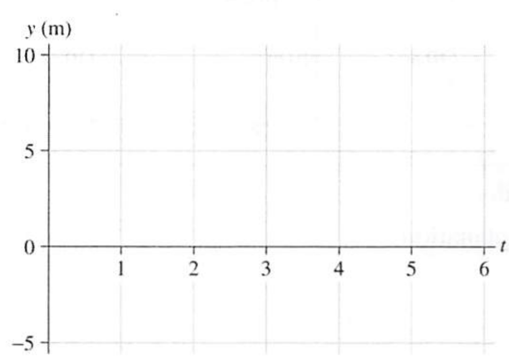




8. The trajectory of a particle is shown below. The particle's position is indicated with dots at 1-second intervals. The particle moves between each pair of dots at constant speed. Draw x-versus-t and y-versus-t graphs for the particle.



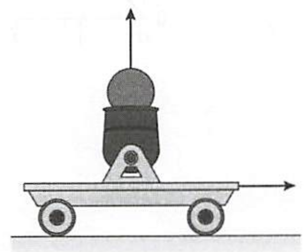




4.2 Projectile Motion

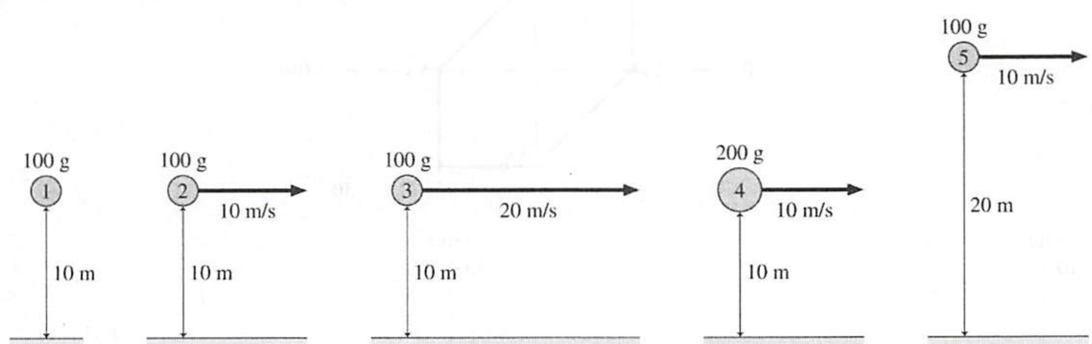
9. Can the following be reasonably modeled as projectile motion? Answer Yes or No.
   a. A rocket launched at a 45° angle. ____________
   b. A cannon ball shot at a 45° angle. ____________
   c. A ping-pong ball shot at a 45° angle. ____________
   d. A heavy crate dropped from an airplane. ____________

10. a. A cart that is rolling at constant velocity fires a ball straight up. When the ball comes back down, will it land in front of the launching tube, behind the launching tube, or directly in the tube? Explain.



b. Will your answer change if the cart is accelerating in the forward direction? If so, how?

11. Rank in order, from shortest to longest, the amount of time it takes each of these projectiles to hit the ground. Ignore air resistance. (Some may be simultaneous.)



Order:

Explanation: