Physics 11
Kinematics Retest 4 Solutions

	a.	b.	c.	d.
1.	X			
2.		X		
3.		X		
4.		X		
5.	X			
6.				X
7.	X			
8.			X	
9.	X	X		
10.		X		
11.				X
12.	X	X	X	X
13.			X	
14.	X			
15.		X		
16.				X
17.		X		
18.				X
19.		X		
20.	X			
21.		X		
22.			X	
23.	X			
24.		X		
25.			X	

1. **Problem**
   True or false? The area under a velocity-time graph is the displacement.
   a. True
   b. False

   Solution
   True.

2. **Problem**
   True or false? When you throw a ball over to your friend, the ball's velocity is zero when it reaches its maximum height.
   a. True
   b. False

   Solution
   False. The vertical velocity is zero at the maximum height, but the horizontal velocity is not.

3. **Problem**
   True or false? If an object is moving to the right, then its acceleration must also be to the right.
   a. True
   b. False

   Solution
   False. An object that is moving to the right at a constant speed has zero acceleration and an object that is moving right and slowing down has a leftward acceleration.

4. **Problem**
   True or false? If an object changes direction, then the line on its velocity-time graph must have a changing slope.
   a. True
   b. False

   Solution
   False. An object that changes direction is represented by a line that crosses the time axis in a velocity-time graph.

5. **Problem**
   True or false? If the velocity vector and the acceleration vector both point in the same direction, then the object must be speeding up.
   a. True
   b. False

   Solution
   True. Acceleration is the change in velocity over time. If acceleration is in the same direction as velocity, then the velocity vector must be increasing and the object must be speeding up.

6. **Problem**
   A football is kicked with a velocity of 25 m/s at an angle of $45°$ above the horizontal. What is the vertical component of its acceleration as it travels along its trajectory? (Ignore air resistance.)

   a. $g \sin(45°)$ upward
   b. $g \sin(45°)$ downward
   c. g upward
   d. g downward

   Solution
   For projectile motion on Earth, the acceleration is always g downward.

7. **Problem**
   Ball 1 is dropped from the top of a building. One second later, ball 2 is dropped from the same building. If air resistance can be ignored, then as time progresses (and while the balls are still in free fall), the distance between them

   a. increases.
   b. remains constant.
   c. decreases.
   d. cannot be determined from the given information.

   Solution
   The distance between the two balls increases over time since distance increases with time squared when acceleration is constant. Using the distance formula for constant acceleration, we see that

   $$\Delta d = d_1 - d_2 = \frac{1}{2}g(t_1^2 - t_2^2) = \frac{1}{2}g(t_1 - t_2)(t_1 + t_2)$$

   So even though $(t_1 - t_2)$ will remain constant at 1 second, $(t_1 + t_2)$ increases as time progresses.

8. **Problem**
   An object is moving to the right and speeding up. Which choice best describes its velocity and acceleration? (Assume right is positive.)

   a. velocity is positive; acceleration is negative.
   b. velocity is negative; acceleration is positive.
   c. velocity and acceleration are both positive.
   d. velocity and acceleration are both negative.

   Solution
   Velocity is positive if the object is moving to the right.
   Velocity is negative if the object is moving to the left.
   Acceleration is positive if the object is moving to the right and speeding up or moving to the left and slowing down.
   Acceleration is negative if the object is moving to the right and slowing down or moving to the left and speeding up.

9. **Problem**
   Which of the following are scalars? *Select all that apply.*

   a. distance
   b. time
   c. displacement
   d. acceleration

   Solution
   A scalar quantity is fully described by magnitude only. A vector quantity is fully described by both magnitude and direction. Distance, speed, and time are scalars. Acceleration, displacement, and velocity are vectors.

   a. scalar
   b. scalar
   c. vector
   d. vector

10. **Problem**
    A car traveling at speed v is able to stop in a distance d. Assuming the same constant acceleration, what distance does this car require to stop when it is traveling at speed $2v$?

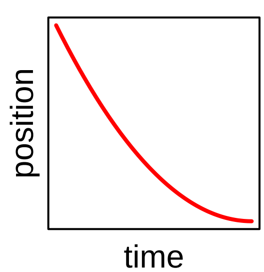
    a. d
    b. $4d$
    c. $\sqrt{2}d$
    d. $2d$

    Solution
    Solve $v_f^2 = v_i^2 + 2ad$ for d and set $v_f = 0$ to get

    $$d = -\frac{v_i^2}{2a}$$

    Therefore, the braking distance is proportional to the square of the initial velocity. If the initial velocity is multiplied by 2, then the car would need 2^2 times the distance to stop.

11. **Problem**
    Which choice best matches the given position-time graph?



    a. moving to the right and speeding up.
    b. moving to the right and slowing down.
    c. moving to the left and speeding up.
    d. moving to the left and slowing down.

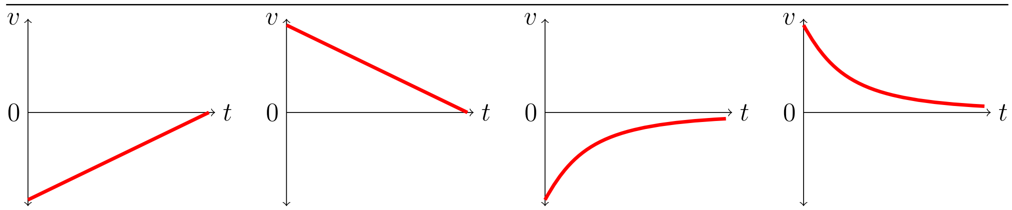
    Solution

The object is moving to the right if its position is increasing and moving to the left if its position is decreasing. The object is speeding up if the tangent line is becoming more vertical and slowing down if the tangent line is becoming more horizontal.

This graph describes an object that is moving to the left and slowing down.

12. **Problem**
Which velocity-time graphs represent the motion of an object that is slowing down? *Select all that apply.*

Graph A	Graph B	Graph C	Graph D

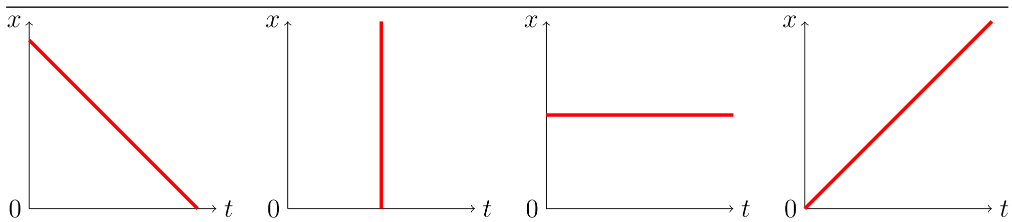


a. Graph A
b. Graph B
c. Graph C
d. Graph D

Solution
Slowing down is represented by a line approaching the time axis on a velocity-time graph.

13. **Problem**
Which position-time graph represents an object at rest?

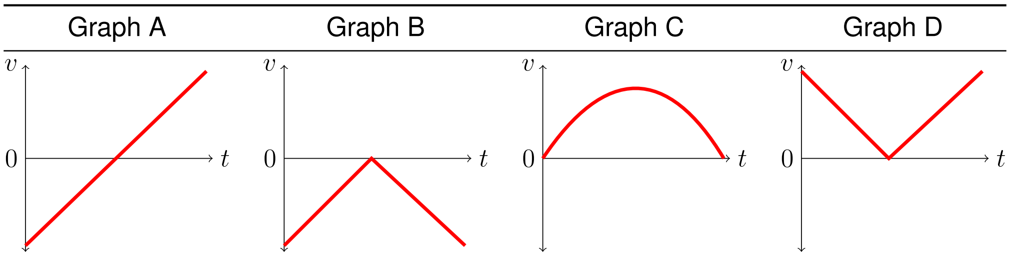
Graph A	Graph B	Graph C	Graph D



a. Graph A
b. Graph B
c. Graph C
d. Graph D

Solution
An object at rest has zero velocity so the slope of its position-time graph must have a slope of zero (horizontal line).

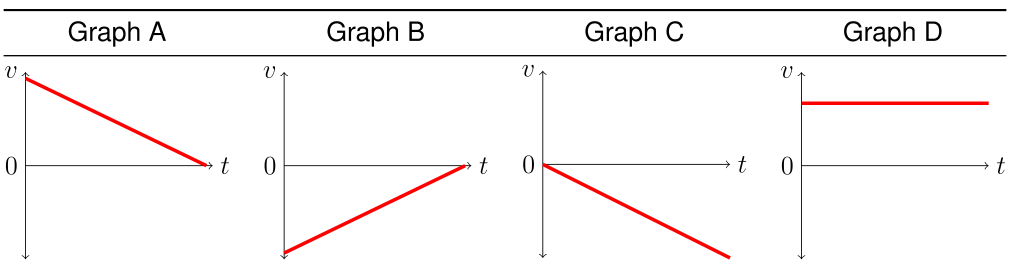
14. **Problem**
Which velocity-time graph represents the motion of an object that changes its direction?



a. Graph A
b. Graph B
c. Graph C
d. Graph D

Solution
Changing direction on a velocity-time graph is represented by a line that crosses the time axis.

15. **Problem**
Which velocity-time graph represents motion with constant positive acceleration?



a. Graph A
b. Graph B
c. Graph C
d. Graph D

Solution
Acceleration is the slope of the velocity-time graph. Therefore, the correct answer is the graph with the positive slope. Note that for positive acceleration it does not matter if the velocity is always negative as long as the slope is positive.

16. **Problem**
Suppose an object travels at a constant velocity of $91.0\,\mathrm{km/h}$. What distance would it travel in $13.0\,\mathrm{minutes}$?

a. 5.2 km
b. 12 km
c. 813 km
d. 19.7 km

Solution
Use the formula for constant velocity motion making sure to convert to the proper units.

$$d = vt = (91.0\,\text{km/h})(13.0\,\text{min})\left(\frac{1\,\text{h}}{60\,\text{min}}\right) = 19.7\,\text{km}$$

17. **Problem**
An F1 car accelerates from 0 to 60 miles per hour in $2.68\,\text{s}$. What is the acceleration of the car in SI units? $(1\,\text{mile} = 1609.34\,\text{m})$

    a. 22.4 m/s^2
    b. 10 m/s^2
    c. 13.1 m/s^2
    d. 7.19 m/s^2

    Solution
First, convert 60 mph to m/s.

$$60\,\text{mph} \times \frac{1609.34\,\text{m}}{1\,\text{mi}} \times \frac{1\,\text{h}}{3600\,\text{s}} = 26.8223\,\text{m/s}$$

Then, divide by the time.

$$a = \frac{v_f - v_i}{t} = \frac{26.8223\,\text{m/s} - 0}{2.68\,\text{s}} = 10\,\text{m/s}^2$$

18. **Problem**
A car travels 20 km at 31 km/h and 223 km at 110 km/h. What is the average speed for this trip?

    a. 42 km/h
    b. 53 km/h
    c. 38 km/h
    d. 91 km/h

    Solution
The average speed is the total distance divided by the total time.

$$v_{avg} = \frac{d_{total}}{t_{total}} = \frac{d_1 + d_2}{d_1/v_1 + d_2/v_2} = \frac{20\,\text{km} + 223\,\text{km}}{\frac{20\,\text{km}}{31\,\text{km/h}} + \frac{223\,\text{km}}{110\,\text{km/h}}} = 91\,\text{km/h}$$

19. **Problem**
A particle initially moving with a velocity of 2 m/s in the x-direction experiences a constant acceleration of 1 m/s^2 in the x-direction and –2 m/s^2 in the y-direction. What are the velocity components of the particle after 4 s?

    a. $v_x = 4\,\text{m/s}, v_y = -8\,\text{m/s}$
    b. $v_x = 6\,\text{m/s}, v_y = -8\,\text{m/s}$
    c. $v_x = -6\,\text{m/s}, v_y = 4\,\text{m/s}$
    d. $v_x = 3\,\text{m/s}, v_y = -2\,\text{m/s}$

    Solution
The velocities can be calculated separately.

$$v_x = 2\,\mathrm{m/s} + (1\,\mathrm{m/s^2})(4\,\mathrm{s}) = 6\,\mathrm{m/s}$$
$$v_y = 0\,\mathrm{m/s} + (-2\,\mathrm{m/s^2})(4\,\mathrm{s}) = 8\,\mathrm{m/s}$$

20. **Problem**
A car with good tires on a dry road can decelerate at about 5.0 m/s^2 when braking. If the car travels with an initial velocity of 34 km/h and brakes under such conditions, what distance would it travel before it stops?

 a. 9 m
 b. 13 m
 c. 1 m
 d. 116 m

Solution
First, convert the initial velocity to m/s.

$$34\,\mathrm{km/h} \times \frac{1000\,\mathrm{m}}{1\,\mathrm{km}} \times \frac{1\,\mathrm{h}}{3600\,\mathrm{s}} = 9.444\,444\,4\,\mathrm{m/s}$$

Then, use the formula $v_f^2 = v_i^2 + 2ad$ with $v_f = 0$ and $a = -5\,\mathrm{m/s^2}$.

$$d = \frac{-v_i^2}{2a} = \frac{-(9.444\,444\,4\,\mathrm{m/s})^2}{2(-5.0\,\mathrm{m/s^2})} = 8.9\,\mathrm{m}$$

21. **Problem**
A ball tossed straight up returns to its starting point in 3.33 s. What was its initial speed? Ignore air resistance.

 a. 11.7 m/s
 b. 16.3 m/s
 c. 18.5 m/s
 d. 9.9 m/s

Solution
The final velocity is equal to the initial velocity, but in the opposite direction ($v_f = -v_i$). Substitute this into the equation $v_f = v_i + at$ and solve for vi:

$$-v_i = v_i + at$$
$$-2v_i = at$$
$$vi = -\frac{at}{2} = -\frac{(-9.8\,\mathrm{m/s^2})(3.33\,\mathrm{s})}{2} = 16.3\,\mathrm{m/s}$$

22. **Problem**
A golf ball is hit with an initial velocity of 14 m/s at an angle of 57° above the horizontal. What is its range (horizontal distance before hitting the ground)? Ignore air resistance and assume a flat golf course.

   a. 14 m
   b. 25 m
   c. 18 m
   d. 13 m

Solution
First, analyze the vertical motion to find the time it takes the ball to hit the ground using the formula $v_f = v_i + at$ with $v_f = -v_i$:

$$t = -\frac{2v_i}{a} = -\frac{2(14\,\mathrm{m/s})\sin(57^\circ)}{-9.8\,\mathrm{m/s^2}} = 2.3962016\,\mathrm{s}$$

Then, use the time to figure out how far the ball travels horizontally (recall that the horizontal velocity is constant).

$$d_x = v_x t = (14\,\mathrm{m/s})(\cos(57^\circ))(2.3962016\,\mathrm{s}) = 18.3\,\mathrm{m}$$

23. **Problem**
A person throws a rock horizontally, with an initial velocity of 32.8 m/s, from a bridge. It falls 6.78 m to the water below. How far does it travel horizontally before striking the water?

   a. 38.6 m
   b. 54.1 m
   c. 51.7 m
   d. 42.4 m

Solution
First analyze the vertical motion to find the time it takes the rock to hit the water using the formula $d = \frac{1}{2}at^2$

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(6.78\,\mathrm{m})}{9.8\,\mathrm{m/s^2}}} = 1.1762965\,\mathrm{s}$$

Then, use the time to figure out how far the rock travels horizontally (recall that the horizontal velocity is constant).

$$d_x = v_x t = (32.8\,\mathrm{m/s})(1.1762965\,\mathrm{s}) = 38.6\,\mathrm{m}$$

24. **Problem**
What is the maximum height reached by a ball thrown straight up with an initial velocity of 33.3 m/s? Assume that the ball is thrown on the surface of the Earth and that it undergoes constant acceleration due to gravity (ignore air resistance).

   a. 83.1 m
   b. 56.6 m
   c. 32.5 m
   d. 97.4 m

Solution
Use the formula $v_f^2 = v_i^2 + 2ad$ with $a = g = -9.8\,\mathrm{m/s^2}$ and $v_f = 0$ (the velocity of the ball at its maximum height is zero). Solve for d:

$$d = \frac{-v_i}{2a} = \frac{-33.3\,\mathrm{m/s}}{2(-9.8\,\mathrm{m/s^2})} = 56.6\,\mathrm{m}$$

25. **Problem**
A ball is thrown straight up with an initial velocity of 38.3 m/s. How long does it take the ball to return to its starting point? Assume that the ball is thrown on the surface of the Earth and that it is undergoing constant acceleration due to gravity (ignore air resistance).

   a. 10.5 s
   b. 14 s
   c. 7.82 s
   d. 14.7 s

Solution
Use the formula for constant acceleration motion using $a = g = -9.8\,\mathrm{m/s^2}$. Also, since the motion is symmetric, the final speed is equal to the initial speed (but the velocity points in the opposite direction) so $v_f = -v_i$.

$$t = \frac{v_f - v_i}{a} = \frac{-v_i - v_i}{g} = \frac{-38.3\,\mathrm{m/s} - 38.3\,\mathrm{m/s}}{-9.8\,\mathrm{m/s^2}} = 7.82\,\mathrm{s}$$