Physics 11
Kinematics Unit Test Solutions

	a.	b.	c.	d.
1.		X		
2.		X		
3.	X			
4.	X			
5.		X		
6.			X	
7.			X	
8.				X
9.			X	
10.		X		
11.			X	
12.			X	
13.		X		
14.			X	
15.			X	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? When a ball is thrown straight up, its acceleration at the top is zero.

   a. True
   b. False

   Solution
   False. The acceleration of the ball is always $9.8\,\mathrm{m/s^2}$ down.

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

   a. True
   b. False

   Solution
   False. The acceleration of the ball is always $9.8\,\mathrm{m/s^2}$ down.

3. **Problem**
   True or false? It is possible to have zero acceleration and still be moving.

   a. True
   b. False

   Solution
   True. An object with a constant nonzero velocity has zero acceleration and is still moving.

4. **Problem**
   True or false? When a ball is thrown straight up, its velocity at the top is zero.

   a. True
   b. False

   Solution
   True. The velocity must be zero for an instant at the top as the velocity changes from up to down.

5. **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

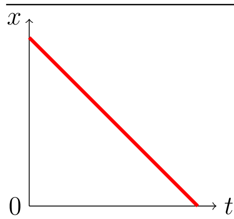
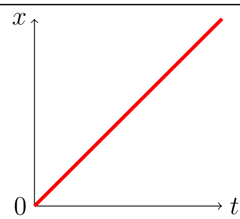
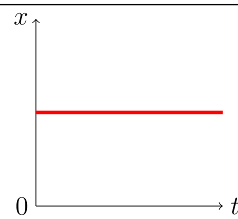
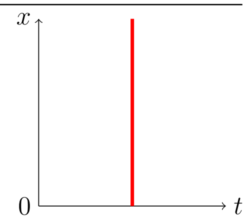
   Solution
   False. The vertical velocity is zero at the maximum height, but the horizontal velocity is not.

6. **Problem**
Can an object's velocity change direction when its acceleration is constant?

   a. No, because the object is always speeding up.
   b. No, because the object is always speeding up or slowing down, but it can never turn around.
   c. Yes, a rock thrown straight up is an example.
   d. Yes, a car that starts from rest, speeds up, slows to a stop, and then backs up is an example.

   Solution
   Yes, a rock thrown straight up is an example. The direction of the rock's velocity changes from up to down while its acceleration is always 9.8 m/s^2 down.

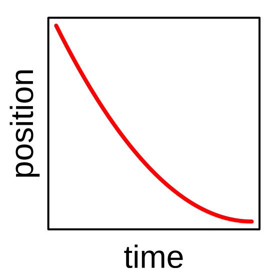
7. **Problem**
Which position-time graph represents an object at rest?

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).

8. **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.

9. **Problem**
Consider a ball that is thrown upwards and which then falls back down. If up is the positive direction, then the ball's velocity

   a. is always positive.
   b. is always negative.
   c. starts positive, then becomes negative.
   d. starts negative, then becomes positive.

   Solution
   When the ball is moving upwards, its velocity is positive. When the ball is moving downwards, its velocity is negative.

10. **Problem**
Consider a ball that is thrown upwards and which then falls back down. If up is the positive direction, then the ball's acceleration

    a. is always positive.
    b. is always negative.
    c. starts positive, then becomes negative.
    d. starts negative, then becomes positive.

    Solution
    The acceleration due to gravity is always downwards, which is the negative direction.

11. **Problem**
Two balls are thrown from the top of a building. One is thrown straight up while the other is thrown straight down, both with same initial speed. If air resistance can be ignored, how do their speeds compare when they hit the ground?

    a. The ball thrown up is going faster.
    b. The ball thrown down is going faster.
    c. Both balls are going the same speed.
    d. It is impossible to determine with the given information.

    Solution
    The ball thrown straight up will have the same speed when it returns to the initial height. Therefore, both balls will be going the same speed when they hit the ground. (The ball thrown downward would hit the ground first because it did not travel the path up and back to the initial height. However, both balls still hit the ground with the same speed.)

12. **Problem**
The acceleration of gravity on the Moon is one-sixth of that on Earth. If you hit a baseball on the Moon with the same speed and angle that you would on Earth, the ball would land

    a. the same distance away
    b. one-sixth as far
    c. 6 times as far
    d. 36 times as far

    Solution
The air time of the ball can be calculated from the formula $v_f = v_i + at$ with $v_f = -v_i$.

$$t = -\frac{2v_i}{a}$$

On Earth, the time is $t_{Earth} = -2v_i/g_{Earth}$. On the Moon, $g_{Moon} = g_{Earth}/6$ so

$$t_{Moon} = -\frac{2v_i}{g_{Earth}/6} = 6 \times \frac{-2v_i}{g_{Earth}} = 6t_{Earth}$$

The air time of the ball is 6 times greater on the Moon than on Earth. Since the horizontal velocity is the same, the ball will travel six times as far.

13. **Problem**
Suppose that several projectiles are launched. Which one will be in the air for the longest time?

    a. The one with the furthest horizontal range.
    b. The one with the greatest maximum height.
    c. The one with the greatest initial speed.
    d. None of the above.

    Solution
Since horizontal and vertical motions can be analyzed separately, only the vertical motion matters for the longest air time. The projectile with the greatest maximum height will stay up in the air for the longest time.

14. **Problem**
A package of supplies is dropped from a plane flying at a constant velocity. Five seconds later, a second package is dropped. Neglecting air resistance, the horizontal distance between the falling packages will

    a. increase
    b. decrease
    c. be constant
    d. any of the above depending on the weight of the packages

    Solution
Since vertical acceleration does not affect horizontal velocity, the two packages with the same constant horizontal velocity will remain the same horizontal distance apart (although the vertical distance will increase).

15. **Problem**
Which of the following are vectors? *Select all that apply.*
   a. distance
   b. speed
   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

16. **Problem**
A fighter plane is launched from a catapult on an aircraft carrier. Starting from rest, it reaches a speed of 260 km/h in 2.78 s. Assuming constant acceleration, what is the length of the aircraft catapult?
   a. 100 m
   b. 361 m
   c. 348 m
   d. 201 m

   Solution
First, convert the final speed to m/s:
$$v_f = 260\,\mathrm{km/h} \times \frac{1000\,\mathrm{m}}{1\,\mathrm{km}} \times \frac{1\,\mathrm{h}}{3600\,\mathrm{s}} = 72.2\,\mathrm{m/s}$$
Then, use the formula for constant acceleration:
$$d = \frac{1}{2}(v_i + v_f)t = \frac{1}{2}(0 + 72.2\,\mathrm{m/s})(2.78\,\mathrm{s}) = 100\,\mathrm{m}$$

17. **Problem**
A truck travels at 41 km/h for 2 hours and at 98 km/h for 9 hours. What is the average speed for the trip?
   a. 87.6 km/h
   b. 69.5 km/h
   c. 97.7 km/h
   d. 89.5 km/h

   Solution
The average speed is the total distance divided by the total time.
$$v_{avg} = \frac{d_{total}}{t_{total}} = \frac{v_1 t_1 + v_2 t_2}{t_1 + t_2} = \frac{(41\,\mathrm{km/h})(2\,\mathrm{h}) + (98\,\mathrm{km/h})(9\,\mathrm{h})}{2\,\mathrm{h} + 9\,\mathrm{h}} = 87.6\,\mathrm{km/h}$$

18. **Problem**
An airplane increases its speed from 122 m/s to 241 m/s, at an average rate of 4 m/s^2. How much time does it take to complete this speed increase?

a. 4.04 s
b. 29.8 s
c. 476 s
d. 20 s

Solution
Use the formula for constant acceleration motion.

$$t = \frac{v_f - v_i}{a} = \frac{241\,\mathrm{m/s} - 122\,\mathrm{m/s}}{4\,\mathrm{m/s^2}} = 29.8\,\mathrm{s}$$

19. **Problem**
Suppose an object travels at a constant velocity of $91.0\,\mathrm{km/h}$. What distance would it travel in $43.0\,\mathrm{minutes}$?

a. 19 km
b. 65.2 km
c. 48.7 km
d. 57.2 km

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

$$d = vt = (91.0\,\mathrm{km/h})(43.0\,\mathrm{min})\left(\frac{1\,\mathrm{h}}{60\,\mathrm{min}}\right) = 65.2\,\mathrm{km}$$

20. **Problem**
A car accelerates from 10 km/h to 117 km/h, at an average rate of 5 m/s^2. How much time does it take to complete this speed increase?

a. 5.94 s
b. 21.4 s
c. 1.45 s
d. 31.6 s

Solution
First, convert the speeds from km/h to m/s.

$$v_i = 10\,\mathrm{km/h} \times \frac{1\,\mathrm{h}}{3600\,\mathrm{s}} \times \frac{1000\,\mathrm{m}}{1\,\mathrm{km}} = 2.78\,\mathrm{m/s}$$
$$v_f = 117\,\mathrm{km/h} \times \frac{1\,\mathrm{h}}{3600\,\mathrm{s}} \times \frac{1000\,\mathrm{m}}{1\,\mathrm{km}} = 32.5\,\mathrm{m/s}$$

Then, use the formula for constant acceleration motion.

$$t = \frac{v_f - v_i}{a} = \frac{32.5\,\mathrm{m/s} - 2.78\,\mathrm{m/s}}{5\,\mathrm{m/s^2}} = 5.94\,\mathrm{s}$$

21. **Problem**
A person throws a rock straight down from a bridge with an initial speed of 19.5 m/s. It falls 37.7 m to the water below. How much time does it take for the rock to hit the water?

   a. 1.42 s
   b. 0.88 s
   c. 1.32 s
   d. 1.09 s

Solution
Use the quadratic formula to solve the equation $h = \frac{1}{2}gt^2 + v_i t$ for t.

$$\frac{1}{2}gt^2 + v_i t - h = 0$$

$$a = \frac{1}{2}g = \frac{1}{2}(9.8\,\mathrm{m/s^2}) = 4.9\,\mathrm{m/s^2}, b = v_i = 19.5\,\mathrm{m/s}, c = -h = -37.7\,\mathrm{m}$$

$$t = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = 1.42\,\mathrm{s}$$

22. **Problem**
A ball tossed straight up returns to its starting point in 2.12 s. What was its initial speed? Ignore air resistance.

   a. 7.3 m/s
   b. 8.4 m/s
   c. 5.6 m/s
   d. 10.4 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:

$$-v_i = v_i + at$$

$$-2v_i = at$$

$$vi = -\frac{at}{2} = -\frac{(-9.8\,\mathrm{m/s^2})(2.12\,\mathrm{s})}{2} = 10.4\,\mathrm{m/s}$$

23. **Problem**
What is the maximum height reached by a ball thrown straight up with an initial velocity of 31.5 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. 50.6 m
   b. 88.4 m
   c. 26.6 m
   d. 94.5 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:

$$d = \frac{-v_i}{2a} = \frac{-31.5\,\mathrm{m/s}}{2(-9.8\,\mathrm{m/s^2})} = 50.6\,\mathrm{m}$$

24. **Problem**
A person throws a rock horizontally, with an initial velocity of 28.5 m/s, from a bridge. It falls 5.99 m to the water below. How far does it travel horizontally before striking the water?

   a. 27.3 m
   b. 31.5 m
   c. 28.7 m
   d. 28.9 m

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

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(5.99\,\mathrm{m})}{9.8\,\mathrm{m/s^2}}} = 1.105\,644\,1\,\mathrm{s}$$

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

$$d_x = v_x t = (28.5\,\mathrm{m/s})(1.105\,644\,1\,\mathrm{s}) = 31.5\,\mathrm{m}$$

25. **Problem**
A golf ball is hit with an initial velocity of 38 m/s at an angle of 34° above the horizontal. What is its range (horizontal distance before hitting the ground)? Ignore air resistance and assume a flat golf course.

   a. 129 m
   b. 103 m
   c. 148 m
   d. 137 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 $v_f = -v_i$:

$$t = -\frac{2v_i}{a} = -\frac{2(38\,\mathrm{m/s})\sin(34^\circ)}{-9.8\,\mathrm{m/s^2}} = 4.336\,598\,\mathrm{s}$$

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

$$d_x = v_x t = (38\,\mathrm{m/s})(\cos(34^\circ))(4.336\,598\,\mathrm{s}) = 137\,\mathrm{m}$$