Physics 11
Kinematics Retest 2 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	X	X	X
12.	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? If an object is moving to the right, then its velocity must also be to the right.

   a. True
   b. False

   Solution
   True. The direction of velocity is always the same as the direction of motion.

2. **Problem**
   True or false? If the velocity-time graph of an object is a horizontal line, then the object must be at rest.

   a. True
   b. False

   Solution
   False. Unless the horizontal line is on the time axis, the object is moving with constant velocity.

3. **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.

4. **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.

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

   a. True
   b. False

   Solution
   True.

6. **Problem**
The gravitational acceleration on Mars is about one-third of that on Earth. If you hit a baseball on Mars with the same speed and angle that you do on Earth, the ball would land

   a. 1/9 times as far
   b. 1/3 times as far
   c. 3 times as far
   d. 9 times as far

   Solution
   The hang 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 Mars, $g_{Mars} = g_{Earth}/3$ so

$$t_{Mars} = -\frac{2v_i}{g_{Earth}/3} = 3 \times \frac{-2v_i}{g_{Earth}} = 3t_{Earth}$$

   The ball is in the air 3 times longer on Mars than on Earth. Since the horizontal velocity is the same, the ball will travel 3 times as far.

7. **Problem**
You hit a volley ball over the net. When the ball reaches its maximum height, its speed is

   a. zero.
   b. less than its initial speed.
   c. equal to its initial speed.
   d. greater than its initial speed.

   Solution
   The vertical velocity is zero at the top while the horizontal velocity remains constant throughout. Therefore, the total speed at the top is less than the initial speed, but not zero.

8. **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. $2d$
   b. d
   c. $\sqrt{2}d$
   d. $4d$

   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.

9. **Problem**
   Which has the greater acceleration: a car that increases its speed from 50 to 60 km/h, or a bike that goes from 0 to 10 km/h in the same time?

   a. The car has the greater acceleration.
   b. The bike has the greater acceleration.
   c. The car and the bike have the same acceleration.
   d. Not enough information given to determine the answer.

   Solution
   Acceleration is the change in velocity over time. The change in velocity is the same (+10 km/h) in both cases. Therefore, both the car and the bike have the same acceleration.

10. **Problem**
    An athlete throws a javelin at four different angles above the horizontal, each with the same speed: 30°, 40°, 60°, 80°. Which two throws cause the javelin to land the same distance away?

    a. 30° and 60°
    b. 40° and 80°
    c. 30° and 80°
    d. 40° and 60°

    Solution
    The range of a projectile can be calculated by first finding the time using the vertical velocity, and then using that time to find the horizontal range. The time can be found using the formula $v_{f,y} = v_{i,y} + at$ with $v_{f,y} = -v_{i,y}$

    $$t = \frac{-2v_{i,y}}{a} = \frac{-2v_i \sin(\theta)}{g}$$

    The horizontal velocity is constant, so the horizontal distance (i.e. range) is

    $$d = v_x t = v_i \cos(\theta) \left(\frac{-2v_i \sin(\theta)}{g} \right) = \frac{-2v_i^2 \cos(\theta) \sin(\theta)}{g}$$

    Therefore, the range would be the same for two angles θ_1 and θ_2 if $\cos(\theta_1)\sin(\theta_1) = \cos(\theta_2)\sin(\theta_2)$. Performing the calculations, we get:

    $$\cos(30^\circ)\sin(30^\circ) = 0.4330127$$
    $$\cos(40^\circ)\sin(40^\circ) = 0.4924039$$
    $$\cos(60^\circ)\sin(60^\circ) = 0.4330127$$
    $$\cos(80^\circ)\sin(80^\circ) = 0.1710101$$

    Since $\cos(\theta)\sin(\theta)$ are the same for 30° and 60°, the range is the same for these two angles.

    Alternatively, we can use the complementary angle identity ($\cos(\theta) = \sin(90^\circ - \theta)$) to get:

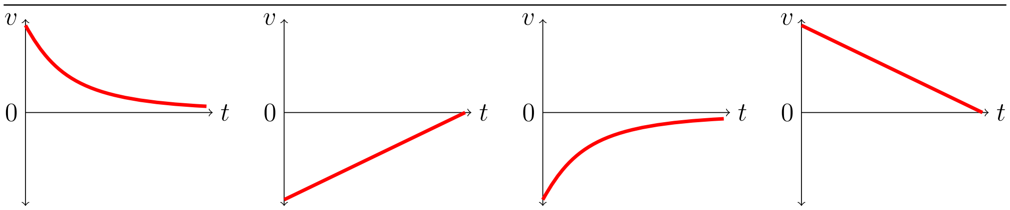
    $$\cos(\theta)\sin(\theta) = \sin(90^\circ - \theta)\sin(\theta)$$

    and notice that the expression would be equal for complementary angles (angles that sum to 90°). For example, if $\theta_1 = 30^\circ$ and $\theta_2 = 60^\circ$, then

    $$\sin(90^\circ - \theta_1)\sin(\theta_1) = \sin(90^\circ - 30^\circ)\sin(30^\circ) = \sin(60^\circ)\sin(30^\circ)$$
    $$\sin(90^\circ - \theta_2)\sin(\theta_2) = \sin(90^\circ - 60^\circ)\sin(60^\circ) = \sin(30^\circ)\sin(60^\circ)$$

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

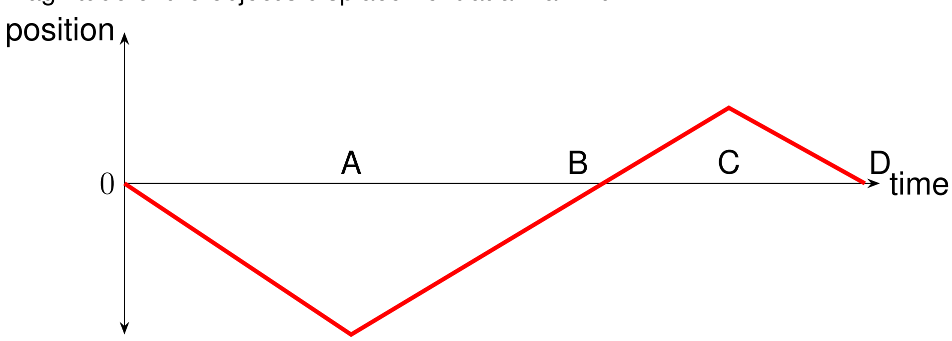
Graph A	Graph B	Graph C	Graph D



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.

12. **Problem**
The motion of an object is described by the following position-time graph. At which point in time is the magnitude of the object's displacement at a maximum?



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

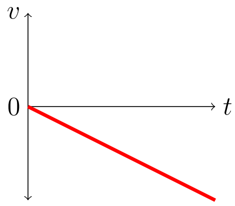
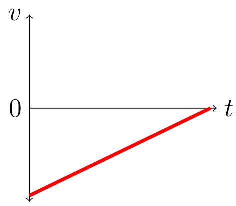
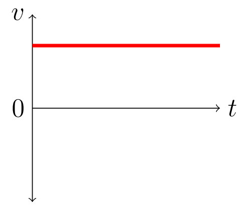
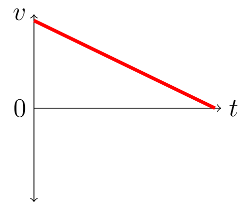
Solution
The displacement is maximum when the position is furthest away from the starting position.

13. **Problem**
What is the magnitude of the slope of a position-time graph?

a. speed
b. acceleration
c. distance
d. pace

Solution
The magnitude of the slope of a position-time graph is the speed of the object.

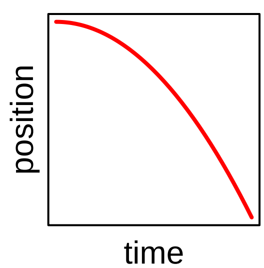
14. **Problem**
Which velocity-time graph represents motion with constant positive acceleration?

Graph A	Graph B	Graph C	Graph D
			

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.

15. **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 speeding up.

16. **Problem**
    How many seconds would it take the Sun's light to reach Earth? The speed of light in vacuum is 3.00×10^8 m/s. The Sun is 1.5×10^{11} m from the Earth.

    a. 0 s
    b. 2.0×10^{-3} s
    c. 5.0×10^2 s
    d. 4.5×10^{19} s

    Solution
    Use the formula for constant velocity motion.

$$t = \frac{d}{v} = \frac{1.5 \times 10^{11}\,\mathrm{m}}{3 \times 10^8\,\mathrm{m/s}} = 5.0 \times 10^2\,\mathrm{s}$$

17. **Problem**
    A light-year (ly) is the distance that light travels in vacuum in one year.
    The speed of light is 3.00×10^8 m/s. How many miles are there in a light-year?
    ($1\,\mathrm{mile} = 1.609 \times 10^3\,\mathrm{m}$, $1\,\mathrm{year} = 365\,\mathrm{days}$)

    a. 5.88×10^{12} mi
    b. 9.46×10^{12} mi
    c. 5.88×10^{15} mi
    d. 9.46×10^{15} mi

    Solution
    Use the formula for constant velocity motion and convert to the desired units.

$$(1\,\mathrm{yr})\left(\frac{365\,\mathrm{days}}{1\,\mathrm{yr}}\right)\left(\frac{24\,\mathrm{h}}{1\,\mathrm{day}}\right)\left(\frac{60\,\mathrm{min}}{1\,\mathrm{h}}\right)\left(\frac{60\,\mathrm{s}}{1\,\mathrm{min}}\right) = 3.1536 \times 10^7\,\mathrm{s}$$

$$d = vt = (3.00 \times 10^8\,\mathrm{m/s})(3.1536 \times 10^7\,\mathrm{s}) = 9.4608 \times 10^{15}\,\mathrm{m}$$

$$(9.4608 \times 10^{15}\,\mathrm{m})\left(\frac{1\,\mathrm{mi}}{1.609 \times 10^3\,\mathrm{m}}\right) = 5.88 \times 10^{12}\,\mathrm{mi}$$

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

    Solution
    The velocities can be calculated separately.

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

19. **Problem**
Suppose an object travels at a constant velocity of $95.0\,\mathrm{km/h}$. What distance would it travel in $25.0\,\mathrm{minutes}$?
    a. 26.2 km
    b. 571 km
    c. 2380 km
    d. 39.6 km

    Solution
    Use the formula for constant velocity motion making sure to convert to the proper units.
    $$d = vt = (95.0\,\mathrm{km/h})(25.0\,\mathrm{min})\left(\frac{1\,\mathrm{h}}{60\,\mathrm{min}}\right) = 39.6\,\mathrm{km}$$

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 87 km/h and brakes under such conditions, what distance would it travel before it stops?
    a. 58 m
    b. 757 m
    c. 44 m
    d. 27 m

    Solution
    First, convert the initial velocity to m/s.
    $$87\,\mathrm{km/h} \times \frac{1000\,\mathrm{m}}{1\,\mathrm{km}} \times \frac{1\,\mathrm{h}}{3600\,\mathrm{s}} = 24.166\,666\,7\,\mathrm{m/s}$$
    Then, use the formula $v_f^2 = v_i^2 + 2ad$ with $v_f = 0$ and $a = -5\,\mathrm{m/s^2}$.
    $$d = \frac{-v_i^2}{2a} = \frac{-(24.166\,666\,7\,\mathrm{m/s})^2}{2(-5.0\,\mathrm{m/s^2})} = 58\,\mathrm{m}$$

21. **Problem**
A person throws a rock straight down from a bridge with an initial speed of 12 m/s. It falls 21.8 m to the water below. How much time does it take for the rock to hit the water?
    a. 1.12 s
    b. 0.73 s
    c. 1.21 s
    d. 0.9 s

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

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

$$a = \frac{1}{2}g = \frac{1}{2}(9.8\,\mathrm{m/s^2}) = 4.9\,\mathrm{m/s^2}, b = v_i = 12\,\mathrm{m/s}, c = -h = -21.8\,\mathrm{m}$$

$$t = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = 1.21\,\mathrm{s}$$

22. **Problem**
A golf ball is hit with an initial velocity of 56 m/s at an angle of 63° above the horizontal. What is its range (horizontal distance before hitting the ground)? Ignore air resistance and assume a flat golf course.

    a. 259 m
    b. 211 m
    c. 204 m
    d. 164 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 $v_f = -v_i$:

$$t = -\frac{2v_i}{a} = -\frac{2(56\,\mathrm{m/s})\sin(63°)}{-9.8\,\mathrm{m/s^2}} = 10.1829317\,\mathrm{s}$$

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

$$d_x = v_x t = (56\,\mathrm{m/s})(\cos(63°))(10.1829317\,\mathrm{s}) = 259\,\mathrm{m}$$

23. **Problem**
What is the maximum height reached by a ball thrown straight up with an initial velocity of 15.6 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. 12.4 m
    b. 13.4 m
    c. 15.5 m
    d. 20.9 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:

$$d = \frac{-v_i}{2a} = \frac{-15.6\,\mathrm{m/s}}{2(-9.8\,\mathrm{m/s^2})} = 12.4\,\mathrm{m}$$

24. **Problem**
A ball tossed straight up returns to its starting point in 4.51 s. What was its initial speed? Ignore air resistance.

    a. 12.4 m/s
    b. 26 m/s
    c. 22.1 m/s
    d. 28 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:

$$-v_i = v_i + at$$
$$-2v_i = at$$
$$vi = -\frac{at}{2} = -\frac{(-9.8\,\mathrm{m/s^2})(4.51\,\mathrm{s})}{2} = 22.1\,\mathrm{m/s}$$

25. **Problem**
A person throws a rock horizontally, with an initial velocity of 33.1 m/s, from a bridge. It falls 8.3 m to the water below. How far does it travel horizontally before striking the water?

    a. 60.4 m
    b. 30.7 m
    c. 29.2 m
    d. 43.1 m

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

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(8.3\,\mathrm{m})}{9.8\,\mathrm{m/s^2}}} = 1.301\,490\,5\,\mathrm{s}$$

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

$$d_x = v_x t = (33.1\,\mathrm{m/s})(1.301\,490\,5\,\mathrm{s}) = 43.1\,\mathrm{m}$$