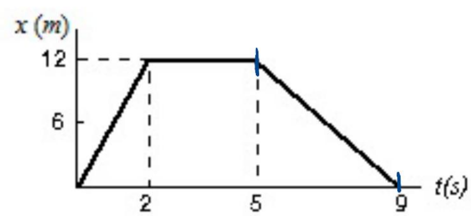
Multiple-choice Section – Each question only has one correct answer.

1. During a short time interval the speed v in m/s of a car is given by $v = at^2 + bt^3$, where the time t is in seconds. The units of a and b are respectively:

   A. $m \cdot s^2;\ m \cdot s^4$
   B. $s^3/m;\ s^4/m$
   C. $m/s^2;\ m/s^3$
   D. $m/s^3;\ m/s^4$
   E. $m/s^4;\ m/s^5$

2. This graph shows the position of a particle as a function of time. What is its average velocity between t = 5s and t = 9s?

   A. 3 m/s
   B. -3 m/s
   C. 12 m/s
   D. -12 m/s
   E. Need additional information.

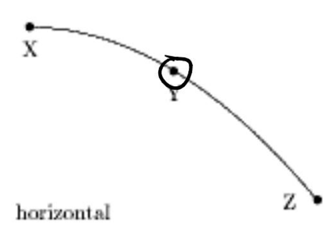


3. Throughout a time interval, while the speed of a particle increases as it moves along the x axis, its velocity and acceleration could be:

   A. positive and negative, respectively
   B. negative and positive, respectively
   C. negative and negative, respectively
   D. positive and zero, respectively

4. A stone is thrown horizontally and follows the path XYZ shown. The direction of the acceleration of the stone at point Y is:

   A. ↓
   B. →
   C. ↘
   D. ↙
   E. ↗



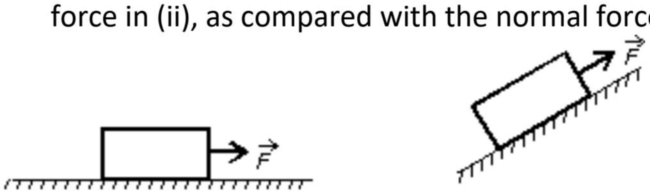
5. A particle moves at constant speed in a circular path. The instantaneous velocity and instantaneous acceleration vectors are:

   A. both tangent to the circular path
   B. both perpendicular to the circular path
   C. perpendicular to each other
   D. opposite to each other

6. You ride on an elevator that is moving with constant downward acceleration while standing on a bathroom scale. The reading on the scale is

   A. equal to your true weight, mg.
   B. less than your true weight, mg.
   C. more than your true weight, mg.

7. A heavy wooden block is dragged by a force $\vec{F}$ along a rough steel plate, as shown below for two cases. The magnitude of the applied force $\vec{F}$ is the same for both cases. The normal force in (ii), as compared with the normal force in (i) is:



(i) (ii)

   A. the same
   B. greater
   C. less
   D. less for some angles of the incline and greater for others
   E. less or greater, depending on the magnitude of the applied force $\vec{F}$

8. A flying insect smashes head-on against your front windshield as you are driving on the freeway.

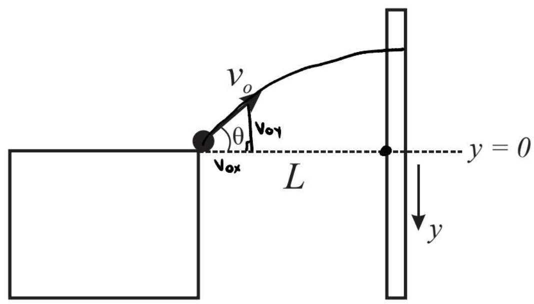
   True or False. The force the insect exerts on your car is smaller than the force your car exerts on the insect.

   A. True
   B. False

9. True or False. Whenever any force $\vec{F}$ acts on an object, that object will move with acceleration $\vec{a}$, according to $\vec{F} = m\vec{a}$.

   A. True
   B. False

- 10a) As shown in the figure, a ball is thrown from the top a one building toward a much taller building a distance L away. The ball is launched at angle θ above horizontal with a speed v_o. Take $y = 0$ as the top of the first building and treat *downwards* as the positive y-direction. What is the final y-position of the ball when it strikes the opposite wall? so $a = (+)$



$V_{ox} = V_o \cos\theta \quad V_{oy} = V_o \sin\theta$

$V_{ox} = \frac{L}{T} \rightarrow V_o \cos\theta = \frac{L}{T} \rightarrow T = \frac{L}{V_o \cos\theta}$

$y_f = y_o + V_{oy}t + \frac{1}{2}at^2 \rightarrow y_f = 0 + V_o \sin\theta \left(\frac{L}{V_o \cos\theta}\right) + \frac{1}{2}g\left(\frac{L}{V_o \cos\theta}\right)^2 \rightarrow \frac{V_o \sin\theta (L)}{V_o \cos\theta} + \frac{1}{2}g\left(\frac{L^2}{V_o^2 \cos^2\theta}\right)$

$$y_f = L(\tan\theta) + \frac{gL^2}{2V_o^2 \cos^2\theta}$$

- 10b) Under what conditions will the ball hit the wall at a *lower* point than its starting height? Under what condition will the ball hit the wall at a *higher* point than its starting point?

The distance the ball is from the wall, the initial velocity, and the angle at which the ball is thrown all influence the height at which the ball will hit the wall.

For example, when the ball is thrown from farther away from the wall (greater L), at a low speed / initial velocity, and at an angle significantly greater than or less than 45°, the ball will hit the wall below y=0. This is true because maximum distance is acheived at 45°, so the farther away the angle is from 45° then the less distance the ball will go, and that combined with low speed and a greater "L" will make the ball hit lower. On the other hand, the ball will hit the wall above y=0 when it's thrown from a distance closer to the wall (smaller "L"), a higher velocity, and at an angle of 45° or close to 45°. However, if the ball is thrown from a distance extremely close to the wall, throwing the ball at a 90° angle will also cause it to hit the wall above y=0 because at 90° sine is equal to 1 and therefore achieves maximum height.

- 10c) Evaluate your answer to part a) in the case that the initial angle of the projectile is zero, $\theta = 0$.

$\tan(0)=0$, $\cos(0)=1$

$$y_f = L(\tan\theta) + \frac{gL^2}{2V_0^2\cos^2\theta} \rightarrow y_f = L(\tan(0)) + \frac{9.8L^2}{2V_0^2\cos^2(0)} \rightarrow 0 + \frac{4.9L^2}{V_0^2} \rightarrow \boxed{y_f = \frac{4.9L^2}{V_0^2}}$$

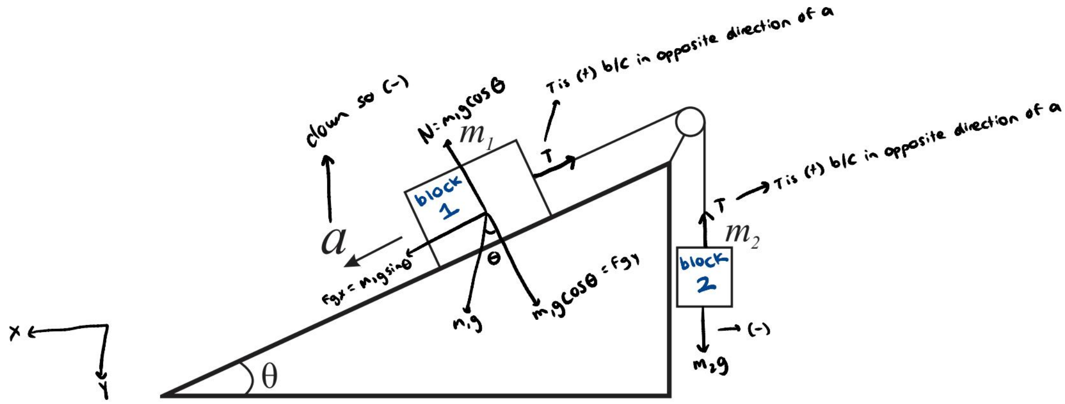
- 10d) How does the final height of the ball in part b) change if the initial speed is doubled?

Since the initial velocity is in the denominator of the equation for final height $\left(y_f = L(\tan\theta) + \frac{gL^2}{2V_0^2\cos^2\theta}\right)$, and is squared, if the initial speed is doubled, the final height will be about 1/4 of what it would've been originally.

- 11a) An inclined plane makes an angle θ with horizontal and has a pulley at the top. A block of mass m_1 on the plane is connected to a freely hanging mass m_2 by a cord passing over the pulley. Assume the string and pulley are massless, and ignore friction. Find the acceleration a of mass m_1 down the incline.

m_1 = block 1

m_2 = block 2



On m_1: (2 forces) $\sum F_{x_2} = ma$ (2nd law) $= T - F_{gx} = m_1 a \longrightarrow T - mg\sin\theta = m_1 a$

On m_2: (2 forces) $\sum F_x = ma$ (2nd law) $= m_2 g - T$

$$m_1 a = \cancel{T} - mg\sin\theta$$
$$+ \quad m_2 a = m_2 g - \cancel{T}$$

$$m_1 a + m_2 a = m_2 g - mg\sin\theta \longrightarrow a(m_1 + m_2) = m_2 g - m_1 g\sin\theta \longrightarrow \boxed{a = \frac{m_2 g - m_1 g\sin\theta}{m_1 + m_2}}$$

m_1 = block 1

m_2 = block 2

- 11b) Evaluate your answer to part a) if $m_2 = 0$ and explain the motion of the system.

$$a = \frac{m_2 g - m_1 g\sin\theta}{m_1 + m_2} \rightarrow \frac{0 - m_1 g\sin\theta}{m_1 + 0} \rightarrow a = \frac{-m_1 g\sin\theta}{m_1} \rightarrow \boxed{a = -g\sin\theta}$$

Since the mass of "block 2" is zero, there will be nothing pulling on the string and therefore no tension pulling "block 1" to the right and preventing it from moving down the inclined plane. As a result, the system ("block 1") will move down the plane (which accounts for the negative value of acceleration seen above) at the rate of the sine value for the angle of the plane multiplied by gravity.

- ~~11b)~~ 11c) Evaluate your answer to part a) if $m_1 = 0$ and explain the motion of the system.

m_1 = block 1

m_2 = block 2

$$a = \frac{m_2 g - m_1 g\sin\theta}{m_1 + m_2} \rightarrow \frac{m_2 g - 0}{0 + m_2} \rightarrow \frac{m_2 g}{m_2} \rightarrow \boxed{a = g \text{ or } a = 9.8\ m/s^2}$$

In this system, where the only influence on the acceleration is gravity and "block 2" is the only object attached to the pulley that has mass, the system will move towards the right and downward. Since "block 1" has a mass of 0, there is nothing creating tension on the string holding "block 2", thereby allowing it to fall freely due to gravity. This means that "block 2" will accelerate downward at the rate of gravity, which would cause "block 1" to be pulled to the right towards the pulley due to the force of "block 2's" downward acceleration.