1. Estimate the total mass of all the people in the world. The current population is approximately 7 billion people.

   a) $10^2$ kg
   b) $10^3$ kg
   c) $10^{11}$ kg
   d) $10^6$ kg
   e) $10^{21}$ kg

   Population $7 \times 10^9$ people
   
   \[
   \text{1 person} \approx 100 \text{ kg}
   \]
   
   \[
   7 \times 10^9 \times 10^2 \quad \text{kg per person} = 7 \times 10^{11} \text{ kg}
   \]

2. You want new carpet for your apartment’s living room, which is a room measuring 10 ft in width and 20 ft in length. How many square meters of carpet do you need to purchase to cover the whole floor?

   a) 5.0 m$^2$
   b) 19 m$^2$
   c) 22 m$^2$
   d) 31 m$^2$
   e) 56 m$^2$

   \[
   10 \text{ ft} \times 20 \text{ ft} \quad \text{convert to meters}
   \]
   
   \[
   10 \text{ ft} \times \frac{1 \text{ m}}{3.281 \text{ ft}} \times 20 \text{ ft} \times \frac{1 \text{ m}}{3.281 \text{ ft}}
   \]
   
   \[
   \frac{10}{3.281} \times \frac{20}{3.281} \quad \text{m}^2 = 19 \text{ m}^2
   \]
3. A person is pulled over for driving 27.5 m/s on a highway with a 55 mi/h speed limit. By how much was that person exceeding the speed limit?

a) 1.3 mi/h
b) 3.6 mi/h
[Correct answer: 6.5 mi/h]
d) 9.2 mi/h
e) The person was not exceeding the speed limit.

\[
\text{Convert m/s to mi/h:}
\]

\[
27.5 \frac{\text{m}}{\text{s}} \times \frac{1 \text{ mile}}{1609 \text{ m}} \times \frac{3600 \text{ s}}{1 \text{ h}} = 61.5 \text{ mi/h}
\]

driving speed = speed limit
61.5 mi/h - 55 mi/h
\[
\boxed{6.5 \text{ mi/h}}
\]

- Tough cop!

4. A race car starting at rest accelerates at a constant rate of 5.50 m/s². What is the velocity of the car after it has traveled 32 meters?

a) 14.7 m/s
b) 18.8 m/s
[Correct answer: 21.2 m/s]
d) 24.6 m/s
e) 27.3 m/s

Rest: \( v_0 = 0 \text{ m/s} \)

\( a = 5.50 \text{ m/s}^2 \)

\( \Delta x = 32 \text{ m} \)

\( v = ? \)

\( v^2 = v_0^2 + 2a\Delta x \) has all the variables except \( v \) known.

\( v^2 = 0^2 + 2(5.5)(32) \)

\( v^2 = 352 \)

\( v = \sqrt{352} \text{ m/s} \)

\( v = 18.76 \text{ m/s} \)
5. A cheetah is jogging at 5 m/s in a straight line towards an antelope who is eating grass 150 m away. The cheetah needs to speed up if it's going to catch the antelope before it notices the cheetah coming. What is the minimum constant acceleration that the cheetah must use to catch the antelope within 20 seconds?

\[ \Delta x = v_0 t + \frac{1}{2} a t^2 \]  
\[ 150 m = 5 m/s \times 20 s + \frac{1}{2} a (20 s)^2 \]  
\[ 150 = 100 + 200a \]  
\[ 50 = 200a \]  
\[ a = \frac{50}{200} = 0.25 m/s^2 \]

6. If the cheetah from the previous problem instead accelerated at 2 m/s², what would its velocity be when it reached the antelope?

\[ v^2 = v_0^2 + 2a \Delta x \]  
\[ v^2 = 5^2 + 2 \times 2 \times 150 \]  
\[ v^2 = 25 + 600 \]  
\[ v^2 = 625 \]  
\[ v = 25 m/s \]
7. In celebration, a cowboy shoots a bullet straight up in the air at a velocity of 670 m/s. How long does it take the bullet to come back down to the same point from which it was shot?

\[ v_0 = 670 \text{ m/s} \text{ straight up; this will be a vertical motion problem!} \]
\[ a = -9.8 \text{ m/s}^2 \]

We know projectiles are symmetric in their motion, so \( v = -v_0 \) in this case. We can confirm this by looking at:
\[ v^2 = v_0^2 + 2a\Delta y \]
This is zero because \( \Delta y \) is zero (the bullet returns to its initial position). So now what?

**Knowns:**
- \( v_0 = 670 \text{ m/s} \)
- \( v = -670 \text{ m/s} \)
- \( a = -9.8 \text{ m/s}^2 \)
- \( t = \) ?

\[ -670 = 670 + (-9.8)t \]
\[ -1340 = -9.8t \]
\[ t = \frac{1340 \times \text{1 minute}}{60 \text{ sec}} = 2.3 \text{ minutes} \]

8. If a ball thrown upward with initial velocity, \( v_0 \), reaches a maximum height, \( h \), what height will the ball reach if it is thrown 3 times faster?

a) 2h  
b) 3h  
c) 4h  
d) 8h  
\[ \text{e) 9h} \]

Want to understand how displacement (\( h = \Delta y \)) acts as a function of initial velocity, \( v_0 \).

Note also that since it is at maximum height at \( h \), we know that \( v = 0 \text{ m/s} \) at that moment.

So let’s solve for \( \Delta y \) as a function of \( v_0 \) and other knowns: i.e. acceleration, \( a \).

\[ \Delta y = -\frac{v_0^2}{2a} = h \]
\[ \Delta y = h \text{ when initial velocity is } v_0 \]

What if initial velocity is \( 3v_0 \)?

\[ \Delta y = -\frac{(3v_0)^2}{2a} \]
\[ \Delta y = -\frac{9v_0^2}{2a} = \frac{9(-v_0^2/2a)}{h} \]

This equals \( \frac{9h}{h} \)

\[ \Delta y = 9h \]
9. I hit the brakes as I pull up to a stop light, but then it turns green and I speed up again. What is true about my acceleration and velocity vectors before and after the light turns green?

a) Before: my $a$ and $v$ vectors point the same way.
   After: my $a$ and $v$ vectors still point the same way.

b) Before: my $a$ and $v$ vectors point in opposite directions.
   After: my $a$ and $v$ vectors point in the same direction.

c) Before: my $a$ and $v$ vectors point the same way.
   After: my $a$ and $v$ vectors point in opposite directions.

d) Before and after, my $v$ vector does not change and $a = 0$.

e) None of the above.

10. The velocity vs. time graph shown describes the motion of an object. Which acceleration vs. time graph best matches this motion? Select the letter that appears under the correct graph.

   \[ \text{Velocity constant, so NO acceleration; thus } a = 0. \]

   \[ \text{Velocity getting larger: slope is positive, so positive acceleration at first.} \]
11. A velocity vs. time graph for an object is shown. Find the average acceleration for the object from \( t = 100 \)s to \( t = 400 \)s.

\[
\text{Acceleration} = \frac{\Delta V}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}
\]

a) \(-0.25 \text{ m/s}^2\)
b) \(-0.33 \text{ m/s}^2\)
c) \(-0.50 \text{ m/s}^2\)
d) \(-0.67 \text{ m/s}^2\)
e) \(-0.72 \text{ m/s}^2\)

\[
\begin{align*}
a &= \frac{-50 - 150}{400 - 100} \\
a &= -1.00 \\
a &= -0.6666666...
\end{align*}
\]

12. You throw a ball to your friend. If we define positive \( y \) as up, what does the acceleration versus time graph look like for its motion during the time after it leaves your hand and before it gets to your friend’s hand? Gravity is the only force acting here, so only acceleration is \(-9.8 \text{ m/s}^2\).

a) \( +a \)
b) \( -a \)
c) \( -a \)
d) \( -a \)
e) \( \text{negative, constant acceleration} \)
13. You're parked in front of a restaurant in downtown Morgantown. Your friends call and want you to pick them up in front of the Chestnut Hotel. Because Morgantown has only one way streets, you drive south 150 m, go 75 m west on Walnut, and travel 100 m north up Chestnut Street to get your friends. What is the magnitude of your displacement vector from your original parking location?

\[
\begin{align*}
\text{a)} & \quad 53 \text{ m} \\
\text{b)} & \quad 90 \text{ m} \\
\text{c)} & \quad 100 \text{ m} \\
\text{d)} & \quad 325 \text{ m} \\
\text{e)} & \quad 1 \text{ km}
\end{align*}
\]

14. A rescue plane drops a package of supplies to stranded hikers on the ground. The plane continues traveling at the same velocity after dropping the package. Neglecting air resistance, at the instant the package lands on the ground, the plane will have traveled

\[
\begin{align*}
\text{a)} & \quad \text{a larger horizontal displacement than the package.} \\
\text{b)} & \quad \text{the same horizontal displacement as the package.} \\
\text{c)} & \quad \text{a smaller horizontal displacement than the package.}
\end{align*}
\]

For projectiles, \( V_x \) (horizontal velocity) is constant: \( V_{ox} = V_x \).

\[
\begin{align*}
D_x & = 75 \text{ m} \\
D_y & = 100 - 150 \\
& = -50 \text{ m}
\end{align*}
\]

Combine to know how far from start to end:

\[
D = \sqrt{D_x^2 + D_y^2} = \sqrt{(-50)^2 + (75)^2} = 90.1 \text{ m}
\]

15. A cargo plane is flying in a horizontal direction with a large \( v_x \). Someone drops a bowling ball out of its cargo bay. As observed by a person standing on the ground and viewing the plane as in the figure below, which of the paths would the bowling ball most closely follow after leaving the plane? Neglect air resistance, and remember to consider the ball's \( v_x \) and \( v_y \).

Again, \( v_x \) is always constant. \( v_y \) starts out as zero here, but the acceleration of gravity makes \( v_y \) get larger & larger with time, so it gradually moves down and faster and faster!
16. A ball is kicked with an initial velocity of 18.0 m/s with an angle of 15.0° from the ground. Find the x (horizontal) component of the initial velocity.

a) 4.66 m/s  
b) 8.13 m/s  
c) 12.3 m/s  
d) 17.4 m/s  
e) 19.7 m/s

\[ \cos(15) = \frac{v_{0x}}{18} \]

\[ v_{0x} = 18 \cos(15°) = 17.4 \text{ m/s} \]

17. A rock is thrown from a 150 m cliff with an initial velocity of 7.0 m/s at an angle of 18° above the horizontal. How long will it take to hit the ground?

a) 2.3 s  
b) 5.8 s  
c) 7.4 s  
d) 10 s  
e) 13 s

**Knowns:**
- \( \text{x-dim} \)
  - \( v_{0x} = 6.66 \text{ m/s} \)
  - \( a_x = 0 \text{ m/s}^2 \)
  - \( v_{x} = 6.66 \text{ m/s} \)
  - \( t = ? \)

- \( \text{y-dim} \)
  - \( v_{0y} = 2.16 \text{ m/s} \)
  - \( a_y = -9.8 \text{ m/s}^2 \)
  - \( \Delta y = -150 \text{ m} \)

\[ \Delta y = v_{0y} t + \frac{1}{2} a_y t^2 \]

\[ -150 = 2.16 t + 0.5 (-9.8) t^2 \]
\[ 0 = -4.9 t^2 + 2.16 t + 150 \]

Quadratic:
\[ t = \frac{-2.16 \pm \sqrt{2.16^2 - 4(-9.8)(150)}}{-9.8} \]
\[ t = \frac{-2.16 \pm \sqrt{4^2 + 2404}}{-9.8} \]
\[ t = \frac{-2.16 \pm 21.67}{-9.8} \]
\[ t = 0.22 \pm 5.54 \]
\[ t = 5.76 \text{ s or negative} \]
18. A missile is designed to explode 7 seconds after launch. One of these missiles is launched at a speed of 60.0 m/s at an angle of 55.0° off the ground. At what horizontal distance from its point of launch will it explode?

\[ V_x = V_x0 = 60 \cos(55°) = 34.4 \, \text{m/s} \]
\[ a_x = 0 \]
\[ V_x = V_x0 = 34.4 \, \text{m/s} \]

What this question is really asking is all about its x-direction.

How far does it go in x before exploding?

So how far can it go in 7 seconds?

\[ \Delta x = V_x t + \frac{1}{2} a_x t^2 \]
\[ \Delta x = V_x t \]
\[ \Delta x = (34.4 \times 7) \, \text{m} \]
\[ \Delta x = 240.9 \, \text{m} \]

19. For the missile in the previous problem, at what vertical height above the ground will it explode?

\[ V_y0 = 60 \sin(55°) = 49.1 \, \text{m/s} \]
\[ a_y = -9.8 \, \text{m/s}^2 \]

\[ \Delta y = V_y0 t + \frac{1}{2} a_y t^2 \]
\[ t = 7 \, \text{s} \]

\[ \Delta y = 49.1 \times 7 + 0.5(-9.8)(7^2) \]
\[ \Delta y = 343.7 - 240.1 \]
\[ \Delta y = 103.6 \, \text{m} \]
20. A ball rolls horizontally off of a desk that is 2.0 m high with a speed of 4.0 m/s. Calculate the magnitude of the velocity just before the ball hits the ground.

a) 4.0 m/s  

b) 5.2 m/s  

c) 6.3 m/s  

d) 9.9 m/s  

Knowing:

\[ v_{x0} = 4 \text{ m/s} \]
\[ v_{y0} = 0 \]
\[ v_x = v_{x0} = 4 \text{ m/s} \]

because \( a_x = 0 \)

\[ v_y = ? \]

\[ \Delta y = 2 \text{ m} \]
\[ a = -9.8 \text{ m/s}^2 \]

We have enough info in \( y \) to solve for \( v_y \), the final \( y \) velocity.

\[ v_y^2 = v_{y0}^2 + 2a\Delta x \]
\[ v_y^2 = 2(-9.8)(-2) \]
\[ v_y^2 = 39.2 \]
\[ v_y = 6.26 \text{ m/s} \]

Now combine \( x \) and \( y \) vector components to get final magnitude:

\[ v = \sqrt{v_x^2 + v_y^2} = \sqrt{4^2 + 6.26^2} = 7.43 \text{ m/s} \]