Please return test to TA or instructor before you leave the room.

Your Name: **Prof. Sarah** TEST #1

Print clearly.

On the Scantron, fill out your student ID, leaving the first column empty and starting in the second column. Also write your name and “Test 1” at the bottom.

There are 20 equally-weighted questions on this test. There is only one correct answer per question. Mark your answer on the Scantron. Take off the last two pages: one is scrap paper and the other is the formula sheet for you to keep.

The key will be posted online after all make-up tests are completed.

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1. A marathon race is 26.2 miles in length. For a typical adult, approximately how many strides will it take to go this length (stride means one step)?

   a. 10
   b. $10^3$
   c. $10^5$
   d. $10^7$
   e. $10^9$

   *b and c will both be marked correct.*

   \[
   26.2 \text{ miles} \times \frac{1609 \text{ m}}{\text{mile}} \times \frac{\text{steps}}{1 \text{ m}} = \# \text{ steps}
   \]

   Around 1-2 m per stride?

   \[
   26.2 \times 1609 \times 1 = 42,155.8
   \]

   \[
   26.2 \times 1609 \times 2 = 84,311.6
   \]

   \[\approx 10^4 - 10^5\]

2. If you added up the age of everyone in Physics 101 Section 2, about how many years total would the class have collectively lived?

   a. 100 years
   b. 3000 years
   c. 20000 years
   d. $10^5$ years
   e. $10^7$ years

   \[
   100 - 200 \text{ students in class}
   \]

   \[
   \text{avg. age 20 yrs}
   \]

   \[
   100 \times 20 = 2000 \text{ yrs}
   \]

   \[
   200 \times 20 = 4000 \text{ yrs}
   \]
3. Your doctor measures that a person is 5.7 feet tall. How tall is that person in centimeters?

a. 187.3 cm
b. 173.7 cm
c. 161.2 cm
d. 18.7 cm
e. 1.7 cm

\[ 5.7 \text{ ft} \times \frac{1 \text{ m}}{3.281 \text{ ft}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 173.73 \text{ cm} \]

4. A stray cat is prowling around the neighborhood. From your neighbor's porch, it travels 8m north, 2m east, pauses to sit for a while, and then walks 16m at an angle of 30° south of east to arrive at your front porch. How far is your porch from your neighbor's?

\[ \sin(30°) = \frac{y_2}{d_2} \quad y_2 = 16 \sin(30°) = 8 \text{ m} \]
\[ \cos(30°) = \frac{x_3}{d_3} \quad x_3 = 16 \cos(30°) = 13.9 \text{ m} \]

\[ \text{Sum of } y: y_1 + y_3 = 8 - 8 = 0 \text{ m} \]
\[ \text{Sum of } x: x_2 + x_3 = 2 + 13.9 = 15.9 \text{ m} \] (bit of loose rounding)
5. A bird is flying at 3 m/s. There is a branch 85 meters away, and the bird suddenly speeds up at a constant rate of 0.5 m/s² towards the branch. How much time will it take the bird to travel those 85 m if it keeps that same acceleration for the whole trip?

\[
\begin{align*}
\text{a. } & 134.1 \text{ s} \\
\text{b. } & 26.6 \text{ s} \\
\text{c. } & 25.4 \text{ s} \\
\text{d. } & 13.3 \text{ s} \\
\text{e. } & -25.4 \text{ s}
\end{align*}
\]

\[a = 0.5 \text{ m/s}^2, \quad v_0 = 3 \text{ m/s}, \quad \Delta x = 85 \text{ m} \]

\[t = ? \]

Either:

\[t = \frac{-3 \pm 9.7}{0.5} = \frac{13.4}{0.5} \text{ s} \quad \text{[This makes sense to have positive time.]} \]

\[t = -3 - 9.7 \quad 0.5 = -25.4 \text{ s} \quad \text{[This makes sense to have positive time.]} \]

6. A car is traveling at 7 m/s. It then decelerates with a constant magnitude of 0.49 m/s². How fast is the car going after it has travelled 5 meters from the point where it started slowing down? Let's say it was travelling east when it started decelerating, where east is defined as positive.

\[a = -0.49 \text{ m/s}^2, \quad \Delta x = 5 \text{ m} \]

\[v_0 = 7 \text{ m/s}, \quad v^2 = v_0^2 + 2a\Delta x \]

\[v^2 = 7^2 + 2(-0.49)(5) \]

\[v^2 = 49 - 4.9 \]

\[v^2 = 44.1 \]

\[v = \sqrt{44.1} = 6.64 \text{ m/s} \]
7. You hold a pebble at rest over a huge hole with water at the bottom. You drop it and hear a splash 2.5 seconds later. Ignoring air resistance, how far down is the surface of the water from where you dropped the pebble?

a. 2.5 m
b. 9.8 m
c. 19 m
d. 24.5 m
e. 30.6 m

\[ V_0 = 0 \text{ m/s (no vertical velocity)} \]
\[ t = 2.5 \text{ s} \]
\[ a = -9.8 \text{ m/s}^2 \text{ (vertical free-fall)} \]

\[ \Delta x = V_0 t + \frac{1}{2} at^2 \]
\[ \Delta x = (0)(2.5) + \left(\frac{1}{2}\right)(-9.8)(2.5)^2 \]
\[ \Delta x = -30.6 \text{ m} \]

Asks "how far down" rather than displacement, so sign doesn't matter.

8. Considering the previous problem, if you instead threw the pebble horizontally with a speed 3 m/s, how much would the time change for the pebble to hit the water?

a. It will take longer for the pebble to hit the water.
b. It will take the same amount of time for the pebble to hit the water.
c. It will take less time for the pebble to hit the water.
d. It depends on the mass of the pebble.
e. Not enough information to determine the answer.

Treat y direction independently!

In this one, we get the same set-up in y:

\[ V_{0y} = 0 \text{ m/s} \]
\[ t = 2.5 \text{ s} \]
\[ a_y = -9.8 \text{ m/s}^2 \]
9. The Duquesne Incline in Pittsburgh is a funicular train that travels up a hillside at 6 miles per hour at an angle of 30.5° upwards from horizontal. What is the y-component of this train’s velocity, assuming the axes are oriented as shown in the figure below?

   a. 0.51 meters per second  
   b. 1.36 meters per second  
   c. 2.31 meters per second  
   d. 3.15 meters per second  
   e. 5.27 meters per second

\[ v_y = \frac{6 \text{ miles}}{h} \sin(30.5°) = 3.045 \frac{\text{miles}}{h} \]

Convert units!

\[ 3.045 \frac{\text{miles}}{h} \times \frac{1609 \text{ m}}{1 \text{ mile}} \times \frac{1 \text{ km}}{3600 \text{ s}} = 1.36 \text{ m/s} \]

10. You walk to class at a constant velocity of \( v \) and arrive in \( t \) seconds. If you instead jog the same distance at a velocity \( 5v \), how much will your trip’s duration change?

   a. It will take twenty-five times as long.  
   b. It will take five times as long.  
   c. It will take one fifth as long.  
   d. It will take one twenty-fifth as long.

From \( \bar{v} = \frac{\Delta x}{\Delta t} \) or \( \Delta x = v_0 t + \frac{1}{2} at^2 \) (\( a=0 \))

\[ \rightarrow \Delta x = V_0 t \rightarrow t = \frac{\Delta x}{v_0} \] how time depends on velocity (when \( a=0 \))

So let's say

\[ \frac{\text{miles}}{1 \text{ km}} \]

\[ \bar{v} = \frac{v}{v} = 1 \text{ m/s} \]

\[ \bar{v} = \frac{v}{5 \text{ m/s}} = 5 \text{ m/s} \]

\[ \Delta x = 100 \text{ m} \]

\[ \Delta x = 100 \text{ m} \]

\[ t = \frac{100 \text{ m}}{1 \text{ m/s}} = 100 \text{ s} \]

\[ t = \frac{100 \text{ m}}{5 \text{ m/s}} = 20 \text{ s} \]

one fifth! \( \frac{20}{100} = \frac{1}{5} \)
11. The graph above left is a motion graph of the horizontal velocity of a sheep moving near a cliff edge, as shown above right. What is the sheep’s average acceleration between 4 and 12 seconds?

- \( a = \frac{-0.7 \text{ m/s}^2}{-3.0 \text{ m/s}^2} \)
- \( +0.7 \text{ m/s}^2 \)
- \( +2.5 \text{ m/s}^2 \)
- Not enough information to determine.

12. For the same sheep graph, which description best represents what is happening?

- The sheep frolicks in one big leap toward the cliff edge.
- The sheep accelerates gradually towards the cliff edge until it falls off the cliff.
- The sheep accelerates rapidly towards the cliff edge until it falls off the cliff.
- The sheep accelerates slowly towards the cliff edge, then stops suddenly and backs up slowly.
- The sheep accelerates gradually towards the cliff edge, then decelerates rapidly until it is backing rapidly away from the cliff.

13. If the sheep from the previous problem were instead standing still for a few seconds and then moving with constant acceleration toward the cliff edge, what would the \( x \) vs \( t \) graph look like?

- Going in + direction (accelerating)
- Acceleration makes a curve in \( x \) vs \( t \)!
14. An artillery shell is fired with an initial velocity of 300 m/s at 65° above the horizontal. To clear an avalanche, it explodes on a mountainside 35.5 seconds after firing. What is the y-direction displacement of this shell where it explodes, relative to its firing point?

a. 10680 m  
   b. 9650 m  
   c. 4500 m  
   d. 3480 m  
   e. -1680 m

\[ \vec{v}_0 = 300 \text{ m/s} \]
\[ \vec{v}_{0y} = 300 \sin(65°) = 271.9 \text{ m/s} \]
\[ \vec{v}_{0x} = 300 \cos(65°) = 126.8 \text{ m/s} \]

**Known:**
\[ t = 35.5 \text{ s} \]
\[ a_y = -9.8 \text{ m/s}^2 \]
\[ \vec{v}_{0y} = 271.9 \text{ m/s} \]
\[ \Delta y = ? \]

\[ \Delta y = \frac{1}{2} a_y t^2 + \vec{v}_{0y} t \]
\[ \Delta y = 271.9(35.5) + \frac{1}{2}(-9.8) (35.5)^2 \]
\[ \Delta y = 9652.5 - 6175.2 \]
\[ \boxed{\Delta y = 3477.25 \text{ m}} \]

(Rounded)

15. My friend is in a boat in the Mon river, and I toss her a ball with an initial velocity of 50 m/s at an angle of 20° above the horizontal direction. I throw it hard enough so it reaches her. Just before she catches the ball, what is the magnitude of the ball’s final velocity in the x-direction?

a. 0 m/s  
   b. 13 m/s  
   c. 17 m/s  
   d. 47 m/s  
   e. Not enough information to determine.

**Vector decomposes...**

\[ \vec{v}_0 = 50 \text{ m/s} \]
\[ \vec{v}_{0y} = 50 \sin(20°) = 17.10 \text{ m/s} \]
\[ \vec{v}_{0x} = 50 \cos(20°) = 46.98 \text{ m/s} \]

Asks for \( v_x \).

\[ v_{ox} = v_x = 46.98 \text{ m/s} \]
\[ (a_x = 0 \text{ for a projectile!}) \]
16. The dotted line in the figure below shows the movement of a projectile shot from the ground. What is true about the acceleration vector at the point in the projectile’s motion that is indicated by a star?

- a. It is zero.
- b. It is horizontal.
- c. It is pointing downward.
- d. Both (a) and (b) above.
- e. None of the above.

17. What are the units of each part \((1, 2, 3)\) of the kinematics equation below?

\[
v^2 = v_0^2 + 2a \Delta x
\]

- a. \(\text{m/s, m/s, m}\)
- b. \(\text{m/s, m/s, m/s}^2\)
- c. all \(\text{m/s}\)
- d. all \(\text{m/s}^2\)
- e. all \(\text{m}^2/\text{s}^2\)

18. Two metal balls are the same size but one weighs twice as much as the other. The two balls roll off a horizontal table with the same speed. In this situation,

- a. Both balls hit the floor at approximately the same horizontal distance from the base of the table.
- b. The heavier ball hits the floor at about half the horizontal distance from the base of the table than does the lighter ball.
- c. The lighter ball hits the floor at about half the horizontal distance from the base of the table than does the heavier ball.
- d. The heavier ball hits the floor considerably closer to the base of the table than the lighter ball, but not necessarily at half the horizontal distance.
- e. The lighter ball hits the floor considerably closer to the base of the table than the heavier ball, but not necessarily at half the horizontal distance.

**No dependence on mass for our standard free-fall!**
19. An orange is rolled horizontally off the top of a countertop 1.5 m above the floor, at a velocity of 2 m/s. How far from the counter does the orange hit the ground?

a. 0.00 m  
b. 0.61 m  
c. 1.11 m  
d. 2.00 m  
e. 3.00 m

*Diagram*

$\Delta y = 1.5\, \text{m}$

Bookkeeping:

\[
\begin{array}{c|c}
& \begin{align*} x & \quad y \\ \hline
V_{0x} & = 2\, \text{m/s} \\ V_{oy} & = 0\, \text{m/s} \\ V_x & = 2\, \text{m/s} \\ \Delta y & = -1.5\, \text{m} \\ a_x & = 0\, \text{m/s}^2 \\ a_y & = -9.8\, \text{m/s}^2 \\ t & = 0.553\, \text{s} \\ \end{align*}
\end{array}
\]

Seems like I don't have enough info; no equation works. Solve for $t$ in $y$ first:

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

\[
-1.5 = 0(t) + \frac{1}{2}(-9.8)(t^2)
\]

\[
-1.5 = -4.9t^2
\]

\[
t = \sqrt{0.306} = 0.553\, \text{s}
\]

Now I can do $x$!

\[
\Delta x = V_{0x}t + \frac{1}{2}(a_x)t^2
\]

\[
\Delta x = (2)(0.553) + \frac{1}{2}(0)(0.553)^2
\]

\[
\Delta x = 1.106\, \text{m}
\]

Orange juice ✓
20. A golf ball is hit at 40 m/s, as shown in the figure above, at an angle of $\theta=45^\circ$. Ignore air resistance and assume the shot is made on a wide, level field. How long does the ball spend in the air?

- a. 1.15 s
- b. 3.12 s
- c. 4.37 s
- d. 5.77 s

\[ V_{oy} = 40 \sin(45^\circ) = 28.28 \text{ m/s} \]
\[ V_{ox} = 40 \cos(45^\circ) \]
\[ V_{ox} = 28.28 \text{ m/s} \]
\[ V_y = 0 \text{ m/s} \]
\[ a_y = -9.8 \text{ m/s}^2 \]

\[ v_y = v_{oy} + a_y t \]
\[ 0 = 28.28 - 9.8 t \]
\[ 28.28 = 9.8 t \]
\[ t = \frac{28.28}{9.8} = 2.886 \]

But this is half the time!
\[ 2.886 \times 2 = 5.77 \text{ s} \]