

PHYS 1110-02 Fall 2026 Quiz 1

Brief Solutions

1. Units of K

The $1/2$ in the formula has no units. The unit for m , a mass, is kilograms, and for v , a speed, is meters per second. This gives $\text{kg} \cdot \text{m}^2/\text{s}^2$.

2. Units of G

We need to find the arrangement of m, kg, s that make the formula true.

$$\frac{\text{kg} \cdot \text{m}}{\text{s}^2} = G \frac{\text{kg}^2}{\text{m}^2}$$
$$G = \frac{\text{kg} \cdot \text{m}}{\text{s}^2} \frac{\text{m}^2}{\text{kg}^2} = \frac{\text{m}^3}{\text{kg} \cdot \text{s}^2}$$

3. Units of x

Numbers like $1/2$ don't affect the units; here, we are only concerned with the units in the formula.

$$\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2} = \frac{\text{kg}}{\text{s}^2} x^2$$
$$x^2 = \frac{\text{kg} \cdot \text{m}^2}{\text{s}^2} \frac{\text{s}^2}{\text{kg}} = \text{m}^2$$
$$x = \text{m}$$

4. Acceleration in g's.

Here, we're defining an acceleration unit, the g , as 9.8 m/s^2 . Then

$$250 \text{ m/s}^2 \frac{g}{9.8 \text{ m/s}^2} = 25.5 g$$

5. Cubic meters in an acre-foot

$$\text{acre} \cdot \text{foot} = \frac{\text{mi}}{8} \cdot \frac{\text{mi}}{80} \cdot 1 \text{ ft} \cdot \left(\frac{1609.3 \text{ m}}{\text{mi}} \right)^2 \cdot \frac{\text{m}}{3.28 \text{ ft}} = 1234 \text{ m}^3$$

I should mention here that I fat-fingered the number of feet in a meter on the test paper; it should be 3.28 feet = 1 meter, not 3.218 feet. Sorry about that. I think I gave equal credit to students who used 3.28 and 3.218.

6. Position-time graph

Also check the last page of this key. I have put diagrams there highlighting the relevant segments of the plot. Those ought to be easier to interpret than the verbal descriptions below.

a. Positive velocity

Velocity is positive where the curve slopes upward. That is the rising edge of the hump.

b. Zero velocity

Velocity is zero where the curve is horizontal. That is at the beginning and end, and also at the top of the hump.

c. Negative velocity

Velocity is negative where the curve slopes downward. That is the falling edge of the hump.

d. Positive acceleration

Acceleration is positive where the slope becomes more positive, which means where the curvature is upward. That is at the beginning and end of the hump.

e. Zero acceleration

Acceleration is zero where the plot is straight. That is at the beginning, end, and middle of the curve where the velocity is negative, and also the straight central segments of the rising and falling edges of the hump.

f. Negative acceleration

Acceleration is negative where the plot curves downward, which is at the beginning and end of the top of the hump.

7. Bicycle course

a. Path length

The distance traveled once around the circuit is 1600 meters.

b. Displacement

Once around the circuit returns the cyclist to where he started, so the displacement is zero.

c. Average speed

The cyclist traveled 1600 meters in 145 seconds, giving $(1600\text{ m})/(145\text{ s}) = 11.0\text{ m/s}$.

d. Average velocity

At the end of the loop, the cyclist is exactly where he was at the start, so his average velocity was zero.

8. Accelerating bullet

We are told the initial and final speeds and the distance traveled, and tasked with finding the time. The constant-acceleration formula linking what we know to what we want to find is

$$x - x_0 = \frac{1}{2}(v + v_0)t$$
$$t = 2 \frac{x - x_0}{v + v_0} = \frac{1.16\text{ m}}{400\text{ m/s}} = 0.0029\text{ s} = 2.9\text{ ms}$$

9. Tybalt and Mercutio

We need to set up a model for the situation. Tybalt and Mercutio are running toward each other with constant velocities. They begin $D = 75\text{ m}$ apart and run until they are $d = 2.5\text{ m}$ apart. Tybalt runs at $v_T = 4.5\text{ m/s}$ and Mercutio at $v_M = 3.0\text{ m/s}$. They run in opposite directions, so their velocities have opposite signs. I'll arbitrarily decide that Tybalt starts at $x = 0\text{ m}$ and Mercutio starts at $x = D$, so Mercutio gets the negative velocity—otherwise they'd be running away from each other! They stop running when the difference between their positions is d , and we want to know when that occurs.

$$\begin{aligned}x_T &= v_T t; & x_M &= D - v_M t \\x_M - x_T &= d \\D - v_M t - v_T t &= d \\D - d &= (v_M + v_T)t \\t &= \frac{D - d}{v_M + v_T} = \frac{72.5\text{ m}}{7.5\text{ m/s}} = 9.7\text{ s}\end{aligned}$$

10. Right triangle

The three sides of the triangle are w , opposite the right angle and thus the hypotenuse; w_x , opposite the angle marked θ ; and w_y , adjacent to the angle marked θ .

a. $\sin \theta = \text{opposite/hypotenuse}$, which is w_x/w .

b. $\cos \theta = \text{adjacent/hypotenuse}$, which is w_y/w .

c. $\tan \theta = \text{opposite/adjacent}$, which is w_x/w_y .

You might be accustomed to thinking that the sine corresponds to the y component while the cosine corresponds to the x component. That is true when the right triangle is in the conventional trigonometric orientation, with the right angle to the lower right and the angle θ to the lower left, both adjacent to a perfectly horizontal leg of the triangle. But this triangle is in a different orientation.

11. Sides in terms of each other

The Pythagorean theorem tells us that $w^2 = w_x^2 + w_y^2$. But the question asked for a formula for w_x in terms of w and w_y , so we rearrange the theorem to read $w_x = \sqrt{w^2 - w_y^2}$. We only want the positive square root, because the length of a side cannot be negative.

An yes, I meant for the question to ask about the triangle in the previous problem, which was problem 10, not problem 7.

12. Components of a vector

The vector has a magnitude of 7.00 m/s at a direction of 35° counterclockwise of the $+x$ axis.

a. x component

$v_x = v \cos \theta = (7.00\text{ m/s}) \cos(35^\circ) = 5.73\text{ m/s}$. Don't forget the units. Units of a vector apply to the Cartesian components as well as to the magnitude.

b. y component

$$v_x = v \sin \theta = (7.00 \text{ m/s}) \sin(35^\circ) = 4.02 \text{ m/s}.$$

13. Vector addition

The question does not ask for the Cartesian components of the vector sum, but we need to find them to obtain the quantities the question does ask about.

$$\vec{A} + \vec{B} = (A_x + B_x, A_y + B_y) = (15 - 48, -20 - 36) \text{ m} = (-33, -56) \text{ m}.$$

a. Magnitude

$$||\vec{A} + \vec{B}|| = \sqrt{33^2 + 56^2} \text{ m} = \sqrt{4225} \text{ m} = 65 \text{ m}.$$

b. Direction (counterclockwise of the $+x$ axis)

Here we need to be careful. Because the x component of this vector is negative, the arctangent function won't return the correct angle, but instead the angle along the same line between $\pm 90^\circ$. To get the correct angle, we'll need to add 180° to the result of the arctangent function.

$$\theta = 180^\circ + \arctan\left(\frac{-56}{-33}\right) = 180^\circ + 59.5^\circ = 239.5^\circ$$

