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PHYS. 211-01 Midterm test 1

Spring 04, February 13, 2004

Name: solutions

Number:

There are 8 problems. All of them are weight equal. First, step by step to carry out your own calculation. Then compare your answer with the multiple choices and circle the correct answer on the sheet. You can bring a calculator. The total time is 50 min.
1. If \( \mathbf{A} = 12\mathbf{i} - 16\mathbf{j} \) and \( \mathbf{B} = -24\mathbf{i} + 10\mathbf{j} \), what is the direction of the vector \( \mathbf{C} = 2\mathbf{A} - \mathbf{B} \)?
   a. \(-49^\circ\)
   b. \(-90^\circ\)
   c. \(-41^\circ\)
   d. \(+49^\circ\)
   e. \(+21^\circ\)

   \[ \mathbf{C} = 2(12\mathbf{i} - 16\mathbf{j}) - (-24\mathbf{i} + 10\mathbf{j}) = 48\mathbf{i} - 42\mathbf{j} \]

   \[ \tan \theta = \frac{y}{x} = -\frac{42}{48} \]

   \[ \therefore \theta = -41.2^\circ \]

2. A bullet is fired through a board, 14.0 cm thick, with its line of motion perpendicular to the face of the board. If it enters with a speed of 450 m/s and emerges with a speed of 220 m/s, what is the bullet's acceleration as it passes through the board?

   a. \(-500 \text{ km/s}^2\)
   b. \(-275 \text{ km/s}^2\)
   c. \(-360 \text{ km/s}^2\)
   d. \(-520 \text{ km/s}^2\)
   e. \(-550 \text{ km/s}^2\)

   We have:

   \[ v_f^2 = v_i^2 + 2a(x_f - x_i) \]

   \[ v_f = 220 \text{ m/s}, \quad v_i = 450 \text{ m/s} \]

   \[ x_f - x_i = 14 \text{ cm} = 0.14 \text{ m} \]

   \[ \therefore a = \frac{v_f^2 - v_i^2}{2(x_f - x_i)} \]

   \[ = \frac{220^2 - 450^2}{0.28} \text{ m/s}^2 \]

   \[ = -550000 \text{ m/s}^2 = -550 \text{ km/s}^2 \]
3. A particle moving with a constant acceleration has a velocity of 20 cm/s when its position is \( x = 10 \text{ cm} \). Its position 7.0 s later is \( x = -30 \text{ cm} \). What is the acceleration of the particle?

a. \(-15 \text{ cm/s}^2\)
b. \(-8.9 \text{ cm/s}^2\)
c. \(-11 \text{ cm/s}^2\)
d. \(-7.3 \text{ cm/s}^2\)
e. \(-13 \text{ cm/s}^2\)

We have:

\[ x_f = x_i + v_i t + \frac{1}{2} a t^2 \]

\[ x_f = -30 \text{ cm}, \quad x_i = 10 \text{ cm} \]
\[ v_i = 20 \text{ cm/s} \quad t = 7.0 \text{ s} \]

So:

\[ a = \frac{x_f - x_i - v_i t}{\frac{1}{2} t^2} \]

\[ = -7.3 \text{ m/s}^2 \]

4. A rock is thrown downward from an unknown height above the ground with an initial speed of 10 m/s. It strikes the ground 3.0 s later. Determine the initial height of the rock above the ground.

a. 44 m
b. 14 m
c. 60 m
d. 30 m
e. 74 m

We assume \( y_i = 0 \).

\[ y_f = y_i + v_{y_i} t + \frac{1}{2} a t^2 \]

\[ = [0 - 10(3) - \left(\frac{1}{2}\right)(9.8)(3^2)] \text{ m} \]

\[ = -74.1 \text{ m} \]
5. A particle moves in the xy plane with a constant acceleration given by \( a = -4.0 \, \text{j m/s}^2 \). At 
\( t = 0 \) its position and velocity are 10i m and \((-2.0i + 8.0 \, \text{j})\) m/s, respectively. What is the 
distance from the origin to the particle at \( t = 2.0 \, \text{s} \)?

a. 6.4 m  
b. 2.0 m  
c. 8.9 m  
d. 10 m  
e. 6.2 m

For \( x \) direction: \( x_i = 10 \, \text{m}, \; v_{xi} = -2 \, \text{m/s}, \; a_x = 0 \).

For \( y \) direction: \( y_i = 0, \; v_{yi} = 8 \, \text{m/s}, \; a_y = 4 \, \text{m/s}^2 \).

So:
\[
X_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2 = 6 \, \text{m}
\]
\[
Y_f = y_i + v_{yi} t + \frac{1}{2} a_y t^2 = 8 \, \text{m}
\]

So the distance \( r = \sqrt{x^2 + y^2} = 10 \, \text{m} \).

6. A rock is projected from the edge of the top of a building with an initial velocity of 12.2 
m/s at an angle of 53° above the horizontal. The rock strikes the ground a horizontal 
distance of 25 m from the base of the building. Assume that the ground is level and that 
the side of the building is vertical. How tall is the building?

a. 25.3 m  
b. 25.6 m  
c. 27.4 m  
d. 29.6 m  
e. 18.9 m

From \( x \) axis information

We can find time:
\[
t = \frac{x_f}{v_{xi}} = 3.41 \, \text{s}.
\]

Then we can find \( y_f \) (building height)

\[
y_f = v_{yi} t - \frac{1}{2} g t^2 = -23.7 \, \text{m/s}.
\]
7. A rifle is aimed horizontally at the center of a large target 60 m away. The initial speed of the bullet is 240 m/s. What is the distance from the center of the target to the point where the bullet strikes the target?

- \(t = \frac{60 \text{ m}}{240 \text{ m/s}} = 0.25 \text{ s.}\)

Then to find \(y_f\):

\[ y_f = y_i + v_{yi} t - \frac{1}{2} gt^2 \]

\[ = 0 + 0 - (4.9)(0.25)^2 \text{ m} \]

\[ = 0.306 \text{ m} = 30.6 \text{ cm} \]

8. A particle moves at a constant speed in a circular path with a radius of 2.06 cm. If the particle makes four revolutions each second, what is the magnitude of its acceleration?

- \(v = \frac{4 \times (2\pi \times 2.06)}{1 \text{ sec}} = 51.8 \text{ cm/s} \)

So \(a_r = \frac{51.8^2 \text{ cm/s}^2}{2.06} = 1300 \text{ cm/s}^2 \)

\[ = 13 \text{ m/s}^2 \]