

Name Solutions Section \_\_\_\_\_

The exam is closed book and closed notes.

"On my honor, I pledge that I have not violated the provisions of the NJIT Student Honor Code." Signature \_\_\_\_\_

**Part I:** There are 10 multiple choice Questions.

Make sure you put your name, section, and ID number on the SCANTRON form. **Failure to do so will cost you two points.** The answers for the multiple choice Questions are to be placed on the SCANTRON form provided. Use a Number 2 pencil to fill in answers on the SCANTRON form. Make sure you give only one (1) answer to each question. **If you erase an answer on the SCANTRON form, make sure all traces are removed.**

**Parts II:** Workout problems. Show ALL your work. Correct answers with unsubstantiated work will receive **ZERO CREDIT.**

**Part I (30 points)**

1. Professor Jones buys a bag of fertilizer for his lawn. The bag of fertilizer, according to the manufacturer, covers an area of 5000 square feet. This area is the closest to [Hint: 1in=2.54cm]

- A) 5000 m<sup>2</sup>  
 B) 1524 m<sup>2</sup>  
 C) 1.524×10<sup>5</sup> m<sup>2</sup>  
 D) 464 m<sup>2</sup>  
 E) 4.64×10<sup>6</sup> m<sup>2</sup>

$$5000\text{ft}^2 \left(\frac{12\text{in}}{1\text{ft}}\right)^2 \left(\frac{2.54\text{cm}}{1\text{in}}\right)^2 \left(\frac{1\text{m}}{100\text{cm}}\right)^2$$

2. Professor Jones observes a chemical reaction. She observes that the reaction takes 3.50 seconds. She further observes that the chemical reaction uses 569 g of chemicals. On average, Professor Jones calculates the rate (in kg per second) at which the chemicals react to be

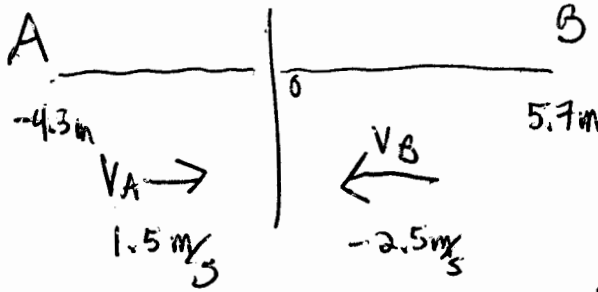
- A) 0.162571 kg/s  
 B) 0.163 kg/s  
 C) 0.2 kg/s  
 D) 163 kg/s  
 E) 1.63×10<sup>5</sup> kg/s

$$\left(\frac{569\text{g}}{3.50\text{s}}\right) \left(\frac{1\text{kg}}{1000\text{g}}\right)$$

3 significant figures

3. Runner A is initially 4.3 m west of a flagpole and is running with a constant velocity of 1.5 m/s due east. Runner B is initially 5.7 m east of the flagpole and is running with a constant velocity of 2.5 m/s due west. How far are the runners from the flagpole when their paths cross? Answer in units of m.

- A) 0.15 m
- B) 0.35 m
- C) 0.55 m
- D) 0.70 m
- E) 1.0 m



$$\Delta x = v_{avg}(t)$$

$$x_{FA} - x_{0A} = v_A t$$

$$x_{FB} - x_{0B} = v_B t$$

Paths cross:  $x_{FA} = x_{FB}$

$$1.5t - 4.3 = -2.5t + 5.7$$

$$t = 2.5 \text{ s}$$

$$x_{FB} = x_{FA} = -0.55 \text{ m}$$

4. A stone was thrown from a bridge vertically upward with initial velocity of 8.3 m/s. After 2 seconds the stone is

- A) 3 m above the bridge
- B) 3 m below the bridge
- C) 36 m above the bridge
- D) 36 m below the bridge
- E) at maximum height



$$\Delta y = v_{0y}t - \frac{1}{2}gt^2$$

$$\Delta y = 8.3 \frac{m}{s}(2s) - \frac{1}{2}(9.8 \frac{m}{s^2})(4s^2)$$

$$= -3.0 \text{ m}$$

5. A position of a football player is given by  $x = 12 - 8t + 3t^2$  where  $t$  is in seconds and position is in meters (measured from left side of field). What is the average velocity of the player between  $t=0$  and  $t=3$  seconds?

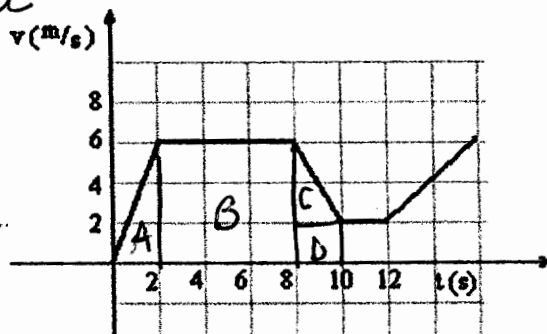
- A) 1 m/s
- B) 4 m/s
- C) 6 m/s
- D) 8 m/s
- E) 10 m/s

$$v_{avg} = \frac{\Delta x}{t} = \frac{15 \text{ m} - 12 \text{ m}}{3 \text{ s}} = 1 \frac{m}{s}$$

6. How far does a runner, whose velocity versus time graph is shown in the figure below, travel in 12 seconds?

- A) 28 m
- B) 36 m
- C) 48 m
- D) 54 m
- E) 66 m

$\Delta x = v_{avg} t = \text{area under } v \text{ vs. } t \text{ curve}$



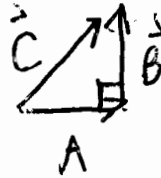
$$\Delta x = \text{Area A} + \text{Area B} + \text{Area C} + \text{Area D}$$

$$= \frac{1}{2}(2)(6) + 6(6) + \frac{1}{2}(2)(4) + 2(2)$$

$$= 54 \text{ m}$$

7. When vectors  $\vec{A}$  and  $\vec{B}$  are added together they form vector  $\vec{C}$ . These vectors satisfy the relationship  $A^2 + B^2 = C^2$ . Which statement is true for these vectors?

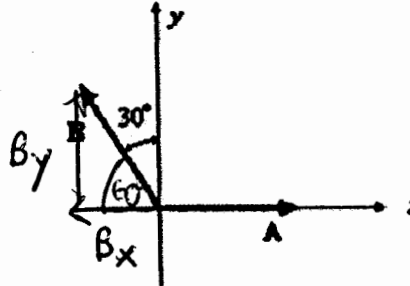
- A) Vectors  $\vec{A}$  and  $\vec{B}$  must be parallel.
- B) Vectors  $\vec{A}$  and  $\vec{B}$  must be anti-parallel.
- C) Vectors  $\vec{A}$  and  $\vec{B}$  must have the same magnitudes.
- D) Vectors  $\vec{A}$  and  $\vec{B}$  must be perpendicular.



$\vec{A}, \vec{B}, \vec{C}$  must form right triangle

8. Refer to the figure given on the right. The components of vectors  $\vec{A}$  and  $\vec{B}$  are

- A)  $A_x = 0$                        $B_x = B \sin 30^\circ$   
 $A_y = 0$                            $B_y = B \cos 30^\circ$
- B)  $A_x = A \sin 90^\circ$            $B_x = B \cos 60^\circ$   
 $A_y = A \cos 90^\circ$            $B_y = B \sin 60^\circ$
- C)  $A_x = A \cos 0^\circ$                $B_x = -B \cos 60^\circ$   
 $A_y = A \sin 0^\circ$                  $B_y = B \cos 30^\circ$**
- D)  $A_x = A \cos 90^\circ$            $B_x = B \sin 60^\circ$   
 $A_y = A \sin 90^\circ$            $B_y = B \cos 60^\circ$



9. An airplane flying horizontally at a constant speed of 350 km/h releases a bundle of food supplies. The bundle falls and strikes the ground in 10.0 seconds. Where, approximately, does the bundle land relative to the plane's position 10.0 seconds from the time of the drop? [neglect air friction].

- A) 1.00 km behind the plane.
- B) 1.00 km ahead of the plane
- C) 350 km behind the plane.
- D) more than 1.0 km behind the plane.
- E) directly beneath the plane.**



$\Delta x_{\text{plane}} = v_{\text{ax}} t$

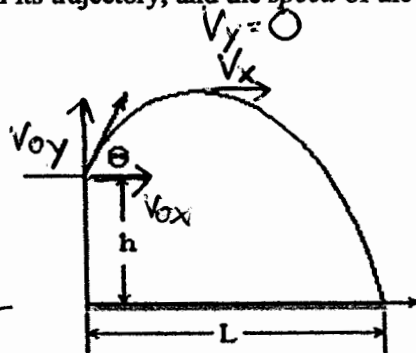
$\Delta x_{\text{bundle}} = v_{\text{bx}} t$

$\Delta x_{\text{plane}} = \Delta x_{\text{bundle}}$  since  
 $v_{\text{bx plane}} = v_{\text{bx bundle}} = 350 \text{ km/h}$

10. A projectile is launched at  $t = 0.0 \text{ s}$  from the edge of a cliff at a height ( $h$ ) of 100 m above the water, with a velocity  $v_0 = 100 \text{ m/s}$ ,  $\theta = 60.0^\circ$  above the horizontal. The projectile rises and falls into the sea. Determine the *time* it takes the projectile to reach the highest point in its trajectory, and the *speed* of the projectile at this point:

Time (s)	Speed (m/s)
A) 5.10	100
B) 8.84	0
<b>C) 8.84</b>	50.0
D) 17.7	86.6
E) 17.7	0

$t = 0 - \frac{v_0 \sin \theta}{-g}$   
 $t = \frac{-86.16 \text{ m/s}}{-9.8 \text{ m/s}^2}$   
 $= 8.84 \text{ s}$

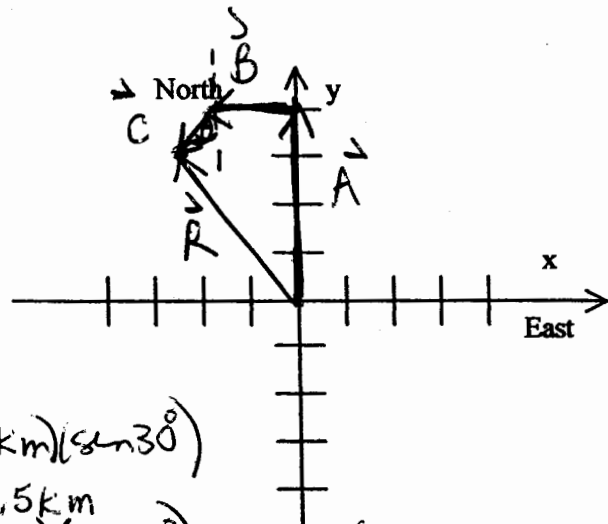


$V = \sqrt{V_x^2 + V_y^2} = \sqrt{(v_0 \cos \theta)^2 + 0} = 50.0 \text{ m/s}$

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Part II: Workout problems (10 points each)

1. A car goes 4 km north, 2 km west, and 1 km in a direction 30° west of south.



a) Draw a clear vector diagram for this motion, using the (x,y) system of coordinates with x pointing east and y pointing north. Indicate on the diagram the resulting total displacement vector. (2 pts)  
(The spacing between the marks on the axes is 1 km).

$$A_x = 0 \quad A_y = 4 \text{ km} \quad C_x = -(1 \text{ km}) \sin 30^\circ = -0.5 \text{ km}$$

$$B_x = 2 \text{ km} \quad B_y = 0 \quad C_y = -(1 \text{ km}) \cos 30^\circ = -0.866 \text{ km}$$

b) Find the components of the resulting displacement vector. (3 pts)

$$R_x = A_x + B_x + C_x = 0 - 2 \text{ km} - 0.5 \text{ km} = -2.5 \text{ km}$$

Answer: x-component: -2.5 km.  
y-component: 3.1 km.

$$R_y = A_y + B_y + C_y = 4 \text{ km} + 0 - 0.866 \text{ km} = 3.134 \text{ km}$$

c) Calculate the magnitude of the displacement. (2 pts)

Answer: 4.0 km.

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(-2.5 \text{ km})^2 + (3.134 \text{ km})^2} = 4.01 \text{ km}$$

d) Find the angle that the displacement vector makes with the positive x-direction. Indicate whether this angle is clockwise (CW) or counter-clockwise (C-CW) from the positive x-axis. (2 pts)

$$\theta = \tan^{-1} \frac{R_y}{R_x} = \tan^{-1} \left( \frac{3.134 \text{ km}}{-2.5 \text{ km}} \right) = -51.4^\circ$$

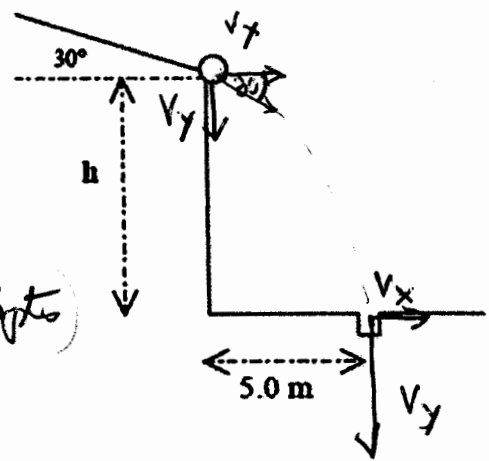
Answer: 129 degrees.  
Circle one: CW / C-CW

e) Write the displacement vector in unit vector notation. (1 pt)

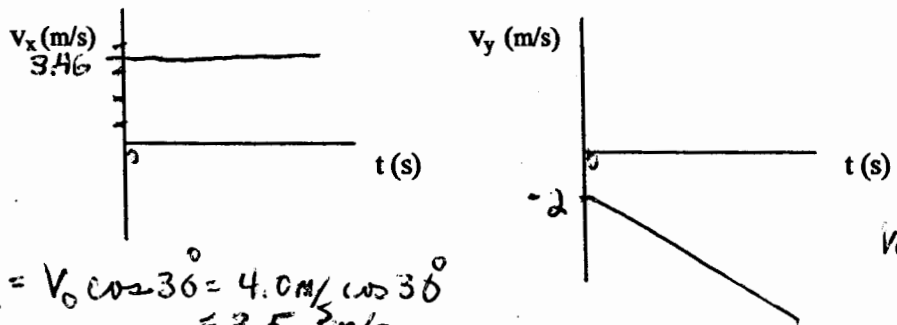
$$\vec{R} = (-2.5 \hat{i} + 3.1 \hat{j}) \text{ km}$$

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2. A small ball rolls down a frictionless 30° ramp. When the ball leaves the ramp, it has a speed of 4.0 m/s. A small hole is located a horizontal distance of 5.0 m from the end of the ramp. (Note: the figure is not drawn to scale)



A) Sketch  $v_x$  vs  $t$  and  $v_y$  vs  $t$ , from the time the ball leaves the ramp. Clearly indicate on your graph the value of these components at  $t=0$ . (3 pts)



$$v_{oy} = -v_0 \sin 30^\circ = -4.0 \text{ m/s} \sin 30^\circ = -2.0 \text{ m/s}$$

$$v_{ox} = v_0 \cos 30^\circ = 4.0 \text{ m/s} \cos 30^\circ = 3.5 \text{ m/s}$$

B) Assuming the ball falls into the small hole, from what height  $h$  does the ball fall? (3 pts)  
 Known:  $\Delta x, v_{ox}, v_{oy}, g$  } need  $t$  to find  $\Delta y$

$$t = \frac{\Delta x}{v_{ox}} = \frac{5.0 \text{ m}}{3.5 \text{ m/s}} = 1.4 \text{ s}$$

Height  
 Answer: 12 m

$$\Delta y = v_{oy}t - \frac{1}{2}gt^2 = -2.0 \text{ m/s}(1.4 \text{ s}) - \frac{1}{2}(9.8 \text{ m/s}^2)(1.4 \text{ s})^2 = -12.4 \text{ m} \approx -12 \text{ m}$$

C) What is the magnitude of the vertical component of the velocity,  $v_y$ , when it hits the floor? (2 pts)

$$v_y = v_{oy} - gt \quad \text{or} \quad v_y^2 = v_{oy}^2 - 2g\Delta y$$

$$v_y = -2.0 \text{ m/s} - 9.8 \text{ m/s}^2(1.4 \text{ s}) \quad v_y^2 = (-2.0 \text{ m/s})^2 - 2(9.8 \text{ m/s}^2)(-12.4 \text{ m})$$

$$= -15.7 \text{ m/s} \approx -16 \text{ m/s} \quad v_y = \sqrt{-15.7 \text{ m/s}} \approx 16 \text{ m/s}$$

Answer: 16 m/s.

D) What is the magnitude of the net velocity,  $v$ , of the ball when it hits the ground? (2 pts)

$$v = \sqrt{v_x^2 + v_y^2}$$

$$= \sqrt{(3.5 \text{ m/s})^2 + (-16 \text{ m/s})^2} = 16.4 \approx 16 \text{ m/s}$$

Answer: 16 m/s