Phys 11C – Eiteneer

Worksheet for Lab 02 - Vectors

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PURPOSE

Vectors are powerful mathematical tools that can be used to solve a variety of problems in the physical sciences. In this worksheet, you will practice solving typical vector problems graphically and using vector components.

PROBLEMS

All work should be neatly done on separate pieces of paper that will be turned in with this handout. Be sure to show all work for full credit.

1) An arrow is launched with an initial speed of 70m/s at an angle 35° above the horizontal. Find the x and y components of the velocity vector:
   a) Graphically (i.e., drawing **to scale** on the supplied graph paper).
   b) Using trigonometry. Write your final answer in vector component form (i.e., using **i**'s and **j**'s).

2) An airplane flies at a bearing of N57°W at a speed of 500mph. Assume the y-axis points north and the x-axis points east. Find the x and y components of the velocity vector.
   a) Graphically.
   b) Using trigonometry. Write your final answer in vector component form.

3) A box sits on a plane that is tilted 25° above the horizontal. A horizontal force of 30N acts on the box. Use trigonometry to write the force in vector component form using (a) a standard coordinate system, and (b) a coordinate system tilted to align itself with the plane.

4) A ship has a top speed of 3m/s in calm water. The current of the ocean tends to push the boat at 2m/s on a bearing of S70°W. What will be the net velocity of the ship if the captain points his ship on a bearing of N55°W and applies full power?
   a) Do the problem graphically. Be sure to clearly indicate the vector heads and tails.
   b) Repeat the problem using vector components.

5) For **A** = <2,-3>, **B** = <4,5>, and **C** = <3,-1> find the following graphically and algebraically (**i**'s and **j**'s).
   a) **A** + 2**B** b) **A** - (**B** + **C**) c) 5**A** – 3**C**

6) For the vectors given in Problem 5, determine:
   a) **A** x **B** b) **A** · (**B** x **C**) c) **A** x (**B** · **C**)
   d) **A** · **B** e) Find the angle between **B** and **C**, using any method.

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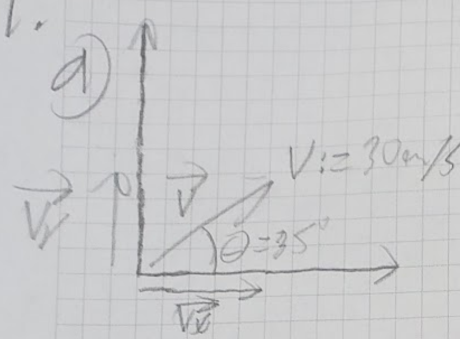
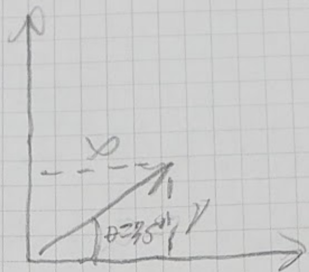
Phys HA lab

1.

a)



or



b) $V_x = |V| \cos\theta$ $\quad \vec{V} = V_x + V_y$

$V_y = |V| \sin\theta$ $\quad \vec{V} = V_x \hat{i} + V_y \hat{j}$

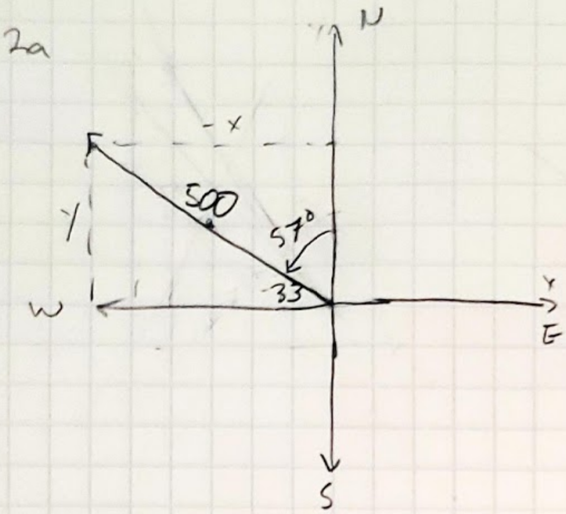
$\vec{V} = (70 m/s, 35°$ north of east$)$

$V_x = (70 m/s)\cos(35°) = 57.34 m/s$

$V_y = (70 m/s)\sin(35°) = 40.15 m/s$

$$\boxed{\vec{V} = V_x \hat{i} + V_y \hat{j} = (57.34 \hat{i} + 40.15 \hat{j}) m/s}$$

2a



$\cos 33 = \frac{x}{500}$ $\sin 33 = \frac{y}{500}$

$x = 419$ $y = 272$

$x = -419\hat{i} + 272\hat{j}$

b

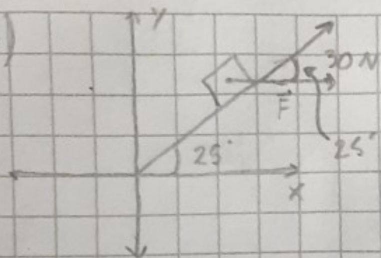
$\vec{v} = 500$ mph
$\theta = N57°W$
$\hookrightarrow \theta = 147°$

$v_x = 500\cos 147$ $v_y = 500\sin 147$

$v_x = -419$ $v_y = 272$

$\vec{v} = -419\hat{i} + 272\hat{j}$

3)

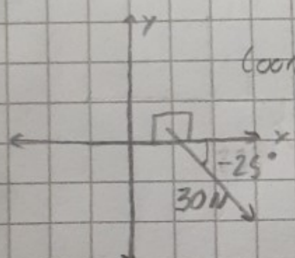


a) $\boxed{\vec{F} = 30\hat{i}\,[N]}$

b) $\vec{F} = F\hat{i} + F\hat{j}$

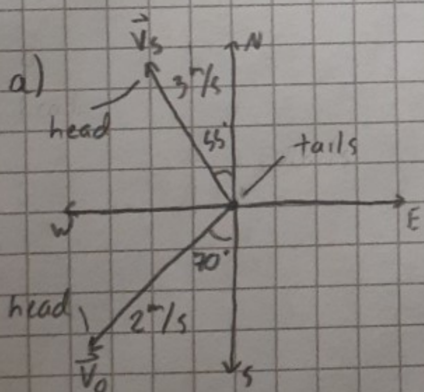
$\vec{F} = (30\cos(360-25)) + (30\sin(360-25))$

$\boxed{\vec{F} = -12.24\hat{i} + 27.39\hat{j}\,[N]}$



Coordinate plane aligned w/ box plane

4) a)



$\vec{V} = \vec{V}_S + \vec{V}_O$

$\vec{V}_S = V_{x_S} + V_{y_S} = 3\cos(90+55) + 3\sin(90+55)$

$\vec{V}_O = V_{x_O} + V_{y_O} = 2\cos(270-70) + 2\sin(270-70)$

$\vec{V} = 4.05\,m/s + (-0.77\,m/s)$

$\boxed{\vec{V} = 3.28\,m/s}$

b) $\vec{V} = \vec{V}_S + \vec{V}_O$

$\vec{V}_S = 3\cos(90+55)\hat{i} + 3\sin(90+55)\hat{j} = 2.65\hat{i} + 1.40\hat{j}$

$\vec{V}_O = 2\cos(270-70)\hat{i} + 2\sin(270-70)\hat{j} = 0.94\hat{i} + (-1.75)\hat{j}$

$\boxed{\vec{V} = 3.59\hat{i} + (-0.35)\hat{j}\,[m/s]}$

David Chavez work:

5) $\vec{A} = (2\hat{i}, -3\hat{j})$

a) $\vec{B} = (4\hat{i}, 5\hat{j})$

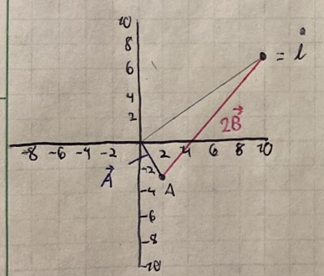
$\vec{C} = (3\hat{i}, -1\hat{j})$

a) $\vec{A} + 2\vec{B} = \vec{l}$

$(2\hat{i} + 2(4\hat{i})) + (-3\hat{j} + 2(5\hat{j}))$

$10\hat{i} + 7\hat{j}$

$l = (10\hat{i}, 7\hat{j})$



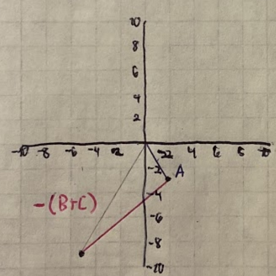
b) $A - (B + C) = \theta$

$A - (4\hat{i} + 3\hat{i}) + (5\hat{j} + (-1\hat{j}))$

$(7\hat{i} + 6\hat{j})$

$(2\hat{i} - 7\hat{i}) + (-3\hat{j} - 6\hat{j})$

$(-5\hat{i} + -9\hat{j}) \quad (-5\hat{i}, -9\hat{j}) = \theta$

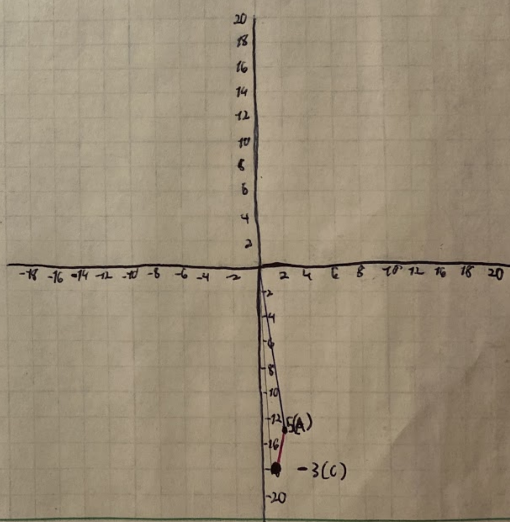


c) $5A - 3C = \Gamma$

$(5(2\hat{i}) - 3(3\hat{i})) + (5(-3\hat{j}) + 3(-1\hat{j}))$

$1\hat{i} \qquad -18\hat{j}$

$\Gamma = (1\hat{i}, -18\hat{j})$



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6. a) $A \times B$ $\qquad A\langle 2,-3\rangle \quad B\langle 4,5\rangle$

$$\vec{C} = \vec{A} \times \vec{B} = \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{bmatrix} = \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -3 & 0 \\ 4 & 5 & 0 \end{bmatrix}$$

$$= \hat{i}\underbrace{(A_y B_z - A_z B_y)}_{C_x} - \hat{j}\underbrace{(A_x B_z - A_z B_x)}_{-C_y} + \hat{k}\underbrace{(A_x B_y - A_y B_x)}_{C_z}$$

$$= C_x\hat{i} + C_y\hat{j} + C_z\hat{k}$$

$$= \hat{i}\underbrace{\cancel{(-3(0) - 0(5))}}_{0} - \hat{j}\underbrace{\cancel{(2(0) - 0(4))}}_{0} + \hat{k}(\overset{10}{2(5)} - \overset{+12}{\overset{-(-12)}{(-3)(4)}})$$

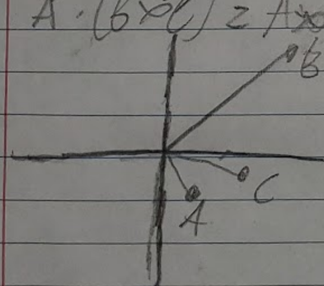
$\boxed{\vec{C} = 22\hat{k}}$ or $\langle 0, 0, 22\rangle$

b) $A \cdot (B \times C)$ $\qquad B\langle 4,5\rangle \; C\langle 3,-1\rangle$

$A\langle 2,-3\rangle \quad \vec{B} \times \vec{C} = \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 4 & 5 & 0 \\ 3 & -1 & 0 \end{bmatrix} \quad \ldots \; 0 \quad \ldots \; 0 \quad + \hat{k}(\overset{-4}{4\cdot(-1)} - \overset{-15}{(5)3})$

$-19\hat{k} \qquad -19$

$\vec{A} \cdot (\vec{B} \times \vec{C}) = A_x(B_x \times C_x) + A_y(B_y \times C_y) + A_z(B_z \times C_z)$



$\theta = \tan^{-1}\left(\frac{y}{x}\right)$

$A_x(0) + A_y(0) + \cancel{A_z}\,\cancel{0}(22) = 0$

Conf'd

$(A \cdot B) \times (A \cdot C)$

$A \cdot B = A_x B_x + A_y B_y + A_z B_z \qquad A \cdot C = A_x C_x + A_y C_y + A_z C_z$

$\underset{8}{2(4)} + \underset{-15}{-3(5)} + 0 = -7 \qquad 2(3) + -3(-1) + 0$

$6 + 3 = 9$

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Lab 02

$$\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 8 & -15 & 0 \\ 6 & 3 & 0 \end{bmatrix} = \hat{i}(A_yB_z - A_zB_y) - \hat{j}(A_xB_z - A_zB_x) + \hat{k}(A_xB_y - A_yB_x)$$

0 −0

b)

$8(3) - (-15)(6)$ −90

$24 + 90 = 114$ $\boxed{A \cdot (B \times C) = 114k}$

c) $A \times (B \cdot C)$

$A \times B \cdot A \times C$

$A \times C$ $A<2, -3>$ $C<3, -1>$

$$\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ C_x & C_y & C_z \end{bmatrix} \quad \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 0 \\ -3 & -1 & 0 \end{bmatrix}$$

$0 - 0 + \hat{k}(A_xB_y + A_yB_x)$

$2(-1) + 3(-3)$

$-2 - 9 = -11$

$0 \cdot 0 + 0 \cdot 0 + (-11)22$

$\boxed{A \times (B \cdot C) = -242}$

d) $A \cdot B = A_xB_x + A_yB_y + A_zB_z$

$2 \cdot 4 + (-3) \cdot 8 + 0 \cdot 0$

$8 - 16 = \boxed{-7}$

e) Angle between B and C $B<4, 5>$ $C<3, -1>$

Len 6.4 Len 3.1

$B \cdot C = 4 \cdot 3 + 5 \cdot (-1) + 0 \cdot 0$

$12 - 5 = 7$

$\boxed{\cos^{-1}(0.34) = 69.77^\circ}$

$$\cos(\text{angle}) = \frac{B \cdot C}{|B| \cdot |C|} = \frac{7}{6.4(3.16)} \approx 0.34$$