PROPOSED SOLUTIONS TO EXERCISES ON VECTOR ADDITION

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CONTENTS

Exercises from *Sears and Zemansky's University Physics (with Modern Physics) 12th Edition*, 2008

EXERCISE 1.30

1.30 Hearing rattles from a snake, you make two rapid displacements of magnitude 1.8 m and 2.4 m. In sketches (roughly to scale), show how your two displacements might add up to give a resultant of magnitude 4.2 m.

$\vec{A} + \vec{B} = \vec{C}$, $|\vec{C}| = 4.2m$

$$|\vec{A}| = \sqrt{(A_x)^2 + (A_y)^2} = 1.8$$

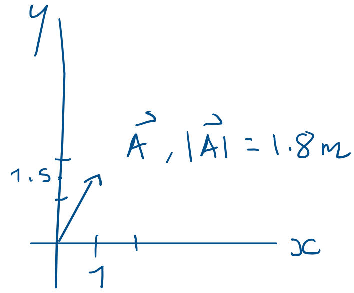
$$(A_x)^2 + (A_y)^2 = (1.8)^2 = 3.24$$

Let $A_x = 1$

$$1 + (A_y)^2 = 3.24$$

$$(A_y)^2 = 2.24$$

$$A_y = \sqrt{2.24} \approx 1.5$$



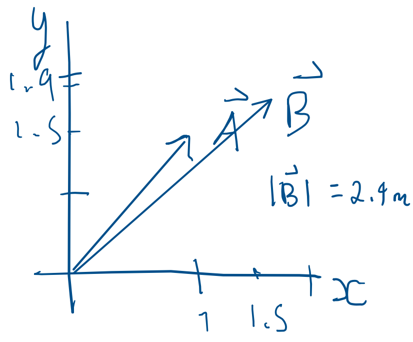
$$|\vec{B}| = \sqrt{(B_x)^2 + (B_y)^2} = 2.4m$$

Let $B_x = 1.5$

$$(1.5)^2 + (B_y)^2 = (2.4)^2 = 5.76$$

$$B_y = \sqrt{5.76 - 2.25}$$

$$= \sqrt{3.51} \approx 1.9$$



$$\vec{A} + \vec{B} = \vec{C}$$

$$(A_x\hat{i} + A_y\hat{j}) + (B_x\hat{i} + B_y\hat{j}) = C_x\hat{i} + C_y\hat{j}$$

$$= (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j}$$

$$= (1 + 1.5)\hat{i} + (1.5 + 1.9)\hat{j}$$

$$= 2.5\hat{i} + 3.4\hat{j}$$

$$\{ C_x = 2.5,\ C_y = 3.4 \}$$

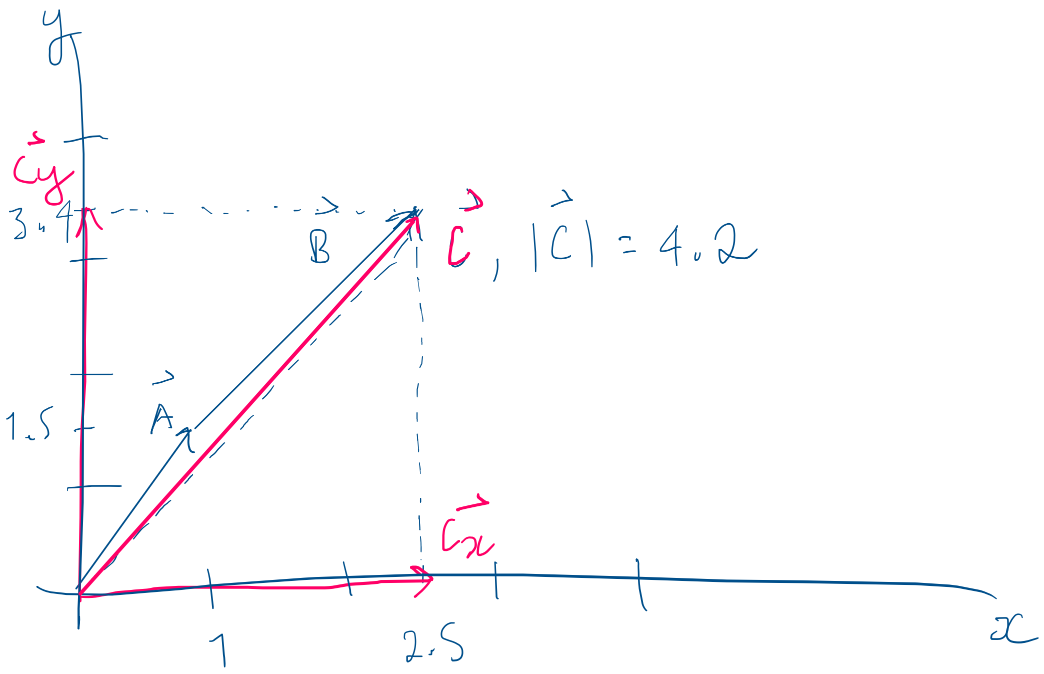
Check

Let $C_x = 2.5$

$$|\vec{C}| = \sqrt{(C_x)^2 + (C_y)^2} = 4.2$$

$$(2.5)^2 + (C_y)^2 = (4.2)^2 = 17.64$$

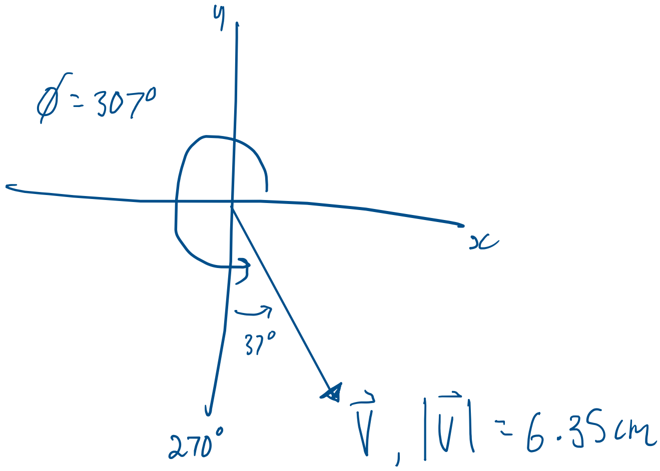
$$C_y = \sqrt{17.64 - 6.25} = \sqrt{11.39} \approx 3.4 \checkmark$$

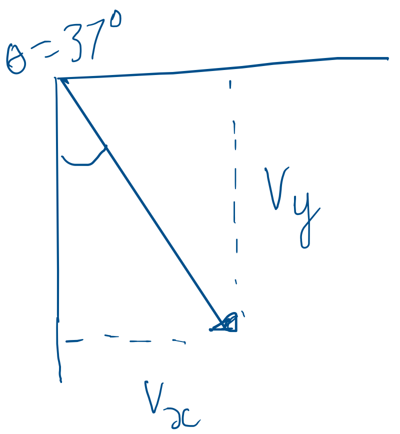


EXERCISE 1.34

1.34 Use a scale drawing to find the x- and y- components of the vector with a magnitude of 6.35 cm and angle of 307°.

$\boxed{1.34}$





$$\sin 37^\circ = \frac{V_x}{6.35}$$

$$V_x = 6.35 \sin 37^\circ \approx 3.82\,\text{cm}$$

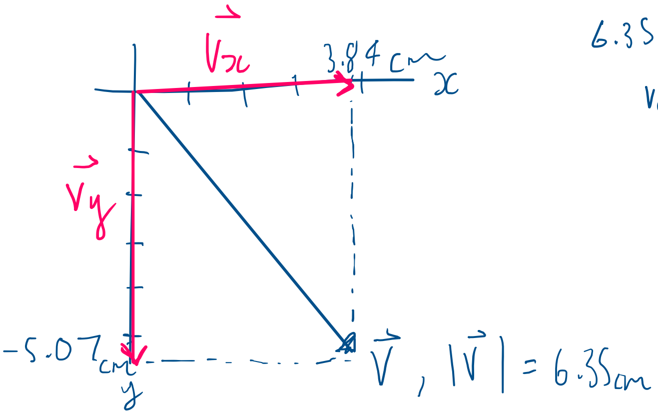
$$|\vec{V}| = \sqrt{(V_x)^2 + (V_y)^2}$$

$$6.35 = \sqrt{(3.82)^2 + (V_y)^2}$$

$$6.35^2 = 3.82^2 + (V_y)^2$$

$$V_y = -\sqrt{6.35^2 - 3.82^2}$$

$$\approx -5.07\,\text{cm}$$



Check

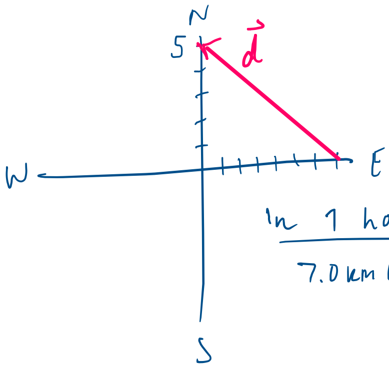
$$|\vec{V}| = 6.35 = \sqrt{(V_x)^2 + (V_y)^2}$$

$$= \sqrt{(3.82)^2 + (-5.07)^2} \approx 6.35 \checkmark$$

EXERCISE 1.44

1.44 A river flows from south to north at 5.0 km/h. On this river, a boat is heading east to west perpendicular to the current at 7.0 km/h. As viewed by an eagle hovering at rest over the shore, how fast and in what direction is this boat travelling?

$\boxed{1.44}$



In 1 hour:

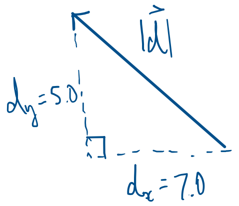
7.0 km East, 5.0 km North

* "How fast & in what direction"

$\frac{|\vec{d}|}{t} = \frac{|\vec{d}|\text{ km}}{1\text{ hour}}$

angle between $\vec{d}$ and directional axis – counterclockwise

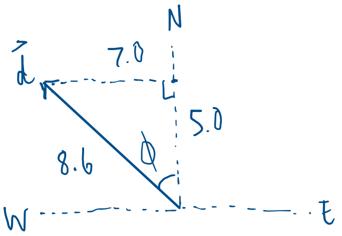
① Magnitude / speed



$$|\vec{d}| = \sqrt{(d_x)^2 + (d_y)^2} = \sqrt{(7)^2 + (5)^2}$$

$$= \sqrt{74} \approx 8.6$$

② Angle / Direction



$$\tan\phi = \frac{7.0}{5.0}$$

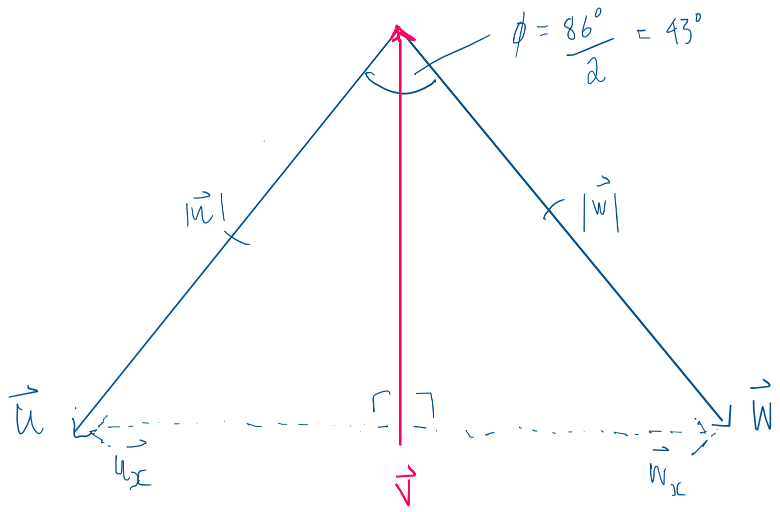
$$\phi = \arctan\left(\frac{7.0}{5.0}\right) \approx 54.5°$$

As viewed by an eagle hovering at rest over the shore, the boat is travelling 54.5° west of north at a speed of 8.6 km/h.

EXERCISE 1.46

1.46 Two ropes in a vertical plane exert equal magnitude forces on a hanging weight but pull with an angle of 86.0° between them. What pull does each one exert if their resultant pull is 372 N directly upward?

$|\vec{u}| = |\vec{w}|$



\# Horizontal forces

$\boxed{\vec{u}}$ $\sin(270^\circ - 43^\circ) = \frac{|\vec{u}_x|}{|\vec{u}|}$

$|\vec{u}| \sin 227^\circ = |\vec{u}_x|$

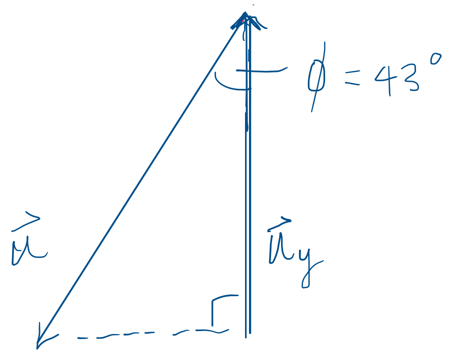
$\boxed{\vec{w}}$ $\sin(270^\circ + 43^\circ) = \frac{|\vec{w}_x|}{|\vec{w}|}$

$|\vec{w}| \sin 313^\circ = |\vec{w}_x|$

$$
\begin{aligned}
|\vec{u}_x| + |\vec{w}_x| &= -|\vec{u}|(-0.731) + |\vec{w}|(-0.731) \\
&= |\vec{u}|(-0.731) - |\vec{u}|(-0.731) \\
&\quad \{ |\vec{u}| = |\vec{w}| \} \\
&= 0
\end{aligned}
$$

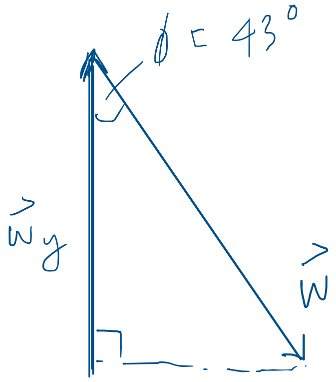
the horizontal forces cancel.

Vertical forces



$$\cos 43^\circ = \frac{|\vec{u}_y|}{|\vec{u}|}$$

$$|\vec{u}_y| = |\vec{u}| \cos 43^\circ$$



$$\cos 43^\circ = \frac{|\vec{w}_y|}{|\vec{w}|}$$

$$|\vec{w}_y| = |\vec{w}| \cos 43^\circ$$

'sum of vertical forces'

$$\text{'Resultant pull'} = 372 = |\vec{u}_y| + |\vec{w}_y|$$

$$= |\vec{u}| \cos 43^\circ + |\vec{w}| \cos 43^\circ$$

$$= |\vec{u}| \cos 43^\circ + |\vec{u}| \cos 43^\circ$$

$$\{ |\vec{u}| = |\vec{w}| \}$$

$$372 = 2|\vec{u}| \cos 43^\circ$$

$$186 = |\vec{u}| \cos 43^\circ$$

$$|\vec{w}| = |\vec{u}| = \frac{186}{\cos 43^\circ} \approx 254 \text{ N}$$

Each rope exerts $\sim$ 254 N of force