PHYS141 OUTLINE QUESTIONS SOLUTIONS

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Exercise 1

Chapter 3, Page 50

Principles of Physics, International Edition
ISBN: 9781118230749
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Solution Verified Answered 2 years ago

Step 1 1 of 2

In order to solve this problem we have to understand that the vector projection on an an axis is given as a product of the vector's magnitude and cosine of the angle between the axis and the vector. Here we have that

$$a\cos\theta = a_x = \frac{a}{2}$$

Which gives that

$$\cos\theta = \frac{1}{2}$$

$$\theta = 60^\circ$$

Now, the tangent of θ is simply

$$\tan\theta = \tan 60^\circ = \sqrt{3}$$

Result 2 of 2

$$\tan\theta = \sqrt{3}$$

Exercise 70 Rate this solution Exercise 2

Exercise 3

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Step 1 1 of 2

The magnitude of any vector r in Cartesian coordinate system is given as a

$$r = \sqrt{x^2 + y^2 + z^2}$$

If we now plug in the given components we obtain that

$$r = \sqrt{15^2 + 15^2 + 10^2} = \sqrt{550}$$

$$r = 23.5\mathrm{m}$$

Result 2 of 2

$$r = 23.5\mathrm{m}$$

Exercise 2 Rate this solution Exercise 4

Exercise 7a

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Solution A Solution B

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Step 1 1 of 4

Givnes:

The dimensions of the room:

(1) Height, $h = 3\ \mathrm{m}$.

(2) Area, $A = 3.7 \times 4.3\ \mathrm{m}^2$.

Step 2 2 of 4

The fly starts at one corner, consider this corner is the origin point. Then the fly flies around, ending up at the diagonally opposite corner. The displacement vector can be expressed as:

$$\vec{d} = l\hat{i} + w\hat{j} + h\hat{k}$$

Where w is the width of the room, l is the length of the room, and h is its height.

Step 3 3 of 4

a) The magnitude of $\vec{d}$ is:

$$|\vec{d}| = \sqrt{w^2 + l^2 + h^2} = \sqrt{3.7^2 + 4.3^2 + 3^2} = 6.42\ \mathrm{m}$$

$$\boxed{|\vec{d}| = 6.42\ \mathrm{m}}$$

Result 4 of 4

a) $|\vec{d}| = 6.42\ \mathrm{m}$

Exercise 6
Rate this solution
Exercise 7b

Exercise 7b

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b) The length of the path can't be less than the magnitude of the displacement but can be greater.

The fly, in this case, flies in a straight line from one edge and then ends up at the diagonally opposite corner, and it's known that the straight line between two points is the shortest way.

Exercise 7a
Rate this solution
Exercise 7c

Exercise 7c

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c) The length can be greater if the fly does not fly in a straight line.

For example, the fly can fly around the room in every possible way, in this case, the length of the path for sure is greater than $6.42 \mathrm{~m}$, but the magnitude of the displacement will always be $6.42 \mathrm{~m}$ if the starting and ending points are fixed.

Exercise 7b
Rate this solution
Exercise 7d

Exercise 7d

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d) The length of the path can equal the magnitude of the displacement if the fly is flying in a straight line from the starting point to the ending point as explained earlier.

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Step 1 1 of 2

e) The displacement vector in unit vector notation is expressed as follows:

$$\vec{d} = l\hat{i} + w\hat{j} + h\hat{k} = 3.7\ (\mathrm{m})\ \hat{i} + 4.3\ (\mathrm{m})\ \hat{j} + 3\ (\mathrm{m})\ \hat{k}$$

$$\boxed{\vec{d} = 3.7\ (\mathrm{m})\ \hat{i} + 4.3\ (\mathrm{m})\ \hat{j} + 3\ (\mathrm{m})\ \hat{k}}$$

Result 2 of 2

$$\vec{d} = 3.7\ (\mathrm{m})\ \hat{i} + 4.3\ (\mathrm{m})\ \hat{j} + 3\ (\mathrm{m})\ \hat{k}$$

Exercise 7d
Rate this solution
Exercise 7f

Exercise 7f

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f) There are four possible short walking ways, d_2, d_3, d_4, and d_5. Each one of them is expressed as:

$$d_2 = w + l + h = 3 + 3.7 + 4.3 = 11 \text{ m}$$
$$d_3 = \sqrt{(h+l)^2 + w^2} = \sqrt{(3+3.7)^2 + 4.3^2} = 7.96 \text{ m}$$
$$d_4 = \sqrt{(h+w)^2 + l^2} = \sqrt{(3+4.3)^2 + 3.7^2} = 8.18 \text{ m}$$
$$d_5 = \sqrt{(l+w)^2 + h^2} = \sqrt{(3.7+4.3)^2 + 3^2} = 8.5 \text{ m}$$

Then the shortest way is d_3 and its length is 7.96 m.

$$\boxed{\text{The length of the shortest way is } 7.96 \text{ m}}$$

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Step 1 1 of 2

To answer these questions we will use the vector algebra and apply it on this two vectors

$$\vec{a} = 5\vec{i} - 4\vec{j} + 2\vec{k}$$

$$\vec{b} = -2m\vec{i} + 2m\vec{j} + 5m\vec{k}$$

a) Now the sum of the tow vectors is given as

$$\vec{a} + \vec{b} = (5 - 2m)\vec{i} + (-4 + 2m)\vec{j} + (2 + 5m)\vec{k}$$

b) The difference between the two is on the other hand given as

$$\vec{a} - \vec{b} = (5 + 2m)\vec{i} + (-4 - 2m)\vec{j} + (2 - 5m)\vec{k}$$

c) To have the desired identity to hold

$$\vec{a} - \vec{b} + \vec{c} = 0$$

to be true, than it has to hold

$$\vec{c} = -(\vec{a} - \vec{b})$$

but we know $\vec{a} - \vec{b}$ from part b) so the vector $\vec{c}$ is given as

$$\vec{c} = (-5 - 2m)\vec{i} + (4 + 2m)\vec{j} + (-2 + 5m)\vec{k}$$

Result 2 of 2

$$\text{a) } \vec{a} + \vec{b} = (5 - 2m)\vec{i} + (-4 + 2m)\vec{j} + (2 + 5m)\vec{k}$$

$$\text{b) } \vec{a} - \vec{b} = (5 + 2m)\vec{i} + (-4 - 2m)\vec{j} + (2 - 5m)\vec{k}$$

$$\text{c) } \vec{c} = (-5 - 2m)\vec{i} + (4 + 2m)\vec{j} + (-2 + 5m)\vec{k}$$

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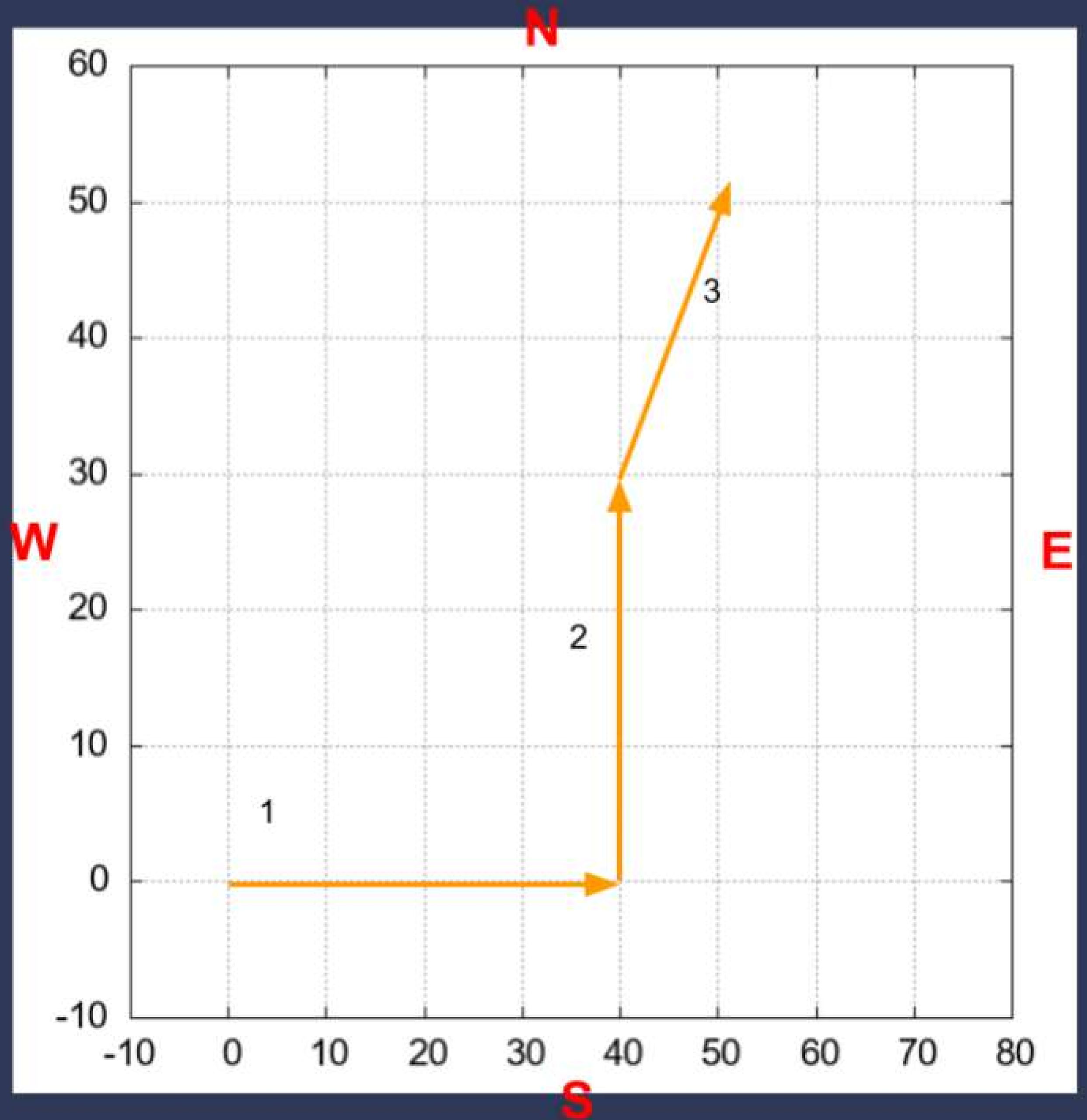
Step 1 1 of 4



Step 2 2 of 4

In order to solve this problem we will have to project the car motion onto two axis. Let's take that direction S-N is y -axis and direction W-E x-axis. Now we have that x and y coordinates are given of each putt are given as

$$C_1 = [40, 0]$$

$$C_2 = [0, 30]$$

$$C_3 = [25\sin\theta, 25\cos\theta]$$

Now the cumulative putt coordinates are given as

$$C = C_1 + C_2 + C_3$$

$$C_x = C_{1x} + C_{2x} + C_{3x} = 40 + 0 + 25\cos\theta$$

$$C_y = C_{1y} + C_{2y} + C_{3y} = 0 + 30 + 25\sin\theta$$

But we know that $\theta = 30^\circ$ and we have that

$$C_x = 40 + 0 + 25 \times 0.5$$

$$C_y = 0 + 30 + 25 \times 0.866$$

$$C_x = 51.7$$

$$C_y = 52.5$$

Step 3 3 of 4

a) The magnitude of the car's displacement vector is defined as

$$C = \sqrt{C_x^2 + C_y^2} = \sqrt{51.7^2 + 52.5^2}$$

$$C = 73.7\text{km}$$

b) The angle of the vector can be found from the well known identity of the vector algebra

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

But we know that

$$\sin\theta = \frac{C_y}{C}$$

$$\cos\theta = \frac{C_x}{C}$$

So after we insert it into the equation above we get that

$$\tan\theta = \frac{C_y}{C_x} = \frac{52.5}{51.7}$$

$\theta = \arctan\frac{52.5}{51.7} = 45.4^\circ$ from the initial position north of east.

Result 4 of 4

$$\text{a) } C = 73.7\text{km}$$

$$\text{b) } \theta = 45.4^\circ \text{east of north}$$

Exercise 11c
Rate this solution
Exercise 13

Exercise 15a

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Solution A Solution B

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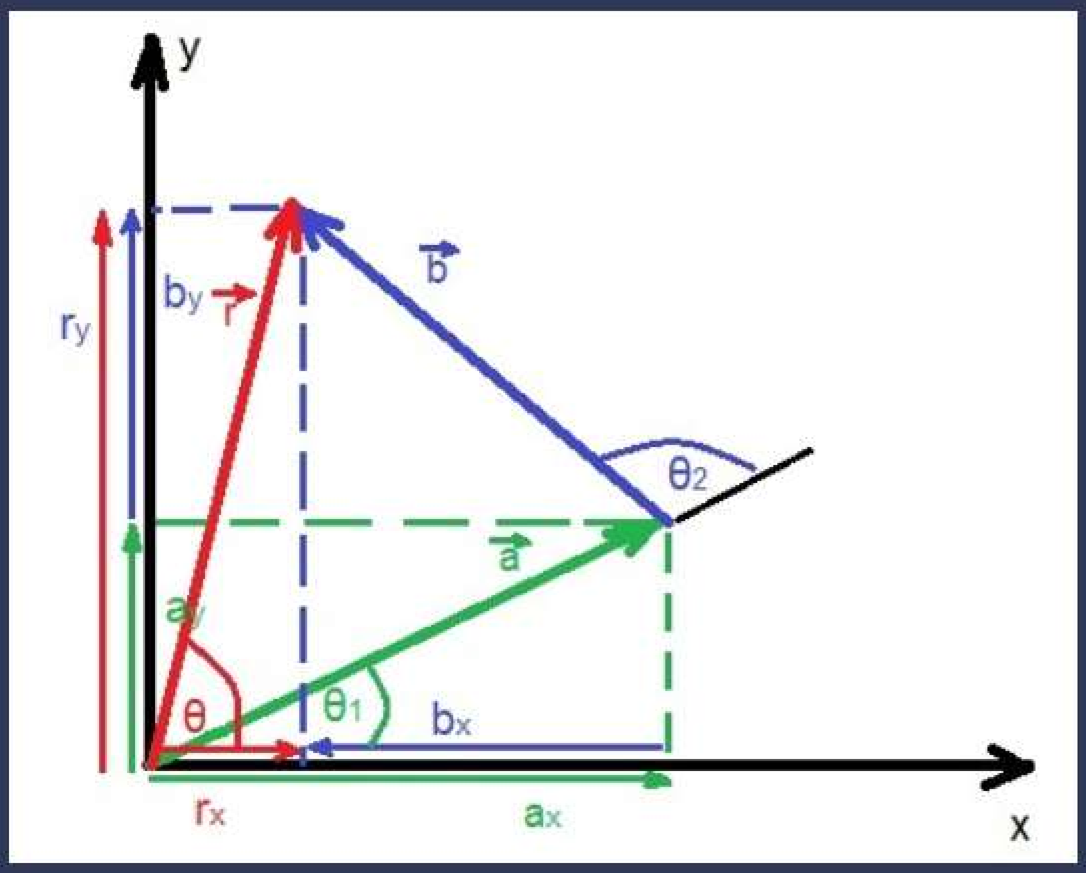
Step 1 1 of 4



Let starts with a sketching all components of vectors on the x and y axis.

Step 2 2 of 4

The x and the y components of the $\vec{r}$ is equal to the sum of x and y components of the vectors $\vec{a}$ and $\vec{b}$. So, we have:

$$\vec{a_x} = a \cdot \cos\theta_1 = 10 \cdot \cos 30 = 8.66 \text{ m}$$
$$\vec{a_y} = a \cdot \sin\theta_1 = 10 \cdot \sin 30 = 5 \text{ m}$$

$$\vec{b_x} = b \cdot \cos(\theta_1 + \theta_2) = 10 \cdot \cos(30 + 105) = -7.07 \text{ m}$$
$$\vec{b_y} = b \cdot \sin(\theta_1 + \theta_2) = 10 \cdot \sin(30 + 105) = 7.07 \text{ m}$$

Step 3 3 of 4

a)

The x component of vector $\vec{r}$ is a sum of x components of vectors $\vec{a}$ and $\vec{b}$.

$$r_x = a_x + b_x = 8.66 \text{ m} - 7.07 \text{ m}$$

$$\boxed{r_x = 1.59 \text{ m}}$$

Result 4 of 4

a) $r_x = 1.59$ m.

Exercise 15b

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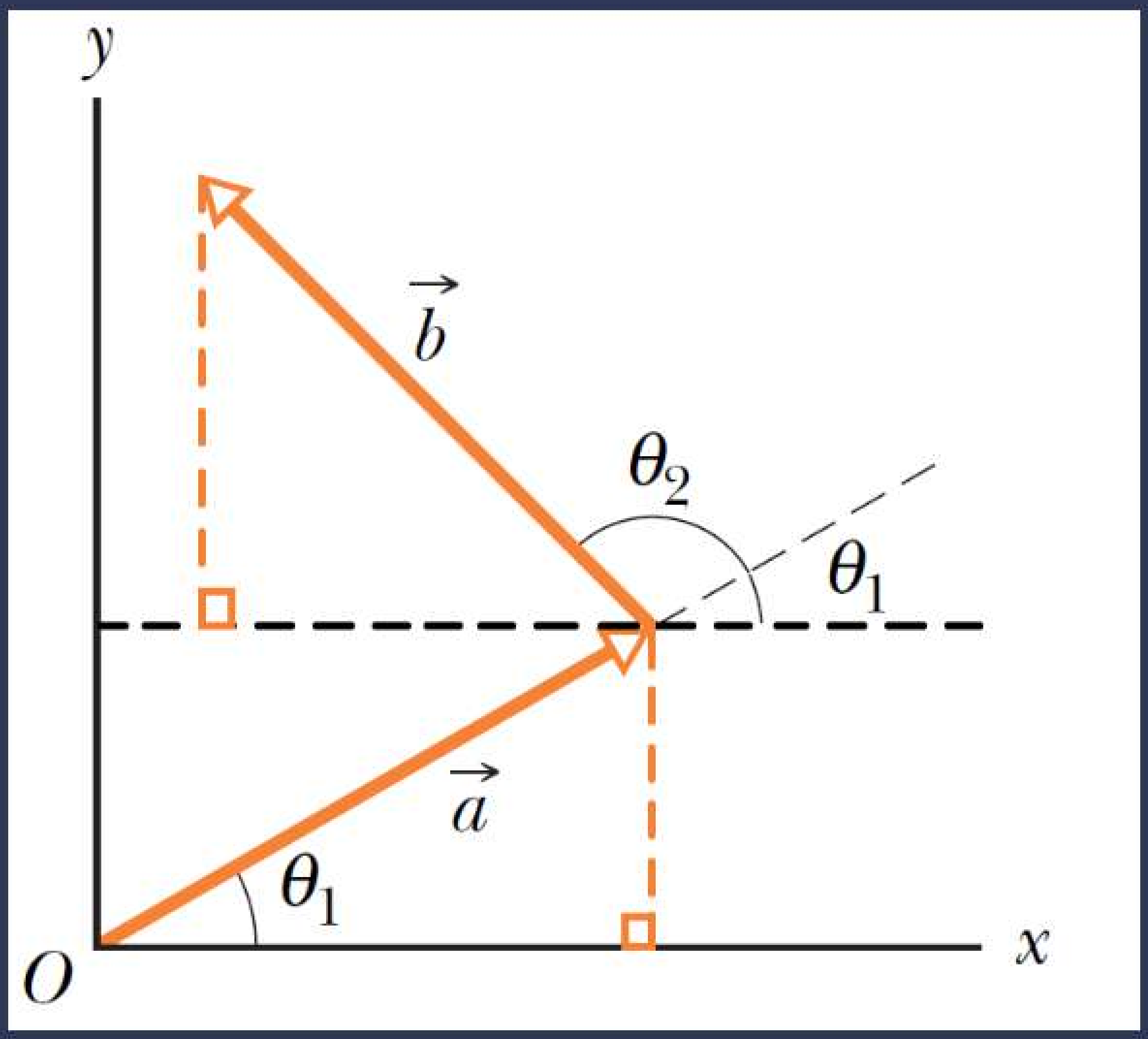
Step 1 1 of 3

$b)$

An extended version of the figure gives the necessary information to find the components of each vector. Use the following trigonometric properties to solve:

$$\sin(\theta) = \frac{opp}{hyp}$$

$$\cos(\theta) = \frac{adj}{hyp}$$



Step 2 2 of 3

Then combine both vectors.

$$\begin{aligned}\vec{b}_x &= 10 \cdot \cos(45^\circ) \\ &\approx 7.07 \rightarrow -7.07 \\ \vec{b}_y &= 10 \cdot \sin(45^\circ) \\ &\approx 7.07 \\ \vec{r}_y &= 12.07\,\text{m}\end{aligned}$$

Result 3 of 3

$$b)\ \vec{r}_y = 12.07\,\text{m}$$

Exercise 15c

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Solution A Solution B

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Step 1

1 of 2

$c)$

The components found from parts a and b can be used to find the magnitude of $\vec{r}$ by using the Pythagorean Theorem. Use the following trigonometric property to find θ:

$$\tan(\theta) = \frac{opp}{adj}$$

$$\begin{aligned} \left|\vec{r}\right| &= \sqrt{1.59^2 + 12.07^2} \\ &\approx 12.17 \end{aligned}$$

Result

2 of 2

$$c) \left|\vec{r}\right| \approx 12.17\,\mathrm{m}$$

Exercise 15b Rate this solution Exercise 15d

Exercise 15d

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Step 1

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$d)$

The components found from parts a and b can be used to find the magnitude of $\vec{r}$ by using the Pythagorean Theorem.

Use the following trigonometric property to find θ:

$$\tan(\theta) = \frac{opp}{adj}$$

$$\theta = \tan\left(\frac{12.07}{1.59}\right)^{-1}$$
$$\approx 82.5^{\circ}$$

Result

2 of 2

$$d)\ \theta = 82.5^{\circ}$$

Exercise 15c
Rate this solution
Exercise 16a

Exercise 23

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Solution Verified Answered 2 years ago

Step 1 1 of 2

In order to solve this problem we have to understand what are parallel vectors. Two vectors are parallel when they are scalar multiple of each other, i.e. it holds

$$\vec{a'} = \alpha\vec{a}$$

If we calculate the magnitude of each side we can express α as

$$\alpha = \frac{|\vec{a'}|}{|\vec{a}|}$$

Now, let's find the magnitudes of our vectors $a = \vec{i} - \vec{j}$ and $\vec{b} = 3\vec{i} + 4\vec{j}$

$$|\vec{a}| = \sqrt{1^2 + 1^2} = \sqrt{2}$$

$$|\vec{b}| = \sqrt{3^2 + 4^2} = 5$$

Now, we can get back to the derived expression above and use the fact that there is a vector parallel to $\vec{a}$ with the magnitude of $\vec{b}$. We have showed that it has to hold

$$\alpha = \frac{|\vec{b}|}{|\vec{a}|}$$

After we insert the obtained values we have that

$$\alpha = \frac{5}{\sqrt{2}}$$

So the parallel vector is given as

$$\vec{a'} = \alpha\vec{a} = \frac{5}{\sqrt{2}}(\vec{i} - \vec{j})$$

Result 2 of 2

$$\vec{a'} = \frac{5}{\sqrt{2}}(\vec{i} - \vec{j})$$

Exercise 22d

Rate this solution

Exercise 24

Exercise 32a

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Solutions Verified

Solution A Solution B

Answered 1 year ago

Step 1

1 of 2

$\mathbf{(a)}$**:** The definition of the cross-product is given by [$\vec{a} \times \vec{b}$ = $|\vec{a}|$ ~ $\left|\vec{b}\right|$ ~ $\sin(\theta)$ ~ $\hat{\boldsymbol{n}}$]

Where, the magnitude of the cross product will be equal to [$\left|\vec{a} \times \vec{b}\right| = |\vec{a}| \left|\vec{b}\right| \sin(\theta)$]

Where, knowing the magnitude of the vector ($\vec{a}$) ` `the length" and the magnitude of the vector ($\vec{b}$), and knowing that the angle between them is a right-angle, then we can find the magnitude of the cross product of the two vectors using (b), hence substituting we get

$$\begin{aligned}\left|\vec{a} \times \vec{b}\right| &= 3 \times 4 \times \sin(90^\circ) \\ &= \boxed{12}\end{aligned}$$

Result

2 of 2

12

Exercise 31
Rate this solution
Exercise 32b

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Exercise 32b

Chapter 3, Page 51

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Solutions Verified

Solution A Solution B

Answered 1 month ago

Step 1 1 of 2

b) The direction of $\vec{a} \times \vec{b}$ can be determined using the Right-Hand Rule. Here we will find that our thumb points in the direction of the $+z$-axis.

The direction of $\vec{a} \times \vec{b}$ was determined to be $\hat{k}$ using the Right-Hand Rule

Result 2 of 2

b) The direction of $\vec{a} \times \vec{b}$ is $\hat{k}$

Rate this solution

Exercise 32a
Exercise 32c

Exercise 32c

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Solutions Verified

Solution A Solution B

Answered 1 month ago

Step 1 1 of 3

c) Knowing that $\vec{a}+\vec{b}+\vec{c}=0$ we can solve for $\vec{c}$ in terms $\vec{a}$ and $\vec{b}$ and then plug that in for $\vec{c}$.

Next, we can rewrite this into a more familiar form using some properties of vector operations.

$$\vec{c}=(-\vec{a}-\vec{b})$$

$$|\vec{a}\times\vec{c}|=|\vec{a}\times(-\vec{a}-\vec{b})|$$

Step 2 2 of 3

Rewrite:

$$=|(\vec{a}\times-\vec{a})+(\vec{a}\times-\vec{b})|=|0+-(\vec{a}\times\vec{b})|=|(\vec{a}\times\vec{b})|$$

$$|\vec{a}\times\vec{c}|=|(\vec{a}\times\vec{b})|=12$$

Result 3 of 3

c) $|\vec{a}\times\vec{c}|=12$

Exercise 32b
Rate this solution
Exercise 32d

Exercise 32d

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Solutions Verified

Solution A Solution B

Answered 1 month ago

Step 1

1 of 2

d) Similarly in part (c), we can use the Right-Hand Rule to figure out the direction of $\vec{a} \times \vec{c}$. Here we will find that our thumb points in the direction of the $-z$-axis.

Note: Remember to use the smaller of the two angles between the directions of the two vectors when using the Right-Hand Rule.

The direction of $\vec{a} \times \vec{c}$ was determined to be $-\hat{k}$ using the Right-Hand Rule.

Result

2 of 2

d) The direction of $\vec{a} \times \vec{c}$ is $-\hat{k}$

Rate this solution

Exercise 32c Exercise 32e

Exercise 32e

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Solutions Verified

Solution A Solution B

Answered 1 month ago

Step 1 1 of 2

e) To determine $\vec{b} \times \vec{c}$ we can use a similar method that we employed in part c).

$\vec{c} = (-\vec{a} - \vec{b})$

$$\begin{aligned}|\vec{b} \times \vec{c}| &= |\vec{b} \times (-\vec{a} - \vec{b})| \\ &= |(\vec{b} \times -\vec{a}) + (\vec{b} \times -\vec{b})| \\ &= |-(\vec{b} \times \vec{a}) + 0| \\ &= |(\vec{a} \times \vec{b})| \\ |\vec{b} \times \vec{c}| &= |(\vec{a} \times \vec{b})| \\ &= 12\end{aligned}$$

Result 2 of 2

e) $|\vec{b} \times \vec{c}| = 12$

Exercise 32f

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Solutions Verified

Solution A Solution B

Answered 1 month ago

Step 1

1 of 2

f) We can implement the Right-Hand Rule one more time and find that our thumb points in the direction of the $+z$-axis.

The direction of $\vec{b} \times \vec{c}$ was determined to be $\hat{k}$ using the Right-Hand Rule.

Result

2 of 2

f) The direction of $\vec{b} \times \vec{c}$ is $\hat{k}$

Exercise 35

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Solution Verified Answered 2 years ago

Step 1 1 of 2

To find the solutions to the questions risen in this problem will use the following formulas for dot and vector product of two vectors.

$$\vec{p} \cdot \vec{q} = |p||q| \cos\theta$$

$$\vec{p} \times \vec{q} = |p||q| \sin\theta \vec{k}$$

where θ is an angle formed by the two vectors and in our case is equal $\theta_p - \theta_q = 220 - 75 = 145°$. Now, we can calculate the requested values

$$\text{a) } \vec{p} \times \vec{q} = |p||q| \sin\theta \vec{k} = 3.5 \times 6.3 \times \sin 145° \vec{k} = 12.6\vec{k}$$

$$\text{b) } \vec{p} \cdot \vec{q} = |p||q| \cos\theta = 3.5 \times 6.3 \times \cos 145° = -18.1$$

Result 2 of 2

$$\text{a) } \vec{p} \times \vec{q} = 12.6\vec{k}$$

$$\text{b) } \vec{p} \cdot \vec{q} = -18.1$$

Exercise 36

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Solution Verified Answered 2 years ago

Step 1 1 of 2

This problem can be solved by food in a straight forward boring way or in a way that is more elegant and that requires some knowledge of basic algebra. We are going to use the second approach. We know by definition that

$$\vec{a} \times \vec{b} = \vec{c}$$

Such that $\vec{c} \perp \vec{a}$ and $\vec{c} \perp \vec{b}$. This fact implies that

$$\vec{a} \cdot (\vec{a} \times \vec{b}) \equiv 0$$

$$\vec{b} \cdot (\vec{a} \times \vec{b}) \equiv 0$$

In our problem we have that

$$(\vec{p_1} + \vec{p_2}) \cdot (\vec{p_1} \times 5\vec{p_2}) = 5(\vec{p_1} + \vec{p_2}) \cdot (\vec{p_1} \times \vec{p_2})$$

Now we can separate the sum as

$$5\vec{p_1} \cdot (\vec{p_1} \times \vec{p_2}) + 5\vec{p_2} \cdot (\vec{p_1} \times \vec{p_2}) = 0 + 0 = 0$$

as we have shown above.

Result 2 of 2

$$(\vec{p_1} + \vec{p_2}) \cdot (\vec{p_1} \times 5\vec{p_2}) = 0$$

Exercise 35
Rate this solution
Exercise 37a

Exercise 41

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Solution Verified Answered 2 years ago

Step 1 1 of 2

In order to solve this problem we will have to write down the components of the two vectors, $\vec{a}$ and $\vec{b}$

$$\vec{a} = 4\vec{i} + 4\vec{j} + 4\vec{k}$$
$$\vec{b} = 3\vec{i} + 2\vec{j} + 4\vec{k}$$

A dot product of the vectors is defined as

$$\vec{a} \cdot \vec{b} = a_i b_i + a_j b_j + a_k b_k = 4 \times 3 + 4 \times 2 + 4 \times 4$$
$$\vec{a} \cdot \vec{b} = 36$$

Now, let's find the magnitude for both vectors

$$|a| = \sqrt{a_i^2 + a_j^2 + a_k^2} = \sqrt{48} = 6.9$$
$$|b| = \sqrt{b_i^2 + b_j^2 + b_k^2} = \sqrt{29} = 5.4$$

To find the angle between $\vec{a}$ and $\vec{b}$ we will use the fact that by definition $\vec{a} \cdot \vec{b} = |a||b| \cos\theta$ from where we express the cosine of the angle as

$$\cos\theta = \frac{\vec{a} \cdot \vec{b}}{|a||b|}$$

So after we plug in the values using the result obtained in part a, we have that

$$\cos\theta = \frac{36}{6.9 \times 5.4}$$
$$\theta = \arccos\frac{36}{6.9 \times 5.4} = 15^\circ$$

Result 2 of 2

$$\theta = 15^\circ$$

Exercise 40 Rate this solution Exercise 42a

Exercise 44

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Solution Verified Answered 2 years ago

Step 1 1 of 2

To solve this problem we will have to develop the given cross product and obtain the equations which are to be solved by using the condition $B_x = B_y$. A cross product of the vectors is by definition

$$\vec{A} \times \vec{B} = \begin{vmatrix} i & j & k \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

Which in our case becomes

$$\vec{F} = q\vec{v} \times \vec{B} = q\begin{vmatrix} i & j & k \\ v_x & v_y & v_z \\ B_x & B_y & B_z \end{vmatrix}$$

And gives us three equations

$$F_x = q(v_y B_z - v_z B_y)$$
$$F_y = -q(v_x B_z - v_z B_x)$$
$$F_z = q(v_x B_y - v_y B_x)$$

Using the fact that

$$\vec{v} = 2\vec{i} + 4\vec{j} + 6\vec{k}$$
$$\vec{F} = 4\vec{i} - 20\vec{j} + 12\vec{k}$$

we will start from the third equation since $B_x = B_y$

$$F_z = q(v_x B_y - v_y B_x) = qB_x(v_x - v_y)$$
$$12 = 3 \times B_x(4 - 6)$$
$$B_x = \frac{12}{6} = 2$$
$$B_y = B_x = 2$$

Now, we can find B_z by plugging in the known values into the equation one solved for B_z

$$F_x = q(v_y B_z - v_z B_y)$$
$$F_x + qv_z B_y = qv_y B_z$$
$$B_z = \frac{F_x + qv_z B_y}{qv_y}$$
$$B_z = \frac{4 + 3 \times 6 \times 2}{3 \times 4}$$
$$B_z = 3.33$$

So the magnetic field is given as

$$\vec{B} = 2\vec{i} + 2\vec{j} + 3.33\vec{k}$$

Result 2 of 2

$$\vec{B} = 2\vec{i} + 2\vec{j} + 3.33\vec{k}$$