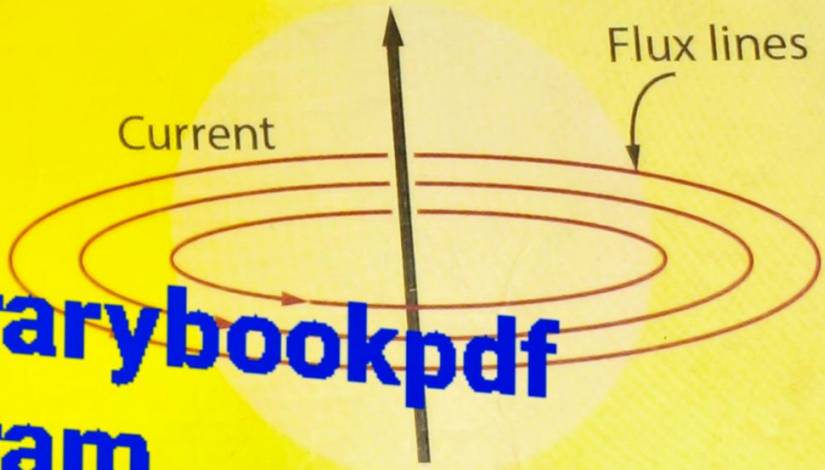
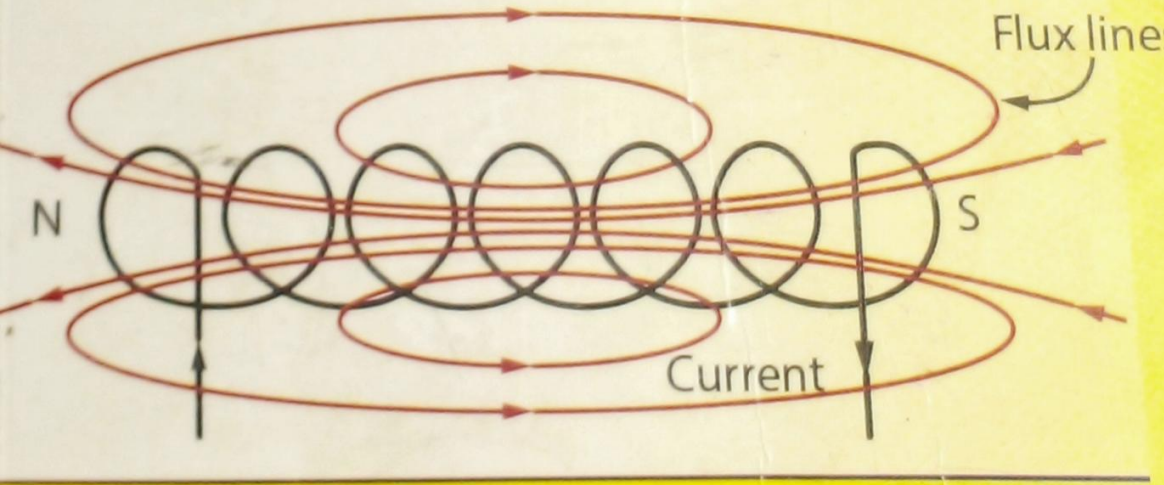
PHYSICS

GRADE 9-10



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Scalar quantity: Is a quantity that is completely described by its magnitude.

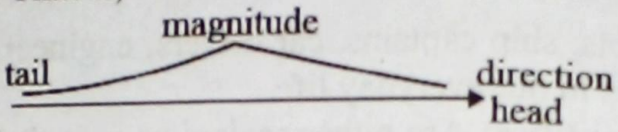
xamples of scalar quantities include: time, mass, length, speed, mperature, power, density, work, energy, pressure, potential fference, electric current, area, volume, charge, amount of substance, minous intensity etc.

ut, if you say your home is 2 km away from your school or a car is oving at 50 km/h or a man is pushing a cart with a force of 100N, all f these information is incomplete unless specified with particular rection as, 2 km away due East, or moving at 50 km/h towards South pushing a cart with a force of 100N towards West. Such quantities at require both magnitude and direction for their complete description e called *vectors*.

Vector quantity: Is a quantity that is completely described by both, its magnitude and direction.

may be written as **F** or $\vec{F}$. The magnitude of the vector is denoted by a light face letter or a letter inside an absolute value. Thus, the magnitude of the force vector may be written as F or |F|.

2) **Graphically**, a vector is represented by an arrow. The length of the arrow between its tail and head gives the magnitude of the vector and the orientation of the arrow head tells us the direction of the vector. That is,



☞ **Important points to remember**

- **Physical quantity**: Is any number that is used to describe a physical phenomenon quantitatively.
- Physical quantities may be categorized as; *basic* or *drived*, *scalar* or *vector*.
  - → **Basic (Fundamental quantities):** Are quantities that are defined based on some standard. **Example**; time, mass, length, temperature, amount of substance, electric current and luminous intensity.
  - → **Drived quantities**: Are quantities that are obtained by multiplying or dividing the basic quantities. **Example**: speed, volume, acceleration, force, pressure, work, charge, heat etc.
  - → **Magnitude:** Is size of given physical quantity. It tells us "how much" or "how big" something measures.
    Magnitude is expressed using a number and a unit. **Example**; 2 kg, where 2 is number and kg is unit.
  - → **Scalars** can be positive, negative or zero.
    There is no direction associated with scalars. That is, it would be nonsense to say 5 kg due North etc.
  - → **All vector** quantities have a direction associated with them. The magnitude of a vector is always positive. But, vectors can have positive or negative direction.

Conceptual Examples

1. Suppose a given physical quantity has both magnitude and direction. Does it mean that it is necessarily a vector quantity? Explain

Explanation: Not necessarily. A quantity to be a vector, it should have both magnitude and direction and it should obey the laws of

vector addition. For example, electric current has both magnitude and direction but it is a scalar quantity since it does not obey the law of vector addition.

2. Do you think that all basic physical quantities are scalar quantities? Explain

   Explanation: Yes! All the seven physical quantities are scalars since they all do not obey vector addition.

3. Do you think that all derived physical quantities are vectors? Explain

   Explanation: No! not all drived physical quantities are vectors. For example, speed, work, volume, pressure, density etc are drived quantities, but none of them are vectors.

4. Can the magnitude of a vector be ever be negative? Explain

   Explanation: Never! The magnitude of a vector cannot be negative. But it may point in the negative axis. For example, the displacements $\Delta s = 2m$ and $\Delta s = -2m$ do have the same magnitude of 2 but are pointing in opposite directions.

1.2 Addition and Subtraction of vectors

Scalar quantities can be added or subtracted in the usual way using ordinary arithmetic. For example; 4 kg + 4 kg = 8 kg. However, when adding a 4N force and a 4N force, it is possible to get a value that ranges for 8N to 0N. That is, the rules of ordinary algebra cannot be used to combine vector quantities. Instead, vector quantities are added or subtracted using vector rules either graphically or analytically.

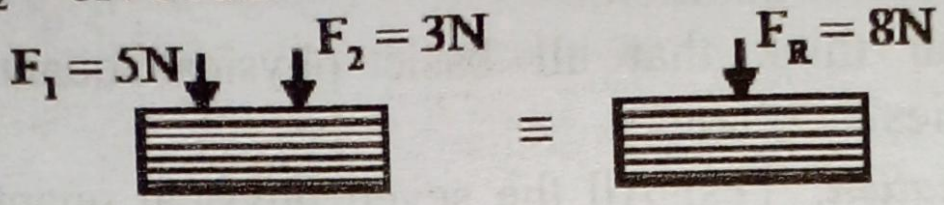
Combining parallel or antiparallel vectors

When two or more vectors are combined, they give another single vector called the *resultant* whose effect is the same as the individual vectors acting together.

Resultant: Is a single vector whose effect is the same as the individual vectors acting together.

hat is; if $F_1 = 5N$ South and $F_2 = 3N$ South, then the resultant force, F_R ;

$$F_R = F_1 + F_2 = 8N \text{ South}$$

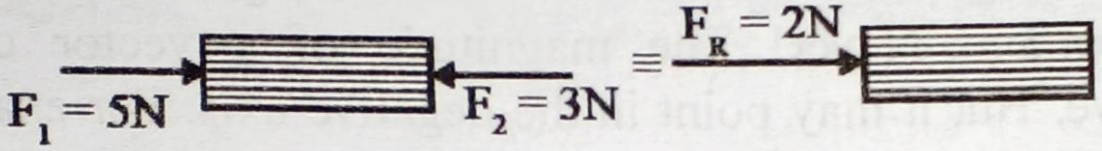


nd;

> The magnitude of the resultant of two anti-parallel vectors, that is, vectors acting in opposite directions is the difference of the magnitude of the vectors, and its direction is the same as the direction of the bigger vector.

hat is; if $F_1 = 5N$ East and $F_2 = 3N$ West, then the resultant force F_R is;

$$F_R = F_1 + F_2 = 2N \text{ East}$$



Conceptual Example

. If two vectors are equal in magnitude but opposite in direction, what can you say about the magnitude and direction of their resultant?

Explanation: Magnitude zero and direction arbitrary. Such vector is called null vector.

ombining perpendicular vectors

erpendicular vectors can be combined using Pythagoras's theorem and ıe direction of the resultant is determined using basic trigonometric ınctions.

> **Pythagoras's theorem:** "the square of the hypotenuse of a right angled triangle is equal to the sum of the squares of the other two sides."

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}} = \frac{b}{c}$$

$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{a}{c}$$

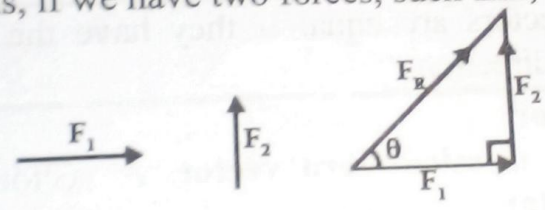
$$\tan\theta = \frac{\text{adjacent}}{\text{adjacent}} = \frac{b}{a}$$

☞ To find the angle θ in degree, we rearranging the trigonometric function as $\theta = tan^{-1}\left(\frac{b}{a}\right) = cos^{-1}\left(\frac{a}{c}\right) = sin^{-1}\left(\frac{b}{c}\right)$ where the operator ($\tan^{-1}$) is called "*tan inverse*" or "*arc tan*". The same naming holds for the others.

It is worth noting to remember that:

The magnitude of the resultant of two perpendicular vectors is obtained using Pythagoras's theorem and its direction is determined using trigonometry function.

That is, if we have two forces, such that,



$\Rightarrow F_R^2 = F_1^2 + F_2^2 \Rightarrow \boxed{F_R = \sqrt{F_1^2 + F_2^2}}$, and its direction say from F_1 is obtained by;

$$\boxed{\tan\theta = \frac{F_2}{F_1}}$$

Conceptual Example

6. If the magnitude of the sum and difference of two nonzero vectors $\vec{A}$ and $\vec{B}$ is equal, what can you say about the two vectors?

Explanation: If |A + B| = |A – B|, then two vectors that is vector A and vector B are mutually perpendicular.

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Equal vectors: Two vectors are equal if they have the same magnitude and the same direction.

Zero \Null\ vector & Unit vector

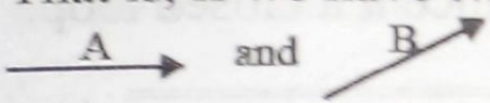
A vector with magnitude zero is called **zero vector**. A vector with magnitude 1 is called **a unit vector**.

Non parallel and non-perpendicular vectors

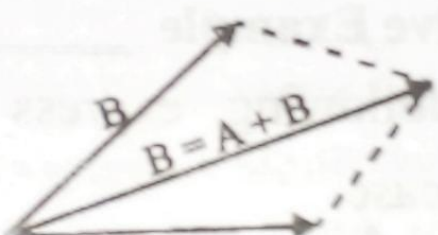
Non parallel and non-perpendicular vectors can be added using the *triangle law* or the *parallelogram law*.

1. **Triangle law**: states that:
"Join the two given vectors *head* to *tail* and the resultant is the vector that is drawn from the *tail* of the first to the *head* of the second vector."

That is, if we have two vectors $\vec{A}$ and $\vec{B}$, such that



Then $\vec{R} = \vec{A} + \vec{B} \equiv$



☞ **Important points to remember**

- Vector addition obeyes *commutative law*. That is the order of vector addition doesn't make any difference in the resultant.

  So that, $\vec{A} + \vec{B} = \vec{B} + \vec{A}$

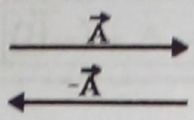
  Graphically,



- While adding vectors graphically, use appropriate scales, such as 1 cm to 5 km or 1 cm to 5N or 1 cm to 5 m/s. Thus, a 3 cm value on paper will correspond to a 15 km or 15N or 15 m/s on actual context and the direction of each vector can be determined using a protractor.

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- The negative of a vector is another vector whose magnitude is equal to the given vector but senses in opposite direction. That is, if vector $\vec{A}$ happens to be;

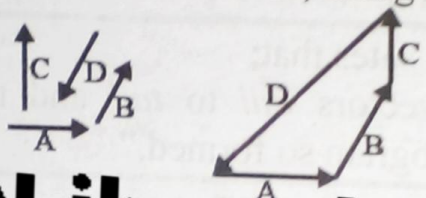


is, then the negative of vector A

Conceptual Example

9. Assume you are adding more than two vectors using the "head to tail" method, if the head of the last vector coincide with the tail of the first vector, what can you say about the magnitude of the resultant of the vectors.

Explanation: Assume we have four vectors with the orientation given, then $\vec{R} = A + B + C + D$, using head to tail.

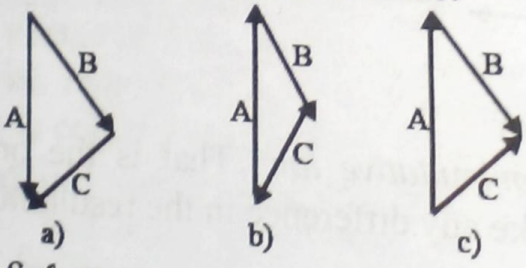


If this is the case, [illegible] closed loop.

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Illustrative Example

10. If you are given the following, express vector $\vec{C}$ in terms of vector $\vec{A}$ and $\vec{B}$ in each case.



Solution:

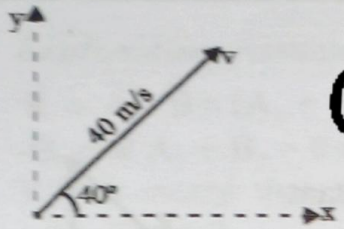
a) $\vec{B} + \vec{C} = \vec{A} \Rightarrow \vec{C} = \vec{A} - \vec{B}$

b) $\vec{A} + \vec{B} + \vec{C} = 0 \Rightarrow \vec{C} = -(\vec{A} + \vec{B})$

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

11. Represent a velocity of 40 m/s directed at an angle of 40° East to North.

Solution: First assume, a scale such as; 1 cm = 10 m/s thus 40 m/s = 4 cm and the angle is measured using a protractor starting from the positive x axis, so we have;



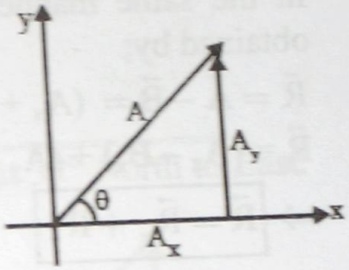
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1.3 Resolving vectors

To make vector addition, subtraction or even multiplication simple, vectors are resolved.

Resolution: Is the process of splitting a vector into components.

Assume we have vector $\vec{A}$ in the xy plane making an angle θ from the positive x axis.



Then, the components of vector $\vec{A}$ can be obtained using trigonometry relations as;

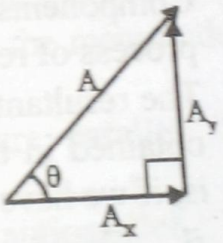
$$\cos\theta = \frac{A_x}{A} \Rightarrow \boxed{A_x = A\cos\theta}$$

$$\sin\theta = \frac{A_y}{A} \Rightarrow \boxed{A_y = A\cos\theta}$$ where,

A_x is the component of vector $\vec{A}$ along the x axis, and

A_y is the component of vector $\vec{A}$ along the y axis.

If the components A_x and A_y are given, then the magnitude of vector A can be obtained using the Pythagoras's theorem.



$$A^2 = A_x^2 + A_y^2$$

$$\boxed{A = \sqrt{(A_x)^2 + (A_y)^2}}$$

The angle that vector $\vec{A}$ makes from, say the positive x axis is obtained from the definition of tangent as;

$$\boxed{\tan\theta = \frac{A_y}{A_x}}$$

The sum of two vectors, say $\vec{A}$ and $\vec{B}$ via the component method is computed as;

$$\vec{R} = \vec{A} + \vec{B} = (A_x + A_y) + (B_x + B_y)$$

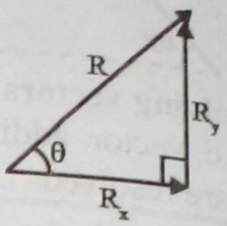
Next, adding components' of the same kind, we have;

$$\vec{R} = (A_x + B_x) + (A_y + B_y)$$

$$\Rightarrow \boxed{\vec{R} = \vec{R}_x + \vec{R}_y}$$

Where, $\vec{R}_x = \vec{A}_x + \vec{B}_x$ and $\vec{R}_y = \vec{A}_y + \vec{B}_y$

The magnitude and direction of the resultant vector can be calculated by;



$$\boxed{R = \sqrt{(R_x)^2 + (R_y)^2}} \text{ and, } \boxed{\tan\theta = \frac{R_y}{R_x}}$$

In the same manner, the difference between vectors $\vec{A}$ and $\vec{B}$ can be obtained by;

$$\vec{R} = \vec{A} - \vec{B} = (A_x + A_y) - (B_x + B_y)$$

$$\vec{R} = (A_x - B_x) + (A_y - B_y)$$

$$\Rightarrow \boxed{\vec{R} = \vec{R}_x + \vec{R}_y}$$

Where, $\vec{R}_x = \vec{A}_x - \vec{B}_x$, and $\vec{R}_y = \vec{A}_y - \vec{B}_y$

☞ Important points to remember

→ To add or subtract physical quantities, they must represents the same type of physical quantity. That is, it would be meaningless to add a *velocity* to a *force*. In the same manner, there is no point to add *time* with *mass*.

→ Components of a vector are parts of the vector obtained after the process of resolution.

→ The resultant of more than two vectors in component from can be obtained in the same manner as we combined two vectors. That is, if we have;

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

$$\vec{R}_x = A_x + B_x + C_x + \ldots$$

$$\vec{R}_y = A_y + B_y + C_y + \ldots$$

Then, $\vec{R} = \vec{R}_x + \vec{R}_y$

Conceptual Examples

12. If the sum of two vectors is zero, what can you conclude about their rectangular components.

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Explanation: Assume we have two nonzero vectors. $\vec{A}$ and $\vec{B}$. If $\vec{R} = \vec{A} + \vec{B} = (A_x + B_x) + (A_y + B_y) = 0$ then, $A_x + B_x = 0 \Rightarrow A_x = -B_x$ and $A_y + B_y = 0 \Rightarrow A_y = -B_y$

Which means that, the two vectors do have equal but opposite components?

13. Assume two vectors $\vec{A}$ and $\vec{B}$. What must be the relation of $\vec{A}$ to $\vec{B}$ if the magnitude of their sum is:

a) $A + B$ b) Zero

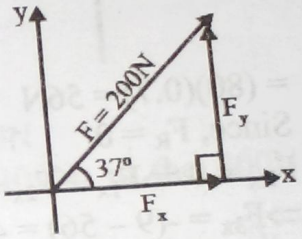
Explanation:

a) A is equal to B

b) A is equal but opposite to B

Illustrative Examples

14. A force vector of magnitude 200N is acting at 37° North to East. Resolve this vector into its x and y components.



Solution: We can draw the given vector in the xy plane as;

Then we have;

$F_x = F \cos\theta = (200)(\cos 37)$

$= (200)(0.8) = 160N$

$F_y = F \sin\theta = (200)(\sin 37) = (200)(0.6) = 120N$

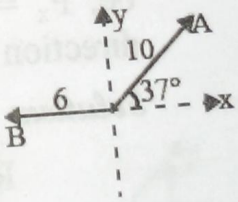
15. The magnitude of vectors $\vec{A}$ and $\vec{B}$ are 3 and 4 respectively. What are the largest and smallest possible values of the magnitudes of their resultant?

Solution: The largest value, is when they are parallel. Thus, $R_{max} = |A + B| = 3 + 4 = 7$.

The smallest value is when they are antiparallel. Thus, $R_{min} = |A - B| = |3 - 4| = 1$.

16. From the given arrangement, find

a) $A + B$ b) $A - B$



Solution:

a) First of all resolve vector A

$\Rightarrow A_x = A \cos 37° = (10)(0.8) = 8$ and

$A_x = A \sin 37° = (10)(0.6) = 6$, but

$B_x = -6$ and $B_y = 0$

$R = A + B = (A_x + B_x) + (A_y + B_y) \Rightarrow R_x = A_x + B_x$, $R_y = A_y + B$

Hence, $R_x = (8 + (-6)) = 2$ and $R_y = (6 + 0) = 6$

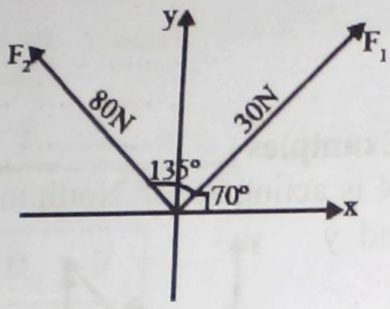
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Finally, $R = \sqrt{R_x^2 + R_y^2} = \sqrt{(2)^2 + (6)^2} = \sqrt{40} = 6.3$.

b) $R = A - B = (A_x - B_x) + (A_y - B_y)$
$R_x = (A_x - B_x) = (8 - (-6)) = 14$ and
$R_y = (A_y - B_y) = (6 - 0) = 6$
$\Rightarrow R = \sqrt{R_x^2 + R_y^2} = \sqrt{(14)^2 + (6)^2} = 15$

17. What third force must be added to the two forces, 30N at 70° and 80N at 135°??

Solution: Let $F_1 = 30N$ and $F_2 = 80N$. So we have;



$F_{1x} = F_1 \cos\theta_1 = 30 \cos 70° = (30)(0.3) = 9N$
$F_{1y} = F_1 \sin\theta_1 = 30 \sin 70° = (30)(0.9) = 27N$
$F_{2x} = F_2 \cos\theta_2 = 80 \cos(135) = (80)(-0.7) = -56N$
$F_{2y} = F_2 \sin\theta_2 = 80 \sin(135) = (80)(0.7) = 56N$

Since, $F_R = 0$

$F_{Rx} = 0 \Rightarrow F_{1x} + F_{2x} + F_{3x} = 0 \Rightarrow F_{3x} = -(F_{1x} + F_{2x})$
$\Rightarrow F_{3x} = -(9 - 56) = 47N$

And, $F_{Ry} = 0 \Rightarrow F_{1y} = F_{2y} = F_{3y} = 0 \Rightarrow F_{3y} = -(F_{1y} + F_{2y})$
$\Rightarrow F_{3y} = -(27 + 56) = -83N$

Therefore, $F_3 = \sqrt{(F_{3x})^2 + (F_{3y})} = \sqrt{(47)^2 + (-83)^2} = 95\,N$ and

$$\tan\theta = \frac{F_{3y}}{F_{3x}} = \frac{-83}{47} \Rightarrow \theta = \tan^{-1}\left(\frac{-83}{47}\right) = 300° \text{ from +ve x axis.}$$

18. The x and y components of two vectors $\vec{P}$ and $\vec{Q}$ are given to be; $P_x = 6$, $P_y = 8$, $Q_x = 3$, $Q_y = 4$. Find the magnitude and direction of their sum.

Solution: $\vec{R} = \vec{R}_x + \vec{R}_y = (P_x + Q_x) + (P_y + Q_y)$

$R_x = (6 + 3) = 9$ & $R_y = (8 + 4) = 12$

Thus, $R = \sqrt{R_x^2 + R_y^2} = \sqrt{(9)^2 + (12)^2} = 15$ and

$$\tan\theta = \frac{R_y}{R_x} = \frac{12}{9} \Rightarrow \theta = \tan^{-1}(1.33) = 53°$$

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Hence, their resultant is R = 15 units at 53°.

19. Calculate the magnitude and direction of a vector whose x and components are given to be 30 and 40 units respectively.

Solution: Let the vector be denoted by letter $\vec{A}$ so we hav $\vec{A} = \vec{A}_x + \vec{A}_y$, its magnitude,

$$|A| = \sqrt{(A_x)^2 + (A_y)^2} = \sqrt{(30)^2 + (40)^2} = 50 \text{ units}$$

Its direction, $\tan\theta = \frac{A_y}{A_x} = \frac{40}{30} \Rightarrow \theta = \tan^{-1}\left(\frac{4}{3}\right) = 53°$

20. Two boys are pushing a table on a smooth horizontal surface w forces of 200N and 300N respectively. What will be magnitude of the resultant force on the table when the boys pu it

a) In the same direction
b) In opposite directions

Solution:

a) $F_R = |F_1 + F_2| = 200N + 300N = 500N$
b) $F_R = |F_1 + F_2| = |200 - 300| = 100N$, in the 300N fo directions.

21. Calculate the resultant displacement of a boy if he walks 5(towards East and 1200m towards.

a) East b) West c) South

Solution: Let displacement be denoted by letters

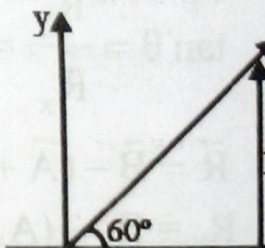
a) $S = S_1 + S_2 = 500 + 1200 = 1700m$ towards East
b) $S = S_1 - S_2 = 500 - 1200 = -700m$ East $= 700m$ West
c) $S = \sqrt{(S_1)^2 + (S_2)^2} = \sqrt{(500)^2 + (1200)^2} = 1300m$

$$\tan\theta = \frac{S_2}{S_1} = \frac{1200}{500} \Rightarrow \theta = \tan^{-1}\left(\frac{12}{5}\right) = 67°$$

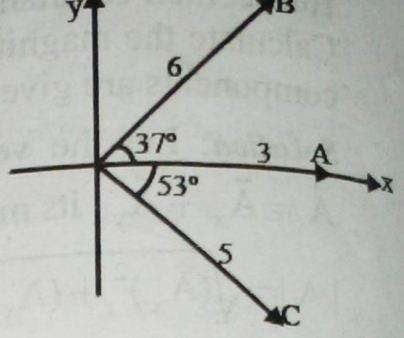
22. Calculate the component of a force of 200N at a direction of 60° to the force.

Solution: Let the force arrangement be as shown; then the component whose shadow lies 60° from the force is F_x.

Thus, $F_x = F\cos\theta = (200)(\cos 60°)$



23. For the vectors shown, find the resultant of:



a) $\vec{A}+\vec{B}+\vec{C}$

b) $\vec{A}+\vec{B}-\vec{C}$

c) $\vec{A}-2\vec{C}$

d) $\vec{B}-(\vec{A}+\vec{C})$

Solution:

Let's first decompose each vector

Vector	x component	Y component
$A=3$	$A_x=3$	$A_y=0$
$B=6$	$B_x=B\cos 37=6(0.8)=4.8$	$B_y=B\sin 37=6(0.6)=3.6$
$C=5$	$C_x=C\cos 53=5(0.6)=3$	$C_y=-C\sin 53=-5(0.8)=-4$

a) $\vec{R}=\vec{R}_x+\vec{R}_y \Rightarrow R_x=A_x+B_x+C_x=(3+4.8+3)=10.8$

$R_y=A_y+B_y+C_y=(0+3.6-4)=-0.4$

Thus, $R=A+B+C=\sqrt{(10.8)^2+(-0.4)^2}=10.8$

$$\tan\theta=\frac{R_y}{R_x}=\frac{-0.4}{10.8}\Rightarrow\theta=\tan^{-1}\left(\frac{-0.4}{10.8}\right)=358^\circ \text{ from +ve x axis}$$

b) $\Rightarrow R_x=A_x+B_x-C_x=3+4.8-3=4.8$

$R_y=A_y+B_y-C_y=0+3.6-(-4)=7.6$

Thus, $R=\sqrt{R_x^2+R_y^2}=\sqrt{(4.8)^2+(7.6)^2}=9$

$$\tan\theta=\frac{R_y}{R_y}=\frac{7.6}{4.8}\Rightarrow\theta=\tan\left(\frac{7.6}{4.8}\right)=58^\circ$$

c) $\vec{R}=\vec{A}-2\vec{C}\Rightarrow R_x=A_x-2C_x=3-2(3)=-3$

$R_y=A_y-2C_y=0-2(-4)=8$

Thus, $R=\sqrt{(-3)^2+(8)^2}=8.5$

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$$\tan\theta=\frac{R_y}{R_x}=\frac{8}{-3}\Rightarrow\theta=\tan^{-1}\left(\frac{-8}{3}\right)=110.6^\circ \text{ from +ve x axis}$$

d) $\vec{R}=\vec{B}-(\vec{A}+\vec{C})\Rightarrow R_x=B_x-(A_x+C_x)=4.8-(3-4)=5.8$

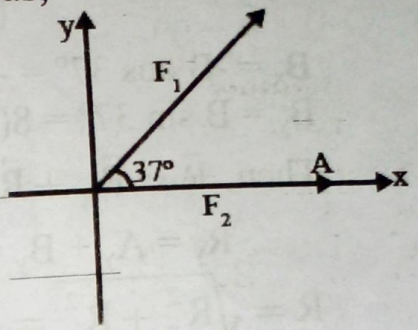
$R_y=B_y-(A_y+C_y)=3.6-(0-4)=7.6$

Thus, $R=\sqrt{(5.8)^2+(7.6)^2}=9.6$

$$\tan\theta = \frac{R_y}{R_x} = \frac{7.6}{5.8} \Rightarrow \theta = \tan^{-1}\left(\frac{7.6}{5.8}\right) = 52.7°$$

24. Calculate the resultant of two forces each 5N acting at a point at an angle of 37° with each other.

Solution: Let the force vectors be acting as;



$F_{1x} = F_1 \cos 37° = 5(0.8) = 4N$

$F_{1y} = F_1 \sin 37° = 5(0.6) = 3N$

$F_{2x} = 5N$ and $F_{2y} = 0$

Then, $\vec{F}_R = \vec{F}_1 + \vec{F}_2 = \vec{F}_{Rx} + \vec{F}_{Ry}$

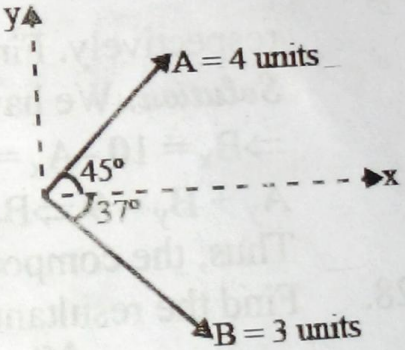
$F_{Rx} = (F_{1x} + F_{2x}) = (4 + 5) = 9N$

$F_{Ry} = (F_{1y} + F_{2y}) = (3 + 0) = 3N$

Thus, $F_R = \sqrt{(F_{Rx}) + (F_{Ry})} = \sqrt{(9)^2 + (3)^2} = 9.5N$

$$\tan\theta = \frac{F_{Ry}}{F_{Rx}} = \frac{3}{9} \Rightarrow \theta = \tan^{-1}\left(\frac{1}{3}\right) = 18°$$

25. For the vectors A and B in the figure, determine the magnitude of their vector sum.



Solution: Let's first resolve the vectors.

$A_x = A \cos 45 = (4)(0.7) = 2.8$ units

$A_y = A \sin 45 = (4)(0.7) = 2.8$ units

$B_x = B \cos 37° = (3)(0.8) = 2.4$ units

$B_y = B \sin 37° = -(3)(0.6) = -1.8$ units

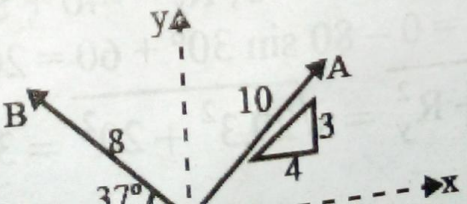
Then, $\vec{R} = \vec{A} + \vec{B} = \vec{R}_x + \vec{R}_y$

$R_x = (A_x + B_x) = 2.8 + 2.4 = 5.2$ units

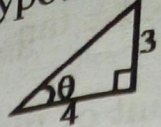
$R_y = (A_y + B_y) = 2.8 - 1.8 = 1$ unit

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(5.2)^2 + (1)^2} = 5.59 \text{ units}$$

26. Determine the magnitude of the vector sum $\vec{R} = \vec{A} + \vec{B}$ and the direction which the resultant makes from the positive x axis.



$A_x = A\cos\theta$, but from, the hyp



$\cos\theta = \frac{4}{5}$

$\sin\theta = \frac{3}{5}$

$= 10\left(\frac{4}{5}\right) = 8$ units

$A_y = A\sin\theta = 10\left(\frac{3}{5}\right) = 6$ units

$B_x = -B\cos 37° = -8(0.8) = -6.4$ units

$B_y = B\sin 37° = 8(0.6) = 4.8$ units

Then, $\vec{R} = \vec{R}_x + \vec{R}_y$, $R_x = A_x + B_x = 8 + (-6.4) = 1.6$ units

$R_y = A_y + B_y = 6 + 4.8 = 10.8$ units

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(1.6)^2 + (10.8)^2} = 10.9$

$\tan\theta = \frac{R_y}{R_x} = \frac{10.8}{1.6} \Rightarrow \theta = \tan^{-1}\left(\frac{10.8}{1.6}\right) = 81.6°$

27. The x and y components of vector $\vec{A}$ are 4 and 6 respectively. The x and y components of vector $(\vec{A} + \vec{B})$ are 10 and 9 respectively. Find the components of vector $\vec{B}$?

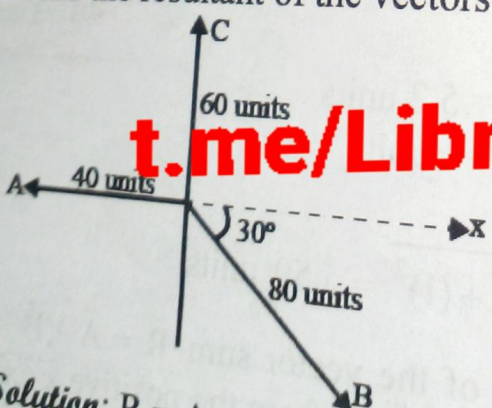
Solution: We have, $A_x = 4$, $A_y = 6$ and $A_x + B_x = 10$

$\Rightarrow B_x = 10 - A_x = 10 - 4 = 6$

$A_y + B_y = 9 \Rightarrow B_y = 9 - A_y = 9 - 6 = 3$

Thus, the components of vector B are; $B_x = 6$ & $B_y = 3$.

28. Find the resultant of the vectors shown below.



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Solution: $R = A + B + C$, $R_x = -40 + 80\cos 30° + 0 = 29.3$ units

$R_y = 0 - 80\sin 30° + 60 = 20$ units

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{29.3^2 + 20^2} = 35.4$ units

$$\tan\theta = \frac{R_y}{R_x} = \frac{20}{29.3} \Rightarrow \theta = \tan^{-1}\left(\frac{20}{29.3}\right) = 34.3^{\circ}$$

General Secondary education certificate exam

29. Two forces 10N and 40N CAN NOT be combined to give a resultant of (EGSECE).

A. 10N B. 40N C. 50N D. 35N

Solution: The magnitude of the resultant of two vectors say $\vec{A}$ & $\vec{B}$ is always in the range $|A - B| \le R \le |A + B|$ in our case, $|10 - 40| \le R \le |10 + 50| \Rightarrow 30 \le R \le 60$. Thus, the resultant can have a magnitude ranging from 30 to 60. **Answer: A**

30. Which of the following differences between two points is a vector quantity? (EGSECE)

A. Pressure B. potential C.electric filed D. temperature

Answer: C

31. A vector of magnitude 20 is added to a vector of magnitude 25. The magnitude of their sum might be? (EGSECE)

A. 12 B. 3 C. 0 D. 47

Solution: The magnitude of the resultant of two vector A and B is always in the range. $|A - B| \le R \le |A + B|$ in our case, $|20 - 25| \le R \le |20 + 25| \Rightarrow 5 \le R \le 45$.

Answer: A

32. A pilot of a tourist plane would like to know the a real displacement from Gonder to Harar as shown. He can determine this displacement between the two tourist attraction sights by calculating. (EGSECE)



A. $H + G$ B. $G + H$ C. $G - H$ D. $H - G$

Solution: From triangle law, $\vec{G} + \vec{S} = \vec{H}$

Answer: D

$\Rightarrow \vec{S} = \vec{H} - \vec{G}$

33. If the tail of vector B is placed at the tip of A and the tail of C is placed at the tip of B, the sum of the three vectors is drawn from the:

A. Tail of A to tip of B
B. Tail of A to tip of C
C. Tail of B to tip of C
D. Tip of C to tail of B

Answer: B

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Unit One: Conceptual Questions

1. Suppose that $\vec{A}$ and $\vec{B}$ have non zero magnitude. Is it possible for $\vec{A} + \vec{B}$ to be zero?
2. Given that $\vec{A} + \vec{B} = 0$. What can you conclude about the two given vectors.
3. Can a component of a vector be greater than the vector's magnitude?
4. If each component of a vector is doubled, how does the magnitude and direction of the vector changes.
5. Can a vector with zero magnitude have one or more components that are nonzero? Explain
6. Suppose vector $\vec{A}$ has x and y components of equal magnitude. What can you say about the possible direction of $\vec{A}$?
7. The components of vector $\vec{A}$ satisfy $A_x < 0$ and $A_y < 0$. What is the range of possible angle of $\vec{A}$?
8. The components of a vector $\vec{A}$ satisfy $A_x > 0$ and $A_y < 0$. What s the range of possible angles for $\vec{A}$?
9. The components of a vector $\vec{A}$ satisfy $A_x = -A_y$. What are the possible directions of $\vec{A}$?
10. Use a sketch to show that two vectors of unequal magnitude cannot add to zero, but that three vectors of unequal magnitude can.
11. Two forces of 50N and 80N act upon a body. What are the maximum and minimum possible values of the resultant force?
12. What is the difference between vector sum and algebraic sum?
13. If A and B are any two nonzero vectors, is it possible that A – B = B – A.
14. Is it possible to add a vector quantity to a scalar quantity?

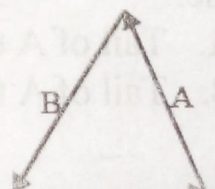
Unit One: Problems

Representation of vectors

15. Represent the following vectors graphically.
    a) 6 m/s north of east
    b) 20m, 37° south of west

Addition and subtraction of vectors

16. A force of $F_1 = 5N$ is applied to a block in a



is applied to the object at an angle of 30° above the horizontal. Use graphical method to find the resultant force.

17. Three vectors A, B and C have the same length L and form an equilateral triangle. Find the magnitude and direction of the vectors.

a) $A + B$ b) $A + B + C$

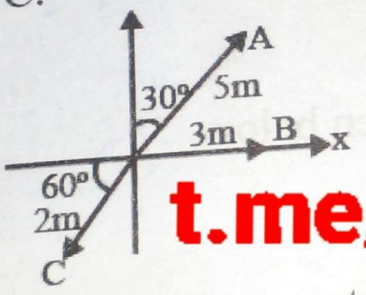
c) $A + B - C$

18. Vector $\vec{A}$ points in the negative y direction and has a magnitude of 5 units. Vector B has twice the magnitude and points in the positive x direction. Find the magnitude of:

A. $\vec{A} + \vec{B}$ B. $\vec{A} - \vec{B}$

Resolving vectors

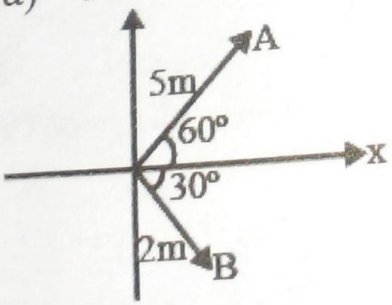
19. Compute the x and y components of each of the vectors A, B and C.



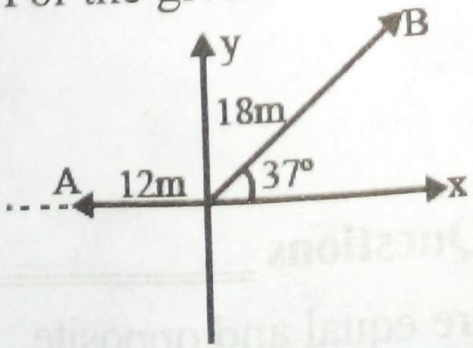
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20. For the given vectors find, the component of:

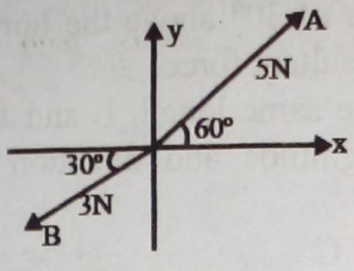
a) $A + B$ b) $A - B$



21. For the given vectors, find the magnitude of $\vec{A} + \vec{B}$.

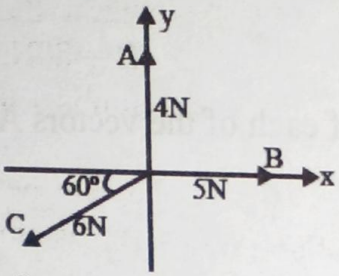


22. You are given vectors $\vec{A}$ and $\vec{B}$ as shown, find $|3\vec{A} - 2\vec{B}|$.

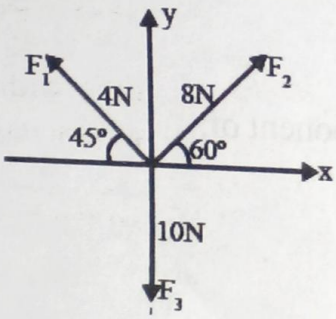


23. If you are given the x and y component of two vectors $\vec{P}$ and $\vec{Q}$ as; $P_x = 3$, $P_y = 6$ and $Q_x = 8$, $Q_y = 10$. Find $|\vec{P} + \vec{Q}|$

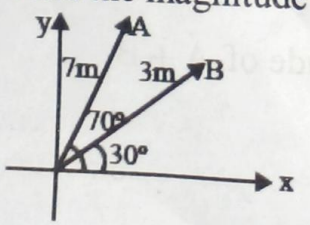
24. Find the resultant of the three force vectors acting on a particle as shown below.



25. Compute the resultant of the forces given below.



26. Find the magnitude of A – B for



Unit One: Explanation to Questions

1. Yes. $\vec{A} + \vec{B} = 0$, when the vectors are equal and opposite.
2. Either they both are zero vectors or the vectors are equal and opposite.
3. No! It may be case for a resultant.
4. The magnitude of the vector also doubled, but its direction is unchanged.
5. No! If we are considering rectangular components.

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6. If $\vec{A}$ is zero vector, its direction will be arbitrary. And if it is nonzero, one possible direction is 45°.
7. The direction angle for $\vec{A}$ is between 180° and 270°.
8. The direction for $\vec{A}$ is between 270° and 360°.
9. The possible directions of $\vec{A}$ are between 90° and 180°, and between 270° and 360°.
10. Suppose we have two unequal vectors $\vec{A}$ and $\vec{B}$ then, $\vec{A}+\vec{B}$ can never be zero. But, three vectors of unequal magnitude can add to zero if they form a triangle.
11. The resultant of any two vectors is always within the range $|A - B| \leq R \leq |A + B|$ for our case, let A = 50N, B = 80N. So we have; $|50 - 80| \leq R \leq |50 + 80|$. Thus the maximum is 130N and the minimum is 30N.

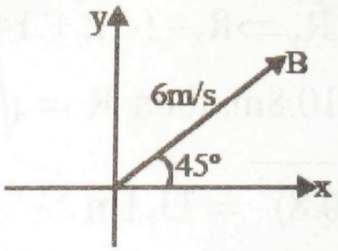
Algebraic sum does not require direction. Scalar can be added using it. But vector sum is direction sensitive, vectors are combined using it.

No! Vector subtraction is not commutative. That is $A - B \neq B - A$.

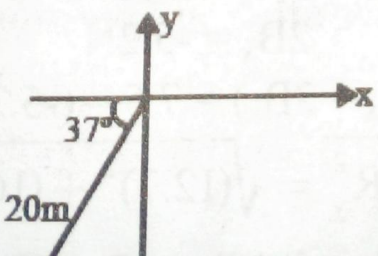
No! it does not make sense to add for example, time with force. Only quantities of the same kind can be added or subtracted.

Unit One: Solution to problems

a) Assume 1 cm = 2 m/s, then 6 m/s ≡ 3 cm, so we have; 45° is measured using protractor.



b) Assume the scale 1 cm = 5m, then 20m ≡ 4 cm, next measure 37° from the negative x axis anti clockwise so you have.

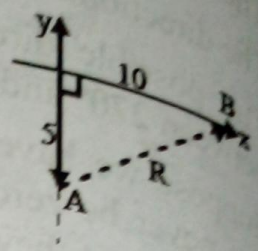


complete the parallelogram [illegible] diagram will be either resultants where R = 8.7 cm ⇒ R = 8.7 N.

17. a) $A + B = -C = -L$ b) $A + B + C = 0$
c) $A + B - C = L$

18. $\vec{A} = 5$ units, $\vec{B} = 10$ units.

$$R = \sqrt{A^2 + B^2} = \sqrt{5 + 10} = 11.2 \text{ units}$$



19. A, $A_x = A \cos 60° = 5 \times 0.5 = 2.5$m
$A_y = A \sin 60° = 5 \times 0.87 = 4.3$m
B, $B_x = 3$m, $B_y = 0$
C, $C_x = -C \cos 60° = -2 \times 0.5 = -1 = 1$m to negative x axis
$C_y = -C \sin 60° = -2 \times 0.87 = -1.74 = 1.74$ to –ve y axis

20.

Vector	x component	y component
A = 5m	2.5m	4.3m
B = 2m	1.74m	-1m

a) $A + B = R_x + R_y \Rightarrow R_x = (2.5 + 1.74) = 4.2$m, $R_y = 3.3$m
b) $A - B \Rightarrow R_x = (2.5 - 1.74) = 0.76$m, $R_y = (4.3 - (-1)) = 5.3$m

21.

Vector	x component	y component
A = 12	$A_x = -12$m	$A_y = 0$
B = 18	$B_x = 14.4$m	$B_y = 10.8$m

$R = A + B = R_x + R_y \Rightarrow R_x = (-12 + 14.4) = R_x = 2.4$m and
$R_y = (0 + 10.8) = 10.8$m, then $R = \sqrt{R_x^2 + R_y^2}$

$$R = \sqrt{(2.4)^2 + (10.8)^2} = 11.1\text{m}$$

22.

Vector	Vector	x component	y component
A = 5N	3A = 15N	$3A_x = 7.5$N	$3A_y = 13$N
B = 3N	2B = 6N	$2B_x = -5.2$N	$2B_y = -3$N

$R = 3A - 2B \Rightarrow R_x = (3A_x - 2B_x) = 7.5 - (-5.2) = 12.7$N, and

$$|3A - 2B| = R = \sqrt{R_x^2 + R_y^2} = \sqrt{(12.7)^2 + (16)^2} = 20.4\text{N}$$

23. $R_x = P_x + Q_x = 3 + 8 = 11$ units, $Ry = P_y + Q_y = 6 + 10 = 16$ units

24.

Vector	x component	y component
A = 4N	$A_x = 0$	$A_y = 4N$
B = 5N	$B_x = 5N$	$B_y = 0$
C = 6N	$C_x = -3N$	$C_y = -5.2N$

$R = A + B \Rightarrow R_x = (0 + 5 - 3) = 2N,\ R_y = (4 + 0 - 5.2) = -1.2N$

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(2)^2 + (-1.2)^2} = 2.33N,\ \tan\theta = \frac{R_y}{R_x} \Rightarrow \frac{-1.2}{2} = 329°$$

25.

Vectors	x component	y component
$F_1 = 4N$	$F_1x = -2.8N$	$F_1y = 2.8N$
$F_2 = 8N$	$F_2x = 4N$	$F_2y = 6.9N$
$F_3 = 10N$	$F_3x = 0$	$F_3y = -10N$

$F_{Rx} = (-2.8 + 4 + 0) = 1.2N$ and $F_{Ry} = (2.8 + 6.9 + 0) = 9.7N$

$$F_R = \sqrt{(F_{Rx}) + (F_{Ry})} = \sqrt{(1.2)^2 + (9.7)^2} = 9.8N,\ \tan\theta = \frac{F_{Ry}}{F_{Rx}} \Rightarrow \theta = 83°$$

26.

Vectors	x component	y component
A = 7,	$A_x = 2.4m$	$A_y = 6.6m$
B = 3m	$B_x = 2.6m$	$B_y = 1.5m$

$A - B \Rightarrow R_x = (2.4 - 2.6) = -0.2;\ R_y = (6.6 - 1.5) = 5.1$

$\Rightarrow R = \sqrt{(0.2)^2 + (5.1)^2} = 5.1m$

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