# Scalar Multiplication of Vectors


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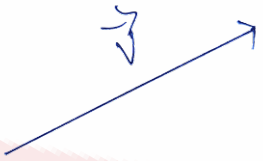
# Scalar Multiplication of Vectors

Let $k$ be a scalar and $\overrightarrow{v}$ a vector then $\overrightarrow{w} = k\overrightarrow{v}$ is the resultant vector.

## Example

Let $\overrightarrow{v}$ be the following vector




For each of the following scalrs, draw the resultant vectors.

(a) $k = -2$

(b) $k = 3$

(c) $k = 0$

(d) $k = \frac{1}{2}$

**Solution**

(a) The negative sign changes the direction of the vector 180°. The number 2 doulbe the magnitude.

(b) $3\overrightarrow{v}$

(c) $0\overrightarrow{v}$ is a point. The 0 affects the magnitude and reduces it to 0. Therefore, we end up with a point.

(d) The resultant vector has half the magnitude but is in the same direction.

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## Collinear Vectors

Two vectors $\overrightarrow{u}$ and $\overrightarrow{v}$ are siad to be collinear if and only if it is possible to find a non-zero scalar $k$ such that $\overrightarrow{u} = k\overrightarrow{v}$

## Unit Vector

A *unit vector* is a vector with magnitude equal to 1.

For any vector $\overrightarrow{v}$ a unit vector in the direction $\overrightarrow{v}$ can be created. How? Provided $\overrightarrow{v}$ is not the zero vector, we can create a vector $\overrightarrow{u} = \frac{\overrightarrow{v}}{|\overrightarrow{v}|}$ that is in the direction $\overrightarrow{v}$ and has magnitude 1. Let's show $\overrightarrow{u}$ has magnitude 1.

$$|\overrightarrow{u}| = \left|\frac{\overrightarrow{v}}{|\overrightarrow{v}|}\right| = \frac{1}{|\overrightarrow{v}|}|\overrightarrow{v}| = 1$$

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## Exercises

1. An airplane is flying at an airspeed of 300km/h. Using a scale of 1 cm equivalent to 50km/h, draw a velocity vector to represent each of the following
   (a) a speed of 150km/h heading in the direction of N45°E
   (b) a speed of 450km/h heading in the direction E15°S
   (c) a speed of 100km/h heading in an easterly direction
   (d) a speed of 300km/h heading on a bearing of 345°
2. An airplane's direction is E25°N. Explain why this is the same as N65°E or a bearing of 65°.
3. The vector $\overrightarrow{v}$ has magnitued 2 i.e. $|\overrightarrow{v}| = 2$. Draw the folllowing vectors and express each of them as a scalar multiple of $\overrightarrow{v}$.
   (a) a vector in the same direction as $\overrightarrow{v}$ with twice its magnitude
   (b) a vector in the same direction as $\overrightarrow{v}$ with one-half its magnitude
   (c) a vector in the opposite direction as $\overrightarrow{v}$ with two-thirds its magnitude
   (d) a vector in the opposite direction as $\overrightarrow{v}$ with twice its magnitude
   (e) a unit vector in the same direction as $\overrightarrow{v}$
4. Three collinear vectors $\overrightarrow{a}$, $\overrightarrow{b}$ and $\overrightarrow{c}$ are such that $\overrightarrow{a} = \frac{2}{3}\overrightarrow{b}$ and $\overrightarrow{a} = \frac{1}{2}\overrightarrow{c}$.
   (a) Determine integer values for $m$ and $n$ such that $m\overrightarrow{c} + n\overrightarrow{b} = \overrightarrow{0}$. How many values are possible for $m$ and $n$ to make this statement true?

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(b) Determine integer values for $d$, $e$ and $f$ such that $d\overrightarrow{a} + e\overrightarrow{b} + f\overrightarrow{c} = \overrightarrow{0}$. Are these values unique?

5. The vectors $\overrightarrow{a}$ and $\overrightarrow{b}$ are perpendicular. Are the vectors $4\overrightarrow{a}$ and $-2\overrightarrow{b}$ are perpendicular? Illustrate your answer with a sketch.

6. If the vectors $\overrightarrow{a}$ and $\overrightarrow{b}$ are noncollinear, determine which of the following paris of vectors are collinear and which are not.
   (a) $2\overrightarrow{a}, -3\overrightarrow{a}$
   (b) $2\overrightarrow{a}, 3\overrightarrow{a}$
   (c) $5\overrightarrow{a}, -\frac{3}{2}\overrightarrow{b}$
   (d) $-\overrightarrow{b}, 2\overrightarrow{b}$

7. The vectors $\overrightarrow{x}$ and $\overrightarrow{y}$ are unit vectors that make and angle of 90° with each other. Calculate the value of $|2\overrightarrow{x} + \overrightarrow{y}|$ and the direction of $2\overrightarrow{x} + \overrightarrow{y}$.

8. The vectors $\overrightarrow{x}$ and $\overrightarrow{y}$ are unit vectors that make an angle of 30° with each other. Calculate the value of $|2\overrightarrow{x} + \overrightarrow{y}|$ and the direction of $2\overrightarrow{x} + \overrightarrow{y}$

9. Draw rhombus ABCS where AB =3cm. For each of the following, name two vectors $\overrightarrow{u}$ and $\overrightarrow{v}$ in you rdiagram such that,
   (a) $\overrightarrow{u} = \overrightarrow{v}$
   (b) $\overrightarrow{u} = 2\overrightarrow{v}$
   (c) $\overrightarrow{u} = -\overrightarrow{v}$
   (d) $\overrightarrow{u} = 0.5\overrightarrow{v}$

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