Answer on Question #42634 – Physics – Mechanics | Kinematics | Dynamics

Question.

A boy is running on a straight road. He runs 500m towards north in 2.10 mins and then turns back and runs 200 m in 1 min. Calculate:

a) His average speed and magnitude of average velocity during first 2.10 mins.
b) His average speed and magnitude of average velocity during the whole journey.

Given:

$l_1 = 500\ m$ is a distance that the boy ran during t_1 towards north

$t_1 = 2.1\ min = 126\ s$

$l_2 = 200\ m$ is a distance that the boy ran during t_2 towards south

$t_2 = 1\ min = 60\ s$

Find:

a) $v_1 = ?$ is average speed during t_1
   $|\overrightarrow{v_1}| = ?$ is a magnitude of average velocity during t_1
b) $v = ?$ is average speed during $t = t_1 + t_2$, during whole journey
   $|\vec{v}| = ?$ is a magnitude of average velocity during $t = t_1 + t_2$, during whole journey

Solution.

By definition the speed of an object is the magnitude of its velocity. It is a scalar quantity.

Velocity is the rate of change of the position of an object, equivalent to a specification of its speed and direction of motion. It is a vector physical quantity.

The average speed of an object in an interval of time is the distance travelled by the object divided by the duration of the interval.

So, average speed is equal to the ratio of total distance traveled to total time of motion:

$$v_{average} = \frac{l_1 + l_2 + \cdots + l_n}{t_1 + t_2 + \cdots + t_n}$$

And magnitude of average velocity equal to the ratio of total vector sum of the distance traveled to total time of motion:

$$|\vec{v}_{average}| = \frac{|\overrightarrow{l_1} + \overrightarrow{l_2} + \cdots + \overrightarrow{l_n}|}{t_1 + t_2 + \cdots + t_n}$$

Choose $|\vec{l}|$ is positive, if we move towards north, and negative, if we move towards south.

Now we can find all we need.

a)

$$v_1 = \frac{l_1}{t_1}$$

$$|\vec{v_1}| = \frac{|\vec{l_1}|}{t_1} = \frac{l_1}{t_1}$$

Calculate:

$$v_1 = \frac{500}{126} = 3.97\frac{m}{s}$$

$|\vec{v_1}| = \frac{500}{126} = 3.97\frac{m}{s}$ towards north

As you can see, the speed matches with the magnitude of velocity if to move in one direction constantly.

b)

$$v = \frac{l_1 + l_2}{t_1 + t_2}$$

$$|\vec{v_1}| = \frac{|\vec{l_1} + \vec{l_2}|}{t_{1+t_2}} = \frac{l_1 - l_2}{t_1 + t_2}$$

Calculate:

$$v = \frac{500 + 200}{126 + 60} = \frac{700}{186} = 3.76\frac{m}{s}$$

$|\vec{v_1}| = \frac{500-200}{126+60} = \frac{300}{186} = 1.61\frac{m}{s}$ towards north

As you can see, the speed doesn't match with the magnitude of velocity if to move in different directions.

Answer.

a)

$$v_1 = \frac{l_1}{t_1} = 3.97\frac{m}{s}$$

$|\vec{v_1}| = \frac{l_1}{t_1} = 3.97\frac{m}{s}$ towards north b)

$$v = \frac{l_1 + l_2}{t_1 + t_2} = 3.76\frac{m}{s}$$

$$|\overrightarrow{v_1}| = \frac{l_1 - l_2}{t_1 + t_2} = 1.61\frac{m}{s} \text{ towards north}$$