Physics 20 Lesson 2 Displacement

I. Pearson text book reference

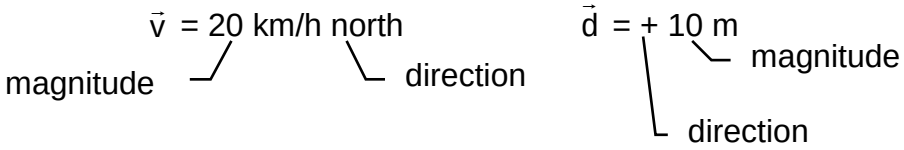
Refer to pages 6 to 10.

II. Motion and Direction

In Lesson 1 we considered motion without any reference to direction. Consider the following illustration: A person walks 10 m to the right, stops for a few seconds, and then walks back at the same speed to where she started. The person had the same speed (rate of motion) for walking away from the reference point and walking toward it, but her **direction** of motion was different. In such cases it is necessary to refer to two things – the speed and the direction. To help us talk about different kinds of motion we have two basic kinds of quantities:

scalar quantity A scalar quantity describes a *magnitude* (a fancy word meaning "amount") without any reference to a direction. Scalars are concerned with magnitudes only.

vector quantity Vector quantities have both a magnitude and a direction. They communicate more information than scalars. For example:



An arrow above a symbol indicates a vector quantity ($\vec{v}$), while a symbol without an arrow indicates a scalar quantity (v).

Students often become confused when something has a velocity of "negative 20 m/s" because they do not see how a speed can be negative. However, the speed is only how fast something is moving, while the "negative" refers to the *direction* of the speed. Some sign conventions for vectors are:

Right	+	**East**	+	**North**	+	**Up**	+
Left	–	**West**	–	**South**	–	**Down**	–

III. Distance and displacement

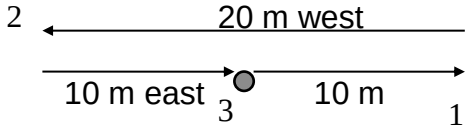
Distance is a <u>scalar</u> term because it only describes the magnitude of a position change with no direction involved. The total distance from the reference point is given with no consideration of any direction changes along the way. The symbol for distance is Δd.

Displacement is different from distance. **Displacement** is the *net* change in position from the starting reference point. Displacement is a <u>vector</u> term because it includes both the magnitude and direction of the position change. The symbol for displacement is $\Delta\vec{d}$.

For displacement we are interested in the *net* distance traveled, therefore we take direction into account. For distance we are interested in the *total* distance involved, therefore we do not care about direction.

Example 1

A person walks 10 m east, then 20m west, and finally 10 m east. What is the person's distance and displacement at each point of the trip?



(this is called a *vector diagram*)

	distance	*displacement*
1	$\Delta d = \Delta d_1$	$\Delta \vec{d} = \Delta \vec{d}_1$
	$\Delta d =$ **10 m**	$\Delta \vec{d} =$ + 10 m or $\Delta \vec{d} =$ **10 m east**
2	$\Delta d = \Delta d_1 + \Delta d_2$	$\Delta \vec{d} = \Delta \vec{d}_1 + \Delta \vec{d}_2$
	$\Delta d =$ 10 m + 20 m	$\Delta \vec{d} =$ + 10 m + (-20) m = **10 m west**
	$\Delta d =$ **30 m**	
3	$\Delta d = \Delta d_1 + \Delta d_2 + \Delta d_3$	$\Delta \vec{d} = \Delta \vec{d}_1 + \Delta \vec{d}_2 + \Delta \vec{d}_3$
	$\Delta d =$ 10 m + 20 m + 10 m	$\Delta \vec{d} =$ + 10 m + (-20) m + 10 m
	$\Delta d =$ **40 m**	$\Delta \vec{d} =$ **0**

Example 2

A man walks 35 m east and then 185 m west:

a. What is the distance traveled?
Distance:
$\Delta d = \Delta d_1 + \Delta d_2 =$ 35 m + 185 m = **220 m**

b. What is the displacement of the man?
Displacement:
$\Delta \vec{d} =$ 35 m east + 185 m west = (+35 m) + (-185 m) = -150 m
$\Delta \vec{d} =$ **150 m west**

Example 3

A man walks 35 m north, 129 m south, 375 m north and finally 785 m south.

a. What was the distance traveled by the man?

$\Delta d = \Delta d_1 + \Delta d_2 + \Delta d_3 + \Delta d_4$

$\Delta d = 35\text{ m} + 129\text{ m} + 375\text{ m} + 785\text{ m}$

$\Delta d =$ **1324** m

b. What is the displacement of the man?

$\Delta \vec{d} = +35\text{ m} + -129\text{ m} + +375\text{ m} + -785\text{ m} = -504\text{ m}$

$\Delta \vec{d} =$ **504 m South**

Example 4

A man walks 75 m west and then 192 m east. If the time required was 90 s,

a. What was the average speed of the man?

$\Delta d = \Delta d_1 + \Delta d_2$

$\Delta d = 75\text{ m} + 192\text{ m}$

$\Delta d = 267\text{ m}$

$v_{ave} = \frac{\Delta d}{\Delta t} = \frac{267\text{ m}}{90\text{ s}}$

$v_{ave} =$ **2.97 m/s**

b. What was the displacement of the object?

$\Delta \vec{d} = \Delta \vec{d}_1 + \Delta \vec{d}_2$

$\Delta \vec{d} = -75\text{ m} + +192\text{ m}$

$= +117\text{ m} =$ **117 m east**

IV. Hand-In Assignment

1. Indicate whether the direction is positive or negative for the following directions:

A. east	B. up	C. down	D. left
E. south	F. west	G. right	H. north

2. Determine the distance and displacement for each of the following questions. Show a vector diagram and the work for each question. An object moves:

   A. 20 m [W] the 40 m [E] (60 m, 20 m east)

   B. 55 m [N] then 14 m [S] then 6.4 m [N] (75.4 m, 47.4 m north)

   C. 8.45 cm up, 3.46 cm down, 0.0561 m up, and 0.0632 m down (23.84 cm, 4.28 cm up)

   D. 3.56 km [E], 7855 m [W], 2.543 km [W], and 5.00×10^5 cm left (18.96 km, 11.84 km W)

   E. 7.5 cm left, 62 mm right, 0.012 m [W], and 2.3 cm [E] (17.2 cm, 0.2 cm W)

   F. 16 km [E], 17,000 m left, 4.5×10^5 cm right, and 25 km [W] (62.5 km, 21.5 km W)

3. An object travels north at 5.0 m/s for 30 s and then south at 8.0 m/s for 45 s.

   A. What was the distance traveled by the object? (510 m)

   B. What was the final displacement of the object? (210 m south)

   C. What was the average speed of the object? (6.8 m/s)

4. An object travels east for 500 m at a speed of 25 m/s and then west for 800 m at 16 m/s.

   A. What was the distance traveled by the object? (1300 m)

   B. What was the final displacement of the object? (300 m west)

   C. What was the average speed of the object? (18.6 m/s)

5. If a runner completes one circuit of a 400 m track in 44.0 s, determine her average speed and final displacement. (9.1 m/s, 0)