Chapter 1: Motion in a Straight Line

Mini Investigation: The Effect of Gravity on the Motion of Objects, page 7

A. Answers may vary. Sample answer:
Yes, I predicted that the spheres would take the same amount of time to fall and they did.
B. No, the spheres took the same amount of time to fall.
C. Unlike in the first drop, the paper takes longer to fall than the sphere. The sphere falls in a straight line while the paper floats in different directions.
D. Once the sheet of paper is crumpled, it falls in the same amount of time as the spheres, and falls in a straight line.

Section 1.1: Distance, Position, and Displacement

Tutorial 1 Practice, page 11

1. Given: $\vec{d}_{\text{inital}} = 16.4 \text{ m [W]}$;
$\vec{d}_{\text{final}} = 64.9 \text{ m [W]}$

Required: $\Delta\vec{d}_{\text{T}}$

Analysis: $\Delta\vec{d}_{\text{T}} = \vec{d}_{\text{final}} - \vec{d}_{\text{initial}}$

Solution:
$$\begin{aligned}\Delta\vec{d}_{\text{T}} &= \vec{d}_{\text{final}} - \vec{d}_{\text{inital}} \\ &= 64.9 \text{ m [W]} - 16.4 \text{ m [W]} \\ \Delta\vec{d}_{\text{T}} &= 48.5 \text{ m [W]}\end{aligned}$$

Statement: The displacement of the golf ball is 48.5 m [W].

2. Given: $\Delta\vec{d}_1 = 3.8 \text{ m [N]}$; $\Delta\vec{d}_2 = 6.3 \text{ m [N]}$

Required: $\Delta\vec{d}_{\text{T}}$

Analysis: $\Delta\vec{d}_{\text{T}} = \Delta\vec{d}_1 + \Delta\vec{d}_2$

Solution:
$$\begin{aligned}\Delta\vec{d}_{\text{T}} &= \Delta\vec{d}_1 + \Delta\vec{d}_2 \\ &= 3.8 \text{ m [N]} + 6.3 \text{ m [N]} \\ \Delta\vec{d}_{\text{T}} &= 10.1 \text{ m [N]}\end{aligned}$$

Statement: The rabbit's total displacement is 10.1 m [N].

3. Given: $\Delta\vec{d}_1 = 4.2 \text{ m [up]}$; $\Delta\vec{d}_2 = 2.7 \text{ m [down]}$

Required: $\Delta\vec{d}_{\text{T}}$

Analysis: $\Delta\vec{d}_{\text{T}} = \Delta\vec{d}_1 + \Delta\vec{d}_2$

Solution:
$$\begin{aligned}\Delta\vec{d}_{\text{T}} &= \Delta\vec{d}_1 + \Delta\vec{d}_2 \\ &= 4.2 \text{ m [up]} + 2.7 \text{ m [down]} \\ &= 4.2 \text{ m [up]} - 2.7 \text{ m [up]} \\ \Delta\vec{d}_{\text{T}} &= 1.5 \text{ m [up]}\end{aligned}$$

Statement: The skateboarder's total displacement is 1.5 m [up].

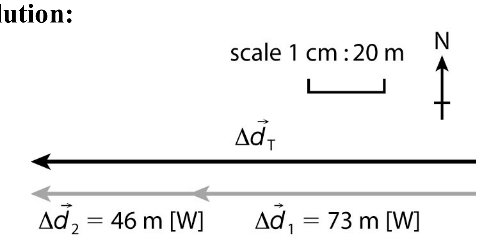
Tutorial 2 Practice, page 13

1. Given: $\Delta\vec{d}_1 = 73 \text{ m [W]}$; $\Delta\vec{d}_2 = 46 \text{ m [W]}$

Required: $\Delta\vec{d}_{\text{T}}$

Analysis: $\Delta\vec{d}_{\text{T}} = \Delta\vec{d}_1 + \Delta\vec{d}_2$

Solution:



This figure shows the given vectors, with the tip of $\Delta\vec{d}_1$ joined to the tail of $\Delta\vec{d}_2$. The resultant vector, $\Delta\vec{d}_{\text{T}}$ is drawn in black, from the tail of $\Delta\vec{d}_1$ to the tip of $\Delta\vec{d}_2$. The direction of $\Delta\vec{d}_{\text{T}}$ is [W].
$\Delta\vec{d}_{\text{T}}$ measures 6.0 cm in length, so using the scale of 1 cm : 20 m, the actual magnitude of $\Delta\vec{d}_{\text{T}}$ is 120 m [W].

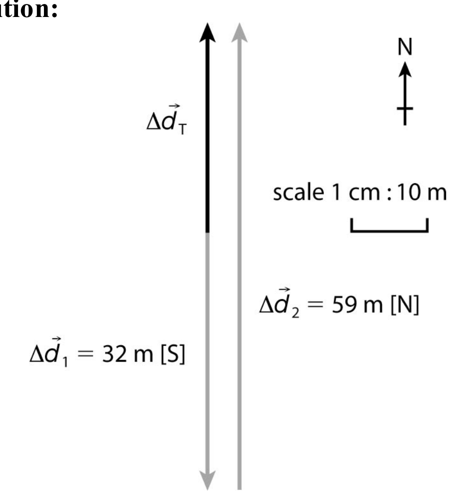
Statement: The car's total displacement is 120 m [W].

2. Given: $\Delta\vec{d}_1 = 32 \text{ m [S]}$; $\Delta\vec{d}_2 = 59 \text{ m [N]}$

Required: $\Delta\vec{d}_{\text{T}}$

Analysis: $\Delta\vec{d}_{\text{T}} = \Delta\vec{d}_1 + \Delta\vec{d}_2$

Solution:



This figure shows the given vectors, with the tip of $\Delta\vec{d}_1$ joined to the tail of $\Delta\vec{d}_2$. The resultant vector, $\Delta\vec{d}_T$ is drawn in black, from the tail of $\Delta\vec{d}_1$ to the tip of $\Delta\vec{d}_2$. The direction of $\Delta\vec{d}_T$ is [N].

$\Delta\vec{d}_T$ measures 2.7 cm in length, so using the scale of 1 cm : 10 m, the actual magnitude of $\Delta\vec{d}_T$ is 27 m [N].

Statement: The robin's total displacement is 27 m [N].

Section 1.1 Questions, page 13

1. (a) The quantity is a scalar because no direction is given.

(b) The quantity is a vector because it includes both distance and direction.

(c) The quantity is a scalar because no direction is given.

2. Answers may vary. Sample answers:

(a) Position is the distance and direction of an object from the point of reference. Displacement is the change in position of an object.

(b) Distance is a scalar quantity of the total length of the path travelled by an object in motion. Displacement is a vector quantity of the change in distance in a certain direction.

3. Given: $\vec{d}_{\text{inital}}$ = 25 m [W]; $\vec{d}_{\text{final}}$ = 76 m [W]

Required: $\Delta\vec{d}_T$

Analysis: $\Delta\vec{d}_T = \vec{d}_{\text{final}} - \vec{d}_{\text{inital}}$

Solution: $\Delta\vec{d}_T = \vec{d}_{\text{final}} - \vec{d}_{\text{inital}}$

$= 76 \text{ m [W]} - 25 \text{ m [W]}$

$\Delta\vec{d}_T = 51 \text{ m [W]}$

Statement: The displacement of the locomotive is 51 m [W].

4. Given: $\vec{d}_{\text{inital}}$ = 52 km [W]; $\vec{d}_{\text{final}}$ = 139 km [E]

Required: $\Delta\vec{d}_T$

Analysis: $\Delta\vec{d}_T = \vec{d}_{\text{final}} - \vec{d}_{\text{inital}}$

Solution: $\Delta\vec{d}_T = \vec{d}_{\text{final}} - \vec{d}_{\text{inital}}$

$= 139 \text{ km [E]} - 52 \text{ km [W]}$

$= 139 \text{ km [E]} + 52 \text{ km [E]}$

$\Delta\vec{d}_T = 191 \text{ km [E]}$

Statement: The total displacement of the car is 191 km [E].

5. (a) Given: $\Delta\vec{d}_1$ = 10 m [W]; $\Delta\vec{d}_2$ = 3.0 m [W]

Required: $\Delta\vec{d}_T$

Analysis: $\Delta\vec{d}_T = \Delta\vec{d}_1 + \Delta\vec{d}_2$

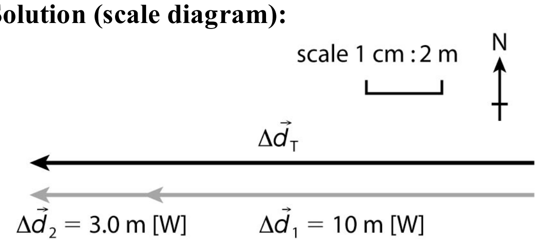
Solution (algebraic):

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

$= 10 \text{ m [W]} + 3.0 \text{ m [W]}$

$\Delta\vec{d}_T = 13.0 \text{ m [W]}$

Solution (scale diagram):



This figure shows the given vectors, with the tip of $\Delta\vec{d}_1$ joined to the tail of $\Delta\vec{d}_2$. The resultant vector, $\Delta\vec{d}_T$ is drawn in black, from the tail of $\Delta\vec{d}_1$ to the tip of $\Delta\vec{d}_2$. The direction of $\Delta\vec{d}_T$ is [W].

$\Delta\vec{d}_T$ measures 6.5 cm in length, so using the scale of 1 cm : 2 m, the actual magnitude of $\Delta\vec{d}_T$ is 13 m [W].

Statement: The total displacement is 13 m [W].

(b) Given: $\Delta\vec{d}_1$ = 10 m [W]; $\Delta\vec{d}_2$ = 3.0 m [E]

Required: $\Delta\vec{d}_T$

Analysis: $\Delta\vec{d}_T = \Delta\vec{d}_1 + \Delta\vec{d}_2$

Solution (algebraic):

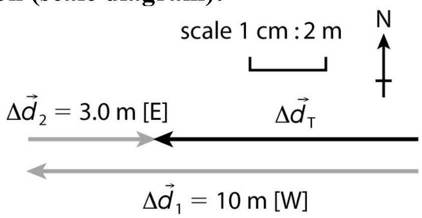
$\Delta\vec{d}_T = \Delta\vec{d}_1 + \Delta\vec{d}_2$

$= 10 \text{ m [W]} + 3.0 \text{ m [E]}$

$= 10 \text{ m [W]} - 3.0 \text{ m [W]}$

$\Delta\vec{d}_T = 7.0 \text{ m [W]}$

Solution (scale diagram):



This figure shows the given vectors, with the tip of $\Delta\vec{d}_1$ joined to the tail of $\Delta\vec{d}_2$. The resultant vector, $\Delta\vec{d}_T$ is drawn in black, from the tail of $\Delta\vec{d}_1$ to the tip of $\Delta\vec{d}_2$. The direction of $\Delta\vec{d}_T$ is [W].

$\Delta\vec{d}_T$ measures 3.5 cm in length, so using the scale of 1 cm : 2 m, the actual magnitude of $\Delta\vec{d}_T$ is 7.0 m [W].

Statement: The total displacement is 7.0 m [W].

(c) Given: $\Delta\vec{d}_1$ = 28 m [N]; $\Delta\vec{d}_2$ = 7.0 m [S]

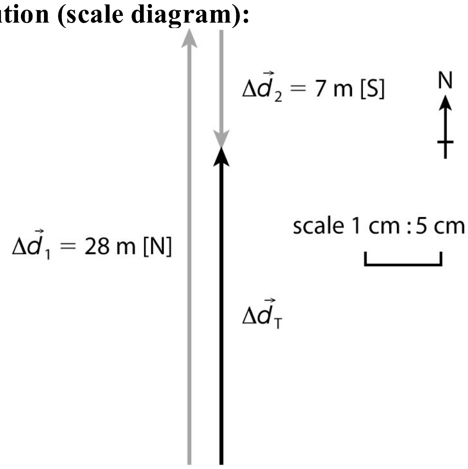
Required: $\Delta\vec{d}_T$

Analysis: $\Delta\vec{d}_T = \Delta\vec{d}_1 + \Delta\vec{d}_2$

Solution (algebraic):

$$\begin{aligned}\Delta\vec{d}_T &= \Delta\vec{d}_1 + \Delta\vec{d}_2\\ &= 28 \text{ m [N]} + 7.0 \text{ m [S]}\\ &= 28 \text{ m [N]} - 7.0 \text{ m [N]}\\ \Delta\vec{d}_T &= 21.0 \text{ m [N]}\end{aligned}$$

Solution (scale diagram):



This figure shows the given vectors, with the tip of $\Delta\vec{d}_1$ joined to the tail of $\Delta\vec{d}_2$. The resultant vector, $\Delta\vec{d}_T$ is drawn in black, from the tail of $\Delta\vec{d}_1$ to the tip of $\Delta\vec{d}_2$. The direction of $\Delta\vec{d}_T$ is [W].

$\Delta\vec{d}_T$ measures 4.2 cm in length, so using the scale of 1 cm : 5 m, the actual magnitude of $\Delta\vec{d}_T$ is 21.0 m [N].

Statement: The total displacement is 21.0 m [N].

(d) Given: $\Delta\vec{d}_1$ = 7.0 km [W]; $\Delta\vec{d}_2$ = 12 km [E]; $\Delta\vec{d}_3$ = 5.0 km [W]

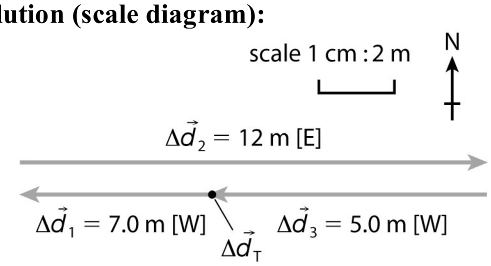
Required: $\Delta\vec{d}_T$

Analysis: $\Delta\vec{d}_T = \Delta\vec{d}_1 + \Delta\vec{d}_2 + \Delta\vec{d}_3$

Solution (algebraic):

$$\begin{aligned}\Delta\vec{d}_T &= \Delta\vec{d}_1 + \Delta\vec{d}_2 + \Delta\vec{d}_3\\ &= 7.0 \text{ km [W]} + 12 \text{ km [E]} + 5.0 \text{ km [W]}\\ &= 7.0 \text{ km [W]} - 12 \text{ km [W]} + 5.0 \text{ km [W]}\\ \Delta\vec{d}_T &= 0.0 \text{ km}\end{aligned}$$

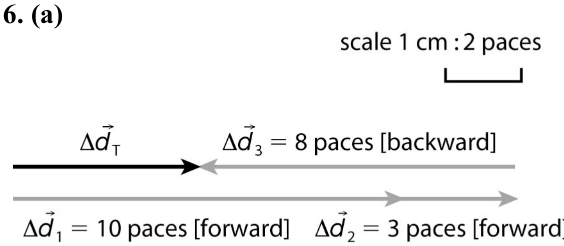
Solution (scale diagram):



This figure shows the given vectors, with the tip of $\Delta\vec{d}_1$ joined to the tail of $\Delta\vec{d}_2$ and the tip of $\Delta\vec{d}_2$ joined to the tail of $\Delta\vec{d}_3$. The resultant vector, $\Delta\vec{d}_T$ is drawn in black, from the tail of $\Delta\vec{d}_1$ to the tip of $\Delta\vec{d}_3$. $\Delta\vec{d}_T$ has no magnitude or direction.

Statement: The total displacement is 0.0 km.

6. (a)



(b) Answers may vary. Sample answer:
I got the result of 5 paces total displacement from the vector scale diagram, so I marked my fifth step while making the 10 paces forward. When I finished the 8 paces backwards, I was almost right at my marker. My experimental results were almost exactly the same as my predicted result.