Chapter 2: Motion in Two Dimensions

Mini Investigation: Garbage Can Basketball, page 59

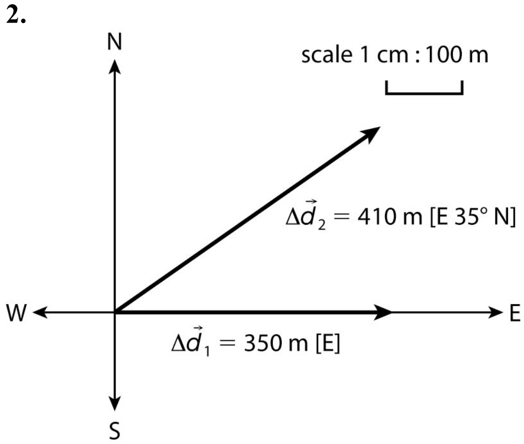
A. Answers may vary. Sample answer:
When launched from knee height, an underhand upward thrust is used such that the ball of paper travels in a parabolic arc. When launched from waist height, a downward arm motion is used to direct the ball of paper to move in a curved trajectory downward into the trash can. When launched from shoulder height, an overhand upward thrust is used to launch the paper ball in a parabolic arc that allows it to land in the trash can.

Section 2.1: Motion in Two Dimensions—A Scale Diagram Approach

Tutorial 1 Practice, page 61

1. Answers may vary. Sample answer:
I think a suitable scale would have the vectors be about 5 cm long. Looking at the smaller displacement, if I divide 350 by 100, I get 3.5. Then if I divide 410 by 100, I get 4.1. Since 3.5 cm and 4.1 cm are both suitable lengths for my vectors I choose a scale of 1 cm : 100 m.

2.



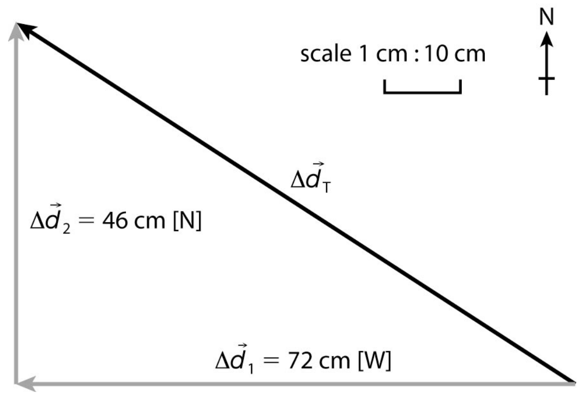
Tutorial 2 Practice, page 64

1. (a) Given: $\Delta\vec{d}_1 = 72$ cm [W]; $\Delta\vec{d}_2 = 46$ cm [N]

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

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

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$ is [W 33° N]. $\Delta\vec{d}_T$ measures 8.5 cm in length, so using the scale of 1 cm : 10 cm, the actual magnitude of $\Delta\vec{d}_T$ is 85 cm.

Statement: The sum of the two vectors is 85 cm [W 33° N].

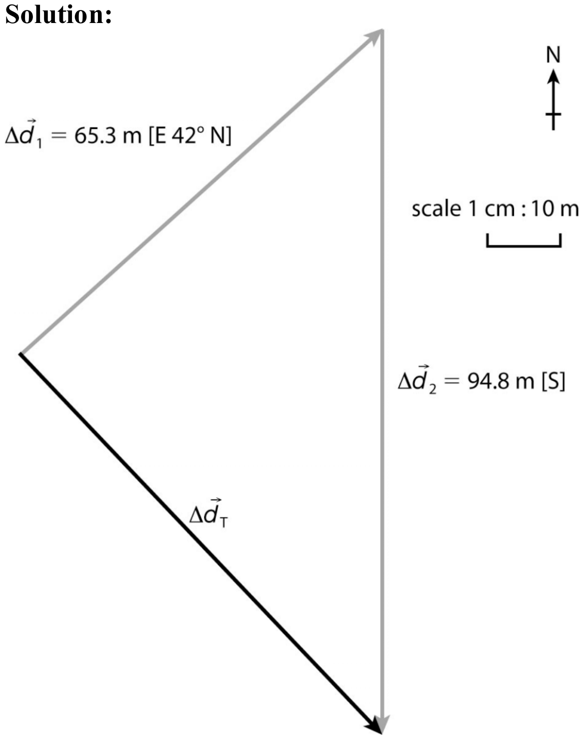
(b) Given: $\Delta\vec{d}_1 = 65.3$ m [E 42° N];

$\Delta\vec{d}_2 = 94.8$ m [S]

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

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

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$ is [W 46° S]. $\Delta\vec{d}_T$ measures 7.05 cm in length, so using the scale of 1 cm : 10 m, the actual magnitude of $\Delta\vec{d}_T$ is 70.5 m.

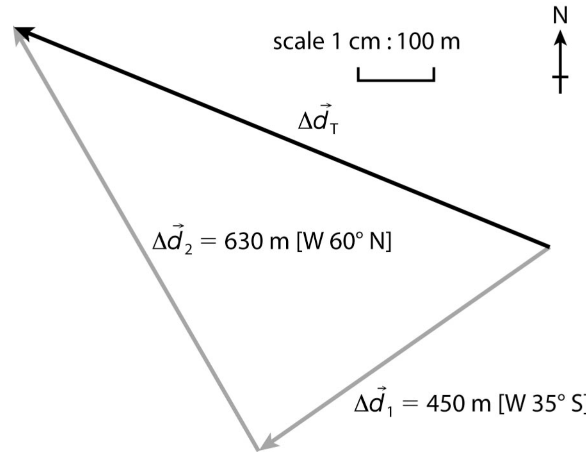
Statement: The sum of the two vectors is 70.5 m [W 46° S].

2. (a) Given: $\Delta\vec{d}_1$ = 450 m [W 35° S]; $\Delta\vec{d}_2$ = 630 m [W 60° N]

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

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

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$ is [W 23° N]. $\Delta\vec{d}_T$ measures 7.4 cm in length, so using the scale of 1 cm : 100 m, the actual magnitude of $\Delta\vec{d}_T$ is 740 m.

Statement: The sum of the two vectors is 740 m [W 23° N].

(b) Given: $\Delta\vec{d}$ = 740 m [W 23° N]; Δt = 77 s

Required: $\vec{v}_{av}$

Analysis: $\vec{v}_{av} = \dfrac{\Delta\vec{d}}{\Delta t}$

Solution:

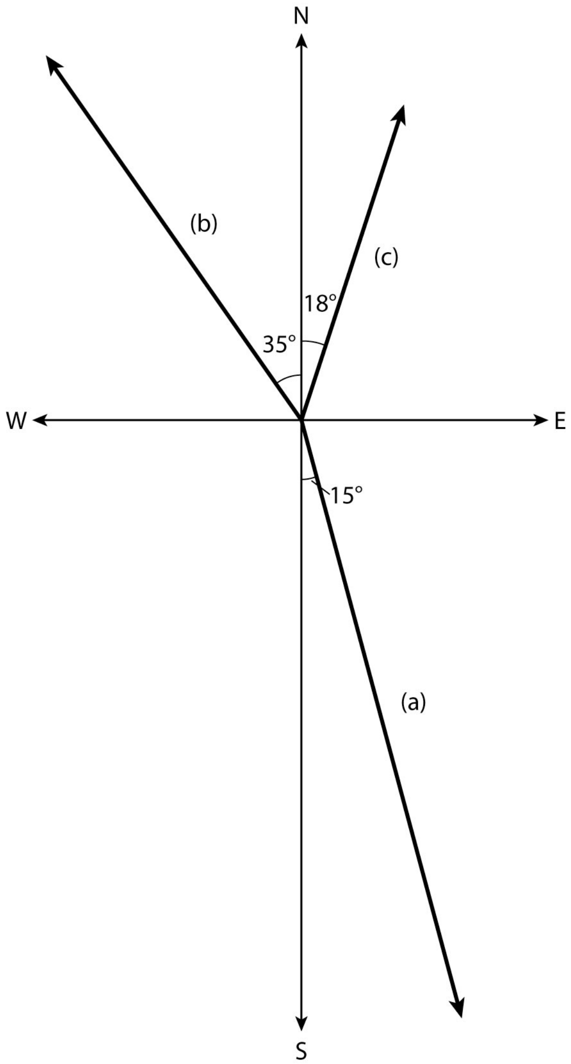
$$\vec{v}_{av} = \frac{\Delta\vec{d}}{\Delta t} = \frac{740 \text{ m [W 23° N]}}{77 \text{ s}}$$

$$\vec{v}_{av} = 9.6 \text{ m/s [W 23° N]}$$

Statement: The cyclist's average velocity is 9.6 m/s [W 23° N].

Section 2.1 Questions, page 65

1.



2. Each vector can be written with the second direction first. The angle will then change to the complementary angle, so subtract the angle from 90°. For example, [S 15° E] becomes [E 75° S].

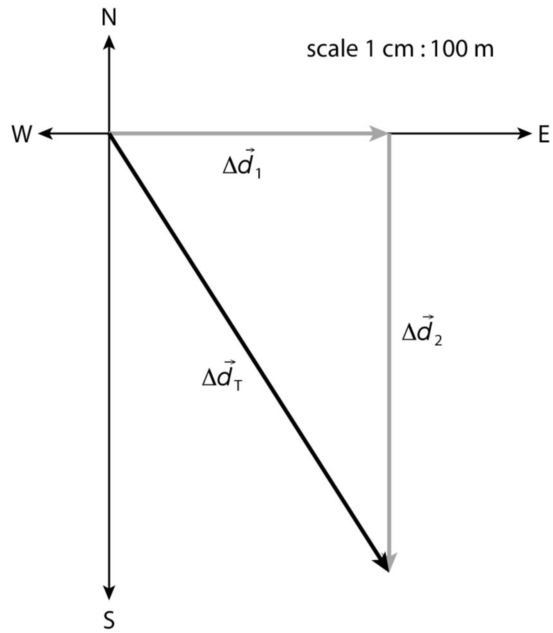
3. (a) The length of $\Delta\vec{d}_1$ is 3.6 cm and the length of $\Delta\vec{d}_2$ is 5.7 cm. Using the scale of 1 cm : 100 m, the actual vector of $\Delta\vec{d}_1$ is 360 m [E] and the actual vector of $\Delta\vec{d}_2$ is 570 m [S].

(b) Given: Figure 11

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

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

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$ is [E 58° S]. $\Delta\vec{d}_T$ measures 6.7 cm in length, so using the scale of 1 cm : 100 m, the actual magnitude of $\Delta\vec{d}_T$ is 670 m.

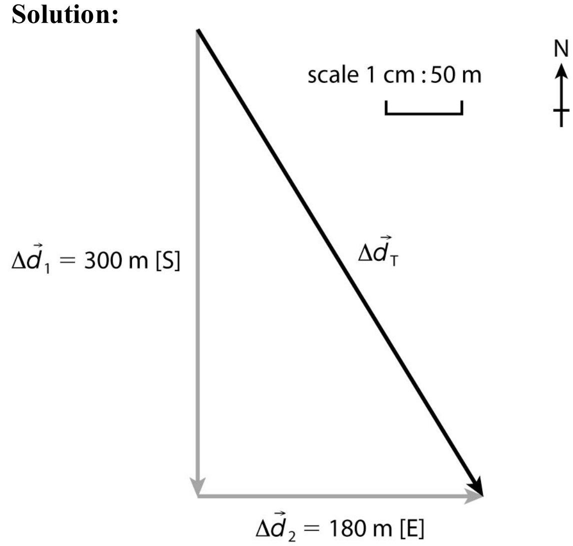
Statement: The sum of the two vectors is 670 m [E 58° S].

4. Given: $\Delta\vec{d}_1 = 300.0$ m [S]; $\Delta\vec{d}_2 = 180.0$ m [E]

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

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

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$ is [S 31° E]. $\Delta\vec{d}_T$ measures 7.0 cm in length, so using the scale of 1 cm : 50 m, the actual magnitude of $\Delta\vec{d}_T$ is 350 m.

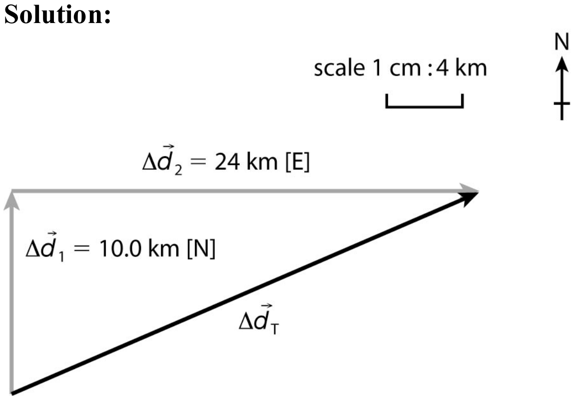
Statement: The taxi's total displacement is 350 m [S 31° E].

5. Given: $\Delta\vec{d}_1 = 10.0$ km [N]; $\Delta\vec{d}_2 = 24$ km [E]

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

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

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$ is [N 67° E]. $\Delta\vec{d}_T$ measures 6.5 cm in length, so using the scale of 1 cm : 4 km, the actual magnitude of $\Delta\vec{d}_T$ is 26 km.

Statement: The total displacement of the two trips is 26 km [N 67° E].

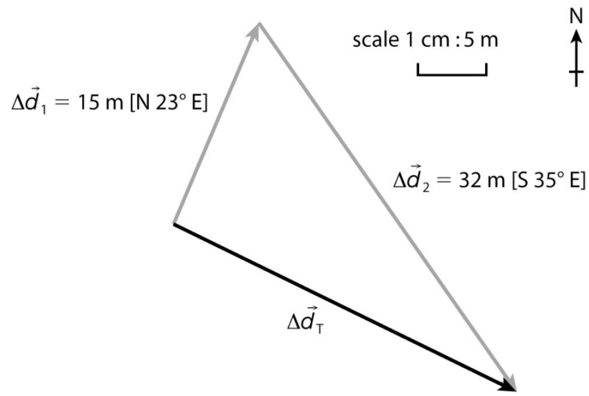
6. Yes, the answer would be the same. Whichever order the vectors are placed, the final position, which is what determines the sum of the vectors, stays the same.

7. Given: $\Delta\vec{d}_1 = 15$ m [N 23° E]; $\Delta\vec{d}_2 = 32$ m [S 35° E]

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

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

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$ is [E 27° S]. $\Delta\vec{d}_T$ measures 5.4 cm in length, so using the scale of 1 cm : 5 m, the actual magnitude of $\Delta\vec{d}_T$ is 27 m.

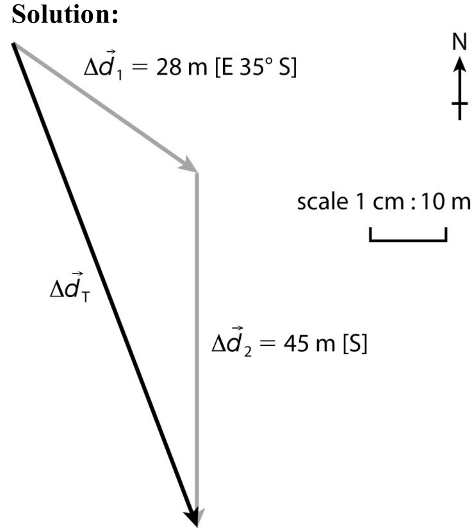
Statement: The horse's total displacement is 27 m [E 27° S].

8. (a) Given: $\Delta\vec{d}_1 = 28$ m [E 35° S]; $\Delta\vec{d}_2 = 45$ m [S]; $\Delta t = 6.9$ s

Required: $\vec{v}_{av}$

Analysis: $\vec{v}_{av} = \dfrac{\Delta\vec{d}_T}{\Delta t}$

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$

is [E 69° S]. $\Delta\vec{d}_T$ measures 6.55 cm in length, so using the scale of 1 cm : 10 m, the actual magnitude of $\Delta\vec{d}_T$ is 65.5 m.

$$\begin{aligned}\vec{v}_{av} &= \frac{\Delta\vec{d}_T}{\Delta t}\\ &= \frac{65.5 \text{ m [E 69° S]}}{6.9 \text{ s}}\\ \vec{v}_{av} &= 9.5 \text{ m/s [E 69° S]}\end{aligned}$$

Statement: The car's average velocity is 9.5 m/s [E 69° S].

(b) Given: $d_1 = 28$ m; $d_2 = 45$ m; $\Delta t = 6.9$ s

Required: v_{av}

Analysis: $v_{av} = \frac{\Delta d_T}{\Delta t}$

$$v_{av} = \frac{d_1 + d_2}{\Delta t}$$

Solution: $v_{av} = \frac{d_1 + d_2}{\Delta t}$

$$\begin{aligned}&= \frac{28 \text{ m} + 45 \text{ m}}{6.9 \text{ s}}\\ v_{av} &= 11 \text{ m/s}\end{aligned}$$

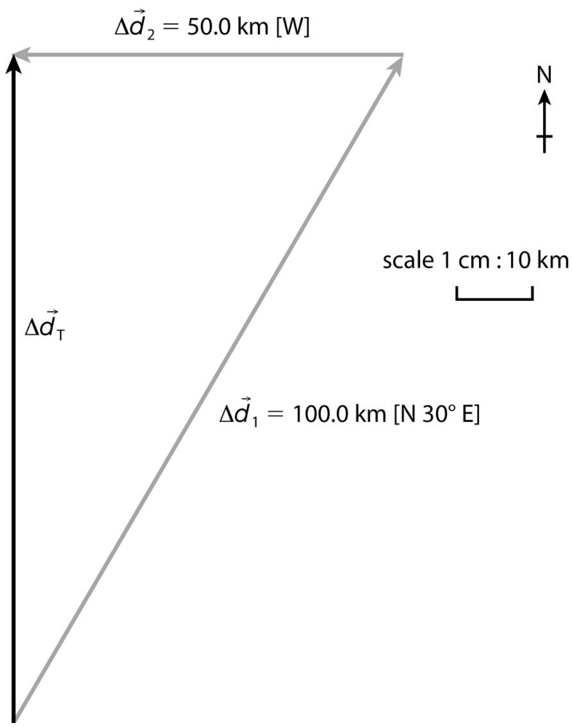
Statement: The car's average speed is 11 m/s.

9. (a) Given: $\Delta\vec{d}_1 = 100.0$ km [N 30° E]; $\Delta\vec{d}_2 = 50.0$ km [W]

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

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

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 $\Delta\vec{d}_2$. Using a compass, the direction of $\Delta\vec{d}_T$ is [N]. $\Delta\vec{d}_T$ measures 8.7 cm in length, so using the scale of 1 cm : 10 km, the actual magnitude of $\Delta\vec{d}_T$ is 87 km.

Statement: The aircraft's total displacement is 87 km [N].

(b) Given: $\Delta\vec{d}_T = 87$ km [N]; $\Delta t = 10.0$ min

Required: $\vec{v}_{av}$

Analysis: $\vec{v}_{av} = \frac{\Delta\vec{d}_T}{\Delta t}$

Solution: $\vec{v}_{av} = \frac{\Delta\vec{d}_T}{\Delta t}$

$$\begin{aligned}&= \frac{87 \text{ km [N]}}{10.0\ \cancel{\text{min}}}\left(\frac{60\ \cancel{\text{min}}}{1 \text{ h}}\right)\\ \vec{v}_{av} &= 5.2\times 10^2 \text{ km/h [N]}\end{aligned}$$

Statement: The aircraft's average velocity is 5.2×10^2 km/h [N] or 520 km/h [N].