

This is a 3-D problem involving average velocity and average speed.

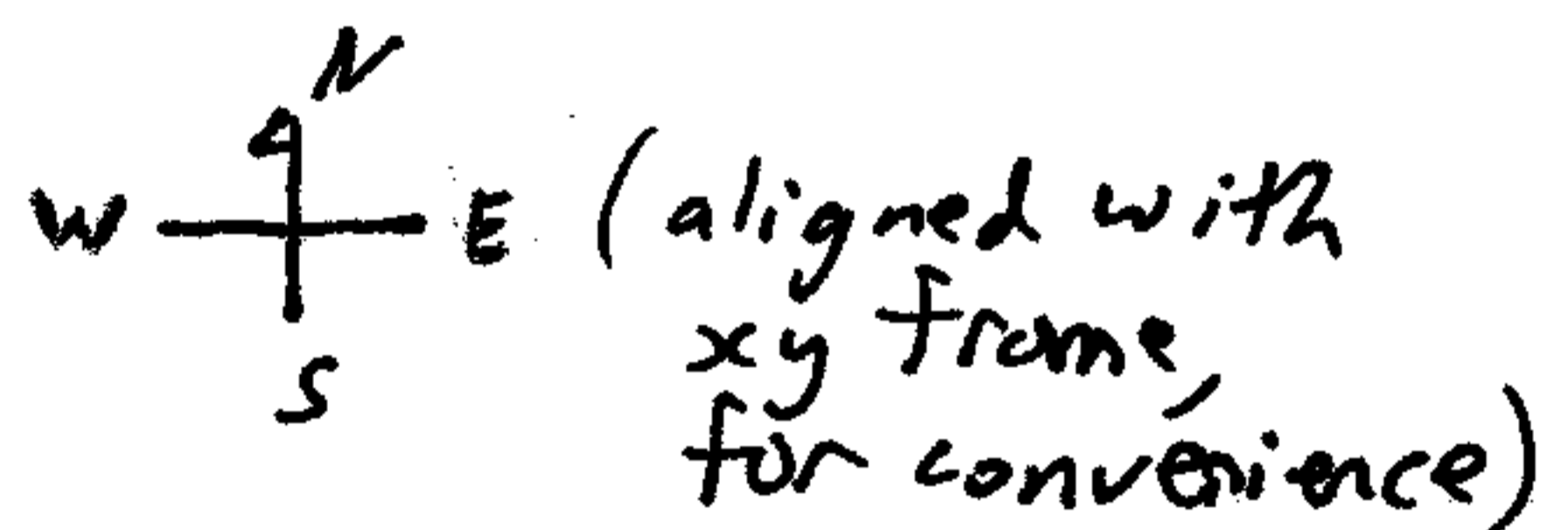
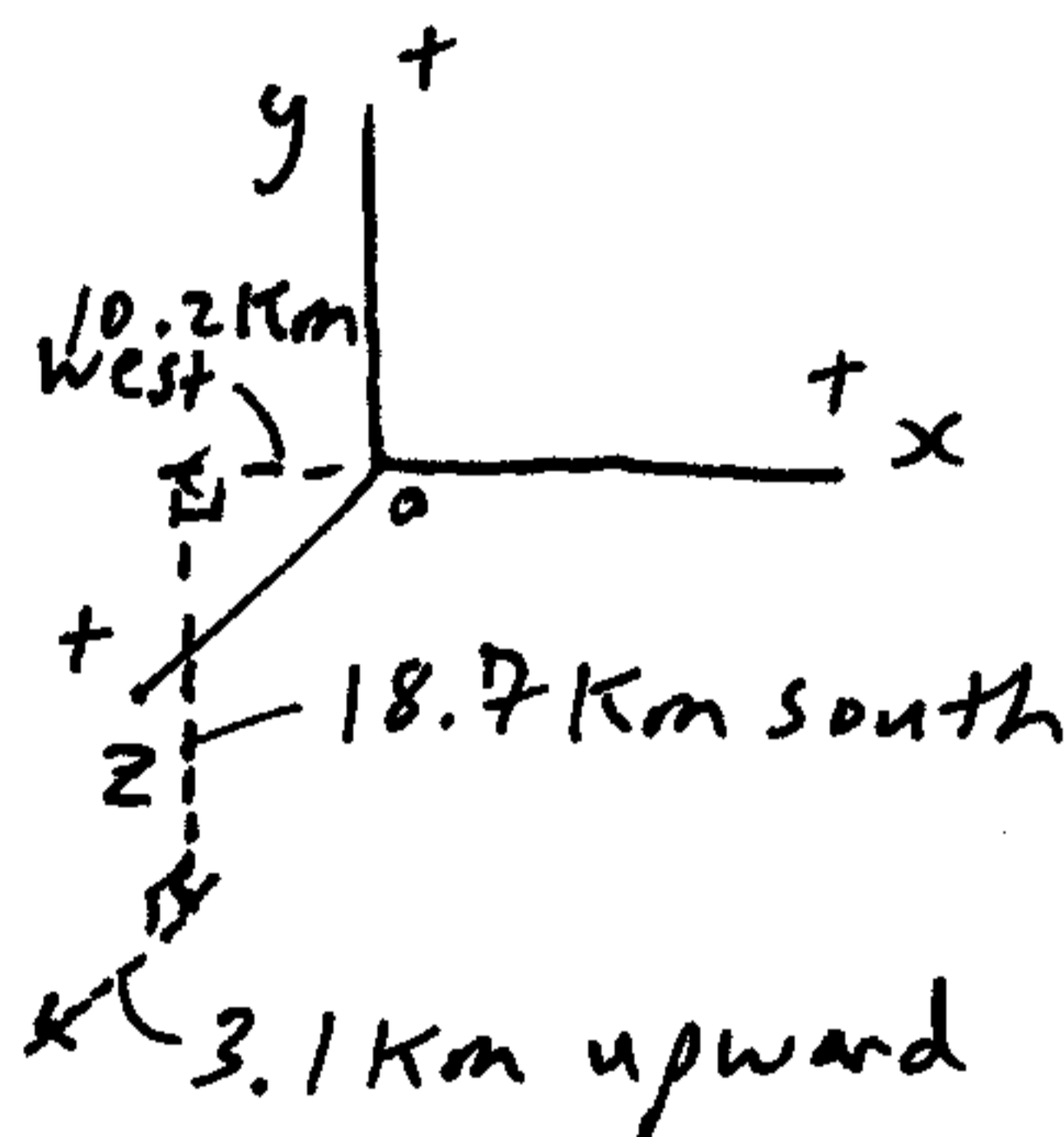
In 4.2 h, a weather balloon drifts 10.2 km west, 18.7 km south, and 3.1 km upward.

(a) Determine the magnitude of the balloon's average velocity, and the angle that this vector makes with the horizontal.

(b) Determine the average speed of the balloon.

Solution:

(a)
(Not to scale)



$$\bar{\mathbf{v}} = \frac{\Delta \vec{r}}{\Delta t} \quad \Delta \vec{r} = -10.2 \hat{i} - 18.7 \hat{j} + 3.1 \hat{k}$$

(units in km)

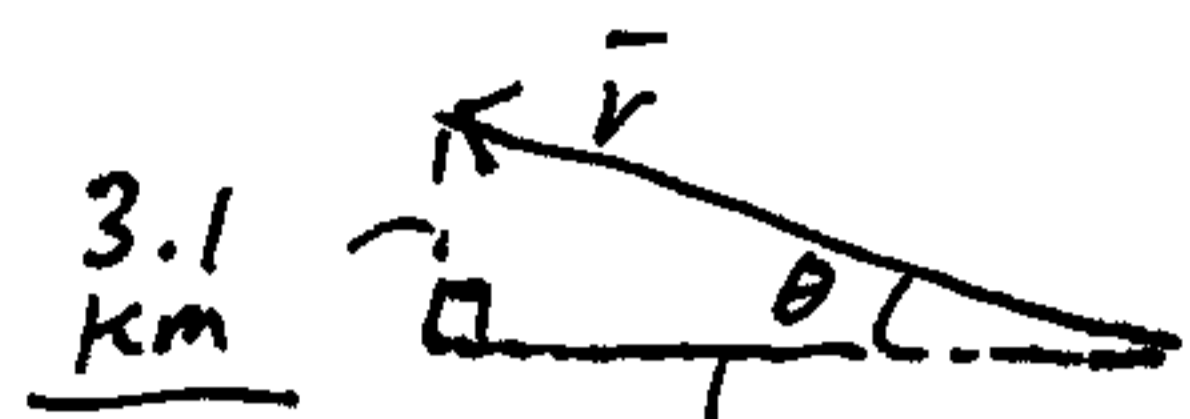
$$\bar{\mathbf{v}} = \frac{-10.2 \hat{i} - 18.7 \hat{j} + 3.1 \hat{k}}{4.2} \quad \Delta t = 4.2 \text{ h}$$

$$\bar{\mathbf{v}} = -2.43 \hat{i} - 4.45 \hat{j} + 0.74 \hat{k}$$

$$|\bar{\mathbf{v}}| = \sqrt{(-2.43)^2 + (-4.45)^2 + (0.74)^2} = 5.1 \text{ km/h}$$

(answer)

Determine θ :



The diagram shows a vector \vec{r} originating from a point. A horizontal dashed line is drawn from the origin to the tip of the vector. The angle between the vector and this horizontal line is labeled θ . A vertical line segment of length 3.1 km is drawn from the tip of the vector down to the horizontal line. Below the horizontal line, a right-angled triangle is shown with legs of length 10.2 km and 18.7 km, and a hypotenuse of length $\sqrt{10.2^2 + 18.7^2}$ km. The horizontal distance from the origin to the tip of the vector is labeled as $\frac{21.3 \text{ km}}{4.2 \text{ h}}$.

$$\frac{3.1 \text{ km}}{4.2 \text{ h}} \quad \frac{\sqrt{10.2^2 + 18.7^2} \text{ km}}{4.2 \text{ h}} = \frac{21.3 \text{ km}}{4.2 \text{ h}}$$

The xy -plane is the horizontal

Using trigonometry, $\theta = \tan^{-1}\left(\frac{3.1}{21.3}\right)$

$\theta = 8.3^\circ$ (answer)

(b) $\bar{s} = \frac{\text{total distance}}{\Delta t}$

$$\bar{s} = \frac{10.2 + 18.7 + 3.1}{4.2} = 7.6 \text{ km/h (answer)}$$