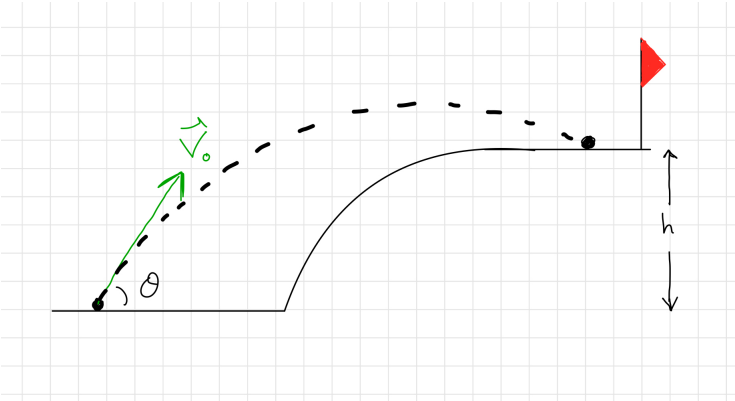
Problem 1

A golfer hits a golf ball off the ground at an angle of $\theta = 65°$, with an initial speed of $v_0 = 9.0$ m/s. The ball lands on a hill a vertical distance of $h = 1.5$ m above the starting position.



(a): 10 points

How long did the ball spend in the air? Give your answer in seconds, to two significant figures.

If the ball was hit at $t = 0$, and t is the time the ball hits the ground, the vertical kinematic equation reads

$$\begin{aligned} h &= (v_0)_y t - \frac{1}{2} g t^2 \\ &= (v_0 \sin\theta) t - \frac{1}{2} g t^2. \end{aligned}$$

Solving this for t, we find

$$t_\pm = \frac{v_0 \sin\theta \pm \sqrt{(v_0 \sin\theta)^2 - 2gh}}{g}.$$

(a): 10 points

There are two solutions, since the ball reaches height h on the way up and on the way down. We take the later time:

$$\begin{aligned} t_+ &= \frac{v_0 \sin\theta + \sqrt{(v_0 \sin\theta)^2 - 2gh}}{2h} \\ &= 1.5 \text{ s} \end{aligned}$$

(b): 5 points

What horizontal distance did the ball travel during its flight? Give your answer in meters, to two significant figures.

In the horizontal direction, if the ball starts at $x = 0$ and lands at x, we have

$$\begin{aligned} x &= (v_0)_x t \\ &= 5.5 \text{ m} \end{aligned}$$

(b): 5 points

Problem 1 continued on next page...

(c): 10 points

With what speed does the ball strike the ground? Give your answer in m/s, to two significant figures.

The horizontal component of the velocity doesn't change: $(v_x)_f = (v_x)_i = v_0 \cos\theta$. The vertical component changes according to:

$$(v_x)_f = (v_x)_i = v_0 \cos\theta$$

$$(v_y)_f = (v_y)_i - gt = v_0 \sin\theta - gt.$$

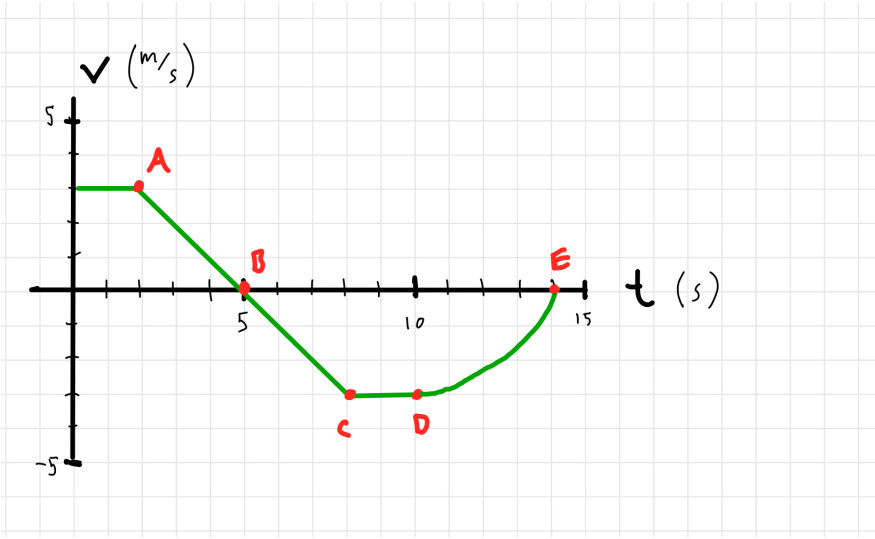
The final speed is thus

$$v_f = \sqrt{(v_0 \cos\theta)^2 + (v_0 \sin\theta - gt)^2} = 7.6 \text{ m/s}$$

(c): 10 points

Problem 2

Consider the velocity graph shown below. There are five points marked A, B, C, D, and E. Suppose the object starts at $x = 0$, and that "right" is the positive direction and "left" is the negative direction.



(a): 7 points

At which of the point(s), if any, does the object return to its starting position? Explain.

The object returns to its starting position at D, since the integral under the curve from zero up until that point is zero.	(a): 7 points

(b): 6 points

Does the object end up to the left or to the right of the starting point? Explain.

The object ends up to the left of the starting point, since the integral of the entire curve is negative.	(b): 6 points

(c): 6 points

Is the acceleration at point B positive, negative, or zero? Explain.

The acceleration is negative because the slope is negative.	(c): 6 points

(d): 6 points

At which of the point(s) was the object moving with the highest speed? Explain.

At points A, C, and D, the speed is 3 m/s; this is the max.	(d): 6 points