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8.1 Constructing a model

1. $h = 0.6x - 0.06x^2$

a)

i) When the football is struck, $x = 0$

$$h = 0.6(0) - 0.06(0)^2$$

$$h = 0\text{m}$$

ii) When $x = 3$

$$h = 0.6(3) - 0.06(3)^2$$

$$h = 1.26\text{m}$$

iii) When $x = 6$

$$h = 0.6(6) - 0.06(6)^2$$

$$h = 1.44\text{m}$$

b) when $x = 15$

$$h = 0.6(15) - 0.06(15)^2$$

$$h = -4.5\text{m}$$

c) The model is not valid when $x = 15$ as the height would be 4.5m below ground level

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$$2. \quad h = -5t^2 + 3t + 8$$

a) When diving board is above water $t=0$

$$h = -5(0)^2 + 3(0) + 8$$

$$h = 8\text{m}$$

b) When $t=1$

$$h = -5(1)^2 + 3(1) + 8$$

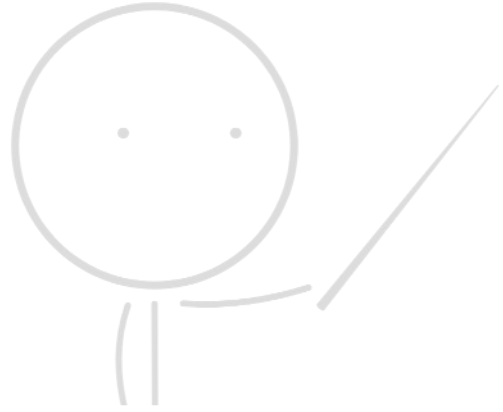
$$h = 6\text{m}$$

c) When $t=3$

$$h = -5(3)^2 + 3(2) + 8$$

$$h = -28\text{m}$$

d) The model is not valid when $t=3$. After the diver enters the water, other forces then act on the diver and so the model ceases to be valid



$$3. \quad h = 0.8x - 0.05x^2$$

a)

i) when $x=2$

$$h = 0.8(2) - 0.05(2)^2$$

$$h = 1.4\text{m}$$

ii) when $x=5$

$$h = 0.8(5) - 0.05(5)^2$$

$$h = 2.75\text{m}$$

iii) when $x=10$

$$h = 0.8(10) - 0.05(10)^2$$

$$h = 3\text{m}$$

b) When $x = 20$
 $h = 0.8(20) - 0.05(20)^2$
 $h = -4\text{m}$

The model is not valid when $x = 20$ as the height would be below ground level

4. $d = 26.8t - kt^2$

a) when $t = 2$, $d = 49.1$
 $49.1 = 26.8(2) - k(2)^2$
 $49.1 = 53.6 - 4k$
 $4k = 4.5$
 $k = 1.125$

$d = 26.8(8) - 1.125(8)^2$
 $d = 142.4\text{m}$

b) The model is valid for positive values of t only. We are also unsure of what happens after $t = 8$, and we therefore can't use this model past that point.

The model is valid for $0 \leq t \leq 8$

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5. $h \geq 0$ means $0.6x - 0.06x^2 = x(0.6 - 0.06x) \geq 0$
We are assuming that $x \geq 0$ after the ball is struck, so we need the bracket to be non-negative:

$$0.6 \geq 0.06x$$
$$x \leq \frac{0.6}{0.06} = 10$$

So the model is valid for $0 \leq x \leq 10$

6. When the diver is above the water, $h=0$
 $-5t^2 + 3t + 8 = 0$
 $t = 1.6$ or $t = -1$

The diver enters the water after 1.6 seconds, since the model is only valid from the time the diver dives until the time the diver enters the water.

Therefore, the model is valid for $0 \leq t \leq 1.6$

7. a) $h \geq 0$ means $0.8x - 0.05x^2 = x(0.8 - 0.05x) \geq 0$
We are assuming that $x \geq 0$ after the shot is thrown, so we need the bracket to be non-negative:

$$0.8 \geq 0.05x$$
$$x \leq \frac{0.8}{0.05} = 16$$

So the model is valid for $0 \leq x \leq 16$

- b) The maximum height occurs at the vertex of the parabola given by
 $h = 0.8x - 0.05x^2$

The x -coordinate of the vertex can be found using
 $x = -\frac{b}{2a}$ where $a = -0.05$ and $b = 0.8$

$$x = -\frac{0.8}{2(-0.05)} = 8$$

Substitute $x = 8$:

$$h = 0.8(8) - 0.05(8)^2$$
$$h = 3.2 \text{ m}$$

c) $h = 0.6x - 0.04x^2$

$$x(0.6 - 0.04x) \geq 0$$

$$0.6 \geq 0.04x$$

$$x \leq \frac{0.6}{0.04} = 15$$

The model is valid for $0 \leq x \leq 15$

The model for Rashid is valid for $0 \leq x \leq 16$

Rashid throws the shot 16m, Sam throws the shot 15m.
Rashid wins by 1m

$$8. \quad h = 1.8 + 1.2x - 0.2x^2$$

a) When ball leaves player's hand, $x=0$
 $h = 1.8 + 1.2(0) - 0.2(0)^2$
 $h = 1.8\text{m}$

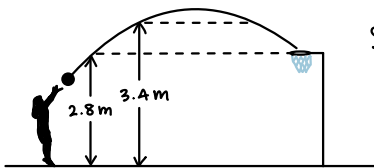
b) When $h = 3.4$
 $3.4 = 1.8 + 1.2x - 0.2x^2$
 $-1.6 = 1.2x - 0.2x^2$
 $-0.2x^2 + 1.2x - 1.6 = 0$

$$x = 4 \quad \text{and} \quad x = 2$$

c) When $h = 2.8$
 $2.8 = 1.8 + 1.2x - 0.2x^2$
 $-1 = 1.2x - 0.2x^2$
 $-0.2x^2 + 1.2x - 1 = 0$
 $x = 5 \quad \text{or} \quad x = 1$

The netball is 2.8m above the ground after it has travelled both 1m and 5m horizontally.

At the shorter distance, the netball will be travelling upward, so $k=5$



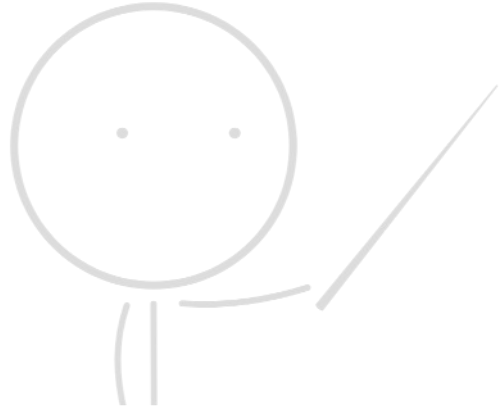
So the model is valid for $0 \leq x \leq 5$

d) Take derivative of $h = 1.8 + 1.2x - 0.2x^2$ and set to zero
 $h'(x) = 1.2 - 0.4x$
 $1.2 = 0.4x$
 $x = 3$

Substitute $x=3$

$$h = 1.8 + 1.2(3) - 0.2(3)^2$$

$$h = 3.6\text{m}$$



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