This worksheet is based on events in the mathematical thriller A Question of Will. Get it now at:

www.MathNovel.com

Escape from the Police Station Worked Solution

Question 1

Calculate Fall Heights and Fall Durations

The fall height for the car park awning is the difference between the police building height and the car park height:

h = 60 - 30 = 30.00 m **(1 mark)**

Fall time to hit the car park awning = $\sqrt{\frac{2\times h}{g}}=\sqrt{\frac{2\times 30}{9.81}}$= 2.47 seconds **(1 mark)**

The fall height for the diving pool is the difference between the police building height and the hotel height:

h = 60 - 15 = 45.00 m **(1 mark)**

Fall time to hit the car park awning = $\sqrt{\frac{2\times h}{g}}=\sqrt{\frac{2\times 45.00}{9.81}}$= 3.03 seconds **(1 mark)**

Calculate Required Running Speed

For the car park awning, the boys have to cross a distance of 17.5 m in 2.47 seconds. That means they need to hit a certain running speed:

$$Running\ speed\ required = \frac{distance}{time}$$

$$Running\ speed\ required = \frac{17.5}{2.47}$$

$$Running\ speed\ required = 7.09\ m/s \quad \textbf{(1 mark)}$$

For the hotel diving pool, the boys have to cross a distance of 25 m in 3.03 seconds. That means they need to hit a certain running speed:

$$Running\ speed\ required = \frac{distance}{time}$$

$$Running\ speed\ required = \frac{25}{3.03}$$

$$Running\ speed\ required = 8.25\ m/s \quad \textbf{(1 mark)}$$

Since the running speed required to reach the car park is lower than for the diving pool, Will and Besra should go for the car park. **(1 mark)**

Question 2

Calculate Vertical Speed at Impact

Will and Besra will accelerate during the fall to the car park for a total time of 2.47 seconds. They'll accelerate at a rate of 9.81 m/s/s during this time.

$$\text{Speed at impact} = \text{g} \times \text{t}$$

$$\text{Speed at impact} = 9.81 \times 2.47$$

$$\text{Speed at impact} = 24.23 \text{ m/s}$$ **(1 mark)**

Will and Besra will accelerate during the fall to the diving pool for a total time of 3.03 seconds.

$$\text{Speed at impact} = \text{g} \times \text{t}$$

$$\text{Speed at impact} = 9.81 \times 3.03$$

$$\text{Speed at impact} = 29.72 \text{ m/s}$$ **(1 mark)**

Calculate Ratio Between Two Impact Speeds

$$Speed\ ratio = 29.72/24.23$$

$$Speed\ ratio = 1.27$$ **(1 mark)**

The diving pool vertical impact speed is 1.27 times the car park awning impact speed. The boys can survive a 30% faster vertical impact with the diving pool than the car park awning (so 1.3 times the car park impact speed). 1.27 times is less than 1.3 times, so based on vertical impact speed Will and Besra should go for the hotel diving pool. **(1 mark)**

Question 3

Calculate How Long to Reach the Required Speed

Car Park: **(1 mark)**

$$t = required\ speed \div acceleration$$

$$t = 7.09 \div 2.$$

$$t = 3.87\ s$$

Diving pool: **(1 mark)**

$$t = required\ speed \div acceleration$$

$$t = 8.25 \div 2.$$

$$t = 4.72\ s$$

This worksheet is based on events in the mathematical thriller A Question of Will. Get it now at:

www.MathNovel.com

Calculate Required Distance to Hit Required Speed

Car Park: **(1 mark)**

$$x = \frac{1}{2}at^2$$

$$x = \frac{1}{2} \times 2. \times 3.87^2$$

$$x = 14.98\ m$$

Diving pool: **(1 mark)**

$$x = \frac{1}{2}at^2$$

$$x = \frac{1}{2} \times 2. \times 4.72^2$$

$$x = 22.28\ m$$

Bonus: Re-arranging the Formula **(2 bonus marks)**

What other formula does this re-arranged one resemble? We can re-arrange it as follows:

$$x = \frac{1}{2}at^2$$

$$\frac{2x}{a} = t^2$$

$$t = \pm\sqrt{\frac{2x}{a}}$$

This is the same formula as the one we used for Question 1 to calculate the time taken for an object to fall a certain distance, except with general acceleration *a* instead of gravity *g*, and with general distance *x* instead of the fall height *h*.

Also note that negative times make mathematical sense, but not physical sense for this particular question, so we only use the *positive* result from this re-arranged formula.