
MEASURING FIREWORKS WITH SOUND

WORKED SOLUTION

Question 1

To calculate the average time recording, we add up the four times and then divide by 4:

$$\textit{Average time recording} = \frac{(1.24 + 1.17 + 1.56 + 1.21)}{4}$$

$$\textit{Average time recording} = 1.295 \text{ seconds (1 mark)}$$

Question 2

The 1.24, 1.17 and 1.21 second recordings are all quite close. However, the 1.56 second recording is very different – it may be that you have made an error when recording the third time. We should discard the 1.56 second recording as an outlier and recalculate the average time based on the remaining three times: (1 mark)

$$\begin{aligned}\textit{Average time recording} &= (1.24 + 1.17 + 1.21) / 3 \\ \textit{Average time recording} &= 1.207 \text{ seconds (1 mark)}\end{aligned}$$

Question 3

To calculate the distance to the launch area, we need to multiply the speed of sound by the average time interval:

$$\begin{aligned}\textit{Distance} &= \textit{speed of sound} \times \textit{average time interval} \\ \textit{Distance} &= 340 \text{ m/s} \times 1.207 \text{ s} \\ \textit{Distance} &= 410.4 \text{ m (1 mark)}\end{aligned}$$

The launch area will meet the safety standards as it is further than 300m away from the spectators. (1 mark)

Question 4

We know the distance that the firework travels to get from the launch area to the grandstand. If we can calculate how long it takes to travel that distance, we can calculate the firework's average speed.

$$\begin{aligned}\textit{Firework time} &= \textit{average measured time interval} - 0.5 \text{ seconds} \\ \textit{Firework time} &= 1.207 \text{ seconds} - 0.5 \text{ seconds} \\ \textit{Firework time} &= 0.707 \text{ seconds (1 mark)}\end{aligned}$$

Speed is distance divided by time:

$$\textit{Firework average speed} = \textit{distance} / \textit{time}$$

$$\textit{Firework average speed} = 410.4 \textit{ m} / 0.707 \textit{ seconds}$$

$$\textbf{\textit{Firework average speed} = 580.5 \textit{ m/s} (1 \textit{ mark})}$$

To calculate the Mach number of the firework (how many times faster than the speed of sound it is travelling), we need to divide the firework speed by the speed of sound:

$$\textit{Firework Mach number} = \textit{firework speed} / \textit{speed of sound}$$

$$\textit{Firework Mach number} = 580.5 / 340$$

$$\textbf{\textit{Firework Mach number} = 1.71 (1 \textit{ mark})}$$

