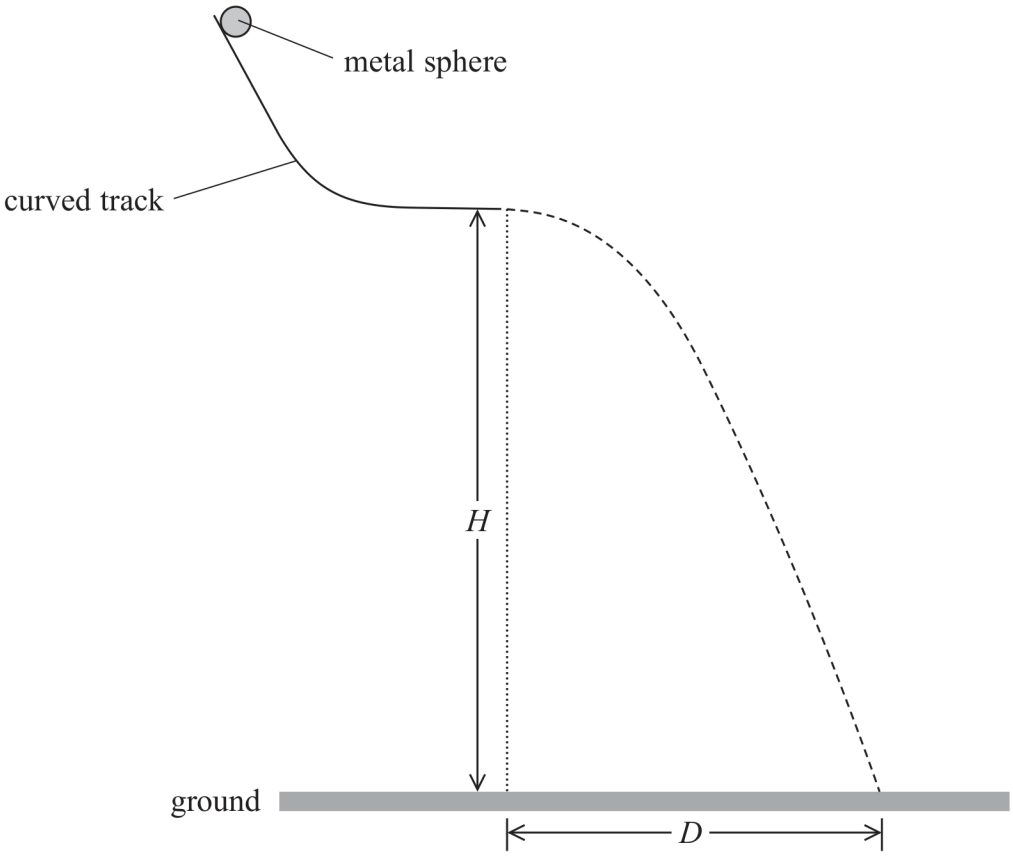
**4** A student investigated the motion of a small metal sphere moving horizontally from the lower end of a rigid curved track.

The track was supported by a clamp stand. The student adjusted the position of the track so that the end of the track was a height $H$ above the ground as shown.

She determined the horizontal distance $D$ travelled by the sphere before it reached the ground, for different values of $H$.




(a) For each value of $H$, the student released the sphere from the same position on the track.

Explain why this ensured the sphere always reached the end of the track with the same horizontal speed.

**(3)**

(b) The student derived the following equation for the relationship between $D$ and $H$

$$D^2 = \frac{2v^2}{g} H$$

where $v$ is the horizontal velocity of the sphere at the end of the track.

She recorded her results in a table.

| ***H* / m** | ***D* / m** | |
|---|---|---|
| 0.2 | 0.38 | |
| 0.35 | 0.53 | |
| 0.5 | 0.63 | |
| 0.75 | 0.76 | |
| 1 | 0.89 | |
| 1.2 | 0.96 | |

Criticise the recording of these results.

**(2)**

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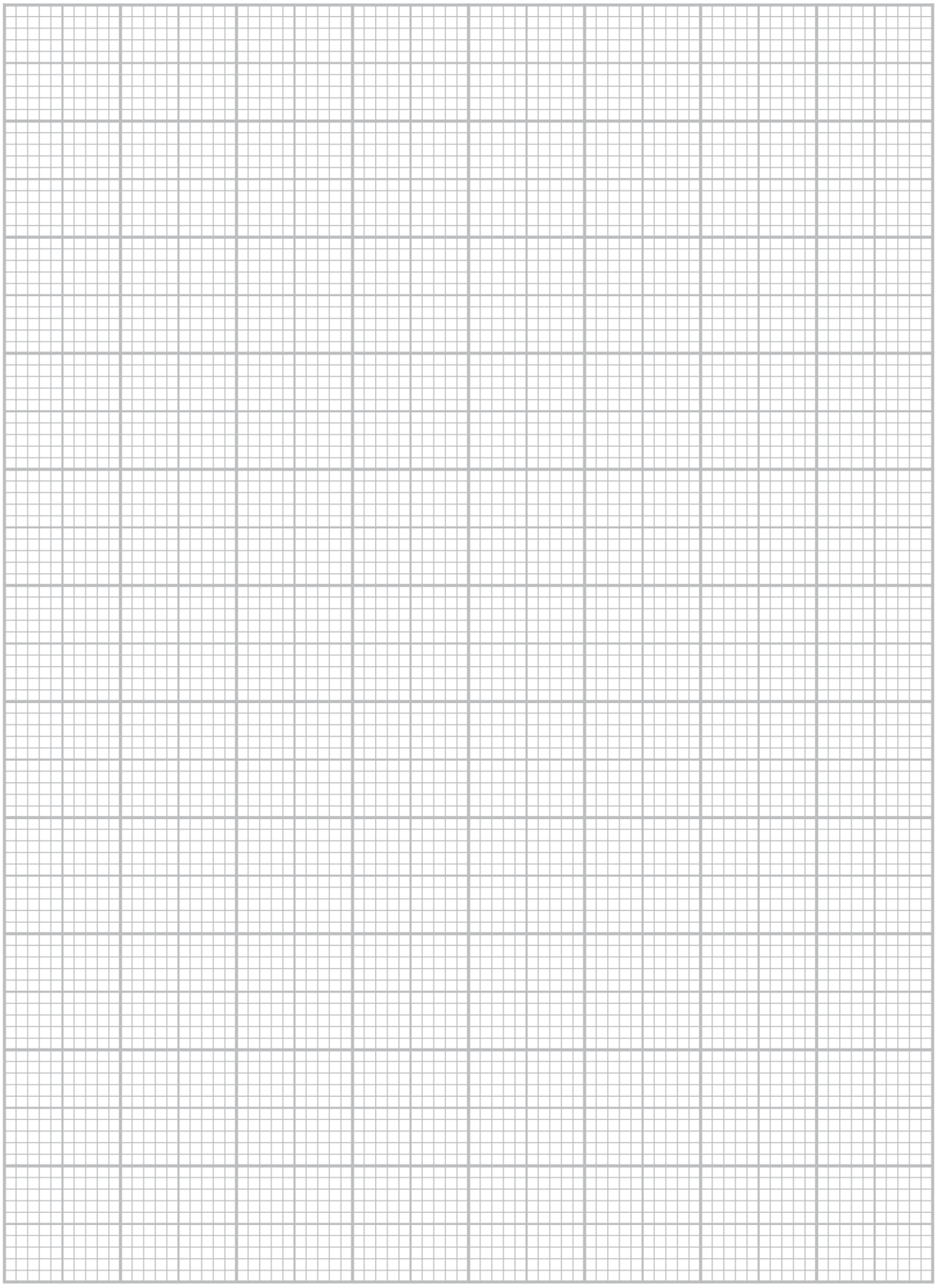
(c) (i) Plot a graph of $D^2$ on the $y$-axis against $H$ on the $x$-axis. Use the additional column of the table for your processed data.

**(6)**



(ii) The gradient of the graph is equal to $\frac{2v^2}{g}$

Determine the value of $v$ using your graph.

**(3)**

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$v =$ ..... $\text{m s}^{-1}$

(iii) The student used a light gate and data logger to measure $v$. The measured value was $1.98\,\text{m s}^{-1}$.

Comment on the value of $v$ determined using your graph.

**(2)**

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**(Total for Question 4 = 16 marks)**



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