

Gravitational force, potential and satellite orbits

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab answers

The answers use the sample results in the table, so your own values will differ slightly. Check that you divided the frame count by 240 to get seconds and that you squared the time before calculating g .

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB D.1

Question 1 Time from frames

$t = 118 \div 240 = 0.492$ s. The ball is released without a push, so the initial velocity is zero, and $s = \frac{1}{2} g t^2$ applies.

$t = 0.492$ s.

Question 2 Value of g

$g = 2 h \div t^2 = 2 \times 0.40 \div (68 \div 240)^2 = 0.80 \div 0.0803 = 9.97$ m/s².

$g = 9.97$ m/s².

Question 3 Mean value

Mean $g = (9.97 + 9.79 + 9.93 + 9.68 + 9.84) \div 5 = 9.84$ m/s². The difference is $(9.84 - 9.81) \div 9.81 \times 100\% = 0.3\%$.

mean $g = 9.84$ m/s².

Question 4 Graph

Since $h = \frac{1}{2} g t^2$, plot h on the y-axis and t^2 on the x-axis. The graph is a straight line through the origin with gradient $\frac{1}{2} g$. The gradient of the best fit through the origin here is 4.90 m/s², giving $g = 9.81$ m/s².

$g = 2 \times \text{gradient} = 9.81$ m/s².

Question 5 Field strength and the Earth

$M = g R^2 \div G = 9.81 \times (6.37 \times 10^6)^2 \div 6.67 \times 10^{-11} = 9.81 \times 4.058 \times 10^{13} \div 6.67 \times 10^{-11} = 5.97 \times 10^{24}$ kg. With your gradient value $g = 9.81$ the mass is 5.97×10^{24} kg.

$M = 5.97 \times 10^{24}$ kg.

Question 6 Uncertainty in frames

The uncertainty in t is $1 \div 68 = 1.5 \%$. Since $g \propto 1/t^2$, the uncertainty in g is $2 \times 1.5 \% = 2.9 \%$, about $\pm 0.3 \text{ m/s}^2$. The longer drops have smaller uncertainties, for example $2 \times 1 \div 153 = 1.3 \%$ for 2.00 m.

$\pm 2.9 \%$.

Question 7 Air resistance

Air resistance reduces the acceleration, so the time is slightly longer and the calculated g slightly smaller. For a dense steel ball moving below 6 m/s, the drag is much smaller than the weight, so the effect is under 1 %.

g is slightly underestimated.

Question 8 Improvements

Use a light gate or electromagnet release with a digital timer instead of counting frames, and repeat each height three times to average the results. Film perpendicular to the wall to avoid parallax errors in reading the release frame.

use electronic timing and repeat the drops.