

Motion with derivatives and integrals

AP Physics C (Mechanics and E&M, calculus-based) · Lab answers

Model answers use the sample table above. Your readings will differ a little. The key skills are converting positions to velocities, estimating slopes and checking the area under the graph against the measured distance.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 1

Question 1 Average velocities

$v = \Delta y / 0.05 \text{ s}$ for each interval: **0.30** m/s (at 0.025 s), **0.76** m/s (at 0.075 s), **1.04** m/s (at 0.125 s), **1.20** m/s (at 0.175 s), **1.28** m/s (at 0.225 s), **1.36** m/s (at 0.275 s), **1.40** m/s (at 0.325 s), **1.42** m/s (at 0.375 s), **1.42** m/s (at 0.425 s), **1.44** m/s (at 0.475 s).

Question 2 Velocity-time graph

The graph is a **curve that rises steeply and then levels off**, so the slope, which is the acceleration, falls with time.

Question 3 Acceleration at the start and end

Start: $(0.76 - 0.3) / 0.05 = \mathbf{9.2 \text{ m/s}^2}$, close to g . End: $(1.44 - 1.42) / 0.05 = \mathbf{0.4 \text{ m/s}^2}$, close to zero within the reading error.

Question 4 Terminal velocity

The curve levels at about **1.44 m/s**.

Question 5 Check by integration

Sum of $v \times 0.05 \text{ s} = 0.581 \text{ m}$ against the measured 0.581 m, so **the two agree**: both are the area under the v - t graph (the sum telescopes to the last position).

Question 6 Explain the shape

At release only weight acts, so $a \approx g$. As speed rises, drag grows, the net force falls and the acceleration shrinks to zero when drag equals weight, giving a **constant terminal velocity**.

Question 7 Uncertainty

Judging the bottom edge of the stack against the rule gives about $\pm 1 \text{ mm}$ in y , which is the largest error in the small first intervals. Improvement: **film closer, use a higher frame**

rate or add a bright marker.