

Motion with derivatives and integrals

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

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

This test covers differentiation and integration of motion, variable acceleration and graph reading. Give every answer with its unit and show the steps of each integral. Marks per part are shown in brackets.

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

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

Question 1 Derivatives of a position function (3 marks)

A particle has $x = t^3 - 6t^2 + 9t$ (m).

- Find $v(t)$ and $a(t)$. (2 marks)
- Find the times at which the particle is at rest. (1 mark)

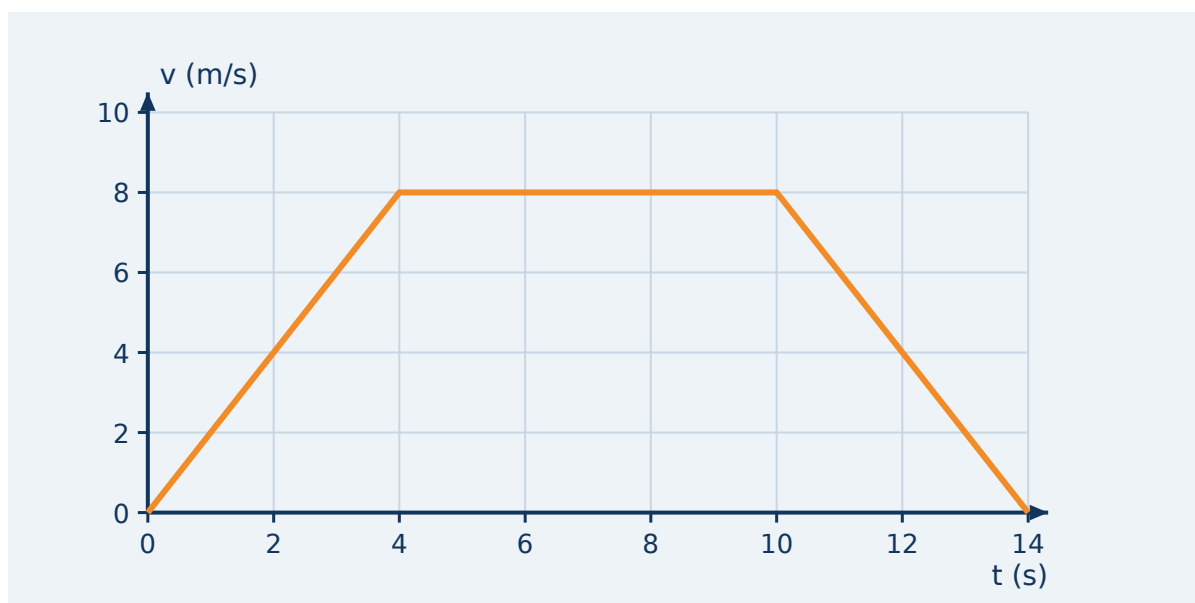
Question 2 Integrating acceleration (2 marks)

A cart has $a = 6t$ (m/s²) and $v(0) = 2$ m/s.

- Find $v(t)$. (1 mark)
- Calculate v at $t = 3$ s. (1 mark)

Question 3 Reading a velocity graph (3 marks)

The graph shows the velocity of a trolley.



Velocity against time for a trolley.

- Calculate the displacement from 0 to 14 s. (2 marks)
- Calculate the acceleration at $t = 2$ s. (1 mark)

Question 4 Exponential slowing (3 marks)

A puck has $a = -0.50v$ and $v(0) = 12$ m/s, so $v = 12e^{(-0.50t)}$.

- Calculate v at $t = 2.0$ s. (1 mark)
- Calculate the total distance travelled before it stops, by integrating v . (2 marks)

Question 5 Acceleration as a function of position (3 marks)

A mass has $a = -9x$ (SI units) and $v = 6.0$ m/s at $x = 0$.

- Use $a = v dv/dx$ to find the largest value of x . (2 marks)
- Calculate v at $x = 1.0$ m. (1 mark)

Question 6 Why constant-acceleration equations fail (2 marks)

A student uses $x = \frac{1}{2}at^2$ for a motion where $a = 12t$.

- Explain why this is wrong. (1 mark)
- State what the area under the a - t graph represents. (1 mark)

Question 7 Speeding up or slowing down (2 marks)

For $x = t^3 - 6t^2 + 9t$ (m), $v = 3t^2 - 12t + 9$ and $a = 6t - 12$.

- State whether the speed is increasing or decreasing at $t = 2.5$ s, using v and a . (1

mark)

- b. State the same for $t = 4.0$ s. (1 mark)

Question 8 Simple harmonic motion (2 marks)

A particle has $x = 0.30 \sin(4.0t)$ (m).

- a. Calculate the maximum speed. (1 mark)
b. Calculate the maximum acceleration. (1 mark)