SCIENCE FOUNDATIONS

Constant-acceleration equations

Difficulty level: Advanced

Science Foundations

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Overview of the concept

This is how a driver works out how far a car travels while it speeds up steadily, or how long it takes to reach highway speed from a stop. A traffic engineer uses the same thinking to set the length of a highway on-ramp so cars can merge safely. A pilot needs to know how much runway a plane needs to get up to takeoff speed. Knowing these equations tells you how distance, speed, and time fit together whenever something speeds up or slows down at a steady rate.



Rule

Constant-acceleration equations: $v = u + a \times t$, $s = u \times t + \frac{1}{2} \times a \times t^2$, and $v^2 = u^2 + 2 \times a \times s$. Here u is the initial velocity, v is the final velocity, a is the acceleration, and s is the displacement.

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Worked examples

EXAMPLE 1

Q A car accelerates from rest at 2 $\frac{m}{s^2}$ for 5 s. Final velocity?

SOLUTION

List knowns: u is 0, a is 2, t is 5.

Pick the equation without s:

$v = u + a \times t$

Substitute:

$v = 0 + 2 \times 5 = 10$ m/s

The result is v = 10 m/s.

EXAMPLE 2

Q A car starts at 10 m/s and accelerates at 2 $\frac{m}{s^2}$ for 3 s. Displacement?

SOLUTION

List knowns: u is 10, a is 2, t is 3.

Pick the equation for s:

$s = u \times t + \frac{1}{2} \times a \times t^2$

Substitute:

$s = 10 \times 3 + \frac{1}{2} \times 2 \times 9$

$= 30 + 9 = 39$ m

The result is s = 39 m.

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Practice questions

1 $v = u + a \times t$: what is u?

- **A** Initial velocity
- **B** Final velocity
- **C** Average velocity
- **D** Change in velocity

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2 Car from rest, a 3, t 5: final velocity?

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3 Car u 5, a 3, t 4: displacement?

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4 Equation for displacement with u, a, t?

A $s = u \times t + \frac{1}{2} \times a \times t^2$

B $s = u \times t + a \times t^2$

C $v = u + a \times t$

D $s = u \times t^2 + \frac{1}{2} \times a \times t$

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5 Equation linking v, u, a, s?

A $v^2 = u^2 + 2 \times a \times s$

B $v = u + a \times t$

C $s = u \times t + \frac{1}{2} \times a \times t^2$

D $v^2 = u^2 + a \times s$

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6 Car u 0, a 4, t 3: displacement?

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7 Car u 5, a 0, t 10: displacement?

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What does s stand for?

A Displacement

B Speed

C Time

D Acceleration

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What does a stand for?

A Acceleration

B Area

C Average speed

D Angle

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Car v 20, u 0, a 5: time?

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ANSWER KEY

1. Initial velocity

2. 15 m/s

3. 44 m

4. $s = u \times t + \frac{1}{2} \times a \times t^2$

5. $v^2 = u^2 + 2 \times a \times s$

6. 18 m

7. 50 m

8. Displacement

9. Acceleration

10. 4 s

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