Kinematics & Motion Graphs

Kinematics · 8 questions · step-by-step answers at the end

Name: Date: Score: / 8

USEFUL EQUATIONS

$v = v_0 + at$ $x = x_0 + v_0t + \frac{1}{2}at^2$ $v^2 = v_0^2 + 2a\Delta x$ $v = dx/dt,\ a = dv/dt$ $\Delta x = \int v\,dt$

Questions

Show your working in the space under each question.

1. A ball is thrown straight up at 15 m/s. How long does it take to reach the top, and how high does it go?

2. A car starts from rest and accelerates at 3.0 m/s² for 4.0 s, then drives at constant velocity for another 2.0 s. Find (a) its speed after 4.0 s and (b) the total distance travelled.

3. An object starts from rest with constant acceleration and travels distance d in the first second. How far does it travel in the first 3 s? In the 3rd second alone?

4. If x(t) = 5 sin(2t), what is the maximum speed?

5. A ball is dropped from height h and hits the ground at speed v. From what height must it be dropped to land at 2v?

6. A car's v–t graph is a straight line from 0 to 12 m/s over 4 s, then constant for 6 s. What is its average velocity over the 10 s?

7. On a v–t graph the line is below the axis but sloping upward. Is the object speeding up or slowing down?

8. $v(t) = 4 - t^2$ m/s. Find the displacement and the distance travelled from t = 0 to 3 s.

Step-by-step answers

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1. $t = v_0/g = 15/9.8 \approx$ **1.5 s**; $h = v_0^2/(2g) = 225/19.6 \approx$ **11.5 m**.

2. 1. (a) Constant acceleration from rest: $v = v_0 + at = 0 + (3.0)(4.0) =$ **12 m/s**.
2. (b) Phase 1: $\Delta x_1 = \frac{1}{2}at^2 = \frac{1}{2}(3.0)(4.0)^2 = 24$ m.
3. Phase 2 (constant v): $\Delta x_2 = vt = (12)(2.0) = 24$ m.
4. Check with the v–t graph: a triangle ($\frac{1}{2}\cdot 4\cdot 12 = 24$) plus a rectangle ($2\cdot 12 = 24$) gives a total area of 48 m.

Answer: (a) 12 m/s (b) 48 m

3. $d \propto t^2$, so **9d** in 3 s. The 3rd second alone covers $9d - 4d =$ **5d**.

4. $v = 10\cos(2t)$, so $v_{max} =$ **10 m/s**.

5. $v \propto \sqrt{h}$, so the height must be **4h**.

6. Area = 24 + 72 = 96 m, so $v_{avg} = 96/10 =$ **9.6 m/s**.

7. v is negative and a is positive (opposite signs), so it is **slowing down**.

8. Displacement $= \int_0^3 (4 - t^2)dt = 12 - 9 =$ **3 m**. It turns around at t = 2 s: the first leg is 16/3 m and the second is $|3 - 16/3| = 7/3$ m, so distance = **23/3 ≈ 7.7 m**.