Answer Key

Kinematics: Constant Acceleration

Practice Questions

1. Given: \( v_i = 0 \), \( d = 1.53 \text{ (km)} = 1530 \text{ (m)} \), \( t = 40 \text{ (s)} \)
Find: \( a = ? \), \( v_f = ? \)

Solution: From \( d = v_i \cdot t + \frac{1}{2} a t^2 \)

\( v_i = 0 \), \( \therefore d = \frac{1}{2} a t^2 \Rightarrow a = \frac{2d}{t^2} \)

\( a = \frac{(2)(1530 \text{ m})}{(40 \text{ s})^2} = \frac{3060 \text{ m}}{1600 \text{ s}^2} = 1.91 \text{ m/s}^2 \)

From \( v_f = v_i + a t \), \( v_f = 0 + (1.91 \text{ m/s}^2)(40 \text{ s}) = 76.4 \text{ m/s} \)

2. Given: \( v_i = 11.0 \text{ m/s} \), \( v_f = 19.4 \text{ m/s} \), \( t = 3.20 \text{ (s)} \)
Find: \( a = ? \), \( d = ? \)

Solution: From \( a = \frac{v_f - v_i}{t} = \frac{(19.4 - 11.0) \text{ m/s}}{3.20 \text{ (s)}} = 2.63 \text{ m/s}^2 \)

From \( d = \left(\frac{v_i + v_f}{2}\right) t = \left(\frac{11.0 + 19.4}{2}\right) (3.20 \text{ s}) = 48.6 \text{ (m)} \)
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3. Given: \( v_i = 17.5 \, \text{m/s} \), \( v_f = 0 \), \( d = 80.0 \, \text{m} \)
   
   Find: \( t = ? \)

   Solution: \( d = \frac{(v_i + v_f) t}{2} \), \( t = \frac{2d}{v_i + v_f} \)

   \( t = \frac{2(80.0 \, \text{m})}{(17.5 + 0)} = 9.14 \, \text{s} \)

4. Given: \( v_i = 100 \, \text{km/hr} = \frac{100 \, \text{km}}{1 \, \text{hr}} \times \frac{1000 \, \text{m}}{1 \, \text{km}} \times \frac{1 \, \text{hr}}{3600 \, \text{s}} \)

   \( v_i = 27.8 \, \text{m/s} \), \( v_f = 0 \), \( a = -7.5 \, \text{m/s}^2 \)

   \( t_i = 0.2 \, \text{s} \), (reaction time)

   Find: \( d_x = ? \)  will the car stop before hitting the deer?

   Solution: \( v_f^2 = v_i^2 + 2a \cdot d_x \), \( d_x = \frac{v_f^2 - v_i^2}{2a} \)

   \( d_x = \frac{0^2 - (27.8 \, \text{m/s})^2}{2(-7.5 \, \text{m/s}^2)} = 5.152 \, \text{m} \)

   During the reaction time (\( t_i = 0.2 \, \text{s} \)), the car's speed: 27.8 m/s

   \( d_i = v_i \cdot t_i = (27.8 \, \text{m/s})(0.2 \, \text{s}) = 5.56 \, \text{m} \)

   The total distance before the car stops: \( d_i + d_x = 5.71 \, \text{m} \)

   5.71 (m) < 60 (m) \[ \text{Yes, the car stops before hitting the deer.} \]
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5. Given: The $1^{st}$ car: $v_i=0$, $a=5.0 \, m/s^2$, $t_i=3.0 \, s$,
   The $2^{nd}$ car, $v=75.0 \, m/s$ (moving constantly)

Find: $t = ?$ for the $1^{st}$ car to catch up to the $2^{nd}$ car.

Solution:

$1^{st}$ car:

$v_f = v_i + at$ 
$v_f = 0 + (5.0 \, m/s^2)(3.0 \, s) = 15.0 \, m/s$

$d = v_f \cdot t + \frac{1}{2}at^2$
$d = (15.0 \, m/s) \cdot t + \frac{1}{2}(5.0 \, m/s^2)t^2$

$\therefore d = 15t + 2.5t^2$

$2^{nd}$ car:

$d = v \cdot t = 75.0 \, t$

Solve this equation: $15t + 2.5t^2 = 75.0 \, t$

$2.5t^2 + 15t - 75.0 \, t = 0$

$2.5t^2 - 60.0 \, t = 0$

$t(2.5t - 60.0) = 0$

$\therefore t = 0 \, (t \neq 0, \text{ ignore it})$, $2.5t - 60.0 = 0 \Rightarrow t = 24 \, s$, to catch up to the $2^{nd}$ car.