

# Physics

## Unit 1: Introduction and Kinematics Review

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1. Know about scientific method, units, fundamental units, unit prefixes, precision, accuracy, significant figures, vectors, scalars
2. Convert 120 Tm to m
3. In the process of delivering milk, a milkman, walks 100 m due east from his truck. He then turns around and walks 20 m due west. What is the milkman's displacement relative to his truck (magnitude and direction)? What distance did he travel?
4. A pigeon flew 10 km across town with an average speed of 5 m/s. How long, in hours, did it take the pigeon to make this journey?
5. A car, starting from rest, accelerates in a straight-line path at a constant rate of  $2 \text{ m/s}^2$ . How far will the car travel in 10 seconds?
6. The minimum takeoff speed for a certain airplane is 50 m/s. What minimum acceleration is required if the plane must leave a runway of length 2000 m? Assume the plane starts from rest at one end of the runway.
7. Water drips from rest from a leaf that is 2 m above the ground. Neglecting air resistance, what is the speed of each water drop when it hits the ground?
8. What maximum height will be reached by a stone thrown straight up with an initial speed of 5 m/s?
9. A cheetah is walking at a speed of 0.5 m/s when it observes a gazelle 15 m directly ahead. If the cheetah accelerates at  $3 \text{ m/s}^2$ , how long does it take the cheetah to reach the gazelle if the gazelle doesn't move?
10. Be able to read graphs and calculate speed, velocity, and acceleration from them.
11. A jumper in the long-jump goes into the jump with a speed of 5 m/s at an angle of  $20^\circ$  above the horizontal. What is the jumper's horizontal speed as they jump? What is their vertical speed?
12. A sailboat leaves a harbor and sails 21 km in the direction  $15^\circ$  north of east, where the captain stops for lunch. A short time later, the boat sails 2 km in the direction  $75^\circ$  south of east. What is the magnitude of the resultant displacement?
13. An eagle is flying due east at 5 m/s carrying a gopher in its talons. The gopher manages to break free at a height of 50 m. What is the magnitude of the gopher's velocity as it reaches the ground?
14. A ball is thrown horizontally from the top of a 100 m tall building with an initial speed of 5 m/s. How far from the base of the building did the ball land?
15. A swimmer swims with a velocity of 15 m/s south relative to the water. The current of the water is 2 m/s relative to the shore. If the current is moving west, what is the velocity of the swimmer relative to the shore?

3. Displacement:  $100\text{ m} - 20\text{ m} = \mathbf{80\text{ m}}$ ;

Distance:  $100\text{ m} + 20\text{ m} = \mathbf{120\text{ m}}$

4.  $\bar{v} = 5 \frac{\text{m}}{\text{s}}, \Delta x = 10\text{ km}$

Convert:  $\frac{10\text{ km}}{1\text{ km}} \left( \frac{10^3\text{ m}}{1\text{ km}} \right) = 10000\text{ m}$

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

$$5 \frac{\text{m}}{\text{s}} = \frac{10000\text{ m}}{t}$$

$$t = \frac{10000\text{ m}}{5 \frac{\text{m}}{\text{s}}} = \mathbf{2000\text{ s}}$$

Convert:  $\frac{2000\text{ s}}{3600\text{ s}} \left( \frac{1\text{ h}}{3600\text{ s}} \right) = 0.56\text{ h}$

5.  $a = 2 \frac{\text{m}}{\text{s}^2}, t = 10\text{ s}, v_0 = 0 \frac{\text{m}}{\text{s}}, x = ?$

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$x = 0\text{ m} + \left( 0 \frac{\text{m}}{\text{s}} \right) (10\text{ s}) + \frac{1}{2} \left( 2 \frac{\text{m}}{\text{s}^2} \right) (10\text{ s})^2$$

$$x = \mathbf{100\text{ m}}$$

6.  $v = 50 \frac{\text{m}}{\text{s}}, x = 2000\text{ m}, v_0 = 0 \frac{\text{m}}{\text{s}}, a = ?$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$\left( 50 \frac{\text{m}}{\text{s}} \right)^2 = \left( 0 \frac{\text{m}}{\text{s}} \right)^2 + 2a(2000\text{ m} - 0\text{ m})$$

$$2500 \frac{\text{m}^2}{\text{s}^2} = (4000\text{ m})a$$

$$a = \mathbf{0.625\text{ m/s}^2}$$

7.  $y_0 = 2\text{ m}, v_0 = 0 \frac{\text{m}}{\text{s}}, a = -9.8 \frac{\text{m}}{\text{s}^2}, v = ?$

$$v^2 = v_0^2 + 2a(y - y_0)$$

$$v^2 = \left( 0 \frac{\text{m}}{\text{s}} \right)^2 + 2 \left( -9.8 \frac{\text{m}}{\text{s}^2} \right) (0\text{ m} - 2\text{ m})$$

$$v^2 = 39.2 \frac{\text{m}^2}{\text{s}^2}$$

$$v = \mathbf{6.26 \frac{\text{m}}{\text{s}}}$$

8.  $v_0 = 5 \frac{\text{m}}{\text{s}}, v = 0 \frac{\text{m}}{\text{s}}, a = -9.8 \frac{\text{m}}{\text{s}^2}, y = ?$

$$v^2 = v_0^2 + 2a(y - y_0)$$

$$\left( 0 \frac{\text{m}}{\text{s}} \right)^2 = \left( 5 \frac{\text{m}}{\text{s}} \right)^2 + 2 \left( -9.8 \frac{\text{m}}{\text{s}^2} \right) (y - 0\text{ m})$$

$$-25 \frac{\text{m}^2}{\text{s}^2} = \left( -19.6 \frac{\text{m}}{\text{s}^2} \right) y$$

$$y = \mathbf{1.28\text{ m}}$$

9.  $v_0 = 0.5 \frac{\text{m}}{\text{s}}, x = 15\text{ m}, a = 3 \frac{\text{m}}{\text{s}^2}, t = ?$

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$15\text{ m} = 0\text{ m} + \left( 0.5 \frac{\text{m}}{\text{s}} \right) t + \frac{1}{2} \left( 3 \frac{\text{m}}{\text{s}^2} \right) t^2$$

$$0 = \left( \frac{3}{2} \frac{\text{m}}{\text{s}^2} \right) t^2 + \left( 0.5 \frac{\text{m}}{\text{s}} \right) t - 15\text{ m}$$

$$t = \frac{-0.5 \pm \sqrt{(0.5)^2 - 4 \left( \frac{3}{2} \right) (-15)}}{2 \left( \frac{3}{2} \right)} = \mathbf{3\text{ s}, -3.33\text{ s}}$$

11. Horizontal:  $v_{0x} = 5 \frac{\text{m}}{\text{s}} \cos 20^\circ = \mathbf{4.70 \frac{\text{m}}{\text{s}}}$

Vertical:  $v_{0y} = 5 \frac{\text{m}}{\text{s}} \sin 20^\circ = \mathbf{1.71 \frac{\text{m}}{\text{s}}}$

12.

	x	y
21 km @ 15° N of E	20.28	5.44
2 km @ 75° S of E	0.52	-1.93
	20.80	3.51

$$r = \sqrt{20.80^2 + 3.51^2} = 21.1\text{ km}$$

$$\theta = \tan^{-1} \frac{3.51}{20.80} = 9.67^\circ \text{ N of E}$$

13.  $x: v_{0x} = 5 \frac{\text{m}}{\text{s}}, y: v_{0y} = 0 \frac{\text{m}}{\text{s}}, y_0 = 50\text{ m}, a_y =$

$$-9.8 \frac{\text{m}}{\text{s}^2}, y = 0\text{ m}, v_y = ?$$

$$v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$$

$$v_y^2 = \left( 0 \frac{\text{m}}{\text{s}} \right)^2 + 2 \left( -9.8 \frac{\text{m}}{\text{s}^2} \right) (0\text{ m} - 50\text{ m})$$

$$v_y^2 = 980 \frac{\text{m}^2}{\text{s}^2}$$

$$v_y = 31.30 \frac{\text{m}}{\text{s}}$$

combine:  $v = \sqrt{v_x^2 + v_y^2}$

$$v = \sqrt{\left( 5 \frac{\text{m}}{\text{s}} \right)^2 + \left( 31.30 \frac{\text{m}}{\text{s}} \right)^2} = \mathbf{31.7\text{ m/s}}$$

14.  $x: v_{0x} = 5 \frac{\text{m}}{\text{s}}, x = ?; y: y_0 = 100\text{ m}, y = 0\text{ m}, a =$

$$-9.8 \frac{\text{m}}{\text{s}^2}, v_{0y} = 0 \frac{\text{m}}{\text{s}}$$

find t:  $y = y_0 + v_{0y} t + \frac{1}{2} a t^2$

$$0\text{ m} = 100\text{ m} + \left( 0 \frac{\text{m}}{\text{s}} \right) t + \frac{1}{2} \left( -9.8 \frac{\text{m}}{\text{s}^2} \right) t^2$$

$$-100\text{ m} = \left( -4.9 \frac{\text{m}}{\text{s}^2} \right) t^2$$

$$20.41 \frac{\text{m}^2}{\text{s}^2} = t^2$$

$$t = \mathbf{4.52\text{ s}}$$

find x:  $x = x_0 + v_{0x} t$

$$x = 0 + \left( 5 \frac{\text{m}}{\text{s}} \right) (4.52\text{ s}) = \mathbf{22.6\text{ m}}$$

15.  $v_{SW} = 15 \frac{\text{m}}{\text{s}} \text{ South}, v_{WG} = 2 \frac{\text{m}}{\text{s}} \text{ West}$

$$v_{SG} = v_{SW} + v_{WG}$$

	x	y
15 m/s S	0	-15
2 m/s W	-2	0
	-2	-15

$$v_{SG} = \sqrt{(-2)^2 + (-15)^2} = 15.1\text{ m/s}$$

$$\theta = \tan^{-1} \frac{-15}{-2} = 82.4^\circ$$

$$v_{SG} = \mathbf{15.1 \frac{\text{m}}{\text{s}} \text{ at } 82.4^\circ \text{ S of W}}$$