PHYSICS 534

ANSWERS

EXER -24 Kinematics Part-1/ 4

Charles Guillaume was awarded the Nobel prize for physics in 1920 for his work on nickel steel alloys.

GUILLAUME

Kinematics

Kinematics is the study of the motion of objects without regard to the forces that produce the motion. There are six important formulas used in kinematics, four are defined and two are derived (from the defined ones).

Using the following six formulas, all the problems in kinematics can be solved:

Defined formulas	Derived formulas
1) $s = v_a t$	5) $2as = v_f^2 - v_i^2$
2) $v_a = \frac{v_f + v_i}{2}$	6) $s = v_i t + \frac{1}{2} a t^2$
3) $\Delta v = v_f - v_i$	
4) $a = \frac{\Delta v}{t}$	

Where: s = distance
v = velocity
v_i = initial velocity
v_f = final velocity
v_a = average velocity
t = time
a = acceleration

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1. An athlete runs 100 m in 10 seconds. What is his average velocity? [10 m/s]

$$v_a = \frac{s}{t} = \frac{100\ m}{10\ s} = 10\ m/s$$

2. A westbound bus travels a distance of 60 m in 8 s. Determine the speed of the bus. [7.5 m/s]

$$v_a = \frac{s}{t} = \frac{60\ m}{8\ s} = 7.5\ m/s$$

3. A tennis ball leaves a racket with an average velocity of 40 m/s. How long will it take to travel 10 metres? [0.25 s]

$$t = \frac{s}{v_a} = \frac{10\ m}{40\ m/s} = 0.25\ s$$

4. A limousine with an initial velocity of 8 m/s accelerates at 4 m/s^2. How long will it take to reach a speed of 100 m/s? [23 s]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{100\ m/s - 8\ m/s}{4\ s} = 23\ s$$

5. A golf ball rolling up a hill at 20 m/s decelerates (slows down) at a rate of 5 m/s^2. What distance does it travel before coming to a stop? [40 m]

$$a = \frac{\Delta v}{t} \quad \text{or} \quad t = \frac{v_f - v_i}{a} = \frac{0 - 20\ m/s}{-5\ m/s^2} = 4\ s$$

$$s = v_a t = (\frac{v_f - v_i}{2})t = (\frac{0 + 20\ m/s}{2})(4\ s) = 40\ m$$

6. A truck is traveling at a constant speed of 72 km/h. How many metres does it travel in 20 seconds? [400 m]

Convert the $72\,\text{km/h}$ to m/s.

$$\frac{72\,\text{km}}{\text{h}} = \frac{72\times 1000\,\text{m}}{3600\,\text{s}} = 20\,\text{m/s}$$

$$s = v_a t = (20\,\text{m/s})(20\,\text{s}) = 400\,\text{m}$$

7. A car accelerates from 0 to 30 m/s in 15 seconds.

a) What was the acceleration? [2 m/s^2]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{30\,\text{m/s} - 0}{15\,\text{s}} = 2\,\text{m/s}^2$$

b) How far did the car travel? [225 m]

$$s = v_a t = \left(\frac{v_f - v_i}{2}\right)t = \left(\frac{30\,\text{m/s} + 0}{2}\right)(15\,\text{s}) = 225\,\text{m}$$

8. A rocket is launched from a space-pad with an acceleration of 100 m/ s^2.

a) What is its velocity after 6 seconds? [600 m/s]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t}$$

or

$$v_f = v_i + at = 0 + (100\,\text{m/s}^2)(6\,\text{s}) = 600\,\text{m/s}$$

b) How high does it rise after 10 s? [5 000 m]

$$s = v_a t = (\frac{v_f - v_i}{2})t = (\frac{600\,m/s + 0}{2})(10\,s) = 3000\,m$$

9. Elizabeth slams on the brakes and skids to a stop from 30 km/h in two seconds.

a) What was the deceleration (in km/h/s)? [15 km/h/s]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{0 - 30\,km/h}{2\,s} = -15\,km/h/s$$

b) What distance did the car skid? [8.3 m]

Convert the $30\ km/h$ to m/s

$$\frac{30\ km}{h} = \frac{30 \times 1000\ m}{3600\ s} = 8.3\ m/s$$

$$s = v_a t = (\frac{v_f - v_i}{2})t = (\frac{8.3\,m/s + 0}{2})(2\,s) = 8.3\,m$$

10. A proton enters an electrical field with a velocity of 2 x 10^3 m/s, travels one metre, then emerges with a velocity of 8 x 10^3 m/s. Find:

a) The average velocity. [5 x 10^3 m/s]

$$v_a = \frac{v_f + v_i}{2} = \frac{(8 \times 10^3\,m/s + 2 \times 10^3\,m/s}{2} = 5000\,m/s$$

b) The accelerating time. [2 x 10^{-4} s]

$$s = v_a t \quad \text{or} \quad t = \frac{s}{v_a} = \frac{1\,\text{m}}{5000\,\text{m/s}} = 0.002\,\text{s}$$

c) The acceleration. [3 x 10^7 m/s^2]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{8\times10^3\ \text{m/s} - 2\times10^3\ \text{m/s}}{0.0002\,\text{s}} = 3\times10^7\ \text{m/s}^2$$

11. A car travels at an average speed of 60 km/h between two points A and B which are 120 km apart. The car makes the return trip (from point B to point A) at 40 km/h, What is the average speed for the round trip?

Note: Total distance (s_T) = Total average velocity (v_a) × Total time (t_T)

or $v_a = \dfrac{s_T}{t_T}$

t_T = Time to go from A to B + Time to return from B to A

$$= \frac{s_{AB}}{v_{AB}} + \frac{s_{BA}}{v_{BA}} = \frac{120\,\text{km}}{60\,\text{km/h}} + \frac{120\,\text{km}}{40\,\text{km/h}} = 2\,\text{h} + 3\,\text{h} = 5\,\text{h}$$

$$\therefore\ v_a = \frac{s_T}{t_T} = \frac{240\,\text{km}}{5\,\text{h}} = 48\,\text{km/h}$$

12. During a period of 5.8 x 10^{-7} s, an electron is accelerated from rest to a velocity of 3.6 x 10^5 m/s. What is its acceleration? [6.2 x 10^{11} m/s^2]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{3.6\times10^5\ \text{m/s} - 0}{5.8\times10^{-7}\ \text{s}} = 6.2\times10^{11}\ \text{m/s}^2$$

13. An airplane must achieve a velocity of 80 m/s for takeoff. If the runway is 1200 m long, what must be the plane's acceleration? [2.7 m/s^2]

$$2as = v_f^2 - v_i^2$$

$$\therefore \quad a = \frac{v_f^2 - v_i^2}{2s} = \frac{(80\,\text{m/s})^2 - 0}{2(1200\,\text{m})} = 2.66\,\text{m/s}^2 = 2.7\,\text{m/s}^2$$

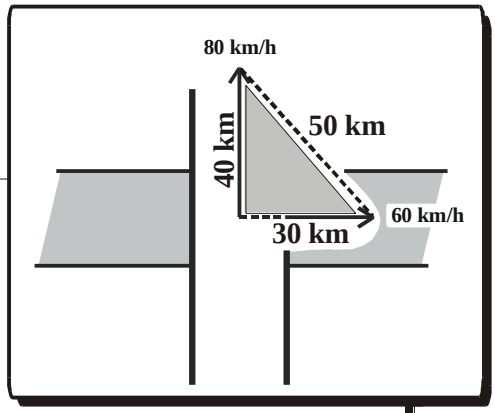
14. A parcel falls off a truck and slides on the road a distance of 90 m before coming to a stop. Due to friction, the parcel decelerates at 5 m/s^2. What was the speed of the truck when the parcel fell? [30 m/s]

$$2as = v_f^2 - v_i^2$$

$$\text{or} \quad v_i^2 = v_f^2 - 2as = 0 - 2(-5\,\text{m/s}^2)(90\,\text{m}) = 900\,\text{m}^2/\text{s}^2$$

$$\therefore \quad v_i = 30\,\text{m/s}$$

15. As indicated in the diagram, two roads intersect at 90^o at overpass. Two automobiles pass the intersection at speeds of 60 km/h and 80 km/h respectively. How far apart will the two cars be in half an hour? [50 km]



Distance of 80 km/h car :

$$s = v_a t = (80\,\text{km/h})(0.5\,\text{h}) = 40\,\text{km}$$

Distance of 60 km/h car :

$$s = v_a t = (60\,\text{km/h})(0.5\,\text{h}) = 30\,\text{km}$$

With reference to the shaded right triangle :

$$s^2 = (40\,\text{km})^2 + (30\,\text{km})^2 = 2500\,\text{km}^2$$

$$\therefore \quad s = 50\,\text{km}$$