PHYSICS 534

ANSWERS

EXERCISE-26 **Kinematics Part-3/ 4**

BOHR

Niels Bohr was awarded the Nobel prize for physics in 1922 for his investigations into the structure of the atom.

1. A car is driven one kilometer in 8.2 s. Determine the average speed both in kilometers per hour and in meters per second. [439 km/h] [122 m/s]

Convert 8.2 s into hours

$$8.2\ \text{s} \times \frac{1\ \text{h}}{3600\ \text{s}} = 0.0022\ \text{h}$$

$$v_a = \frac{s}{t} = \frac{1\ \text{km}}{0.0022\ \text{h}} = 439\ \text{km/h}$$

Convert 1 km into meters

$$1\ \text{km} \times \frac{1000\ \text{m}}{1\ \text{km}} = 1000\ \text{m}$$

$$v_a = \frac{s}{t} = \frac{1000\ \text{m}}{8.2\ \text{s}} = 122\ \text{m/s}$$

2. A jet travels with a constant speed of 500 km/h. Determine the distance (in km)it travels in half a minute. [4.15 km]

Convert 0.5 min into hours

$$0.5\ \text{min} \times \frac{1\ \text{h}}{60\ \text{min}} = 0.0083\ \text{h}$$

$$s = v_a t = (500\ \text{km/h})(0.0083\ \text{h}) = 4.15\ \text{km}$$

3. A boat travels at 22 km/h in a river whose water current is traveling at 3 km/h. How long will it take the boat to go 50 km upstream and back downstream? [4.6 h]

Upstream:

$$\because s = v_a t \quad \therefore t = \frac{s}{v_a} = \frac{s}{v_{Boat} - v_{Water}} = \frac{50\ \text{km}}{22\ \text{km/h} - 3\ \text{km/h}} = \frac{50\ \text{km}}{19\ \text{km/h}} = 2.6\ \text{h}$$

Downstream:

$$\because s = v_a t \quad \therefore t = \frac{s}{v_a} = \frac{s}{v_{Boat} - v_{Water}} = \frac{50\ \text{km}}{22\ \text{km/h} + 3\ \text{km/h}} = \frac{50\ \text{km}}{25\ \text{km/h}} = 2\ \text{h}$$

Answer: $2.6 + 2 = 4.6\ \text{h}$

4. An airplane has a normal speed of 400 km/h in still air. Assuming a wind velocity of 50 km/h, how long would it take the plane to make an 800 km trip?

a) With no wind [2 h]

$$t = \frac{s}{v_a} = \frac{800\ \text{km}}{400\ \text{km/h}} = 2\ \text{h}$$

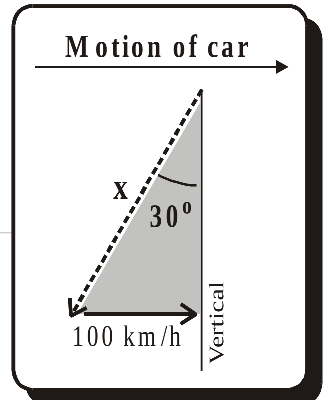
b) With a tail wind [1.78 h]

$$t = \frac{s}{v_a} = \frac{800\ \text{km}}{400\ \text{km/h} + 50\ \text{km/h}} = 1.78\ \text{h}$$

c) With a head wind [2.29 h]

$$t = \frac{s}{v_a} = \frac{800\ \text{km}}{400\ \text{km/h} - 50\ \text{km/h}} = 2.29\ \text{h}$$

5. A car is traveling at a constant velocity of 100 km/h on a rainy day. As shown in the diagram, the tracks of the rain drops on the side window make an angle of 30° with the vertical. Determine the velocity of the rain drops (disregard air resistance). [200 km/h]



With reference to the shaded triangle

$$\because\ \sin 30^\circ = \frac{100\ \text{km/h}}{x}$$

$$\therefore\ x = \frac{100\ \text{km/h}}{\sin 30^\circ} = \frac{100\ \text{km/h}}{0.5} = 200\ \text{km/h}$$

6. If the brakes of an automobile can decelerate it at 7 m/s², what time is required to reduce the velocity of the automobile from 157 km/h to 75 km/h? [3.3 s]

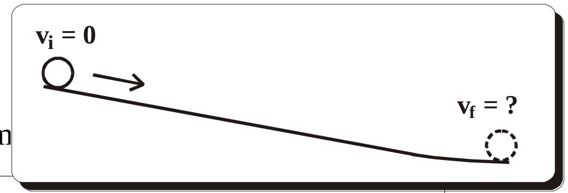
Convert the velocities from km/h to m/s:

$$\frac{157\ \text{km}}{\text{h}} = \frac{157 \times 1000\ \text{m}}{3600\ \text{s}} = 43.6\ \text{m/s} \qquad \frac{75\ \text{km}}{\text{h}} = \frac{75 \times 1000\ \text{m}}{3600\ \text{s}} = 20.8\ \text{m/s}$$

$$\because\ a = \frac{\Delta v}{t}$$

$$\therefore\ t = \frac{\Delta v}{a} = \frac{v_f - v_i}{a} = \frac{20.8\ \text{m/s} - 43.6\ \text{m/s}}{-7\ \text{m/s}^2} = 3.26\ \text{s} = 3.3\ \text{s}$$

7. Starting from rest, a ball takes 5 s to slide down an inclined plane 150 cm long. Determine:



a) The speed at the bottom of the incline [0.6 m

$$v_a = \frac{s}{t} = \frac{1.5\ \text{m}}{5\ \text{s}} = 0.3\ \text{m/s}$$

$$\text{But}\ \ v_a = \frac{v_f + v_i}{2} \quad \therefore\ v_i = 2v_a + v_f = 2(0.3\ \text{m/s}) + 0 = 0.6\ \text{m/s}$$

b) The acceleration [0.12 m/s^2]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{0 - 0.6\ \text{m/s}}{5\ \text{s}} = -0.12\ \text{m/s}^2$$

8. A runner runs a distance of 0.2 km in an amazing time of 21.71 s. Calculate his average speed. [9.2 m/s]

$$\because\ s = v_a t \quad \therefore\ v_a = \frac{s}{t} = \frac{200\ \text{m}}{21.71\ \text{s}} = 9.2\ \text{s}$$

9. A wheel whose radius is 75 cm is rotating at 20 RPM (revolutions per minute). What is the velocity in meters per second? [1.6 m/s]

<u>Note</u>: Each revolution of the wheel covers a distance of one circumference ($2\pi r$)

$$\text{Thus,}\quad \frac{20(2\pi r)}{60\ \text{s}} = \frac{20(2)(3.14)(0.75\ \text{m})}{60\ \text{s}} = 1.57\ \text{m/s} = 1.6\ \text{m/s}$$

10. In an acceleration test of a sports car, from rest, the speeds were listed below. For each case, calculate the acceleration:

	TIME (s)	VELOCITY (m/s)	ACCELERATION (m/s^2)
a)	5.0	18	$a = \Delta v / t = v_f - v_i = 18\ m/s / 5\ s = 3.6$
b)	10.0	29	$a = \Delta v / t = v_f - v_i = 29\ m/s / 10\ s = 2.9$
c)	15.0	35	$a = \Delta v / t = v_f - v_i = 35\ m/s / 15\ s = 2.3$

[3.6]
[2.9]
[2.3]

11. In a panic stop, a car's brakes can produce an acceleration of -8.0 m/s^2. If a car is traveling at 35 m/s, what will be its speed after applying the brakes for a time of: [19 m/s] [11 m/s]

a) 2.0 s

$$\because\ a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} \quad \therefore\ v_f = v_i + at = 35\ m/s + (-8\ m/s^2)(2\ s) = 19\ m/s$$

b) 3.0 s

$$\because\ a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} \quad \therefore\ v_f = v_i + at = 35\ m/s + (-8\ m/s^2)(3\ s) = 11\ m/s$$

12. From rest, a truck accelerates at 2.0 m/s^2 to a distance of 400 m. Determine:

a) The distance it travels during the 5th second. [9 m]

$$\text{At } t = 4\ s: \quad s = v_i t + \frac{1}{2}at^2 = 0 + \frac{(2.0\ m/s^2)(4\ s)^2}{2} = 16\ m$$

$$\text{At } t = 5\ s: \quad s = v_i t + \frac{1}{2}at^2 = 0 + \frac{(2.0\ m/s^2)(5\ s)^2}{2} = 25\ m$$

$$\therefore\ \text{Distance} = 25\ m - 16\ m = 9\ m$$

b) The final velocity. [40 m/s]

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

$$v_f^2 = 2as + v_i^2 = 2(2\ m/s^2)(400\ m) + 0 = 1600\ m^2/s^2$$

$$\therefore\ v_f = 40\ m/s$$

13. The speed of light is one of the constants of nature. Its value is 3 x 10^8 m/s. The nearest star to our planet earth is 4.2 light years away. That is, it takes light 4.2 years to reach us from this star. How far away is this star from the earth? [4.0 x 10^{16} m]

<u>Calculate the number of seconds there are in one year</u>

$$t = (365.25\text{ days})(24\text{ h})(60\text{ min})(60\text{ s}) = 3.16\times10^{7}\text{ s}$$
$$s = v_a t = (3\times10^{8}\text{ m/s})(4.2)(3.16\times10^{7}\text{ s}) = 3.98\times10^{16}\text{ m} = 4.0\times10^{16}\text{ m}$$

14. How far will a vehicle travel if it decelerates from 17.0 m/s to 9.0 m/s in 3.0 s? [38.5 m]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{9.0\text{ m/s} - 17.0\text{ m/s}}{3\text{ s}} = \frac{-8\text{ m/s}}{3\text{ s}} = -2.7\text{ m/s}^2$$
$$\because\ 2as = v_f^2 - v_i^2$$
$$\therefore\ s = \frac{v_f^2 - v_i^2}{2a} = \frac{(9\text{ m/s})^2 - (17.0\text{ m/s})^2}{2(-2.7\text{ m/s}^2)} = \frac{-208\text{ m}^2/\text{s}^2}{-5.4\text{ m/s}^2} = 38.5\text{ m}$$

15. A spacecraft approaching the moon at 11.2 km/h slows down to 1.6 km/h in order to achieve lunar orbit. What acceleration, in km/h/s, will perform the operation in 8.0 min? [-0.02 km/h/s]

$$\Delta v = v_f - v_i = 1.6\text{ km/h} - 11.2\text{ km/h} = -9.6\text{ km/h}$$
Convert 8.0 minutes into seconds: $8.0\text{ min}\times\frac{60\text{ s}}{1\text{ min}} = 480\text{ s}$
$$a = \frac{\Delta v}{t} = \frac{-9.6\text{ km/h}}{480\text{ s}} = -0.02\text{ km/h/s}$$

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