PHYSICS 534

ANSWERS

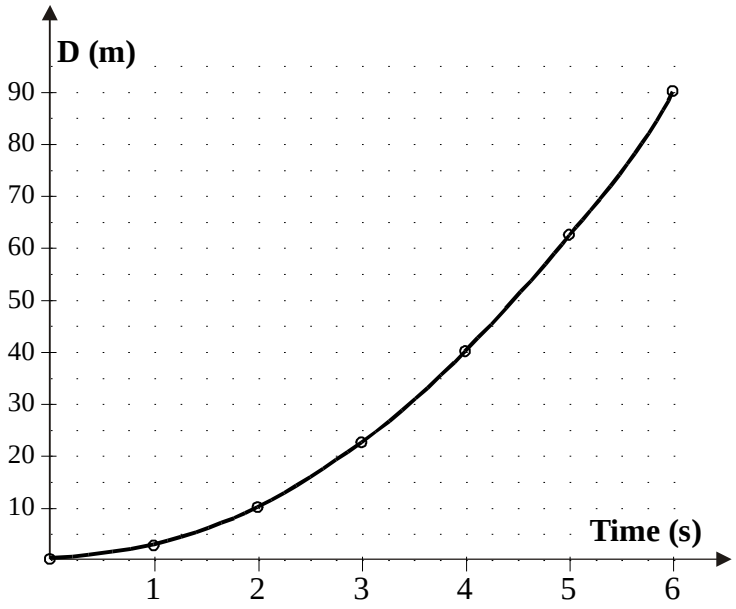
EXER 29 Acceleration Part-2 /2

FRANCK

James Franck was awarded the Nobel prize for physics in 1925 for his work on the impact of electrons on atoms.

1. A cart is placed on an inclined plane and allowed to run down the slope. The following data was recorded. Make a graph plotting the distance (y-axis) versus the time (x-axis).

Time (s)	0	1	2	3	4	5	6
Distance (m)	0	2.5	10	22.5	40	62.5	90



2. Explain the difference between:

a) Distance and displacement

Distance is a scalar (it has no direction).
Displacement is a vector (it has direction).

b) Speed and velocity

Speed is a scalar (it has no direction).
Velocity is a vector (it has direction).

c) Average velocity and instantaneous velocity

Average velocity is a theoretical value having a constant value.
Instantaneous velocity is the velocity at any instant.

- ***Note***: **To keep the math simple, use a value of 10 m/s^2 rather than 9.8 m/s^2 for the acceleration due to gravity.**

3. What is the displacement of a subway train as it is accelerated uniformly from 22 m/s to 44 m/s northbound for 25 seconds. [825 m North]

$$s = v_A t = (\frac{v_f + v_i}{2})t$$
$$= (\frac{44\ m/s + 22\ m/s}{2})(25\ s)$$
$$= (\frac{22\ m/s}{2})(25\ s) = (33\ m/s)(25\ s) = 825\ m\ [North]$$

4. Starting from rest, a racing car is accelerated to a velocity of 41 m/s in a time of 8 seconds. What distance does the car travel? [164 m]

$$\mathbf{s = v_A t = (\frac{v_f + v_i}{2})t}$$
$$\mathbf{= (\frac{41\ m/s + 0}{2})(8\ s)}$$
$$\mathbf{= (20.5\ m/s)(8\ s) = 164\ m}$$

5. At an intersection, as the light turns green, a car is accelerated at 6.1 m/s^2. What distance does the car travel during the first 6 seconds? [109.8 m]

$$\mathbf{s = v_i t + \frac{1}{2}at^2}$$
$$\mathbf{= 0 + \frac{1}{2}(6.1\ m/s^2)(6\ s)^2}$$
$$\mathbf{= (3.05\ m/s^2)(36\ s^2) = 109.8\ m}$$

6. A stone is dropped from a helicopter. The stone takes 10 s to reach the ground. With what velocity does the stone hit the ground? [100 m/s]

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

$$\Delta v = at$$

$$v_f - v_i = at$$

$$\therefore\ v_f = at + v_i = (10\ m/s^2)(10\ s) + 0 = 100\ m/s$$

7. Due to its specific weight, an airplane must reach a velocity of 71 m/s in order for it to takeoff into the air. If the runway is 1000 m long, what must be the acceleration of the plane? [2.5 m/s^2]

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

$$a = \frac{v_f^2 - v_i^2}{2s} = \frac{(71\ m/s)^2 - 0}{2(1000\ m)} = \frac{5041\ m^2/s^2}{2000\ m} = 2.5\ m/s^2$$

8. A plane is accelerated from a speed of 2 m/s at the rate of 3 m/s^2 over a distance of 530 m. What is its speed after traveling this distance? [56 m/s]

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

$$v_f^2 = 2as + v_i^2 = 2(3\ m/s^2)(530\ m) + (2\ m/s)^2$$

$$= 3180\ m^2/s^2 + 4\ m^2/s^2$$

$$= 3184\ m^2/s^2$$

$$\therefore\ v_f = 56.4\ m/s = 56\ m/s$$

9. Decelerating a plane on the ground at a rate of 8 m/s^2, a pilot stops the plane in a distance of 484 m. How fast was the plane going before the braking began? [88 m/s]

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

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

$$= 0 - 2(-8\ m/s^2)(484\ m)$$

$$= 7744\ m^2/s^2$$

$$\therefore\ v_f = 88\ m/s$$

10. A brick falls freely from a high scaffold:

a) What is its velocity after 4 seconds? [40 m/s]

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

$$\text{or}\quad v_f = at + v_i$$

$$= (10\ m/s^2)(4\ s) + 0 = 40\ m/s$$

b) How far does it fall during the 4th second? [35 m]

Note: During the 4th second is from t = 3 s to t = 4 s.

The velocity at t = 3 s is 30 m/s and the velocity at t = 4 s is 40 m/s

Thus, during the 4th second: $v_A = \frac{v_f + v_i}{2} = \frac{40\ m/s + 30\ m/s}{2} = 35\ m/s$

$$\therefore\ s = v_A t = (35\ m/s)(1\ s) = 35\ m$$

11. An elevator starts upwards from rest with an acceleration of 0.5 m/s^2. How high does it rise in 6 seconds? [9 m]

$$s = v_i t + \frac{1}{2}at^2$$
$$= 0 + \frac{1}{2}(0.5\ \text{m/s}^2)(6\ \text{s})^2$$
$$= (0.25\ \text{m/s}^2)(36\ \text{s}^2) = 9\ \text{m}$$

12. A car increases its speed uniformly from 40 km/h to 60 km/h in 8 seconds. Find:

a) The acceleration (in m/s/s) [0.7 m/s^2]

$$\text{Convert the velocities to m/s: } 40\ \text{km/h} \times \frac{1000\ \text{m}}{3600\ \text{s}} = 11.1\ \text{m/s}$$
$$60\ \text{km/h} \times \frac{1000\ \text{m}}{3600\ \text{s}} = 16.7\ \text{m/s}$$
$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{16.7\ \text{m/s} - 11.1\ \text{m/s}}{8\ \text{s}} = 0.7\ \text{m/s}^2$$

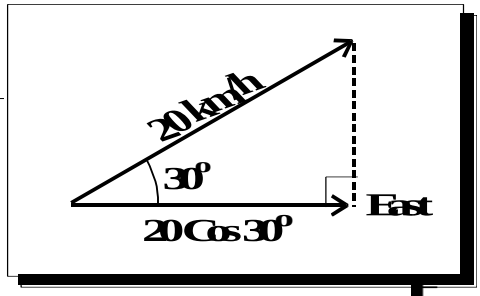
b) The distance traveled (in metres) [111.2 m]

$$s = v_A t$$
$$= \left(\frac{v_f + v_i}{2}\right)t$$
$$= \left(\frac{16.7\ \text{m/s} + 11.1\ \text{m/s}}{2}\right)(8\ \text{s}) = 111.2\ \text{m}$$

13. A hurricane is drifting at a speed of 20 km/h in a direction 30^{o} North of East. How fast is it moving (in km/h)?:

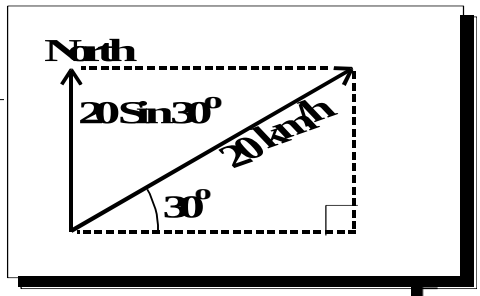
a) Eastward [17.3 km/h]

$$v_{East} = (20\ km/h)(Cos\ 30^{o})$$
$$= 17.3\ km/h\ East$$



b) Northward [10.0 km/h]

$$v_{North} = (20\ km/h)(Sin\ 30^{o})$$
$$= 10.0\ km/h\ North$$



14. An electron is moving through a vacuum tube of a CRT with a speed of 2.4 x 10^{8} m/s. Suddenly, it hits the glass plate and is stopped in a distance of 0.06 mm. Calculate the deceleration. [4.8 x 10^{20} m/s^{2}]

$$s = v_A t \quad \therefore \quad t = \frac{s}{v_A} = \frac{s}{\frac{v_f + v_i}{2}} = \frac{0.06\times10^{-3}\ m}{\frac{0 + 2.4\times10^{8}\ m/s}{2}} = \frac{0.06\times10^{-3}\ m}{1.2\times10^{8}\ m/s} = 5\times10^{-13}\ s$$

$$a = \frac{\Delta v}{t}$$
$$= \frac{v_f - v_i}{t} = \frac{0 - 2.4\times10^{8}\ m/s}{5\times10^{-13}\ s} = -4.8\times10^{20}\ m/s^{2}$$

15. A vehicle starts from rest and accelerates at 1.5 m/s/s. Find:

a) The speed after 4 seconds [6 m/s]

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

$$\therefore\ v_f = at + v_i$$

$$= (1.5\ m/s^2)(4\ s) + 0 = 6\ m/s$$

b) The distance traveled during the 3rd second. [3.8 m]

Note: During the 3rd second is from t = 2 s to t = 3 s.

The velocity at t = 3 s is: $v_f = at + v_i = (1.5\ m/s^2)(3\ s) + 0 = 4.5\ m/s$

The velocity at t = 2 s is: $v_f = at + v_i = (1.5\ m/s^2)(2\ s) + 0 = 3.0\ m/s$

Thus, the average velocity during the 3rd s is: $v_A = \frac{4.5\ m/s + 3.0\ m/s}{2} = 3.75\ m/s$

$\therefore\ s = v_A t = (3.75\ m/s)(1\ s) = 3.75 m/s = 3.8\ m/s$

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