PHYSICS 534

ANSWERS

EXERCISE-25 **Kinematics Part-2/ 4**

Albert Einstein received the Nobel prize for physics in 1921 for his work on the photoelectric effect (today known as the Einstein effect).

EINSTEIN

1. A raceway car travels at 60 km/h for 2 hours from point-A to point-B. On the return trip, from point-B to point-A, the car travels at 40 km/h for 3 hours. Determine the average speed for the round trip. [48 km/h]

From point A to point B: $s = v_a t = (60\ \text{km/h})(2\ \text{h}) = 120\ \text{km}$

From point B to point A: $s = v_a t = (40\ \text{km/h})(3\ \text{h}) = 120\ \text{km}$

For the round trip: $s_T = v_a t_T \quad \therefore\ v_a = \dfrac{s_T}{t_T} = \dfrac{240\ \text{km}}{5\ \text{h}} = 48\ \text{km/h}$

2. Starting at city-A, a bus travels at an average speed of 100 km/h for 2 hours. It stops at a town station for 1 hour, then continues at an average speed of 120 km/h for 2 hours to city-B. Calculate the ***average speed*** for the bus in traveling from city-A to city-B. [88 km/h]

First 2 hours: $s = v_a t = (100\ \text{km/h})(2\ \text{h}) = 200\ \text{km}$

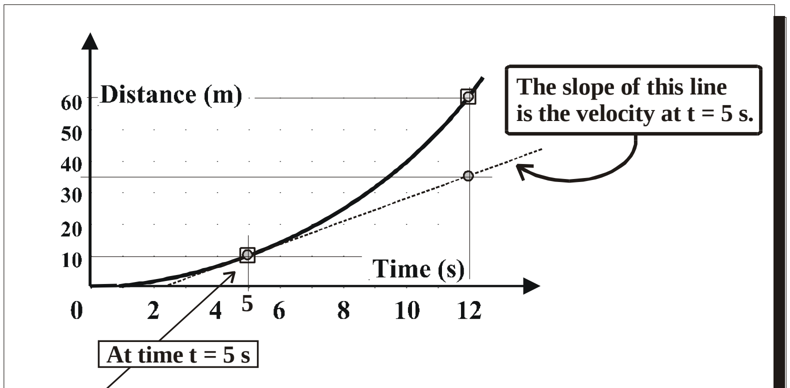
Last 2 hours: $s = v_a t = (120\ \text{km/h})(2\ \text{h}) = 240\ \text{km}$

Entire trip: $s_T = v_a t_T \quad \therefore\ v_a = \dfrac{s_T}{t_T} = \dfrac{200\ \text{km} + 240\ \text{km}}{2\ \text{h} + 1\ \text{h} + 2\ \text{h}} = \dfrac{440\ \text{km}}{5\ \text{h}} = 88\ \text{km/h}$

3. Describe in your own words what is meant by this statement:
A vehicle accelerates uniformly at a rate of 5 m/s^2.

Each second, the velocity increases by 5 m/s.

4. The graph on the right represents the distance versus time graph for a vehicle accelerating uniformly for 12 seconds.



$$\text{Velocity} = \text{Slope} = \frac{\Delta Y}{\Delta X} = \frac{35\ \text{m} - 10\ \text{m}}{12\ \text{s} - 5\ \text{s}} = \frac{25\ \text{m}}{7\ \text{s}} = 3.6\ \text{m/s}$$

a) Is the velocity constant? **No**

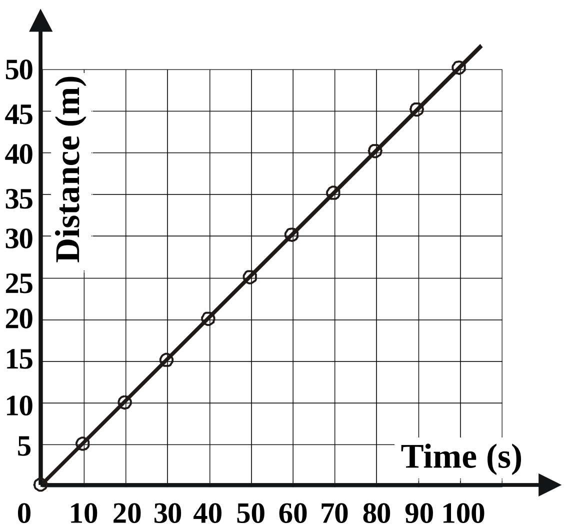
b) What does the slope (tangent) to the curve represent? **Velocity (m/s)**

c) What is the average velocity? **5 m/s** **(60 m/12 s)**

d) What is the ***instantaneous*** velocity at time t = 5 s? **3.6 m/s** **Slope = (35-10) / (12-5)**

5. The table below represents the distance an object moves for a period of 100 s.

Time (s)	Distance (m)
0	0
10	5
20	10
30	15
40	20
50	25
60	30
70	35
80	40
90	45
100	50



a) What does the slope represent? **Velocity**

b) What does the area under the curve represent? **Nothing**

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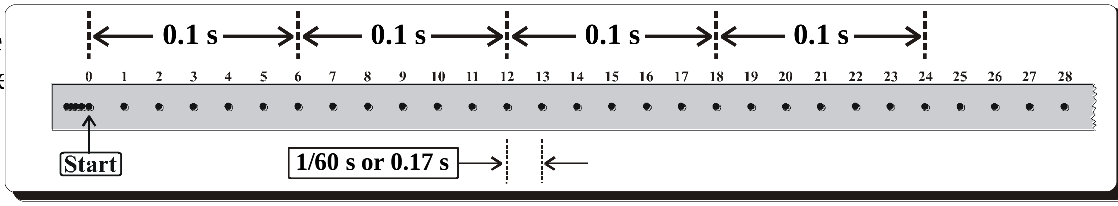


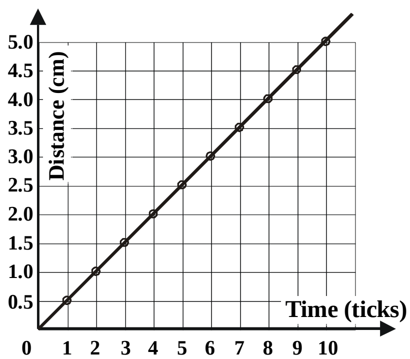
Determine: a) The average velocity for the first 6 “ticks”. $v_a = \frac{s}{t} = \frac{3\text{ cm}}{6\text{ ticks}} = 0.5\text{ cm/tick}$

b) The average velocity for the last 6 “ticks”. $v_a = \frac{s}{t} = \frac{3\text{ cm}}{6\text{ ticks}} = 0.5\text{ cm/tick}$

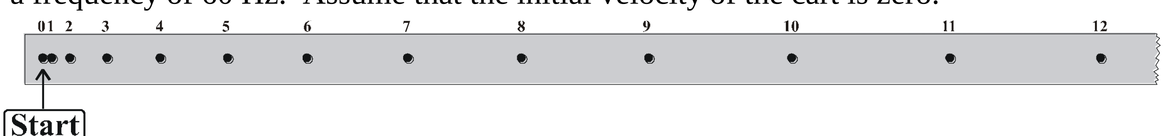
c) The average velocity for the trip. $v_a = \frac{s}{t} = \frac{14\text{ cm}}{28\text{ ticks}} = 0.5\text{ cm / tick}$

d) The average acceleration for the trip. **0**

e) Graph the distance versus time for the first 10 ticks.



7. The following recording was made by a cart rolling down an incline plane using a timer with a frequency of 60 Hz. Assume that the initial velocity of the cart is zero.



Determine: a) The average velocity for the first 6 “ticks” $v_a = \frac{s}{t} = \frac{3.5\text{ cm}}{0.1\text{ s}} = 35\text{ cm/s}$

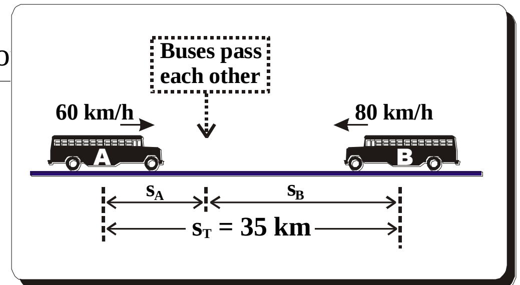
b) The average velocity for the last 6 “ticks”. $v_a = \frac{s}{t} = \frac{10.5\text{ cm}}{0.1\text{ s}} = 105\text{ cm/s}$

c) The average velocity for the trip. $v_a = \frac{s}{t} = \frac{14\text{ cm}}{0.2\text{ s}} = 70\text{ cm / s}$

d) The average acceleration for the trip. $\mathbf{a = \frac{2s}{t^2} = \frac{2(14)\text{ cm}}{(0.2\text{ s})^2} = 700\text{ cm / s}^2}$

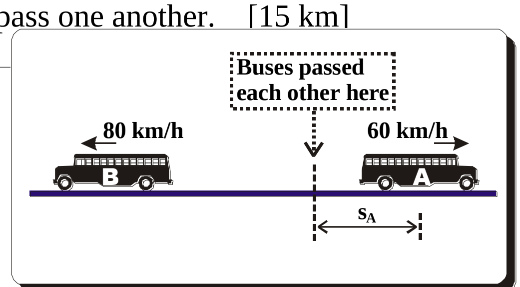
8. Bus-A and bus-B are 35 km apart on a straight road. Both buses leave their departure points simultaneously traveling towards each other. Bus-A travels with an average velocity of 60 km/h while bus-B travels with an average velocity of 80 km/h. Find:

a) In how many ***minutes*** will the buses pass one ano



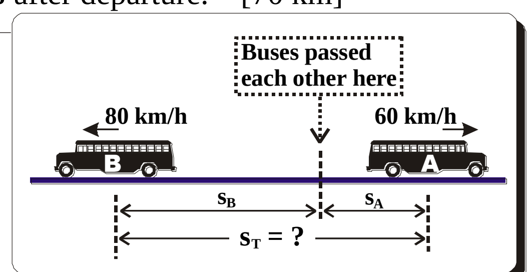
$$s_A + s_B = 35\text{ km}$$
$$\therefore\ v_A t + v_B t = 35\text{ km}$$
$$(60\text{ km/h})t + (80\text{ km/h})t = 35\text{ km}$$
$$\text{or}\quad (140\text{ km/h})t = 35\text{ km}$$
$$t = \frac{35\text{ km}}{140\text{ km/h}} = 0.25\text{ h} = (0.25\text{ h})(\frac{60\text{ min}}{1\text{ h}}) = 15\text{ min}$$

b) The distance bus-A has traveled when the buses pass one another. [15 km]



$$s_A = v_a t$$
$$= (60\text{ km/h})(0.25\text{ h}) = 15\text{ km}$$

c) The distance between the two buses ***45 minutes*** after departure. [70 km]



From part – a above, the buses pass each other after 15 minutes.

$$\therefore t = 45\text{ min} - 15\text{ min} = 30\text{ min} = 0.5\text{ h}$$
$$s_A = v_A t = (60\text{ km/h})(0.5\text{ h}) = 30\text{ km}$$
$$s_B = v_B t = (80\text{ km/h})(0.5\text{ h}) = 40\text{ km}$$
$$s_T = s_A + s_B = 30\text{ km} + 40\text{ km} = 70\text{ km}$$

9. A truck traveling at 60 km/h comes to a stop in 10 seconds. Find its ***deceleration***:

a) In km/h/s [6]

$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{0 - 60\text{ km/h}}{10\text{ s}} = -6\text{ km/h/s}$$

b) In m/s/s [1.7]

$$\text{Convert 60 km/h to m/s:}\quad 60\frac{\text{km}}{\text{h}} = 60\frac{1000\text{ m}}{3600\text{ s}} = 16.7\text{ m/s}$$
$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{0 - 16.7\text{ m/s}}{10\text{ s}} = -1.67\text{ m/s}^2 = -1.7\text{ m/s}^2$$

10. A motorcyclist traveling at 10 m/s suddenly accelerates uniformly at a rate of 2 m/s^2. In how many seconds will the cyclist travel at 30 m/s? [10 s]

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

$$\therefore\ t = \frac{\Delta t}{a} = \frac{v_f - v_i}{a} = \frac{30\ m/s - 10\ m/s}{2\ m/s^2} = 10\ s$$

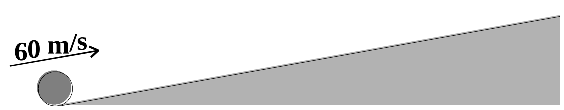
11. A car and a truck are waiting for the green traffic light at an intersection. When the light turns green, the car accelerates at a rate of 10 m/s^2 while the truck accelerates at a rate of 4 m/s^2. How far apart will they be 4 s after take off? [48 m]

$$s_{CAR} = v_i t + \frac{at^2}{2} = 0(4\ s) + \frac{(10\ m/s^2)(4\ s)^2}{2} = 80\ m$$

$$s_{TRUCK} = v_i t + \frac{at^2}{2} = 0(4\ s) + \frac{(4\ m/s^2)(4\ s)^2}{2} = 32\ m$$

$$\Delta s = s_{CAR} - s_{TRUCK} = 80\ m - 32\ m = 48\ m$$

12. A tennis ball rolling up a smooth hill at 60 m/s slows down at a uniform rate of 12 m/s/s. How far does it travel along the hill before coming to a stop? [150 m]



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

$$\therefore\ s = \frac{v_f^2 - v_i^2}{2a} = \frac{0 - (60\ m/s)^2}{2(-12\ m/s^2)} = \frac{-3600\ m^2/s^2}{-24\ m/s^2} = 150\ m$$

13. A car travels along a straight highway with ***uniform*** motion. At 3:45 PM, the odometer of the car reads 12 064.0 kilometers. At 3:48 PM, the odometer reads 12 069.0 kilometers.

a) What is the velocity of the car in km/h? [100 km/h]

$$v_a = \frac{s}{t} = \frac{12069.0 - 12064.0}{3\text{ min }(\frac{1\text{ h}}{60\text{ min}})} = \frac{5\text{ km}}{0.05\text{ h}} = 100\text{ km/h}$$

b) What is the velocity of the car in m/s? [27.8 m/s]

$$100\,\frac{\text{km}}{\text{h}} = 100(\frac{1000\text{ m}}{3600\text{ s}}) = 27.8\text{ m/s}$$

c) At this rate, how many kilometres will the car travel in 30 minutes? [50 km]

$$s = v_a t = (100\text{ km/h})(0.5\text{ h}) = 50\text{ km}$$

14. A wheel with a radius of 50 cm rotates at a rate of 4 RPMs.

a) How fast is the wheel traveling in m/s? [0.21 m/s]

<u>Note</u>: Each revolution covers a distance of one circumference.

$$\mathbf{v = \frac{s}{t} = \frac{4(2\pi r)}{60\text{ s}} = \frac{4(2)(3.14)(0.5\text{ m})}{60\text{ s}} = 0.21\text{ m/s}}$$

b) How far does it travel in 20 s? [4.2 m]

$$s = v_a t = (0.21\text{ m/s})(20\text{ s}) = 4.2\text{ m}$$

15. A boat travels at a speed of 4 m/s in still water. If the water current of a river is 3 m/s, determine the magnitude of the boat's velocity in going:

a) Upstream [1 m/s]

$$v = v_{Boat} + v_{River} = 4\ m/s - 3\ m/s = 1\ m/s \text{ upstream}$$

b) Downstream [7 m/s]

$$v = v_{Boat} + v_{River} = 4\ m/s + 3\ m/s = 7\ m/s \text{ downstream}$$

c) Across the river [5 m/s]

$$v^2 = v_{Boat}^2 + v_{River}^2$$

$$\therefore\ v = \sqrt{v_{Boat}^2 + v_{River}^2}$$

$$= \sqrt{(4\ m/s)^2 + (3\ m/s)^2} = \sqrt{25\ m^2/s^2} = 5\ m/s$$

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