Motion along a straight line

Practice Problems

Practice Problem 1:

A swimmer travels one complete lap in a pool that is 50.0-meters long. The first leg is covered in 20.0 seconds, the second leg is covered in 25.0 seconds. What was his average speed for the lap?

- Solution:

$$speed = \frac{distance}{time}$$

$$speed = \frac{50 + 50}{20 + 25} = 2.22 m/s$$

Practice Problem 2:

The position of a body on the x axis varies as a function of time according to the following equation

$$x(\text{meters}) = (3t + 2t^2)\text{m}$$

Find its velocity and acceleration when $t = 3$ sec.

Solution

Because the body moves in a straight line, $\mathbf{r} = x$. From Eq. 3

$$v = \frac{dx}{dt} = \frac{d}{dt}(3t + 2t^2) = (3 + 4t)\ \text{m/sec}$$

The velocity of the body at $t = 3$ sec is therefore

$$v(t = 3\ \text{sec}) = 3 + 4 \times 3 = 15\ \text{m/sec}$$

From Eq. 5

$$a = \frac{dv}{dt} = \frac{d}{dt}(3 + 4t) = 4\ \text{m/sec}^2$$

Notice that a is a constant, and therefore $a(t = 3\ \text{sec}) = 4\ \text{m/sec}^2$.

Practice Problems set 3:

Q . A student drives to college 15 km away from home in half an hour. After classes, he returns home in 20 min. Find (a) the average speed on his way to college, (b) the average speed for the round trip, (c) his average velocity for the entire trip.

Q. The position of a particle moving along the x axis is given by $x = 3 + 17t - 5t^2$, where x is in meters and t is in seconds. (a) What is the position of the particle at $t = 1$, 2, and 3 sec? (b) At what time does the particle return to the origin? (c) What is the instantaneous velocity at $t = 1$, 2, and 3 sec? (d) At what time is the instantaneous velocity of the particle zero? (e) What is the velocity of the particle as it passes through the origin? (f) What is the acceleration of the particle as it passes the origin?

Practice Problems set 4:

Q The position of a particle moving in a straight line is given by $x = 5 + 2t + 4t^2 - t^3$, where x is in meters. (a) Find an expression for the instantaneous velocity as a function of time. (b) Find the position of the particle at $t = 0, 1, 0.1$, and 0.01 sec. (c) What is the average velocity between $t = 0$ sec and $t = 1$ sec, between $t = 0$ sec and $t = 0.1$ sec, and between $t = 0$ sec and $t = 0.01$ sec? (d) What is the instantaneous velocity at $t = 0$ sec? (e) What conclusion do you draw from the answers in (c) and (d)?

Q A car is driving east at 60 km/h, it then makes a turn and travels north at 50 km/h. If it takes 2 sec to make the turn, what is the average acceleration of the car over this 2 second interval?

Q Consider the particle of problem on left (a) Find an expression for the acceleration of the particle as a function of time. (b) What is the instantaneous velocity of the particle at $t = 0$, 1, 0.1, and 0.01 sec? (c) What is the average acceleration between $t = 0$ sec and $t = 1$ sec, between $t = 0$ sec and $t = 0.1$ sec, between $t = 0$ sec and $t = 0.01$ sec? (d) What is the instantaneous acceleration at $t = 0$ sec? (e) What conclusion can you draw from the answers in (c) and (d)?

Practice Problem 5:

EXAMPLE A boy throws a ball upward with an initial velocity of 12 m/sec. How high does it go?

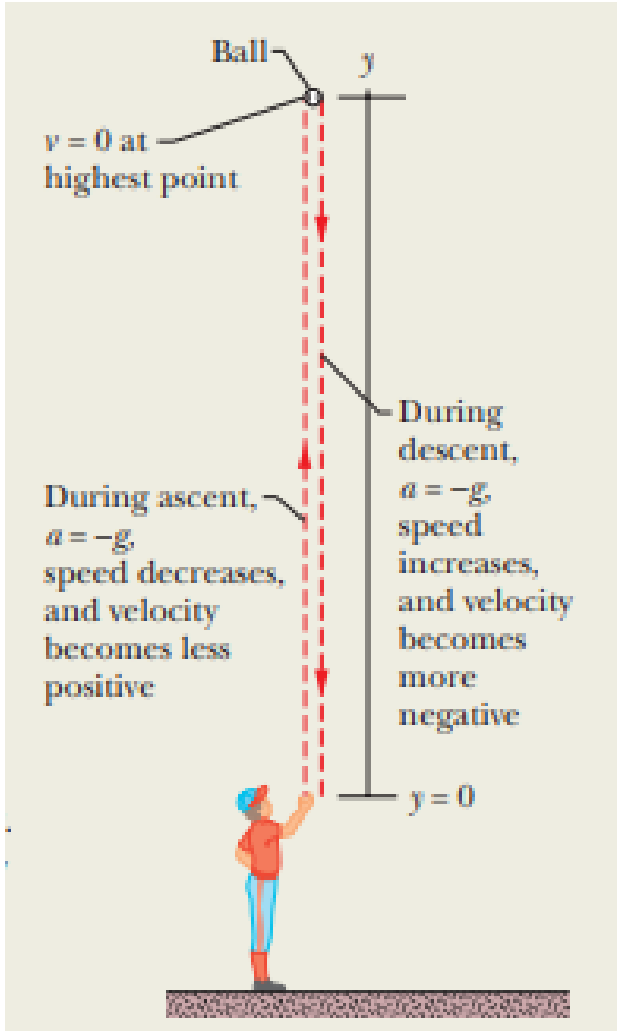
Solution We choose the starting point as the origin and the upward direction as positive. Because velocity is a vector displacement divided by time, upward velocity is also positive. The force of gravity is in the negative y direction, so the sign of the acceleration is therefore negative. First list what is known and what is to be found

$$v_{0y} = 12\,\text{m/sec}, \quad v_y = 0 \text{ (at its highest point)}, \quad a_y = g = -9.8\,\text{m/sec}^2$$

$$y = ?$$

We select the 3rd equation of motion because all the quantities in that equation are known except y, the quantity that we want to find

$$v_y^2 - v_{0y}^2 = 2a_y y$$



Practice Problem 5(cont'd)

Solving for y, we write

$$y = \frac{v_y^2 - v_{0y}^2}{2a_y}$$

Substituting the numerical values for the quantities in the equation,

$$y = \frac{0 - (12\,\text{m/sec})^2}{2(-9.8\,\text{m/sec}^2)}$$

$$= 7.3\,\text{m}$$

Practice Problem 6

EXAMPLE A boy throws a ball upward with an initial velocity of 12 m/sec and catches it when it returns. How long was it in the air?

Solution As in the previous example, we choose the starting point as the origin and the upward direction as positive.

$v_{0y} = 12\,\text{m/sec}, \quad a_y = -9.8\,\text{m/sec}^2, \quad y = 0$ (vector displacement is zero because it returns to his hand), $t = ?$

Select 2nd equation of motion

$$y = v_{0y}t + \frac{1}{2}a_y t^2 \qquad \text{.....eq. 1}$$

Using the fact that $y = 0$, Eq. 1 becomes

$$0 = v_{0y}t + \frac{1}{2}a_y t^2$$

We see immediately that if we divide both sides of the equation by t, we obtain

$$0 = v_{0y} + \frac{1}{2}a_y t$$

Practice Problem 6(cont'd)

$$t = -\frac{2\,v_{0y}}{a_y}$$

$$= -\frac{2 \times 12\ \text{m/sec}}{-9.8\ \text{m/sec}^2}$$

$$= 2.45\ \text{sec}$$

Note: If the ball had landed on a roof, then the left side of Eq. 1 would not be zero and the equation to be solved would be quadratic.

Practice Problem 7: (Sample problem 2.05)

In Fig, a pitcher tosses a baseball up along a y axis, with an initial speed of 12 m/s.

(a) How long does the ball take to reach its maximum height?

(b) What is the ball's maximum height above its release point?

(c) How long does the ball take to reach a point 5.0 m above its release point?

Practice Problem 8: (Sample Problem 2.04)

A popular web video shows a jet airplane, a car, and a motorcycle racing from rest along a runway (Fig. 2-10). Initially the motorcycle takes the lead, but then the jet takes the lead, and finally the car blows past the motorcycle. Here let's focus on the car and motorcycle and assign some reasonable values to the motion. The motorcycle first takes the lead because its (constant) acceleration $a_m = 8.40\ \text{m/s}^2$ is greater than the car's (constant) acceleration $a_c = 5.60\ \text{m/s}^2$, but it soon loses to the car because it reaches its greatest speed $v_m = 58.8\ \text{m/s}$ before the car reaches its greatest speed $v_c = 106\ \text{m/s}$. How long does the car take to reach the motorcycle?

Practice Problem 9: (End of chapter Problem 2)

•2 Compute your average velocity in the following two cases: (a) You walk 73.2 m at a speed of 1.22 m/s and then run 73.2 m at a speed of 3.05 m/s along a straight track. (b) You walk for 1.00 min at a speed of 1.22 m/s and then run for 1.00 min at 3.05 m/s along a straight track. (c) Graph x versus t for both cases and indicate how the average velocity is found on the graph.

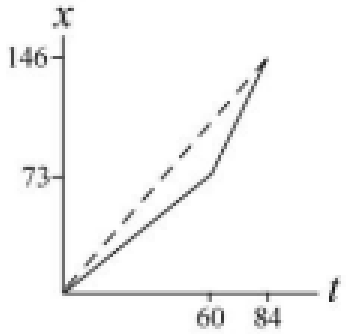
Answers:

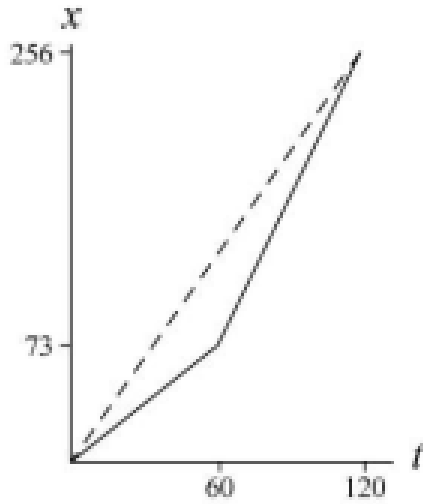
2a. v_{avg} = 1.74 m/s

2b. v_{avg} = 2.14 m/s

Part c (Problem no. 2)(Solution):

(c) The graphs are shown below (with meters and seconds understood). The first consists of two (solid) line segments, the first having a slope of 1.22 and the second having a slope of 3.05. The slope of the dashed line represents the average velocity (in both graphs). The second graph also consists of two (solid) line segments, having the same slopes as before — the main difference (compared to the first graph) being that the stage involving higher-speed motion lasts much longer.





Practice Problem 10 (Sample Problem 2.01)

You drive a beat-up pickup truck along a straight road for 8.4 km at 70 km/h, at which point the truck runs out of gasoline and stops. Over the next 30 min, you walk another 2.0 km farther along the road to a gasoline station.

(a) What is your overall displacement from the beginning of your drive to your arrival at the station?

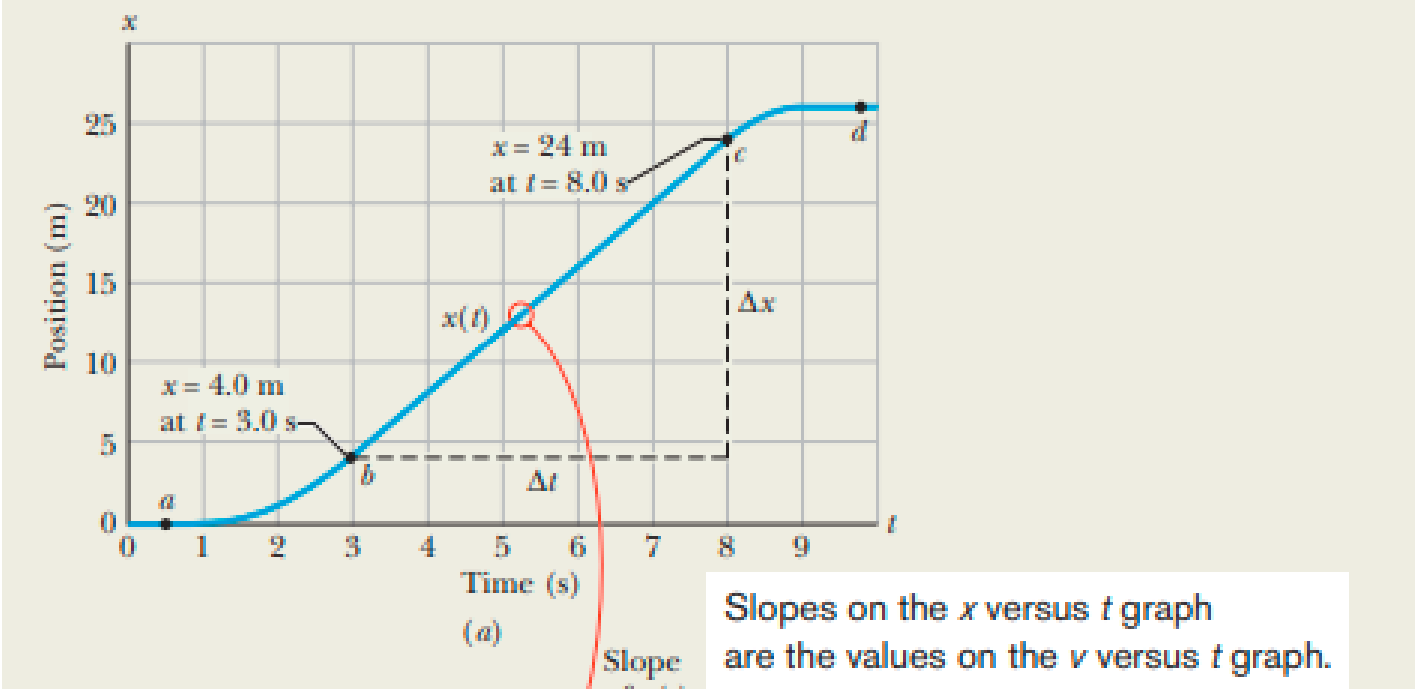
(b) What is the time interval Δt from the beginning of your drive to your arrival at the station?

(c) What is your average velocity v_{avg} from the beginning of your drive to your arrival at the station? Find it both numerically and graphically.

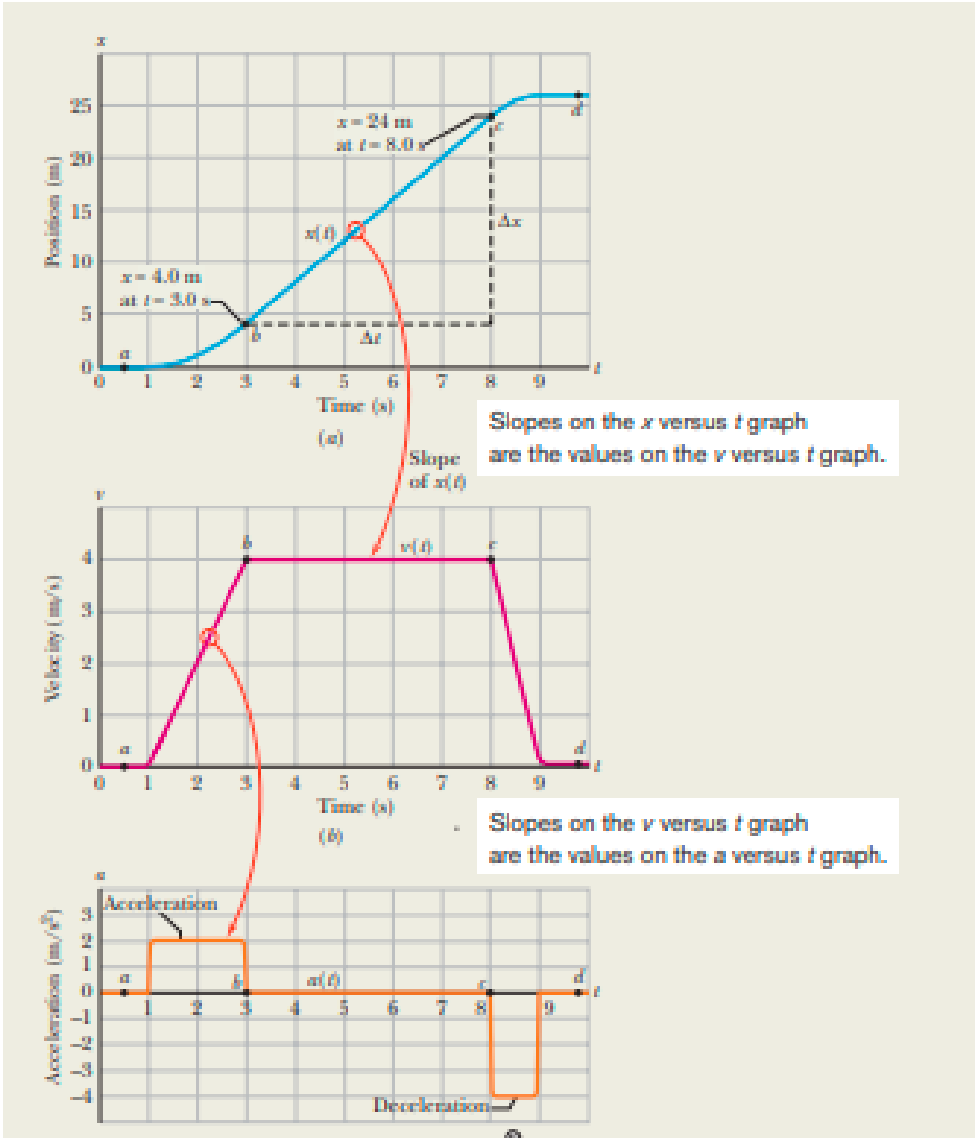
(d) Suppose that to pump the gasoline, pay for it, and walk back to the truck takes you another 45 min. What is your average speed from the beginning of your drive to your return to the truck with the gasolinw?

Practice Problem 11(Sample Problem 2.02)

Figure is an x(t) plot for an elevator cab that is initially stationary, then moves upward (which we take to be the positive direction of x), and then stops. Plot v(t) and a(t).



Practice Problem(Sample Problem 2.02) (answers)



Note :

Draw graph with proper Calculations

Homework questions:

- Practice problems:
- End of chapter 2 textbook " Fundamentals of Physics"by Halliday & Resnick Jearl Walker 10th Edition"

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- Sample problems:

2.01, 2.02, 2.03, 2.04 and 2.05

Adapted from:

Book:

Fundamentals of Physics by Halliday Resnick & Jearl Walker 10th edition