Wrocław University of Science and Technology

Physics

JZL1001913C

summer semester

2020/2021

Wednesday, 18:20 - 19:50

Friday, 18:20 - 19:50

virtual room (ZOOM)

Sylwia Majchrowska

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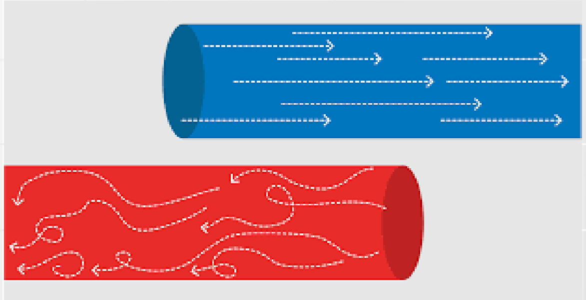
What is Physics?

One purpose of physics is to study the motion of objects—how fast they move, for example, and how far they move in a given amount of time. Some engineers are fanatical about this aspect of physics as they determine the performance of their cars before and during a race. Geologists use this physics to measure tectonic-plate motion as they attempt to predict earthquakes. Medical researchers need this physics to map the blood flow through a patient when diagnosing a partially closed artery, and motorists use it to determine how they might slow sufficiently when their radar detector sounds a warning.



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Motion

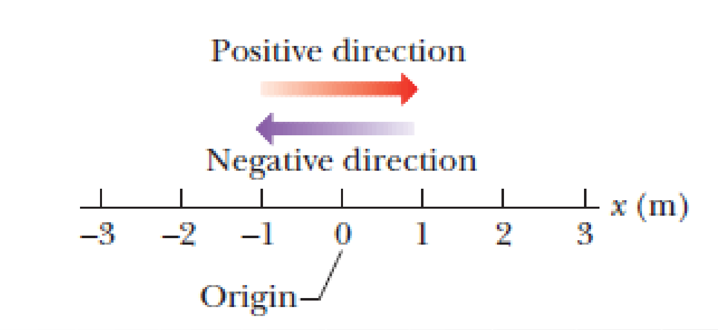
The classification and comparison of motions = **kinematics**

Some restriction (assumptions)

1. The motion is along a straight line only. The line may be vertical, horizontal, but it must be straight.
2. Forces (pushes and pulls) cause motion but will not be discussed today. Here we discuss only the motion itself and changes in the motion. Does the moving object speed up, slow down, stop, or reverse direction? If the motion does change, how is time involved in the change?
3. The moving object is either a **particle** (by which we mean a point-like object) or an object that moves like a particle (such that every portion moves in the same direction and at the same rate).

Position and Displacement

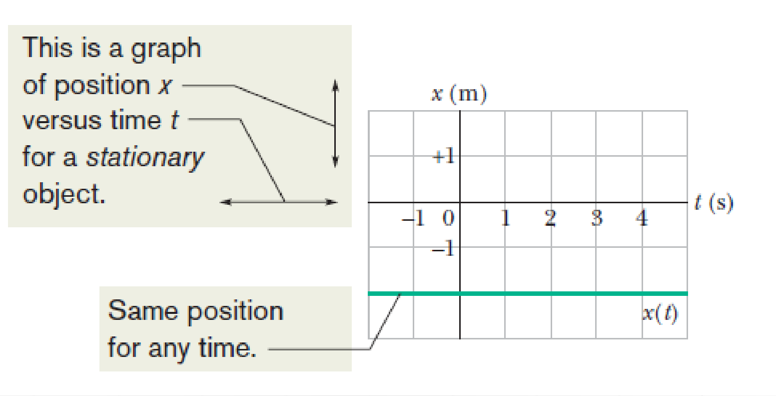
A change from position x_1 to position x_2 is called a **displacement** Δx.



$$\Delta x = x_2 - x_1$$

The symbol , the Greek uppercase delta, represents a change in a quantity, and it means the final value of that quantity minus the initial value.

The graph of $x(t)$ for object that is stationary at x^2 m. The value of x is -2 m for all times t.



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Vector or scalar quantity

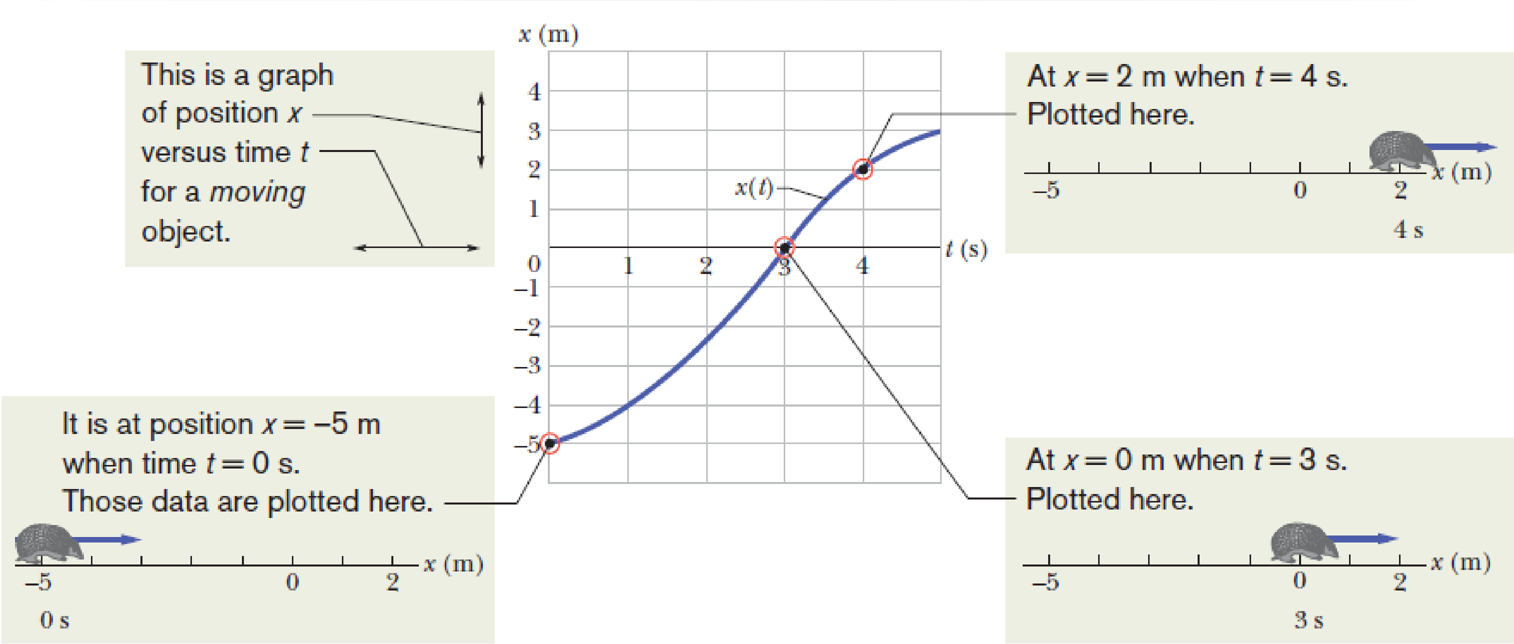
Displacement is an example of a **vector quantity**, which is a quantity that has both a direction and a magnitude.

Vector quantity has two features:

1. Its *magnitude:* for displacement it is the distance (such as the number of meters) between the original and final positions.
2. Its *direction*, from an original position to a final position, can be represented by a plus sign or a minus sign if the motion is along a single axis.

A **scalar** is a quantity that is fully described by a magnitude only.

Plotting movement



The armadillo is apparently first noticed at t=0s when it is at the position x=-5 m. It moves toward x = 0m, passes through that point at t = 3 s, and then moves on to increasingly larger positive values of x.

The graph is more abstract, but it reveals how fast the armadillo moves.

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Average Velocity and Average Speed

Actually, several quantities are associated with the phrase "how fast."
One of them is the **average velocity** v_{avg}, which is the ratio of the displacement x that occurs during a particular time interval t to that interval:

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}.$$

The notation means that the position is x_1 at time t_1 and then x_2 at time t_2.A common unit for v_{avg} is the meter per second (m/s). You may see other units in the problems, but they are always in the form of length/time.

Average speed s_{avg} is a different way of describing "how fast" a particle moves. Whereas the average velocity involves the particle's displacement x, the average speed involves the total distance covered (for example, the number of meters moved), independent of direction; that is

$$s_{avg} = \frac{\text{total distance}}{\Delta t}.$$

Because average speed does *not* include direction, it lacks any algebraic sign. Sometimes s_{avg} is the same (except for the absence of a sign) as v_{avg}. However, the two can be quite different.

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Sample problem 1

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 our 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 gasoline?

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Sample problem - solution

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?

$$\Delta x = x_2 - x_1 = 10.4\ \text{km} - 0 = 10.4\ \text{km}.$$

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Sample problem - solution

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?

$$v_{\text{avg,dr}} = \frac{\Delta x_{\text{dr}}}{\Delta t_{\text{dr}}}.$$

Rearranging and substituting data then give us

$$\Delta t_{\text{dr}} = \frac{\Delta x_{\text{dr}}}{v_{\text{avg,dr}}} = \frac{8.4\ \text{km}}{70\ \text{km/h}} = 0.12\ \text{h}.$$

So,
$$\Delta t = \Delta t_{\text{dr}} + \Delta t_{\text{wlk}}$$
$$= 0.12\ \text{h} + 0.50\ \text{h} = 0.62\ \text{h}.$$

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Sample problem - solution

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 our drive to your arrival at the station? Find it both numerically and graphically.

$$v_{avg} = 10.4 \text{ km} / 0.62 \text{ h} = 16.8 \text{ km/h}$$

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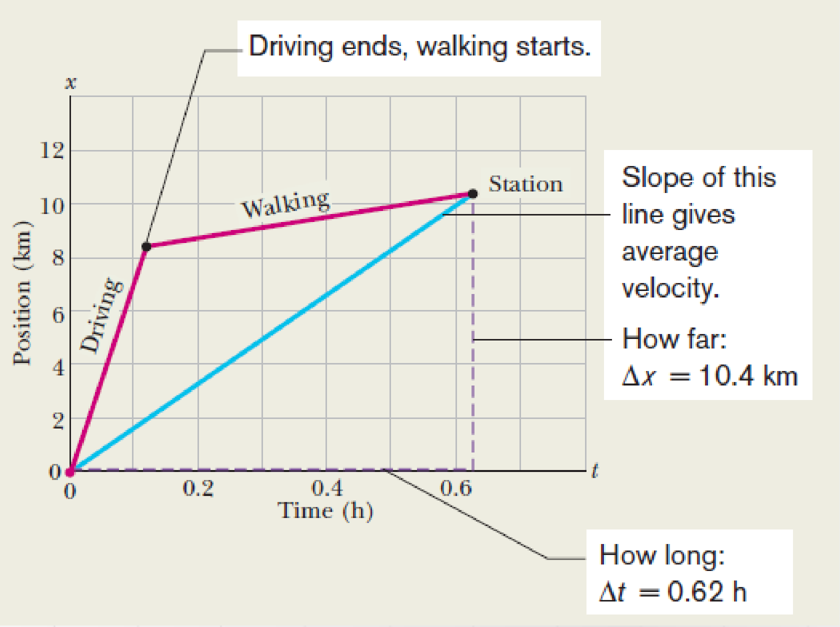
Sample problem - solution

To find v_{avg} graphically, first we graph the function $x(t)$ as shown in graph, where the beginning and arrival points on the graph are the origin and the point labeled as "Station." Your average velocity is the slope of the straight line connecting those points; that is, v_{avg} is the ratio of the *rise* (x 10.4 km) to the *run* (t 0.62 h), which gives us v_{avg} 16.8 km/h.



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Sample problem - solution

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?

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(c) What is your average velocity v_{avg} from the beginning of our 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 gasoline?

The total distance is 8.4 km + 2.0 km + 2.0 km = 12.4 km

The total time interval is 0.12 h + 0.50 h + 0.75 h = 1.35 h

s_{avg} = 12.4 km / 1.35h = 9.19 km/h

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Average acceleration

When a particle's velocity changes, the particle is said to undergo **acceleration** (or to accelerate). For motion along an axis, the **average acceleration** a_{avg} over a time interval t is

$$a_{avg} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

A common unit of acceleration is the meter per second per second: m/(s * s) or m/s^2. Other units are in the form of length/(time time) or length/$time^2$.

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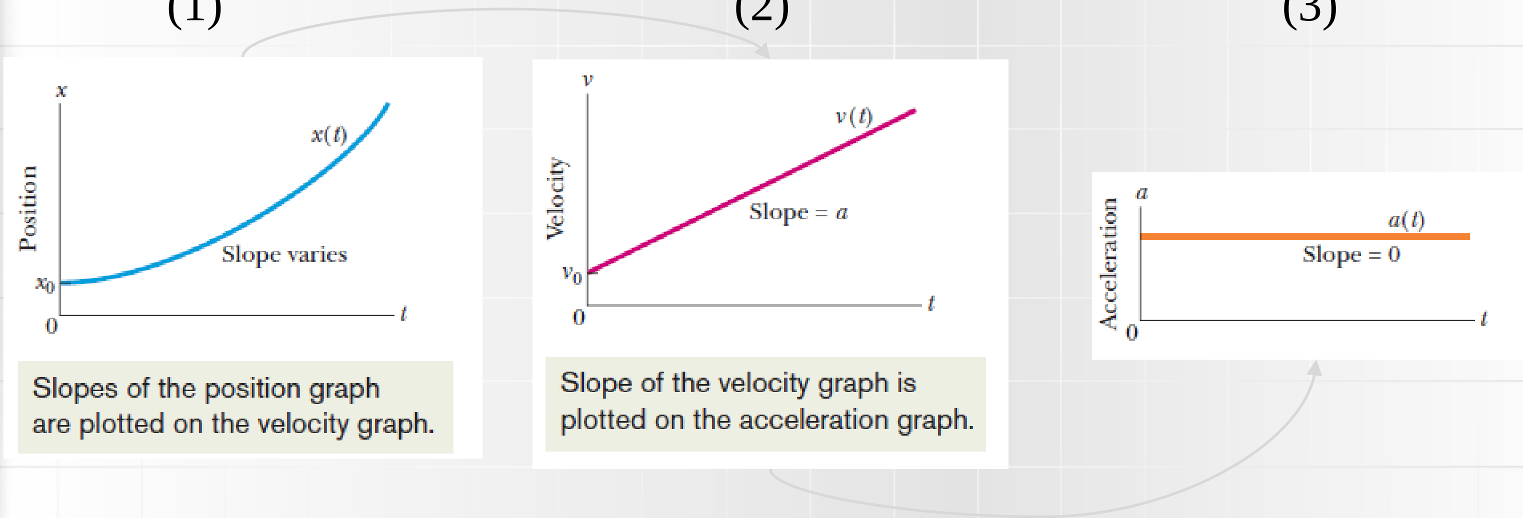
Constant Acceleration

In many types of motion, the acceleration is either constant or approximately so. For example, you might accelerate a car at an approximately constant rate when a traffic light turns from red to green.

(1) (2) (3)



(1) The position $x(t)$ of a particle moving with constant acceleration.
(2) Its velocity $v(t)$, given at each point by the slope of the curve of $x(t)$.
(3) Its (constant) acceleration, equal to the (constant) slope of the curve of $v(t)$.

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Equations for constant acceleration

When the acceleration is constant we can write that $a = a_{avg} = \frac{v - v_0}{t - 0}$

Here v_0 is the velocity at time t 0 and v is the velocity at any later time t.
We can recast this equation as

$$v = v_0 + at$$

As a check, note that this equation reduces to $v = v_0$ for $t = 0$, as it must.

$$v_{avg} = \frac{x - x_0}{t - 0} \longrightarrow x = x_0 + v_{avg}t,$$

For the linear velocity function, the *average* velocity over any time interval (say, from t 0 to a later time t) is the average of the velocity at the beginning of the interval (v_0) and the velocity at the end of the interval (v).

$$v_{avg} = \tfrac{1}{2}(v_0 + v)$$

Equation	Missing Quantity
$v = v_0 + at$	$x - x_0$
$x - x_0 = v_0 t + \frac{1}{2}at^2$	v
$v^2 = v_0^2 + 2a(x - x_0)$	t
$x - x_0 = \frac{1}{2}(v_0 + v)t$	a
$x - x_0 = vt - \frac{1}{2}at^2$	v_0

$$v_{avg} = v_0 + \tfrac{1}{2}at.$$

$$x - x_0 = v_0 t + \tfrac{1}{2}at^2$$

$$v^2 = v_0^2 + 2a(x - x_0).$$

$$x - x_0 = \tfrac{1}{2}(v_0 + v)t.$$

$$x - x_0 = vt - \tfrac{1}{2}at^2$$

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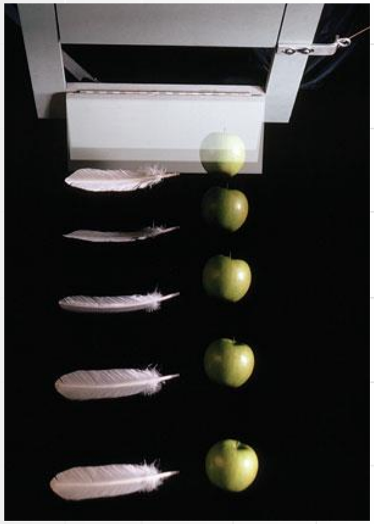
Free-Fall Acceleration

If you tossed an object either up or down and could somehow eliminate the effects of air on its flight, you would find that the object accelerates downward at a certain constant rate. That rate is called the **free-fall acceleration,** and its magnitude is represented by *g*. The acceleration is independent of the object's characteristics, such as mass, density, or shape; it is the same for all objects.

> The free-fall acceleration near Earth's surface is $a = -g = -9.8\ \mathrm{m/s^2}$, and the *magnitude* of the acceleration is $g = 9.8\ \mathrm{m/s^2}$.



A feather and an apple free fall in vacuum at the same magnitude of acceleration *g*. The acceleration increases the distance between successive images. In the absence of air, the feather and apple fall together.

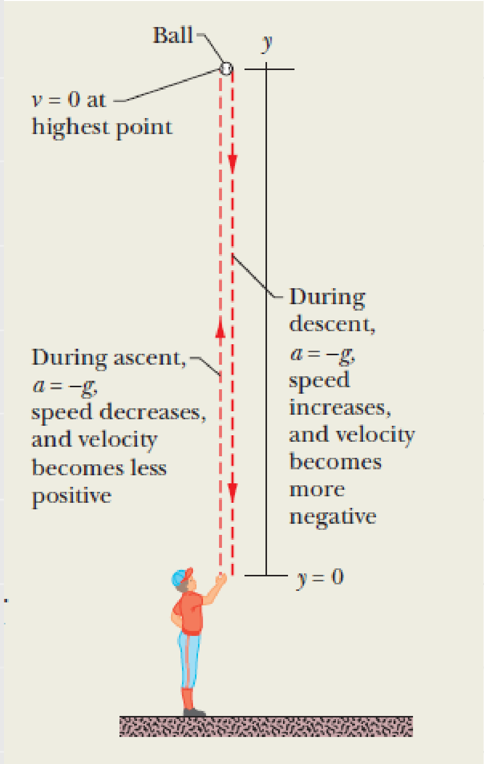
Sample problem 2

In graph, 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?



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Sample problem 2

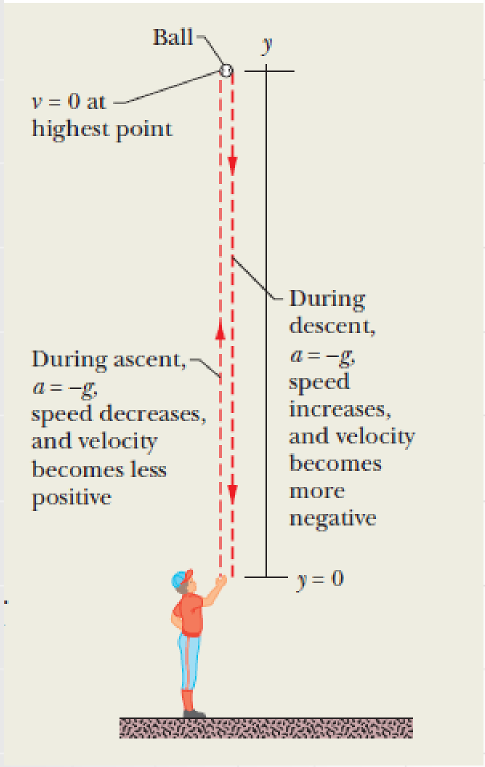
In graph, a pitcher tosses a baseball up along a *y* axis, with an initial speed of 12 m/s.

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

$$t = \frac{v - v_0}{a} = \frac{0 - 12\text{ m/s}}{-9.8\text{ m/s}^2} = 1.2\text{ s}$$

(1) Once the ball leaves the pitcher and before it returns to his hand, its acceleration is the free-fall acceleration a = - g.

(2) The velocity v at the maximum height must be 0.



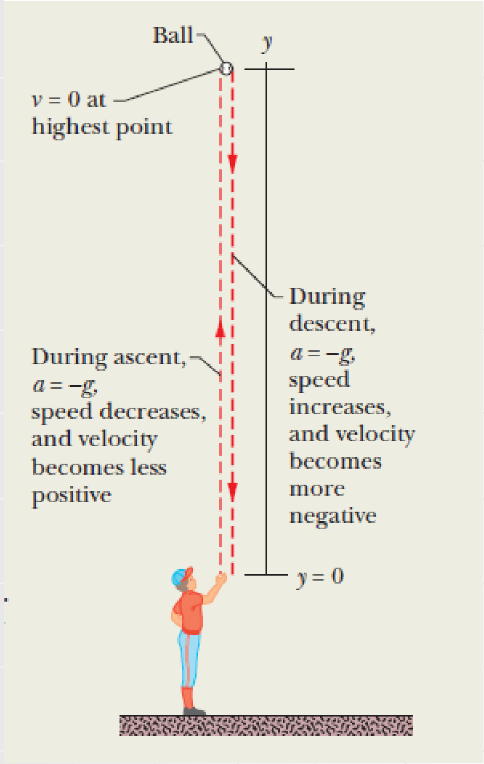
Sample problem 2

In graph, 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?

$$y = \frac{v^2 - v_0^2}{2a} = \frac{0 - (12\text{ m/s})^2}{2(-9.8\text{ m/s}^2)} = 7.3\text{ m}$$



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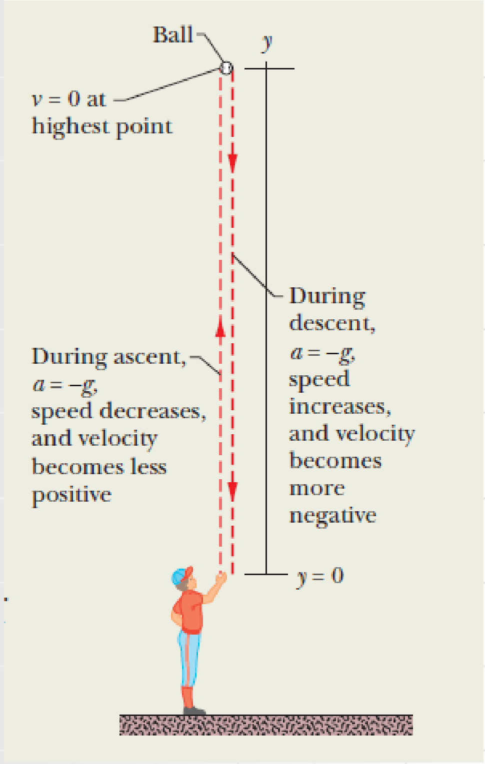
Sample problem 2

In graph, 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?



$$y = v_0 t - \tfrac{1}{2} g t^2$$

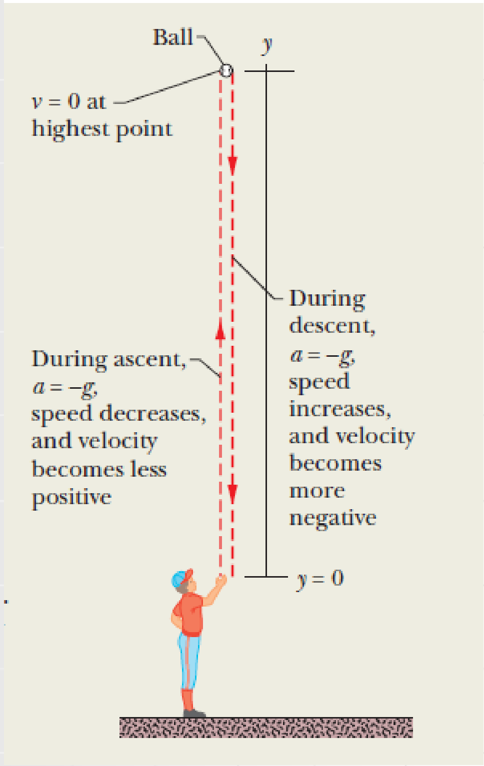
$$5.0\ \text{m} = (12\ \text{m/s})t - (\tfrac{1}{2})(9.8\ \text{m/s}^2)t^2$$

$$4.9t^2 - 12t + 5.0 = 0.$$

$$t = 0.53\ \text{s} \quad \text{and} \quad t = 1.9\ \text{s}$$

Motion phenomena - Kinematics

All right. So if you go to our website today, you will find I've assigned some problems and you should try to do them. They apply to this chapter. Then next week we'll do anothers problems connected with motion phenomena.



Closer look at calendar

	FEBRUARY	MARCH					APRIL				MAY					JUNE			JULY	
MON	22	1	8	15	22	29	5	12 Mon O	19	26	3	10	17	24	31	7	14	21	28	5
TUE	23	2	9	16	23	30 Fri E	6	13	20	27	4	11	18	25	1	8	15	22	29	6
WED	24	3	10	17	24	31	7	14	21	28	5	12	19	26	2 Thu E	9	16	23	30	7
THU	25	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	1	8
FRI	26	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9
SAT	27	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26	3	10
SUN	28	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	4	11
E - EVEN O - ODD	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E

Lecture
Exercise
Revision/exam

Wednesday, 18:20 - 19:50
Friday, 18:20 - 19:50

Office hours:
Monday, 20:30 - 21:30
virtual room

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Quizz

Kahoot link:
https://kahoot.it/challenge/08736132?challenge-id=459c69ba-0699-474d-ae7d-12916780bd23_1614952577307

Deadline: 10th March 2021, 18:00