Combining Mastering Physics with Mastering Chemistry

Suppose you have already registered with Mastering Chemistry

Go to Mastering Physics website as a returning user and log in with username and password from Mastering Chemistry

Click on Knight/Jones/Field "College Physics"

Enter the Mastering Physics access code

Use student number as student ID

If you've used something other than student number for Mastering Physics, please change it to student number

GENERAL PHYSICS I: PHYS 1020

Schedule - Fall 2007
(lecture schedule is approximate)

Week	Date		Lecture	Cutnell & Johnson	Topic	Labs/Tests (Tuesdays, Wednesdays, Thursdays)
1	F	Sept 7	1	Chapter 1	Introduction	No lab or tutorial
2	M	10	2			No lab or tutorial
	W	12	3	Chapter 2	Kinematics in one dimension	
	F	14	4			
3	M	17	5			Errors Lecture
	W	19	6	Chapter 3	Kinematics in two dimensions	
	F	21	7			
4	M	24	8			Experiment 1: Measurement of Length and Mass
	W	26	9	Chapter 4	Forces and Newton's laws	
	F	28	10			

The first lab period is next week

It is the errors lecture (in the lab)

You should attend so you know how to combine errors of measurement

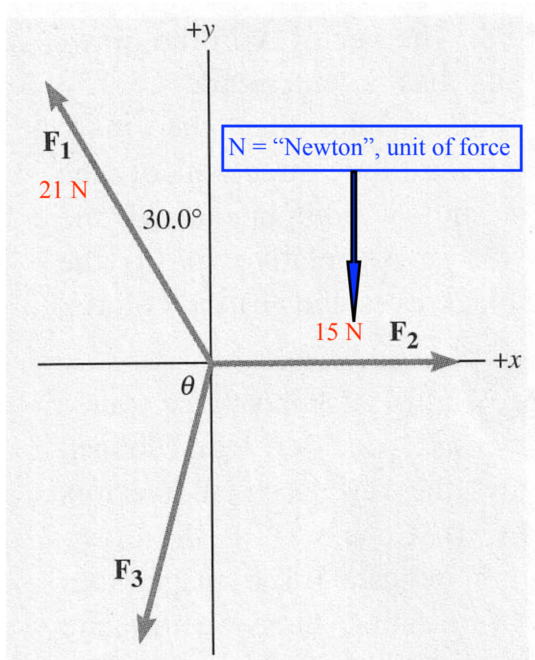
Prob. 1.46/46:
Three forces are applied to an object.

What must be the magnitude and direction of $\mathbf{F}_3$ if the sum of the forces is zero?

Need $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$

So, $\vec{F}_3 = -\vec{F}_1 - \vec{F}_2$

Components:



Summary of Chapter 1

Vectors have a magnitude **and** a direction
Scalars have just a magnitude

Vectors add nose to tail
Simplify by breaking vectors into x, y components

Vectors are subtracted by reversing the direction of the vector to be subtracted and then adding:

A - B = A + (-B)

or, $\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$

Alternative notation for vectors

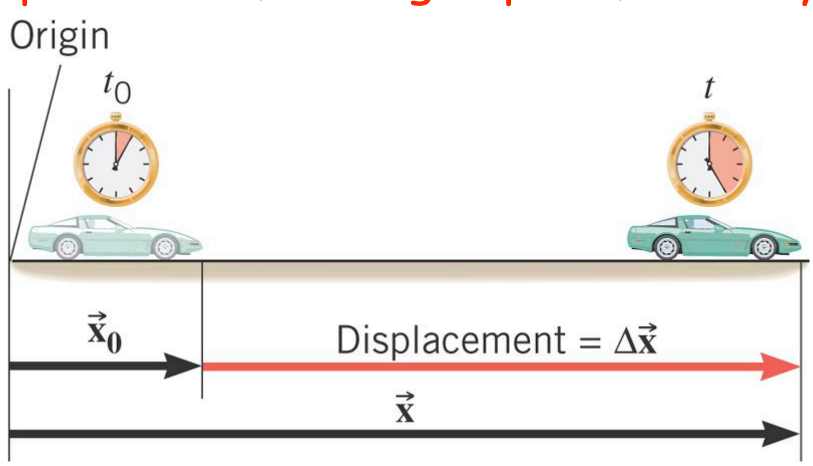
Dimensions must be the consistent in all terms of an equation
The basic dimensions are mass, length and time
[M], [L] and [T], (kg, m, s)

Chapter 2: Kinematics in One Dimension

Will cover motion in a straight line with constant acceleration:

- Displacement – not always the same as distance travelled
- Speed, velocity, acceleration
- Equations of motion in one dimension
- Free fall under gravity - which way is up?
- Graphical representation

Displacement, average speed, velocity



Car starts at x_o at time t_o, reaches x at time t

Distance travelled = $x - x_o$

Displacement, $\Delta\vec{x} = \vec{x} - \vec{x}_0$

$$\text{Average speed} = \frac{\text{Distance}}{\text{Elapsed time}} = \frac{x - x_0}{t - t_0}$$

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Elapsed time}} = \frac{\Delta\vec{x}}{t - t_0}$$

Displacement and distance not necessarily the same

Example: Car travels 50 km to east, then 20 km to west in 1 hour.

Distance travelled = 50 + 20 = 70 km

Average speed = 70 km/h

Displacement $= \vec{x}_{final} - \vec{x}_{initial} = 30$ km to east

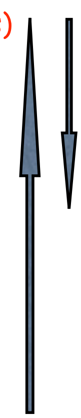
Average velocity = 30 km/h to east

Example: A car makes a trip due north for 3/4 of the time and due south for 1/4 of the time. The average northward velocity has a magnitude of 27 m/s. The average southward velocity has a magnitude of 17 m/s.

What is the average velocity for the entire trip?

Put T = time for the entire trip.

$x_1 = (3T/4) \times (27\ m/s)$



$x_2 = (T/4) \times (17\ m/s)$

Average velocity = Displacement/Time

= $(x_1 - x_2)/T$, to the north

= 3 × 27/4 – 17/4 m/s

= 16 m/s, to the north

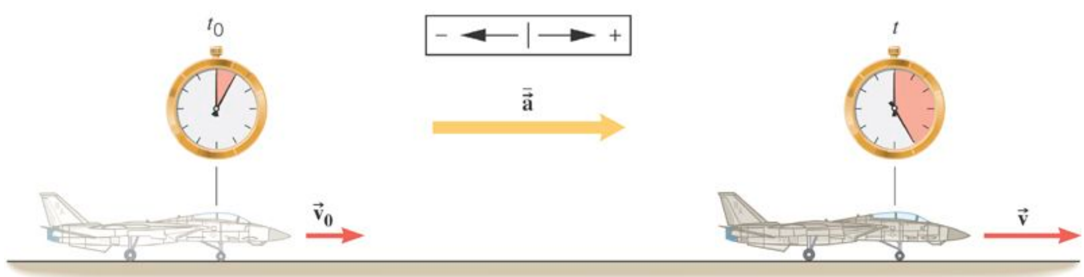
Instantaneous Velocity

The velocity measured during a vanishingly small time interval. That is, the velocity at a particular instant in time.

$$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t}$$

This differs from the average velocity because the average is measured over an extended time during which the object may be accelerating.

Acceleration

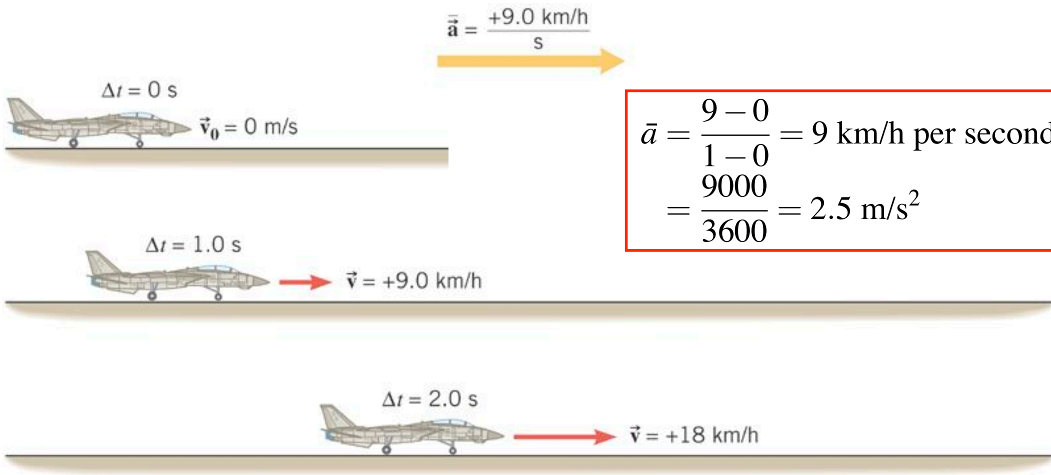


$$\text{Average acceleration} = \frac{\text{Change in velocity}}{\text{Elapsed time}} = \frac{\vec{v} - \vec{v}_0}{t - t_0}$$

$$\text{Instantaneous acceleration} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t}$$

Any change of velocity, including slowing down, is an "acceleration".

Average acceleration



$$\bar{a} = \frac{9-0}{1-0} = 9 \text{ km/h per second}$$
$$= \frac{9000}{3600} = 2.5 \text{ m/s}^2$$

$$\bar{a} = \frac{18-9}{2-1} = 9 \text{ km/h per second}$$

Two cars are moving in a straight section of a highway. The acceleration of the first car is greater than the acceleration of the second car and both accelerations have the same direction.

Clicker Question

Which one of the following is true?

a) The velocity of the first car is always greater than the velocity of the second car.

b) The velocity of the second car is always greater than the velocity of the first car.

c) In the same time interval, the velocity of the first car changes by a greater amount than the velocity of the second car.

d) In the same time interval, the velocity of the second car changes by a greater amount than the velocity of the first car.

Equations of Motion

Consider an object that has speed v_o at time $t = 0$.
It is accelerated in a straight line at a constant rate to speed v at time t.

Acceleration:

$$a = \frac{v - v_0}{t}, \text{ so } v = v_0 + at \qquad (1)$$

Average speed:

$$\bar{v} = \frac{x - x_0}{t} = \frac{v + v_0}{2} = \frac{v_0 + at + v_0}{2}$$

$$x - x_0 = v_0 t + \frac{1}{2}at^2 \qquad (2)$$

From previous page:

$$\bar{v} = \frac{x - x_0}{t} = \frac{v + v_0}{2}$$

$$x - x_0 = \frac{1}{2}(v + v_0)t \qquad (3)$$

And:

(1) $v - v_0 = at$

(3) $\dfrac{v + v_0}{2} = \dfrac{x - x_0}{t}$

Multiply –

$$(v - v_0) \times \frac{(v + v_0)}{2} = at \times \frac{(x - x_0)}{t}$$

$$v^2 - v_0^2 = 2a(x - x_0) \qquad (4)$$

The famous four formulae

$$v = v_0 + at \qquad (1)$$

$$x - x_0 = v_0 t + \frac{1}{2}at^2 \qquad (2)$$

$$x - x_0 = \frac{1}{2}(v + v_0)t \qquad (3)$$

$$v^2 - v_0^2 = 2a(x - x_0) \qquad (4)$$

You will definitely need to know these!

Example: A runner accelerates to a velocity of 5.36 m/s due west in 3 seconds. His average acceleration is 0.640 m/s^2, also directed due west. What was his velocity when he began accelerating?

Take quantities pointing to the east (right) as positive.

$$\begin{aligned} v_0 &= ? \\ v &= -5.36 \text{ m/s} \\ a &= -0.640 \text{ m/s}^2 \\ t &= 3 \text{ s} \end{aligned}$$

$$v - v_0 = at \qquad (1)$$

So:

$$v_0 = v - at = -5.36 - (-0.640) \times 3 = -3.44 \text{ m/s}$$

Answer: 3.44 m/s due west.

The course web site: www.physics.umanitoba.ca/~birchall/PHYS1020

On first page of course handout

PHYS 1020, General Physics I

FALL 2007

Welcome to Physics 1020!

Instructors	Required Materials	Schedule	Policies/Evaluation	Suggested Problems	Formula Sheet

Information on "Mastering Physics"

Marks files

Lecture Notes

www.physics.umanitoba.ca/~birchall/PHYS1020/Instructors_16102.html

	**Lecture Section & Times:** *A01, MWF 8:30 (Room 118 St. John's)* *Dr. J. Birchall, 205 Allen Bldg, 474-6205* email: birchall@physics.umanitoba.ca **Consultation Times**: Mon/Tue 1:30-2:30 *Lecture notes* ← These lecture notes
	**Lecture Section & Times:** *A02, MWF 11:30 (Room 208 Armes)* *Dr. JH Page, 334 Allen Bldg, 474-9852* email: jhpage@cc.umanitoba.ca **Consultation Times**: Mon 1:00-2:00, Fri 12:30-2:00 *Lecture notes*
	**Lecture Section & Times:** *A03, MWF 14:30 (Room 200 Armes)* *Dr. M. Gericke, 213 Allen Bldg, 474-6203* email: mgericke@physics.umanitoba.ca **Consultation Times**: Mon, Wed, 10:00-11:30 *Lecture Notes*
	**Lecture Section & Time:** *A04, MTuWThF, 13:30 (Room 315 Machray)* *Dr. M.S. Mathur, 221 Allen Bldg, 474-9378* email: mmathur@cc.umanitoba.ca **Consultation Times**: Mon/Wed/Fri: 9:30 - 10:30

The famous four formulae

$v = v_0 + at$	No x, x_0	(1)
$x - x_0 = v_0 t + \frac{1}{2}at^2$	No final speed, v	(2)
$x - x_0 = \frac{1}{2}(v + v_0)t$	No acceleration, a	(3)
$v^2 - v_0^2 = 2a(x - x_0)$	No time, t	(4)

You will definitely need to know these!

Example: A car accelerates from rest to a final speed in two stages. Each stage takes the same time T.

In stage 1, the car's acceleration is a = 3.0 m/s^2 and ends at speed v_1.

At the end of stage 2, the car is travelling 2.5 times as fast as at the end of stage 1. The acceleration is a′.

Question: what is the acceleration during stage 2?

Hints:

- What is v_1 in terms of a and T ?
- What is the final speed in terms of v_1, a′ and T ?

Clickers!

Prob. 2.C9: A runner runs half the remaining distance to the finish line every ten seconds. She runs in a straight line and does not ever reverse her direction.

Does her acceleration have a constant magnitude?

Hint

- Suppose she starts at 2L from finish, covers a distance L in the first 10 s. Average speed is $v_1 = L/10$.
- In the second 10 s, she covers a distance L/2. Average speed is $v_2 = L/20$, and so on..

Average acceleration is (change in speed)/time – is it same from v_1 to v_2 as it is from v_2 to v_3 in the next 10 s ?

a) the acceleration is constant

b) the acceleration increases

c) the acceleration decreases

Example: In the 100 m dash a sprinter accelerates from rest to a top speed with an acceleration of 2.68 m/s^2. After achieving top speed, he runs the rest of the race at that speed. If the total race is run in 12.0 s, how far does he run while accelerating?

Put T = duration of acceleration, runs a distance x_1 in this time

The remaining time is 12 – T seconds (total time is 12 s)
The remaining distance is 100 - x_1 metres (total distance 100 m)

Initial speed, $v_0 = 0$, final speed, v = ?

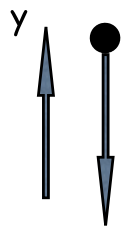
Acceleration, a = 2.68 m/s^2 during time T and zero afterwards

Total distance run = 100 m

Free Fall - negligible air resistance

g = acceleration due to gravity = 9.80 m/s^2

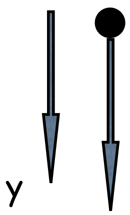
Which way is up? – two choices (equally good)



(1) y-axis is pointing up

Acceleration by gravity is downward, opposite in direction to the y-axis.

a = –g = –9.80 m/s^2



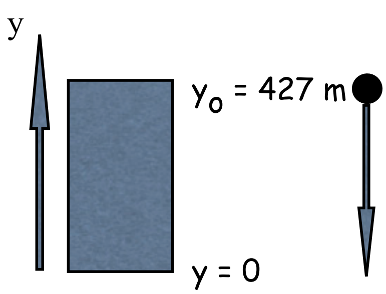
(2) y-axis is pointing down

Acceleration by gravity is downward, in same direction as the y-axis.

a = +g = +9.80 m/s^2

Example: A coin is dropped from the top of a building 427 m high. Ignoring air resistance,

(a) at what speed does the coin hit the ground?
(b) how long does it take to reach the ground?



a = –g = –9.80 m/s^2 v$_0$ = 0

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

a) Speed of hitting the ground: find the equation that involves speed and distance, but not time. $v^2 - v_0^2 = 2a(x - x_0)$

b) Time to reach the ground: what is the average speed on way down?

GENERAL PHYSICS I: PHYS 1020

Schedule - Fall 2007
(lecture schedule is approximate)

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4	M	24	8			Experiment 1: Measurement of Length and Mass
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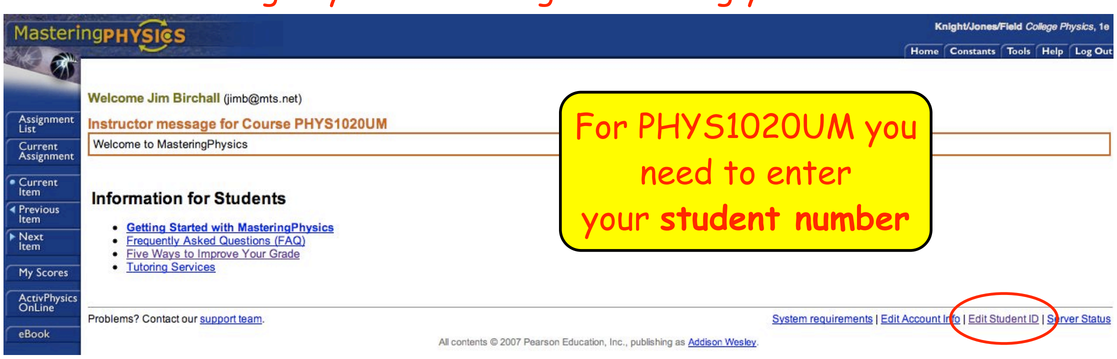
	F	28	10			

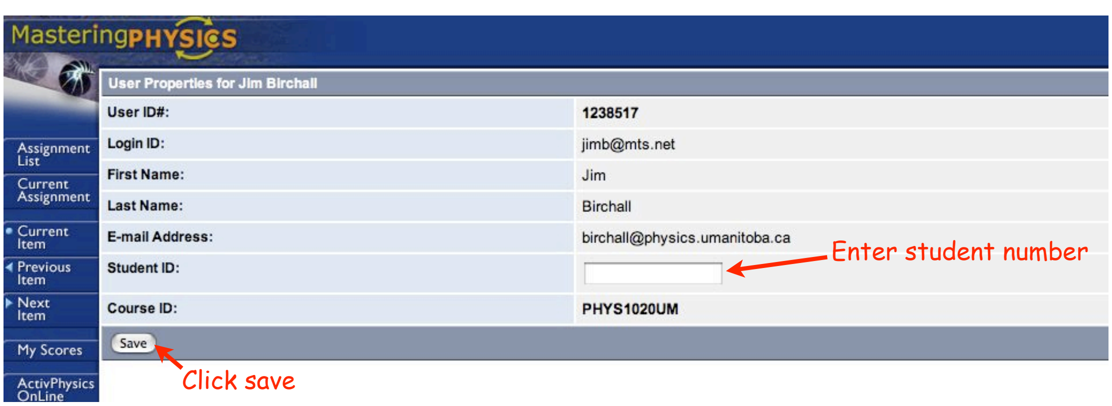
The first lab period is this week

It is the errors lecture (in the lab)

You should attend so you know how to combine errors of measurement

Mastering Physics: Entering/correcting your student ID





Mastering Physics

The first Mastering Physics assignment should be available today, after 5 pm – check PHYS1020 website, or Mastering Physics

It has a number of practice problems and problems for credit

It should be completed by Monday, September 24 at 5 pm

Register for Mastering Physics if you haven't done so already! (5% of final grade is from Mastering Physics assignments)

The famous four formulae

$$v = v_0 + at \quad (1)$$

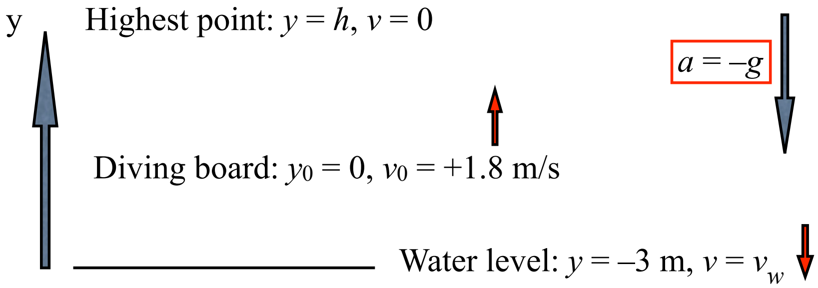
$$x - x_0 = v_0 t + \frac{1}{2}at^2 \quad (2)$$

$$x - x_0 = \frac{1}{2}(v + v_0)t \quad (3)$$

$$v^2 - v_0^2 = 2a(x - x_0) \quad (4)$$

You will definitely need to know these!

Example: A diver springs upward with an initial speed of 1.8 m/s from a 3 m diving board. Find the speed with which he strikes the water and the highest point he reaches.



On entry into water, $y = -3$ m:

$$\begin{aligned} v_w^2 &= v_0^2 + 2a(y - y_0) \\ &= 1.8^2 + 2(-9.8)(-3) \\ v_w &= 7.88 \text{ m/s} \end{aligned}$$

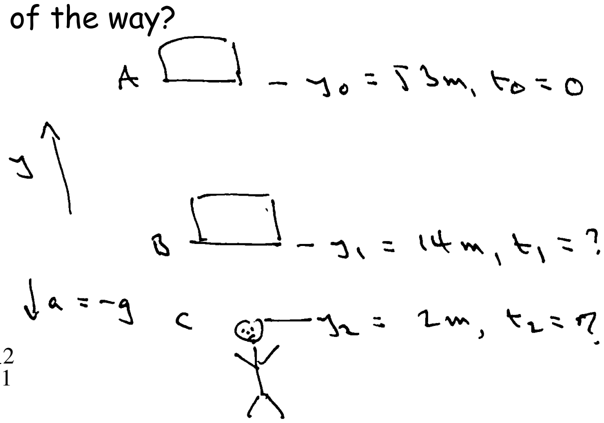
At highest point, $v = 0$:

$$\begin{aligned} v^2 &= v_0^2 + 2a(y - y_0) \\ 0 &= 1.8^2 + 2(-9.8)h \\ h &= 1.8^2/(2 \times 9.8) = 0.17 \text{ m} \end{aligned}$$

As diver is falling, $v_w = -7.88$ m/s

Prob. 2.53/54: A block falls from the top of a building 53 m high. A man 2 m tall notices it when it is 14 m above the ground. How much time does he have to get out of the way?

Use: $x - x_0 = v_0 t + \frac{1}{2}at^2$



At B: $y_1 = y_0 + v_0 t_1 - \frac{1}{2}gt_1^2$

$14 = 53 + 0 - 0.5 \times 9.8 t_1^2$

$\rightarrow t_1 = 2.82$ s

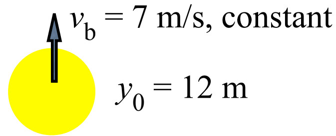
At C: $y_2 = y_0 + v_0 t_2 - \frac{1}{2}gt_2^2$

$2 = 53 + 0 - 0.5 \times 9.8 t_2^2$

$\rightarrow t_2 = 3.23$ s

The time to the crunch is $t_2 - t_1 = 0.41$ s

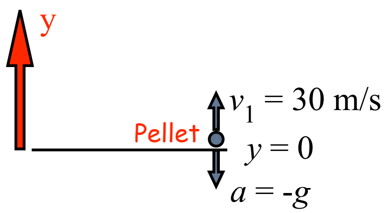
2.78/56: A hot air balloon is ascending straight up at a constant speed of 7.0 m/s. When the balloon is 12.0 m above the ground, a gun fires a pellet straight up from ground level with an initial speed of 30.0 m/s. At what two places are the balloon and pellet at the same height at the same time?



Balloon: $y_b = y_0 + v_b t$

Pellet: $y_p = 0 + v_1 t - \frac{1}{2} g t^2$

Pellet and balloon meet when $y_b = y_p$



$$y_0 + v_b t = v_1 t - \frac{1}{2} g t^2$$

$$\frac{1}{2} g t^2 + (v_b - v_1) t + y_0 = 0$$

$$\text{or, } 4.9t^2 - 23t + 12 = 0$$

$$t = \frac{23 \pm \sqrt{23^2 - 4 \times 4.9 \times 12}}{9.8} = \underline{0.598 \text{ s, or } 4.096 \text{ s}}$$

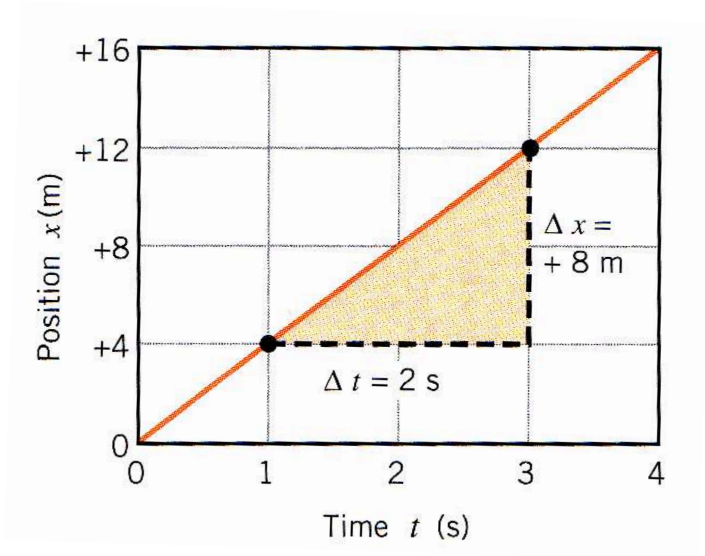
$$\boxed{t = 0.598 \text{ s, or } 4.096 \text{ s}}$$

Balloon: $y_b = y_0 + v_b t \ = 12 + 7t$

So, $y_b = 16.19$ m, or 40.67 m

The pellet passes the balloon on the way up at 16.2 m, then passes it again on the way down at 40.7 m.

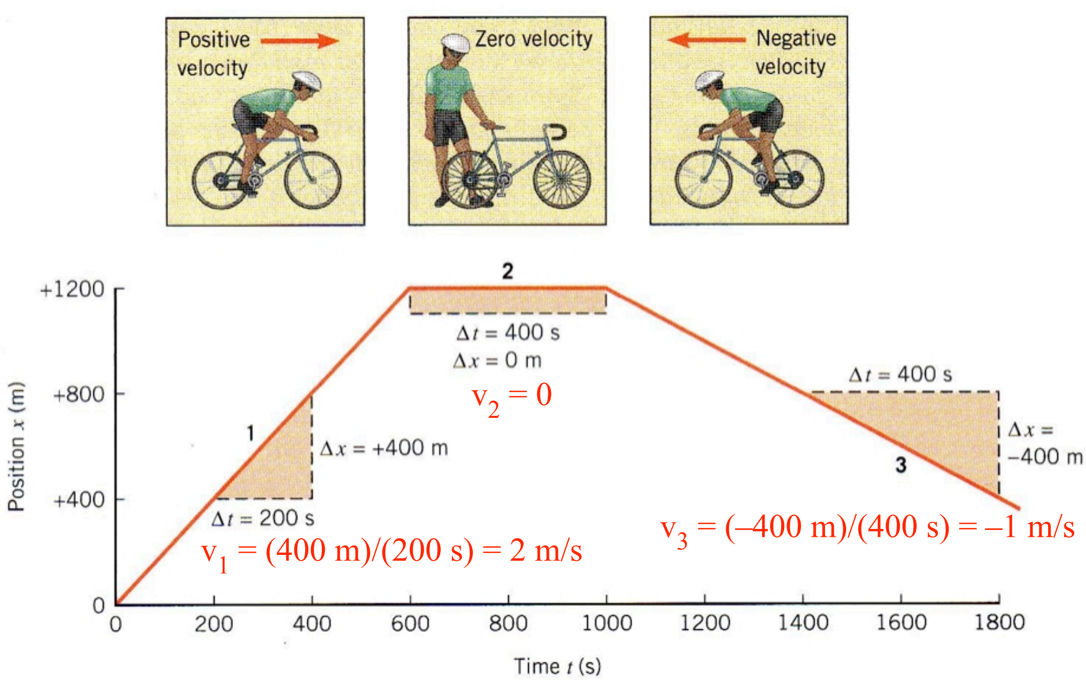
Graphical Analysis



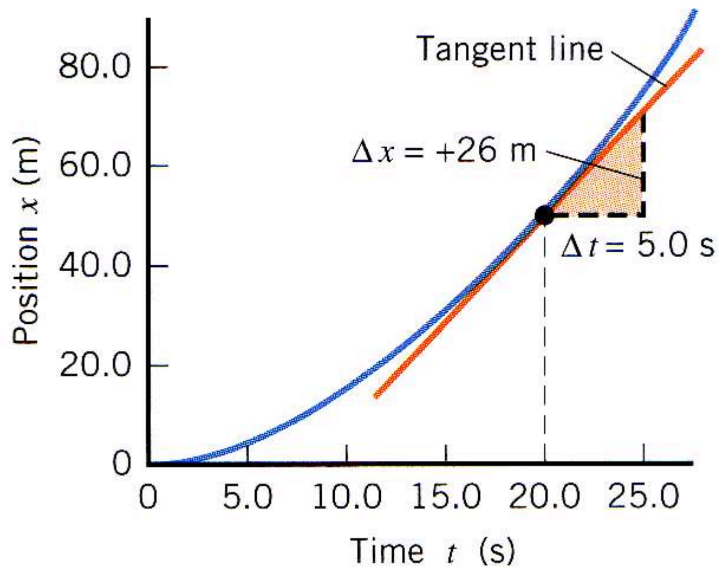
Average speed = $\Delta x/\Delta t$ = (8 m)/(2 s) = 4 m/s

The slope of the curve is constant, so the speed is constant

Changing speed

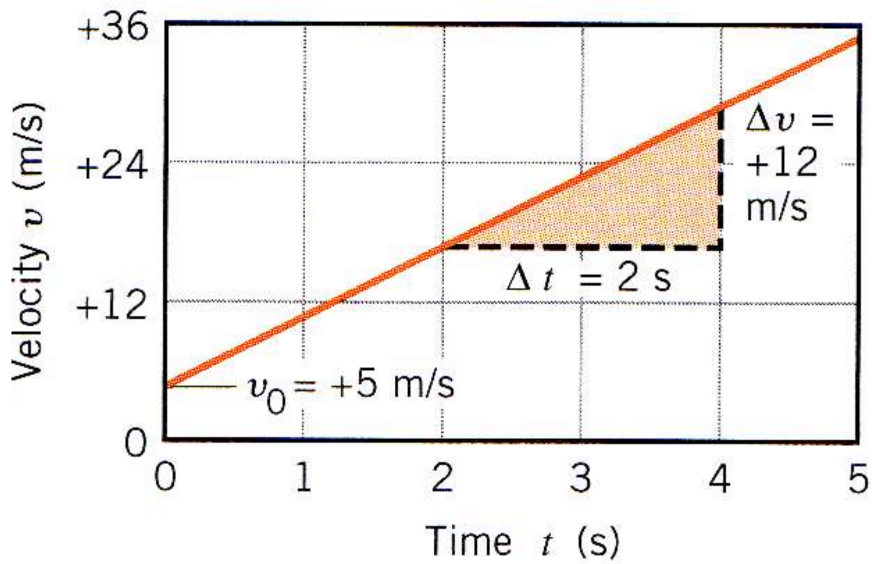


Speed not constant



Instantaneous speed at t = 20 s is (26 m)/(5 s) = 5.2 m/s

Acceleration

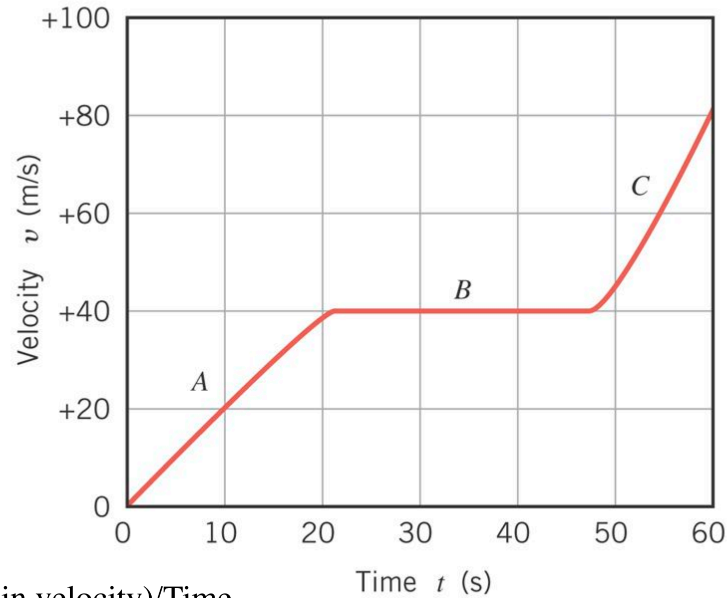


Acceleration = (12 m/s)/(2 s) = 6 m/s^2

The slope of the curve is constant, so the acceleration is constant

2.57/-: A snowmobile moves according to the velocity-time graph shown.

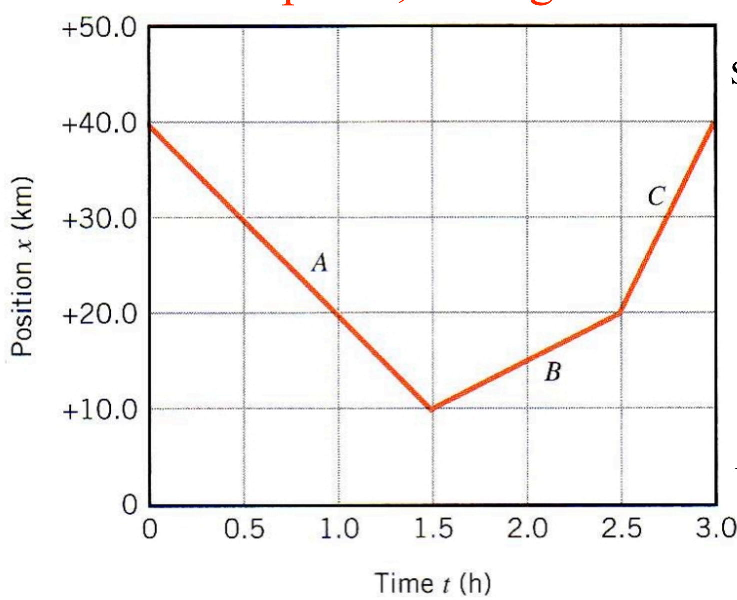
What is its average acceleration during each of the segments, *A*, *B* and *C*?



Acceleration = (change in velocity)/Time

A: $a = 40/20 = 2$ m/s^2
B: $a = 0$ m/s^2
C: $a = (80 - 40)/12 = 3.3$ m/s^2

What are speeds, average acceleration? 2.60/58



$$\text{Speed} = \frac{x_{final} - x_{initial}}{\text{Time}}$$

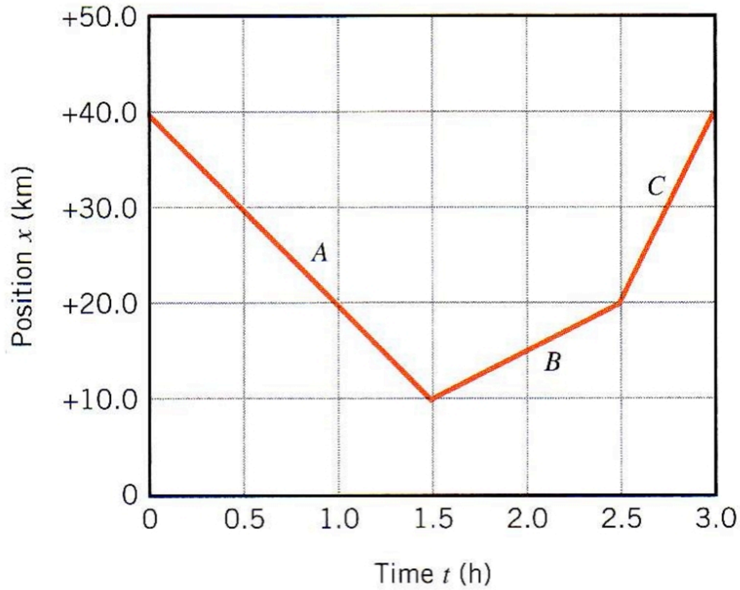
$$v_A = \frac{10-40}{1.5} = -20 \text{ km/h}$$

$$v_B = \frac{20-10}{2.5-1.5} = +10 \text{ km/h}$$

$$v_C = \frac{40-20}{3.0-2.5} = +40 \text{ km/h}$$

$$\text{Average acceleration} = \frac{v_C - v_A}{T} = \frac{40-(-20)}{3} = 20 \text{ km/h}^2$$

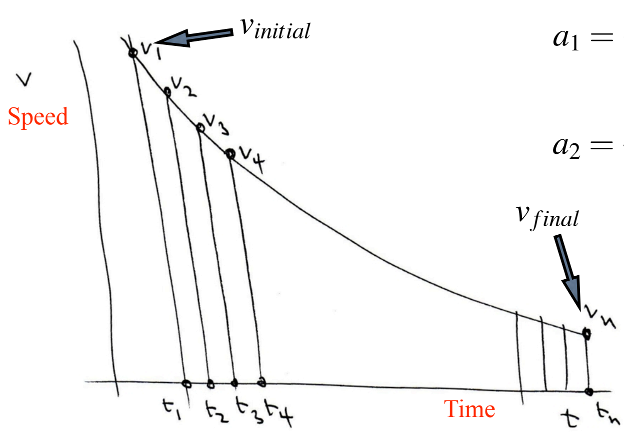
Question about average acceleration



Average acceleration $= \frac{v_C - v_A}{T}$ What about v_B?

Question about average acceleration

Average acceleration is $\bar{a} = \frac{v_{final} - v_{initial}}{T}$



$$a_1 = \frac{v_2 - v_1}{t_2 - t_1} = \frac{v_2 - v_1}{\Delta t},$$

$$a_2 = \frac{v_3 - v_2}{t_3 - t_2} = \frac{v_3 - v_2}{\Delta t}, \text{ etc}$$

Work out the acceleration at each point, make all the time intervals equal:

Question about average acceleration

$$a_1 = \frac{v_2 - v_1}{\Delta t}$$

$$a_2 = \frac{v_3 - v_2}{\Delta t}$$

$$a_3 = \frac{v_4 - v_3}{\Delta t} \text{ etc}$$

Calculate the average acceleration:

$$\bar{a} = [a_1 + a_2 + \ldots + a_n] \times \frac{1}{n}$$

$$= \frac{(\cancel{v_2} - v_1) + (v_3 - \cancel{v_2}) + \ldots}{\Delta t} \times \frac{1}{n}$$

All of the speeds cancel apart from v_1 and v_n, the first and last values

The total elapsed time is $T = n\Delta t$

So, the average acceleration is $\bar{a} = \dfrac{v_{final} - v_{initial}}{T}$

Speed, Velocity and Acceleration

$$\text{Average speed} = \frac{\text{Distance}}{\text{Elapsed time}} = \frac{x - x_0}{t - t_0}$$

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Elapsed time}} = \frac{\Delta \vec{x}}{t - t_0}$$

$$\text{Instantaneous velocity } \vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t}$$

$$\text{Average acceleration} = \frac{\text{change in velocity}}{\text{elapsed time}} = \frac{\vec{v} - \vec{v}_0}{t - t_0}$$

$$\text{Instantaneous acceleration} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t}$$