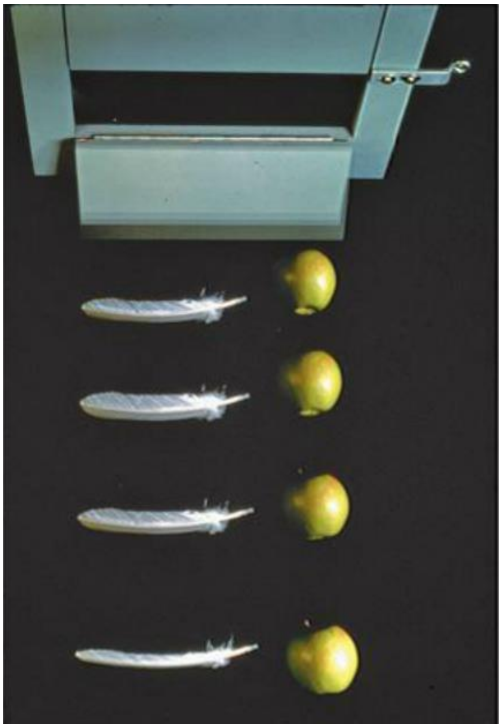
PHY131H1F
Class 5



Today, Chapter 2, Sections 2.5 to 2.7

- Freefall
- Acceleration due to gravity
- Motion on an inclined plane
- Differentiating velocity to get acceleration
- Integrating acceleration to get velocity
- Non-constant acceleration

Clicker Question

- What does the speedometer in your car measure?

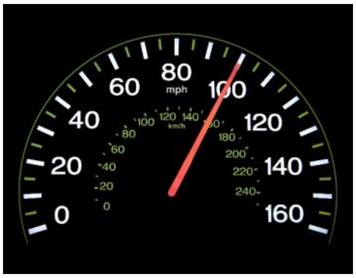
A. distance traveled

B. average speed

C. average velocity

D. instantaneous speed

E. instantaneous velocity



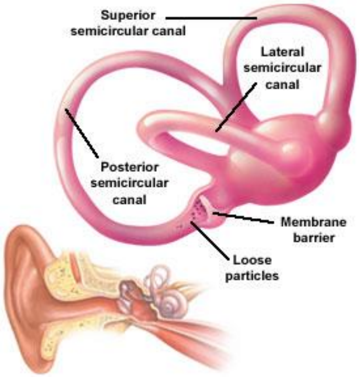
[image downloaded Jan. 9 2013 from http://phoneky.com/applications/?p=preview&id=a1a32446&st=2]

Last day I asked at the end of class:

Video by Aaron Lazare http://youtu.be/sxkcHnogPLE]

- Which is easier to **see**: velocity or acceleration?
- ANSWER: velocity. Our eyes are very good at noticing when things are moving, but it is difficult to tell if an object is accelerating or not just by looking at it.

- Which is easier to **feel**: velocity or acceleration?
- ANSWER: acceleration. Since velocity is relative, it is actually **impossible** to feel if you are moving or not! But it is very easy to feel if you are accelerating. The semicircular canals in your ears are designed specifically to detect acceleration.



Clicker Question

- Your car starts at rest, and then you speed up to a maximum of 120 km/hr over a time of 25 seconds. During this time:

A. both your velocity and acceleration were constant.

B. your velocity was constant, but your acceleration was changing.

C. your velocity was changing, but your acceleration was constant.

D. both your velocity and acceleration were changing.

Very few things in real life have constant acceleration!!!

- For something to have constant acceleration, all the forces on the object must remain **constant** as it moves.
- This is rare; it is usually **NOT** true for people that are running or walking, automobiles, trains, or animals.
- Two things actually **do** have constant acceleration:
  - **Objects in freefall** (flying through space under the influence of gravity only with negligible air resistance)
  - **Objects sliding or rolling down an inclined plane** (with negligible friction)

Acceleration due to Gravity

In ~1600, Galileo measured the acceleration of marbles rolling down inclined planes. He found:

- Steeper inclines gave greater accelerations.
- When the incline was vertical, acceleration was a certain maximum, same as that of a freely falling object.
- When air resistance was negligible, all objects fell with the same unchanging acceleration.

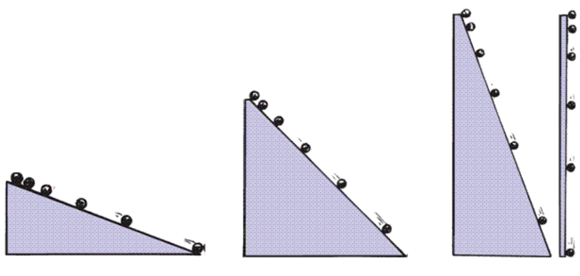
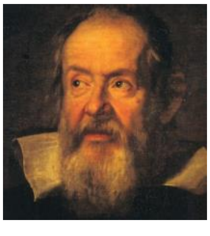


Image of Galileo downloaded Sep. 20 2013 from: http://commons.wikimedia.org/wiki/File:Galileo-sustermans.jpg]



Free Fall

= Falling under the influence of gravity only, with no air resistance.

- Freely falling objects on Earth accelerate at the rate of 9.8 m/s/s, i.e., 9.8 m/s^2
- The exact value of free fall acceleration depends on altitude and latitude on the earth.

Acceleration Due to Gravity, g in m/s^2

Country	City	G-Constant	Country	City	G-Constant
Argentina	Buenos Aires	9.7979	Mexico	Mexico City	9.7799
Australia	Sydney	9.7979	Morocco	Rabat	9.7964
Austria	Vienna	9.8099	Netherlands	Amsterdam	9.8129
Belgium	Brussels	9.8114	New Zealand	Wellington	9.8039
Belize	Manamah	9.7904	Norway	Oslo	9.8189
Bolivia	La Paz	9.7844	Panama	Panama City	9.7814
Brazil	Brasilia	9.7889	Peru	Lima	9.7829
Canada	Montreal	9.8069	Philippines	Manila	9.7844
	Ottawa	9.8069	Poland	Swider	9.8159
	Toronto	9.8054	Portugal	Lisbon	9.8009
	Vancouver	9.8099	Rumania	Bucharest	9.8054
Czeck Republic	Prague	9.8114	Saudi Arabia	Riyad	9.7904
Chile	Santiago	9.7979	Sweden	Stockholm	9.8189
China	Hong Kong	9.8099	Singapore	Singapore	9.7814
Colombia	Bogota	9.7799	South Africa	Johannesburg	9.7919
Costa Rica	San Jose	9.7829	Spain	Madrid	9.8024
Cypress	Nicosia	9.7979	Switzerland	Bern	9.8084
Denmark	Copenhagen	9.8159	Taiwan	Taipei	9.7904
Ecuador	Quito	9.7724	Tunisia	Tunis	9.7799
Finland	Helsinki	9.8189	Turkey	Ankara	9.8024
Germany	Dusseldorf	9.8129	Uruguay	Montevideo	9.7964
Great Britain	London	9.8144	USA	Anchorage	9.8189
Greece	Athens	9.8009		Atlanta	9.7964
Guatemala	Guatemala City	9.7844		Boston	9.8039
Hungary	Budapest	9.8069		Chicago	9.8024
Indonesia	Djakarta	9.7814		Dallas	9.7949
Iraq	Baghdad	9.7964		Detroit	9.8039

- Average: 9.799 m/s^2
- For Problem Sets, Tests and the Exam in this class: let's use $g = 9.80\ m/s^2$

Free Fall—How Fast?

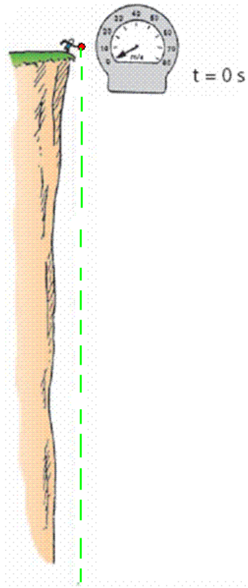
The velocity acquired by an object starting from rest is

Velocity = acceleration x time

So, under free fall, when acceleration is 9.8 m/s^2, the speed is

- 9.8 m/s after 1 s.
- 19.6 m/s after 2 s.
- 29.4 m/s after 3 s.

And so on.



Clicker Question

A tennis ball is thrown directly upward, and air resistance on the ball is negligible as it flies.

At one instant, it is traveling upward with a speed of 4.9 m/s.

1.0 seconds later, what will its speed be?

A. 0

B. 4.9 m/s

C. 9.8 m/s

D. 15 m/s

E. 20 m/s

Free Fall—How Far?

The distance covered by an accelerating object starting from rest is

Distance = (1/2) x acceleration x time x time

So, under free fall, when acceleration is 9.8 m/s^2, the distance is:

- 4.9 m after 1 s,
- 20 m after 2 s,
- 44 m after 3 s,

and so on…

Freefall Example

a. What is the instantaneous velocity of a freely falling object 10.0 s after it is released from a position of rest?
b. What is its average velocity during this 10.0 s interval?
c. How far will it fall during this time?

Announcements

- The first term test will be on Tuesday, Sep 30, from 6:00pm to 7:30pm.
- Test 1 will cover chapters 1-3 plus the Error Analysis Mini-Document, plus what was done in Practicals
- You must bring a calculator and one 8.5x11' aid sheet which you prepare, double-sided
- If you have a conflict at that time with an academic activity (test, lecture, tutorial, lab), you must register to write at the alternate sitting of this test by going to portal and filling out the online form no later than Sep. 25 by 4:00pm.

Clicker Question

A 600 g basketball and a 60 g tennis ball are dropped from rest at a height of 3 m above the ground. As they fall to the ground, air resistance is negligible.
Which of the following statements is true for the balls as they fall?

A. The force of gravity is 10 times greater on the basketball than on the tennis ball
B. The force of gravity is the same on both balls
C. The force of gravity is slightly larger on the basketball than on the tennis ball

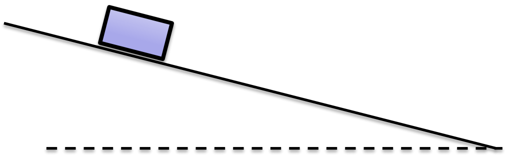
Clicker Question

A 600 g basketball and a 60 g tennis ball are dropped from rest at a height of 3 m above the ground. As they fall to the ground, air resistance is negligible.
Which of the following statements is true for the balls as they fall?

A. The acceleration of the basketball is 10 times greater than the acceleration of the tennis ball
B. The acceleration of both balls is the same
C. The acceleration of the basketball is slightly larger than the acceleration of the tennis ball

Motion on an Inclined Plane

- Consider an object sliding down a straight, frictionless inclined plane



Clicker Question

(From the PHY131H1F Midterm Test 1, Fall 2013.)

At time $t = 0$, small red marble is released from rest at the top of a smooth, frictionless incline that is at an angle θ relative to the horizontal. The red marble begins rolling down the incline. A short time later, when $t = T$, a blue marble is released from rest at the top of the same incline, and begins to roll in the same direction as the red marble. At a time $t = 2T$, what is the speed of the red marble relative to the blue marble?

A. $Tg\sin(\theta)$

B. $2Tg\sin(\theta)$

C. $\frac{1}{2}T^2 g\sin(\theta)$

D. $\frac{3}{2}T^2 g\sin(\theta)$

E. zero

Instantaneous Acceleration

The instantaneous acceleration a_s at a specific instant of time t is given by the derivative of the velocity

$$a_s \equiv \lim_{\Delta t \to 0} \frac{\Delta v_s}{\Delta t} = \frac{dv_s}{dt} \qquad \text{(instantaneous acceleration)}$$

Note: Knight uses "s" to denote a distance in a general direction. Usually in problems we substitute x or y instead of s.

Finding Velocity from the Acceleration

If we know the initial velocity, v_{is}, and the instantaneous acceleration, a_s, as a function of time, t, then the final velocity is given by

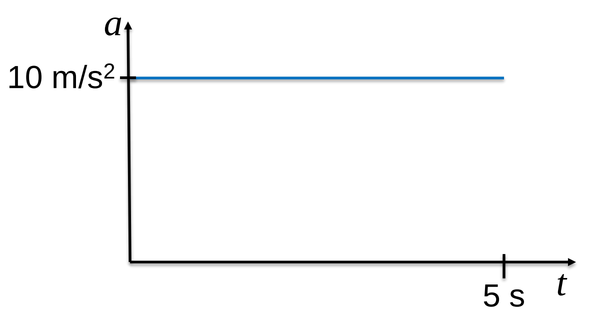
$$v_{fs} = v_{is} + \lim_{\Delta t \to 0} \sum_{k=1}^{N} (a_s)_k \Delta t = v_{is} + \int_{t_i}^{t_f} a_s \, dt$$

Or, graphically,

$v_{fs} = v_{is}$ + area under the acceleration curve a_s between t_i and t_f

Clicker Question 7

- An object starts at rest, and has a constant acceleration of +10 m/s^2 for 5 seconds.



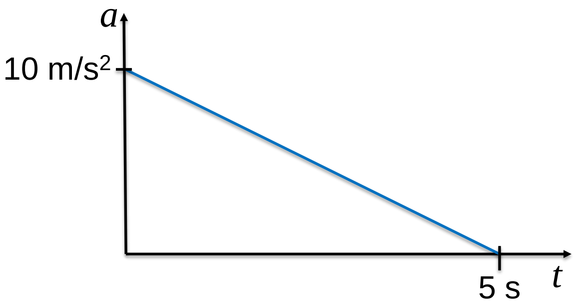
- How fast is the object going after 5 seconds?

A. 10 m/s
B. 25 m/s
C. 50 m/s
D. 100 m/s
E. 500 m/s

Clicker Question 8

- An object starts at rest, and has an initial acceleration of +10 m/s^2.
- As it speeds up, its acceleration decreases at a constant rate.
- After 5 seconds, it is traveling at a constant velocity ($a = 0$).
  - How fast is the object going after 5 seconds?

A. 10 m/s
B. 25 m/s
C. 50 m/s
D. 100 m/s
E. 500 m/s



When Acceleration Changes Abruptly

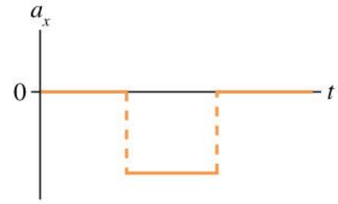
- Consider an object that has a constant acceleration, a_1, from t_A until t_B
- At t_B its acceleration suddenly changes to a_2, and remains constant until t_C.
- Strategy:
  – Divide the motion into segments 1 & 2.
  – You can use the equations of constant acceleration in each segment
  – The final position and velocity of segment 1 become the initial position and velocity of segment 2.

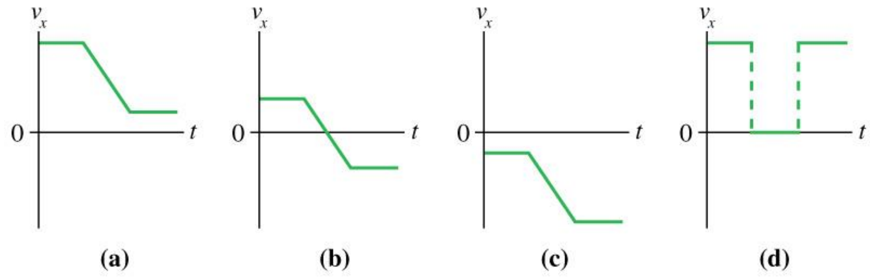
Challenge Problem 2.77

A rocket is launched straight up with constant acceleration. Four seconds after liftoff, a bolt falls off the side of the rocket. The bolt hits the ground 6.0 s later. What was the rocket's acceleration?

Clicker Question

Which velocity-versus-time graph or graphs goes with this acceleration-versus-time graph? The particle is initially moving to the right and finally to the left.





Before Class 6 on Wednesday

- Please read Chapter 3 of Knight.
- There is a MasteringPhysics PreClass Quiz on chapter 3 due Wed. 8am.
- Something to think about: Can you add a scalar to a vector? Can you multiply a vector by a scalar?