Spring 2014

PHYS-2010

Lecture 13

Clicker Question

Room Frequency BA

$$(1)\ t_{max} = \frac{2v_0 \sin\theta}{g} \qquad (2)\ H = \frac{v_0^2 \sin^2\theta}{2g} \qquad (3)\ R = \frac{v_0^2 \sin 2\theta}{g}$$

If you fire a projectile from ground level, it hits the ground some distance *R* away (the range) at some time *t*.

If you keep the launch angle fixed, but double the initial launch speed, what will happen to the **time t** at which it hits the ground?

(A) Twice as large.

(B) Four times as large.

(C) Eight times as large.

(D) Something else.

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If you fire a projectile from ground level, it hits the ground some distance *R* away (the range) at some time *t*.

If you keep the launch angle fixed, but double the initial launch speed, what will happen to the **Range *R*** of flight?

(A) Twice as large.

(B) Four times as large.

(C) Eight times as large.

(D) Something else.

Announcements

- Read Giancoli Chapter 4 (sections 4.1-4.6).
- **CAPA # 5** is due next Tuesday at 11 pm.
- **Written homework # 3 due on Friday** this week.
- Reminder: there are several links to various useful **resources** on the course website (under the right-most tab "Resources"):
  - Giancoli Textbook website;
  - PhET simulations;
  - Thinkwell;
  - Prof. Dubson's Notes (under "Lecture Info" tab)

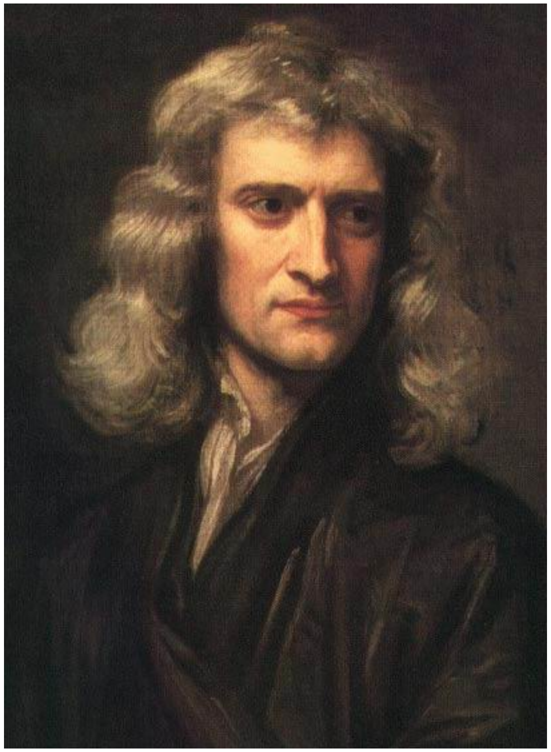
We now know some of the basics about how objects move under constant acceleration.

Kinematics.

We now want to know why what causes these accelerations (forces).

Dynamics

Dynamics: Newton's Laws of Motion



Isaac Newton: 1643-1727

English physicist, mathematician, astronomer, natural philosopher, alchemist, and theologian.

1687: Philosophiæ Naturalis Principia Mathematica.

Newton described universal gravitation and the three laws of motion.

Showed that the motion of objects on Earth and of celestial bodies are governed by the same set of natural laws, thus removing the last doubts about heliocentrism and advancing the scientific revolution.

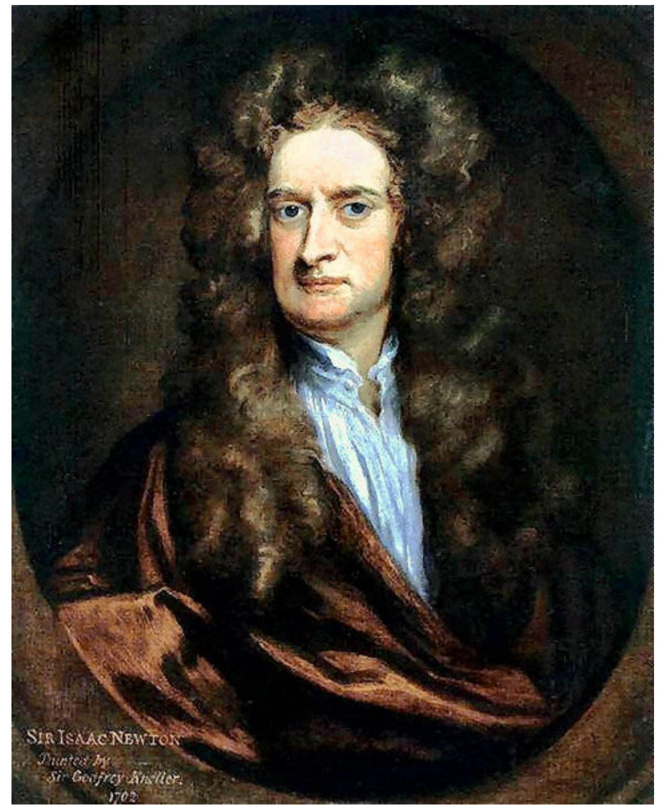
Dynamics: Newton's Laws of Motion

Mechanics:

Three laws of motion.

Conservation laws: momentum, angular momentum.

Gravitation. (Coined the term "gravity".)



Optics:

Built the first "practical" reflecting telescope.

Developed a theory that white light is composed of different wavelengths of light.

Mathematics:

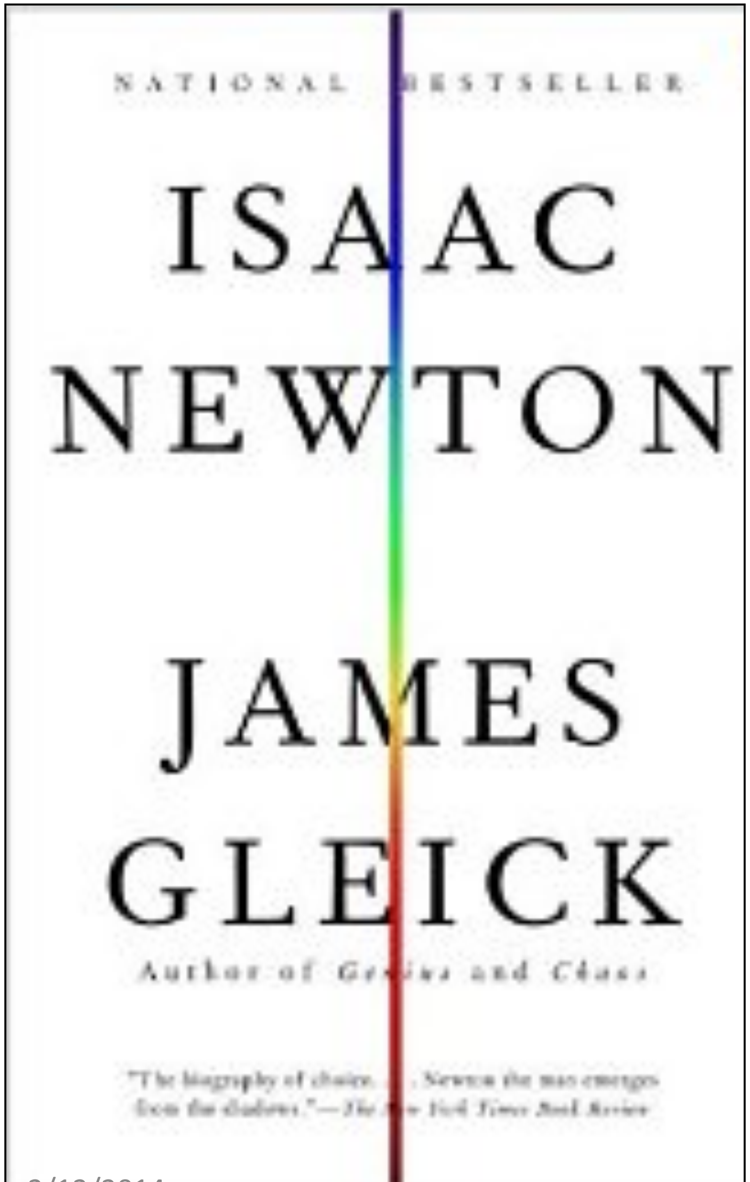
Invented the calculus (with Leibniz).

Biblical hermeneutics:

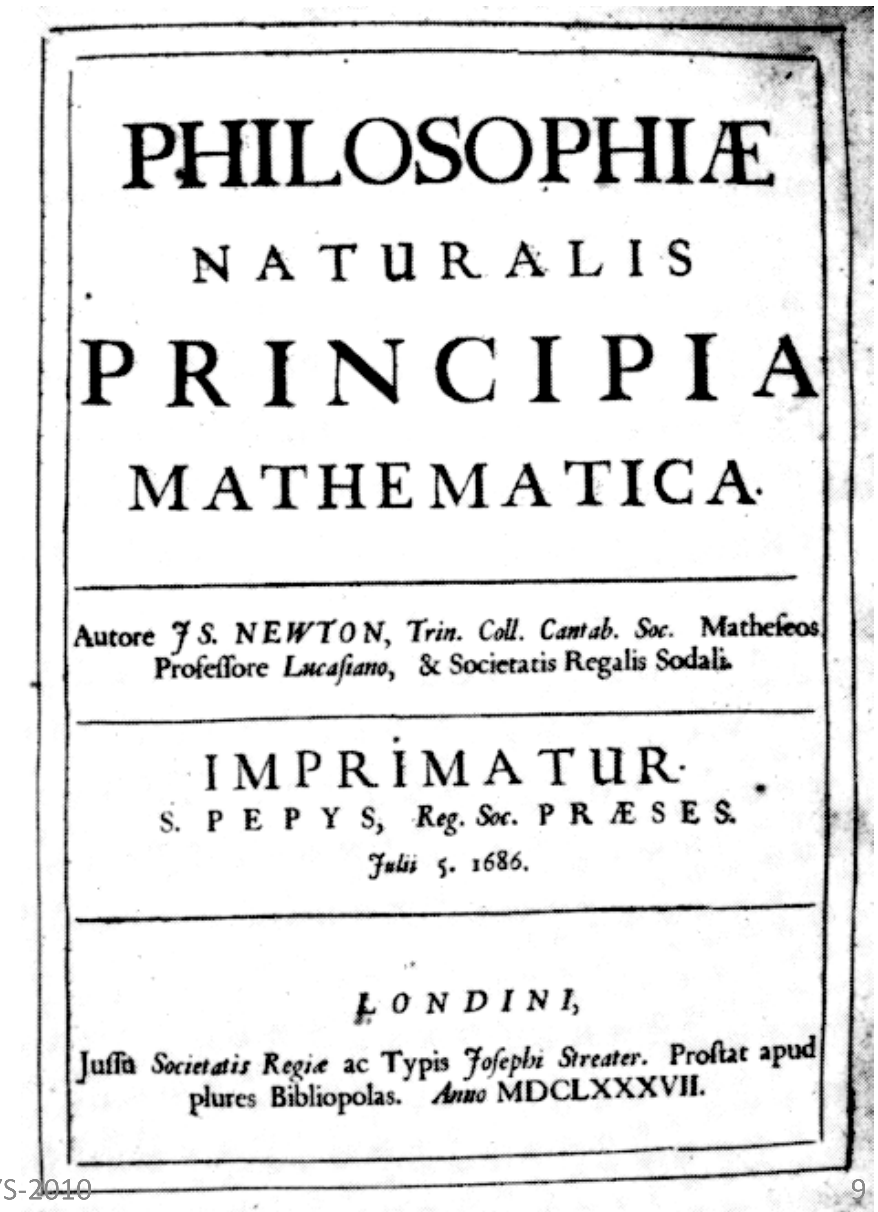
Wrote many religious tracts.

Alchemist: $Pb \rightarrow Au$

Excellent biography of Newton.
Very interesting insight on character.



Reminds one why they called
it Philosophy back then.



Newton's Three Laws

Newton's Laws (as stated) hold in an
"Inertial Reference Frame" (non-rotating / non-accelerating):

I. "Law of Inertia": Every object continues in its state of rest or uniform motion (constant velocity along a straight line), as long as ***no net force*** acts on it.

II. Acceleration is proportional to force and inversely proportional to mass. Famous $\vec{F}_{\text{net}} = m\vec{a}$ equation.

III. Whenever one object exerts a force on a second object, the second exerts an equal force in the opposite direction on the first. $\vec{F}_{\text{AB}} = -\vec{F}_{\text{BA}}$

Newton's First Law

Every object continues in its state of rest, or of uniform velocity in a straight line, as long as no net force acts on it.

Ancients believed that either rest (terrestrial bodies) or circular motion (celestial bodies) was the natural state of objects.

An object moving at some velocity usually slows down to a stop, and thus it seemed that rest was the natural state.

Galileo thought that this was not true and that without friction or air resistance an object in motion would simply continue in motion. Newton liked this idea.

Cases with very, very little friction demonstrate this physics.

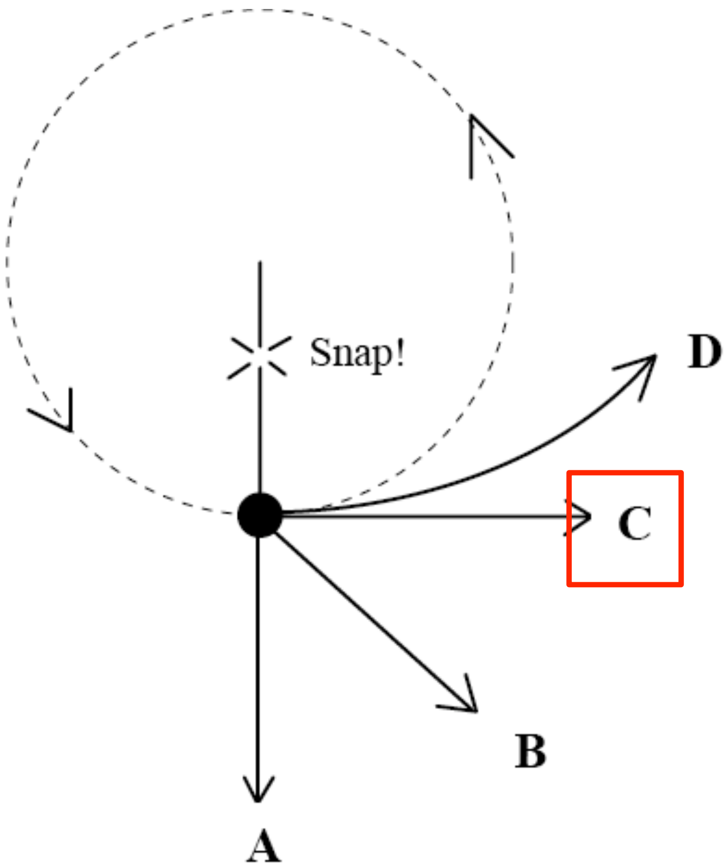
http://en.wikipedia.org/wiki/Curling

Clicker Question

Room Frequency BA

An astronaut in intergalactic space is twirling a rock on a string. Suddenly the string breaks when the rock is at the point shown.

Which path (A, B, C, or D) does the rock follow after the string breaks?



At the point indicated the rock has a velocity vector to the right.

When the string breaks, there are no more forces acting on the rock.

According to Newton's first law, the rock must move with constant velocity in a straight line.

Clicker Question

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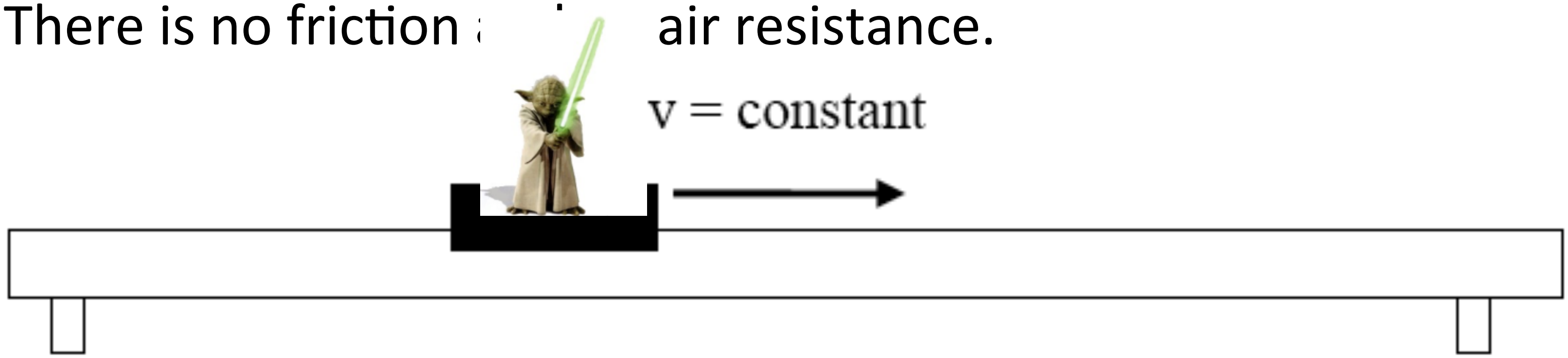
Yoda is gliding along an air track at constant speed.
There is no friction a … air resistance.



What can you say about the net force (total force) on the glider?

A) The net force is zero.

B) The net force is non-zero and is in the direction of motion.

C) The net force is non-zero and is in the direction opposite the motion.

D) The net force is non-zero and is perpendicular to the motion.

Velocity is constant, thus acceleration is zero.
$F = ma = 0$. So, net force is zero.

Newton's Second Law

Acceleration is proportional to force and inversely proportional to mass.

$$\vec{F}_{\text{net}} = m\vec{a} \qquad \vec{a} = \vec{F}_{\text{net}} / m$$

Knowing the forces acting on an object of mass (*m*), we can calculate the accelerations.

Then we can use these accelerations to calculate the kinematics (motion).

Note that the direction of the acceleration is the same as the direction of the net force vector.

The **unit of force** in the SI system is the **Newton (N)**.

Note that the pound is a unit of force, not of mass, and can therefore be equated to Newtons but not to kilograms.

1 Newton ~ 0.22 pounds.

TABLE 4–1
Units for Mass and Force

System	Mass	Force
SI	kilogram (kg)	newton (N) $(= kg \cdot m/s^2)$
cgs	gram (g)	dyne $(= g \cdot cm/s^2)$
British	slug	pound (lb)

Conversion factors: 1 dyne $= 10^{-5}$ N; 1 lb $\approx$ 4.45 N.

Force is a vector, so **Newton's 2nd Law** is a vector equation:

$$\vec{F} = m\vec{a} \quad \longrightarrow \quad \begin{cases} F_x = ma_x \\ F_y = ma_y \end{cases}$$