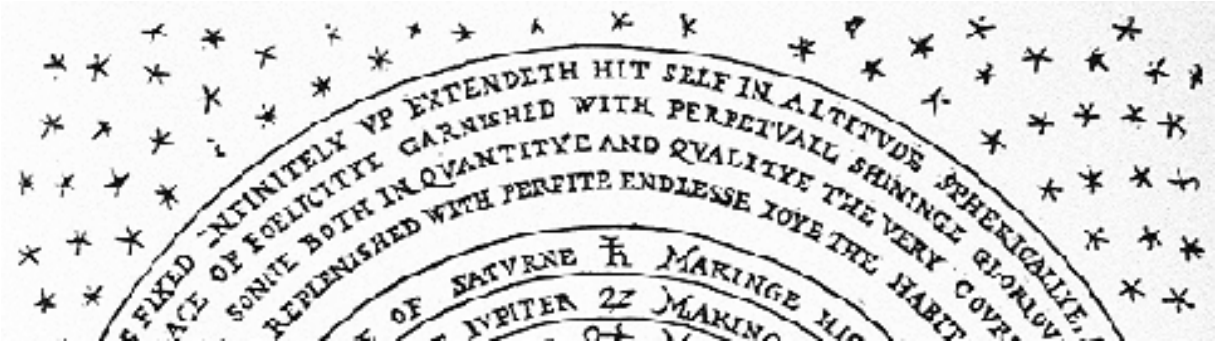


PHY1033C/HIS3931/IDH 3931 : Discovering Physics:

The Universe and Humanity's Place in It

Fall 2016

Prof. Peter Hirschfeld, Physics

Announcements

- Reading this week: Gregory, Chapter 8

Observations of the moon,
The Moon as a Falling Body
Newton's Cannon

- HW6 due Tues. Oct. 18; No HW this week

- Midterm announcemtns

Midterm exam

- In class Thursday, Oct. 20
- Covers all material up through Tuesday (Galileo)
- Bring: ID, scratch paper, calculator
- Format: 30% mult. choice 40% short answer 30% essay (choice of 2)
- Test review sessions (general)
  -NPB East lounge 5pm Monday (Ariel)
  -NPB 2165 5:30pm Wednesday (PH)
- 1 side paper “cheat sheet” (handwritten) allowed

Last time

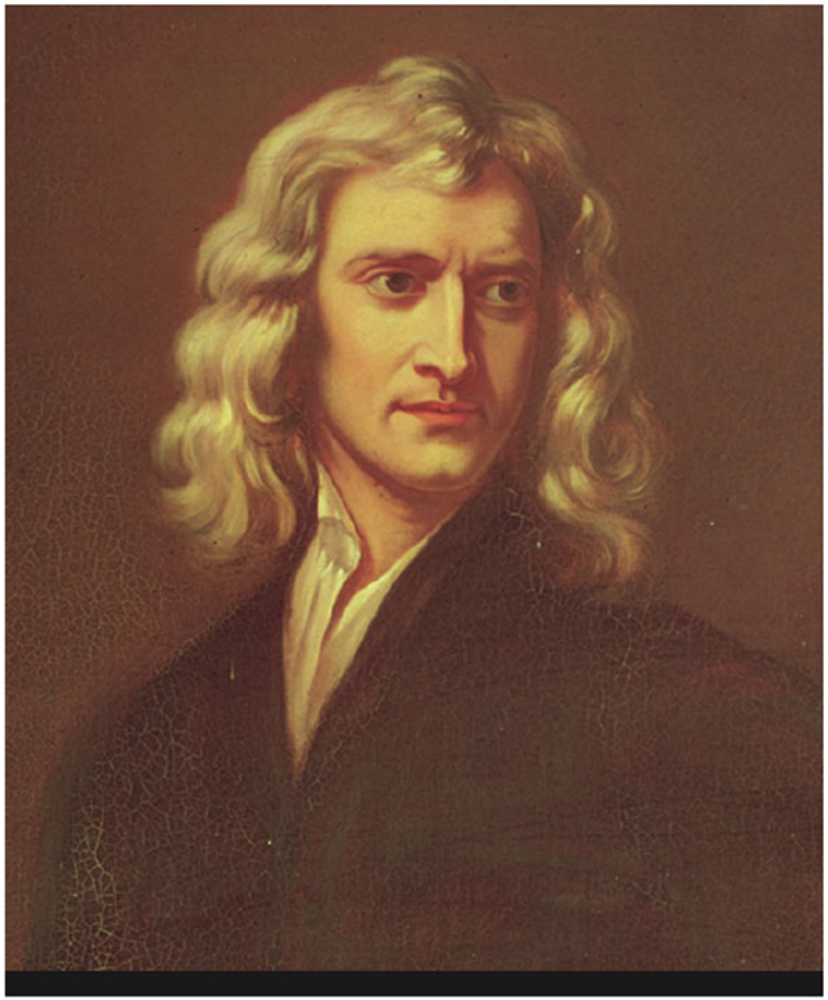
- Publication (1610) of Starry Messenger : moons of Jupiter, craters on the moon, many new stars
- Galileo's discovery of the phases of Venus (1610)
- Galileo's disguised Copernicanism begins to worry Church authorities; Galileo denounced 1613
- 1616 he goes to Rome to fix things up, is forbidden to teach or hold Copernican ideas; soon prohibition applied to everyone
- Galileo searches for way to prove Earth moves; starts thinking about motion at Earth's surface. He decides a ship in uniform (circular) motion (around the Earth) has the same physical laws as one at rest ("relativity"). Tries to make a (failed) theory of the tides.
- Publication and withdrawal of Dialogue Concerning two Chief World Systems (1632); trial (1633) condemns Galileo for heresy

Which of the following statement about Galileo's Dialogue Concerning the Two Chief World Systems is incorrect?

1. The "dialogue" was between three imaginary characters arguing the merits of theories of the solar system.
2. One character, Simplicio, made obviously stupid arguments that angered Pope Urban VIII
3. It was published, but immediately forbidden by the Vatican.
4. The two systems in the title were a) Copernican and b) Tychonian
5. It was written in Italian rather than Latin, because Galileo wanted everyone to be able to read it.

Sir Isaac Newton

- 1642 – 1727
- Formulated basic concepts and laws of mechanics
- Universal Gravitation
- Calculus
- Light and optics



Newton's First Law (inertia)

- An object moves with a velocity that is constant in magnitude and direction, unless acted on by a nonzero total force

  (The total force is defined as the vector sum of all the external forces exerted on the object)

"An object at rest remains at rest; an object in motion remains in motion, unless acted upon by a force"

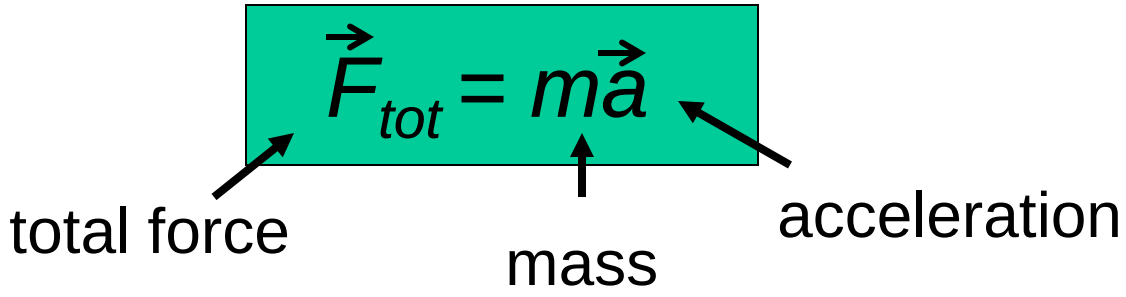
Inertia: the tendency of an object to continue in its original motion

Mass: measure of inertia

- Or, a measure of the resistance of an object to changes in its motion due to a force
- A *scalar* – has no direction
- SI units are kg

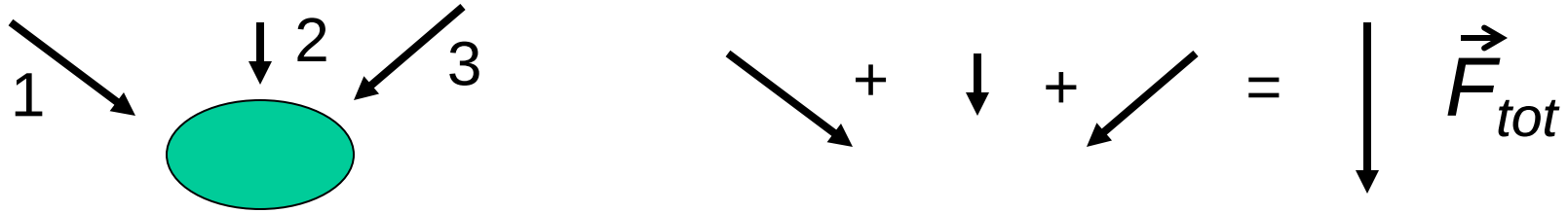
Newton's Second Law

- The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

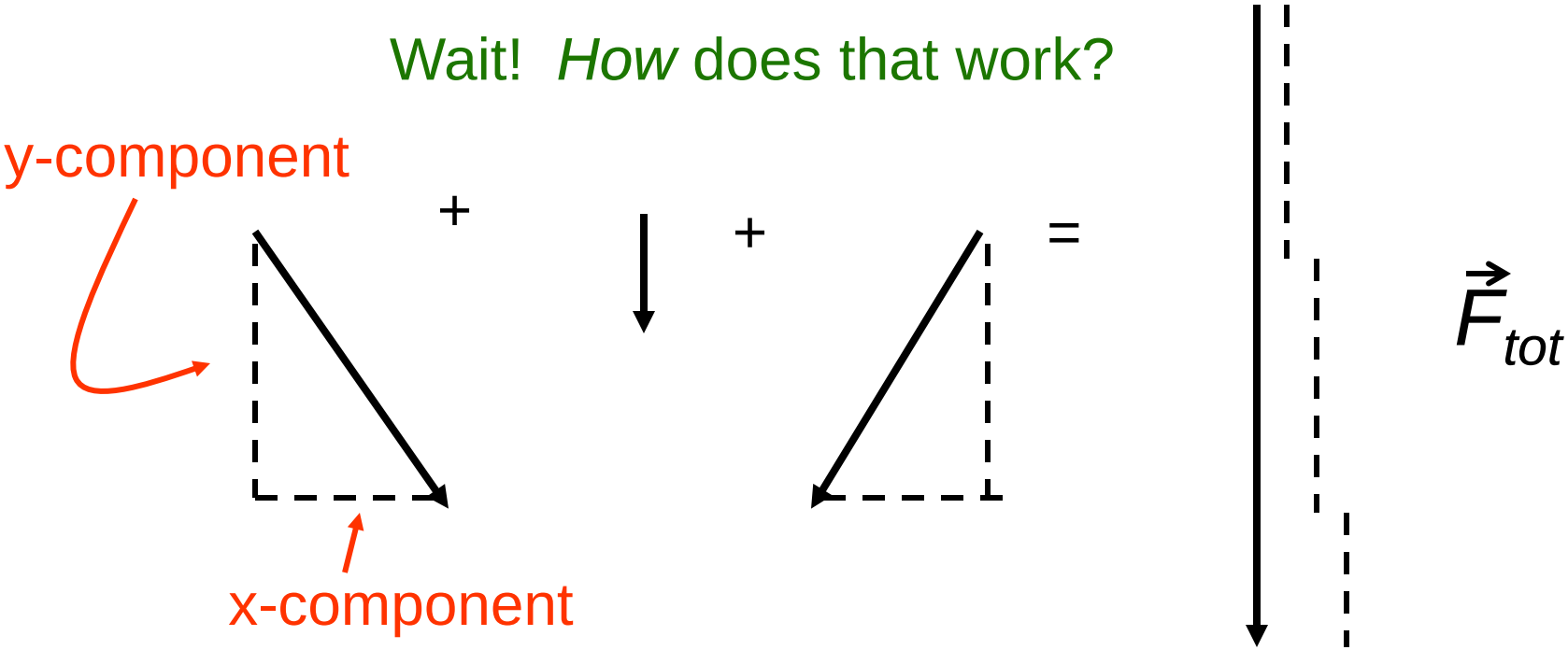


$\vec{F}_{tot}$ and $\vec{a}$ are both *vectors* – they have a direction

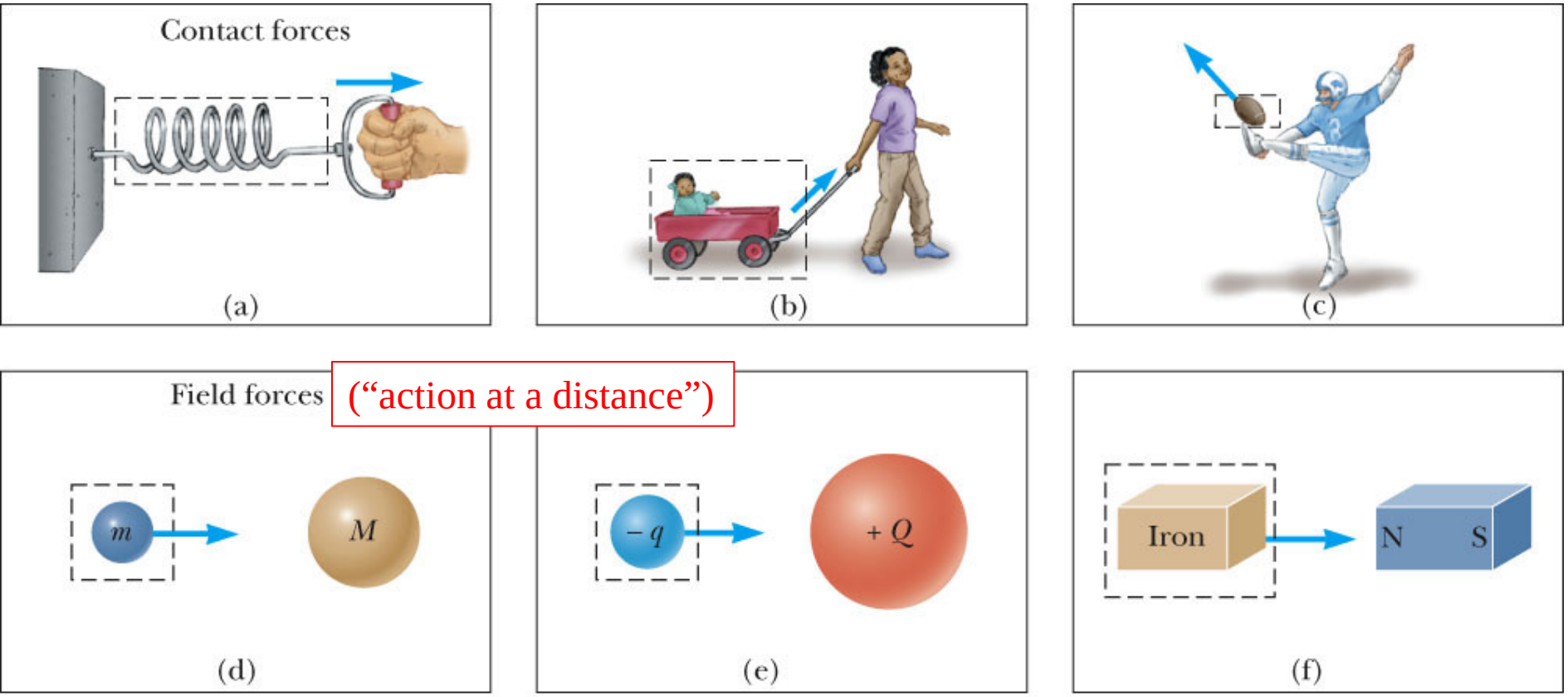
Here $\vec{F}_{tot}$ is the sum of *all* the forces acting *on* the object itself.



Wait! *How* does that work?



Contact and Field Forces



Units of Force

- SI unit of force is a Newton (N)

$$1\,\mathrm{N} \equiv 1\,\frac{\mathrm{kg\,m}}{\mathrm{s}^2}$$

- US Customary unit of force is a pound (lb)

$$1\ \mathrm{N} = 0.225\ \mathrm{lb}$$

Clicker question

A constant force is exerted for a short time interval on a cart that is initially at rest on an air track. This force gives the cart a certain final speed. The same force is exerted for the same length of time on another cart, also initially at rest, that has twice the mass of the first one. The final speed of the heavier cart is

1. one-fourth
2. four times
3. half ✓
4. double
5. the same as

Gravitational Force

- Mutual force of attraction between any two objects with mass *in the universe*
- Expressed by Newton's Law of Universal Gravitation:

$$F_g = G\frac{m_1 m_2}{r^2}$$

Weight

- The magnitude of the gravitational force acting on an object of mass *m* near the Earth's surface is called the weight *w* of the object

  W = *mg* is a special case of Newton's second Law

  - *g* is the acceleration due to gravity=9.8 m/s^2
- *g* can also be found from the Law of Universal Gravitation

Clicker question 3

Krypton is planet with the same radius as earth but 100 times the mass. Superman's weight on that planet would be:

A. 10 times that on earth

B. Same as that on earth

$$F_g = G\frac{m_1 m_2}{r^2}$$

C. 1000 times that on earth

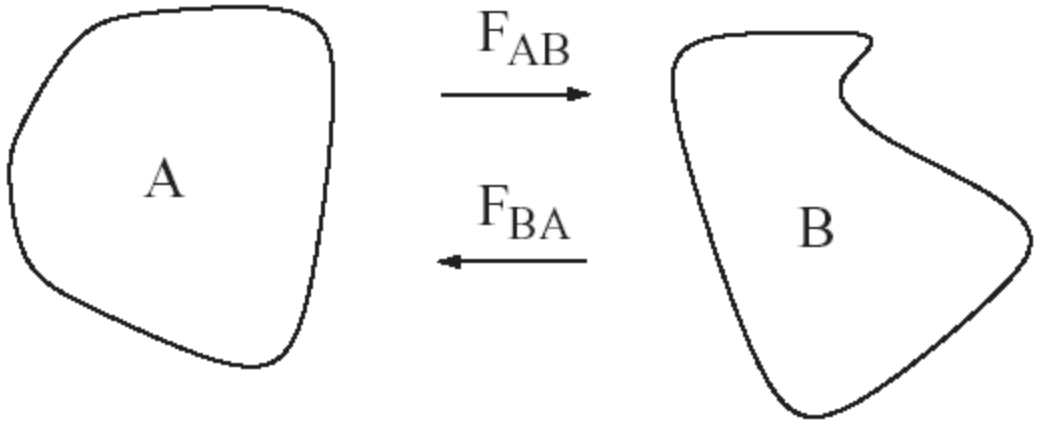
D. 100 times that on earth

Newton's 3rd law:

``to every action there is an equal and opposite reaction“

or,

``For every object A which exerts a force on B, B exerts an equal and opposite force on A".



Whoa! Prof. H, You're telling us that

- **when we push on a wall, it pushes back?**
- **when we sit down in a chair, it pushes up?**
- **the road pushes cars along it?**
- **the air pushes along airplanes?**

Oops, is this Aristotle? No!

- **when we drop a ball, not only does it fall to the earth, but that the earth falls *up* towards the ball?**
- **the earth pulls the moon towards it, and the moon pulls the earth towards it?**

Yes!

Demo: reaction carts:

Robert Goddard (1882-1945)

Robert Goddard and the NY Times

TOPIC OF THE TIMES

... After the rocket quits our air and really starts on its longer journey [to the moon], its flight would be neither accelerated not maintained by the [proposed by Goddard solid rocket based on] explosion of the charges ... . To claim that it would be is to deny a fundamental law of dynamics, and only Dr. Einstein and his chosen dozen, so few and fit, are licensed to do that.

... That Professor Goddard with his "chair" in Clark College and the countenancing of the Smithsonian Institution, does not know the relation of action and reaction, and of the need to have something better than a vacuum against which to react — to say that would be absurd. Of course he only seems to lack the knowledge ladled out daily in high schools.

Editorial comments, *The New York Times*, 13 January 1920

Robert Goddard and the NY Times II

- "...an editorial feature of the *New York Times* dismissed the notion that a rocket could function in a vacuum and commented on the ideas of Robert H. Goddard...Further investigation and experimentation have confirmed the findings of Issac Newton in the 17th Century, and it is now definitely established that a rocket can function in a vacuum as well as in an atmosphere. The *Times* regrets the error."

  --New York Times, July 17 1969

Discussion question

- A lazy horse argues, “I can’t pull the wagon since I can never exert more of a force on it than it exerts on me, according to Newton’s 3rd law. What is the key reason the cart can really move?

C=cart
H=horse
G=ground

Q: If you push a 200 kg refrigerator on ice with F_{net} =1000 N from rest, how fast is it going after 2s?

A. V = 10 m/s B. v = 0 C. v = 5 m/s D. 0.1 m/s E. 0.5 m/s

Q: If you push a 200 kg refrigerator on ice with F_{net} =1000 N from rest, how fast is it going after 2s?

A: $a = F_{net}/m = 1000\ N / 200\ kg = 5\ m/s^2$. Given acceleration a, we recall equation valid for constant acceleration which tells us the velocity after a certain time: $v = at$.

So $v = 5\ m/s^2 \bullet 2\ s = 10\ m/s$. Answer: A