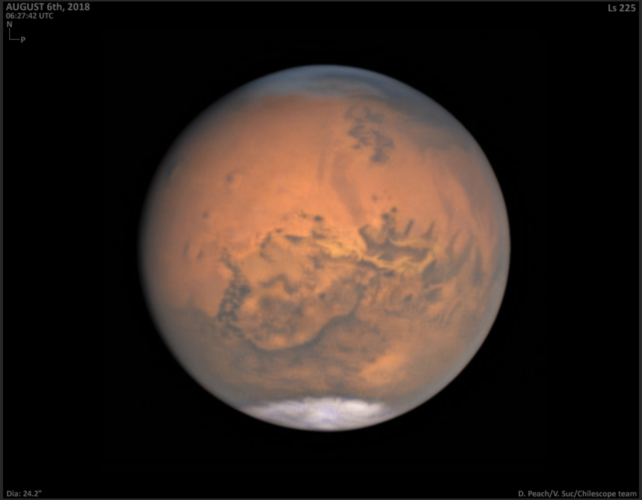
# Announcements

- New WebWorK due Wednesday!
- Lab tonight for Group B!
  - Already posted for you to print on the website
  - Meet in Collins 324
- Poll: `rembold-class.ddns.net`

# APOD!



AUGUST 6th, 2018
06:27:42 UTC
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P
Ls 225
Dia: 24.2"
D. Peach/V. Suc/Chilescope team

# Review Question

Halley's comet has a period of 76 years. At it's closest approach, it is about 0.6 AU from the Sun. What is the maximum distance Halley's comet reaches from the Sun? (*Hint: You can "undo" a cubed by taking the cube root or raising it to the 1/3 power*)

A. 17.94 AU

B. 35.28 AU

C. 35.88 AU

D. 75.4 AU

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# Enter Galileo!

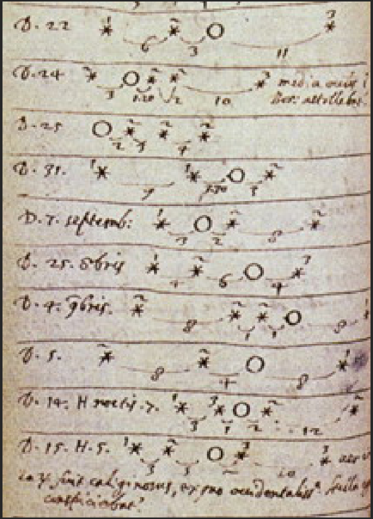
## Kepler

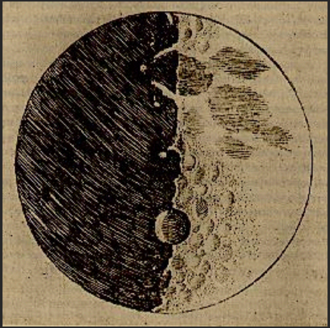
- Derived entirely from Brahe's naked eye observations
- Only "proof" was that they explain everything nice and simple

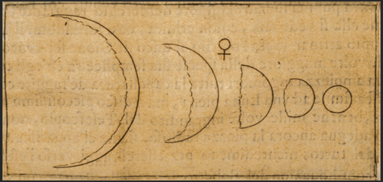
## Galileo

- Strongly believed in Copernicus's heliocentric solar system
- Wanted to *prove* that the Earth orbited the Sun
- Did not *invent* the telescope, but was almong the first to use it to study the heavens
- Widely published his findings

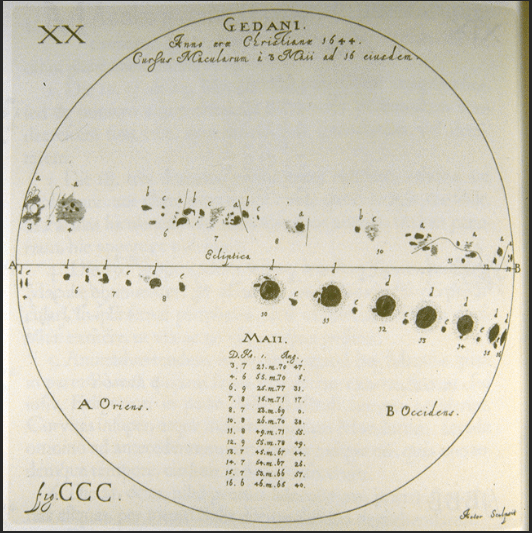
# The Observations of Galileo







# Sunspots!



XX
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Anno aerae Christianae 1644.
Cursus Macularum à 3 Maii ad 16 eiusdem.
Ecliptica
A
B
MAII.
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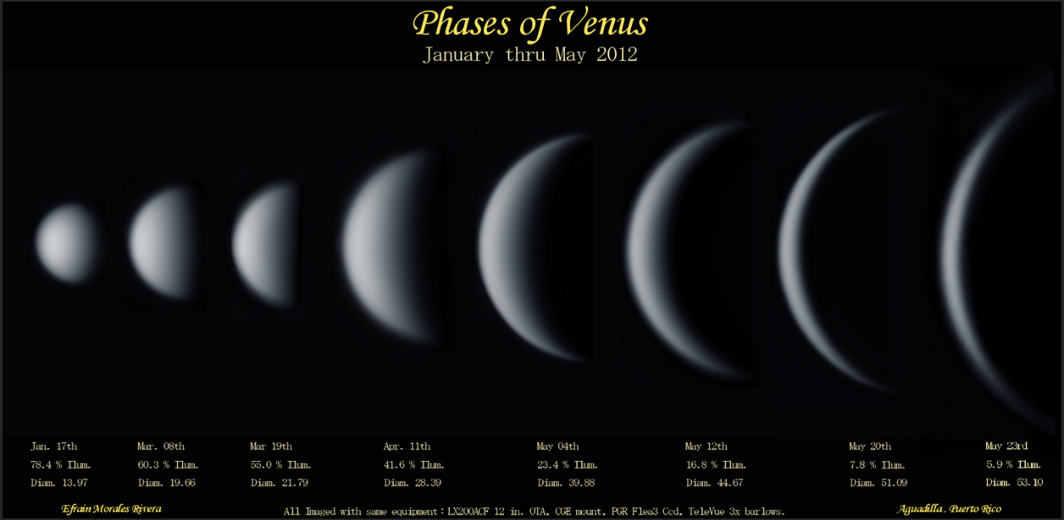
3. 7 21.m.70 47.
4. 6 55.m.70 5.
6. 9 25.m.77 31.
7. 8 16.m.71 17.
8. 7 23.m.69 0.
10. 8 26.m.70 38.
11. 8 49.m.71 55.
12. 9 55.m.78 49.
13. 7 45.m.67 44.
14. 7 64.m.67 28.
15. 7 53.m.66 57.
16. 6 46.m.65 40.
A Oriens.
B Occidens.
fig. CCC.

# More Modern Phases of Venus



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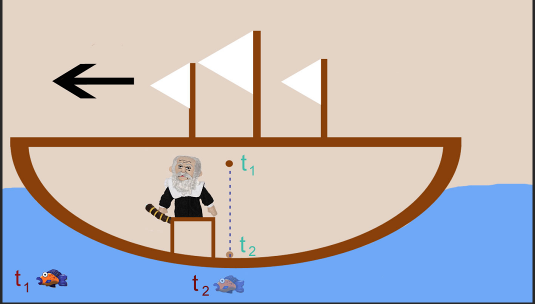

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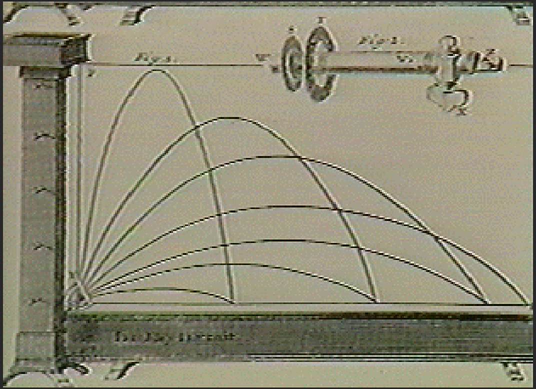
  - Inertia
  - Falling bodies
  - Projectiles



# Kepler and Galileo

- Around during the same time period
  - Keplers first Laws published in 1609
  - Galileo's first telescope observations 1610
- Despite church resistance, the heliocentric model gain acceptance over the next 50 years

Kepler: 1571-1630

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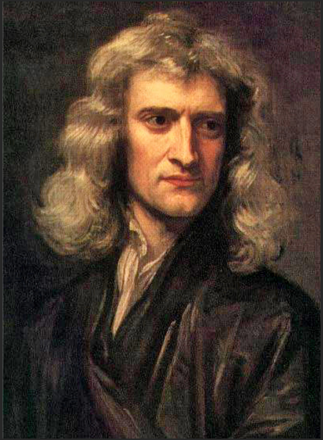
Galileo: 1564-1642

# Good Sir Isaac



Isaac Newton: 1642-1727

- Was able to relate the behavior of orbiting bodies to the behavior of bodies on Earth
- Short and Succinct: Summarized everything in four sentences...

# Newton's First Law

**Newton's First Law**

A body continues in a state of rest or uniform motion in a straight line unless acted on by a force.

- Implications for astronomy?
  - A object that falls when released must be feeling a force
  - An object moving in a circle must have a force acting upon it, else it would travel in a straight line
- Generally thought of as the inertia law

# Newton's Second Law

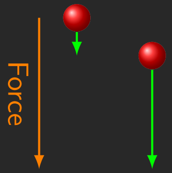
**Newton's Second Law**

The force on an object is equal to the mass of the object multiplied by its acceleration.

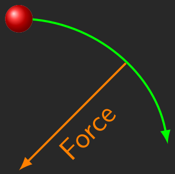
$$F = ma$$

- An acceleration is analogous to a change in motion
- Such a change in motion depends only on the force applied and the mass of the object
- The change in motion is in the same direction as the force!

# Force Examples




A ball dropping must feel a force to accelerate downwards!




A ball curving at a constant speed must still feel a force turning it!

# Basic Units

- To compare our equations and answers, we really need a standard way of measuring things.
- In science (or if you live anywhere besides the US or England) this is the SI metric system
  - Meters for distance
  - Seconds for time
  - Kilograms for mass
- All other SI units are defined in terms of these base units

$$1\,\mathrm{N} = 1\,\mathrm{kgm/s^2}$$

- For most physics formula:
  - SI Units In = SI Units Out
  - Non-SI Units In = IT IS A MYSTERY Out

# The Standards

## Meters

- Originated in France
- 1/10 millionth of the equator to North Pole distance
- Now defined officially by the wavelength of the orange-red light of burning Krypton

## Second

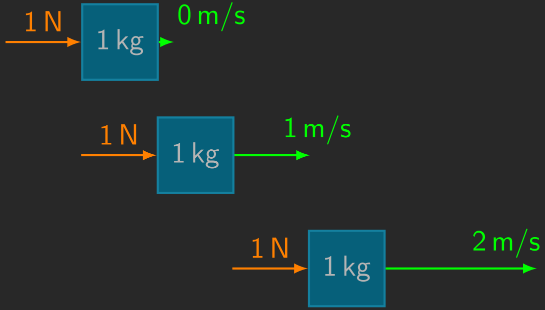
- Defined as 1/86400 of a solar day
- Irregularies in Earth's rotation made this tricky
- Now defined in terms of atomic vibrations in Cesium atoms

## Kilogram

- The mass of this cylindrical block of metal:

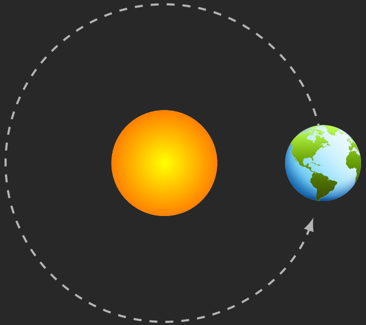
# The Newton

- The SI unit for force is the Newton (N)
  - A 1 N force accelerates a 1 kg mass by 1 m/s each second



# Circular Motion

- Of particular interest to us is circular motion, since such motion largely describes the motion of the planets
- Newton tells us that, even if our planets are moving at a constant speed, a force must be present to keep them moving in a circular orbit



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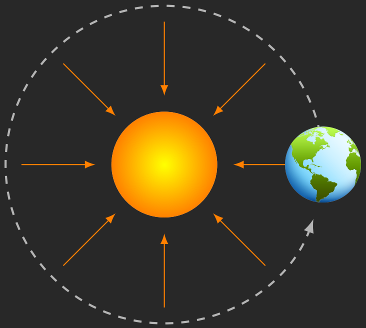

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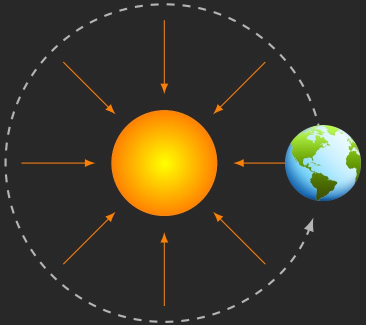
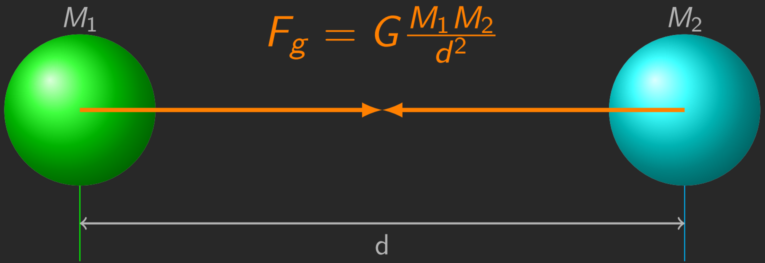


But what is this regulating force?

# Sup G?

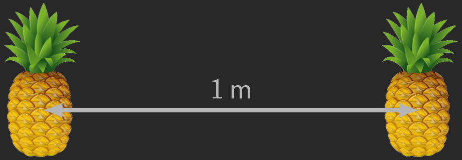
- Gravity! The universal attractor
  - Anything with mass attracts anything else with mass
  - Strength of force depends on the masses involved
  - Strength of the force diminished rapidly with distance

$$F_g = G\frac{M_1 M_2}{d^2}$$



# The Gravitational Constant G

- What is the gravitational force between:
  - Two 1 kg masses (say pineapples)
  - 1 meter apart?



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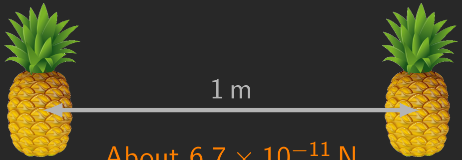


About $6.7 \times 10^{-11}$ N

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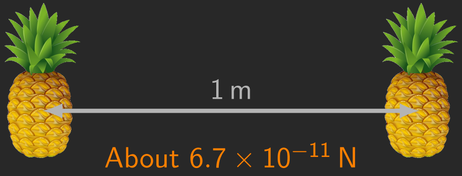


- $G$ indicates the scale of the gravitational force in your units
- $G = 6.67 \times 10^{-11}\ \mathrm{Nm^2/kg^2}$
- You must be using standard units to match $G$!

# Gravitational Force on You!

**Example**

Let's find the force of gravity between you, an average 70 kg individual, and the Earth, with its $5.97 \times 10^{24}$ kg mass. The Earth has an average radius of 6378 km. What acceleration do you experience?

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$$F_g = ma = 685.2\,\mathrm{N} = (70)a \quad \Rightarrow a = 9.79\,\mathrm{m/s^2}$$