Gravity

—Newton’s Universal Law—
Not “*what it is*” but “*what it does*”.

What Gravity Does

m_1

$\mathbf{F}$

All objects pull all other objects

r

The forces on two objects are

- equal in magnitude
- opposite in direction

Proportional to masses of each object

$m_1 m_2$

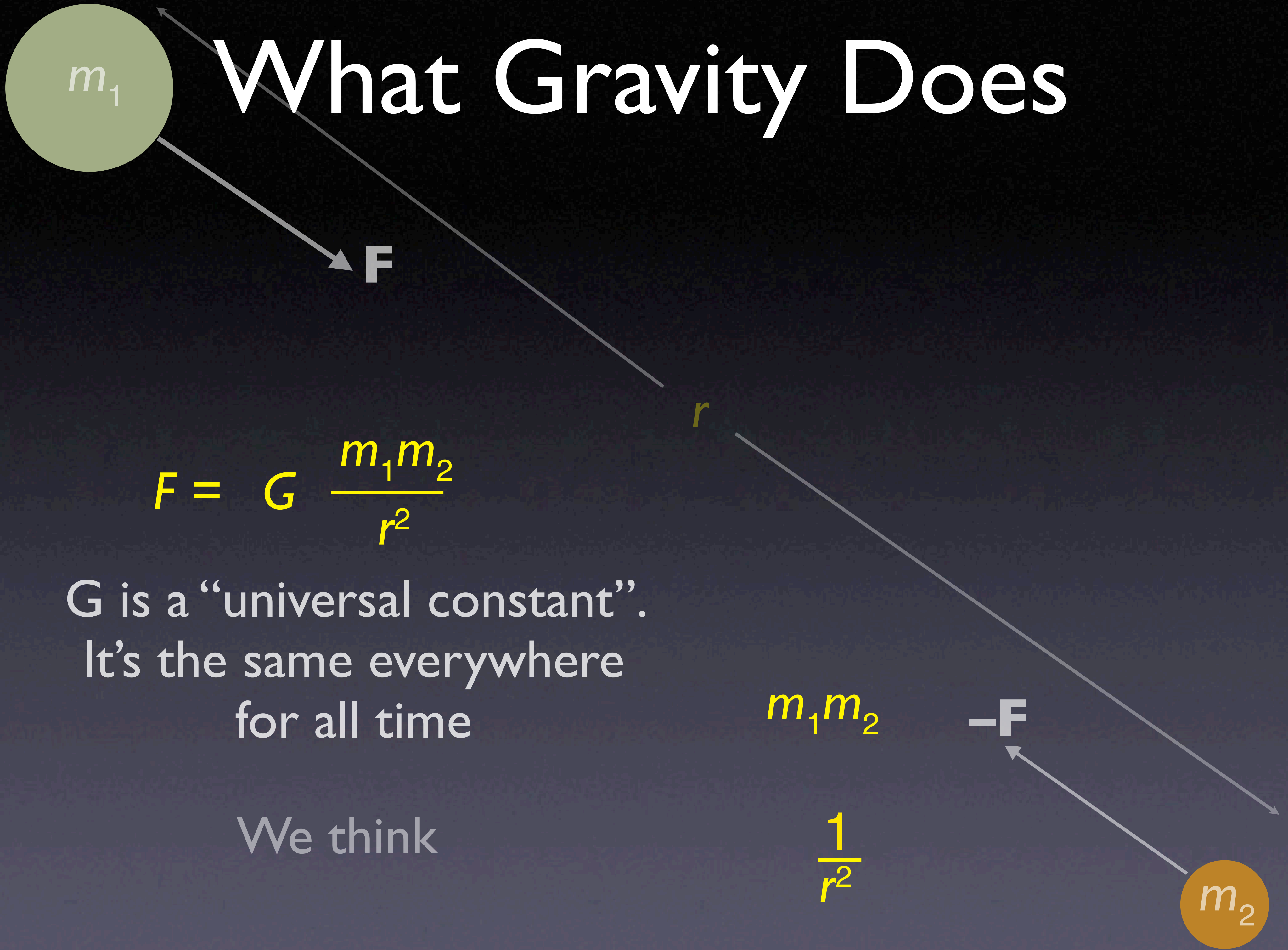
$-\mathbf{F}$

Inversely proportional to the distance-squared between their centres.

$$\frac{1}{r^2}$$

m_2

What Gravity Does



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

G is a "universal constant".
It's the same everywhere
for all time

We think

$m_1 m_2$

$$\frac{1}{r^2}$$

What's G?

- Force between two 1-kg masses, 1 m apart —too small to measure
- On earth, $g = G\, m_{earth}/r^2_{earth}$
  —what r_{earth} do we use? (Newton solved this)
  —Have Gm_{earth} together, have to guess m_{earth}.
- Kepler's $K = Gm_{sun}/4\pi^2$ – similar problem

Enter
Henry's Torsion Balance

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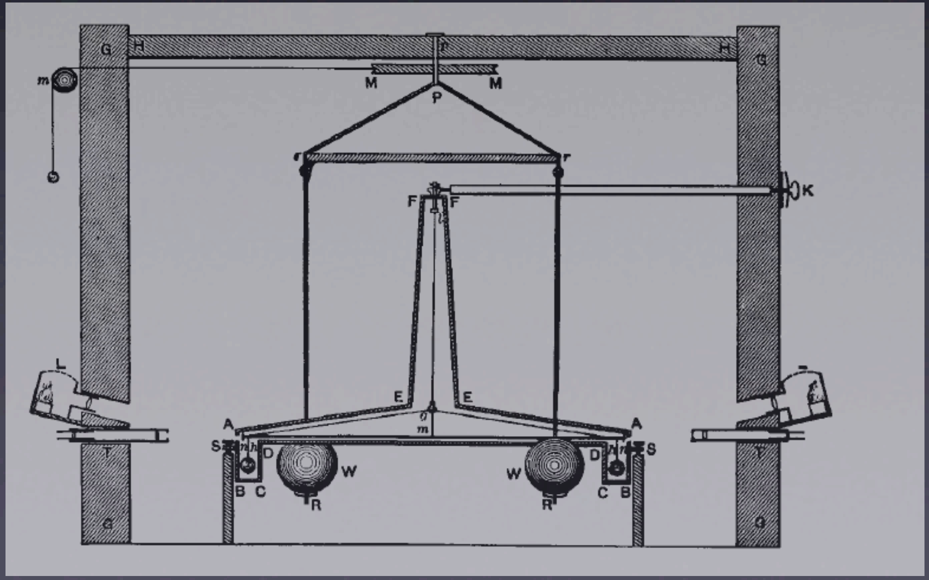
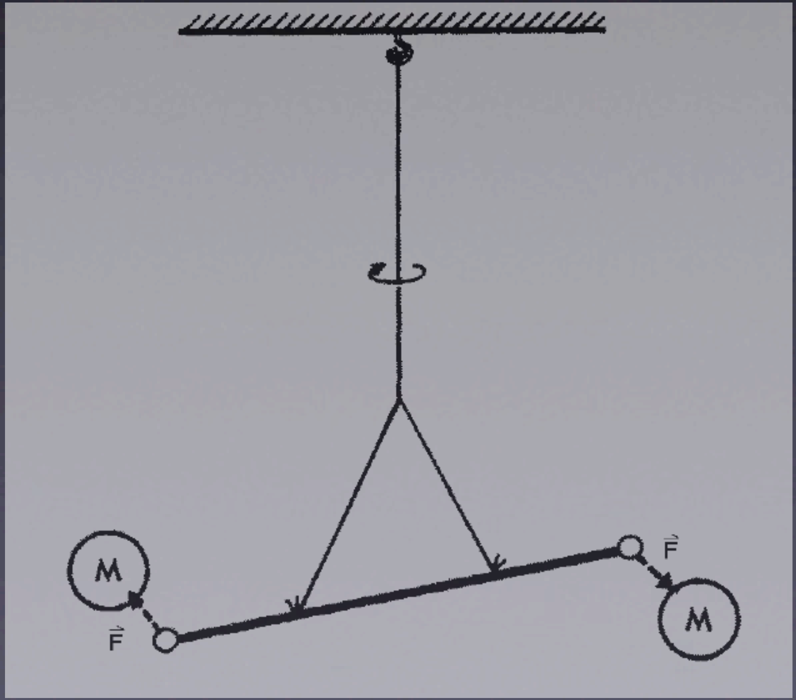
Henry Cavendish that is... (1798)



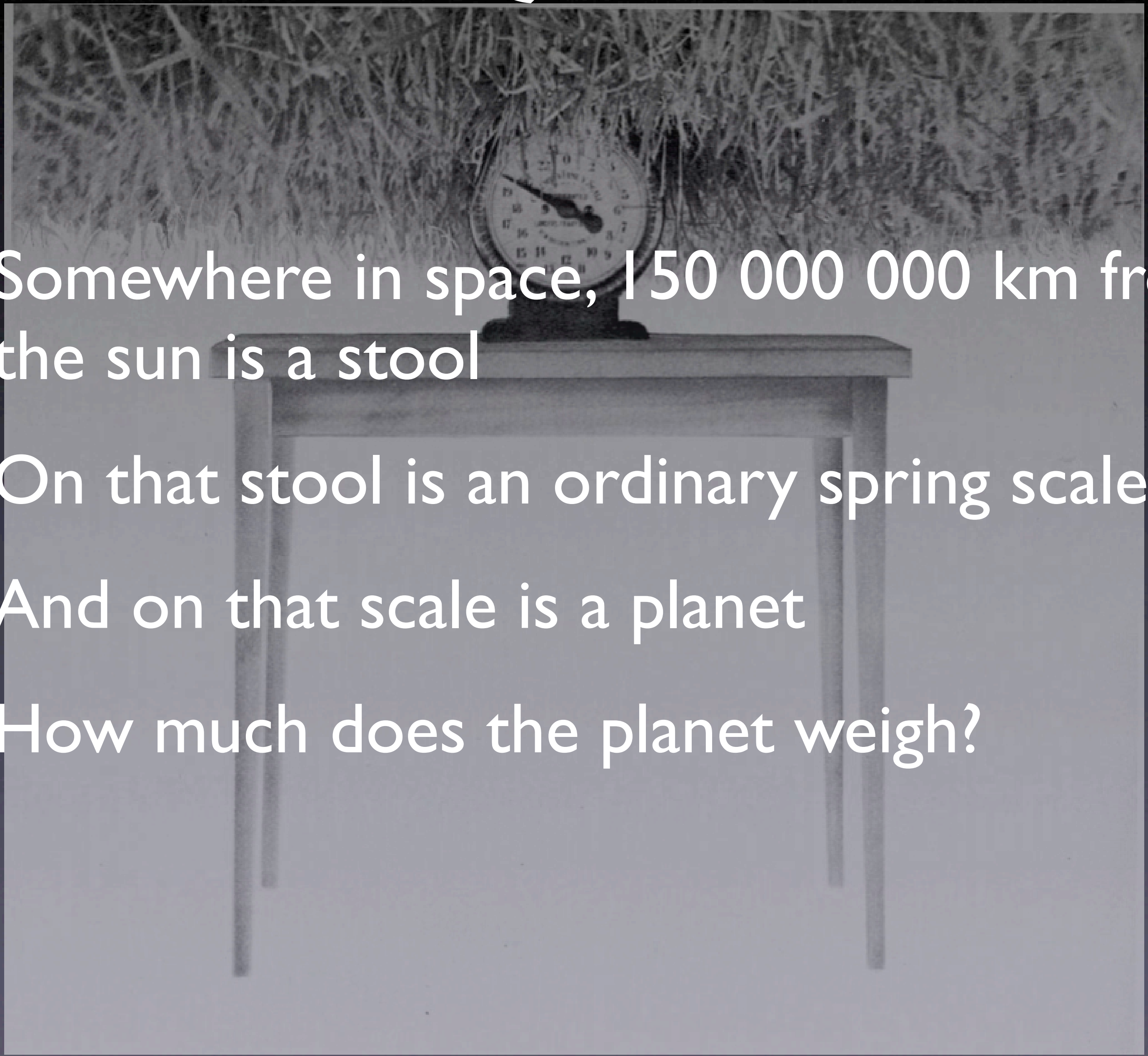


Enter
Henry's Torsion Balance

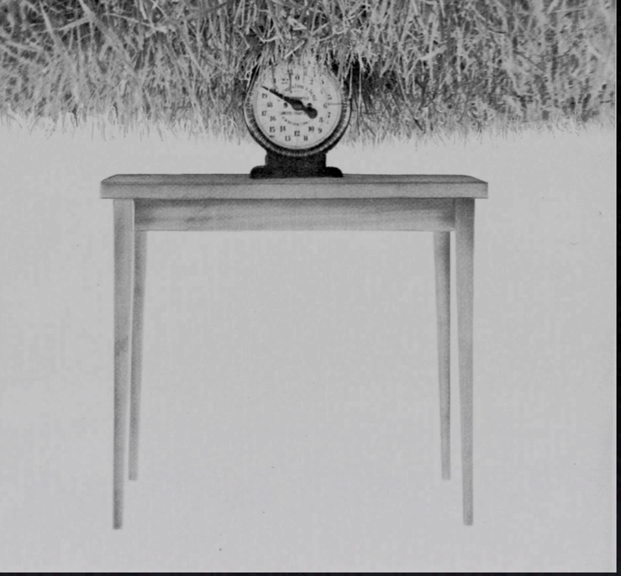
Henry Cavendish that is...

$G = 0.667 \times 10^{-10}\ N\text{-}m^2/kg^2$

Quiz



- Somewhere in space, 150 000 000 km from the sun is a stool
- On that stool is an ordinary spring scale
- And on that scale is a planet
- How much does the planet weigh?



Answer

- The stool has a very weak gravitational field
- The planet is not heavy enough to crush the stool
- The planet weighs 45 N

  (the same as the stool weighs)
- The planet's mass is 5.972 sextillion metric tonnes.

  (5.972×10^{24} kg)

Universal Gravitation

Gives a unified "explanation" of

- Apples falling on earth
- Moon's orbit around earth
- Moons around other planets (Jupiter)
- Solar System — Planets, Asteroids, Comets
- Tides
- Galaxies

Small scale

- At the size of atoms and molecues
- Gravity is a relatively small force
- Electricity and magnetism dominates

Inside the atom's nucleus

- There are two nuclear forces
- "Weak"
- "Strong"

Fundamental Forces

- Gravitation
- Electricity, ~~and~~ magnetism and weak
- Strong nuclear force
- ~~Weak nuclear force~~

This explains everything

Conservation Laws

- Momentum
- Energy
- Charge
- and more...