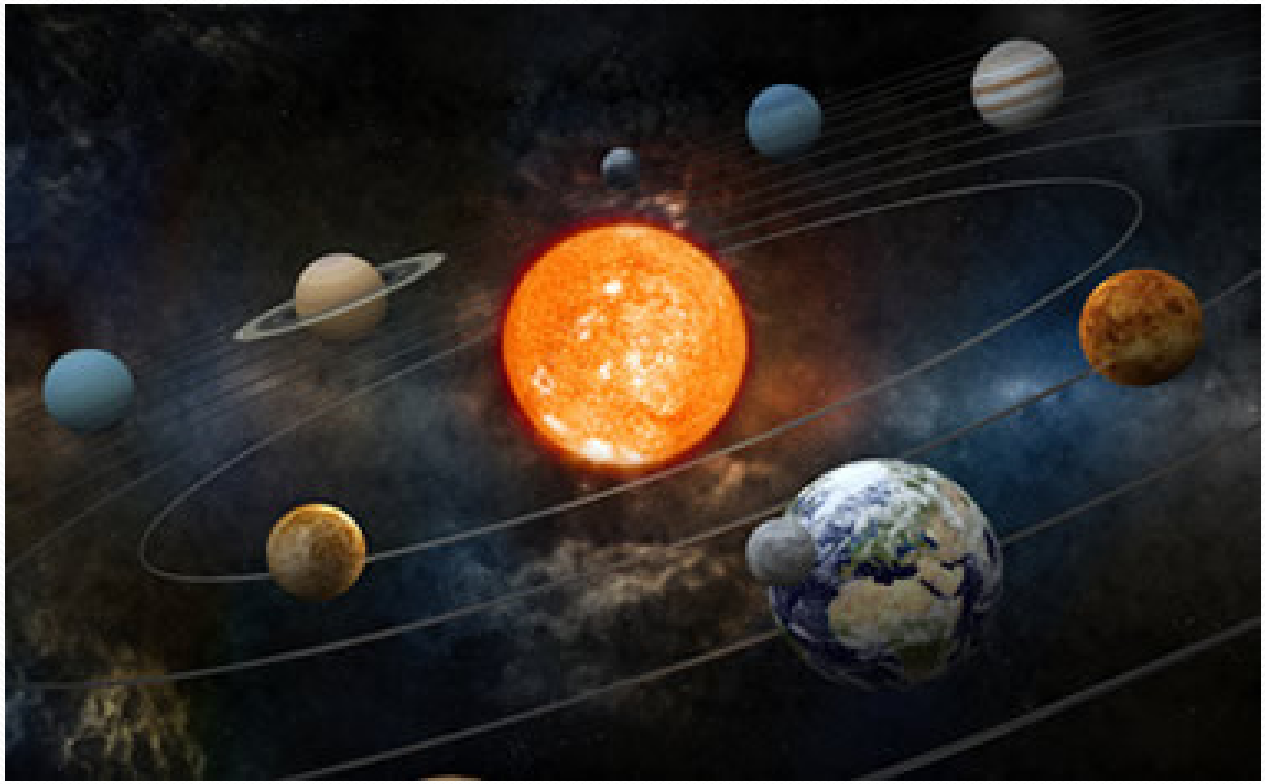
May the *mass times acceleration* be with you …



… Sir Isaac Newton

OBE 1 Newton?

Alexander Pope's Epitaph

Nature and Nature's laws lay hid in night:
God said, "Let Newton be!" and all was light.

c.f. Genesis 1:3
And God said, "Let there be light," and there was light.

Lord Byron

Newton, (that proverb of the mind,) alas!
Declared, with all his grand discoveries recent,
That he himself felt only ‘like a youth
Picking up shells by the great ocean—Truth.’

Isaac Newton

Plato is my friend, Aristotle is my friend, but my best friend is truth.

If I have seen further it is by standing on the shoulders of giants.

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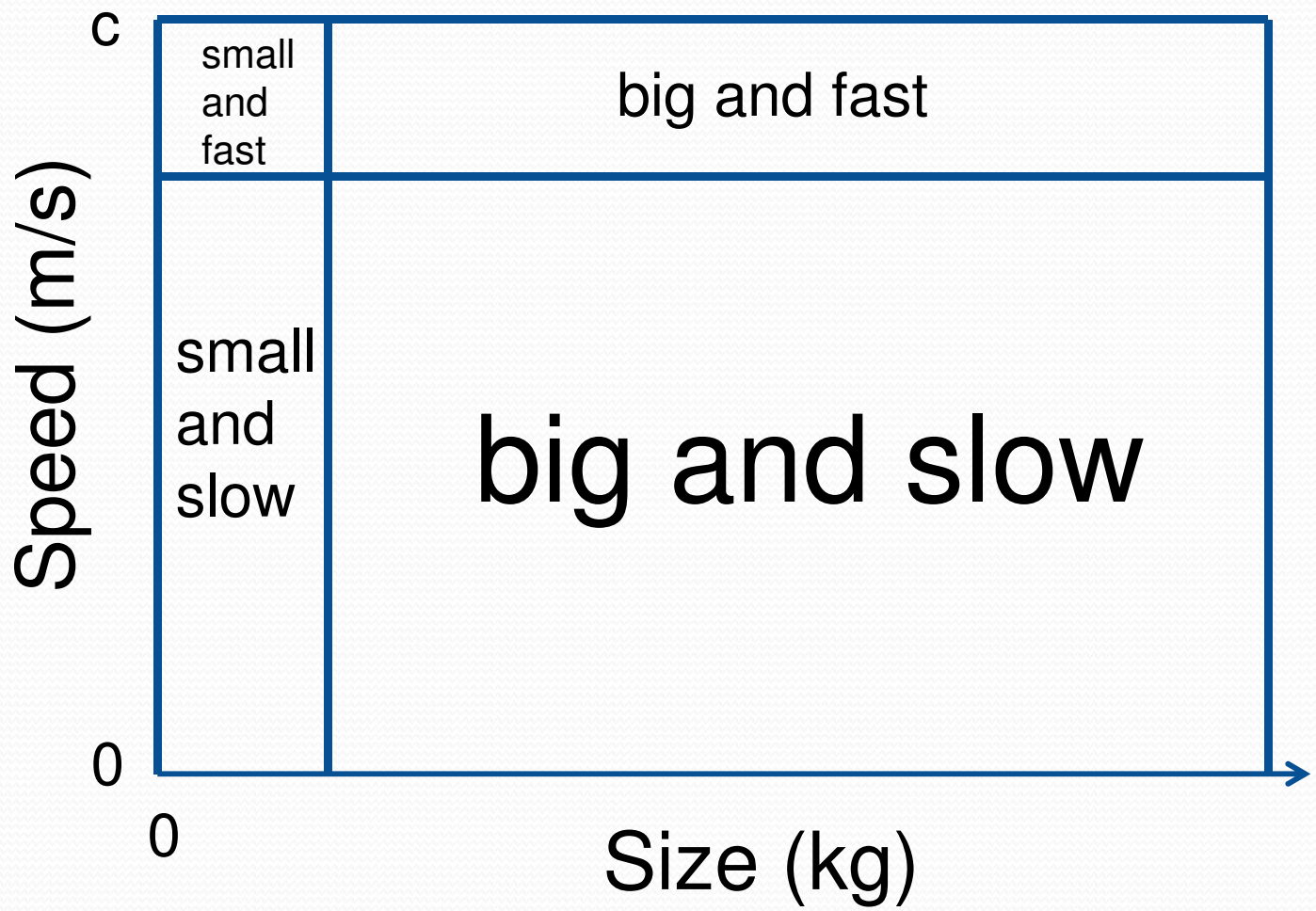
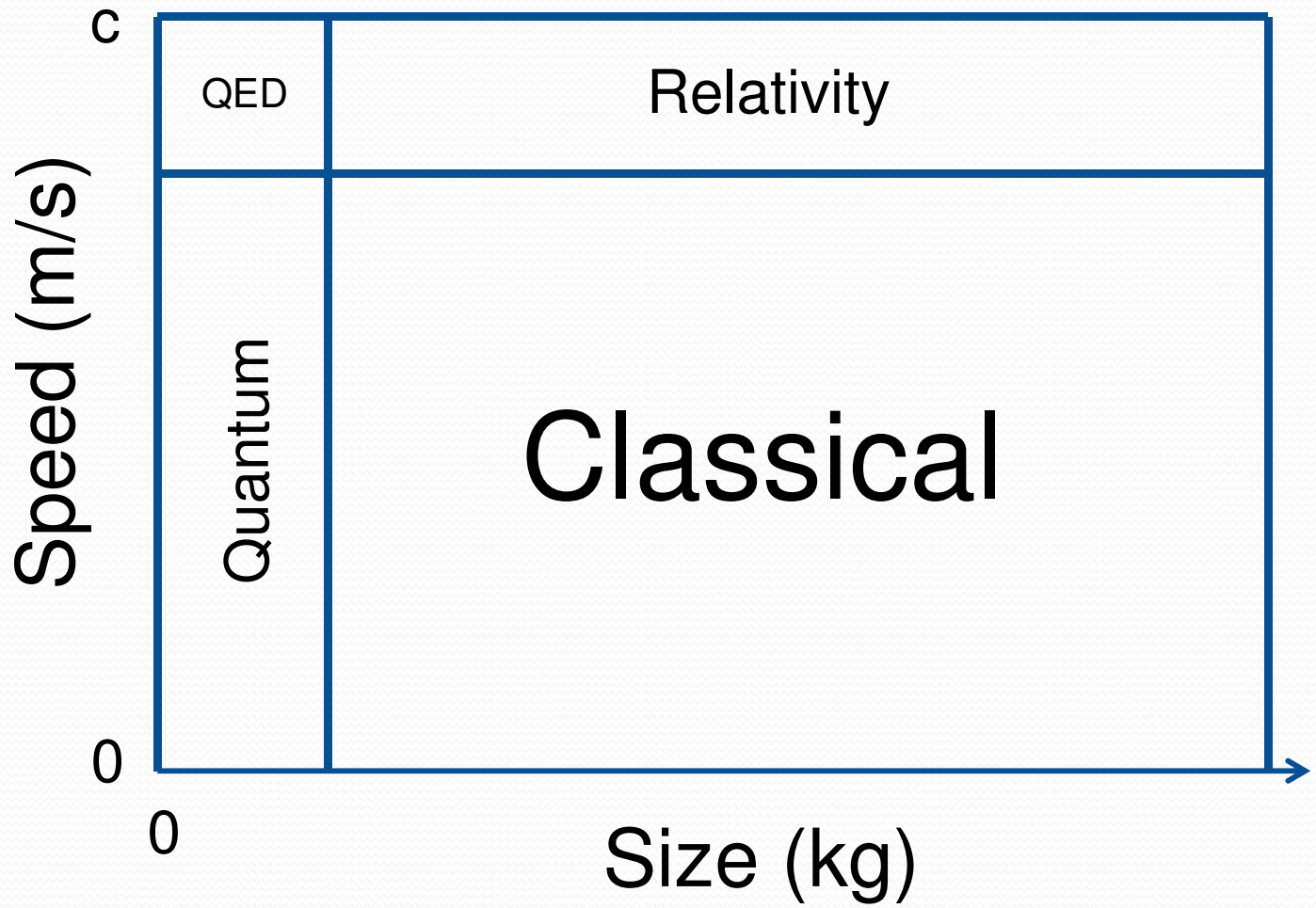
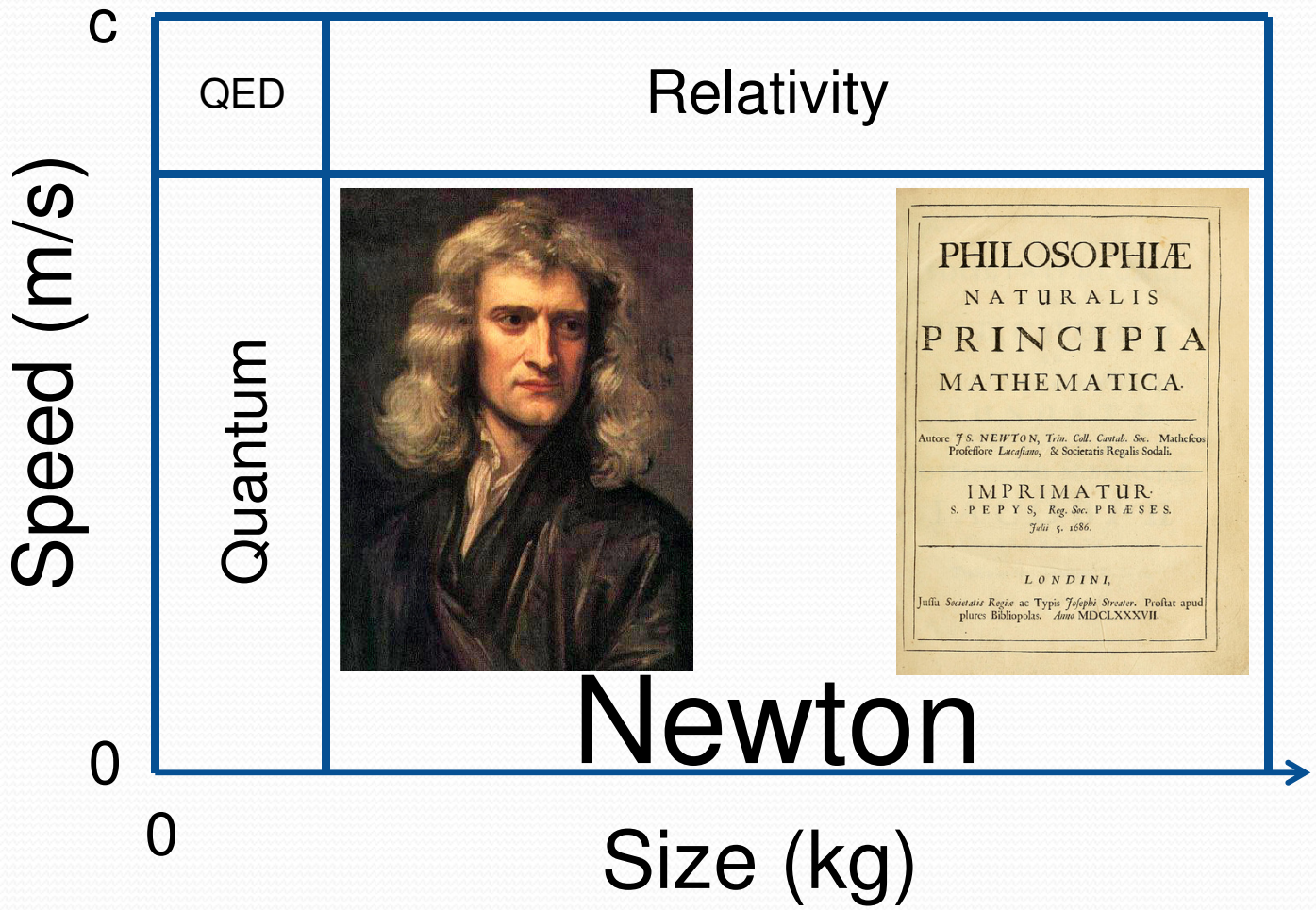
The 4 Boxes of Physics



The 4 Boxes of Physics



The 4 Boxes of Physics



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1. Isaac Newton was born December 25, 1642, the same year that which other famed scientist died?

A. Tycho Brahe

B. John Napier

C. Johannes Kepler

D. Galileo Galilei

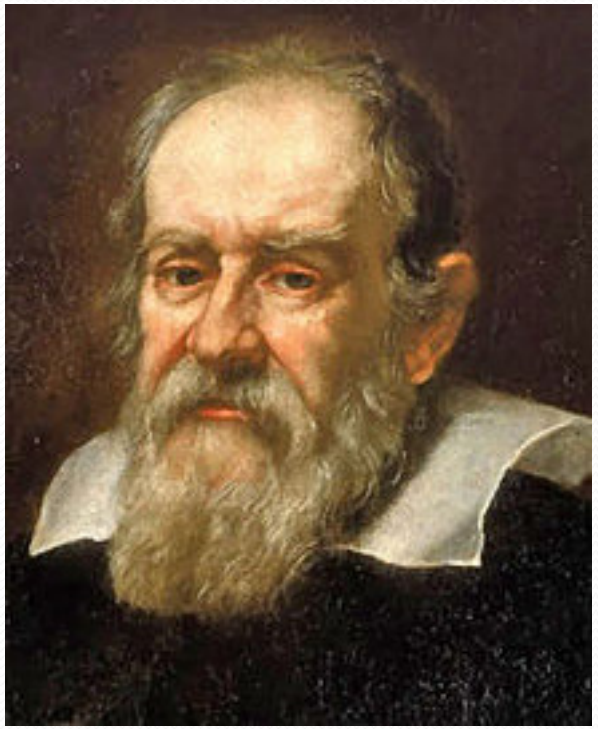
1. Isaac Newton was born December 25, 1642, the same year that which other famed scientist died?

A. Tycho Brahe (1546-1601)

B. John Napier (1550-1617)

C. Johannes Kepler (1571-1630)

D. Galileo Galilei (1564-1642)



2. Where was Isaac Newton born?

A. London

B. Hastings

C. Stratford on Avon

D. Woolsthorpe-by-Colsterworth

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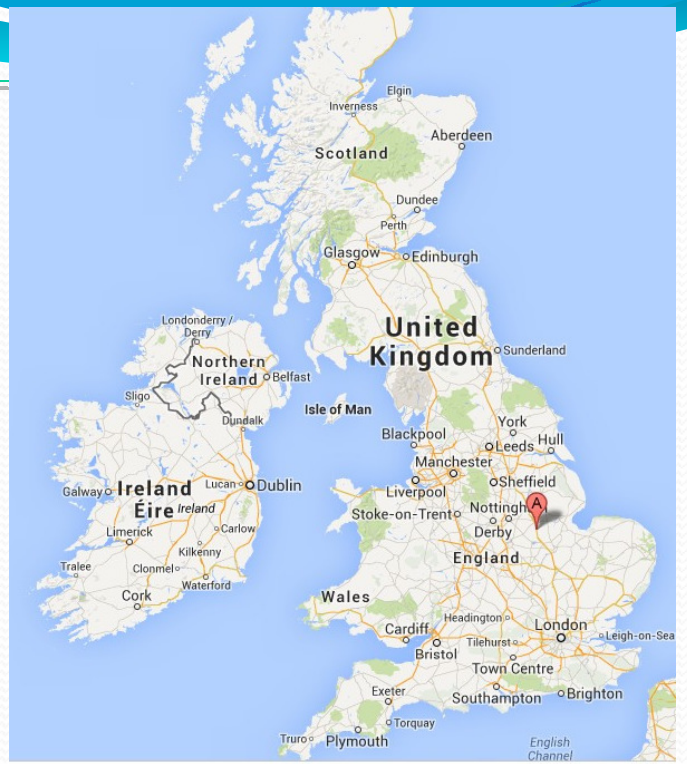


3. Newton was the second Lucasian professor at which university?

A. Oxford

B. Cambridge

C. Imperial College London

D. University of Edinburgh

3. Newton was the second Lucasian professor at which university?

B. Cambridge

4. Who was the first Lucasian professor?

A. Isaac Barrow

B. Charles Babbage

C. George Gabriel Stokes

D. Stephen Hawking

4. Who was the first Lucasian professor?

A. Isaac Barrow (1663-1669)

B. Charles Babbage (1828-1839)

C. George Gabriel Stokes (1849-1903)

D. Stephen Hawking (1979-2009)

5. Which event temporarily closed his university after he received his B.A. in August 1665?

A. The Execution of Charles I

B. The Great Plague

C. The Great Fire of London

D. The Battle of Waterloo

5. Which event temporarily closed his university after he received his B.A. in August 1665?

A. The Execution of Charles I (1649)

B. The Great Plague (1665-1666)

C. The Great Fire of London (1666)

D. The Battle of Waterloo (1815)

6. What was the name of Newton's most important work, published as three books in July 1687?

A. *Method of Fluxions*

B. *De motu corporum in gyrum*

C. *Philosophiæ Naturalis Principia Mathematica*

D. *Optiks*

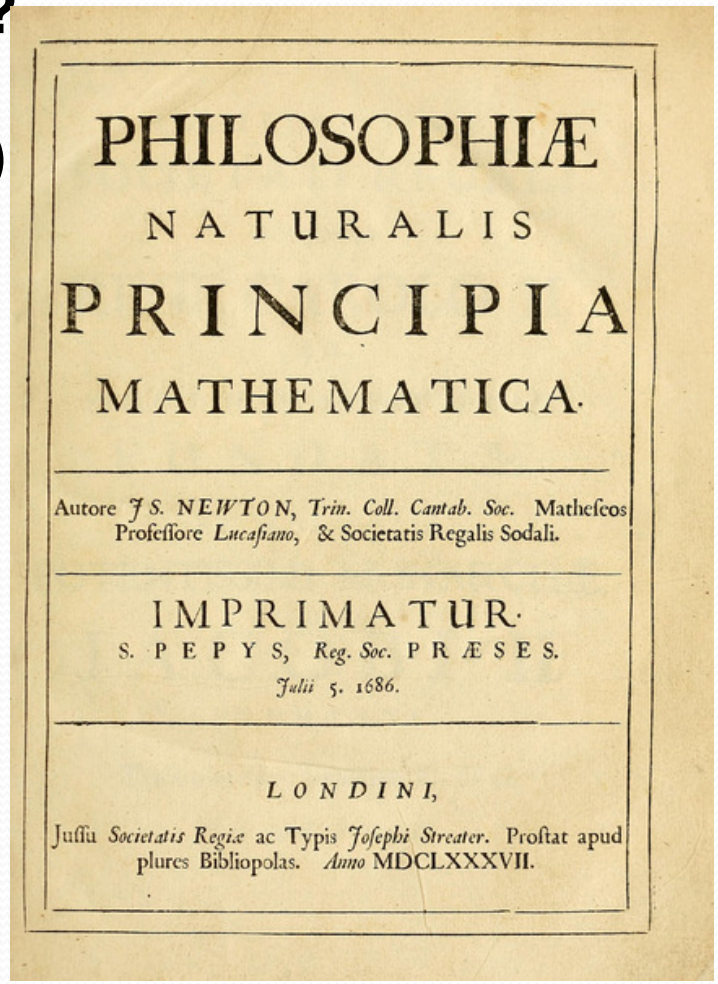
6. What was the name of Newton's most important work, published as three books in July 1687?

A. *Method of Fluxions (1671 → 1736!)*

B. *De motu corporum in gyrum (1684)*

C. *Philosophiæ Naturalis Principia Mathematica*

D. *Optiks* (1704)


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *J S. NEWTON, Trin. Coll. Cantab. Soc.* Matheſeos Profeſſore *Lucaſiano*, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
Julii 5. 1686.

LONDINI,
Juſſu *Societatis Regiæ* ac Typis *Joſephi Streater*. Proſtat apud plures Bibliopolas. *Anno* MDCLXXXVII.

"Newton … spread the light of mathematics on a science which up to then had remained in the darkness of conjectures and hypotheses." – Clairaut

7. With whom did Newton have a major row over the invention of fluxions (calculus)?

A. His mother

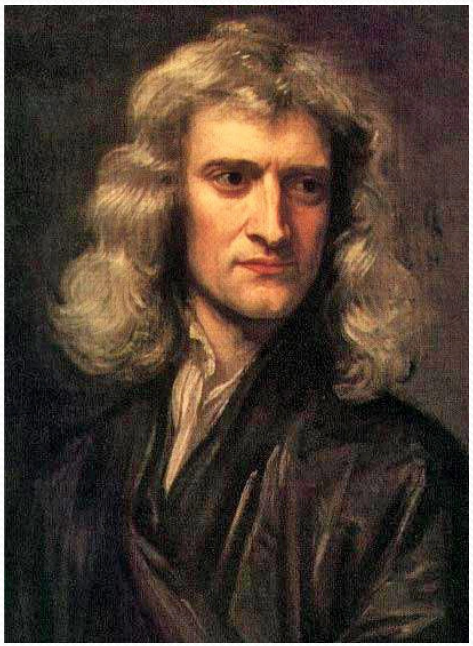
B. Edmund Halley

C. Robert Hooke

D. Gottfried Leibniz

7. With whom did Newton have a major row over the invention of fluxions (calculus)?

D. Gottfried Leibniz



8. Newton built the first known type of which telescope?

A. Refracting

B. Reflecting

C. Cassegrain reflector

D. Hubble deep space

8. Newton built the first known type of which telescope?

B. Reflecting

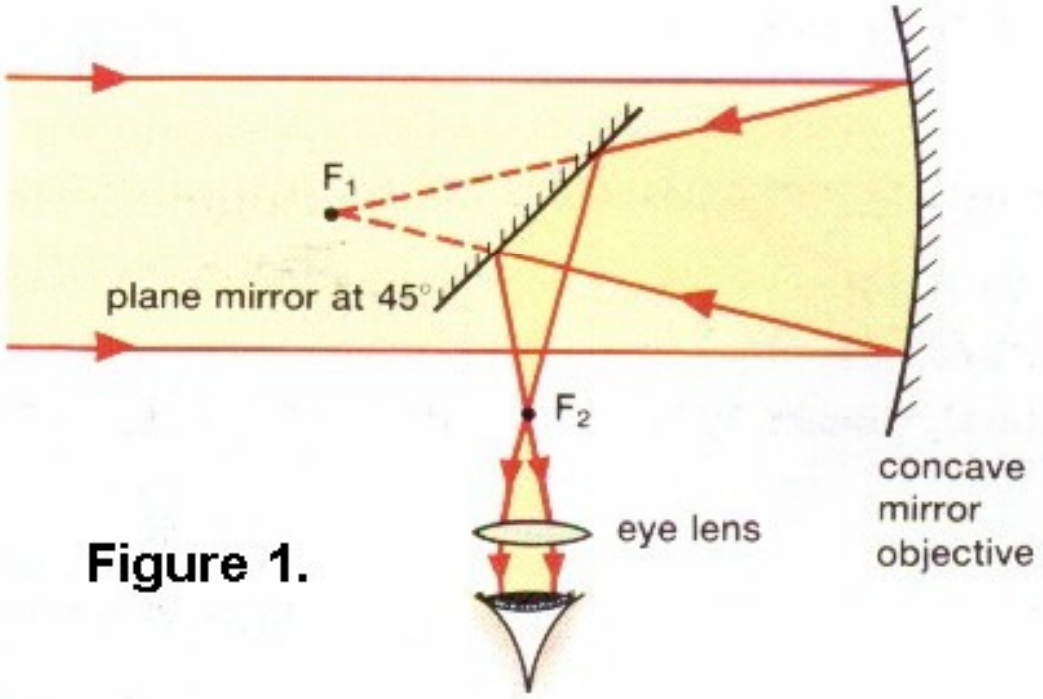


Figure 1.

9. What is the value of G, the universal constant of gravitation, including units?

A. 1.496×10^{11} m

B. 8.988×10^{9} Nm^2/C^2

C. 6.674×10^{-11} Nm^2/kg^2

D. 9.109×10^{-31} kg

9. What is the value of G, the universal constant of gravitation, including units?

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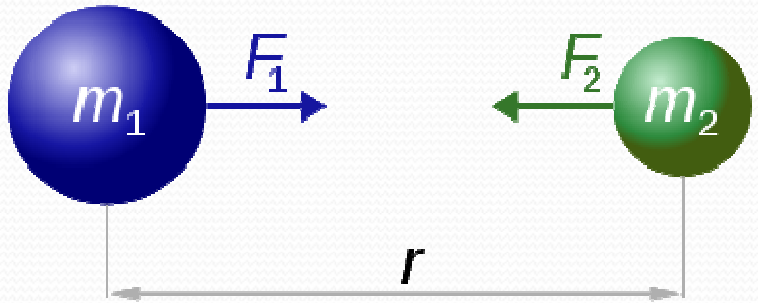


$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

10. Newton became Warden and Master of which British government institution?

A. The Tower of London

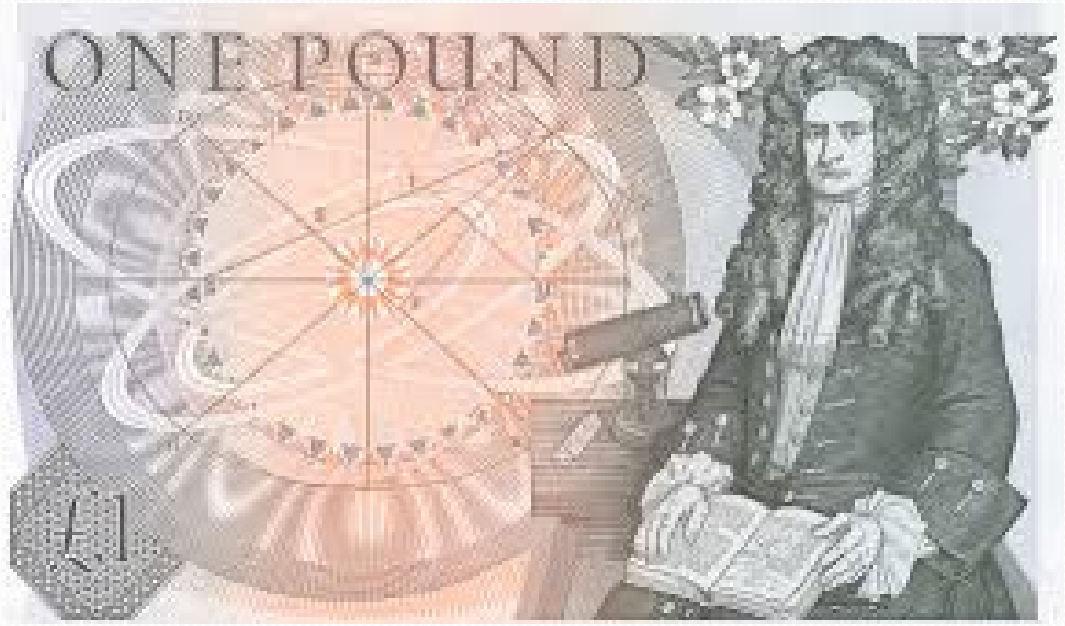
B. The Bank of England

C. The Royal Mint

D. The Horse Guards

10. Newton became Warden and Master of which British government institution?

C. The Royal Mint



11. Bonus joke: What was the name of Newton's dog?

A. Diamond

B. Sparky

C. Ruff

D. Cat

11. Bonus joke: What was the name of Newton's dog?

1 Joule = 1 newton-meter

(1 J = 1 N-m)

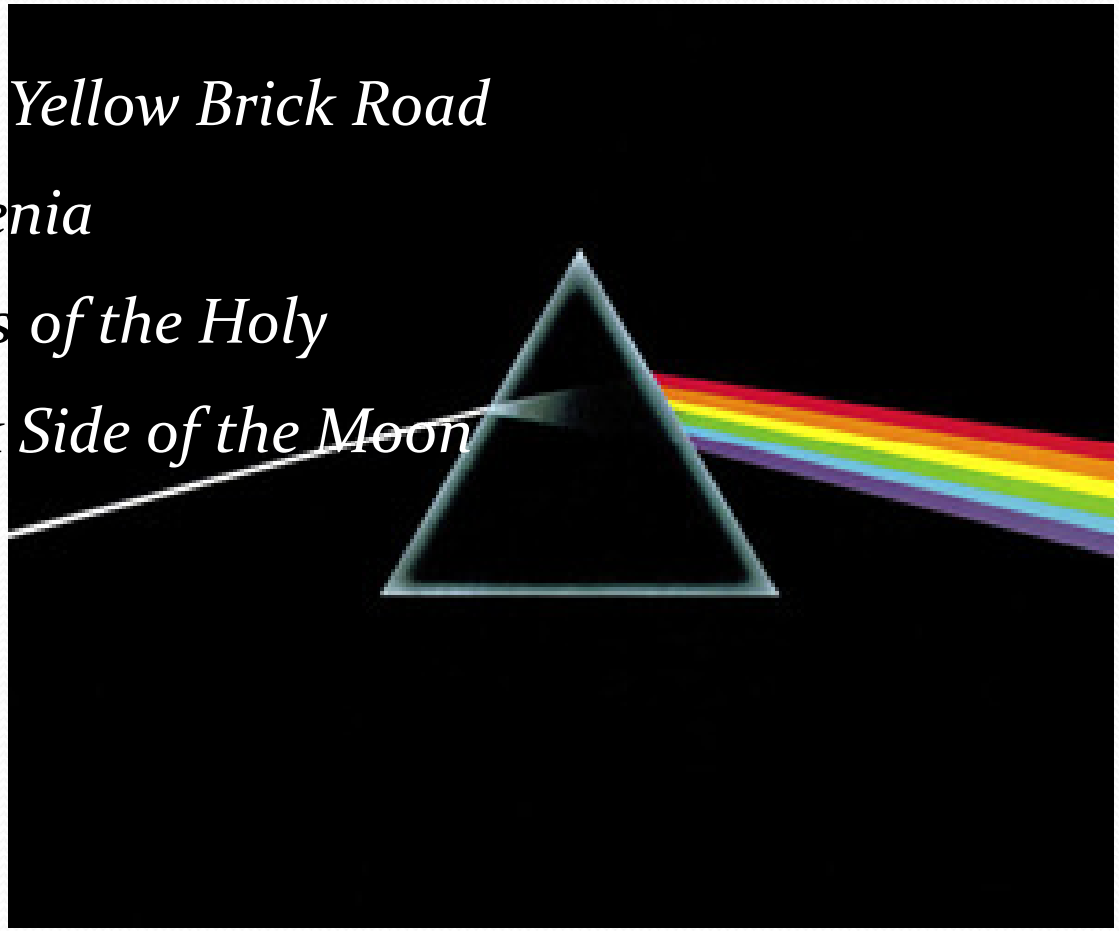
12. Bonus song: Name the band and the 1973 album

A. Elton John *Goodbye Yellow Brick Road*

B. The Who *Quadrophenia*

C. Led Zeppelin *Houses of the Holy*

D. Pink Floyd *The Dark Side of the Moon*



Eclipse

More quizzes at: www.johnkwhite.ie

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Quizzes -- Physics

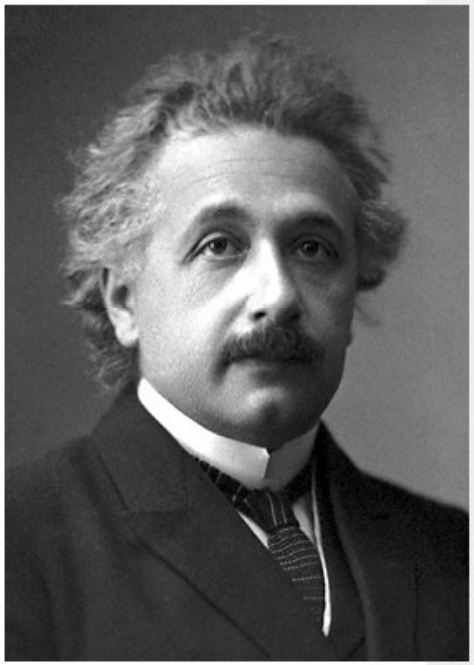
Try your hand a the following quizzes: Physics | Geography | Math | History | Arts | Letters
50 questions of increasing difficulty. Can you get to level 5?

☐ Random questions?

0/0 Level 1	Select a choice: +1 for a correct answer, -1 for a wrong answer. The correct answer appears here.

When was Isaac Newton born?

- 1643
- 1743
- 1843
- 1943



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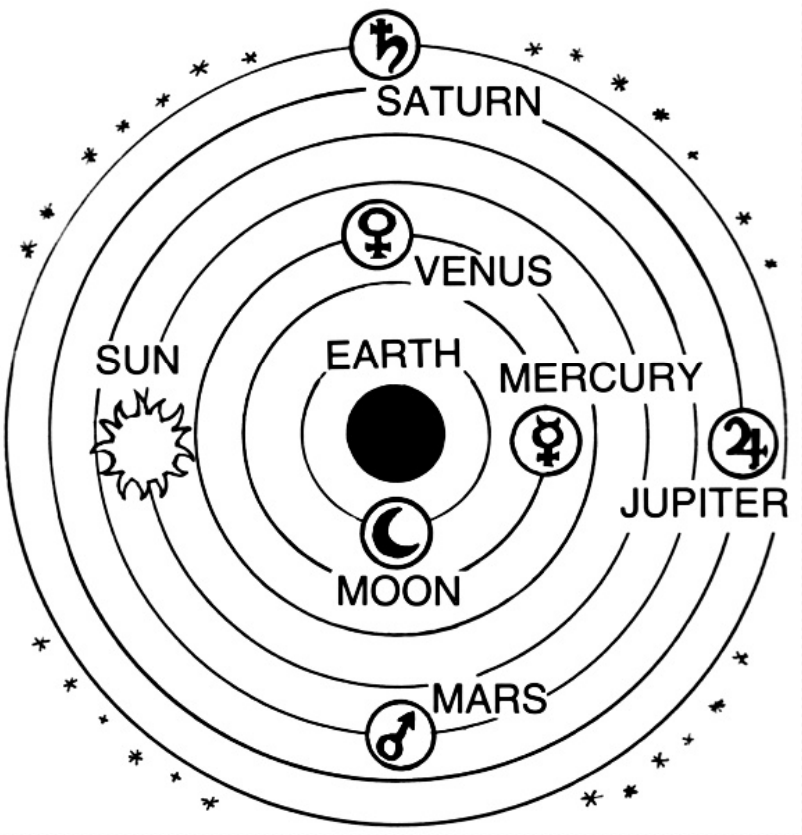
But can Newton explain the NEW heavens?



G, M, m, r

Ptolemy, Copernicus, Brahe, Kepler, Galileo, …?

But can Newton explain the NEW heavens?

$$F = \frac{GMm}{r^2} \qquad F = \frac{mv^2}{r}$$

$$\frac{GMm}{r^2} = \frac{mv^2}{r} \text{ or } v = \sqrt{\frac{GM}{r}}$$

but $T = \frac{2\pi r}{v}$ $\therefore$ $\mathbf{T = \frac{2\pi r}{\sqrt{\frac{GM}{r}}} = \frac{2\pi}{\sqrt{GM}} r^{\frac{3}{2}}}$

But can Newton explain the NEW heavens?

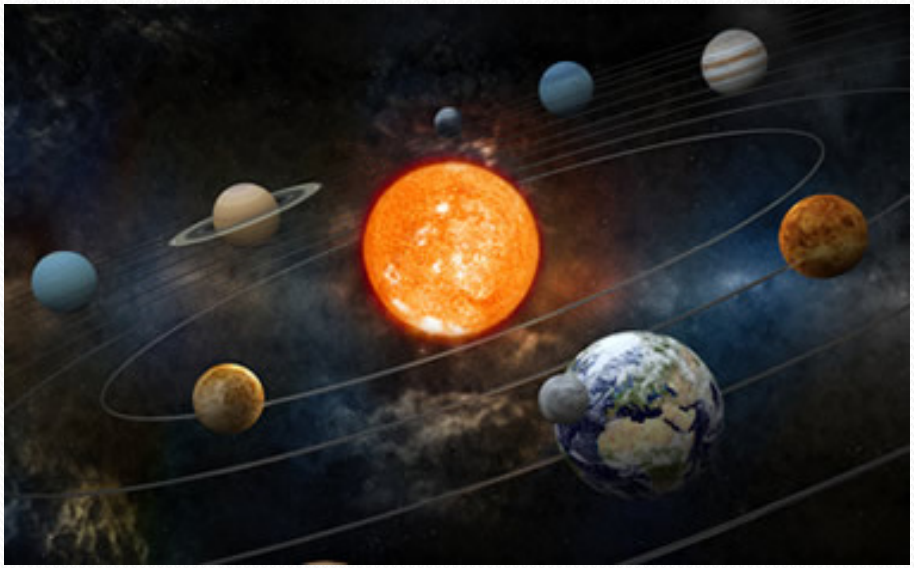
$$T = \frac{2\pi}{\sqrt{GM}} r^{\frac{3}{2}}$$

$$T \propto r^{3/2}$$

But can Newton explain the NEW heavens?

Planet	Dist, R_p x 10^6 km	R_p/R_E (au)	$T = (R_p/R_E)^{1.5}$ (years)	(days)
Mercury	57.9	0.39	0.24	88
Venus	108.2	0.72	0.62	225
Earth	149.6	1	1	365
Mars	227.9	1.52	1.88	687
Jupiter	778	5.20	11.86	
Saturn	1427	9.54	29.46	
Uranus	2870	19.18	84.03	
Neptune	4497	30.06	164.81	
Pluto	5900	39.44	247.67	

1 year = 365.256



Mystery planet?

Can Newton debunk astrology?

$$F \propto \frac{m}{r^2}$$

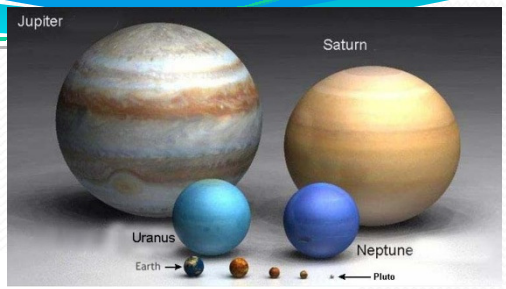


Table 8.1 Planetary mass, distance from earth, and relative force

Planet	*Mass (kg)*	*Distance (km)*	*Mass/Distance^2 (kg/km^2)*	*Rank*
Sun	2.0×10^{30}	1.5×10^{8}	8.9×10^{13}	1
Mercury	3.2×10^{23}	9.2×10^{7}	3.8×10^{7}	7
Venus	4.9×10^{24}	4.1×10^{7}	2.8×10^{9}	4
Earth	6.0×10^{24}	—	—	—
Moon	7.4×10^{22}	3.8×10^{5}	5.0×10^{11}	2
Mars	6.4×10^{24}	7.8×10^{7}	1.0×10^{9}	5
Jupiter	1.9×10^{27}	6.3×10^{8}	4.8×10^{9}	3
Saturn	5.7×10^{26}	1.3×10^{9}	3.5×10^{8}	6
Uranus	8.7×10^{25}	2.7×10^{9}	1.2×10^{7}	8
Neptune	1.0×10^{26}	4.4×10^{9}	5.4×10^{6}	9
Pluto	1.1×10^{24}	5.8×10^{9}	3.3×10^{4}	10

Can Newton debunk astrology?

$$F \propto \frac{m}{r^2}$$

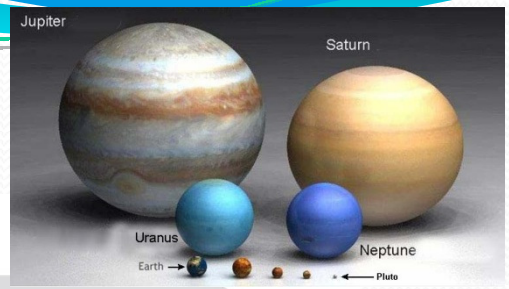


Table 8.2 Normalized planetary mass, distance from earth, and relative force

Planet	*Mass (normalized)*	*Distance (normalized)*	*M/d^2 (%)*
Sun	332,998.8	1.0	99.43
Mercury	0.1	0.6	0.00
Venus	0.8	0.3	0.00
Earth	1.0	—	—
Moon	0.0	0.0	0.56
Mars	1.1	0.5	0.00
Jupiter	317.9	4.2	0.01
Saturn	95.1	8.5	0.00
Uranus	14.5	18.2	0.00
Neptune	17.2	29.1	0.00
Pluto	0.2	38.5	0.00

- **Do birthdates indicate success in life?**
- **Where did lucky numbers come from?**
- **How did the days get their names?**
- **How do pyramid scams work?**
- **When did the real downturn in the economy occur?**
- **Why are North American sports leagues better than in Europe?**
- **How do stock pickers win at the market?**
- **Why is the average person *not* the most likely?**

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Newton's Three Laws

Newton's First Law: equilibrium

$$\Sigma \mathbf{F} = 0$$

Newton's Second Law: momentum

$$\mathbf{F} = m\mathbf{a} \quad (F = d\mathbf{p}/dt) \quad (\mathbf{p} = m\mathbf{v})$$

Newton's Third Law: action-reaction

$$\mathbf{F}_{12} = -\mathbf{F}_{21}$$

(Some say only two since N1 is a subset of N2 for $\mathbf{a} = 0$)

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Are you an Aristotlean or Newtonian thinker? – three tests

Test 1

a. Which is heavier: a ton of feathers or a ton of bricks?

b. Which hits the ground first: a ton of feathers or a ton of bricks?

Are you an Aristotlean or Newtonian thinker? – three tests

Test 1

In 1971, **Apollo 15 Commander David Scott**

dropped a 1.3-kg aluminum hammer
and a 0.03-kg falcon feather
at the same time

Which hit the moon first?

hammer and feather drop

Are you an Aristotlean or Newtonian thinker? – three tests

Test 1

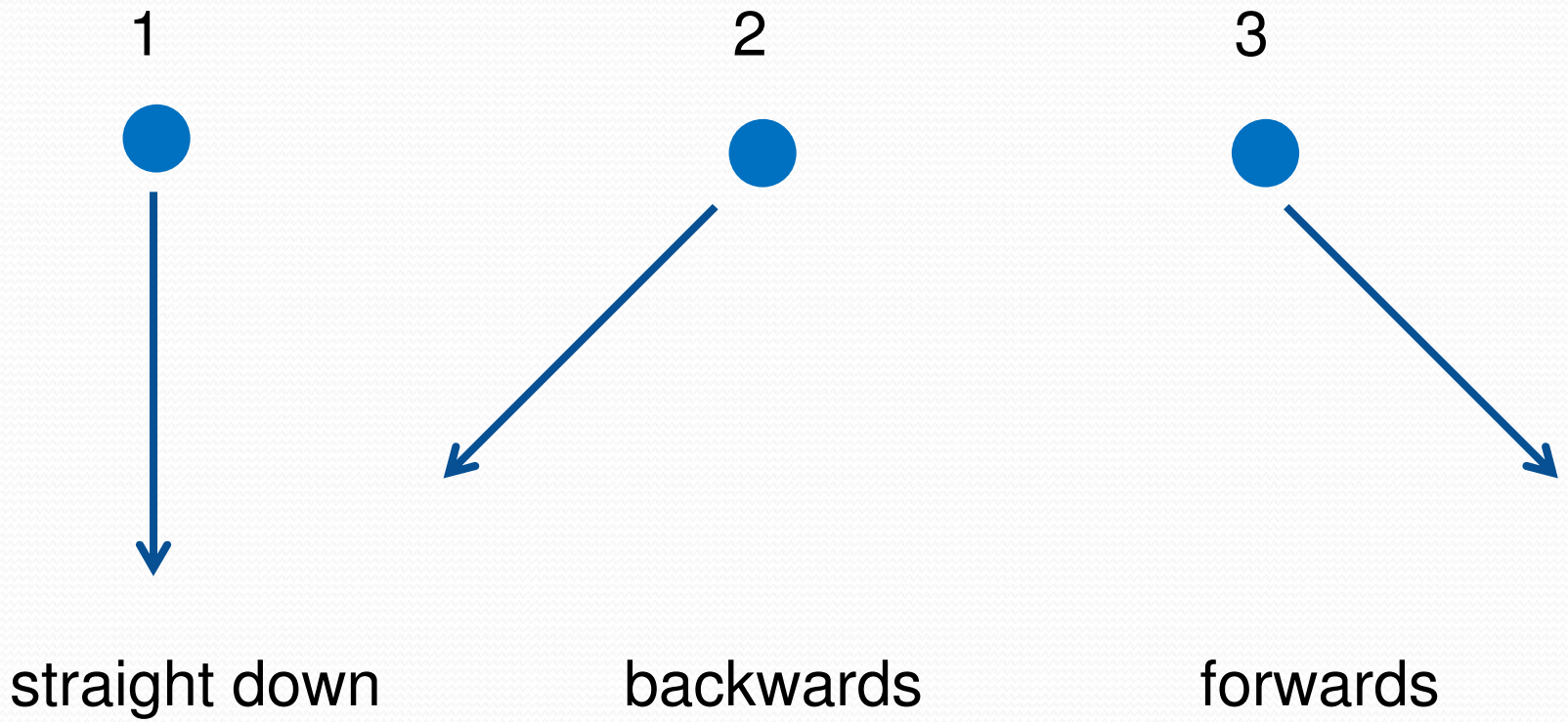
Aristotle believed that heavier objects fall faster than lighter objects, an idea that seems reasonable at first glance.

"We see that bodies which have a greater impulse either of weight or of lightness, if they are alike in other respects, move faster over an equal space, and in the ratio which their magnitudes bear to each other." *Physics* (Book IV)

This wrong thinking was not wholly overturned for 2,000 years.

Are you an Aristotlean or Newtonian thinker? – three tests

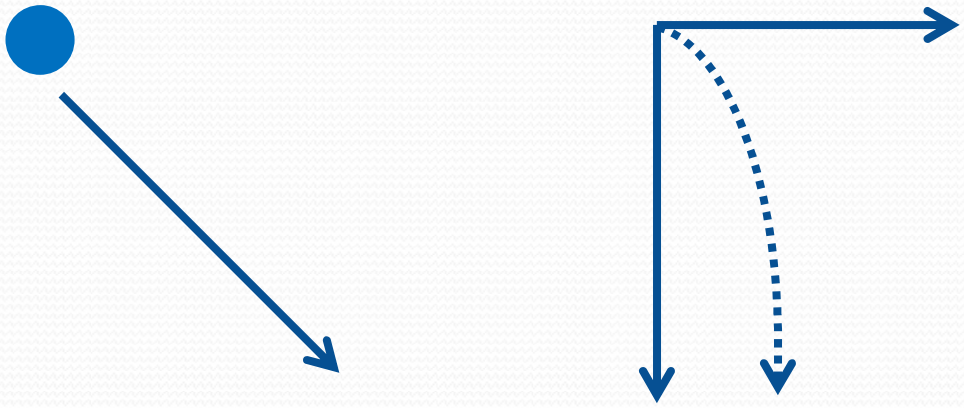
Test 2 Drop an object while walking

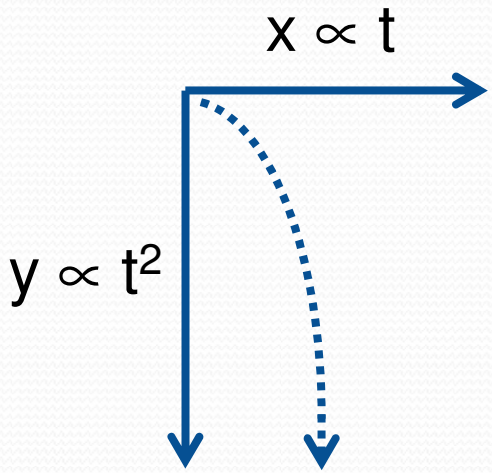


Are you an Aristotlean or Newtonian thinker? – three tests

Test 2 Drop an object while walking

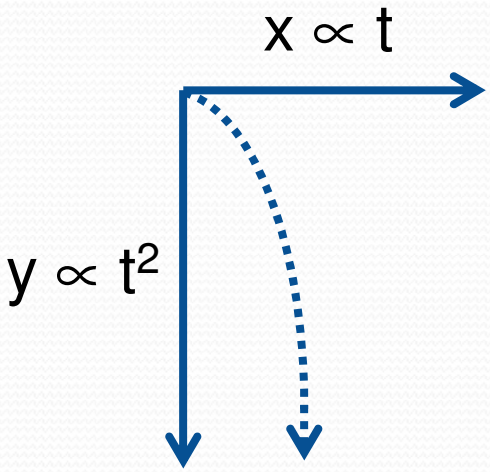
3 forwards!





Are you an Aristotlean or Newtonian thinker? – three tests

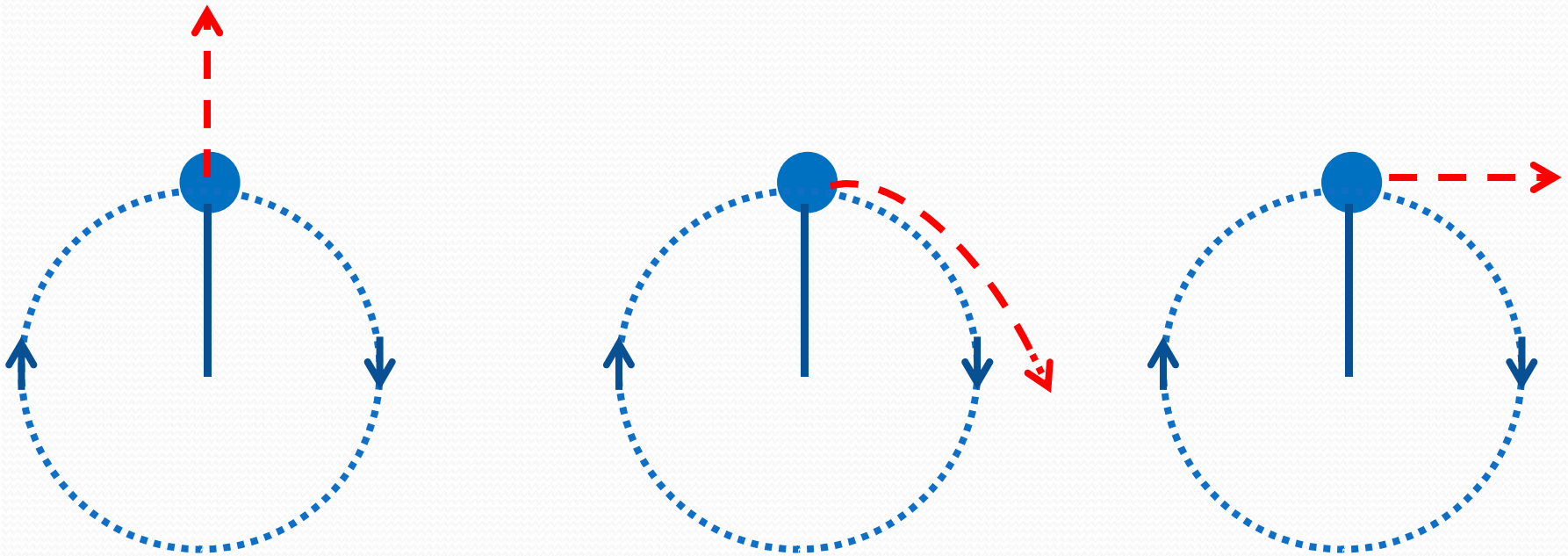
Test 2 Drop an object while walking



Dam busters or bouncing bombs

Are you an Aristotlean or Newtonian thinker? – three tests

Test 3 Let a spinning object go



1
radial

2
curved

3
tangential

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Newton Top 10

- *Principia* (formulation of laws of motion)
- Gravitation (universal)
- Calculus (rate of change)
- Three laws
- Telescope
- Optics (white-light recombination)
- Colour = wavelength
- Multiple-prism beam expanders
- Generalized binomial theorem
- Cooling Law

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NEW TON

NEW TON

NEW TON

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The Generalized Binomial Theorem

$$(a + b)^n = ?$$

al-Karaji (d. 1029) constructed a table of binomial coefficients up to $(a+b)^5$.
Blaise Pascal created his famous table of coefficients for higher *n* (1653).

Newton generalized for all values of *n*, including fractions and negatives:

$$\mathbf{(a+b)^n = a^n + na^{n-1}b + [n(n-1)a^{n-2}b^2] / 2! + [n(n-1)(n-2)a^{n-3}b^3] / 3! + \ldots + b^n}$$

For $-1 < n < 1$, produces an infinite, converging series.

Newton's consideration of infinite series and limits through the binomial theorem led directly to his development of calculus.

The Generalized Binomial Theorem

$$(a + b)^n = ?$$

$$(a+b)^n = \sum_{k=0}^{n} \binom{n}{k} a^k b^{n-k}$$

The Generalized Binomial Theorem

$$(a + b)^n = ?$$

1

1 2 1

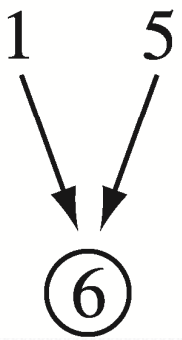
1 3 3 1

1 4 6 4 1

1 5 10 10 5 1

1 (6) 15 20 15 6 1

add two numbers from above



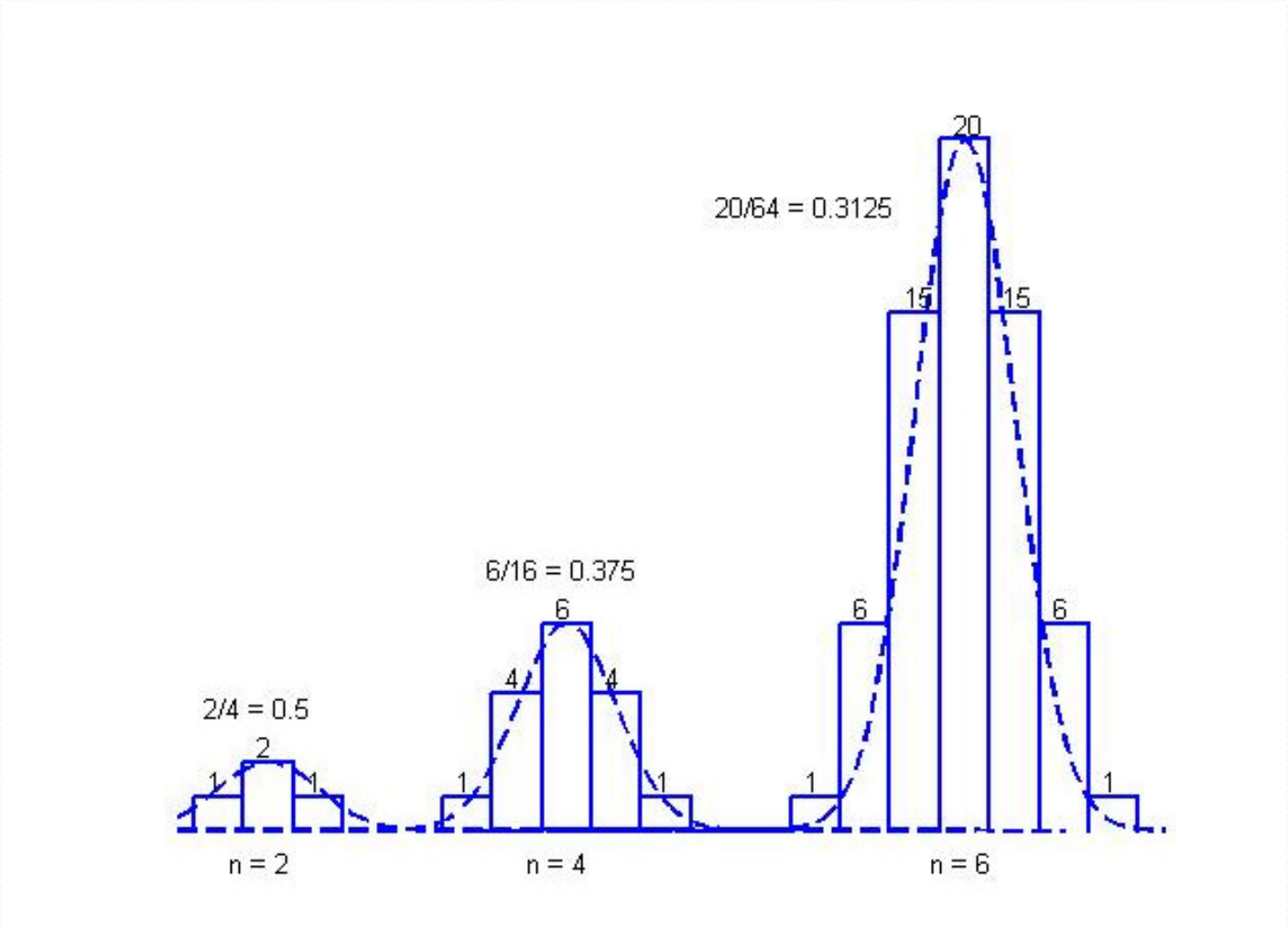
1 right, 5 wrong

'6 choose 1' = 6

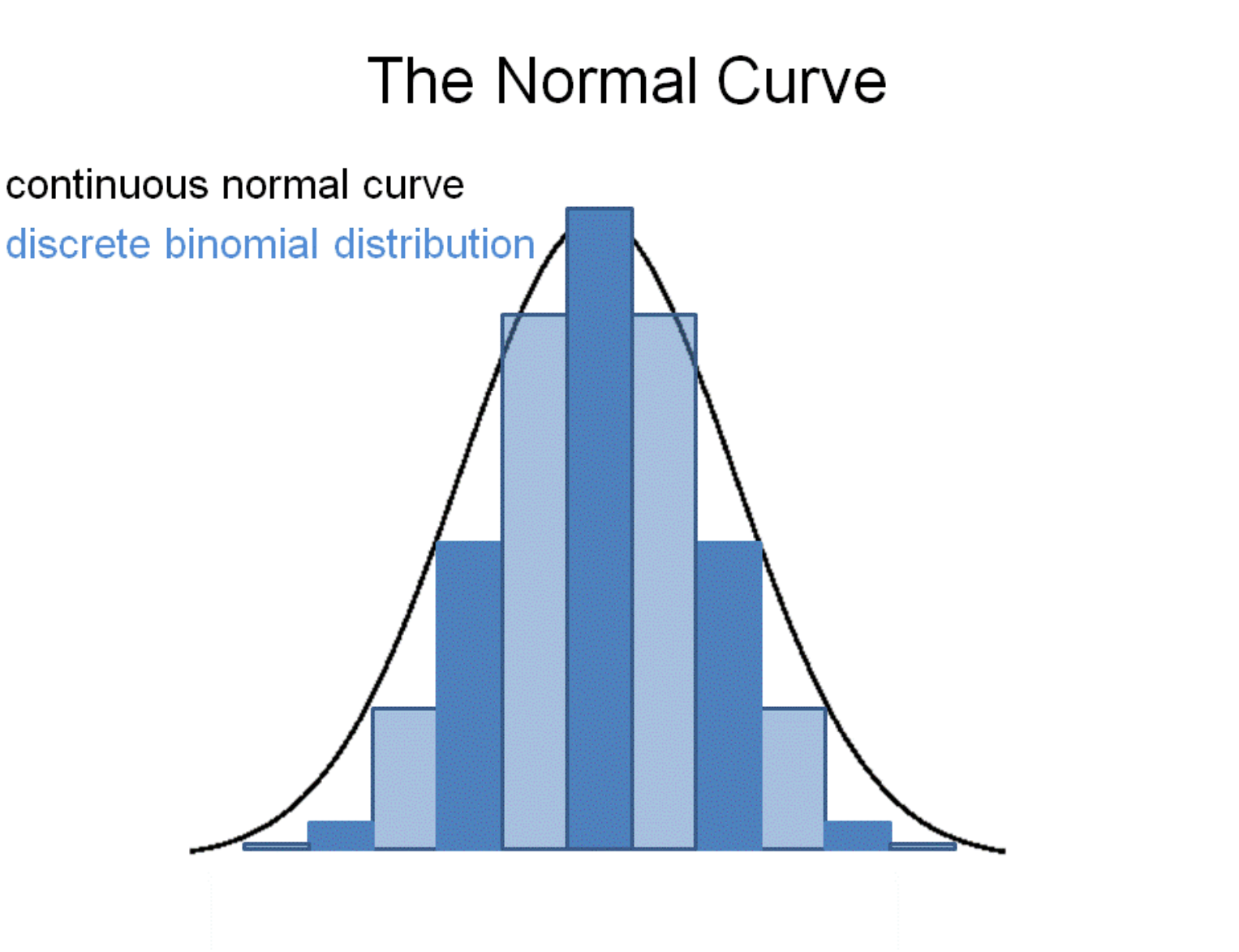
$= 6!/1!/5!$

$$= \frac{6 \times 5 \times 4 \times 3 \times 2 \times 1}{1 \times 5 \times 4 \times 3 \times 2 \times 1}$$

The Generalized Binomial Theorem



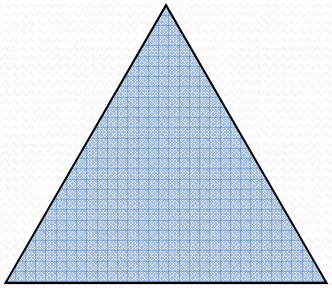
The Generalized Binomial Theorem

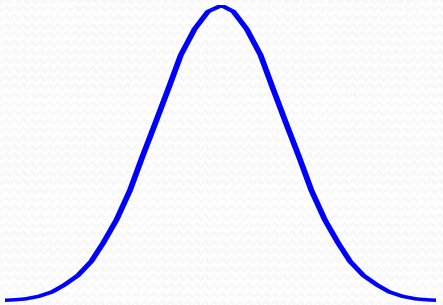


The Generalized Binomial Theorem

How Newton and Pascal became Gauss

Carl Friedrich Gauss (1777-1855) worked on an equation to determine odds for computationally difficult higher rows of Pascal's Triangle. The discrete **binomial** became a continuous **Gaussian** (aka bell or normal).



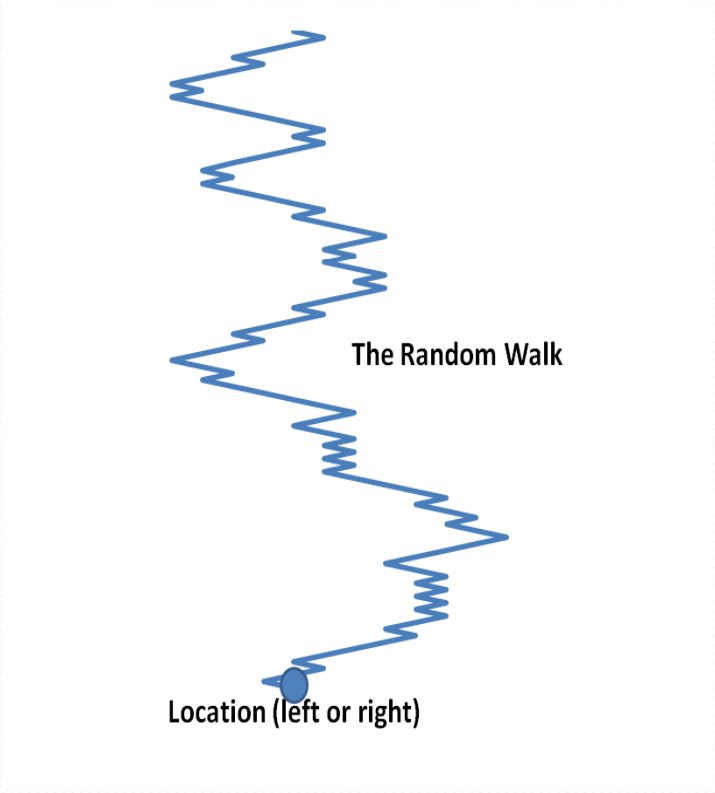


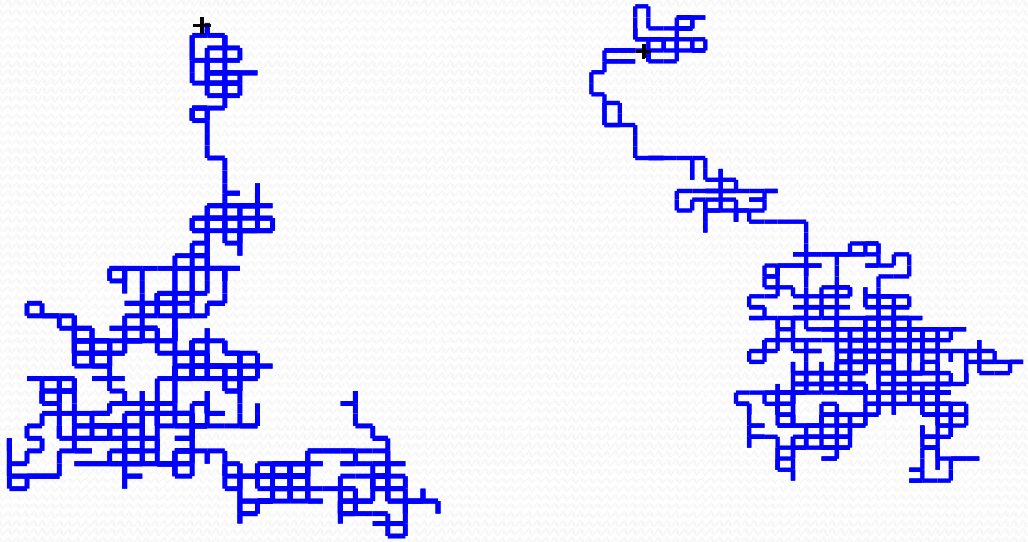
$$(p+q)^n = \sum_{k=0}^{n} \binom{n}{k} p^k q^{n-k}$$

$$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\bar{x})^2}{2\sigma^2}}$$

The Generalized Binomial Theorem

Random Walks





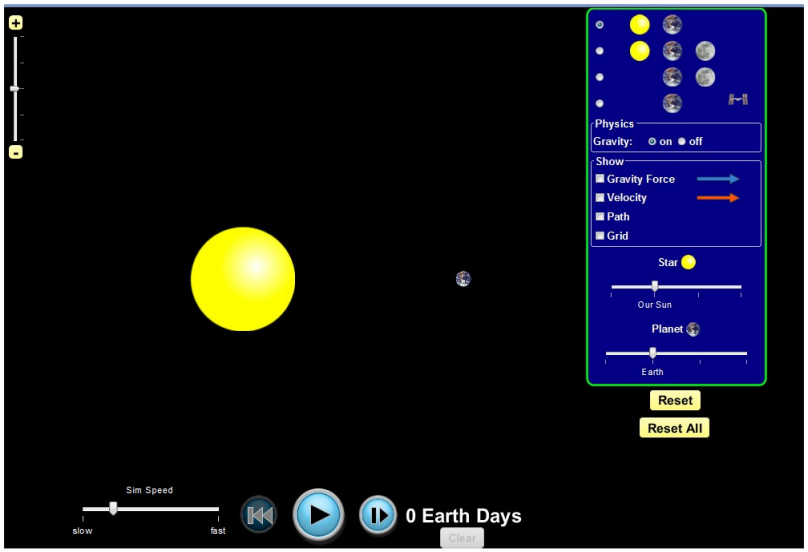
motion of molecules in a gas or liquid, fluctuating stocks, roulette winnings, animal search paths, weather.

1-D

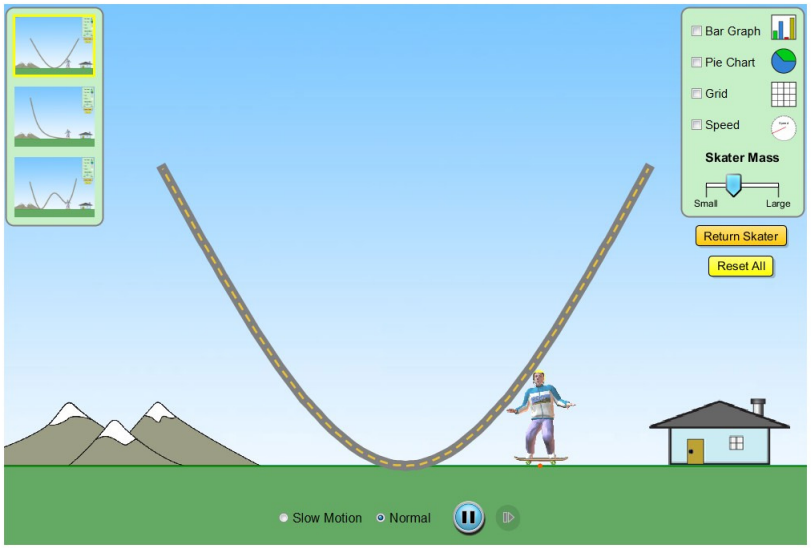
2-D

- The 4 Boxes of Physics
- A Get-to-know-Isaac-Newton Quiz
- Majestic Clockwork
- THE THREE LAWS
- Are you Aristotle or Newton?
- Newton Top Ten
- Hollywood Newton
- A Binomial Game
- PhET Simulations
- After Newton

PhET: phet.colorado.edu



Gravity and Orbits



Energy Skate Park

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> Newton?

After Newton, the world was not the same.
But then came **Einstein**.
After Einstein the world was **really** not the same.

- Curved space
- Length and time contractions = f(velocity)

$$L = \frac{L_0}{\gamma(v)} = L_0\sqrt{1 - {v^2}/{c^2}}$$

Some Useful Links

PhET (U of B): http://phet.colorado.edu/

Hyperphysics (U of G): http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Experiments (UCD): http://www.ucd.ie/physics/currentstudents/labresources/index.html

Do The Math! downloads and videos: http://www.johnkwhite.ie/DoTheMathDownloads.html