Science emerges during the Reformation - the Rise of Causality

- **The Reformation**[1]**:** protestant reform movements in the Christian Church.

  (**Key people:** Martin Luther, John Calvin, John Knox ...)

  - Biblical revival and translation of Bible into ordinary language
  - An improvement in the intellectual and moral standards of the clergy
  - Emphasis on the sovereignty of God

- **Why did science take off during the Reformation?**

  Why not 2000 years earlier in Athens, or even earlier in Babylon, China, Egypt, India ... ?

  - For Einstein this was not the right question: for him the amazing thing was that science had ever taken off.
  - Others feel that the spirit of the Reformation was significant ... that the intellectual freedom of the time gave the necessary impetus for the **secular skepticism** tradition to try to re-assert itself ...

[1] Information from the *Cambridge Encyclopaedia.*

The Rise of Causality

- **Causality**[2] a word that entered philosophy via science after the time of Newton
- describes the relationship between two events in terms of the application of a rule of 'law' of nature.

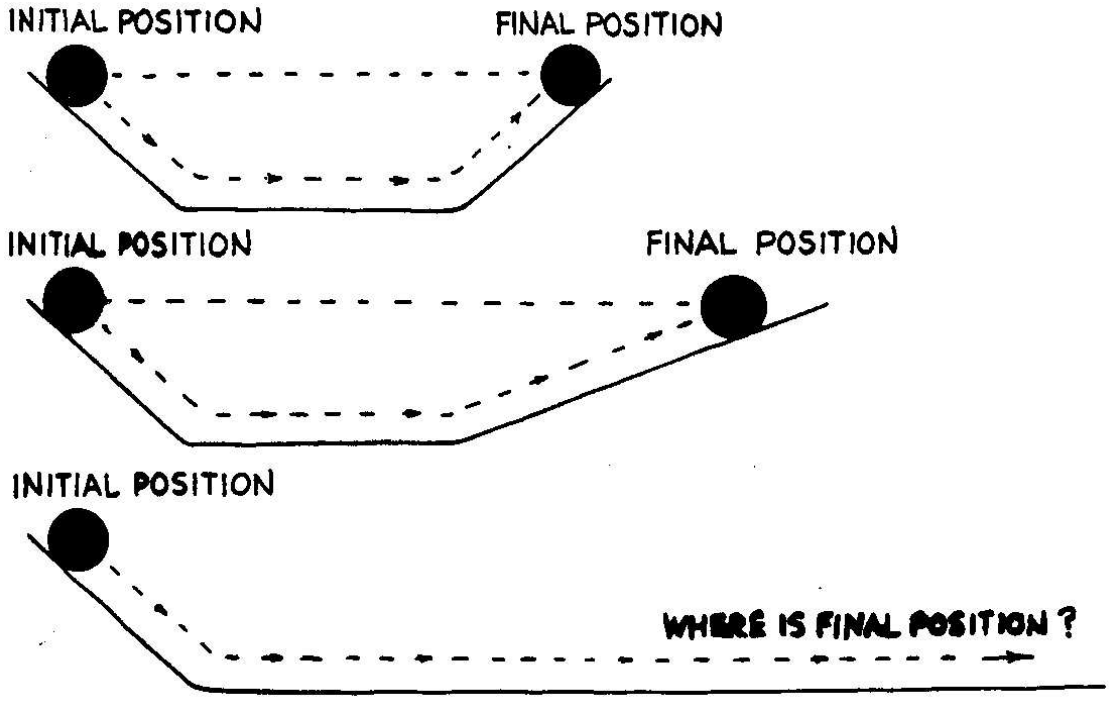
... implication that nature is predictable because of the existence of these 'laws'

... the idea that a similar causality applied outside physics was a cornerstone of the Enlightenment ...

[2]For our purposes.

Galileo's Key Experiment

- Fast-forwarding past Copernicus, Brahe, Kepler and Galileo's
  amazing discoveries with his telescope ..
- Discuss this experiment[3]:



- **Conclusion:** the object will continue to move in a straight line with a steady speed.

Forces produce changes in motion

(Recall what the Greeks said: **forces produce motion** or
forces produce velocities.)

So, **forces produce accelerations**.

- Fred Hoyle called this: **the idea for which the world had waited for 2000 years.**

[3]Figure taken from excellent book *Conceptual Physics* by Hewitt.

- **Developed by Newton in his *Principia*:**

$$\mathbf{F = ma}$$

- **'Strict' Causality:** if at some instant we know
  - the position of an object, and
  - its speed and direction of motion,

  then, using Newton's Second 'Law' which tells us how the motion of an object is changed by a force, we can predict its subsequent motion, moment by moment.
- **'Laws' of Nature** following the spectacular successes of Newtonian mechanics, expressed in elegant mathematical form (largely Greek geometry), Newton's laws began to be regarded as 'universal laws of nature'.
- **Laplace's famous boast:**

  that if he were given at some instant the positions, together with speeds and directions of motion, of all particles, then he could predict the future of the universe.

- **What is a 'law of nature'?**
  - Galileo went a long way towards defining science as we now think of it we he defined
    - **measurable or primary qualities:** things all 'reasonable' people could agree on: number, length, weight, geometrical shape.
    - **immeasurable or secondary qualities**: were things that existed in the mind of the observer: taste, colour, warmth.

    As an example of his science, he measured how the distance d travelled down a slope depended on the time taken t. He found that the relationship could be described by $d \propto t^2$, a 'law'.

    This approach is in the spirit of **secular skepticism**.
  - By the time of Laplace, Newton's 'laws' had a much more
    elevated status, more in the **metaphysical idealism** spirit.

    Recall one of their guiding principles:
    - The universe 'possesses' an intelligence which is accessible to human awareness, if that has been developed to a high enough degree.

    Were Newton's 'laws' not an example of this awareness?

$$\mathbf{F} = \mathbf{ma} \text{ and } \mathbf{F} = \frac{GMm}{r^2}$$

- The **Enlightenment**

  Philosophers[4] set out to apply Newton's method beyond the material ('outer') world, in the ('inner') worlds of the human mind.

  Their plan:

  – to formulate general laws on the basis of observation ('inner' and 'outer'), and

  – to deduce specific conclusions from such laws.

  Condorcet: human and physical events were 'equally susceptible to being calculated and all that is necesary to reduce the whole of nature to laws similar to those which Newton discovered with the aid of calculus, is to have a sufficient number of observations and mathematics that is complex enough.'

  The 'father of the social sciences', Comte, in the early 19^{th} century took things even further along the metaphysical idealism path with his 'positivism'.

[4]Reference: *The Age of Enlightenment* by Isaiah Berlin

- **Isaiah Berlin[5] commenting on the Enlightenment**
  - A wider thesis underlay Enlightenment thought:
    - To all true questions there must be one true answer, and only one, all others being false. Otherwise, questions cannot be genuine questions.
    - There must exist a path which leads clear thinkers to the correct answers ... as much in the moral, social and political worlds as in the natural sciences ...
    - If the answers to these questions - the truth - are discovered ... men will follow them, for there would be no temptation to do otherwise.
    - And so a perfect life can be conceived ...
  - This creed was not confined to Enlightenment thinkers, In various forms it has been in Western thought from the pre-Socratics ... ... if no true answers to questions exist, how can knowledge ever be attainable in any province? This was the heart of European rational, and indeed spiritual, thought for many ages.

Berlin: 'I do not know why I have always felt skeptical about this almost universal belief, but I did.'

[5] See **Monism** in handout on History of Ideas and Political Theory by Berlin

We now move on to the 20^{th} century with a few quotes from Heisenberg.