**HI2D5, Science, Technology and Society, 1400 to Present**

**Week 4. The Mathematization of the World, 1400-1700. Dr. Michael Bycroft, 21 Oct 2019**

**Introduction**

* Mathematics and natural philosophy were distinct in ancient Greece
* By 1700 it made sense to refer to ‘The Mathematical Principles of Natural Philosophy’
* How did this change come about, and how complete was it?
* Mathematics seems ahistorical, but it is part of history like everything else in this module

**Mathematics in the university, c. 1500**

* Quadrivium = geometry, arithmetic, music, astronomy [and optics]
  + Ancient Babylonians, Assyrians, Egyptians (arithmetic, astronomy)
* Ancient Greeks and Romans, eg. Pythagoras (music), Euclid (geometry, optics), Ptolemy’s *Almagest* (astronomy)
* Islamic writers, eg. al-Haytham (optics), al-Khwarizmi (algebra)
* Religion, eg. date of Easter, prayer times and directions, inheritance rules
* But the quadrivium was not part of natural philosophy – why?
  + Aristotle’s cosmology ie. the sublunary sphere is imprecise
  + Aristotle’s matter theory ie. the four elements are qualities, not quantities
  + Natural philosophy a higher-status discipline in universities than mathematics
  + Sheer difficulty, eg. the motions of the planets
  + Absence of measurement, eg. local motion

**Mathematics in the Renaissance, 1400-1600**

* Humanism
  + Plato – insensible Forms; theory of triangular atoms
  + Democritus and Lucretius – world made of moving atoms
  + Euclid, Archimedes – source of mathematical tools
  + Educational reforms, eg. Petrus Ramus (1515-1572) in France
  + Astrology, eg. Jerome Cardano (1501-1576) – Martin Luther, Edward VI, Jesus, himself...
  + Astrology combines maths, Platonism, patronage, practicality
* Artisans
  + ‘mathematical practitioners’, eg. Sebastian Cabot
  + navigation, assaying, gunnery, accounting, landscaping...
  + the fine arts – linear perspective; proportions of buildings, humans, fonts
* Reformation
  + Martin Luther’s 95 theses (1517), Augsburg Confession, written mainly by Philip Melanchthon, Prof. at U. Wittenburg (1530), Henry VIII breaks with Rome (1532-5)
  + Society of Jesus (est. 1534), Council of Trent (1545-1563), Gregorian Calendar (1582)
  + Maths a form of worship, evades metaphysics, informs calendrical reform
  + Protestant example: Philip Melanchthon (1497-1560) at U. Wittenburg
  + Catholic example: Christoph Clavius (1538-1612) at the Jesuit College in Rome

**Galileo and the rate of free fall**

* Galileo Galilei (1564-1642)
  + Art teacher at Academy of Art and Design, Florence – teaches perspective
  + University professor at U. Pisa then U. Padua
  + Courtier to Grand Dukes of Tuscany
  + Engineer – invents a tuning device, hydrostatic balance, military compass...
* Lectures in natural philosophy
  + Galileo’s own lectures and those of Jesuits at Roman College
  + Aristotle: free fall due to endeavour towards centre of universe
  + Medieval Aristotelians: idea of ‘wasting impetus’, used to explain why thrown objects move sideways even when out of contact with the thing that threw them
  + Falling bodies accelerate in proportion to their *distance* from the centre of universe
* Table-top experiment
  + What path does a cannonball follow?
  + Guidobaldo del Monte (1545-1607), marquis, soldier, books on perspective and military architecture, close to Grand Dukes of Tuscany
  + Real cannonballs hard to measure – so roll ball off table-top instead
  + Measurements show that vertical distance is the square of horizontal distance
* Explaining discrepant data
  + Aristotelean response: nature is imprecise
  + Platonic response: nature is precise, even if our senses tell us otherwise
  + Galileo gives accounting analogy to convey this Platonic idea
* Quantifying horizontal motion
  + Aristotle and Aristotelians: horizontal motion is ‘unnatural’ and tends to slow
  + Galileo: horizontal speed is constant
  + Upward slopes slow bodies down, downwards slopes speed them up, flat surfaces...?
  + Experience superfluous, careful recollection enough, cf. Plato’s dialogue *Meno*
* Separating vertical and horizontal motion
  + Aristotle: vertical and horizontal motion are engaged in a ‘struggle’
  + Galileo: the two vary independently of each-other
  + A spiral is just a mixture of circular motion and straight-line motion (Archimedes)
  + Rain falls at same speed on a still day and windy day (Jerome Cardano)
* *There is much more to measurement than measurement*

**The limits of mathematics, c. 1700**

* Is quantification enough?
  + Galileo: often, eg. attempts to explain free fall often just get in the way
  + Most natural philosophers, 1660-1760 – no, a mechanical explanation needed as well
* What can be quantified?
  + Planetary motion, projectile motion, light and colour – thoroughly quantified by 1704
  + But what about electricity, magnetism, heat, chemical reactions, botany....?
* Who should do the quantifying?
  + Artisans, with their tried and tested methods and their immersion in practice
  + Scholars, with their general principles and new-fangled mathematics