Introduction

- Empirical discipline that relies heavily on observable and quantifiable phenomena.
- Hypothesizing, experimentation, observation and induction.

The Middle Ages

- 3 classes (feudal system - rigid): clergy of the Catholic Church, nobles and peasants (serf)
- Christianity in the form of Catholicism
- Church dominated life

- Scholasticism
  - All learning and intellectual thought was aimed at attaining a better understanding of the truths and tenets of Christianity
  - Better understanding of God
  - Deductive in its approach
  - Not aimed at questioning status quo or discovering new knowledge but to explain and account for it

- The Geocentric Universe
  - Series of concentric spheres with a fixed or motionless earth at its center
  - Spheres made of a crystalline substance and moved in circular orbits
  - Beyond this was Heaven, the location of God → deeply influenced by Christian thought

- Emerging Doubts about Geocentric Universe
  - The observations did not always correspond to the accepted scheme
  - Proposed supposed explanations which only revealed the inadequacies of the premises that governed the geocentric model

The Renaissance (14th to 17th Century)

- Emerging doubts about the dogma of Middle Ages
- Advent of voyages of discovery and exchanges with other parts of the world also triggered this shift
- They disproved ancient beliefs about the southern part of the globe and revealed new continents not previously known, thus challenging established authority.
- God-centered world gave way to a worldview that focused on the potential of the individual and predominant of the human being.

- **Rejecting the Medieval World View**
  - Revival of ancient Greeks and Romans knowledge – classical knowledge
  - Change in mind set, radical paradigm shift
  - New perspective
  - Archimedes
    - Proposed that the universe operated on the basis of mechanical forces
    - Posed as a direct challenge to the medieval belief that God controlled universe
  - Galen – Roman physician
    - Dissected monkeys and pigs
    - Not until, Andreas Vesalius (15th Century) dissected human bodies to verify Galen’s conclusions were they thoroughly disproved.

- Respected authorities subject to critical examination and questioning
- Previous dogmas open to challenge and demolition

- **Mathematics**
  - Language of science
  - Key to navigation, military science and geography
  - Promoting a degree of certainty that was otherwise impossible

- **Humanism**
  - Emphasis on the individual
  - Importance of skepticism and curiosity
  - God-centered → One that put mankind in the center
  - Rejected chief assumption that pursuit of knowledge was for glorification of God
  - Focus on history, chemistry, medicine as compared to scholastic thinkers who examined more abstract, theological
  - Believe they controlled their destinies, not church
  - Encourage Europeans to believe that nature could be manipulated and directed towards human ends
  - Set the state for Protestant Reformation in 1517

- **Emergence of the Underpinnings of Science**
  - Use of instruments, conducting of experiments and emphasis on close observation
  - Developing amalgamation between the worlds of the artisan and intellectual
  - Renaissance artists’ desire to imitate nature led them to rely on close observation
  - Accurate renderings of nature established new standards for studies
  - Leonardo da Vinci

- **Emergence of New Media**
The Scientific Revolution

- Invented by Johann Gutenberg
- Heralded age of print, information and knowledge could be disseminated to an audience in an inexpensive and accessible manner.
- Exchange of ideas became easier and more widespread
- Church used to be sole source of information
- Impact nature of religion -> translations, bible in widespread circulation
- No longer dictated by church; he could read God’s word without an intermediary
- Gradual weakening of the stranglehold that the Church exerted over the faith of its people

The Reformation (1517 – 1648)
- Lost confidence in church’s religion leadership
- Seemed too concerned with worldly affairs
- The Renaissance secularized European society
- Permanently destroy the religious unity of central and Western Europe

Scientific Revolution (16th – 17th Century)

Interactions: Individuals and Contexts

- REVOLUTION
  - Denotes rapid, collective political change involving large numbers of people.
  - Causing a drastic and far-reaching change in ways of thinking and behaving
- Not rapid, complex movement with false starts
- Did not involve more than a hundred people in widely separated studies
- Fundamental transformation in scientific ideas
- Gave direction to scientific research and advancement through the rise of scientific method
- Separation of science and religion
- Corrected old and wrong knowledge, new discoveries
- Establishment of new social institutions to support the emerging scientific enterprise
- Entire process of pursuit of natural knowledge was informal
- New scientific concepts & methods set the standard for assessing validity of the knowledge
- Shift in medieval worldview → Stage for future developments

Nicolaus Copernicus (1475 - 1543)
- Mathematician and faithful Christian
- Relied for his data on the records of predecessors
- Heliocentric or sun-centered conception
- Aristotle was born before Ptolemy
- Did not reject Aristotle’s principle of existence of heavenly spheres moving in circular orbits
- Challenged Ptolemaic picture in conservative manner
- Conservative, believed restored a pure understanding of God’s designs
- Denounced when more astronomers became attracted to his ideas, when the work of Galileo appeared
**IMPACT:**

- **HELIO – GEO:** significant!
  - Raised serious questions about Aristotle’s astronomy and physics
  - Uncertainty about human role in universe (no longer superior beings) and God’s location
  - Humans = small part of a whole
  - Decreased mysticism

- **New direction for thinking**
  - New ideas in future
  - Influenced other scientists (Kepler and Galileo) who presented more evidence to substantiate Copernican ideas and improve his system
  - Provided an intellectual springboard for criticism of geocentric model
  - Provide another way of confronting some of the errors in Ptolemaic astronomy
  - Allowed others who were discontented with Ptolemaic view to think in new directions

**Galileo Galilei (1564 - 1642)**

- Italian mathematician and natural philosopher
- First rough theory of inertia – only a change in motion required a cause
- First well-defined formulas that accounted for the normal motion of objects on a moving earth
- First used telescope to observe sky
  - Documented irregularities on the surface of the sun and craters on the moon
  - Discovered Jupiter’s moons and named them the Medician stars (contradicting Aristotelian principles that everything should revolve around Earth) = solid proof against geocentrism
  - Venus exhibited a full set of phases and orbited Sun = support for heliocentrism
  - Discovered celestial bodies
- Published book “The Starry Messenger” which allowed him to move in powerful social circles
  - Hoped that Copernicanism could coexist peacefully with the religious wisdom of Church
- Combined abstract mathematics and practical experiments to produce new physics
- Universe subject to mathematical laws (mathematical regularity everywhere)
  - Mathematical models applied to social relations
  - New natural philosophy portrayed nature as mechanistic
  - Power of mathematical arguments proved more persuasive than physical observations
- Transformed Copernicanism from a theory about astronomy into a larger debate about role of Science in revealing true nature of world
- New relationship between religion and science (controversy – challenged powerful churchmen)
- Firm belief in ideas and penchant for controversy made him the best-known scientist of his time
- Conflict with Catholic Church

**IMPACT:**

- Believed in equal partnership between Science and the Church in seeking truth
  - Believed that the church saved souls and the scientists should explain the physical world
  - Church’s role was to “tell us how to go to heaven, not how the heavens go”
- Made a thorough case for the heliocentric model
The Scientific Revolution

- Corrected old Aristotelian theories and principles (eg Jupiter’s moons, surface of moon/sun)
- Explained problem of motion
  o Concept of acceleration
  o Principle of inertia
- Telescope: concrete evidence that Earth moves, discover new celestial bodies, form some idea of distances between stars
  - First instrument to enhance observing capabilities
- Well-publicised ideas, determined to spread his findings
  o Popularized Copernican system especially in Northwest Europe (outside Italy)
  o Use of Italian instead of Latin to publish findings led to interest and greater awareness among commoners in Science
  o Simplified concepts to let everyone understand
- Influenced man’s ideas of his place in universe and purpose in life
  o Not superior anymore
  o Only part of a whole vast universe
- Scientific method
  o Reduced complex problems to most simple terms
  o Approach based on mathematical reasoning
- Proposed concept of a universe subject to mathematical laws
  o People were now convinced about the power of mathematical arguments which appeared irrefutable rather than stick to mere physical observation
  o This intellectual shift was a momentous change for Western civilization – using MATH in science
- Change in thought (ancient – modern)
  o Dialogue compares a character supporting Aristotelian system, made to look hopeless stupid, in a symbol of Galileo’s conviction that the Aristotelian system, based on arbitrary and mystical hypothesis, was outdated in the world of exact science
  o Evidence-based science, not mystical beliefs
- Stood up against the church and advocated his ideas
  o Others started to believe it
  o High-profile trial hampered further scientific work in Italy (banned by Catholic Church)
- His ideas were modelled after Copernicus’, adding in some math
- Bent to wishes of church
  o Recanted his theories
  o Banned from working on those ideas
  o Books were banned
  o Put under house arrest

Francis Bacon (1561 - 1626)
- Lawyer and one-time Lord Chancellor
- Scientific method built on inductive principles
- Through organized experiments and thorough, systematic observations, correct generalizations could be developed.
- Any knowledge of nature should be enlisted to improve the human condition.
- People were rejecting the past not from simple contempt or overweening pride but from a firm understanding that the world was more complex.
- Cannot remain self-contained → New worlds of the mind were emerging
- Baconian empiricism

**Isaac Newton**

- English experimenter, empiricist, and university mathematician
- Invented calculus – a mathematical means of calculating rates of change
- Law of universal gravitation
  - There is gravitational force acting between any two objects in the universe
- Optics
  - Composition of light – white light comprised different colours
  - Splitting and recombining a ray of light between 2 prisms proved this
  - Hooke criticized him as it revealed the nature of light but had did not explain
- Motion
  - Orderly picture of the universe
  - Motion governed by same set of natural laws by demonstrating consistency between Kepler’s laws of planetary motion and his theory of gravitation, removing last doubts about heliocentrism and advancing the SR
- Laws of motion helped development in other fields
  - Engineers: design new kind of working parts for machinery
  - Push and pull of gravitation showed geographers that Earth was not a perfect sphere, altering nature of mapmaking
  - Math of gravity can predict ebb and flow of tides, even in uncharted waters
  - Gigantic leap in maritime industry
- Gave Man greater power over his environment with newly acquired knowledge (exert control)

**IMPACT:**

- Combined math, meticulous analysis and predictive capabilities
  - Convincing, clear conclusion to debate between helio and geo
- Universal Law of Gravitation
  - One mathematically proven universal law can explain all motion in universe
  - Secrets of natural world could be known by human investigations
- World seen in mechanistic terms
  - One large machine operated according to natural laws in absolute time, space and motion
- Solar system perfectly explained by assuming that major organizing force was gravity
- Conclusively affirmed laws of motion, linked with Kepler’s laws of planetary motion
- Scientific community recognized his findings as revolutionary
  - Proven with such clarity and logic so as to be nearly indisputable by rational argument
History Year 3 || The Scientific Revolution

- Mechanical analysis became widely known, accepted as basis for all future astronomy
  - Plausible and demonstrable model for workings of universe
    - Solely relying on mechanics
    - Separate of spiritual influence
    - Profound break from Middle Ages

- Before Newton, astronomy had been considered at best a theoretical science, based little on direct evidence
  - More often called ‘philosophy’, for its proponents were hypotheses without proof
  - Usually used God in efforts to explain structures and phenomena
  - Newton changed this: theories backed by solid mathematical proofs, mechanical explanation of universe without mysticism or spirituality
  - Astronomy earned right to be known as a science, more distinct break from theology and move towards mechanism

The Significance of the Scientific Revolution

**Emergence of ‘Science’ as an intellectual discipline**
- Scientific method: Hypothesis, observations from experiments, generalization induced, tests of the generalization by experiments

**Wider Influence of Scientific Thought**
- Ardent propagandizes through writings of the great innovators
- Convinced public that science now offered a promise of certainty that was not to be found elsewhere

**The Spread of Scientific Knowledge**
- Scientific learning and investigation increased
- Emergence of new learned societies and journals that enabled the new scientists to communicate their ideas to each other and disseminate them to a wider literate public

**Science Institutionalized**
- Scientific society
- Scientific work should be a cooperative endeavor and information should be exchanged among practitioners
- Beginning of professional scientific journal
- In 1660, the Royal Society of London for Improving Natural Knowledge was formed
  - Granted a charter by King Charles II – First sign of a link with political authority
  - Indicated presence of central governments in all areas of society
- Science, secure in royal patronage, became a model for all thought.
- Membership in these societies was limited and highly prized, a sign of glamour that began to attach itself to the new studies.

**The Wider Appeal of Science**
- Science became applied in a variety of fields and fashion

**New Knowledge**
History Year 3
The Scientific Revolution

Advances in Medicine
- **Galen** came up with an inaccurate human anatomy through animal dissection
  - Belief that there were 2 separate blood systems – one controlled muscular activities and contained bright red blood (arteries), the other governed the digestive functions and contained dark red blood (veins)
  - Treatment of disease influenced by Galen’s doctrine of 4 bodily humors: blood, yellow bile, phlegm, black bile
- **Andreas Vesalius** made accurate drawings of the human anatomy
  - Blood originated from the heart, not the liver
- **William Harvey**
  - Same blood flows in both veins and arteries and blood makes a complete circuit as it passes through the body.
  - Capillaries were discovered
  - Led to medical breakthroughs
    - Doctors in Europe learned how to produce a vaccine to prevent smallpox

Enlightenment (Age of Reason)
- The Scientific Revolution also paved the way for the Enlightenment
- Changed the way people lived
- Scholars began to question the workings of society and government, rejecting traditional ideas (purpose of government, best form of it)
- A period of revolution in philosophy in which reason and rationality became the primary way of knowing the world
- The universe is governed by natural rather than supernatural forces
- Rigorous application of SM can answer fundamental questions in all areas of inquiry
- The human race can be educated to achieve near infinite improvement.

On Human Nature
- Thomas Hobbes, John Locke – 2 English philosophers
- Changed the way people viewed the individual’s role in society
- **Hobbes**
  - A state with no government – they would constantly fight among themselves.
  - People enter into a contract with a ruler, preferably one with absolute power
  - Could not rebel even if they thought the ruler was a tyrant
- **John Locke**
  - Government created order in society.
  - Rulers could stay in power only as long as they had the consent of those they governed. If he is a tyrant, people had the right to rebel.
  - People had natural rights and government was responsible for protecting these rights – his power should be limited

Social and Economic Ideas
- Urged religious toleration and condemned wars of religion
- Freedom of speech and the press
- Believed censorship was harmful because it kept people from learning about new ideas
- Encouraged education to end ignorance, prejudice, superstition
- Called for end to slavery and torture, cruel punishments for crimes, more humane treatment of the mentally ill

Three Influential Views of Running a Country
- Montesquieu
  o Separation of power: legislature, executive, judiciary
  o Each branch of government should be carefully defined to provide balance
- Voltaire
  o Common sense, religious toleration and freedom of thought
  o Best ruler is a ruler who studied the science of government and protected the basic rights of people
- Rousseau
  o People were equal and all titles of rank should be abolished
  o Make a contract with one another, not with a ruler
  o Beliefs in equality and in the will of the majority
  o Spokesman for the common people

CONCLUSION
- Decisive in shaping the modern mentality
- Shattered medieval view of the universe
- Re-orientating Western thought
- Knowledge of Newtonian science and dissemination of useful learning
- All knowledge could emulate scientific knowledge
- Led people to examine institutions and traditions with inquiring, critical and skeptical spirit
- Theology became not fit for interest of practical, well-informed people
- Magic, witchcraft and astrology, still widespread among European masses, regarded with disdain by elite culture

<table>
<thead>
<tr>
<th>Positive</th>
<th>Negative</th>
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<tbody>
<tr>
<td>- Led to end of blind faith</td>
<td>- Loss of traditional faith</td>
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<tr>
<td>- Quest for reasoning and intellectual enquiry</td>
<td>- Setback for masses who believed in their religious faiths because spiritual beliefs was shattered by revolutionary ideas of scientists</td>
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<tr>
<td>- Freedom for human exploration and discovery was given a new lease of life</td>
<td>- No longer had same view of things</td>
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## History Year 3 || The Scientific Revolution

<table>
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<tr>
<th>Event</th>
<th>Description</th>
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| Religious unity destroyed | - Church served as refuge for the religious, guidance.  
- When discoveries overturned tenets of traditional belief, now here to turn to.  
- New confidence in ability of human powers that ended doubts and uncertainties previously |
| New innovations in mathematics and sciences | - Rising tide of skepticism and loss of faith in existence of heaven  
- Advancements in medicine | - Most tangible positive consequences took time to be accepted by the world and utilized  
- Only felt in full spectrums in the later centuries  
- New innovations in mathematics and sciences \( \rightarrow \) navigation and map-making  
- New innovations in medicine \( \rightarrow \) Vaccines which reduced mortality rates/improve longevity  
- More organized and permanent scientific activity with emergence of scientific journals  
- New weaponry  
- New weaponry  
- Newton’s laws made fire cannons more accurate |
| Astronomy: New model of the universe | - Customs and traditions (superstition) binded by religious doctrines came under attack  
- Did not affect masses (Commoners)  
- Made no difference to the practicalities of everyday life  
- E.g. telescope  
- Only changed the intellectual community/educated elite  
- Rest still stuck to old beliefs |

### Important concepts

Change leads to more change  
Change can be positive or negative

### Tips for essays 😊

- Factor 1 was significant. It contributed to the SR... However, Factor 1 was overshadowed by equally, if not more, significant factors.
- Factor 2 is like Factor 1 BUT it..., making it MORE significant.
- At the end of each argument, LINK it back to the question

**Conclusion:**
- Without F3, F1 would have been less likely to happen.
- F2 also occurred on the basis that F3 occurred.
- **I strong believe that...**

### Points to note! (Rubrics)

- Cause and effect relationships (implications)
- Interplay of historical factors and historical context then
- Significance of issues