

Totally complete answers would have dealt with the following:

A. Summarize what Aristotle had to say about the motion of objects, how his medieval followers adjusted Aristotle's ideas, and how Galileo's explanation of motion differed from both Aristotle and his medieval followers.

Aristotle:

All motion requires a mover, even in case of an arrow loosed from bowstring

Velocity proportional to force and inversely proportional to resistance (or density of the medium)

Natural motion vs violent motion

Heavenly bodies move in perfect circles at uniform velocities

Medieval commentators:

Philoponus (and Avicenna): force can be impressed on arrow

Avicenna: body receives impressed force according to weight

Buridan: impressed force only diminishes if there is resistance. Weight adds to impressed force in case of falling body  $\Rightarrow$  acceleration

Galileo:

Aristotle (and medievals) wrong: Not all motion requires a mover, e.g. uniform circular motion is a natural state like rest

Aristotle wrong: velocity not proportional to force (e.g. bodies fall at essentially same rate)

Motion on earth can be described by mathematics

B. Discuss the role of religion in the development of science and the scientific method, beginning with the ancient Greeks, including the medieval period, and extending up through Galileo's trial. Can you give examples where the actions of religious authorities hindered scientific progress? Helped it?

Ancient Greeks: Milesian, sometimes called Ionian society differed from mythopoeic societies in that rather than simply ascribing all they saw around them to the agency of deities, they believed that one could understand the underlying working of nature by thinking rationally about it. They believed in deities, but did not refer to them in their writings about the motion of bodies in the heavens, except in the sense that an orderly perfection was associated with motion in this realm. A related group, the Pythagoreans were also inspired by mathematics to identify regularities and patterns in nature, but never removed divine agency from their discussions completely.

Medievals: Western European scholars were strongly influenced by the church. Early on, Aquinas and members of the Paris school tried to reconcile the newly rediscovered ideas of Aristotle with church doctrine, but ran into trouble with his claim that the universe was eternal, with no beginning or end, which contradicted the story of Genesis. Aristotle also said that no vacuum was possible, and that heavenly motions were always circular; these assertions apparently placed limits on the power of God. These aspects of Aristotelian philosophy and others were forbidden by the Condemnation of 1277. While Aristotle, ... Ptolemy placed the Earth motionless at the center of the universe, the issue of the Earth's motion was also discussed in medieval times (Oresme) and occasionally even openly advocated (de Cusa). This was problematic for church authorities primarily because they contradicted scripture, particularly the story of Joshua, wherein God made the sun stand still, implying that it was normally moving.

## Early modern Europe

Copernicus recognizes the problem of conflict with scripture, addresses it head on in his preface letter to Pope in *de Revolutionibus*, openly advocating Earth's motion only towards the end of his life. Immediately thereafter there is a window where Copernican ideas are open to discussion, and Kepler does his work, albeit mostly in northern Europe where Church's influence is lessening as Protestantism becomes dominant.

Church's opposition peaks under Urban VIII in reaction to Galileo's advocacy.

Jesuitical investigation recommends advocating Tychonian geocentric scheme. After early hearing in Rome, Galileo is forbidden to teach or hold Copernican opinions, as is rest of Catholic world. After trial in 1633, he is forbidden to publish.

Galileo's argument for Earth spinning include his analysis of inertial motion at Earth's surface, analogy with doing an experiment (playing tennis!) on a moving ship. This related more to Earth's spinning than to its revolution around the sun, however. He proposed that the tides could distinguish this latter motion, since he felt combined rotating and revolving would lead to a sloshing motion of the oceans (not correct).

For the most part, the role of religion has been either neutral or negative when philosophers and scientists were exploring new ideas. However it worked in positive ways as well: for example, the Church's condemnation of Aristotle was probably mostly a positive development, as mindless devotion to his natural philosophy writings had held back science much more than the Church during the early middle ages. Galileo's desperate and ultimately failed attempts to prove that the Earth moved were inspired by the conflict with the Church, and eventually led to real new insights about the motion of terrestrial objects.