

# OCR

Oxford Cambridge and RSA

**Friday 9 June 2017 – Morning**

**LEVEL 2 CAMBRIDGE NATIONAL IN SCIENCE**

**R072/02/1** How scientific ideas have developed

**INSERT**

**Duration:** 1 hour



## **INSTRUCTIONS TO CANDIDATES**

- This Insert contains the case study required to answer Question 1. Question 1 accounts for 25% of the total marks.

## **INFORMATION FOR CANDIDATES**

- This document consists of 4 pages. Any blank pages are indicated.

## **INSTRUCTION TO EXAMS OFFICER/INVIGILATOR**

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## Views of the Heavens

### Ptolemy (AD100–170)

I looked at the sky with my own eyes just like ancient astrologers used to do hundreds of years before my time. They recorded exactly where each star is in the sky. This was very important to them because many people used to believe that the stars affect our lives just as the Sun clearly causes the seasons.

I watch the Sun rising in the East each morning and setting in the West each evening. I think that the Sun is going around the Earth. This takes just over 365 days.

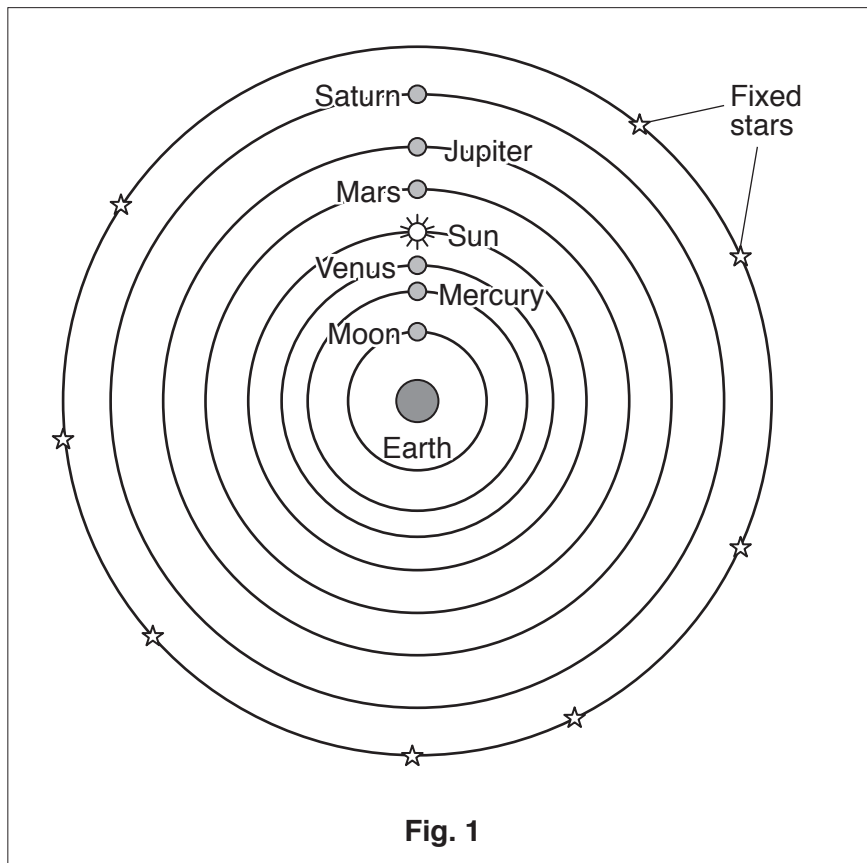
I also watch the moon at night. It is not as bright as the Sun. It is also going around us, but it has 'phases'. This means that its shape seems to change regularly, going through a complete cycle every 29 days.



I can see lots of stars each night. Most of them move in regular patterns across the sky. There are also bright objects that look similar to stars. Some of them move in a more complicated way, sometimes going in the opposite direction. We call them 'wanderers' but you know them as planets.

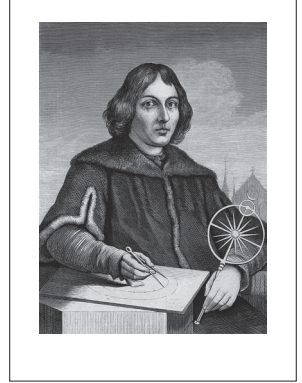
I have made lots of models from my observations. I published my ideas in convenient tables. These can be used to work out the future or past positions of the planets and the stars.

Everything I can see in the sky seems to travel around the Earth. I think that they must be fixed to invisible rotating spheres. As you can see in **Fig. 1**, the moon's sphere is closest to Earth and the stars are fixed to the outside sphere. Each sphere moves around the Earth at a different speed.



### Copernicus (AD1473–1543)

Ptolemy described the Universe by assuming that the Earth was at the centre. I have managed to make a much better model by assuming that the Sun is at the centre of the Universe. I think that the Earth and all the other planets are circling around the Sun. The moon is the only object which goes around the Earth. The stars seem to move because the Earth rotates.



### Brahe (AD1546–1601)

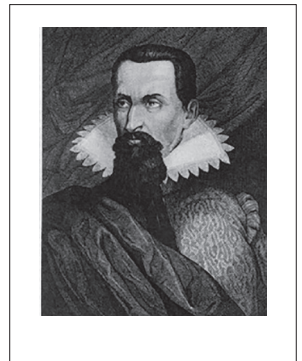


I used a new piece of equipment called a quadrant circle to make much more precise measurements than those which had been made before. My table of planetary positions and my star catalogue were the most accurate naked eye astronomical measurements of my day. When I observed a comet in 1577, I showed that it started a long way away and yet travelled very close to the Sun. This shattered the idea of the invisible spheres, since the comet would have to travel through the spheres on its journey. I developed my own 'geoheliocentric theory' in which the Sun orbits the Earth and the other planets orbit the Sun.

### Kepler (AD1571–1630)

I worked with Brahe to analyse the data which he had collected. I used his very precise data to work out that the planets are going around the Sun as Copernicus had said. My calculations showed that the orbits were not quite circular. Eventually, I showed that the orbits were ellipses. This is the first of my three Laws of Planetary Motion.

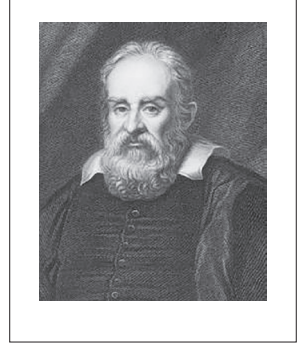
I cannot understand what is keeping the planets in these elliptical orbits. It is clearly not the old idea of 'invisible spheres'. I shall call it a 'life force' as there seems to be no natural explanation except an action of God himself.



## Galileo (AD1564–1642)

I became interested in the heavens, and I built my own telescope in 1609. This was soon after the first lenses were made in Holland. I saw many more stars than other scientists did previously and did detailed drawings of the craters on the moon. I used my telescope to discover the fact that Venus has ‘phases’ like the moon. The phases could only be explained if Venus is always closer to the Sun than the Earth. This proved that Copernicus and not Ptolemy had been right.

In 1616, the church declared the idea that the Sun was the centre of the Universe was “foolish and absurd ... since it explicitly contradicts Holy Scripture”. Since most people believed that the church was correct, some scientists were persecuted. In 1632 I published a book which tried to explain the science, but I was charged with heresy. I was tried and forced to deny that I was right. I spent the last ten years of my life under house arrest.

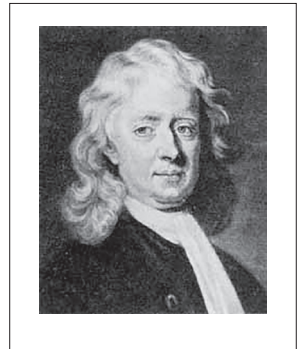


## Newton (AD1643–1727)

My first Law of Motion says that objects move in a straight line unless a force makes them change direction. Orbits like the ones that Kepler had described meant that there must be a force pulling them towards the centre of the orbit.

I described a new force which I called Gravity. It makes objects accelerate towards each other. The force depends on the mass of the objects and the distance between them. Objects with a lot of mass are more affected by gravity. The further away from the object, the weaker the force of gravity gets.

My third Law says that every action has an equal and opposite reaction. Gravity makes an apple drop to the Earth from a tree. It also attracts the Earth towards the apple. I worked out the equations to show how this explains the movement of the planets. Small objects orbit around bigger ones, but the small objects do make bigger ones move a little. **Table 1** shows the relative size and mass of the largest objects in the Solar System, compared to the Earth.



	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
<b>Mass</b>	0.05	0.81	1.00	0.11	317.00	95.00	14.00	17.00
<b>Diameter</b>	0.38	0.95	1.00	0.53	11.00	9.10	3.90	3.80
<b>Distance from the Sun</b>	0.4	0.7	1.0	1.5	5.2	9.5	19.2	30.1

**Table 1**

The Sun has a mass of 333 000 and a diameter of 109 using the same scale.

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