

# Astronomy

1 In the 1600s, Johannes Kepler developed a series of laws for how the planets of the solar system orbit the Sun. These are known as Kepler’s laws of planetary motion.

a) The planets orbit the Sun in almost circular orbits. Explain how, as a planet orbits the Sun, it can be constantly accelerating while its speed remains constant.

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[2]

Kepler’s third law states:

$$T^2 = kr^3$$

Where:  $T$  = time taken for a full orbit (the orbital period) in s

$k$  = a constant known as Kepler’s constant in  $s^2/m^3$

$r$  = distance from the orbiting object to the object it is orbiting in m

Kepler’s third law can also be applied to the orbits of moons around planets and dwarf planets. **Figure 1** shows data about some of Pluto’s moons.

**Figure 1**

| Moon     | Distance from Pluto (m) | (Distance from Pluto) <sup>3</sup> (m <sup>3</sup> ) | Orbital period (s) | (Orbital period) <sup>2</sup> (s <sup>2</sup> ) |
|----------|-------------------------|------------------------------------------------------|--------------------|-------------------------------------------------|
| Styx     | $42.4 \times 10^6$      | $7.62 \times 10^{22}$                                | $1.74 \times 10^6$ | $3.03 \times 10^{12}$                           |
| Nix      | $48.7 \times 10^6$      | $1.16 \times 10^{23}$                                | $2.15 \times 10^6$ | $4.62 \times 10^{12}$                           |
| Kerberos | $57.8 \times 10^6$      | $1.93 \times 10^{23}$                                | $2.78 \times 10^6$ | $7.73 \times 10^{12}$                           |
| Hydra    | $64.7 \times 10^6$      | $2.71 \times 10^{23}$                                | $3.30 \times 10^6$ | $1.09 \times 10^{13}$                           |

b) The moons listed in **Figure 1** were first imaged using the Hubble Space Telescope, a space-based optical telescope.

Suggest **two** explanations for why it was initially only possible to image the moons with a space-based optical telescope, and not with a ground-based optical telescope.

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2. ....

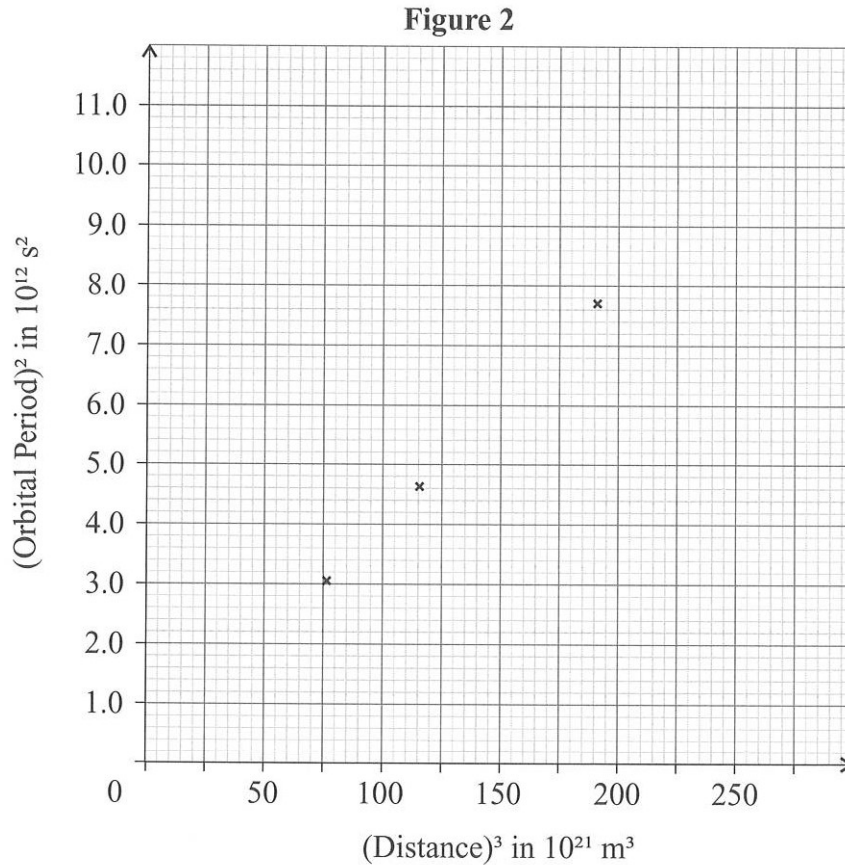
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[2]

**Figure 2** shows an incomplete graph of the square of the orbital period of the moons against the cube of their distance from Pluto.



- c) Complete the graph in **Figure 2** by plotting the missing point for Hydra. Draw a line of best fit. [2]
- d) Using **Figure 2**, calculate Kepler's constant for objects orbiting Pluto.

Kepler's constant = ..... s<sup>2</sup>/m<sup>3</sup>  
[2]

- e) Some theories suggest that another of Pluto's moons, called Charon, used to orbit Pluto at a smaller distance than its current orbit. Suggest what change occurred, if any, in the speed of Charon's orbit when it moved from its old orbit to its current orbit. Explain your answer.

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[2]

[Total 10 marks]

2 The Steady State and Big Bang theories provide two different explanations for the evolution of the Universe.

a)\* Describe these two theories for the evolution of the Universe and compare and contrast the evidence supporting each. State which theory is currently accepted and explain your answer.

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[6]

The evolution of a single star occurs in distinct stages. The first three stages are as follows:

nebula → main sequence star → red giant

b) In a stable red giant, the force of gravity is balanced by the star’s thermal expansion. Describe how the balance between the forces of gravity and the star’s thermal expansion changes through the stages of the star’s life cycle shown.

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[3]

c) A red supergiant star eventually evolves into a black hole. Compare the mass and density of the red supergiant and the black hole it will eventually evolve into. Explain your answer.

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[4]

[Total 13 marks]

**Exam Practice Tip**

The evolution of the universe and the evolution of individual stars — both of these topics require you to recall a whole lot of information in a specific order. A good way to jog your memory in the exam is to scribble down a flow chart or bullet points outlining the key facts in the correct order.

Score:   
**23**

