Gravitational fields – 2022 GCE Physics A Component 01

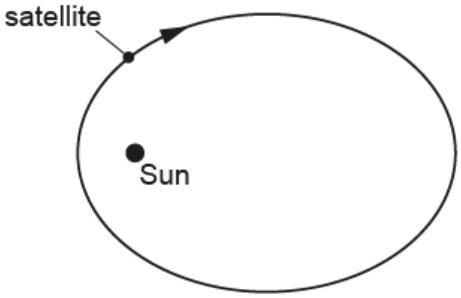
1. June/2022/Paper_H556/01/No.23

(a) A planet of mass m is in a circular orbit around a star of mass M.

Use the equation for Newton's law of gravitation and your knowledge of circular motion to show that the relationship between the orbital period T of the planet and its orbital radius r is $T^2 \propto r^3$.

[3]

(b) The Solar Orbiter satellite was launched in February 2020.
This satellite moves around the Sun in an elliptical orbit with a period of 168 days.
The diagram below shows the elliptical orbit of this satellite.



The closest distance of the satellite to the Sun is 4.20×10^{10} m and its furthest distance from the Sun is 1.37×10^{11} m.
The mass of the Sun is 2.0×10^{30} kg and the mass of the satellite is 209 kg.

(i) The Earth has a mean orbital distance of 1.50×10^{11} m around the Sun and an orbital period of 365 days.

Use **Kepler's third law** to calculate the mean orbital distance of the satellite from the Sun.

distance = ... m **[2]**

(ii) The total kinetic and gravitational potential energy of the satellite in its orbit remains constant.

Calculate the change in the kinetic energy of the satellite as it travels from its furthest point from the Sun to its closest point to the Sun.

change in kinetic energy = ... J **[3]**

(iii) Suggest why the total energy of the satellite in its orbit around the Sun is not the same as the total energy of the satellite during its launch from the surface of the Earth.

.....

..... **[1]**

2. June/2022/Paper_H556/03/No.1

The table shows some data on the planet Venus.

Mass / kg	4.87×10^{24}
Radius / km	6050
Density of atmosphere at surface / kg m^{-3}	65
Period of rotation about its axis / hours	5830

(a) Calculate the magnitude of the gravitational field strength g at the surface of Venus.

Give your answer to **3** significant figures.

g = ... N kg^{-1} **[3]**

(b) Two identical space probes, **A** and **B**, land on a flat surface on Venus.

Probe **A** lands at the north pole. Probe **B** lands on the equator.

Each probe has mass 760 kg and volume 1.7 m^3.

(i) Calculate the centripetal acceleration a of probe **B** at the equator due to the rotation of Venus about its axis.

a = ... m s^{-2} **[3]**

(ii) The atmosphere exerts the same upthrust on each probe.

Using your answer to **(a)**, calculate the upthrust acting on each probe.

upthrust = ... N **[3]**

(iii) Explain which probe will experience the greater normal contact force from the surface of Venus.

.....

.....

.....

.....

.....

..... **[3]**