Q1.

Olympus Mons is the highest mountain on Mars. The height of Olympus Mons is 22 km, which is 0.6% of the radius of Mars.

The change in gravitational field strength from the bottom to the top of Olympus Mons is

☐ **A** – 0.6%

☐ **B** – 1.2%

☐ **C** + 1.2%

☐ **D** + 0.6%

(Total for question = 1 mark)

Q2.

The International Space Station (ISS) is an artificial satellite in a low Earth orbit.

The ISS has a mass of 4.19×10^5 kg and orbits at a height of 4.10×10^5 m above the surface of the Earth in a circular orbit.

radius of Earth = 6.37×10^6 m

mass of Earth = 5.98×10^{24} kg

(a) Calculate the time taken for the ISS to complete one orbit of the Earth.

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Time taken = ...

(b) Calculate the gravitational field strength exerted by the Earth at the height of the ISS.

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Gravitational field strength = ...

(c) Astronauts on board the ISS experience apparent weightless conditions.

Explain why the gravitational force exerted on the astronauts by the Earth appears to be absent.

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(Total for question = 7 marks)

Q3.

When two protons are placed a small distance apart, electric and gravitational forces act on each proton.

Which statement about this situation is **not** correct?

☐ **A** The forces act along the line joining the centres of the two protons.

☐ **B** The electric force is greater than the gravitational force.

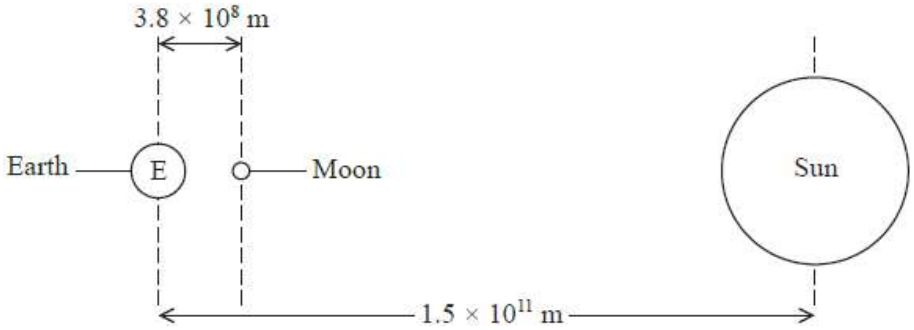
☐ **C** The electric force may be attractive or repulsive.

☐ **D** The gravitational force is attractive.

(Total for question = 1 mark)

Q4.

Tides are caused by the gravitational forces exerted by the Sun and the Moon on the water in the Earth's oceans. The diagram below (not to scale) shows the distances from the Earth to the Sun and from the Earth to the Moon.



mass of Sun = 2.0×10^{30} kg

mass of Moon = 7.0×10^{22} kg

(a) Show that the gravitational force of the Sun on the Earth is about 200 times greater than the gravitational force of the Moon on the Earth.

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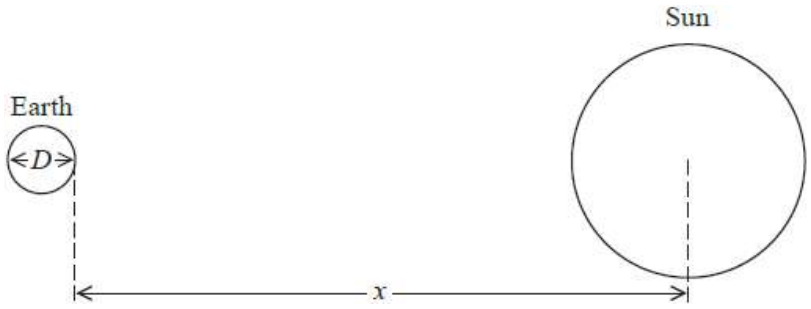
(b) The tides depend on the difference in the gravitational field strength produced by the Sun and the Moon on opposite sides of the Earth.

Gravitational field strength at a point, due to the Sun, is given by $g = \frac{GM}{r^2}$

where M = mass of Sun

r = distance of the point from the centre of Sun (not to scale).

The diagram shows the Earth and the Sun.



(i) State two expressions for the gravitational field strength at opposite sides of the Earth, due to the Sun.

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(ii) Use these expressions to explain why the Sun has a relatively small effect on the tides.

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(Total for question = 5 marks)

Q5.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

The gravitational field strength at the surface of the Earth is 9.81 N kg^{-1}. A satellite is orbiting at a height above the surface of the Earth equal to twice the radius of the Earth.

What is the gravitational field strength at this height?

☐ **A** 1.1 N kg^{-1}

☐ **B** 2.5 N kg^{-1}

☐ **C** 3.3 N kg^{-1}

☐ **D** 4.9 N kg^{-1}

(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The gravitational field strength on the surface of Mars is g. The Moon has about the same density as Mars but only half the radius.

What is the gravitational field strength on the surface of the Moon?

☐ **A** $g/4$

☐ **B** $g/2$

☐ **C** $2g$

☐ **D** $4g$

(Total for question = 1 mark)

Q7.

Which of the following is **not** a unit of field strength?

☐ **A** N A m^{-1}

☐ **B** N C $^{-1}$

☐ **C** N kg^{-1}

☐ **D** V m^{-1} **(Total for question = 1 mark)**

Q8.

Navstar 1 was a navigation satellite placed in a circular orbit about the Earth in 1978.
It was the first Global Positioning System satellite to be launched.

(a) (i) Show that the orbital time T for a satellite in a circular orbit of radius r about the Earth of mass M is given by

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

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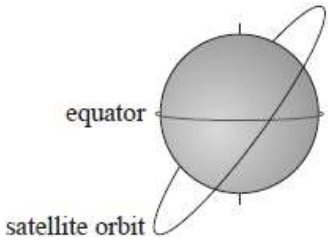
(ii) The plane of the satellite's orbit was inclined at an angle to the plane of the equator as shown.



Calculate the number of times that the satellite crossed over the equator each day.

radius of orbit = 2.66×10^7 m
mass of the Earth = 6.0×10^{24} kg

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Number of times satellite crosses equator = ...

(b) A student calculated the increase in the potential energy of the satellite from launch to its final orbit height. He used the equation $\Delta E_{grav} = mg\Delta h$

Explain how the actual value for ΔE_{grav} differed from the value calculated using $\Delta E_{grav} = mg\Delta h$

(2)

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(Total for question = 8 marks)

Q9.

Mercury is the smallest planet in the Solar System and the closest planet to the Sun.
Its orbital period around the Sun is the shortest of all the planets in the Solar System.

(a) Mercury takes 7.60×10^6 s to make one complete orbit about the Sun.

Calculate the radius of this orbit.
You may assume that the orbit is circular.

mass of Sun = 1.99×10^{30} kg

(3)

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Radius of orbit = ...

(b) (i) Derive an expression for the gravitational field strength g at a distance R from a point mass M.

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(ii) Calculate g at the surface of a uniform sphere with the same mass and radius as Mercury.

mass of Mercury = 3.30×10^{23} kg
radius of Mercury = 2.44×10^{6} m

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g = ...

(Total for question = 7 marks)