Gravitational Fields

Question Paper

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Physics from Creation to Collaps
Sub Topic	Gravitational Fields
Booklet	Question Paper

Time Allowed: **53 minutes**

Score: **/44**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 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 = 1 mark)

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2 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 2 = 1 mark)

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3 Protons experience both electric and gravitational forces.

Comparing the forces between two protons in a nucleus, it is correct to say that the

☒ **A** electric force is much stronger than the gravitational force.

☒ **B** gravitational force is much stronger than the electric force.

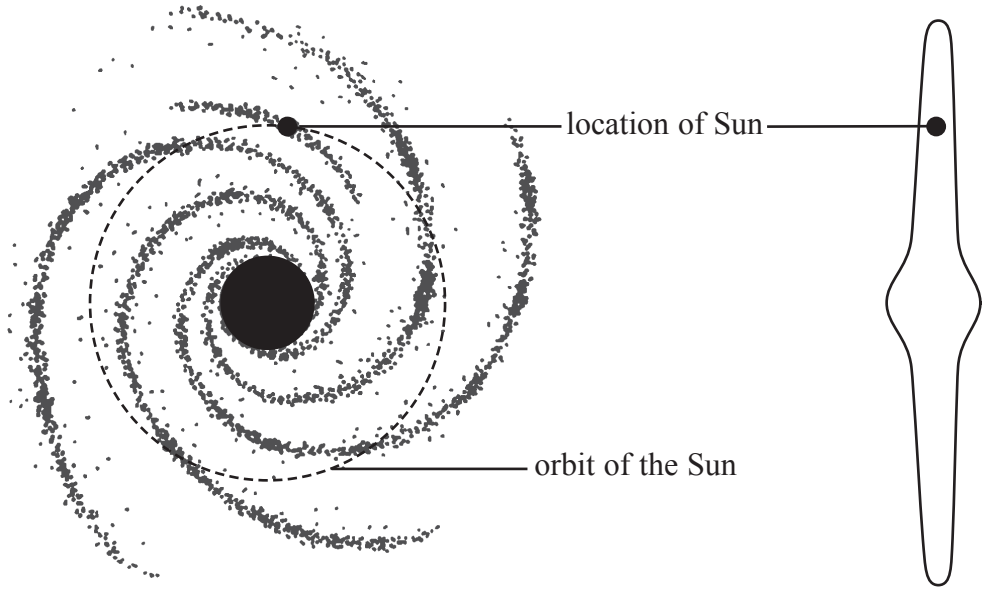
☒ **C** electric force is shorter range than the gravitational force.

☒ **D** gravitational force is shorter range than the electric force.

(Total for Question 3 = 1 mark)

4 The Sun is a typical star in our galaxy, the Milky Way. It is 2.5×10^{20} m from the centre of the galaxy. The Sun orbits the centre of the galaxy at a speed of 220 km s^{-1}.

The diagrams below represent the Milky Way. The central black area represents a very high density of stars, known as the nucleus of the galaxy. The total mass of stars within the orbit of the Sun may be treated as a point mass at the centre of the galaxy.



Face-on view Side-on view

(a) Calculate the mass of the Milky Way within the orbit of the Sun.

(3)

Mass = ...

(b) (i) The vast majority of stars in the Milky Way are observed to be within the nucleus of the galaxy.

Explain why it might be expected that stars similar to the Sun, but further away from the centre of the galaxy, would orbit at a lower speed than the Sun.

(2)

(ii) Stars similar to the Sun, but further away from the centre of the galaxy, are actually observed to have orbital speeds that are all approximately the same as the Sun's.

Explain what astronomers can conclude from these observations.

(2)

(Total for Question 4 = 7 marks)

5 The Hubble Space Telescope (HST) was placed in orbit in 1990 with the aim of producing high resolution images of astronomical objects.

HST is in a low Earth orbit at a height of 569 km above the Earth's surface. The orbit is nearly circular and its plane is inclined at an angle of 28.5° to the equatorial plane.

radius of the Earth = 6.36×10^3 km

(a) Show that the strength of the Earth's gravitational field at the height of HST is about 8 N kg^{-1}.

(3)

(b) By considering the gravitational force acting on HST, calculate the time it takes for HST to make one complete orbit of the Earth.

(4)

Orbital time = ...

(c) Communications satellites stay above the same place on the Earth's surface at all times.

State and explain two changes to the orbit of HST for it to remain above the same place on the Earth's surface at all times.

(2)

(Total for Question 5 = 9 marks)

6 So far, manned space flight has only taken us to the Moon. There are plans to send a manned mission to Mars, our nearest planetary neighbour, later this century.

(a) Calculate the weight of an astronaut of mass 72.0 kg on the surface of Mars.

mass of Mars = 6.42×10^{23} kg

diameter of Mars = 6.79×10^{6} m.

(2)

Weight of astronaut = ...

(b) (i) It takes Mars 5.94×10^7 s to orbit the Sun.

Show that the radius of the orbit is about 2×10^{11} m. Assume the orbit is circular.

mass of Sun = 1.99×10^{30} kg

(3)

(ii) Mars does **not** have a circular orbit. As Mars completes one orbit of the Sun, the distance from Mars to the Sun varies by ±10% of the average distance to the Sun.

Calculate the ratio of the maximum radiation flux from the Sun at the surface of Mars F_{max} to the minimum radiation flux F_{min} over one orbit.

(3)

F_{max} / F_{min} = ...

(Total for Question 6 = 8 marks)

7 The physicist James Joule married in 1847 and visited the Cascade de Sallanches whilst on his honeymoon. This is one of the tallest vertical waterfalls in France, with the largest drop falling for just over 270 m.

It is claimed that, whilst at the waterfall, Joule performed an experiment to measure the temperature of the water at the top and bottom.

(a) (i) Consider 1.0 kg of water falling through a distance of 270 m.

Show that the temperature rise due to the gravitational potential energy change is about 0.6 K.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(3)

(ii) State an assumption that you made.

(1)

(b) A physics student plans to repeat Joule's experiment.

She intends to use a thermometer with a precision of 0.25 K.

Discuss the extent to which she will be able to draw a valid conclusion from her measurements with this thermometer.

(3)

(Total for Question 7 = 7 marks)

8 Europa is a moon of Jupiter. Europa is thought to contain an abundant supply of water and is therefore seen as a possible place for primitive life.

(a) Calculate the value of g at the surface of Europa.

mass of Europa = 4.8×10^{22} kg
radius of Europa = 1600 km

(2)

g = ...

(b) Explain how Europa is maintained in a circular orbit about Jupiter.

(2)

(c) Calculate the time taken for Europa to make one orbit.

mass of Jupiter = 1.90×10^{27} kg
radius of Europa's orbit = 6.71×10^{5} km

(3)

Time taken = ...

(d) The average distance of Jupiter from the Sun is 5.2 times the average distance of the Earth from the Sun.

Calculate the ratio of the brightness (flux) of the Sun as seen from the Earth to the brightness as seen from Jupiter.

(3)

Ratio = ...

(Total for Question 8 = 10 marks)