Name: _____

Edexcel_Gravity_New

Questions

Date:

Time:

Total marks available:

Total marks achieved: _____

Questions

Q1.

The gravitational field strength at the surface of the Earth is 9.8 N kg^{-1}. A satellite is orbiting at a height above the ground equal to the radius of the Earth.

The gravitational field strength, in N kg^{-1}, at this height is

- **A** 0.0
- **B** 2.5
- **C** 4.9
- **D** 9.8

(Total for Question = 1 mark)

Q2.

Which of the following is **not** a similarity between gravitational fields and electric fields?

(1)

- **A** For a point charge or point mass, the field follows the inverse square law.
- **B** For a point charge or point mass, the field is radial.
- **C** Both fields act at a distance.
- **D** Both fields act on all particles.

(Total for question = 1 mark)

Q3.

A small satellite has a weight of 1200 N at the Earth's surface. It is launched into a circular orbit with radius equal to twice the radius of the Earth. The weight of the satellite in this orbit is

- **A** 0 N
- **B** 300 N
- **C** 600 N
- **D** 1200 N

(Total for question = 1 marks)

Q4. The force between two masses and the force between two charges can be modelled in a similar way, using gravitational and electric fields. A difference between these models is that

- **A** an electric field is always a radial field.
- **B** an electric field is always the stronger field.
- **C** a gravitational field cannot be shielded.
- **D** a gravitational field extends over an infinite range.

(Total for Question = 1 mark)

Q5.

Exoplanets are planets orbiting stars other than our own Sun. Most exoplanets discovered so far are giant planets similar to the planet Jupiter. The exoplanet Kepler-7b has a mass about 0.43 times the mass of Jupiter, and a radius about 1.6 times the radius of Jupiter.

Take the gravitational field strength at the surface of Kepler-7b to be g_K, and the gravitational field strength at the surface of Jupiter to be g_J.

The ratio $\frac{g_K}{g_J}$ is

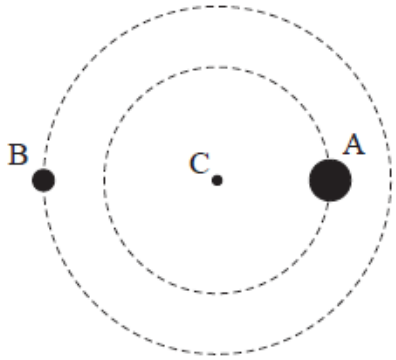
- **A** 0.17
- **B** 0.27
- **C** 0.69
- **D** 1.1

(Total for question = 1 mark)

Q6.

The diagram shows two black holes, A and B, orbiting each other.

Assume that the centre of mass C of the system is the centre of a circular orbit for each black hole as shown in the diagram.



Black hole A is in an orbit of radius 2.9×10^{10} m and black hole B is in an orbit of radius 3.6×10^{10} m. Both orbit with the same period, so the total distance between them is 6.5×10^{10} m.

(a) Calculate the force between the black holes.

mass of Sun, $M_{\odot} = 1.99 \times 10^{30}$kg
mass of black hole A = $36M_{\odot}$
mass of black hole B = $29M_{\odot}$

(2)

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Force = ...

(b) By considering the orbit of one black hole about C, determine the period of the orbit.

(3)

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Period = ...

(Total for question = 5 marks)

Q7.

The Moon has an orbit around the Earth of radius 3.86×10^8 m, with a time period of 2.36×10^6 s.

(a) (i) Using the data provided, show that the product GM is about 4.1×10^{14} m^3 s^{-2}, where M is the mass of the Earth.

(3)

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(ii) At the surface of the Earth g is measured to be 9.81 N kg^{-1}.

Calculate a value for the radius of the Earth.

(2)

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Radius of the Earth = ...

(b) It has been estimated that, at any one time, there may be about a thousand small asteroids orbiting the Earth. These asteroids orbit at between five to ten times the distance of the Moon from the Earth. Most make no more than one orbit before being pulled out of this orbit by the Sun.

Suggest why these asteroids do not remain in a stable orbit around the Earth.

(2)

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(Total for question = 7 marks)

Q8.

The first satellite weather picture was taken in 1960. Today more than 200 weather satellites are in use. Some of these satellites are in a geostationary orbit around the Earth, so that they remain at the same point above the Earth's surface all the time.

(a) (i) Show that the magnitude of the gravitational field strength g at a point outside of the Earth is given by

$$g = \frac{GM}{r^2}$$

where r is the distance of the point from the centre of the Earth and M is the mass of the Earth.

(2)

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(ii) Use this expression together with an expression for the centripetal acceleration to show that the radius of a satellite's orbit is given by

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

where T is the time for one orbit of the satellite.

(3)

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(iii) Hence calculate a value for the radius of the geostationary orbit.

$M = 6.0 \times 10^{24}$ kg

(3)

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Radius = ...

(b) State why all geostationary satellites are in an orbit above the Earth's equator.

(1)

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(Total for question = 9 marks)

Q9.

Communication satellites were first proposed in 1945 by the science fiction author Athur C. Clarke. In an article published in the magazine Wireless World he asked whether rocket stations could give worldwide radio coverage.

In the article Clarke states:

"There are an infinite number of possible stable orbits, circular and elpitical, in which a rocket would remain if the initial conditions were correct. A velocity of 8 km s^{-1} applies only to the closest possible orbit, one just outside the atmosphere, and the period of revolution would be about 90 minutes. As the radius of the orbit increases the velocity decreases, since gravity is diminishing and less centrifugal force is needed to balance it."

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(a) State what is meant in the article by the phrase "gravity is diminishing", and criticise the statement that "less centrifugal force is needed to balance (the satellite)".

(3)

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(b) (i) By deriving an appropriate equation, show that the orbital speed of a satellite decreases as the radius of orbit increases.

(3)

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(ii) By deriving an appropriate equation, show that the orbital period of a satellite increases as the orbital speed decreases.

(2)

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(c) The period T of a satellite in a circular orbit is given by the equation

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

Where r is the radius of orbit and M is the mass of the Earth

Calculate the period of a satellite in an orbit 4.0×10^5 m above the surface of the Earth.

mass of the Earth = 5.98×10^{24} kg

radius of the Earth = 6.36×10^6 m

(2)

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Period of satellite = ...

(d) After a time the radius of a satellite's orbit will start to decrease due to the resisitive forces acting on the satellite from the atmosphere. As this happens the satellite speeds up.

Describe the energy changes occurring as the radius of the orbit decreases.

(2)

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(Total for question = 12 marks)