Name: _____

Edexcel_Gravity_Old

Questions

Date:

Time:

Total marks available:

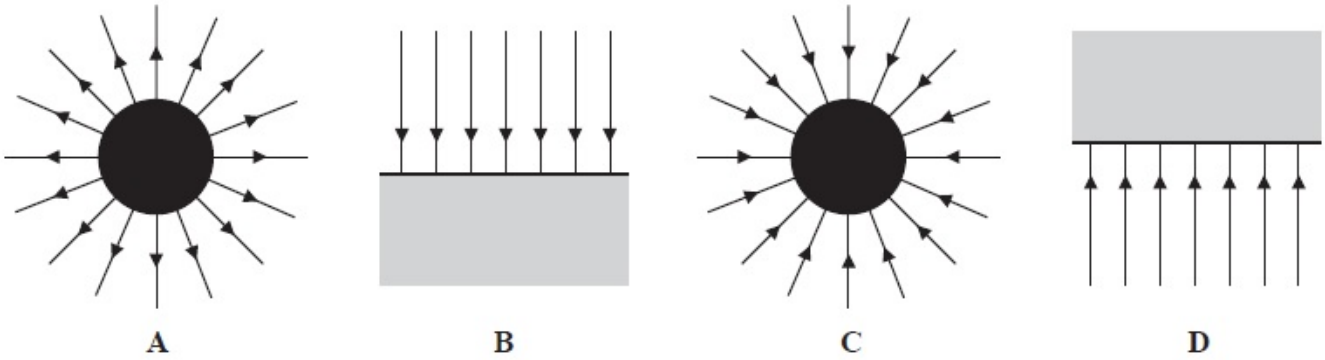
Total marks achieved: _____

Questions

Q1.

Select one answer from A to D and put a cross in the box (☒)

Electric and gravitational fields can be represented in similar ways. Which of the diagrams below **cannot** be used for a gravitational field?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question = 1 mark)

Q2.

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)

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.

Select one answer from A to D and put a cross in the box (☒)

Newton's law of gravitation can be applied to the Earth-Moon system. Which of the following statements is **not** correct?

☒ **A** The value of **G** at the surface of the Moon is the same as that at the surface of the Earth.

☒ **B** The gravitational force between the Earth and the Moon is proportional to the square of the separation of the Earth and the Moon.

☒ **C** The gravitational force between the Earth and the Moon is proportional to the mass of the Moon.

☒ **D** The orbital time of the Moon about the Earth is independent of the mass of the Moon.

(Total for Question = 1 mark)

Q5.

Charged particles produce both electrostatic and gravitational fields.

Which of the following statements applies to both fields?

☒ **A** Field strength at a point is inversely proportional to the distance from the particle.

☒ **B** Field strength can only be zero at infinity.

☒ **C** Forces between particles can be attractive or repulsive.

☒ **D** Force is inversely proportional to the square of distance between particles.

(Total for question = 1 mark)

Q6.

Select one answer from A to D and put a cross in the box (☒)

The electrostatic interaction between two charges and the gravitational interaction between two masses can be represented by similar equations.

Which of the following is correct?

☒ **A** The force variation in both fields obeys an inverse square law.

☒ **B** Both fields are examples of strong interactions.

☒ **C** Both have a field strength variation that is inversely proportional to distance.

☒ **D** Electric charge is exactly analogous to mass.

(Total for Question = 1 mark)

Q7.

Select one answer from A to D and put a cross in the box (☒)

Which of the following statements is correct?

☒ **A** Electrostatic forces have a much longer range than gravitational forces.

☒ **B** Gravitational forces have a much longer range than electrostatic forces.

☒ **C** Gravitational and electrostatic forces both obey an inverse square law.

☒ **D** Gravitational and electrostatic field strength are both scalar quantities.

(Total for Question = 1 mark)

Q8. 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)

Q9.

Mars is our nearest neighbour in the solar system. In August 2003 the distance between Mars and the Earth was the closest in recorded history at 5.6×10^{10} m.

mass of Mars = 6.4×10^{23} kg

mass of Earth = 6.0×10^{24} kg

Calculate the gravitational force between Mars and the Earth when they were at this distance.

(2)

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Gravitational force = ...

(Total for question = 2 marks)

Q10.

(a) Derive an expression for the gravitational field strength g at a distance r from the centre of a mass M. Use the list of equations at the end of this question paper.

(2)

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(b) Use your expression to calculate g at the surface of the Earth.

mass of Earth $M_E = 5.97 \times 10^{24}$ kg
radius of Earth $r_E = 6.38 \times 10^{6}$ m

(1)

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g = ...

(Total for Question = 3 marks)

Q11.

In a physics lesson a student learns that the Earth is 81 times more massive than the Moon. Searching the Internet, she is surprised to discover that the gravitational field strength at the surface of the Earth is only 6 times greater than that at the surface of the Moon.

Use the above data to compare the radius of the Earth with that of the Moon.

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(Total for Question = 3 marks)

Q12.

In 2015 Chinese scientists were considering a plan to build and put into orbit a massive space station that would supply energy to Earth.

The project would involve placing the space station in a geostationary orbit. The space station would be equipped with large solar panels. The space station would then transfer energy to Earth as microwaves.

The space station is to orbit at the same rate as the Earth's rotation.

Calculate the height of the space station above the surface of the Earth.

mass of Earth = 5.98×10^{24} kg
radius of Earth = 6.36×10^{6} m

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Height of space station = ...

(Total for question = 4 marks)

Q13.

In a science fiction television programme the gravitational field strength on the Moon becomes equal to that of the Earth. The radius of the Moon stays constant.

(a) Calculate the mass of the Moon that would be required for the gravitational field strength at its surface to equal the gravitational field strength at the surface of the Earth.

radius of the Moon = 1.74×10^6 m

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Mass of Moon required = ...

(b) Explain why a more massive Moon would have no effect on the time taken for the Moon to orbit the Earth.

(2)

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(c) Suggest what effect a more massive Moon would have at the Earth's surface.

(1)

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(Total for question = 5 marks)

Q14.

* Describe the similarities and differences between electric and gravitational fields.

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(Total for question = 6 marks)

Q15.

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)

Q16.

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

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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)

Q17.

The Moon takes 27.3 days to make one complete orbit of the Earth.

(a) (i) Show that the orbital angular velocity of the Moon is about 3×10^{-6} rad s^{-1}.

(2)

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(ii) Calculate the radius of the Moon's orbit.

mass of Earth = 6.4×10^{24} kg

(4)

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Radius = ...

(b) The Moon is gradually moving further away from the Earth because of the action of tides.

(i) State and explain how this increasing distance affects the moon's orbital period.

(2)

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(ii) In 200 years the radius of the Moon's orbit is predicted to increase by 8 m.

Calculate the rate of increase of the radius of the orbit in cm per year.

(1)

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Rate of increase = ...cm per year

*(iii) In practice, the rate of increase of the orbital radius due to tidal action will not have been constant. Suggest why this rate of change might have been different in the very distant past.

(3)

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(Total for Question = 12 marks)

Q18.

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.

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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)

Q19.

Current theory predicts that there is a massive black hole at the centre of every galaxy.
It is suggested that if galaxies approach, then their central black holes begin to orbit each other until the galaxies merge.

In 2009, astronomers found convincing evidence of two such black holes orbiting as a binary system. From data collected, they estimated that the separation of the black holes was 3.2×10^{15} m and that their masses were 1.6×10^{39} kg and 4.0×10^{37} kg.

(a) (i) State the origin of the force that maintains the black holes in an orbit.

(1)

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(ii) Show that the magnitude of this force is about 4×10^{35} N.

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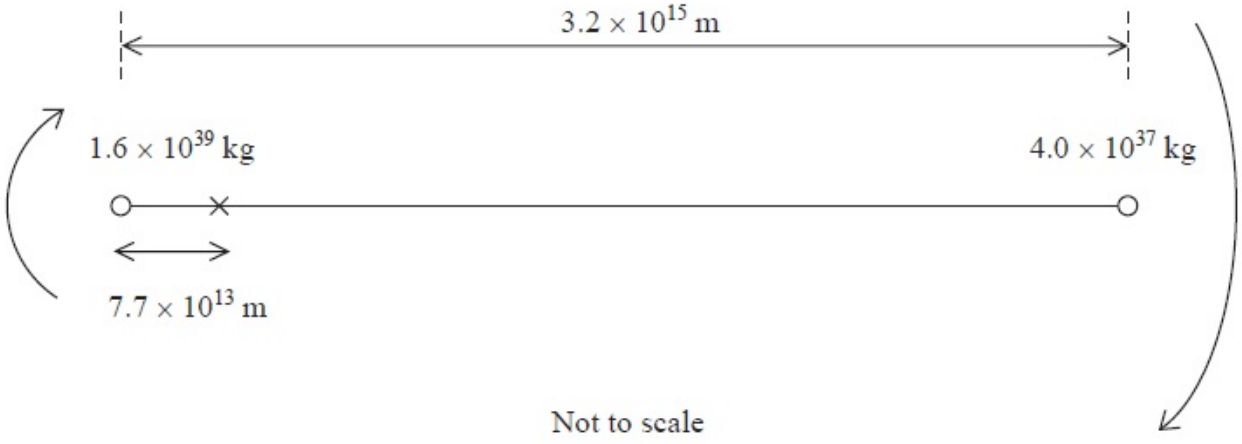
(iii) The black holes orbit about a point 7.7×10^{13} m from the larger mass black hole.



Show that the orbital time of the binary system is about 100 years.

(3)

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(b) As the black holes swallow up matter, radiation is emitted. To observers on Earth this radiation appears to be red shifted.

*(i) State what red shift means and discuss the conclusions that can be drawn from the observation that radiation from all distant galaxies is red shifted.

(3)

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(ii) Suggest why the light from both black holes is red shifted, even though the black holes are orbiting each other and hence moving in opposite directions.

(2)

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(iii) The observed red shift for the two black holes was 0.38.

Calculate the distance of the merging galaxies from the Earth.

$H_o = 1.6 \times 10^{-18}\ s^{-1}$

(3)

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Distance from the Earth = ...

(Total for Question = 14 marks)

Q20.

***** The Hubble Space Telescope (HST) was launched in 1990 into an orbit of radius 6940 km. The satellite makes 15 complete orbits of the Earth every 24 hours and its position high above the Earth's atmosphere has allowed high quality images of extremely distant objects to be produced.

(a) (i) Show that the HST has a centripetal acceleration of about 8 m s^{-2}.

(4)

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(ii) The HST is kept in orbit by the gravitational pull of the Earth. Use your answer to (a)(i) to calculate a value for the mass of the Earth.

(3)

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Mass = ...

(b) The telescope was named in honour of Edwin Hubble who measured the red shift of light from a number of galaxies and related it to their distance from the Earth.

Explain what is meant by the term *red shift* in this context and state the inference that Hubble made from his measurements.

(2)

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(c) The song "Nine Million Bicycles" by Katie Melua includes the lines, "We are 12 billion light years from the edge, that's a guess, no one can ever say it's true".

(i) Explain how the line "12 billion light years from the edge" implies an age of 12 billion years for the universe.

(2)

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(ii) Calculate the value of the Hubble constant consistent with an age of 12 billion years for the universe.

1 billion years = 3.15×10^{16} s

(2)

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Hubble constant = ...

(iii) These lyrics were famously contested by Dr Simon Singh in the Guardian newspaper. He argued that the correct age was 13.7 billion years, and disputed that scientists had guessed the age of the universe. As a result Katie performed the song with revised lyrics.

Discuss the suggestion in the song that values for the age of the universe are only guesses.

(3)

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(Total for Question = 16 marks)