A-Level Physics

Gravitational Fields (Multiple Choice)

Question Paper

Time available: 28 minutes
Marks available: 20 marks

1. A planet of radius R and mass M has a gravitational field strength of g at its surface.

Which row describes a planet with a gravitational field strength of $4g$ at its surface?

	Radius of planet	Mass of planet	
A	$2R$	$2M$	⬭
B	$R\sqrt{2}$	$\frac{M}{2}$	⬭
C	$\frac{R}{\sqrt{2}}$	$\frac{M}{2}$	⬭
D	$\frac{R}{\sqrt{2}}$	$2M$	⬭

(Total 1 mark)

2. The Moon orbits the Earth in 27 days.

What is the angular speed of the Moon's orbit?

A 4.3×10^{-7} rad s^{-1} ⬭

B 2.7×10^{-6} rad s^{-1} ⬭

C 3.7×10^{-2} rad s^{-1} ⬭

D 2.3×10^{-1} rad s^{-1} ⬭

(Total 1 mark)

3. The radius of the Earth is R and the acceleration due to gravity at the surface of the Earth is g.

What is the escape velocity for a mass m at the surface of the Earth?

A $\sqrt{gR}$ ⬭

B $\sqrt{2gR}$ ⬭

C $\sqrt{2mgR}$ ⬭

D $\sqrt{\frac{2gR}{m}}$ ⬭

(Total 1 mark)

4. A planet has a mass M and a radius R.
Loose material at the equator only just remains in contact with the surface of the planet.
This is because the speed at which the planet rotates is very large.

What is the period of rotation of the planet?

A $2\pi\sqrt{\frac{R^2}{GM}}$ ⬭

B $2\pi\sqrt{\frac{GM}{R^2}}$ ⬭

C $2\pi\sqrt{\frac{R^3}{GM}}$ ⬭

D $2\pi\sqrt{\frac{GM}{R^3}}$ ⬭

(Total 1 mark)

5. Satellites **N** and **F** have the same mass and move in circular orbits about the same planet.
The orbital radius of **N** is less than that of **F**.

Which is smaller for **N** than for **F**?

A the gravitational force on the satellite ⬭

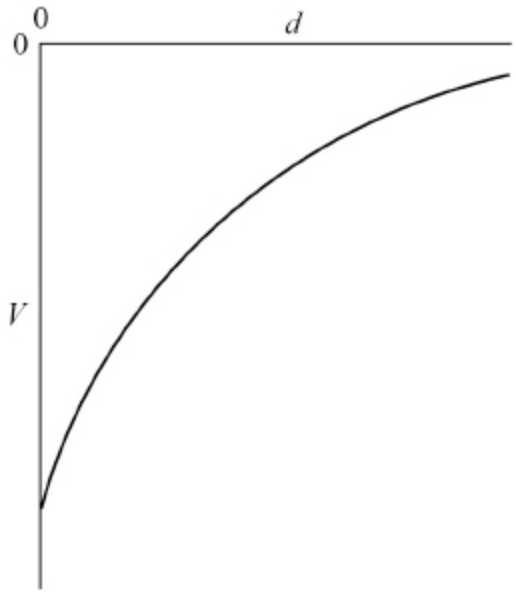
B the speed of the satellite ⬭

C the kinetic energy of the satellite ⬭

D the orbital period of the satellite ⬭

(Total 1 mark)

6. The graph shows how the gravitational potential V varies with the vertical distance d from the surface of the Earth.



What does the gradient of the graph represent at the surface of the Earth?

A potential energy ⬭

B mass of the Earth ⬭

C magnitude of the gravitational constant ⬭

D magnitude of the gravitational field strength ⬭

(Total 1 mark)

7. What is the angular speed of a satellite in a geostationary orbit around the Earth?

A 1.2×10^{-5} rad s^{-1} ⬭

B 7.3×10^{-5} rad s^{-1} ⬭

C 4.4×10^{-3} rad s^{-1} ⬭

D 2.6×10^{-1} rad s^{-1} ⬭

(Total 1 mark)

8. An object moves freely at 90° to the direction of a gravitational field.

The acceleration of the object is

A zero. ⬭

B opposite to the direction of the gravitational field. ⬭

C in the direction of the gravitational field. ⬭

D at 90° to the direction of the gravitational field. ⬭

(Total 1 mark)

9. The distance between the Sun and the Earth is 1.5×10^{11} m

What is the gravitational force exerted on the Sun by the Earth?

A 3.5×10^{22} N ⬭

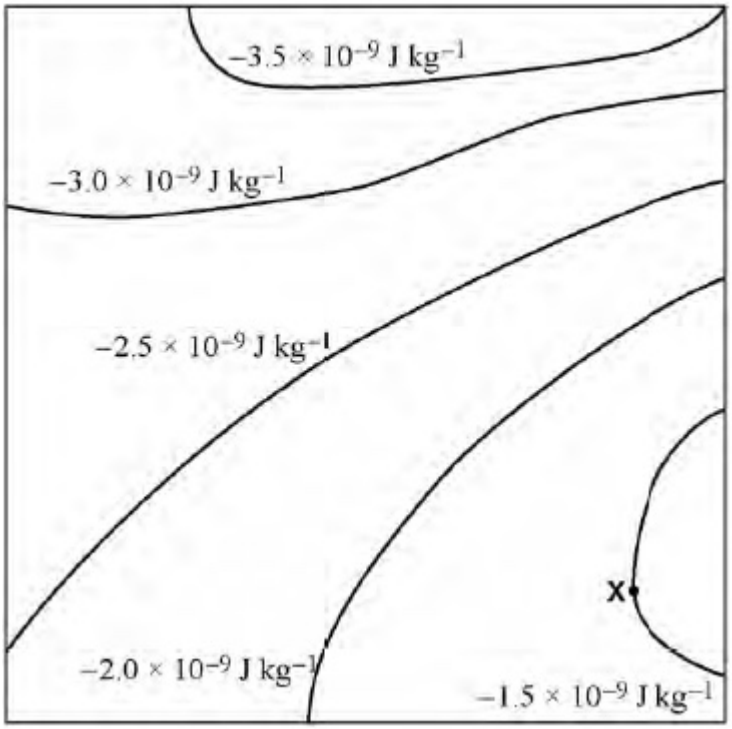
B 1.7×10^{26} N ⬭

C 5.3×10^{33} N ⬭

D 8.9×10^{50} N ⬭

(Total 1 mark)

10. The diagram shows equipotential lines near a group of asteroids.



Which arrow shows the direction of the gravitational field at **X**?

A ↑ ⬭

B ↓ ⬭

C ← ⬭

D → ⬭

(Total 1 mark)

11. Planet **N** has a gravitational potential $-V$ at its surface. Planet **M** has double the density and double the radius of planet **N**. Both planets are spherical and have uniform density.

What is the gravitational potential at the surface of planet **M**?

A $-16V$ ⬭

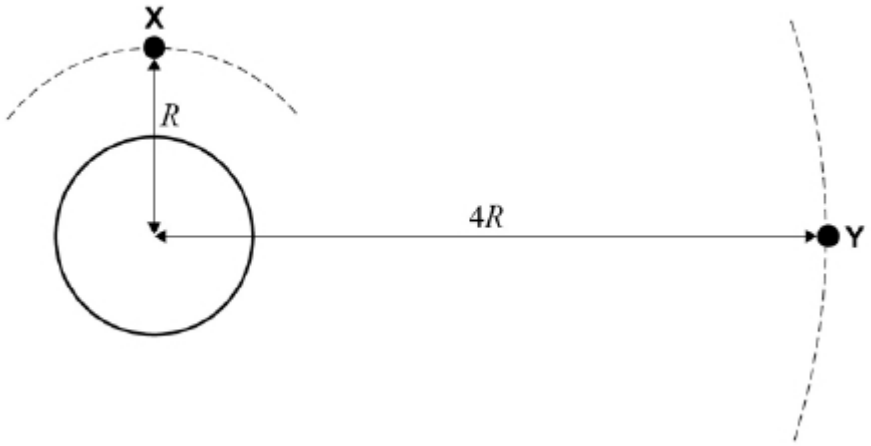
B $-8V$ ⬭

C $-4V$ ⬭

D $-0.2V$ ⬭

(Total 1 mark)

12. Satellites **X** and **Y** orbit the Earth at distances R and $4R$ respectively, as shown in the diagram.



Which statement is **incorrect**?

A The speed of **Y** is greater than the speed of **X** ⬭

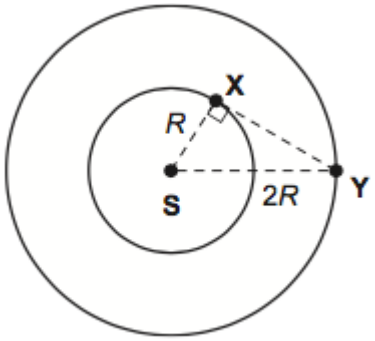
B The time period of **Y** is greater than the time period of **X**. ⬭

C The potential energy of **Y** is greater than the potential energy of **X**. ⬭

D The gravitational force acting on **Y** is less than the gravitational force acting on **X**. ⬭

(Total 1 mark)

13. Two planets **X** and **Y** are in concentric circular orbits about a star **S**. The radius of the orbit of **X** is *R* and the radius of orbit of **Y** is 2*R* .



The gravitational force between **X** and **Y** is F when angle **SXY** is 90°, as shown in the diagram.

What is the gravitational force between **X** and **Y** when they are nearest to each other?

A $2F$

B $3F$

C $4F$

D $5F$

(Total 1 mark)

14. Which of the following statements about Newton's law of gravitation is correct?

Newton's gravitational law explains

A the origin of gravitational forces. ⬭

B why a falling satellite burns up when it enters the Earth's atmosphere. ⬭

C why projectiles maintain a uniform horizontal speed. ⬭

D how various factors affect the gravitational force between two particles. ⬭

(Total 1 mark)

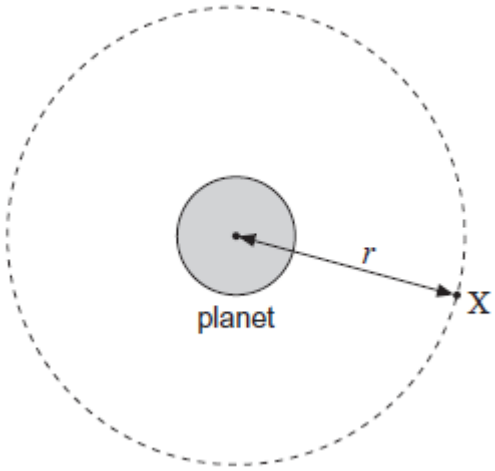
15. A geosynchronous satellite is in a constant radius orbit around the Earth. The Earth has a mass of 6.0×10^{24} kg and a radius of 6.4×10^{6} m.

What is the height of the satellite above the Earth's surface?

A 1.3×10^{7} m
B 3.6×10^{7} m
C 4.2×10^{7} m
D 4.8×10^{7} m

(Total 1 mark)

16. A satellite X is in a circular orbit of radius r about the centre of a spherical planet of mass M.

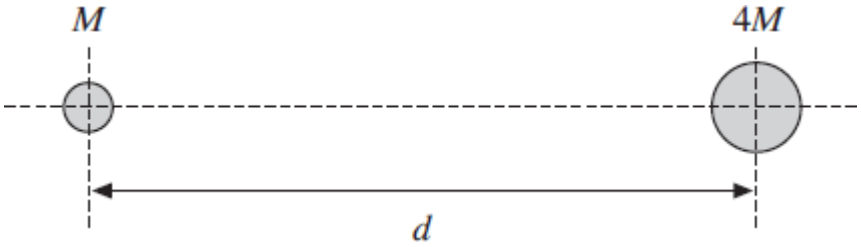


Which line, **A** to **D**, in the table gives correct expressions for the centripetal acceleration a and the speed v of the satellite?

	Centripetal acceleration a	Speed v
A	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{2r}}$
B	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{r}}$
C	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{2r}}$
D	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{r}}$

(Total 1 mark)

17. Two stars of mass *M* and 4*M* are at a distance *d* between their centres.



The resultant gravitational field strength is zero along the line between their centres at a distance y from the centre of the star of mass *M*.

What is the value of the ratio $\frac{y}{d}$?

A $\frac{1}{2}$

B $\frac{1}{3}$

C $\frac{2}{3}$

D $\frac{3}{4}$

(Total 1 mark)

18. Mars has a diameter approximately 0.5 that of the Earth, and a mass of 0.1 that of the Earth. The gravitational potential at the Earth's surface is −63 MJ kg^{-1}.
What is the approximate value of the gravitational potential at the surface of Mars?

A −13 MJ kg^{-1}

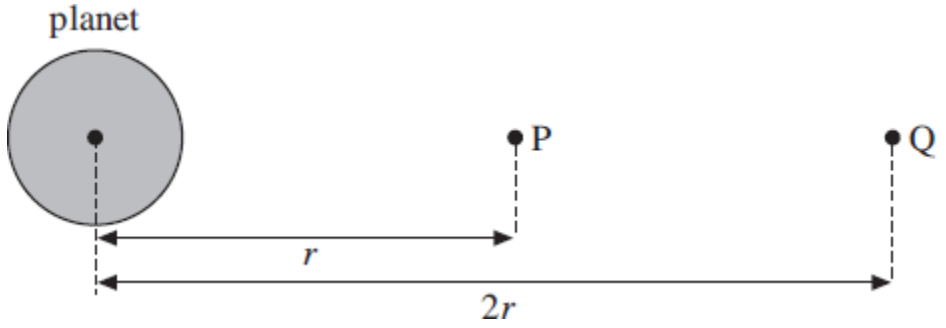
B −25 MJ kg^{-1}

C −95 MJ kg^{-1}

D −320 MJ kg^{-1}

(Total 1 mark)

19. The diagram shows two points, P and Q, at distances r and $2r$ from the centre of a planet.



The gravitational potential at P is −16 kJ kg^{-1}. What is the work done on a 10 kg mass when it is taken from P to Q?

A – 120 kJ

B – 80 kJ

C + 80 kJ

D + 120 kJ

(Total 1 mark)

20. Two satellites, P and Q, of the same mass, are in circular orbits around the Earth. The radius of the orbit of Q is three times that of P. Which one of the following statements is correct?

A The kinetic energy of P is greater than that of Q.

B The weight of P is three times that of Q.

C The time period of P is greater than that of Q.

D The speed of P is three times that of Q.

(Total 1 mark)