Q1. Two identical uniform spheres each of radius R are placed in contact. The gravitational force between them is F.

The spheres are now separated until the force of attraction is $\frac{F}{9}$.

What is the distance between the **surfaces** of the spheres after they have been separated?

A $2R$

B $4R$

C $8R$

D $12R$

(Total 1 mark)

Q2. A satellite of mass m is in a circular orbit at height R above the surface of a uniform spherical planet of radius R and density ρ.

What is the force of gravitational attraction between the satellite and the planet?

A $\frac{\pi\rho GmR}{3}$

B $\frac{2\pi\rho GmR}{3}$

C $\frac{\pi\rho GmR^2}{3}$

D $\frac{2\pi\rho GmR^2}{3}$

(Total 1 mark)

Q3. The following data refers to two planets, P and Q.

	Radius / km	Density / kg m^{-3}
planet P	8000	6000
planet Q	16 000	3000

The gravitational field strength at the surface of P is 13.4 N kg^{-1}.
What is the gravitational field strength at the surface of Q?

A 3.4 N kg^{-1}

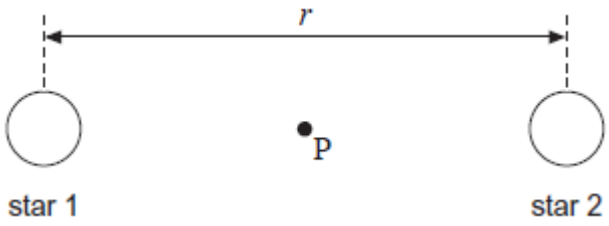
B 13.4 N kg^{-1}

C 53.6 N kg^{-1}

D 80.4 N kg^{-1}

(Total 1 mark)

Q4. The diagram shows an isolated binary star system. The two stars have equal masses, M, and the distance between their centres is r.



The point P is half-way between the two stars.
What is the gravitational field strength at P?

A zero

B $-\frac{GM}{r^2}$

C $-\frac{2GM}{r^2}$

D $-\frac{4GM}{r^2}$

(Total 1 mark)

Q5. Which one of the following statements about gravitational potential is **incorrect**?

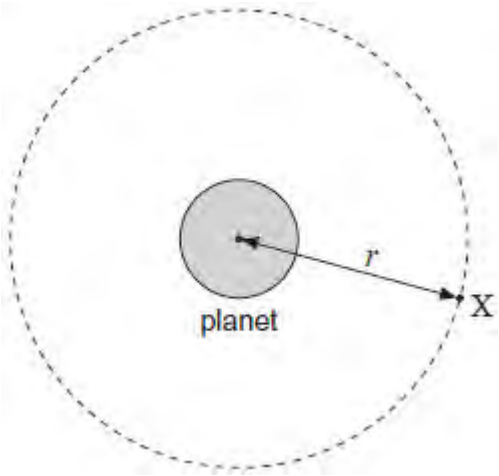
A It is analogous to the electric potential at a point in an electric field.

B It is equal to the gravitational potential energy of a mass of 1 kg.

C It is a vector quantity.

D The difference in gravitational potential between two points at different heights above the Earth depends on the position of the points.

Q6. 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)

Q7.A satellite orbiting the Earth moves to an orbit which is closer to the Earth.

Which line, **A** to **D**, in the table shows correctly what happens to the speed of the satellite and to the time it takes for one orbit of the Earth?

	Speed of satellite	**Time For One Orbit Of Earth**
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

(Total 1 mark)

Q8. In the equation $X = \frac{ab}{r^n}$, X represents a physical variable in an electric or a gravitational field, a is a constant, b is either mass or charge and n is a number.

Which line, **A** to **D**, in the table provides a consistent representation of X, a and b according to the value of n?

The symbols E, g, V and r have their usual meanings.

	n	***X***	***a***	***b***
A	1	E	$\frac{1}{4\pi\varepsilon_0}$	charge
B	1	V	$\frac{1}{4\pi\varepsilon_0}$	mass
C	2	g	G	mass
D	2	V	G	charge

(Total 1 mark)

Q9. A planet has a radius half the Earth's radius and a mass a quarter of the Earth's mass. What is the approximate gravitational field strength on the surface of the planet?

A 1.6 N kg^{-1} ⬭

B 5.0 N kg^{-1} ⬭

C 10 N kg^{-1} ⬭

D 20 N kg^{-1} ⬭

(Total 1 mark)

Q10. Two stars of mass M and $4M$ 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)

Q11. 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)

Q12. A spacecraft of mass m is at the mid-point between the centres of a planet of mass M_1 and its moon of mass M_2. If the distance between the spacecraft and the centre of the planet is d, what is the magnitude of the resultant gravitational force on the spacecraft?

A $\frac{Gm(M_1 - M_2)}{d}$

B $\frac{Gm(M_1 + M_2)}{d^2}$

C $\frac{Gm(M_1 - M_2)}{d^2}$

D $\frac{Gm(M_1 + M_2)}{d}$

(Total 1 mark)

Q13. Which one of the following statements about gravitational potential is correct?

A gravitational potential can have a positive value

B the gravitational potential at the surface of the Earth is zero

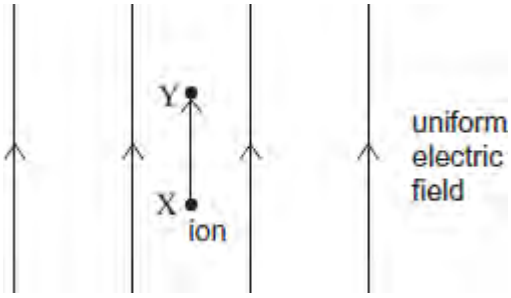
C the gravitational potential gradient at a point has the same numerical value as the gravitational field strength at that point

D the unit of gravitational potential is N kg^{-1}

(Total 1 mark)

Q14. A uniform electric field of electric field strength E is aligned so it is vertical. An ion moves vertically through a small distance Δd from point X to point Y in the field.

There is a uniform gravitational field of field strength g throughout the region.



Which line, **A** to **D**, in the table correctly gives the gravitational potential difference, and the electric potential difference, between X and Y?

	Gravitational potential difference	**Electric potential difference**
A	$g\Delta d$	$E\Delta d$
B	$g\Delta d$	$\frac{E}{\Delta d}$
C	$\frac{g}{\Delta d}$	$E\Delta d$
D	$\frac{g}{\Delta d}$	$\frac{E}{\Delta d}$

(Total 1 mark)

Q15. When a space shuttle is in a low orbit around the Earth it experiences gravitational forces F_E due to the Earth, F_M due to the Moon and F_S due to the Sun. Which one of the following correctly shows how the magnitudes of these forces are related to each other?

mass of Sun = 1.99×10^{30} kg
mass of Moon = 7.35×10^{22} kg
mean distance from Earth to Sun = 1.50×10^{11} m
mean distance from Earth to Moon = 3.84×10^{8} m

A $F_E > F_S > F_M$

B $F_S > F_E > F_M$

C $F_E > F_M > F_S$

D $F_M > F_E > F_S$

(Total 1 mark)

Q16. The gravitational field strengths at the surfaces of the Earth and the Moon are 9.8 N kg^{-1} and 1.7 N kg^{-1} respectively. If the mass of the Earth is 81 × the mass of the Moon, what is the ratio of the radius of the Earth to the radius of the Moon?

A 3.7

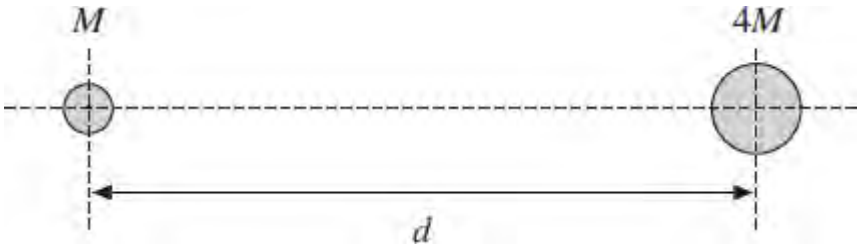
B 5.8

C 14

D 22

(Total 1 mark)

Q17. 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)

Q18. 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)

Q19. Two satellites P and Q, of equal mass, orbit the Earth at radii R and $2R$ respectively. Which one of the following statements is correct?

A P has less kinetic energy and more potential energy than Q.

B P has less kinetic energy and less potential energy than Q.

C P has more kinetic energy and less potential energy than Q.

D P has more kinetic energy and more potential energy than Q.

(Total 1 mark)

Q20. A small mass is situated at a point on a line joining two large masses m_1 and m_2 such that it experiences no resultant gravitational force. Its distance from the centre of mass of m_1 is r_1 and its distance from the centre of mass of m_2 is r_2.

What is the value of the ratio $\frac{r_1}{r_2}$?

A $\frac{m_1^2}{m_2^2}$

B $\frac{m_2^2}{m_1^2}$

C $\sqrt{\frac{m_1}{m_2}}$

D $\sqrt{\frac{m_2}{m_1}}$

(Total 1 mark)

Q21. Which one of the following gives a correct unit for $\left(\frac{g^2}{G}\right)$?

A $N\ m^{-2}$

B $N\ kg^{-1}$

C $N\ m$

D N

(Total 1 mark)

Q22. The gravitational field strength at the surface of the Earth is 6 times its value at the surface of the Moon. The mean density of the Moon is 0.6 times the mean density of the Earth.

What is the value of the ratio $\left(\frac{\text{radius of Earth}}{\text{radius of Moon}}\right)$?

A 1.8

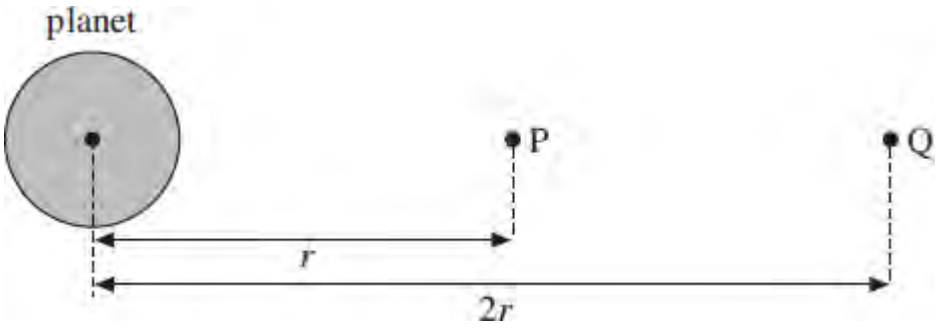
B 3.6

C 6.0

D 10

(Total 1 mark)

Q23. The diagram shows two points, P and Q, at distances *r* and 2*r* 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)

Q24. When a charge moves between two points in an electric field, or a mass moves between two points in a gravitational field, energy may be transferred.
Which one of the following statements is correct?

A No energy is transferred when the movement is parallel to the direction of the field.

B The energy transferred is independent of the path followed.

C The energy transferred is independent of the start and finish points.

D Energy is transferred when the movement is perpendicular to the field lines.

(Total 1 mark)

Q25. The Earth moves around the Sun in a circular orbit with a radius of 1.5×10^8 km.
What is the Earth's approximate speed?

A $1.5 \times 10^3 \text{ms}^{-1}$

B $5.0 \times 10^3 \text{ms}^{-1}$

C $1.0 \times 10^4 \text{ms}^{-1}$

D $3.0 \times 10^4 \text{ms}^{-1}$

(Total 1 mark)

Q26. Which one of the following statements about gravitational fields is **incorrect**?

A Moving a mass in the direction of the field lines reduces its potential energy.

B A stronger field is represented by a greater density of field lines.

C Moving a mass perpendicularly across the field lines does not alter its potential energy.

D At a distance *r* from a mass the field strength is inversely proportional to *r*.

(Total 1 mark)

Q27. An object on the surface of a planet of radius *R* and mass *M* has weight *W*.
What would be the weight of the same object when on the surface of a planet of radius 2*R* and mass 2*M*?

A $\frac{W}{4}$

B $\frac{W}{2}$

C W

D $2W$

(Total 1 mark)

Q28. The gravitational field strength on the surface of a planet orbiting a star is 8.0 N kg^{-1}. If the planet and star have a similar density but the diameter of the star is 100 times greater than the planet, what would be the gravitational field strength at the surface of the star?

A 0.0008 N kg^{-1}

B 0.08 N kg^{-1}

C 800 N kg^{-1}

D 8000 N kg^{-1}

(Total 1 mark)

Q29. 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)

Q30. Which one of the following statements about Newton's law of gravitation is correct?

Newton's law of gravitation 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)

Q31. If an electron and proton are separated by a distance of 5×10^{-11} m, what is the approximate gravitational force of attraction between them?

A 2×10^{-57} N

B 3×10^{-47} N

C 4×10^{-47} N

D 5×10^{-37} N

(Total 1 mark)

Q32. A spherical planet of uniform density ρ has radius R.

Which line, **A** to **D**, in the table gives correct expressions for the mass of the planet and the gravitational field strength at its surface?

	mass of planet	**gravitational field strength at surface**
A	$\frac{4\pi R^2 \rho}{3}$	$\frac{4\pi GR\rho}{3}$
B	$\frac{4\pi R^3 \rho}{3}$	$\frac{4\pi GR\rho}{3}$
C	$\frac{4\pi R^2 \rho}{3}$	$\frac{4\pi G\rho}{3}$
D	$\frac{4\pi R^3 \rho}{3}$	$\frac{4\pi G\rho}{3}$

(Total 1 mark)

Q33. The gravitational potential at the surface of the Earth, of radius R, is V. What is the gravitational potential at a point at a height R above the Earth's surface?

A $\frac{V}{4}$

B $\frac{V}{2}$

C V

D $2V$

(Total 1 mark)

Q34. A satellite is in orbit at a height h above the surface of a planet of mass M and radius R. What is the velocity of the satellite?

A $\sqrt{\frac{GM}{(R+h)}}$

B $\sqrt{\frac{GM\ (R+h)}{R}}$

C $\frac{\sqrt{GM\ (\sqrt{R+h})}}{R}$

D $\frac{\sqrt{GM}}{(R+h)}$

(Total 1 mark)

Q35. A 10 μF capacitor is fully charged to a pd of 3.0 kV. The energy stored in the capacitor can be used to lift a load of 5.0 kg through a vertical height *h*. What is the approximate value of *h*?

A 0.03 mm

B 0.9 mm

C 0.3 m

D 0.9 m

(Total 1 mark)

Q36. Masses of *M* and 2*M* exert a gravitational force *F* on each other when the distance between their centres is *r*. What is the gravitational force between masses of 2*M* and 4*M* when the distance between their centres is 4*r*?

A 0.25 *F*

B 0.50 *F*

C 0.75 *F*

D 1.00 *F*

(Total 1 mark)

Q37. A planet has a radius half the Earth's radius and a mass a quarter of the Earth's mass. What is the approximate gravitational field strength on the surface of the planet?

A 1.6 N kg^{-1}

B 5.0 N kg^{-1}

C 10 N kg^{-1}

D 20 N kg^{-1}

(Total 1 mark)

Q38. At the surface of the Earth the gravitational field strength is *g*, and the gravitational potential is *V*. The radius of the Earth is *R*. An object, whose weight on the surface of the Earth is *W*, is moved to a height 3*R* above the surface. Which line, **A** to **D**, in the table gives the weight of the object and the gravitational potential at this height?

	weight	**gravitational potential**
A	$\frac{W}{16}$	$\frac{V}{4}$
B	$\frac{W}{4}$	$\frac{V}{3}$
C	$\frac{W}{4}$	$\frac{V}{4}$
D	$\frac{W}{16}$	$\frac{V}{3}$

(Total 1 mark)

Q39. A satellite of mass *m* travels in a circular orbit of radius *r* around a planet of mass *M*. Which one of the following expressions gives the angular speed of the satellite?

A $\sqrt{GMr}$

B $\sqrt{Gmr}$

C $\sqrt{\frac{Gm}{r^3}}$

D $\sqrt{\frac{GM}{r^3}}$

(Total 1 mark)

Q40. The gravitational force between two uniform spheres is 3.1×10^{-9} N when the distance between their centres is 150 mm. If the mass of one sphere is 2.5 kg, what is the mass of the other?

A 0.043 kg

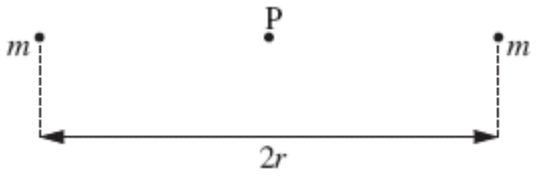
B 0.42 kg

C 2.8 kg

D 4.1 kg

(Total 1 mark)

Q41. The diagram shows two point masses each of mass *m* separated by a distance 2*r*.



What is the value of the gravitational field strength at the mid-point, P, between the two masses?

A $\frac{4Gm}{r^2}$

B $\frac{2Gm}{r^2}$

C $\frac{Gm}{2r^2}$

D zero

(Total 1 mark)

Q42. The diagram shows two positions, **X** and **Y**, on the Earth's surface.

Which line, **A** to **D**, in the table gives correct comparisons at **X** and **Y** for gravitational potential and angular velocity?

	gravitational potential at X compared with Y	**angular velocity at X compared with Y**
A	greater	greater
B	greater	same
C	greater	smaller
D	same	same

(Total 1 mark)

Q43. What would the period of rotation of the Earth need to be if objects at the equator were to appear weightless?

radius of Earth = 6.4×10^{6} m

A 4.5×10^{-2} hours

B 1.4 hours

C 24 hours

D 160 hours

(Total 1 mark)

Q44. As a comet orbits the Sun the distance between the comet and the Sun continually changes. As the comet moves towards the Sun this distance reaches a minimum value.
Which one of the following statements is **incorrect** as the comet approaches this minimum distance?

A The potential energy of the comet increases.

B The gravitational force acting on the comet increases.

C The direction of the gravitational force acting on the comet changes.

D The kinetic energy of the comet increases.

(Total 1 mark)

Q45. Two protons are 1.0×10^{-14} m apart. Approximately how many times is the electrostatic force between them greater than the gravitational force between them?
(Use the Data and Formulae booklet)

A 10^{23}

B 10^{30}

C 10^{36}

D 10^{42}

(Total 1 mark)

Q46. A 10 mF capacitor is charged to 10 V and then discharged completely through a small motor. During the process, the motor lifts a weight of mass 0.10 kg. If 10% of the energy stored in the capacitor is used to lift the weight, through what approximate height will the weight be lifted?

A 0.05 m

B 0.10 m

C 0.50 m

D 1.00 m

(Total 1 mark)

Q47. A projectile moves in a gravitational field. Which one of the following is a correct statement about the gravitational force acting on the projectile?

A The force is in the direction of the field.

B The force is in the opposite direction to that of the field.

C The force is at right angles to the field.

D The force is at an angle between 0° and 90° to the field.

(Total 1 mark)

Q48. The gravitational potential difference between the surface of a planet and a point P, 10 m above the surface, is 8.0 J kg^{-1}. Assuming a uniform field, what is the value of the gravitational field strength in the region between the planet's surface and P?

A 0.80 N kg^{-1}

B 1.25 N kg^{-1}

C 8.0 N kg^{-1}

D 80 N kg^{-1}

(Total 1 mark)

Q49. An artificial satellite of mass *m* is in a stable circular orbit of radius *r* around a planet of mass *M*. Which one of the following expressions gives the speed of the satellite?
G is the universal gravitational constant.

A $\left(\frac{Gm}{r}\right)^{\frac{1}{2}}$

B $\left(\frac{GM}{r}\right)^{\frac{1}{2}}$

C $\frac{Gm}{r}$

D $\left(\frac{Gm}{r}\right)^{\frac{3}{2}}$

(Total 1 mark)

Q50. Two identical spheres exert a gravitational force *F* on each other. What is the gravitational force between two spheres, each twice the mass of one of the original spheres, when the separation of their centres is twice the original separation?

A *F*

B 2*F*

C 4*F*

D 8*F*

(Total 1 mark)