1)

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. 3R
B. 4R
C. 8R
D. 9R

2)

The following data refer 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}

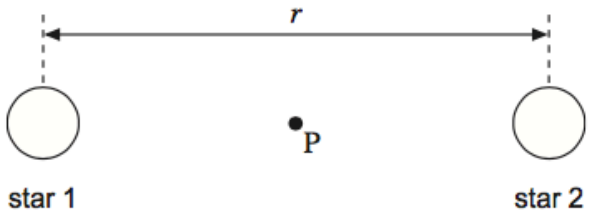
3)

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.

4)

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

5)

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.

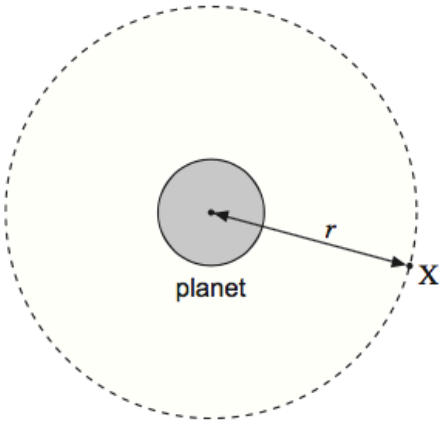
Which line, **A** to **D**, in the table provides a consistent representation of X, a and b according to the value of n?

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

6)

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	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{r}}$

7)

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

8)

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 $\mathrm{N\,kg^{-1}}$.

9)

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

A $F_E > F_S > F_M$

B $F_S > F_E > F_M$

C $F_E > F_M > F_S$

D $F_M > F_E > F_S$

10)

The gravitational field strengths at the surfaces of the Earth and the Moon are $9.8\,\mathrm{N\,kg^{-1}}$ and $1.7\,\mathrm{N\,kg^{-1}}$ 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

11)

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 $-63\,\text{MJ kg}^{-1}$.
What is the approximate value of the gravitational potential at the surface of Mars?

A $-13\,\text{MJ kg}^{-1}$

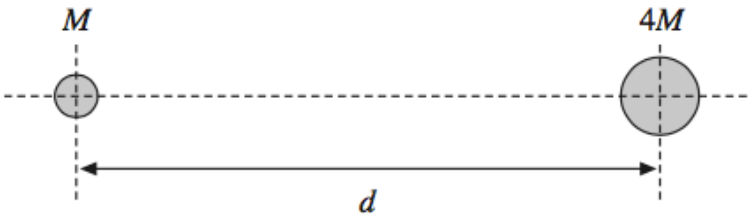
B $-25\,\text{MJ kg}^{-1}$

C $-95\,\text{MJ kg}^{-1}$

D $-320\,\text{MJ kg}^{-1}$

12)

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 $\frac{3}{4}$

13)

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.

14)

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.

15)

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 $2R$ and mass $2M$?

A $\frac{W}{4}$

B $\frac{W}{2}$

C W

D $2W$

16)

The gravitational field strength on the surface of a planet orbiting a star is $8.0\,\text{N kg}^{-1}$. 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 $0.0008\,\text{N kg}^{-1}$

B $0.08\,\text{N kg}^{-1}$

C $800\,\text{N kg}^{-1}$

D $8000\,\text{N kg}^{-1}$

17)

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.

18)

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

A 0.25 F
B 0.50 F
C 0.75 F
D 1.00 F

19)

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 $1.6\,\text{N kg}^{-1}$
B $5.0\,\text{N kg}^{-1}$
C $10\,\text{N kg}^{-1}$
D $20\,\text{N kg}^{-1}$

20)

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

21)

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.

22)

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

A $0.80\,\text{N kg}^{-1}$

B $1.25\,\text{N kg}^{-1}$

C $8.0\,\text{N kg}^{-1}$

D $80\,\text{N kg}^{-1}$

23)

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

24)

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 $3R$ 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	$\frac{W}{16}$	$\frac{V}{3}$