Exam Papers Practice

Gravitational Fields

Question Paper

Course	HL IB Physics
Section	Fields
Topic	Gravitational Fields
Difficulty	Medium

To be used by all students preparing for HL IB Physics
Students of other boards may also find this useful

Question 1

The mass of a potential landing module heading for Jupiter is 4000 kg. The gravitational field strength on Jupiter is roughly 2.5 times that on Earth. What is the weight of the landing module on Earth?

A. 4000 N

B. 100 000 N

C. 10 000 N

D. 40 000 N

[1 mark]

Question 2

A planet has triple the mass of Earth and a third of its radius. What is the gravitational field strength on the surface of the planet?

A. 10 N kg^{-1}

B. 270 N kg^{-1}

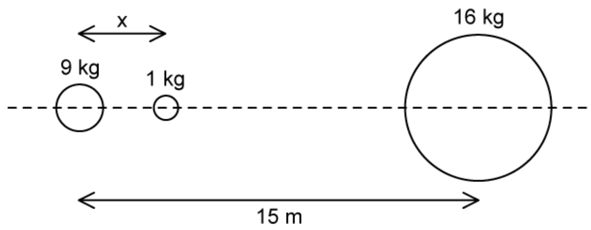
C. 90 N kg^{-1}

D. 240 N kg^{-1}

[1 mark]

Question 3

The diagram below shows three uniform masses in a straight line.



The resultant gravitational force on the 1 kg mass is zero if the distance *x* is:

A. $\frac{45}{7}\mathrm{m}$

B. 45 m

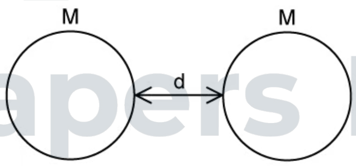
C. $\frac{27}{5}\mathrm{m}$

D. 35 m

[1 mark]

Question 4

The gravitational force between two identical uniform spheres of mass *M* is *F* when the distance between them *d.*



If the radius of each sphere is *x*, what is the correct expression for mass, *M*?

A. $\frac{F(d+2x)^2}{G}$

B. $\sqrt{\frac{Fd^2}{G}}$

C. $\sqrt{\frac{F(d+2x)}{G}}$

D. $\sqrt{\frac{F(d+2x)^2}{G}}$

[1 mark]

Question 5

A satellite of mass m is placed in a geostationary orbit. If the Earth's angular velocity is ω rad s^{-1}, what is the circumference of the satellite's orbit?

A. $\left(\frac{GM}{\omega^2}\right)^{\frac{1}{3}}$

B. $2\pi\sqrt{\frac{GMm}{\omega^2}}$

C. $2\pi\left(\frac{GM}{\omega^2}\right)$

D. $2\pi\left(\frac{GM}{\omega^2}\right)^{\frac{1}{3}}$

[1 mark]

Question 6

A spherical planet of uniform density has two times the mass of the Earth and three times the average radius. The magnitude of the gravitational field strength at the surface of the Earth is g. What is the gravitational field strength at the surface of the planet?

A. $\frac{3}{4}g$

B. $\frac{2}{3}g$

C. $\frac{2}{9}g$

D. 18g

[1 mark]

Question 7

The inverse square law means that halving the radius of a planet results in quadrupling the gravitational field strength at its surface.

The centres of two planets are separated by a distance *R*. The gravitational force between the two planets is *F*. What will the force between the planets be when their separation increases to 4*R*?

A. $\frac{F}{16}$

B. 4*F*

C. $\frac{F}{4}$

D. *F*

[1 mark]

Question 8

A mass at point *P* gives rise to a gravitational field strength *g* at point *X* as shown.

An identical mass is placed at point Q as shown.

What is the resultant gravitational field strength at *X* in this new situation?

A. zero

B. between *g* and zero

C. between 2*g* and *g*

D. greater than 2*g*

[1 mark]

Question 9

A spacecraft travels away from Earth in a straight line with its motors shut down. At one instant, the speed of the spacecraft is 5.7 km s^{-1}. After a time of 1000 s, the speed is 5.2 km s^{-1}. The gravitational field strength acting on the spacecraft during this time interval is:

A. -5×10^{-4} N kg^{-1}

B. 5×10^{1} N kg^{-1}

C. -5×10^{-1} N kg^{-1}

D. -1×10^{1} N kg^{-1}

[1 mark]

Question 10

Which of the following statements about uniform gravitational fields is **incorrect**?

A. The field strength is equal at every point in a uniform gravitational field

B. The acceleration of freefalling bodies is dependent on their mass

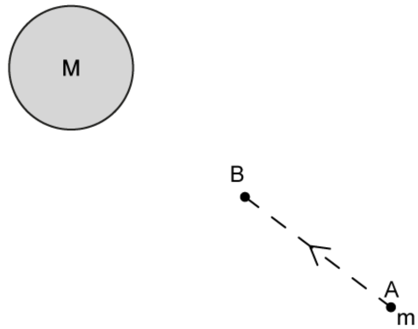
C. The field lines in a uniform gravitational field are parallel to each other

D. There is a uniform gravitational field near the Earth's surface

[1 mark]

Question 11

A test mass *m* moves between position A and B as shown, in the presence of a source mass *M*.



Which of the following statements is correct?

A. Negative work is done on *m* by the gravitational field from A to B

B. The gravitational field of *M* does negative work on *m*

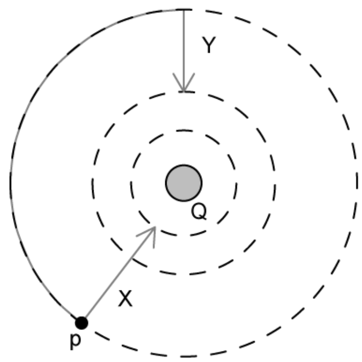
C. *m* moves along an equipotential

D. The gravitational field of *M* does work on *m*

[1 mark]

Question 12

A positive charge Q is deposited on the surface of a small sphere. The dotted lines represent equipotentials.



A small positive point charge is moved from point P closer to the sphere along two different paths X and Y. What is the best comparison of the work done along X and Y, W_X and W_Y?

A. $W_X = W_Y$

B. $W_X < W_Y$

C. $W_X > W_Y$

D. $W_X \approx W_Y$

[1 mark]

Question 13

Equipotential surfaces corresponding to lines of constant gravitational potential are conventionally drawn so that the difference in potential between any two adjacent surfaces is the same.

Consider the equipotential surfaces for a spherical mass *M*. Which of the following statements is incorrect?

A. Equipotential surfaces are spheres of constant radius around *M*

B. The distance between equipotential surfaces increases with distance from *M*

C. No work is done by the gravitational field of *M* if a test mass moves along an equipotential surface

D. The radius of each equipotential surface depends on the diameter of *M*

[1 mark]

Question 14

Which of the following statements about gravitational fields is correct?

A. The gravitational potential is zero whenever the gravitational field strength is zero

B. The gravitational potential is negative because the gravitational field is repulsive

C. The gradient of the gravitational potential at a point is inversely proportional to the radial distance from some massive body

D. The area under a field strength–distance curve represents the change in gravitational potential between two points

[1 mark]

Question 15

The mass of Jupiter is m_J and the mass of its moon Europa is m_E.

If their radii is given by r_J and r_E respectively, what is the ratio $\frac{\text{escape velocity of Europa}}{\text{escape velocity of Jupiter}}$?

A. $\sqrt{\frac{m_E\ r_E}{m_J\ r_J}}$

B. $\sqrt{\frac{m_E\ r_J}{m_J\ r_E}}$

C. $\sqrt{\frac{m_J\ r_J}{m_E\ r_E}}$

D. $\sqrt{\frac{m_J\ r_E}{m_E\ r_J}}$

[1 mark]

Question 16

A satellite of mass 2000 kg is in the Earth's gravitational field. It moves radially from a point where the gravitational potential is $-40\ \text{MJ kg}^{-1}$ to a point where the gravitational potential is $-10\ \text{MJ kg}^{-1}$. What is the direction of movement of the satellite and the change in its gravitational potential energy?

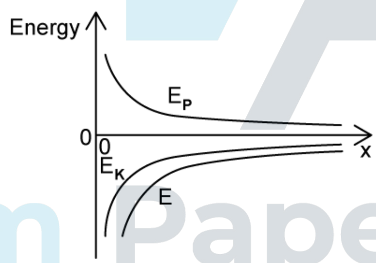
	Direction of movement of satellite	Change in gravitational potential energy / GJ
A.	Parallel to a field line	60
B.	Antiparallel to a field line	30
C.	Along an equipotential	30
D.	Antiparallel to a field line	60

[1 mark]

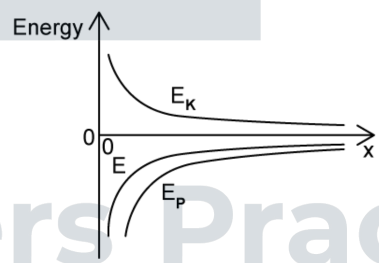
Question 17

Which graph shows how the kinetic energy E_K, the potential energy E_P and the total energy E of the international space station varies with distance x from the centre of Earth?

A



B



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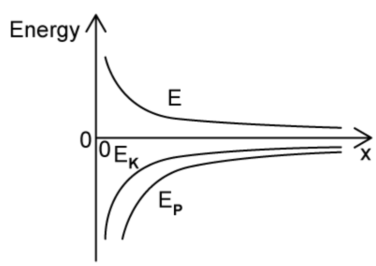
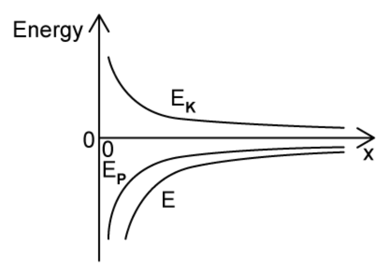


D



[1 mark]

Question 18

A probe is launched from the surface of the Earth, which has a radius *R*, at half the required escape velocity.

What is the maximum height from the surface the probe will reach, before returning to the ground (with a bang)?

A. R

B. $\frac{R}{2}$

C. $\frac{R}{3}$

D. $\frac{R}{4}$

[1 mark]

Question 19

The radius of the Sun is approximately 700 000 km. If all of its mass were compressed into a certain radius, it would collapse into a black hole, which is known to be a body from which "not even light can escape".

Which length gives the best estimate for the radius at which the Sun's mass would collapse into a black hole?

Use the following data:

- Mass of the Sun = 2×10^{30} kg
- Speed of light = 3×10^{8} m s^{-1}
- Gravitation constant = 6.67×10^{-11} N m^{2} kg^{-2}

A. 3 mm

B. 3 cm

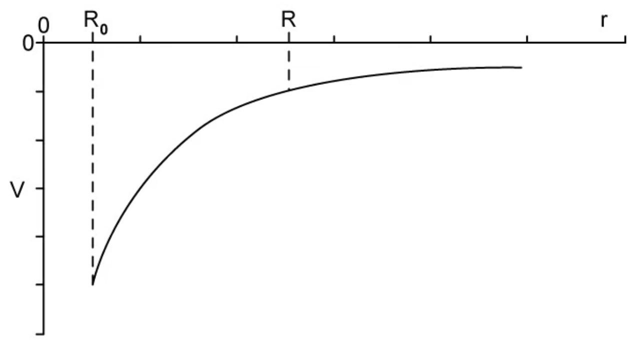
C. 3 km

D. 3×10^{5} km

[1 mark]

Question 20

The graph shows the variation of gravitational potential *V* with distance *r* from the centre of a spherical planet of mass *M* and radius R_0.



Which statement best describes how to determine the gravitational field strength at a distance $r = R$ from the planet?

A. The area enclosed by the horizontal axis, the line $r = R_0$, the line $r = R$, and the curve

B. The gradient at the point $r = R$

C. The inverse of the gradient at the point $r = R$

D. The negative of the gradient at the point $r = R$

[1 mark]

Question 21

The gravitational field strength is *g* and the gravitational potential is *V* at the surface of Earth, which has a radius of *r*.

Which row in the table gives the correct value of the gravitational field strength and the gravitational potential at a height of 2*r* from Earth's surface?

	Gravitational field strength	Gravitational potential
A.	$\frac{g}{3}$	$\frac{V}{3}$
B.	$\frac{g}{4}$	$\frac{V}{2}$
C.	$\frac{g}{9}$	$\frac{V}{3}$
D.	$\frac{g}{16}$	$\frac{V}{2}$

[1 mark]