Gravitational Field Practice Questions (HL) [56 marks]

1. Planets X and Y orbit the same star.

The average distance between planet X and the star is five times greater than the average distance between planet Y and the star.

What is $\frac{orbital\ period\ of\ planet\ X}{orbital\ period\ of\ planet\ Y}$?

A. $\sqrt[3]{5}$

B. $\sqrt{5}$

C. $\sqrt[3]{5^2}$

D. $\sqrt{5^3}$

2. Planets X and Y move in circular orbits around the same star.

The orbital period of planet Y is twice the orbital period of planet X. The orbital radius of planet X is R.

What is the orbital radius of planet Y?

A. $\sqrt[3]{2}R$

B. $\sqrt[3]{4}R$

C. $2R$

D. $4R$

3. Kepler's Third law relates the orbital period T of a planet about its sun to its orbital radius r. The mass of the Sun is M.

What is a correct algebraic form of the law?

A. $T = \frac{2\pi r^{1.5}}{(GM)^{0.5}}$

B. $T = \frac{2\pi r^{1.5}}{GM}$

C. $T = \frac{4\pi r^{0.67}}{(GM)^2}$

D. $T = \frac{4\pi r^{0.67}}{GM}$

4. The mass of a planet X is 300 times larger than the mass of the Earth and its radius is 10 times larger than the radius of the Earth. What is the gravitational field strength on the surface of planet X in terms of the gravitational field strength g on the surface of Earth?

A. $\frac{g}{30}$

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

C. $3\,g$

D. $30\,g$

5. The radius of the Earth is R. A satellite is launched to a height $h = \frac{R}{4}$ above the Earth's surface.

What is $\frac{gravitational\ force\ on\ satellite\ at\ the\ surface}{gravitational\ force\ on\ satellite\ at\ height\ h}$?

A. $\frac{4}{5}$

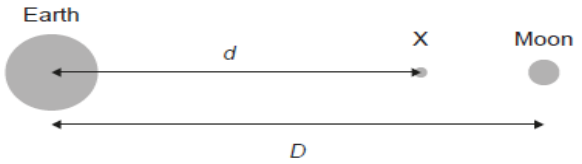
B. $\frac{16}{25}$

C. $\frac{25}{16}$

D. $\frac{5}{4}$

6.

The centre of the Earth and the Moon are a distance D apart. There is a point X between them where their gravitational fields cancel out. The distance from the centre of the Earth to X is d. The mass of the Earth is M_E and the mass of the Moon is M_M.



What is correct at X?

A. $\frac{M_E}{d} = \frac{M_M}{D-d}$

B. $\frac{M_E}{D-d} = \frac{M_M}{d}$

C. $\frac{M_E}{d^2} = \frac{M_M}{(D-d)^2}$

D. $\frac{M_E}{d^2} = \frac{M_M}{D^2-d^2}$

7.

P and Q are two moons of equal densities orbiting a planet. The orbital radius of P is twice the orbital radius of Q. The volume of P is half that of Q. The force exerted by the planet on P is *F*. What is the force exerted by the planet on Q?

A. *F*

B. 2*F*

C. 4*F*

D. 8*F*

8.

An astronaut is orbiting Earth in a spaceship. Why does the astronaut experience weightlessness?

A. The astronaut is outside the gravitational field of Earth.

B. The acceleration of the astronaut is the same as the acceleration of the spaceship.

C. The spaceship is travelling at a high speed tangentially to the orbit.

D. The gravitational field is zero at that point.

9.

A simple pendulum has a time period T on the Earth. The pendulum is taken to the Moon where the gravitational field strength is $\frac{1}{6}$ that of the Earth.

What is the time period of the pendulum on the Moon?

A. $T\sqrt{6}$

B. T

C. $\frac{\sqrt{6}}{6}T$

D. $\frac{T}{6}$

10.

A satellite is orbiting Earth in a circular path at constant speed. Three statements about the resultant force on the satellite are:

I. It is equal to the gravitational force of attraction on the satellite.
II. It is equal to the mass of the satellite multiplied by its acceleration.
III. It is equal to the centripetal force on the satellite.

Which combination of statements is correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11.

The gravitational field strength at the surface of a planet of radius *R* is g. A satellite is moving in a circular orbit a distance *R* above the surface of the planet. What is the magnitude of the acceleration of the satellite?

A. 0

B. $\frac{g}{4}$

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

D. g

12.

Which is the definition of gravitational field strength at a point?

A. The sum of the gravitational fields created by all masses around the point

B. The gravitational force per unit mass experienced by a small point mass at that point

C. $G\frac{M}{r^2}$, where M is the mass of a planet and r is the distance from the planet to the point

D. The resultant force of gravitational attraction on a mass at that point

13.

An object of mass m released from rest near the surface of a planet has an initial acceleration z. What is the gravitational field strength near the surface of the planet?

A. z

B. $\frac{z}{m}$

C. mz

D. $\frac{m}{z}$

14.

Planet X has a gravitational field strength of $18\ N\ kg^{-1}$ at its surface. Planet Y has the same density as X but three times the radius of X. What is the gravitational field strength at the surface of Y?

A. $6\ m\ s^{-2}$

B. $18\ m\ s^{-2}$

C. $54\ m\ s^{-2}$

D. $162\ m\ s^{-2}$

15.

A satellite travels around the Earth in a circular orbit. What is true about the forces acting in this situation?

A. The resultant force is the same direction as the satellite's acceleration.

B. The gravitational force acting on the satellite is negligible.

C. There is no resultant force on the satellite relative to the Earth.

D. The satellite does not exert any force on the Earth.

16.

Satellite X orbits a planet with orbital radius *R*. Satellite Y orbits the same planet with orbital radius 2*R*. Satellites X and Y have the same mass.

What is the ratio $\frac{\text{centripetal acceleration of X}}{\text{centripetal acceleration of Y}}$?

A. $\frac{1}{4}$

B. $\frac{1}{2}$

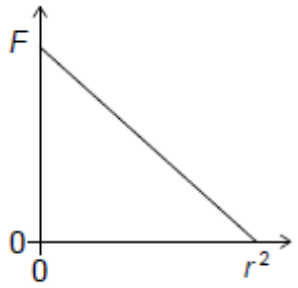
C. 2

D. 4

17.

Which graph shows the relationship between gravitational force *F* between two point masses and their separation *r*?

A.



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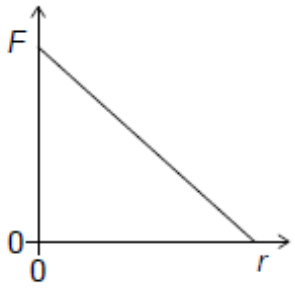
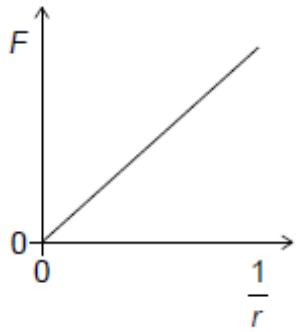
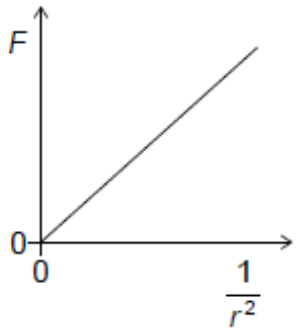


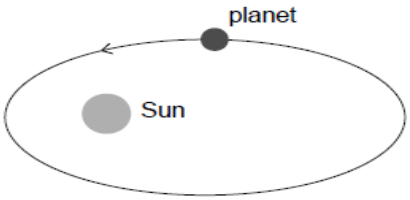
C.



D.



35. A planet orbits the Sun in an elliptical orbit moving in the direction shown.



At the position shown, which quantity is decreasing for the planet?

A. Acceleration

B. Angular momentum

C. Kinetic energy

D. Gravitational potential energy

36.

Planets X and Y orbit the same star.

The average distance between planet X and the star is five times greater than the average distance between planet Y and the star.

What is $\frac{orbital\ period\ of\ planet\ X}{orbital\ period\ of\ planet\ Y}$?

A. $\sqrt[3]{5}$

B. $\sqrt{5}$

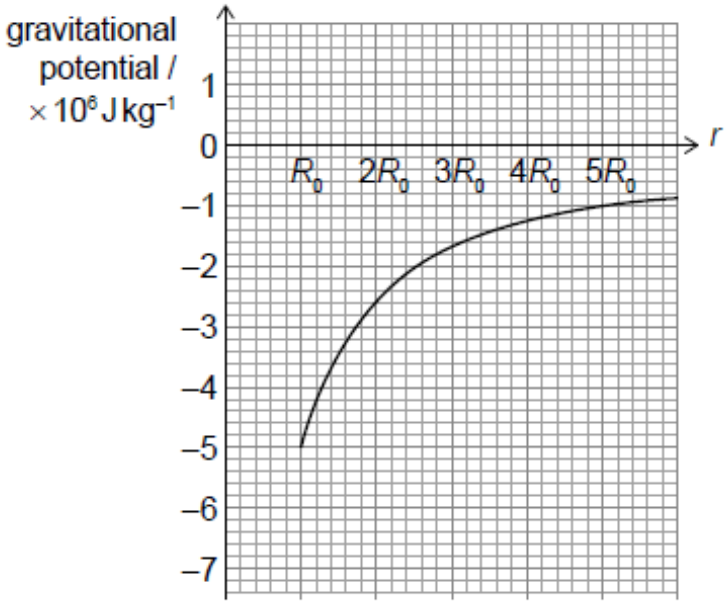
C. $\sqrt[3]{5^2}$

D. $\sqrt{5^3}$

37.

A spherical planet has a radius R_0.

The graph shows the variation of the gravitational potential due to the planet with distance r from the centre of the planet.



What is the escape speed from the surface of the planet?

A. 1.6×10^3 m s^{-1}

B. 2.2×10^3 m s^{-1}

C. 3.2×10^3 m s^{-1}

D. 4.5×10^3 m s^{-1}

38.

A space probe moves in a circular orbit around Earth. The kinetic energy of the probe is E.

The probe will reach the escape speed when its **kinetic** energy is increased at least to:

A. $\sqrt{2}E$

B. $2E$

C. $2\sqrt{2}E$

D. $4E$

39.

What is the escape speed from the surface of a planet of radius r that has an acceleration of gravity g at its surface?

A. $\sqrt{\frac{g}{r}}$

B. $\sqrt{gr}$

C. $\sqrt{\frac{2g}{r}}$

D. $\sqrt{2gr}$

40.

A satellite of mass m is in orbit around a planet of radius R and mass M. The total energy of the satellite is $-\frac{GMm}{4R}$.

What is the radius of the orbit?

A. R

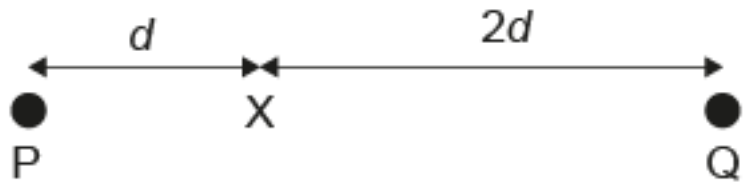
B. $\frac{4R}{3}$

C. $2R$

D. $\frac{8R}{3}$

41.

Two isolated point masses, P of mass *m* and Q of mass 2*m*, are separated by a distance 3*d*. X is a point a distance *d* from P and 2*d* from Q.



What is the net gravitational field strength at X and the net gravitational potential at X?

	Net gravitational field strength at X	Net gravitational potential at X
A.	$\frac{Gm}{d^2}$	0
B.	$\frac{Gm}{d^2}$	$-\frac{Gm}{d}$
C.	$\frac{Gm}{2d^2}$	0
D.	$\frac{Gm}{2d^2}$	$-\frac{2Gm}{d}$

42.

The escape speed from the surface of earth is v_{esc}. The radius of earth is *R*. A satellite of mass m is in orbit at a height $\frac{R}{4}$ above the surface of the Earth. What is the energy required to move the satellite to infinity?

A. $\frac{mv^2_{esc}}{5}$

B. $\frac{2mv^2_{esc}}{5}$

C. mv^2_{esc}

D. $2mv^2_{esc}$

43.

The mass of Mars is about ten times that of the Moon. The radius of Mars is about twice that of the Moon.

What is the $\frac{escape\ speed\ from\ Mars}{Moon}$?

A. $\sqrt{5}$

B. $2\sqrt{5}$

C. 5

D. 25

44.

Two satellites are in circular orbits around the Earth. Both satellites have the same mass and satellite X is closer to Earth than satellite Y.

What is correct for the orbital periods of X and Y and the total energies of X and Y?

	Orbital periods	Total energies
A.	X greater than Y	X greater than Y
B.	X greater than Y	Y greater than X
C.	Y greater than X	X greater than Y
D.	Y greater than X	Y greater than X

45.

An object of mass m is launched from the surface of the Earth. The Earth has a mass M and radius r. The acceleration due to gravity at the surface of the Earth is g. What is the escape speed of the object from the surface of the Earth?

A. $\sqrt{gr}$

B. $\sqrt{2gr}$

C. $\sqrt{2Mgr}$

D. $\sqrt{2mgr}$

46.

Three statements about Newton's law of gravitation are:

I. It can be used to predict the motion of a satellite.
II. It explains why gravity exists.
III. It is used to derive the expression for gravitational potential energy.

Which combination of statements is correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

47.

A satellite of mass m orbits a planet of mass M in a circular orbit of radius r. What is the work that must be done on the satellite to increase its orbital radius to $2r$?

A. $\frac{GMm}{r}$

B. $\frac{GMm}{2r}$

C. $\frac{GMm}{4r}$

D. $\frac{GMm}{8r}$

48.

Which is a correct unit for gravitational potential?

A. $m^2 s^{-2}$

B. J kg

C. $m s^{-2}$

D. $N m^{-1} kg^{-1}$

49.

A planet has radius *R*. The escape speed from the surface of the planet is *v*. At what distance from the surface of the planet is the orbital speed 0.5*v*?

A. 0.5*R*

B. *R*

C. 2*R*

D. 4*R*

50.

A satellite orbits planet X with a speed v_X at a distance r from the centre of planet X.
Another satellite orbits planet Y at a speed of v_y at a distance r from the centre of planet Y. The mass of planet X is M and the mass of planet Y is $4M$. What is the ratio of $\frac{v_X}{v_y}$?

A. 0.25

B. 0.5

C. 2.0

D. 4.0

51.

Two satellites W and X have the same mass. They have circular orbits around the same planet. W is closer to the surface than X. What quantity is smaller for W than for X?

A. Gravitational force from the planet

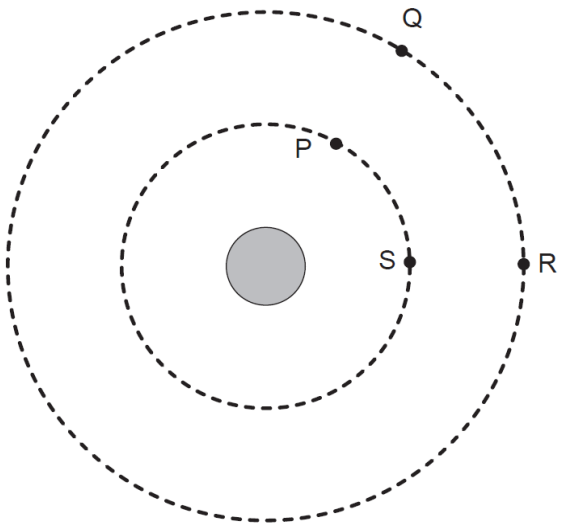
B. Angular velocity

C. Orbital speed

D. Orbital period

52.

P and S are two points on a gravitational equipotential surface around a planet. Q and R are two points on a different gravitational equipotential surface at a greater distance from the planet.



The greatest work done by the gravitational force is when moving a mass from

A. P to S.

B. Q to R.

C. R to P.

D. S to R.

53.

The gravitational potential is V at a distance R above the surface of a spherical planet of radius R and uniform density. What is the gravitational potential a distance $2R$ above the surface of the planet?

A. $\frac{V}{4}$

B. $\frac{4V}{9}$

C. $\frac{V}{2}$

D. $\frac{2V}{3}$

54.

A satellite in a circular orbit around the Earth needs to reduce its orbital radius.

What is the work done by the satellite rocket engine and the change in kinetic energy resulting from this shift in orbital height?

	Work done by the satellite rocket engine	Kinetic energy
A.	positive	increase
B.	positive	decrease
C.	negative	increase
D.	negative	decrease

55.

Satellite X is in orbit around the Earth. An identical satellite Y is in a higher orbit. What is correct for the total energy and the kinetic energy of the satellite Y compared with satellite X?

	Total energy of satellite X	Kinetic energy of satellite X
A.	larger	larger
B.	smaller	larger
C.	larger	smaller
D.	smaller	smaller

56.

The escape speed from a planet of radius R is v_{esc}. A satellite orbits the planet at a distance R from the surface of the planet. What is the orbital speed of the satellite?

A. $\frac{1}{2}v_{esc}$

B. $\frac{\sqrt{2}}{2}v_{esc}$

C. $\sqrt{2}v_{esc}$

D. $2v_{esc}$

ANSWERS (no questions 18-34)

1. D	13. A		37. C	49. B
2. B	14. C		38. B	50.B
3. A	15. A		39. D	51. D
4. C	16. D		40. C	52. C
5. C	17. D		41. D	53.D
6. C			42. A	54. C
7. D			43. A	55. B
8. B			44. D	56. A
9. A			45. B	
10. D			46. B	
11. B		35. D	47. C	
12. B		36. D	48. A	