HL Paper 1

A field line is normal to an equipotential surface

A. for both electric and gravitational fields.
B. for electric but not gravitational fields.
C. for gravitational but not electric fields.
D. for neither electric nor gravitational fields.

The mass of a planet is M and its radius is R. In order for a body of mass m to escape the gravitational attraction of the planet, its kinetic energy at the surface of the planet must be at least

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

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

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

D. $\frac{GM}{R^2}$

The escape speed of a rocket from the surface of Earth depends on the universal gravitational constant *G*. Other factors that may affect the escape speed are the

I. mass of Earth
II. radius of Earth
III. mass of the rocket.

Which of the above factors is/are correct?

A. I and II only
B. I and III only
C. II only
D. III only

What is the unit of $G\varepsilon_0$, where *G* is the gravitational constant and ε_0 is the permittivity of free space?

A. C kg^{-1}

B. C^2 kg^{-2}

C. C kg

D. C^2 kg^2

In an experiment, oil droplets of mass *m* and charge *q* are dropped into the region between two horizontal parallel plates. The electric field *E* between the plates can be adjusted. Air resistance is negligible. Which is correct when the droplets fall vertically at constant velocity?

A. *E*=0

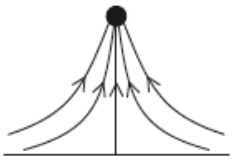
B. $E < \frac{mg}{q}$

C. $E = \frac{mg}{q}$

D. $E > \frac{mg}{q}$

A positive point charge is placed above a metal plate at zero electric potential. Which diagram shows the pattern of electric field lines between the charge and the plate?

A.



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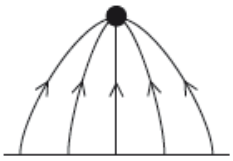

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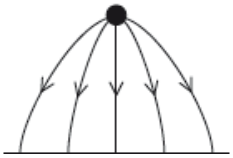
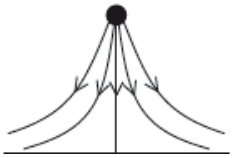


D.

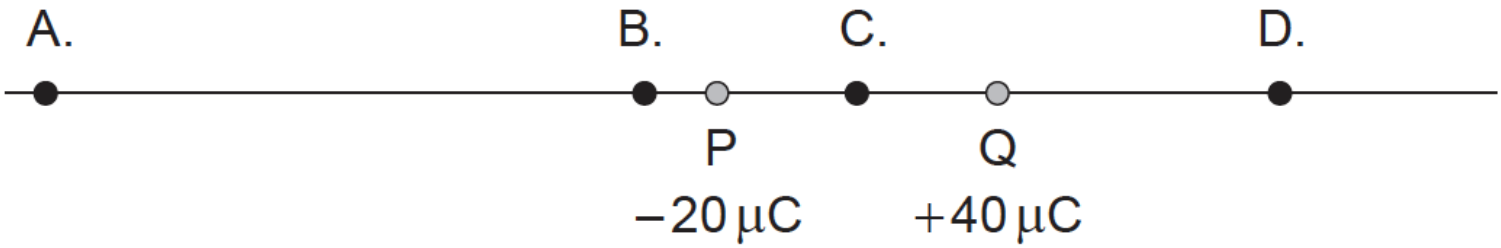


A satellite at the surface of the Earth has a weight *W* and gravitational potential energy *E*p. The satellite is then placed in a circular orbit with a radius twice that of the Earth.

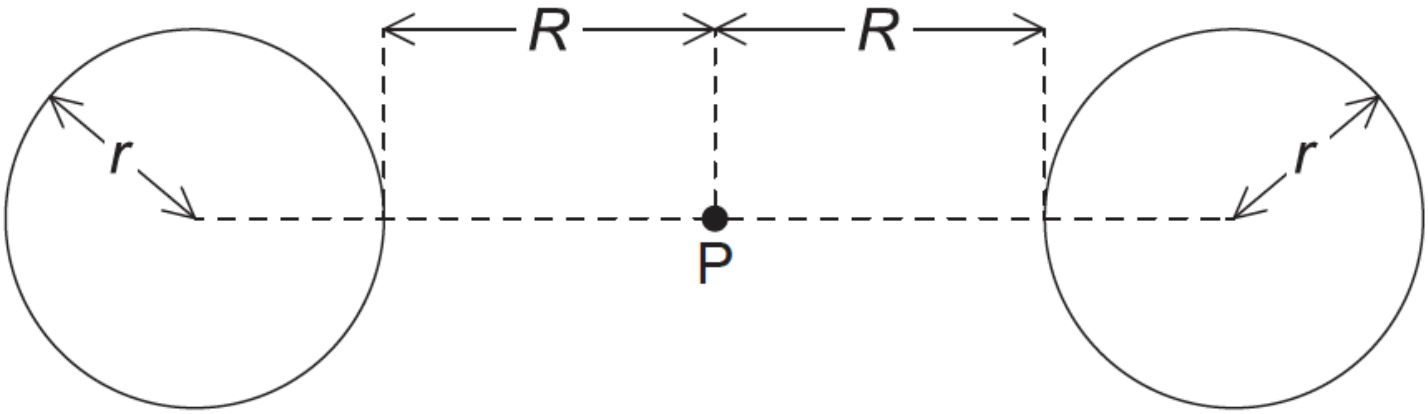
What is the weight of the satellite and the gravitational potential energy of the satellite when placed in orbit?

	Weight	Gravitational potential energy
A.	$0.25\,W$	$0.25\,E_p$
B.	$0.5\,W$	$0.25\,E_p$
C.	$0.25\,W$	$0.5\,E_p$
D.	$0.5\,W$	$0.5\,E_p$

The diagram shows two point charges P and Q. At which position is the electric field strength equal to zero?



Two spherical objects of mass *M* are held a small distance apart. The radius of each object is *r*.



Point P is the midpoint between the objects and is a distance *R* from the surface of each object. What is the gravitational potential at point P?

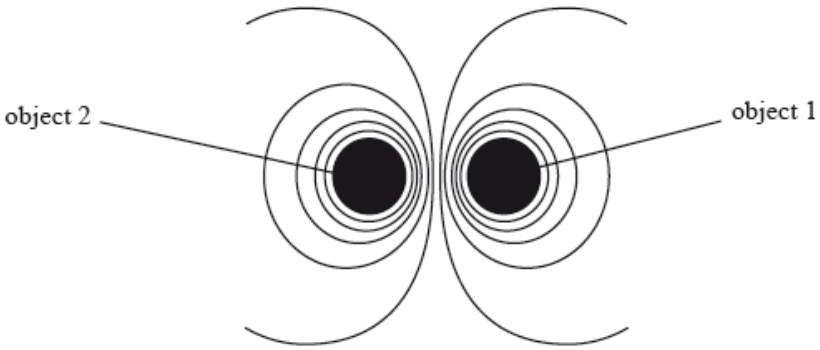
A. $-\frac{GM}{(r+R)^2}$

B. $-2\frac{GM}{r+R}$

C. $-\frac{GM}{r+R}$

D. 0

The diagram shows equipotential lines due to two objects.



The two objects could be

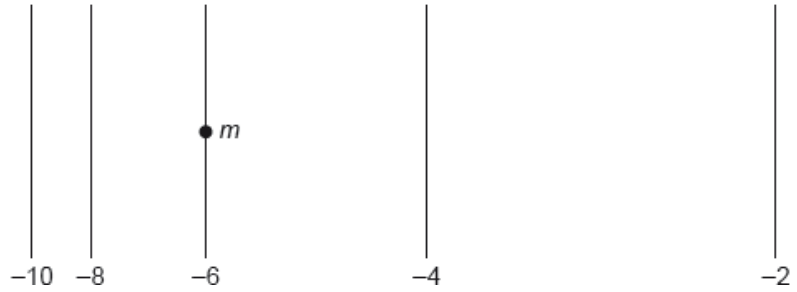
A. electric charges of the same sign only.

B. masses only.

C. electric charges of opposite sign only.

D. masses or electric charges of any sign.

The diagram shows 5 gravitational equipotential lines. The gravitational potential on each line is indicated. A point mass *m* is placed on the middle line and is then released. Values given in MJ kg^{-1}.



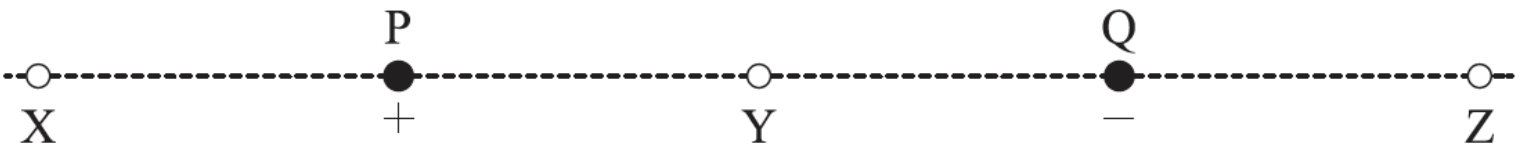
Which is correct about the direction of motion and the acceleration of the point mass?

	Direction	Acceleration
A.	to the right	decreasing
B.	to the right	increasing
C.	to the left	decreasing
D.	to the left	increasing

At the surface of a planet of radius *r*, the gravitational field strength is *g* and the gravitational potential is *V*. Which gives the gravitational field strength and gravitational potential at a height 3*r* above the surface?

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

A positive point charge P and a negative point charge Q of equal magnitude are held at fixed positions. Y is a point midway between P and Q.



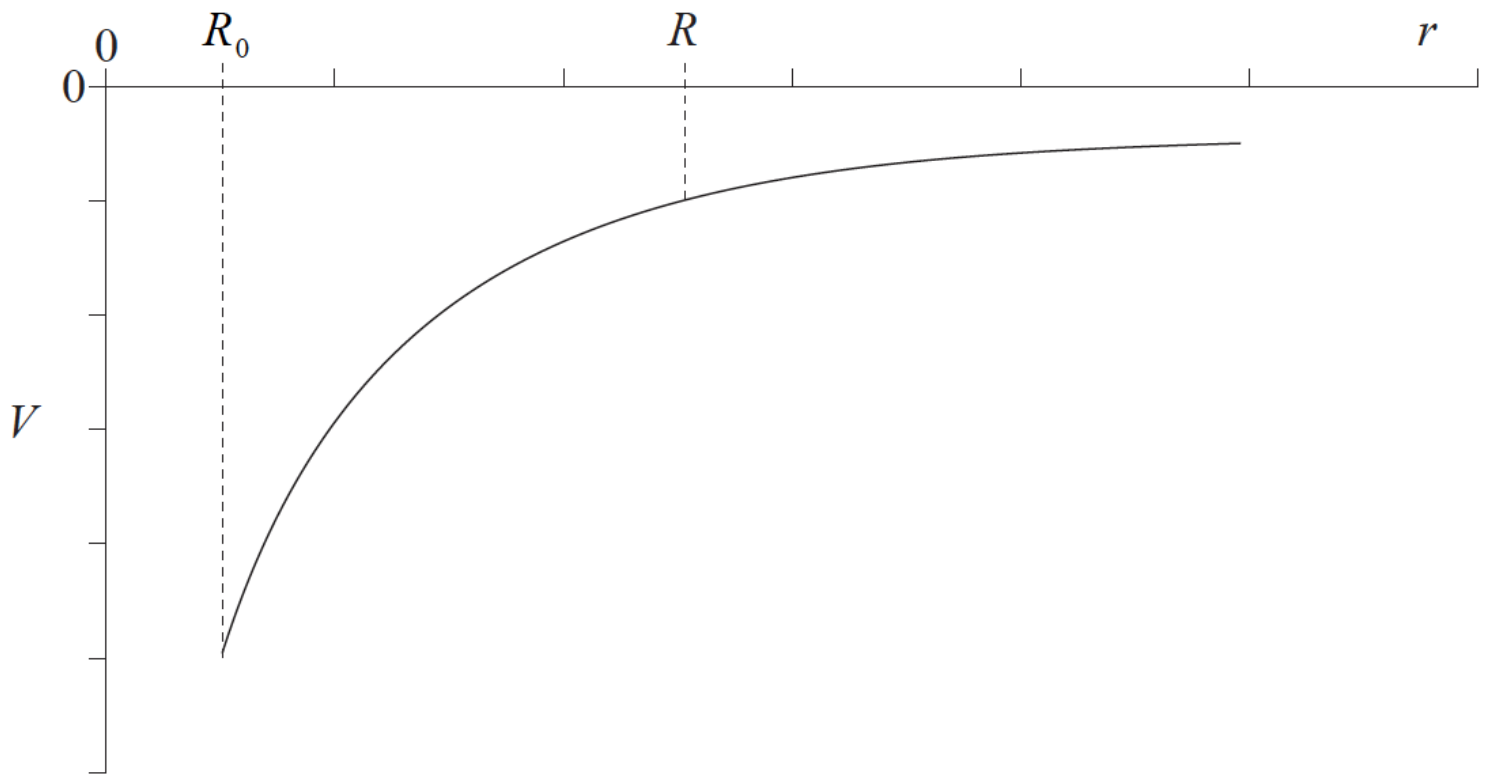
Which of the following gives the direction of the electric field due to the charges at X, Y and Z?

	X	Y	Z
A.	to right	to left	to right
B.	to right	to right	to left
C.	to left	to right	to right
D.	to left	to right	to left

A satellite is moved from a low orbit to a higher orbit. Which of the following accurately describes the energy of the satellite?

	Total energy	Gravitational potential energy	Kinetic energy
A.	stays the same	decreases	increases
B.	stays the same	increases	decreases
C.	increases	decreases	increases
D.	increases	increases	decreases

The sketch graph shows how the gravitational potential V of a planet varies with distance r from the centre of the planet of radius R_0.



The magnitude of the gravitational field strength at the point $r=R$ equals the

A. area between the graph and the r-axis between $r=R$ and $r=R_0$.

B. gradient of the graph at $r=R$.

C. inverse of the gradient of the graph at $r=R$.

D. value of V at $r=R$ divided by R^2.

A spacecraft moves towards the Earth under the influence of the gravitational field of the Earth.

The three quantities that depend on the distance r of the spacecraft from the centre of the Earth are the

I. gravitational potential energy of the spacecraft
II gravitational field strength acting on the spacecraft
III. gravitational force acting on the spacecraft.

Which of the quantities are proportional to $\frac{1}{r^2}$?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

An electron of mass m_e orbits an alpha particle of mass m_α in a circular orbit of radius r. Which expression gives the speed of the electron?

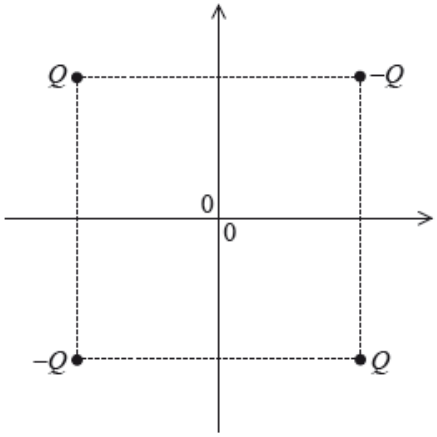
A. $\sqrt{\frac{2ke^2}{m_e r}}$

B. $\sqrt{\frac{2ke^2}{m_a r}}$

C. $\sqrt{\frac{4ke^2}{m_e r}}$

D. $\sqrt{\frac{4ke^2}{m_a r}}$

Two positive and two negative point charges of equal magnitude are placed at the vertices of a square as shown. The origin of the axes is at the centre of the square.



The electric potential is zero

A. at the origin of the axes only.

B. along both the x-axis and the y-axis.

C. along the y-axis only.

D. along the x-axis only.

A moon of mass *M* orbits a planet of mass 100*M*. The radius of the planet is *R* and the distance between the centres of the planet and moon is 22*R*.

What is the distance from the centre of the planet at which the total gravitational potential has a maximum value?

A. 2*R*

B. 11*R*

C. 20*R*

D. 2*R* and 20*R*

The mass of the Earth is M_E and the mass of the Moon is M_M. Their respective radii are R_E and R_M.

Which is the ratio $\frac{\text{escape speed from the Earth}}{\text{escape speed from the Moon}}$?

A. $\sqrt{\frac{M_{\mathrm{M}}R_{\mathrm{M}}}{M_{\mathrm{E}}R_{\mathrm{E}}}}$

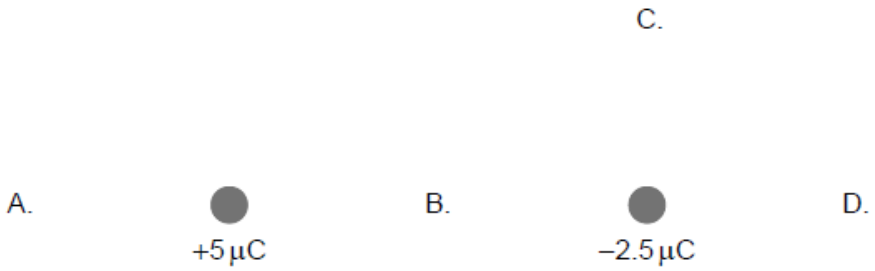
B. $\sqrt{\frac{M_{\mathrm{E}}R_{\mathrm{E}}}{M_{\mathrm{M}}R_{\mathrm{M}}}}$

C. $\sqrt{\frac{M_{\mathrm{E}}R_{\mathrm{M}}}{M_{\mathrm{M}}R_{\mathrm{E}}}}$

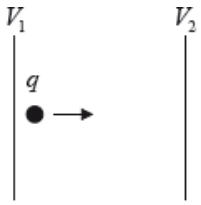
D. $\sqrt{\frac{M_{\mathrm{M}}R_{\mathrm{E}}}{M_{\mathrm{E}}R_{\mathrm{M}}}}$

Two point charges are at rest as shown.

At which position is the electric field strength greatest?



The diagram below shows a particle with positive charge *q* accelerating between two conducting plates at potentials V_1 and V_2.



Which of the following is the kinetic energy gained by the charge in moving between the plates?

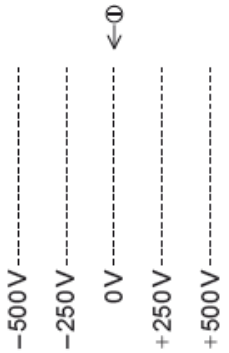
A. V_2q

B. V_1q

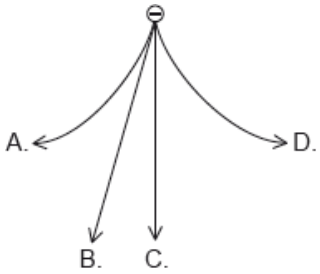
C. $(V_1 - V_2)q$

D. $(V_2 - V_1)q$

A negatively charged particle falls vertically into a region where there is an electric field. The equipotentials of this field are shown.



What is the path followed by the particle?



Which of the following experiments provides evidence for the existence of matter waves?

A. Scattering of alpha particles

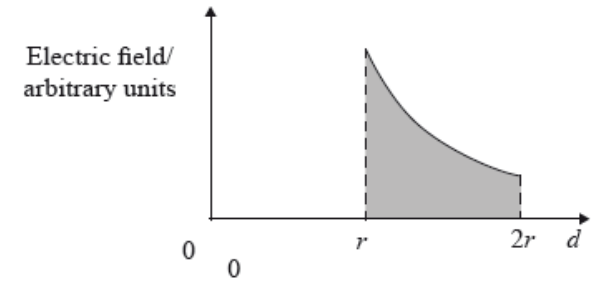
B. Electron diffraction

C. Gamma decay

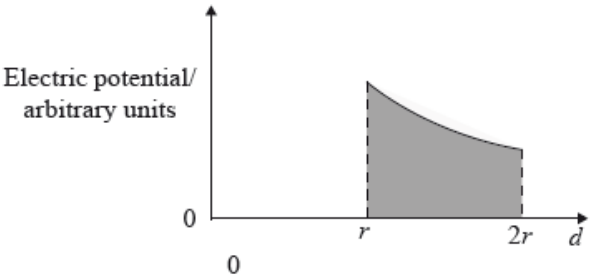
D. Photoelectric effect

The two graphs below represent the variation with distance, d, for $d = r$ to $d = 2r$ of the electric field and the electric potential around an isolated point charge.

Graph 1:



Graph 2:



The work done by an external force in moving a test charge $+q$ from $d = 2r$ to $d = r$ is equal to q multiplied by the

A. shaded area under graph 1.

B. shaded area under graph 2.

C. average value of the electric field.

D. average value of the electric potential.

A charge of –3 C is moved from A to B and then back to A. The electric potential at A is +10 V and the electric potential at B is –20 V. What is the work done in moving the charge from A to B and the total work done?

	Work done in moving from A to B / J	Total work done / J
A.	30	0
B.	30	60
C.	90	0
D.	90	180

Which of the following represents a scalar and a vector quantity?

	Scalar	Vector
A.	electric potential	electric potential gradient
B.	electric potential gradient	electric potential
C.	electric potential	electric potential difference
D.	electric potential gradient	electric field

Gravitational potential at a point is defined as the work done

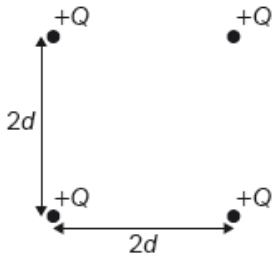
A. per unit mass in moving a small mass from infinity to the point.

B. in moving a unit mass from infinity to the point.

C. in moving a small mass from infinity to the point.

D. per unit mass in moving a unit mass from infinity to the point.

Four identical, positive, point charges of magnitude *Q* are placed at the vertices of a square of side 2*d*. What is the electric potential produced at the centre of the square by the four charges?



A. 0

B. $\frac{4kQ}{d}$

C. $\frac{\sqrt{2}kQ}{d}$

D. $\frac{2\sqrt{2}kQ}{d}$

The diagram shows two parallel metal plates X and Y.

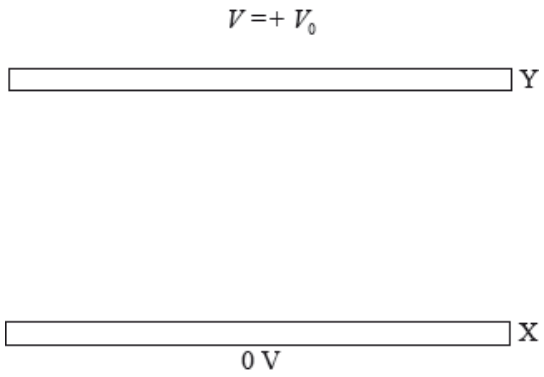


Plate X is at Earth potential (0 V) and the potential of plate Y is V_0.

Which of the following is correct in respect of the magnitude and the direction of the electric field between the plates?

	Magnitude	Direction
A.	constant	X → Y
B.	increasing	Y → X
C.	constant	Y → X
D.	increasing	X → Y

The escape speed from the surface of a planet depends on

A. both the radius and the mass of the planet.

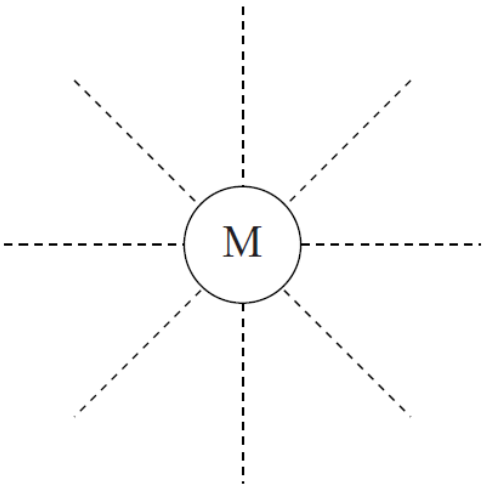
B. only the radius of the planet.

C. only the mass of the planet.

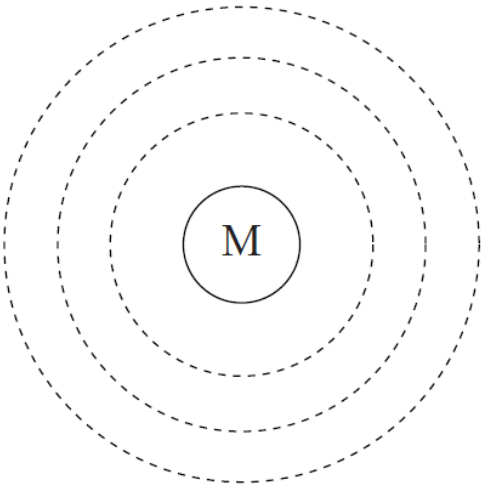
D. only the gravitational field strength at the surface of the planet.

M is a spherical mass situated far away from any other masses. Which of the following represents gravitational equipotential surfaces having constant potential difference between them?

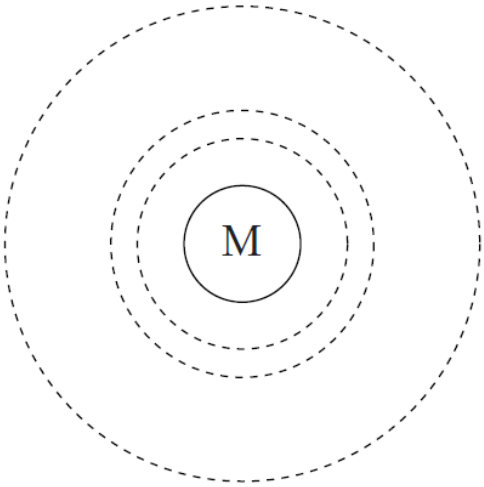
A.



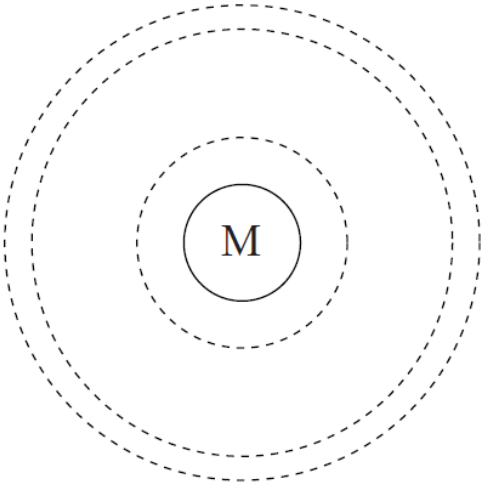
B.



C.



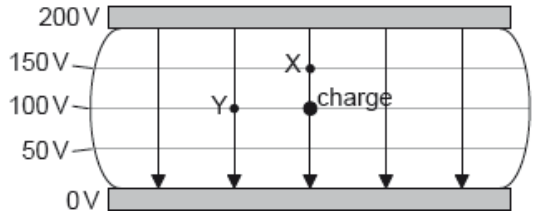
D.



A satellite in close-Earth orbit moves to an orbit further from the Earth's surface. Which of the following concerning the speed of the satellite and its gravitational potential energy in the new orbit is correct?

	Speed of the satellite	Gravitational potential energy
A.	increases	decreases
B.	increases	increases
C.	decreases	decreases
D.	decreases	increases

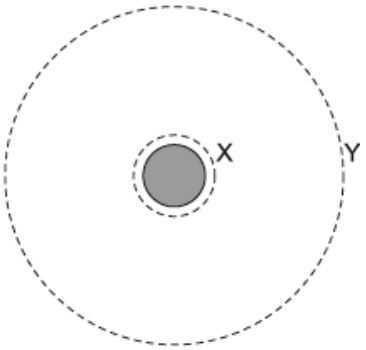
The diagram shows the electric field and the electric equipotential surfaces between two charged parallel plates. The potential difference between the plates is 200 V.



What is the work done, in nJ, by the electric field in moving a negative charge of magnitude 1 nC from the position shown to X and to Y?

	To X	To Y
A.	50	0
B.	–50	0
C.	50	100
D.	–50	–100

A satellite orbiting a planet moves from orbit X to orbit Y.



What is the change in the kinetic energy and the change in the gravitational potential energy as a result?

	Kinetic energy	Gravitational potential energy
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

At the surface of a planet of radius *r*, the gravitational potential is -6.4×10^{7}J kg^{-1}. The gravitational potential at a height of *r* above the surface is

A. -12.8×10^{7}J kg^{-1}.

B. -6.4×10^{7}J kg^{-1}.

C. -3.2×10^{7}J kg^{-1}.

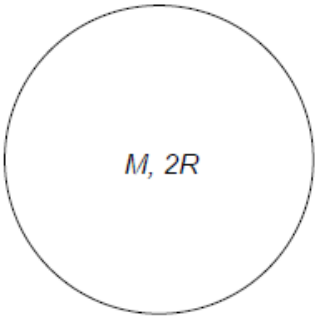
D. -1.6×10^{7}J kg^{-1}.

Four uniform planets have masses and radii as shown. Which planet has the smallest escape speed?

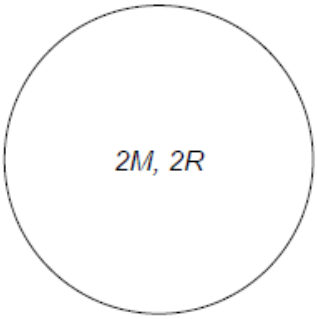
A.

B.

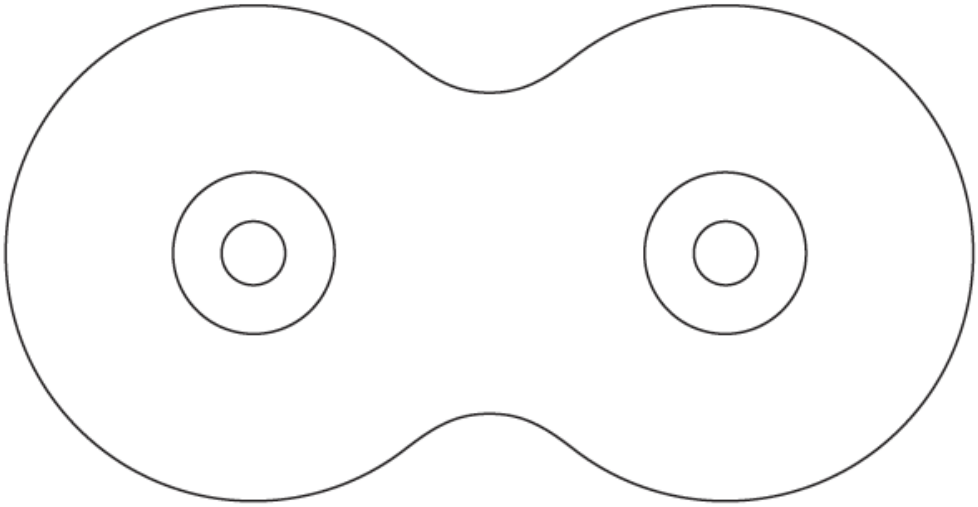
C.



D.



The diagram shows equipotential lines around two sources.



Possible sources are

I. two equal masses

II. two equal charges of same sign

III. two equal charges of opposite sign.

What is/are the possible source(s) for the equipotential lines?

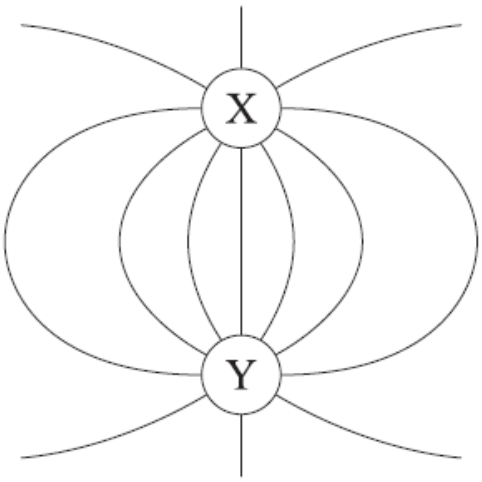
A. I and II only

B. I and III only

C. II only

D. III only

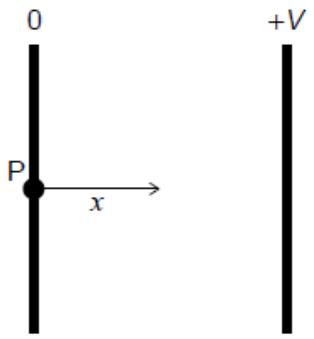
The diagram shows the electric field pattern due to two point charges X and Y. Y is a negative charge.



Which of the following correctly identifies the charge X and the direction of the electric field?

	Sign of charge X	Direction of electric field
A.	positive	Y to X
B.	positive	X to Y
C.	negative	X to Y
D.	negative	Y to X

An electric field acts in the space between two charged parallel plates. One plate is at zero potential and the other is at potential $+V$.

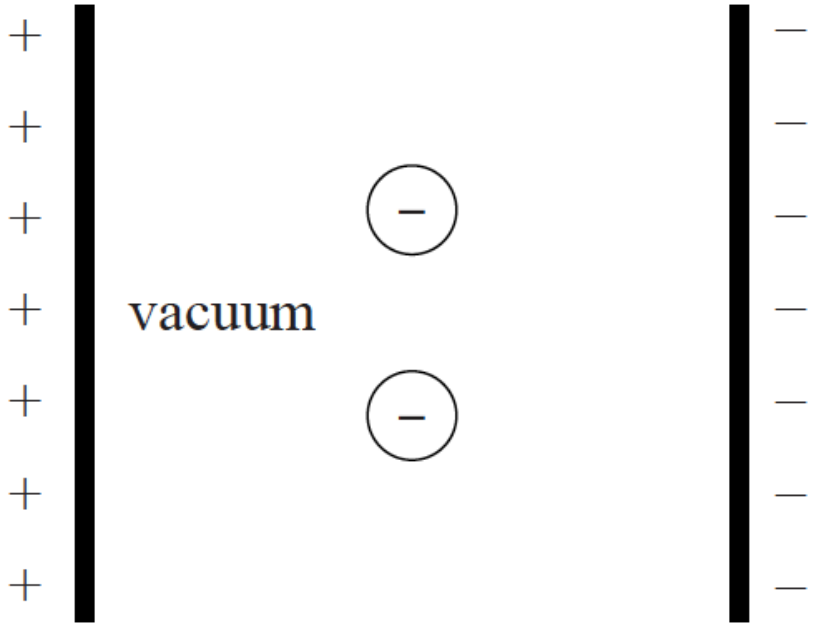


The distance x is measured from point P in the direction perpendicular to the plate.

What is the dependence of the electric field strength E on x and what is the dependence of the electric potential V on x?

	E	***V***
A.	proportional to $\frac{1}{x^2}$	constant
B.	constant	proportional to x
C.	proportional to x	proportional to x
D.	proportional to x^2	constant

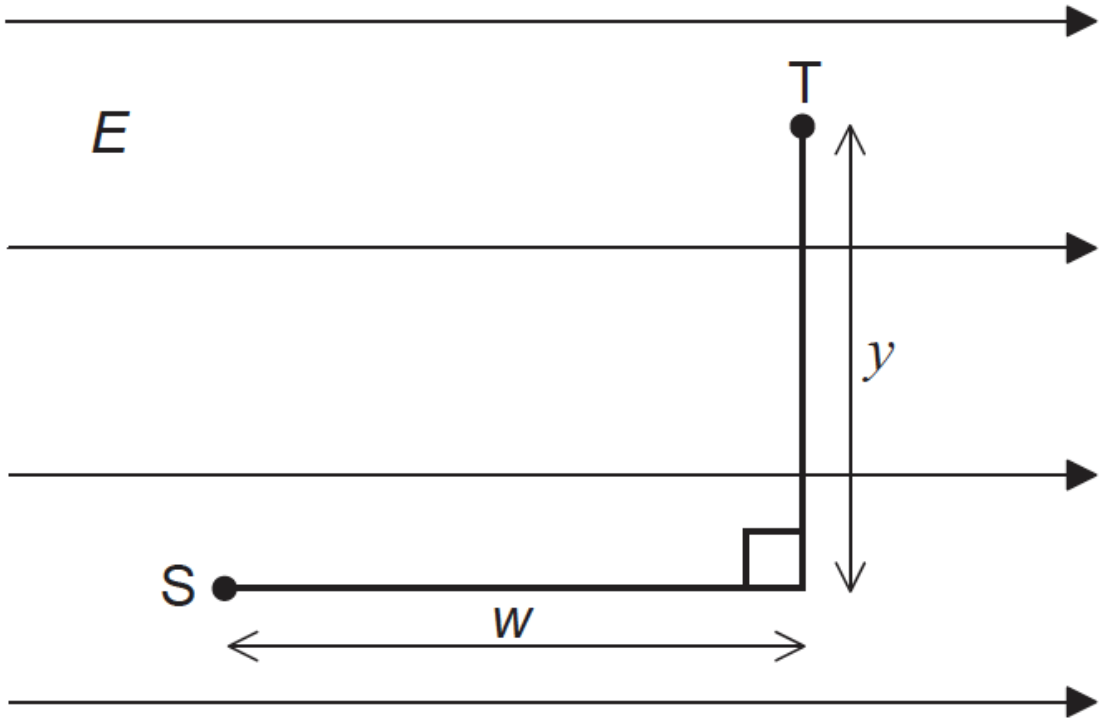
Two negatively charged particles are released from rest half-way between two oppositely charged parallel plates in vacuum.



The particles take the same time to reach the positively charged plate. The particles must have the same

A. charge only.
B. mass only.
C. mass and charge.
D. ratio of mass to charge.

A particle of charge *q* is at point S in a uniform electric field of strength *E*. The particle moves a distance *w* parallel to the field lines and then a distance *y* perpendicular to the field lines to reach point T.



What is the change in electric potential energy of the charge between S and T?

A. *Eqw*

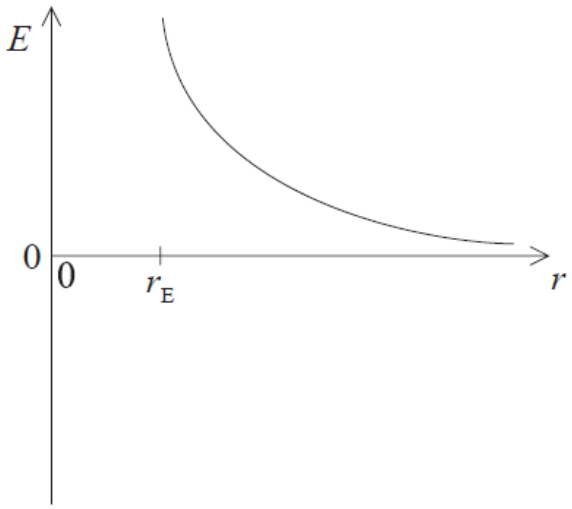
B. *Eqy*

C. *Eq* (*y* + w)

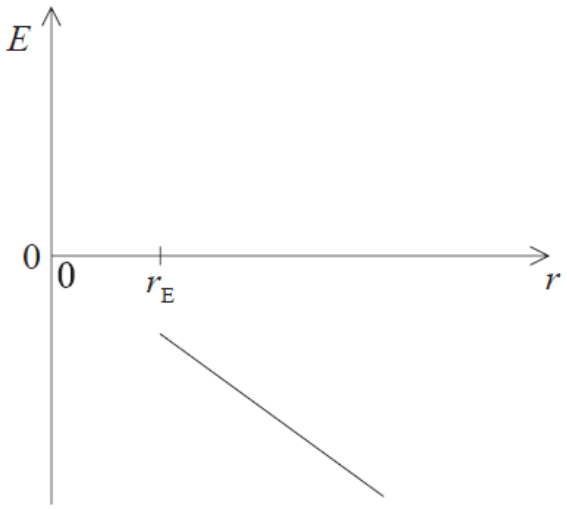
D. *Eq* $\sqrt{y^2 + w^2}$

Which graph shows how the total energy *E* of an orbiting satellite varies with distance *r* from the centre of the Earth, where r_E is the radius of the Earth?

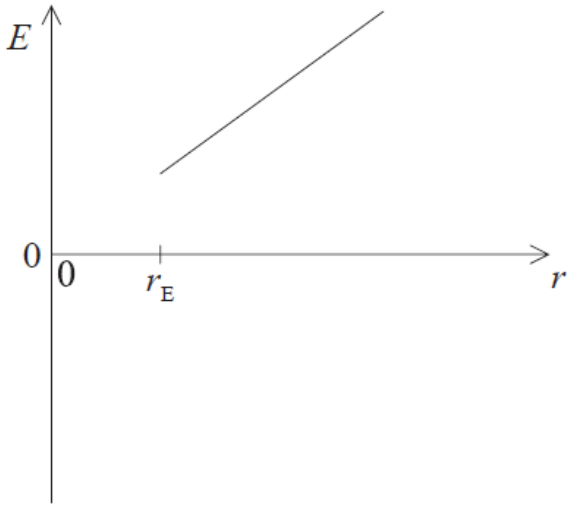
A.



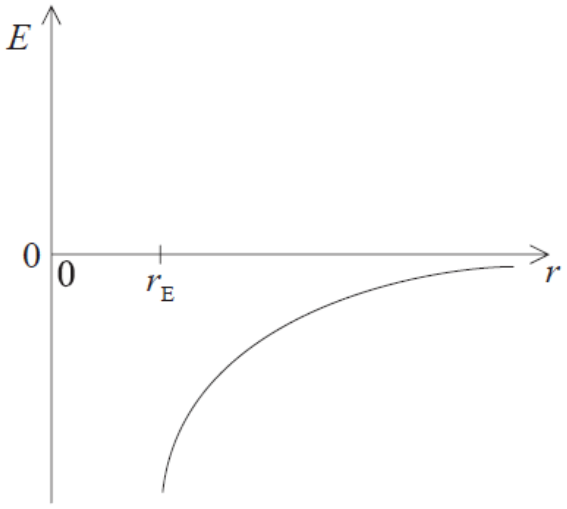
B.



C.

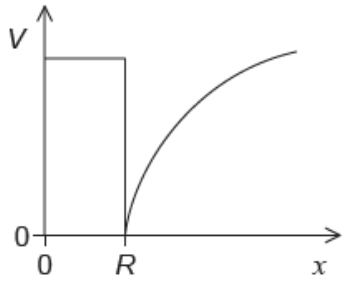


D.

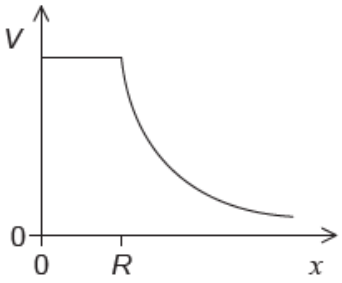


An isolated hollow metal sphere of radius *R* carries a positive charge. Which graph shows the variation of potential *V* with distance *x* from the centre of the sphere?

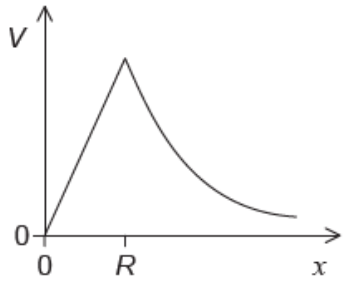
A.



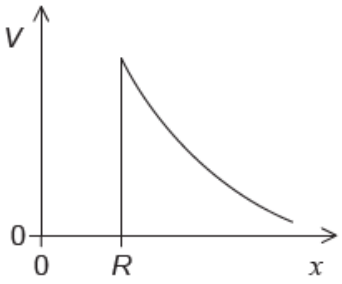
B.



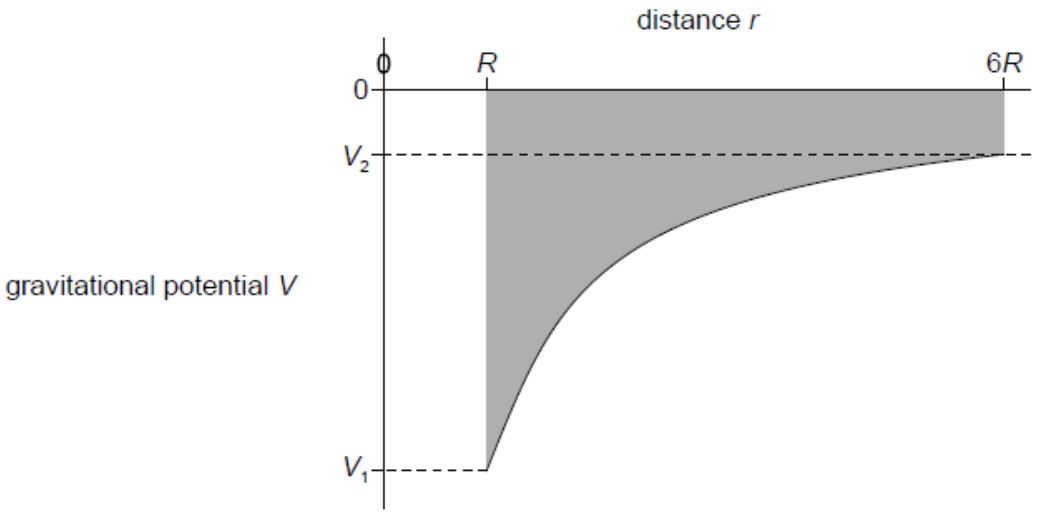
C.



D.



The graph shows the variation of the gravitational potential V with distance r from the centre of a uniform spherical planet. The radius of the planet is R. The shaded area is S.



What is the work done by the gravitational force as a point mass m is moved from the surface of the planet to a distance $6R$ from the centre?

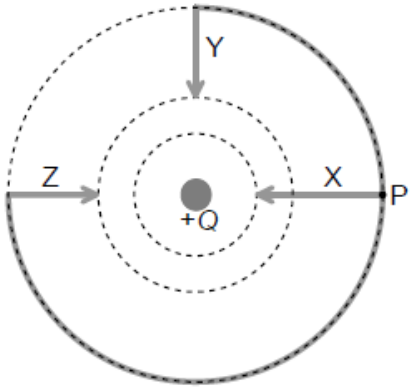
A. m ($V2 - V1$)

B. m ($V1 - V2$)

C. mS

D. S

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 three different paths X, Y and Z. The work done along each path is W_X, W_Y and W_Z. What is a correct comparison of W_X, W_Y and W_Z?

A. $W_Z > W_Y > W_X$

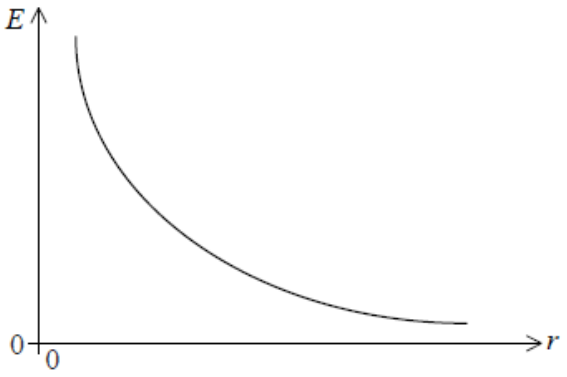
B. $W_X > W_Y = W_Z$

C. $W_X = W_Y = W_Z$

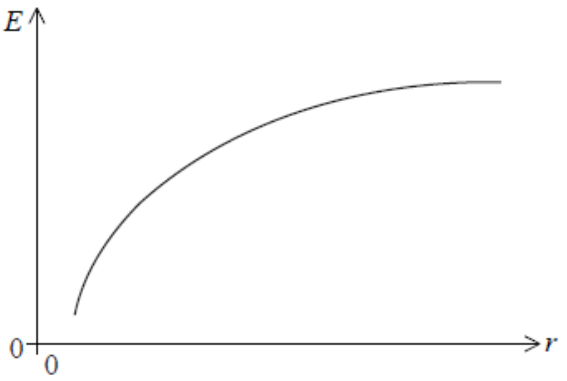
D. $W_Z = W_Y > W_X$

Which of the following graphs represents how the total energy *E* of an orbiting satellite varies with orbital radius *r*?

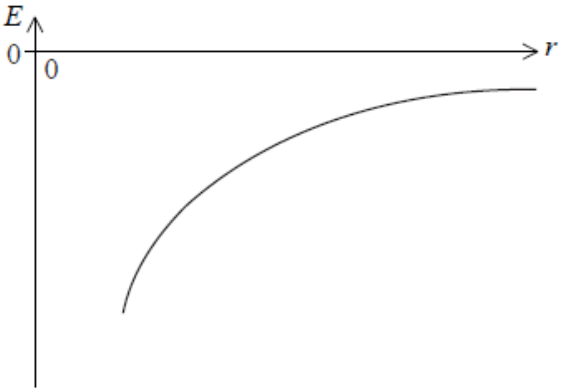
A.



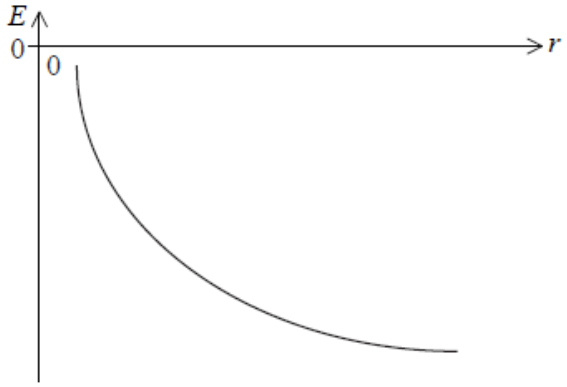
B.



C.



D.



Which diagram shows a correct equipotential line due to two point charges X and Y of opposite sign?

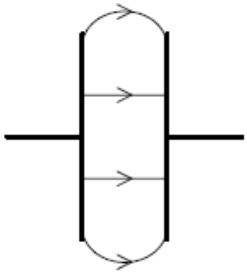
A.

B.

C.

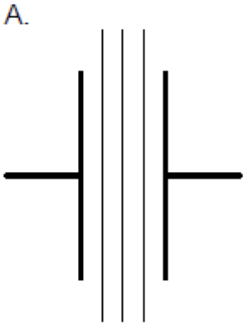
D.

Two parallel metal plates are connected to a dc power supply. An electric field forms in the space between the plates as shown.

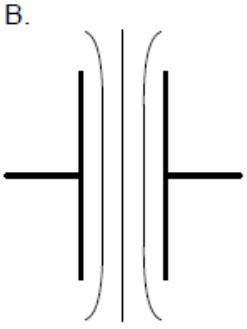


What is the shape of the equipotentials surfaces that result from this arrangement?

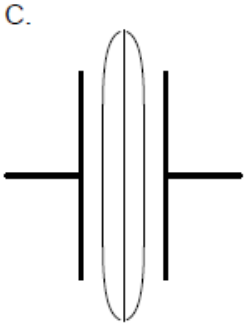
A.



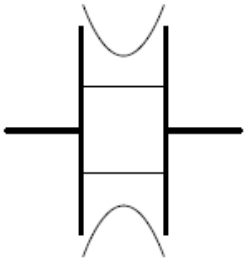
B.



C.



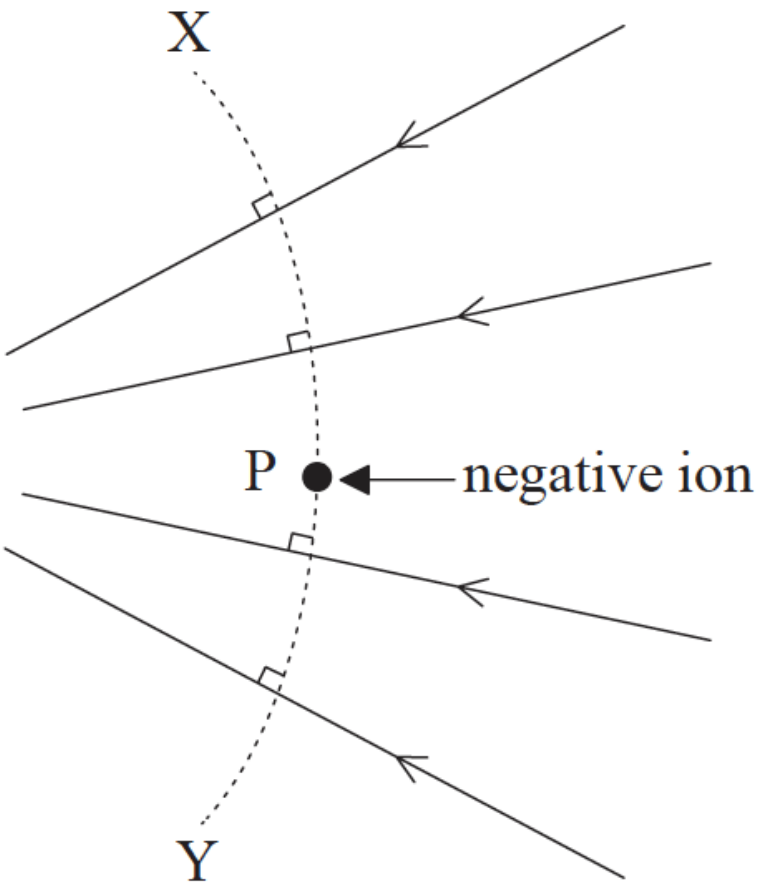
D.



A spacecraft is in orbit at a distance *r* from the centre of the Earth. The engine of the spacecraft is fired and it moves to a new orbit of radius 2*r*. Which of the following describes the variations in kinetic energy and total energy of the spacecraft?

	Kinetic energy	Total energy
A.	decrease	increase
B.	decrease	decrease
C.	increase	increase
D.	increase	decrease

A negative ion is held at point P in an electric field as represented by the arrowed field lines.



Which of the following describes the effect on the negative ion when it is displaced in a particular direction?

	Direction of displacement	Effect on the negative ion
A.	to the left	magnitude of electric force on the ion is unchanged
B.	to the right	potential energy of ion increases
C.	along XY towards X	potential energy of ion increases
D.	along XY towards Y	magnitude of electric force on the ion is unchanged

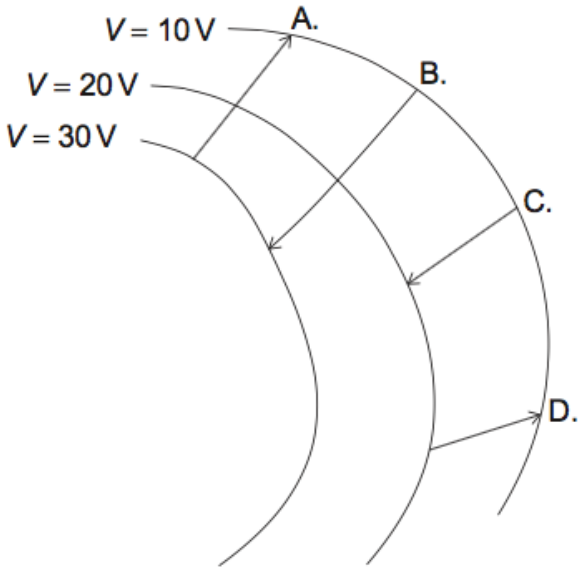
An electron is held close to the surface of a negatively charged sphere and then released. Which describes the velocity and the acceleration of the electron after it is released?

	Velocity	Acceleration
A.	decreasing	constant
B.	decreasing	decreasing
C.	increasing	constant
D.	increasing	decreasing

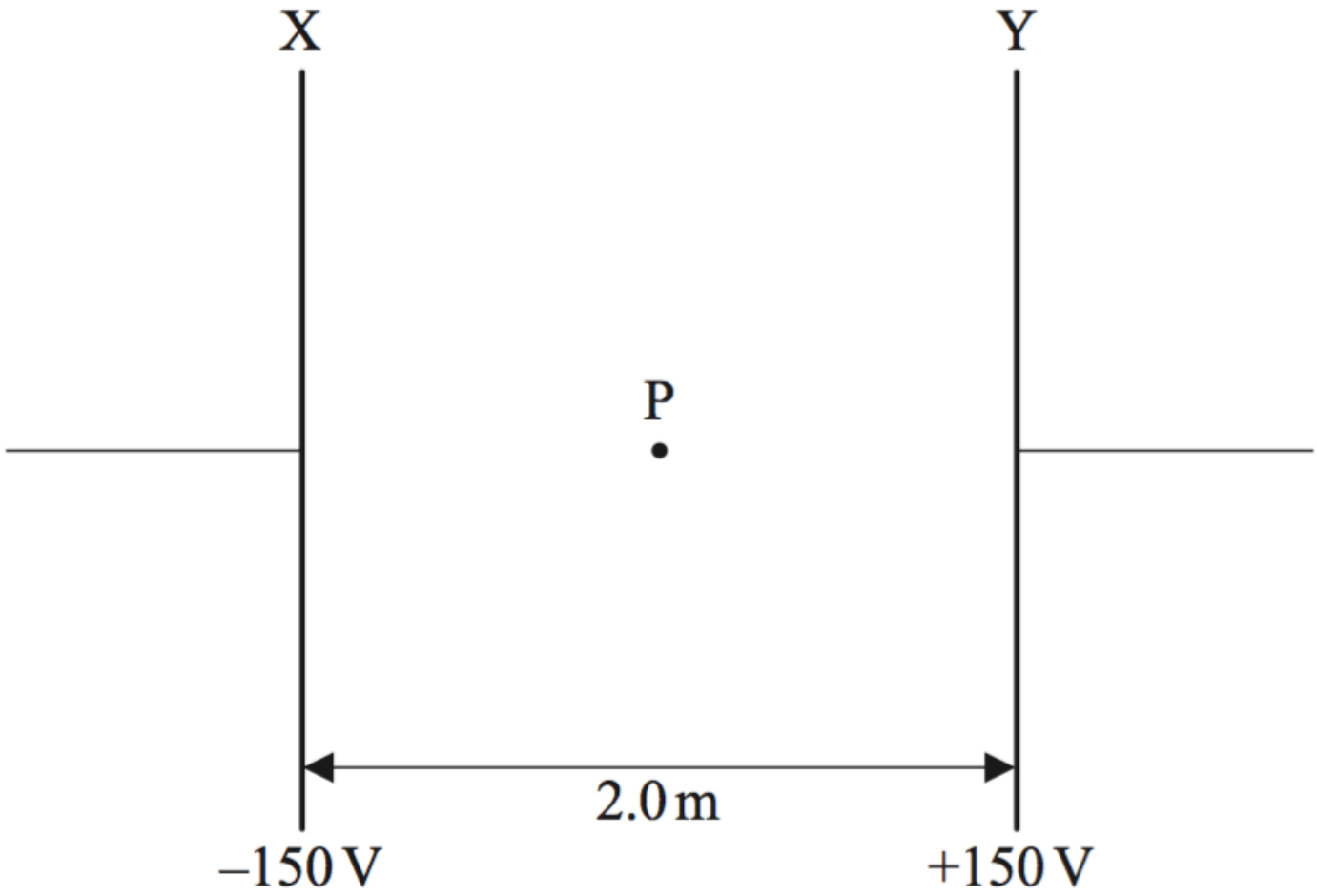
A satellite of mass 1500 kg is in the Earth's gravitational field. It moves from a point where the gravitational potential is –30 MJ kg^{-1} to a point where the gravitational potential is –20 MJ kg^{-1}. What is the direction of movement of the satellite and the change in its gravitational potential energy?

	Direction of movement of satellite	Change in gravitational potential energy / GJ
A.	away from Earth	15
B.	away from Earth	75
C.	towards Earth	15
D.	towards Earth	75

A negative charge moves in an electric field. Equipotential lines for the field and four possible paths of the charge are shown. Which path corresponds to the largest work done on the charge by the field?



Two charged parallel metal plates, X and Y, are separated by a distance of 2.0 m. X is at a potential of -150 V and Y is at a potential of +150 V.



Point P is midway between X and Y. Which of the following gives the electric field strength at point P?

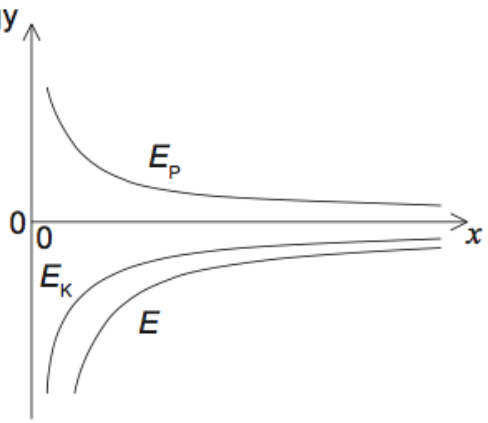
A. 150 Vm^{-1} to the right
B. 150 Vm^{-1} to the left
C. 300 Vm^{-1} to the right
D. 300 Vm^{-1} to the left

A satellite in orbit about Earth moves to another orbit that is closer to the surface of Earth. When the satellite moves into the orbit closer to Earth, which of the following correctly describes the change in speed of the satellite and the change in its gravitational potential energy?

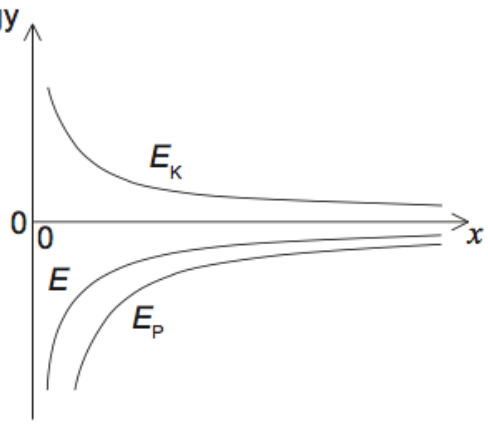
	Speed	Gravitational potential energy
A.	decreases	decreases
B.	decreases	increases
C.	increases	increases
D.	increases	decreases

A satellite orbits a planet. Which graph shows how the kinetic energy E_K, the potential energy E_P and the total energy E of the satellite vary with distance x from the centre of the planet?

A.

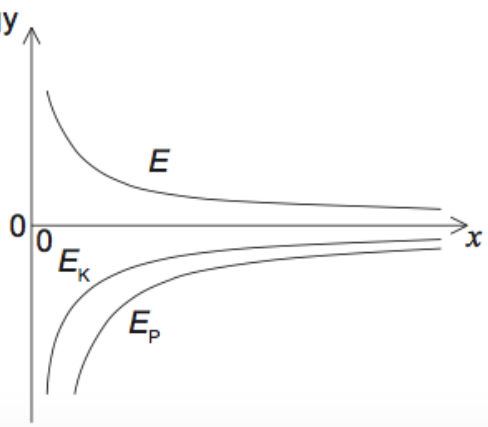


B.

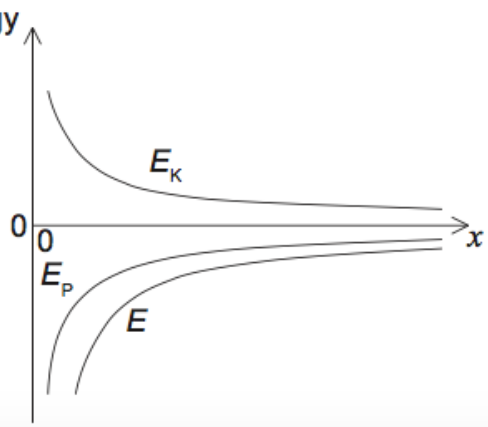


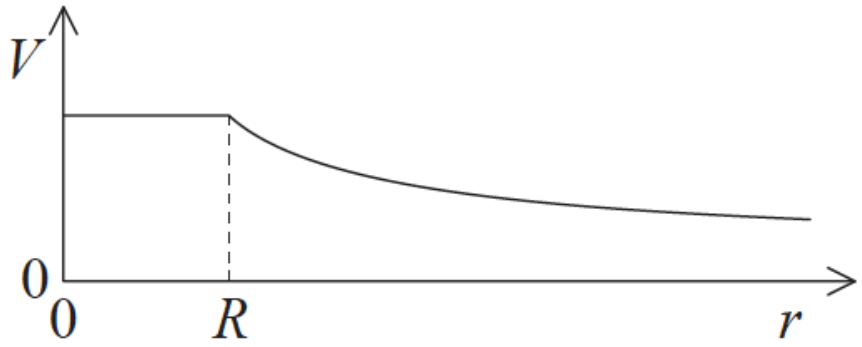
The graph shows the variation with distance r of the electric potential V for a positively charged hollow sphere of radius R.

C.



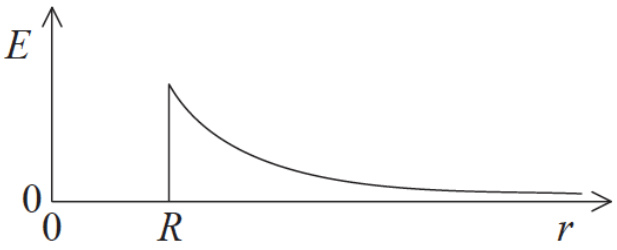
D.



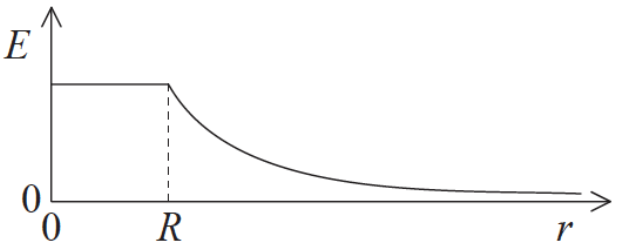


Which graph shows how the magnitude of the electric field E varies with r?

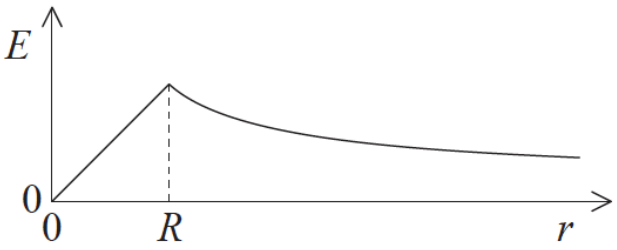
A.



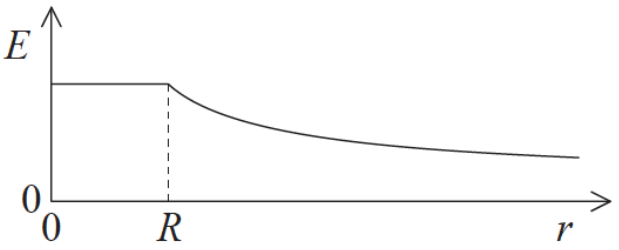
B.



C.

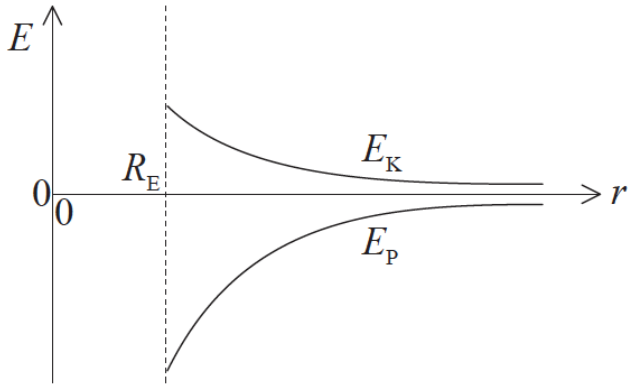


D.

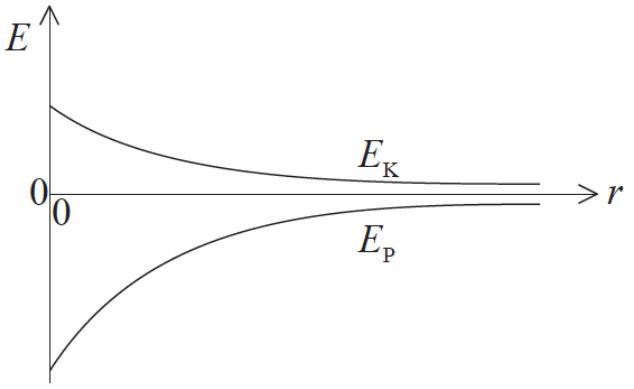


A satellite is in orbit about Earth at a distance r from the centre of Earth. The gravitational potential energy of the satellite is E_P and its kinetic energy is E_K. The radius of Earth is R_E. Which graph shows how both E_P and E_K vary with r?

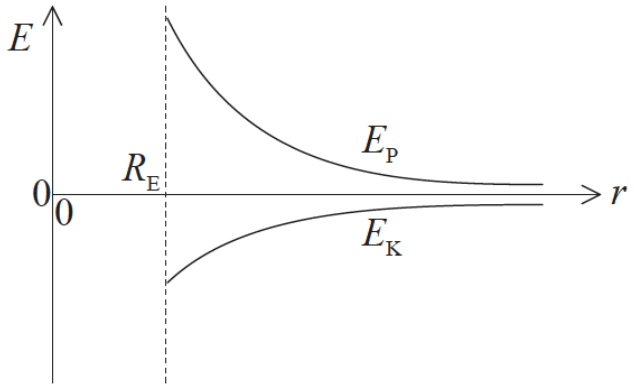
A.



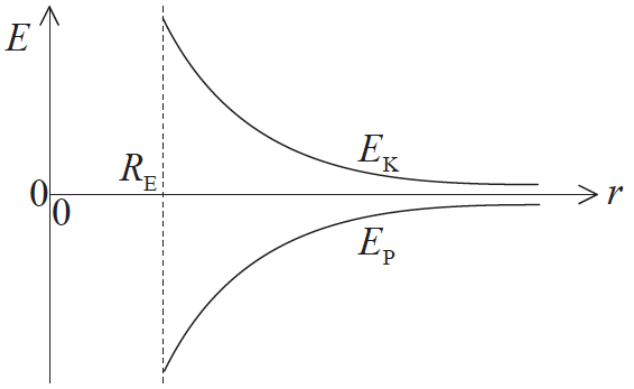
B.



C.



D.

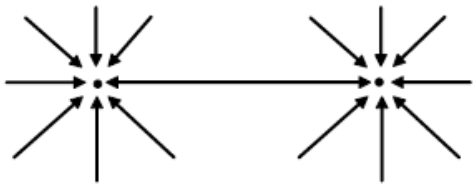


A spacecraft moves from point X to point Y in the gravitational field of Earth. At point X, the gravitational potential is -14MJkg^{-1}. At point Y, the gravitational potential is -2MJkg^{-1}. Which of the following describes the direction of the motion of the spacecraft relative to Earth and the change in gravitational potential?

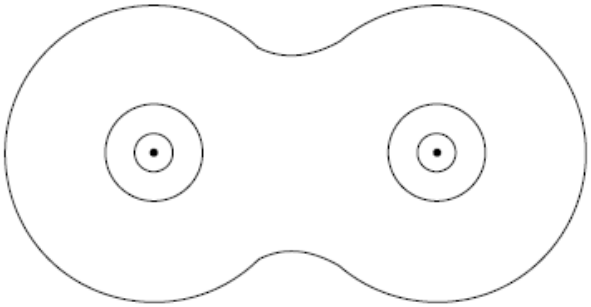
	Direction of Motion	Change in gravitational potential
A.	towards Earth	$+12\,\text{MJ kg}^{-1}$
B.	towards Earth	$-12\,\text{MJ kg}^{-1}$
C.	away from Earth	$+12\,\text{MJ kg}^{-1}$
D.	away from Earth	$-12\,\text{MJ kg}^{-1}$

Which of the diagrams below best represents the equipotential surfaces around two identical point masses?

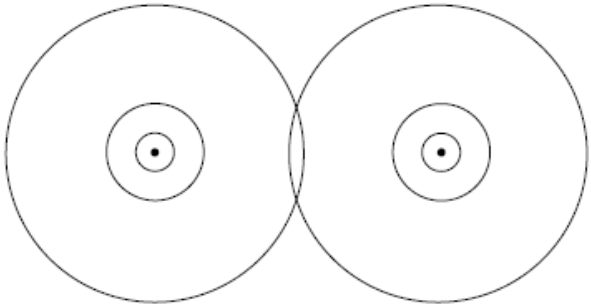
A.



B.



C.



D.