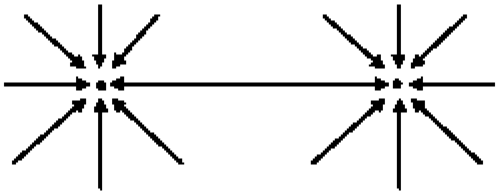
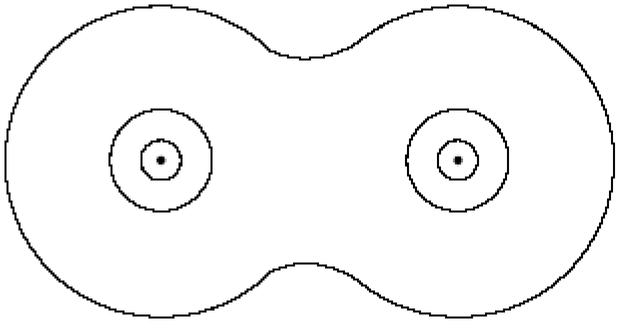
1. Which of the diagrams below best represents the equipotential surfaces around two identical point masses?

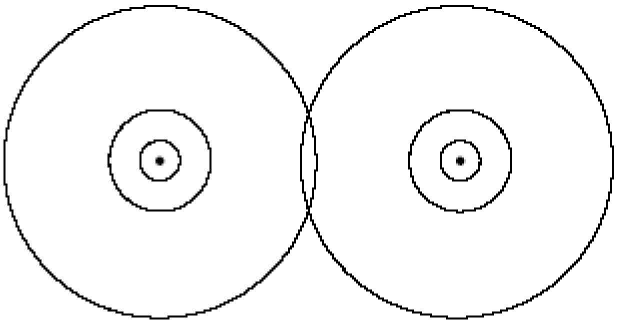
A.



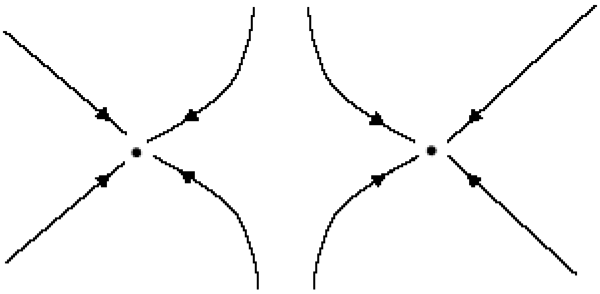
B.



C.



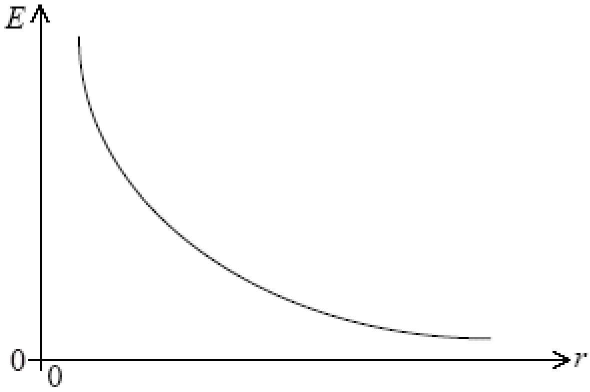
D.



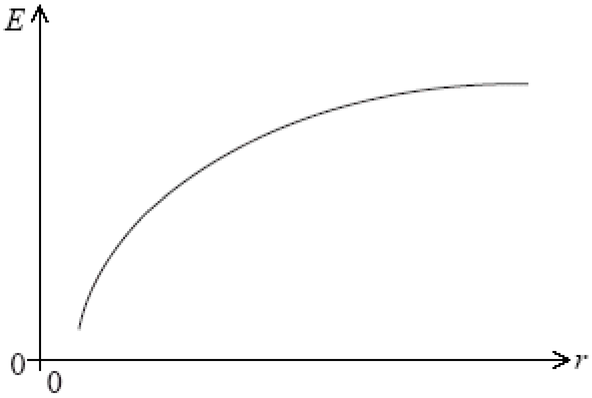
(Total 1 mark)

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

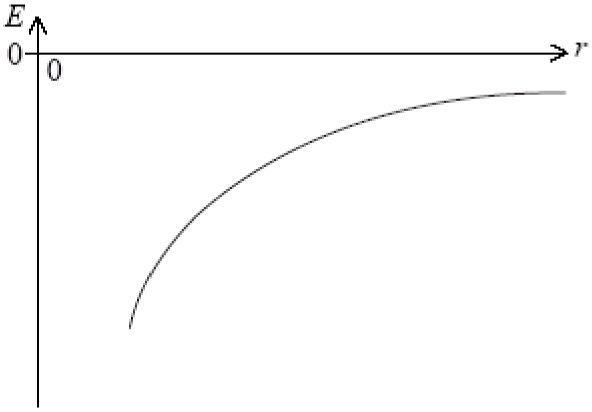
A.



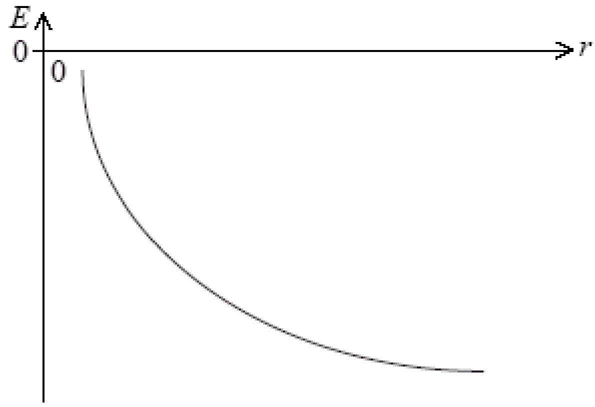
B.



C.



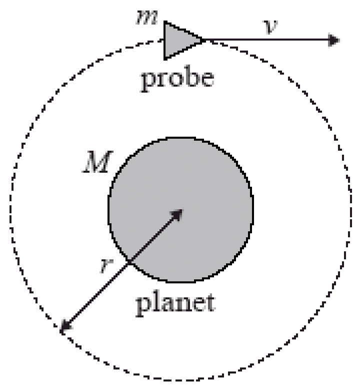
D.



(Total 1 mark)

3. This question is about a probe in orbit.

A probe of mass *m* is in a circular orbit of radius *r* around a spherical planet of mass *M*.



(diagram not to scale)

(a) State why the work done by the gravitational force during one full revolution of the probe is zero.

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(1)

(b) Deduce for the probe in orbit that its

(i) speed is $v = \sqrt{\frac{GM}{r}}$.

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(2)

(ii) total energy is $E = -\frac{GMm}{2r}$.

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(2)

(c) It is now required to place the probe in another circular orbit further away from the planet.
To do this, the probe's engines will be fired for a very short time.

State and explain whether the work done on the probe by the engines is positive, negative **or** zero.

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(2)
(Total 7 marks)

4. A spacecraft moves from point X to point Y in the gravitational field of Earth. At point X, the gravitational potential is -14 MJ kg^{-1}. At point Y, the gravitational potential is -2 MJ kg^{-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	$+12$ MJ kg^{-1}
B.	towards Earth	-12 MJ kg^{-1}
C.	away from Earth	$+12$ MJ kg^{-1}
D.	away from Earth	-12 MJ kg^{-1}

(Total 1 mark)

5. 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 $2r$. 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

(Total 1 mark)

6. This question is about orbital motion.

(a) A satellite, of mass m, is in orbit about Earth at a distance r from the centre of Earth. Deduce that the kinetic energy E_K of the satellite is equal to half the magnitude of the potential energy E_P of the satellite.

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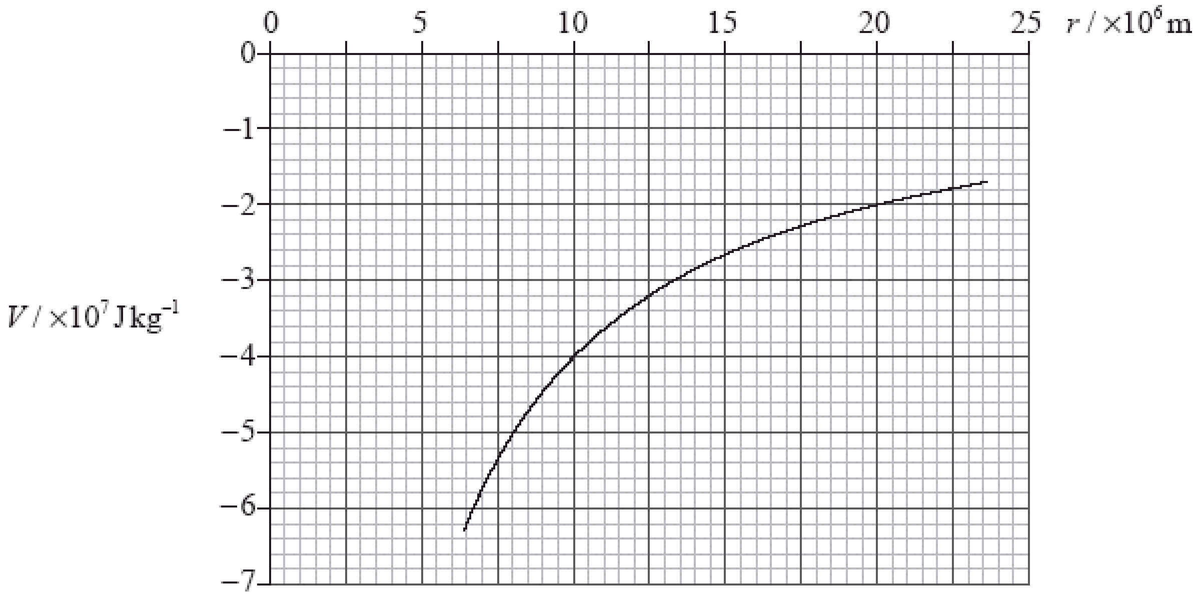
(3)

(b) The graph shows the variation with distance r of the Earth's gravitational potential V. Values of V for $r < R$, where R is the radius of Earth, are not shown.



The satellite in (a) has a mass of 8.2×10^2 kg and it is in orbit at a distance of 1.0×10^7 m from the centre of Earth. Using data from the graph and your answer to (a), calculate for the satellite

(i) its total energy.

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(2)

(ii) its orbital speed.

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(2)

(iii) the energy it must gain to move to an orbit a distance 2.0×10^7 m from the centre of the Earth.

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(2)
(Total 9 marks)

7. 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.

(Total 1 mark)

8. 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.

(Total 1 mark)

9. 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. $\dfrac{GMm}{R}$

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

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

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

(Total 1 mark)

10. This question is about gravitational fields and potential.

(a) Define *gravitational field strength* and state how it is related to gravitational potential.

Definition: ....

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Relationship: ....

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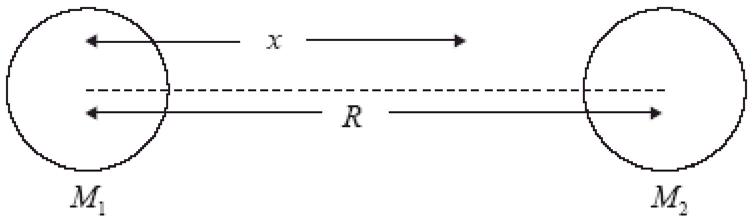
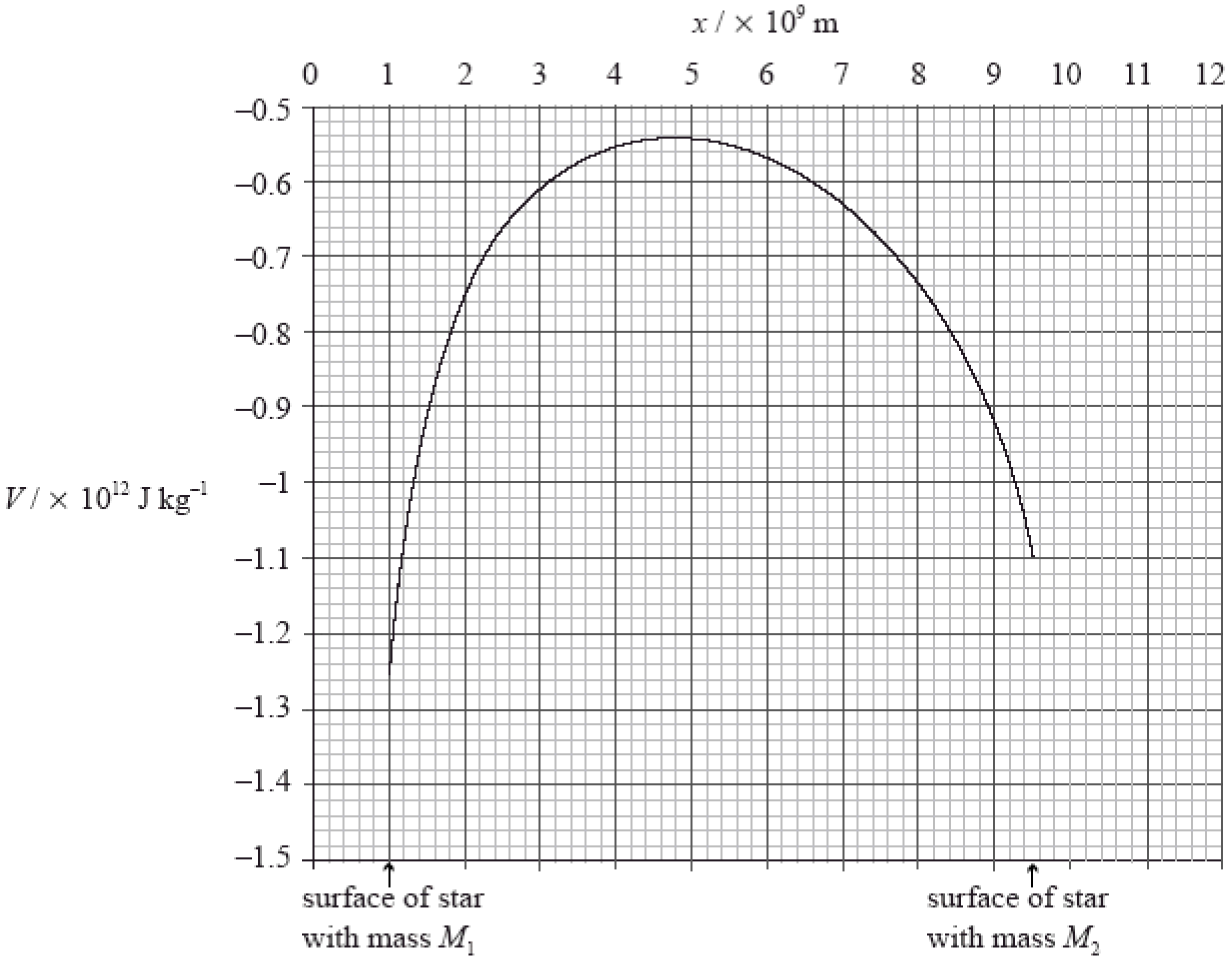
(3)

(b) A binary star system consists of two stars with masses M_1 and M_2 rotating about a common centre. The centres of the two stars are separated by a distance $R = 1.2 \times 10^{10}$ m.

The diagram is not to scale.



The total gravitational potential due to the stars at any point along a line joining their centres is V. The graph shows how V varies with the distance x from the centre of star M_1. (Values of the potential inside each star are not known.)



A particle is launched with kinetic energy E_K from the surface of star with mass M_2. The particle arrives at the surface of the star of mass M_1. Use the graph to

(i) explain whether the kinetic energy of the particle at the surface of M_1 is less than, equal to, **or** larger than E_K.

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(2)

(ii) determine the distance x at which the gravitational field strength due to the two stars is zero.

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(2)

(iii) determine the ratio $\frac{M_1}{M_2}$.

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(3)
(Total 10 marks)

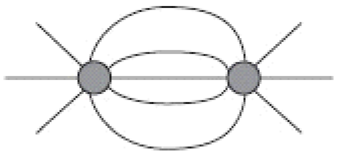
11. A satellite is in orbit about Earth. The satellite moves to an orbit closer to Earth. Which of the following correctly gives the change in the potential energy and the kinetic energy of the satellite?

	change in potential energy	change in kinetic energy
A.	decreases	increases
B.	decreases	decreases
C.	increases	increases
D.	increases	decreases

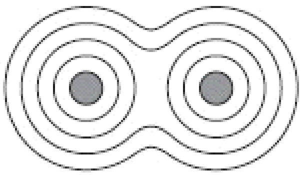
(Total 1 mark)

12. Which of the following diagrams best represents the gravitational equipotential surfaces due to two equal spherical masses?

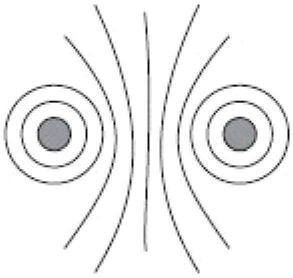
A.



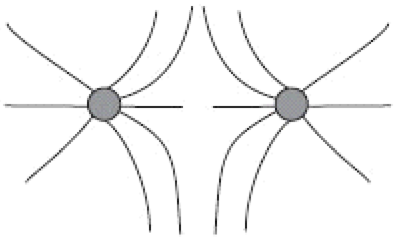
B.



C.



D.



(Total 1 mark)

13. Gravitational potential

(a) Define *gravitational potential* at a point in a gravitational field.

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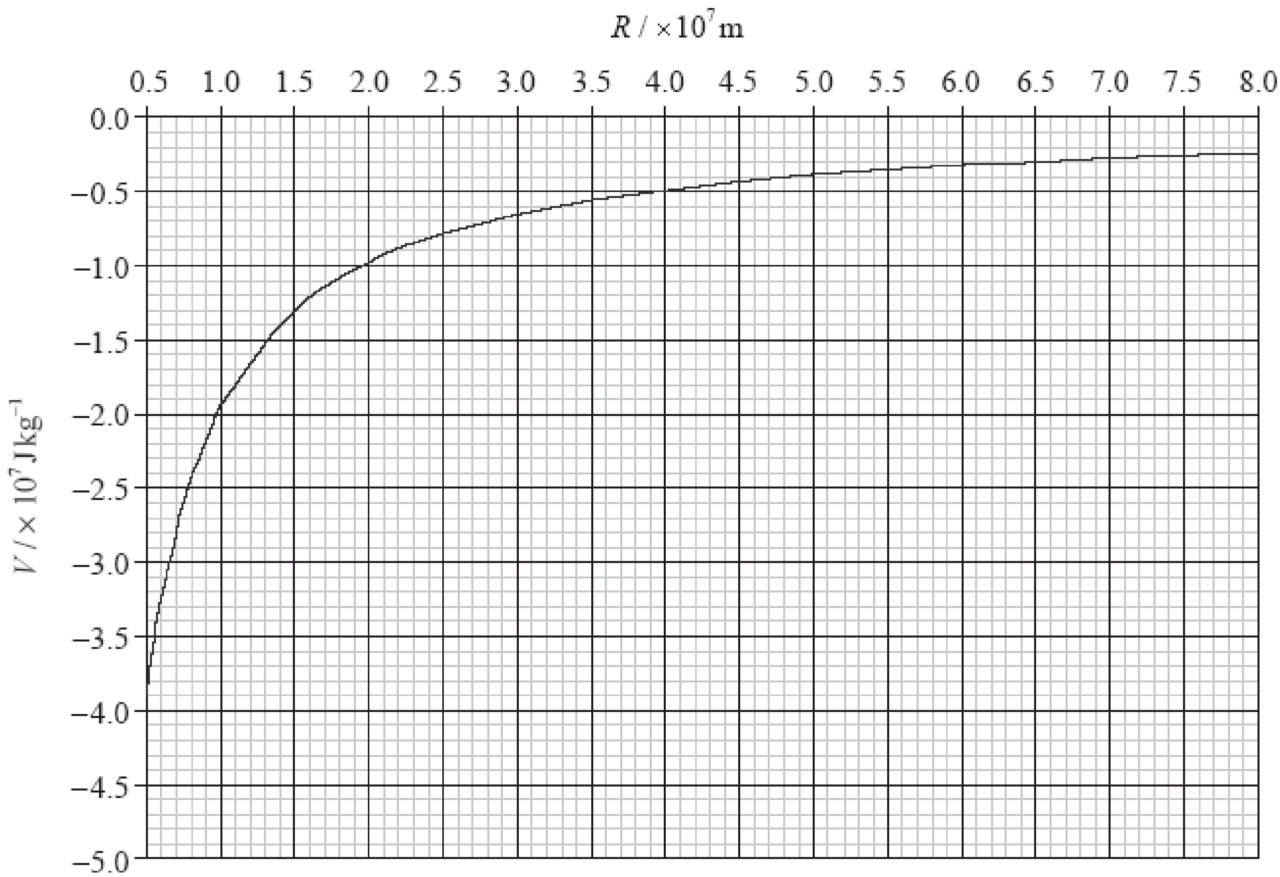
(3)

(b) The graph below shows the variation with distance R from the centre of a planet of the gravitational potential V. The radius R_0 of the planet = 5.0×10^6 m. Values of V are not shown for $R < R_0$.



Use the graph to determine the magnitude of the gravitational field strength at the surface of the planet.

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(3)

(c) A satellite of mass 3.2×10^3 kg is launched from the surface of the planet. Use the graph to determine the minimum launch speed that the satellite must have in order to reach a height of 2.0×10^7 m above the surface of the planet. (You may assume that it reaches its maximum speed immediately after launch.)

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(4)

(Total 10 marks)