

1

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 MJ kg^{-1} .

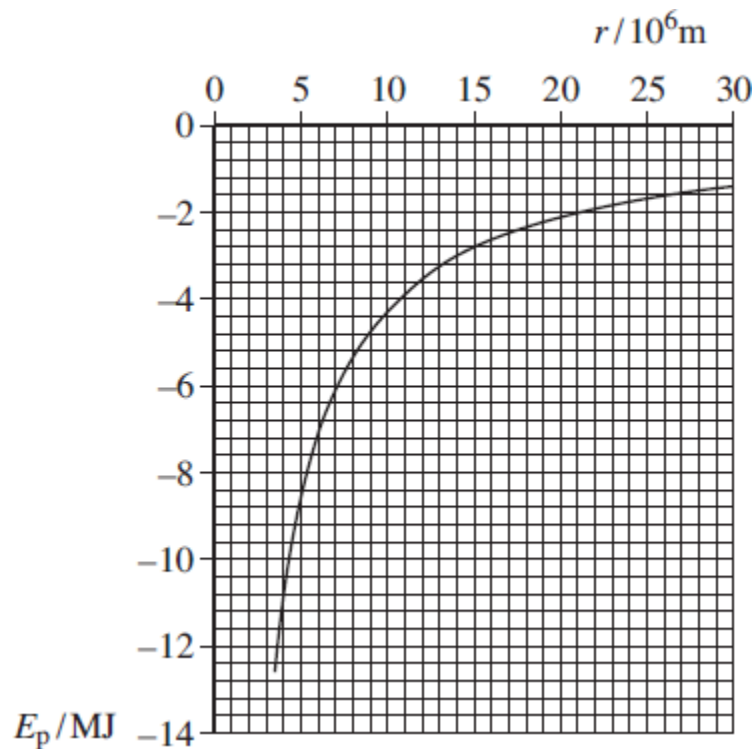
What is the approximate value of the gravitational potential at the surface of Mars?

- A -13 MJ kg^{-1}
- B -25 MJ kg^{-1}
- C -95 MJ kg^{-1}
- D -320 MJ kg^{-1}

(Total 1 mark)

2

The graph below shows how the gravitational potential energy, E_p , of a 1.0 kg mass varies with distance, r , from the centre of Mars. The graph is plotted for positions above the surface of Mars.



(a) Explain why the values of E_p are negative.

(2)

- (b) Use data from the graph to determine the mass of Mars.

mass of Mars _____ kg

(3)

- (c) Calculate the escape velocity for an object on the surface of Mars.

escape velocity _____ m s⁻¹

(3)

- (d) Show that the graph data agree with $E_p \propto \frac{1}{r}$

(3)

(Total 11 marks)

3

The gravitational potential at the surface of the Earth, of radius R , is V . What is the gravitational potential at a point at a height R above the Earth's surface?

A $\frac{V}{4}$

B $\frac{V}{2}$

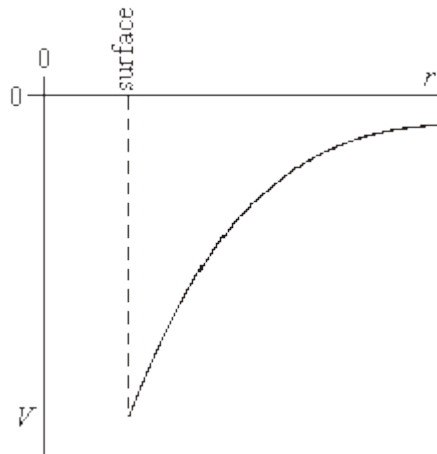
C V

D $2V$

(Total 1 mark)

4

The graph shows how the gravitational potential, V , varies with the distance, r , from the centre of the Earth.



What does the gradient of the graph at any point represent?

A the magnitude of the gravitational field strength at that point

B the magnitude of the gravitational constant

C the mass of the Earth

D the potential energy at the point where the gradient is measured

(Total 1 mark)

5

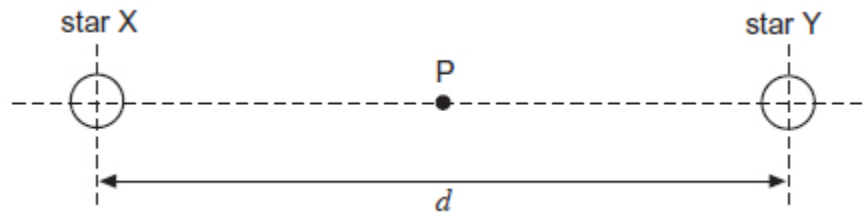
Near the surface of a planet the gravitational field is uniform and for two points, 10 m apart vertically, the gravitational potential difference is 3 J kg^{-1} . How much work must be done in raising a mass of 4 kg vertically through 5 m?

- A 3 J
- B 6 J
- C 12 J
- D 15 J

(Total 1 mark)

6

X and Y are two stars of equal mass M . The distance between their centres is d .



What is the gravitational potential at the mid-point P between them?

- A $\frac{GM}{2d}$
- B $-\frac{GM}{d}$
- C $-\frac{4GM}{d}$
- D $-\frac{8GM}{d}$

(Total 1 mark)

7

A mass of 5 kg is moved in a gravitational field from a point X at which the gravitational potential is -20 J kg^{-1} to a point Y where it is -10 J kg^{-1} . The change in potential energy of the mass, in J, between X and Y is

- A -50
- B -10
- C +10
- D +50

(Total 1 mark)

1 A

[1]

(a) zero potential at infinity (a long way away)

- energy input needed to move to infinity (from the point)
- work done by the field moving object from infinity
- potential energy falls as object moves from infinity

2

(b) Any pair of coordinates read correctly

$\pm 1/2$ square

Use of E_p or $V = (-)\frac{GM}{r}$

Rearrange for M

$$6.4 (\pm 0.5) \times 10^{23} \text{ kg}$$

3

(c) Reads correct potential at surface of Mars = -12.6 (MJ)

or reads radius of mars correctly (3.5×10^6)

equates to $\frac{1}{2} v^2$ (condone power of 10 in MJ)

use of $v = \sqrt{2GM/r}$ with wrong radius

$5000 \pm 20 \text{ m s}^{-1}$ (condone 1sf e.g. 5 km s^{-1})

e.c.f. value of M from (b) may be outside range for other method 6.2
 $\times 10^{-9} \times \text{their } M$

(d) Attempts 1 calculation of Vr

B1

Many values give 4.2.... so allow mark is for reading and using correct coordinates but allow minor differences in readings
Ignore powers of 10 but consistent

Two correct calculation of Vr

B1

Three correct calculations with conclusion

B1

3

[11]

3 B

[1]

4 A

[1]

5 B

[1]

6 C

[1]

7 D

[1]