AQA – Gravitational fields – A2 Physics P2

1. June/2021/Paper_7408_2/No.02

0 2 The Global Positioning System (GPS) uses satellites to support navigation on Earth.

0 2 . 1 One GPS satellite is in a circular orbit at a height h above the surface of the Earth. The Earth has mass M and radius R.

Show that the angular speed ω of the satellite is given by

$$\omega = \sqrt{\frac{GM}{(R+h)^3}}$$

[2 marks]

0 2 . 2 Calculate the orbital period of the satellite when h equals 2.02×10^7 m.

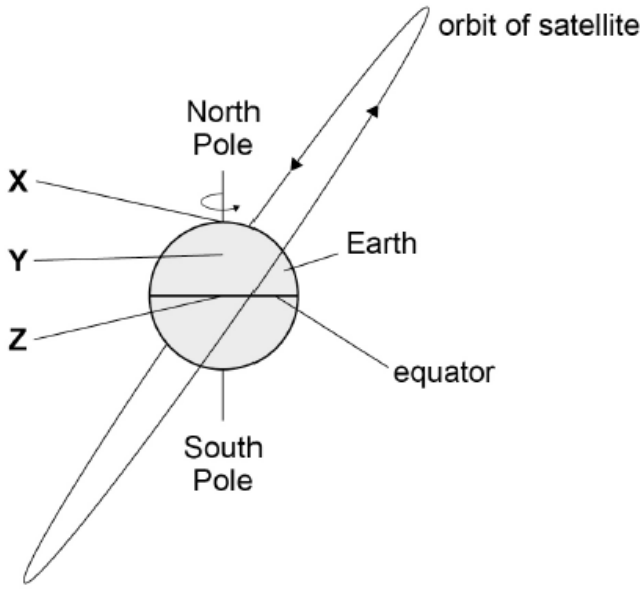
[2 marks]

orbital period = _____ s

0 2 . 3 **Figure 3** shows the orbital plane of the satellite inclined at an angle to the equator. **X**, **Y** and **Z** are locations on the Earth.

X is at the North Pole, **Y** is on a high mountain and **Z** is on the equator.

Figure 3



The satellite is to be launched from one of the locations.

State and explain which launch site **X**, **Y** or **Z** minimises the amount of fuel required to send the satellite into its orbit.

[2 marks]

0 2 . 4 The satellite has a mass of 1630 kg.

Calculate the gravitational potential energy of the satellite when in the orbit in Question **02.2**.

[2 marks]

gravitational potential energy = _____ J

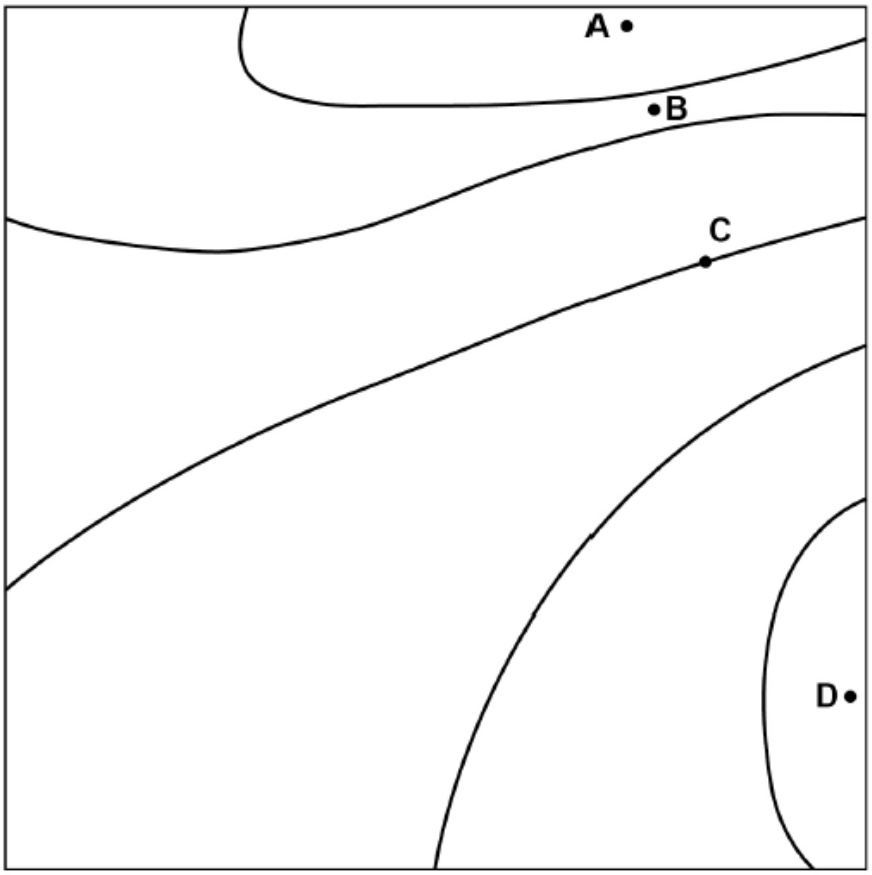
0 2 . 5 A different satellite is in a higher circular orbit.

Explain how the linear speed of this satellite compares with the linear speed of the satellite in Question **02.1**.

[2 marks]

2. June/2021/Paper_7408_2/No.11

The diagram shows gravitational equipotentials. Adjacent equipotentials are separated by an equal gravitational potential difference V.



Which point has the greatest gravitational field strength?

[1 mark]

A ⬭

B ⬭

C ⬭

D ⬭

3. June/2021/Paper_7408_2/No.12

A planet has radius R and density ρ. The gravitational field strength at the surface is g.

What is the gravitational field strength at the surface of a planet of radius $2R$ and density 2ρ?

[1 mark]

A $2g$ ⬭

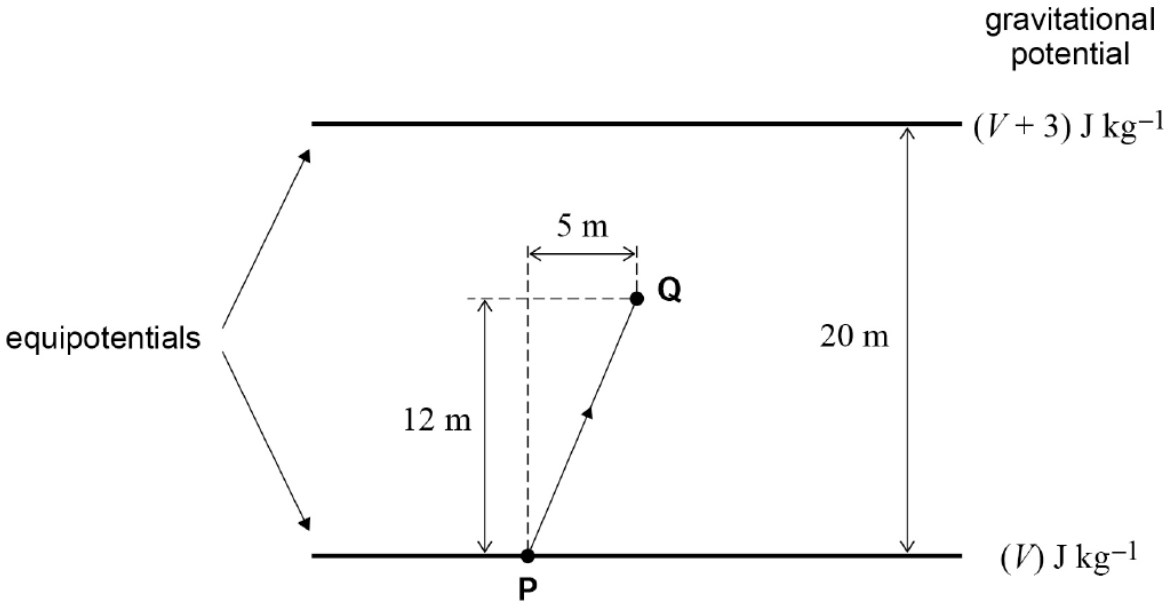
B $4g$ ⬭

C $8g$ ⬭

D $16g$ ⬭

4. June/2021/Paper_7408_2/No.13

The diagram shows equipotential lines for a uniform gravitational field. The lines are separated by 20 m.



An object of mass 4 kg is moved from **P** to **Q**.

What is the work done against gravity to move the object?

[1 mark]

A 7.2 J ⬭

B 7.8 J ⬭

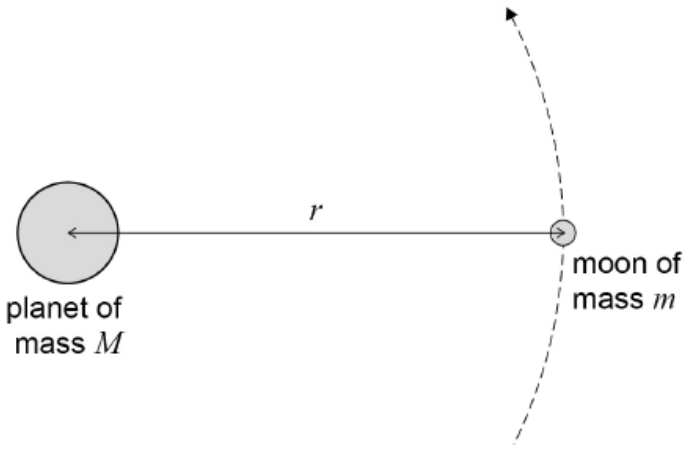
C 10.2 J ⬭

D 36 J ⬭

5. June/2020/Paper_7408_2/No.02

0 2 **Figure 2** shows a moon of mass m in a circular orbit of radius r around a planet of mass M, where $m << M$.

Figure 2



The moon has an orbital period T.
T is related to r by

$$T^2 = kr^3$$

where k is a constant for this planet.

0 2 . 1 Show that $k = \dfrac{4\pi^2}{GM}$

[3 marks]

Table 2 gives data for two of the moons of the planet Uranus.

Table 2

Name	T / days	r / m
Miranda	1.41	1.29×10^8
Umbriel	4.14	**X**

0 2 . 2 Calculate the orbital radius **X** of Umbriel.

[2 marks]

orbital radius = _____ m

0 2 . 3 Calculate the mass of Uranus.

[3 marks]

mass = _____ kg

Table 3 gives data for three more moons of Uranus.

Table 3

Name	Mass / kg	Diameter / m
Ariel	1.27×10^{21}	1.16×10^{6}
Oberon	3.03×10^{21}	1.52×10^{6}
Titania	3.49×10^{21}	1.58×10^{6}

0 2 . 4 Deduce which moon in **Table 3** has the greatest escape velocity for an object on its surface.
Assume the effect of Uranus is negligible.

[3 marks]

0 2 . 5 A spring mechanism can project an object vertically to a maximum height of $1.0\ \text{m}$ from the surface of the Earth.

Determine whether the same mechanism could project the same object vertically to a maximum height greater than $100\ \text{m}$ when placed on the surface of Ariel.

[3 marks]

6. June/2020/Paper_7408_2/No.13

What is the angular speed of a satellite in a geostationary orbit around the Earth?

[1 mark]

A $1.2 \times 10^{-5}\ \text{rad s}^{-1}$ ⬭

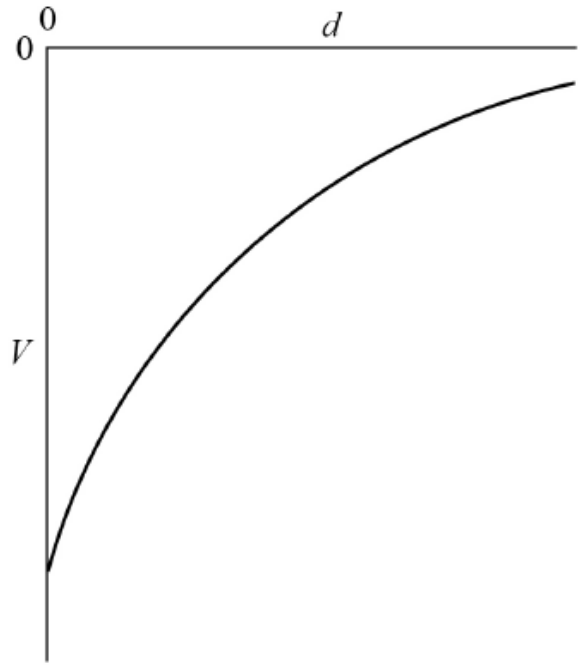
B $7.3 \times 10^{-5}\ \text{rad s}^{-1}$ ⬭

C $4.4 \times 10^{-3}\ \text{rad s}^{-1}$ ⬭

D $2.6 \times 10^{-1}\ \text{rad s}^{-1}$ ⬭

7. June/2020/Paper_7408_2/No.12

The graph shows how the gravitational potential V varies with the vertical distance d from the surface of the Earth.



What does the gradient of the graph represent at the surface of the Earth?

[1 mark]

A potential energy ⬭

B mass of the Earth ⬭

C magnitude of the gravitational constant ⬭

D magnitude of the gravitational field strength ⬭