

Gravitational force, potential and satellite orbits

Physics grades 11-12 (A Level · IB · Class 11-12) · Test

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

This test lasts 45 minutes and is worth 20 marks. Calculators are allowed. Use $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ and give final answers with units and sensible significant figures. Measure all distances from the centre of the planet.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB D.1

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

Question 1 Field strength definition (2 marks)

Define gravitational field strength and state its direction.

Question 2 Mars (3 marks)

Mars has mass $6.42 \times 10^{23} \text{ kg}$ and radius $3.39 \times 10^6 \text{ m}$. Use $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$.

- Calculate the field strength at its surface. (2 marks)
- Calculate the weight of a 70 kg person on Mars. (1 mark)

Question 3 Satellite orbit (3 marks)

A satellite orbits the Earth at radius $7.2 \times 10^6 \text{ m}$. Use $G M = 3.98 \times 10^{14} \text{ m}^3/\text{s}^2$.

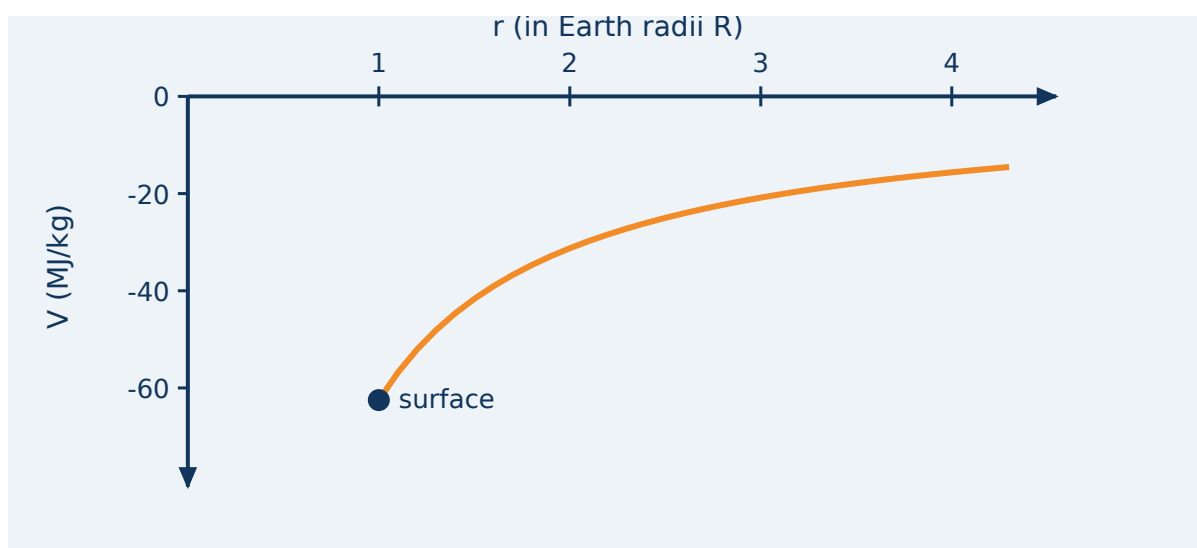
- Calculate its orbital speed. (2 marks)
- Calculate its period in hours. (1 mark)

Question 4 Kepler's third law (3 marks)

- State Kepler's third law. (1 mark)
- Planet A orbits a star at a distance of $1.0 \times 10^{11} \text{ m}$ with a period of 200 days. Planet B orbits the same star at $4.0 \times 10^{11} \text{ m}$. Calculate the period of planet B. (2 marks)

Question 5 Potential graph (3 marks)

The graph shows the potential V of the Earth.



Gravitational potential of the Earth ($V = -GM/r$).

- Calculate V at the surface using $G M = 3.98 \times 10^{14} \text{ m}^3/\text{s}^2$ and $R = 6.37 \times 10^6 \text{ m}$. (1 mark)
- Use the graph to find the energy needed to lift 1.0 kg from the surface to $r = 2R$. (2 marks)

Question 6 Escape speed of Venus (3 marks)

Venus has mass $4.87 \times 10^{24} \text{ kg}$ and radius $6.05 \times 10^6 \text{ m}$.

- Calculate the escape speed. (2 marks)
- Explain why the escape speed does not depend on the mass of the rocket. (1 mark)

Question 7 Weightlessness (2 marks)

Explain why astronauts in a spacecraft orbiting the Earth feel weightless although gravity still acts on them.

Question 8 Negative potential (1 mark)

State why gravitational potential is negative at a finite distance from a planet.