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WORKSHEETS
ATTEMPT | CHECK | CORRECT | IMPROVE

OCR A A Level Gravitational Fields 1 worksheet

35–40 minutes independent practice + 15–20 minutes review | 37 marks

Specification points covered

- 5.4.1(a) State what is meant by a gravitational field and represent it using field lines.
- 5.4.1(b) Model the field of a spherical mass as though the mass were concentrated at its centre.
- 5.4.1(c) Sketch and interpret gravitational field lines around one mass and between two masses.
- 5.4.1(d–e) Use $g = F/m$ and recognise that a gravitational field exerts a force on a mass.
- 5.4.2(a) Use $F = GMm/r^2$ for two point masses.
- 5.4.2(b–c) Use $g = GM/r^2$ and apply the uniform-field approximation close to Earth's surface.

Helios binary-asteroid survey

A science team will map the field around two nearly spherical asteroids before flying a survey craft through the region. Model each asteroid as a point mass at its centre when the craft is outside it.
Asteroid A: mass 6.00×10^{12} kg; radius 1.50 km. Asteroid B: mass 1.50×10^{12} kg; radius 0.800 km. Their centres are 8.00 km apart.
Take $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}. For Question 11, take Earth's mass as 5.97×10^{24} kg and Earth's radius as 6.37×10^{6} m.

1. Mapping a gravitational field

1. State what is meant by a gravitational field. State what the direction of an arrow on a gravitational field line represents. [2 marks]

2. Figure 1 shows the binary asteroid pair. On the figure, draw a possible pattern of gravitational field lines for the region. Include arrowheads and use more field lines terminating on A than on B. State what a closer spacing of field lines represents. [4 marks]

Figure 1: plan view of the binary asteroid pair; A is the larger primary asteroid

3. Outside each asteroid, the team models it as a point mass at its centre. Explain why this is a suitable model for this calculation. Explain why the separation in $F = GMm/r^2$ is measured from centre to centre, rather than from surface to surface. [3 marks]

4. Write the equation linking gravitational field strength g, force F and mass m. State the SI unit of gravitational field strength. [2 marks]

2. Field strength and gravitational force

5. Calculate the gravitational field strength at the surface of asteroid A. [3 marks]

6. A calibration sensor of mass 280 kg rests at the surface of A. Calculate the magnitude of the gravitational force acting on it. [2 marks]

7. Calculate the magnitude of the gravitational force between asteroids A and B. State the direction of the force on A due to B. [3 marks]

8. A 1.00 kg test mass is 3.00 km from the centre of A, where the field strength due to A is 4.45×10^{-5} N kg^{-1}. State the magnitude and direction of the gravitational force on the test mass. [2 marks]

3. The inverse-square field around asteroid A

9. Table 1 gives field strengths due to A at several distances from its centre. (a) Calculate the missing value. (b) Use the values at 1.50 km and 3.00 km to show that the data are consistent with an inverse-square relationship. (c) Use field-line language to explain why the field strength decreases with distance. [5 marks]

Table 1: gravitational field strength due to asteroid A

Distance from A's centre / km	1.50	3.00	4.50	6.00
g due to A / 10^{-5} N kg^{-1}	17.8	4.45		1.11

10. At 3.00 km from the centre of A, g = 4.45 × 10^{-5} N kg^{-1}. At what distance from the centre will g = 1.11 × 10^{-5} N kg^{-1}? Show your reasoning. [2 marks]

4. Comparing a local and a large-scale field

11. A separate Earth-orbiting instrument is 4.00 × 10^{5} m above Earth's surface. Calculate the gravitational field strength there. Explain why a laboratory calculation involving a vertical displacement of 2.0 m can treat Earth's field as uniform. [4 marks]

5. A constrained survey route

12. For a low-altitude survey pass, a 750 kg craft must experience a force due to A below 0.020 N and remain no more than 5.00 km from A's centre. Table 2 gives primary-field data; ignore the field due to B for this route choice. Select the suitable station and justify your choice with calculations and the distance condition. State one limitation of this simplified route model. [5 marks]

Table 2: primary-field data provided for the route choice

Station	Distance from A's centre / km	g due to A / N kg^{-1}
P	3.00	4.45 × 10^{-5}
Q	4.50	1.98 × 10^{-5}
R	6.00	1.11 × 10^{-5}

Review and improve

□ I say that a field is a region where a mass experiences a force.
□ I give a quantity a direction where the question asks for one.