Homework — Part 1: Review of the lesson

6 problems. Solve them in your notebook. Show every step: formula → numbers → answer with unit.

Key formulas (all in the data booklet)
$F = \frac{GMm}{r^2}$ $g = \frac{F}{m}$ $g = \frac{GM}{r^2}$ $r = R + h$ (distance from the **centre**)
$G = 6.67 \times 10^{-11}\ \text{N m}^2\,\text{kg}^{-2}$, $M_E = 5.97 \times 10^{24}\ \text{kg}$, $R_E = 6.37 \times 10^{6}\ \text{m}$

Level 1 — Basic

1. An astronaut of mass 70 kg stands on the Moon. Mass of the Moon $= 7.35 \times 10^{22}$ kg, radius of the Moon $= 1.74 \times 10^{6}$ m.

(a) **Calculate** the gravitational field strength on the surface of the Moon. **[2]**

(b) **Calculate** the weight of the astronaut on the Moon. **[1]**

2. Two metal spheres have masses 5.0 kg and 0.50 kg. The distance between their centres is 8.0 cm.

Calculate the gravitational force between the spheres. (Hint: change cm to m first.) **[2]**

Level 2 — Intermediate

3. A satellite of mass 450 kg orbits the Earth at a height of 2000 km above the Earth's surface.

(a) **Calculate** the gravitational field strength at the height of the satellite. **[3]**

(b) **Calculate** the gravitational force on the satellite. **[1]**

4. On the Earth's surface $g = 9.81\ \text{N kg}^{-1}$.

Determine the height above the Earth's surface where $g = 4.9\ \text{N kg}^{-1}$ (about half). **[3]**

Level 3 — Exam-style

5. Paper 1A

A planet has radius R. At a distance $3R$ from the centre of the planet, the gravitational field strength is $1.2\ \text{N kg}^{-1}$. What is the gravitational field strength at the surface of the planet?

A. 0.13 N kg^{-1} B. 3.6 N kg^{-1} C. 4.8 N kg^{-1} D. 10.8 N kg^{-1}

[1]

6. Paper 2

The gravitational field strength at the surface of Mars is $3.7\ \text{N kg}^{-1}$. The radius of Mars is 3.39×10^6 m.

(a) **State** what is meant by *gravitational field strength*. [1]

(b) **Show that** the mass of Mars is about 6.4×10^{23} kg. [2]

(c) A space lander of mass 600 kg is on the surface of Mars. **Calculate** its weight. [1]

(d) The moon Phobos is 9.38×10^6 m from the centre of Mars. **Determine** the gravitational field strength of Mars at this distance. [2]

(e) **Outline** why the gravitational field above a small area of the surface of Mars can be treated as uniform. [1]

Answers (short)

1	(a) 1.62 N kg^{-1} (b) 113 N
2	2.6×10^{-8} N
3	(a) 5.68 N kg^{-1} ($r = 8.37 \times 10^{6}$ m) (b) 2.56×10^{3} N
4	$h \approx 2.6 \times 10^{6}$ m (about 2600 km)
5	D
6	(a) force per unit mass on a small test mass (b) $M = 6.37 \times 10^{23}$ kg (c) 2220 N (2.2×10^{3} N) (d) 0.48 N kg^{-1} (e) field lines are almost parallel and equally spaced there