

15/19

F5 Newtonian Gravity**Fields**

F5.1 Complete the questions in the table; you may assume that all measurements are made above the surface of the astronomical body:

Mass of body /kg	Distance from centre of body	Gravitational field strength at this distance /N kg ⁻¹
(a)	6400 km = Earth radius	9.8
Earth mass	2 × Earth radius	(b)
4.8×10^8 (asteroid)	6100 km	(c)
(d)	3.2×10^6 m	4.0

F5.2 Calculate the force of attraction between two metal spheres each of mass 20 kg whose centres are 20 cm apart.

- F5.3
- At a distance of 1.0×10^7 m from the centre of planet Mogg, the gravitational field strength (g) due to Mogg is 2.1 N kg^{-1} . Calculate g at a distance of 5.0×10^7 m.
 - The planet Mogg is completely spherical, with radius 2.3×10^6 m. Calculate g at a height of 100 km above the surface of the planet. Use the information given in (a).
 - Using the information in (a) and (b), calculate the gravitational field strength due to planet Mogg at a distance of 3.0×10^6 m from the centre.

Potential

F5.4 For a planet of mass 6.0×10^{24} kg, calculate the following:

- The gravitational potential in J kg^{-1} at a distance 6.4×10^6 m from the centre of the planet
- The distance from the centre of the planet where the gravitational potential is $-1.1 \times 10^6 \text{ J kg}^{-1}$

F5.5 For a planet of mass 1.0×10^{24} kg, calculate the gravitational potential, in J kg^{-1} , at the following distances from the centre of the planet:

- a) (i) 2.0×10^7 m (ii) 4.0×10^7 m
- b) Calculate the gravitational potential energy of a 200 kg satellite at the point mentioned in (a)(ii).
- F5.6 a) Calculate the mass of a star which gives a gravitational potential of $-8.9 \times 10^8 \text{ J kg}^{-1}$ at a distance 1.5×10^{11} m from it.
- b) Calculate the gravitational potential energy of a 6.8×10^{24} kg planet at this point.
- F5.7 The gravitational potential at the surface of a moon is -2.8 MJ kg^{-1} , and its radius is 1700 km.
- a) Calculate the potential at a point 3400 km *above the surface* of the moon.
- b) Calculate the height *above the surface* of a point with potential -1.2 MJ/kg .
- F5.8 A 2.400×10^{22} kg moon orbits a 7.200×10^{24} kg planet with an orbital radius of 2.500×10^8 m.
- a) Calculate the gravitational potential at the point half way between the centres of the planet and its moon. [For this question and part (b), take the universal gravitational constant to be $G = 6.674 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$.]
- b) Calculate the gravitational potential at a point 6.800×10^8 m from the centre of the planet and on the same side of the planet as its moon.
- F5.9 Calculate the escape velocity from the surface of the Earth. The Earth's radius is 6400 km, and its mass was calculated in F5.1(a).
- F5.10 Calculate the minimum velocity which a space probe needs to be given to escape from the gravitational field of a star if it starts 1.5×10^{11} m from the centre of the star. The mass of the star is 3.3×10^{30} kg.