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 a) 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.

b) 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).

c) 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:

a) The gravitational potential in J kg^{-1} at a distance 6.4×10^6 m from the centre of the planet

b) The distance from the centre of the planet where the gravitational potential is -1.1×10^6 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 -8.9×10^8 J kg^{-1} 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 $G = 6.674 \times 10^{-11}$ N m^2 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.