Escape Velocity I

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Take $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}, where necessary.

1. (a) What is the minimum gravitational potential energy which an object of mass m needs to gain if it is to completely escape the gravitational field of a planet whose mass is M and radius is R.

   (b) Equate this to the kinetic energy required to show that the minimum velocity needed is

   $$v_e = \sqrt{\frac{2GM}{R}}$$

   (c) Show how this can be re-written as

   $$v_e = \sqrt{2g_s R},$$

   Where g_s is the surface gravitational field strength.

2. A rocket of mass 5.0×10^5 kg is standing on the surface of a planet whose mass is 6.6×10^{23} kg and radius is 3.4×10^6 m. If the rocket is to leave the gravitational field of the planet and all the kinetic energy is supplied in a single thrust, calculate:

   (a) the surface gravitational potential of the planet,

   (b) the minimum initial kinetic energy of the rocket,

   (c) the minimum velocity at which the rocket must be projected.

3. A neutron star has a mass of 5.0×10^{29} kg and radius of 12 km. Calculate

   (a) the density of the neutron star,

   (b) the size of the gravitational field strength at its surface,

   (c) the size of the gravitational potential at its surface,

   (d) the impact velocity of a meteorite on its surface, assuming that it was at rest at the extreme limit of the star's gravitational field.

4. The sun has a mass of 2×10^{30} kg. If the sun were to turn into a black hole (where the escape velocity is 3.0×10^8 m s^{-1}), calculate the radius the sun would have.