Gravitational Force, Potential Energy, and Potential Worksheet

1. What is the speed of a satellite that orbits the earth at a height of 500 km? How long does it take to go around the earth once?

2. A satellite that always looks down at the same spot on the earth's surface is called a geosynchronous satellite. Find the distance of this satellite from the surface of the earth.

3. What is the gravitational potential energy stored in the gravitational field between the earth and the moon?

4. What is the earth's gravitational potential at the position of the moon? (Orbital radius of the moon = 3.84×10^8 m)

5. What is the gravitational potential energy of a 500 kg satellite placed at a distance from the earth center equal to 5 earth radii? What is the gravitational potential at that distance?

6. Prove that the total energy of the earth (mass m) as it orbits the sun (mass M) is $E = -\frac{1}{2}mv^2$ or $E = -\frac{GMm}{2r}$, where r is the radius of the earth's circular orbit.

7. Show that the escape speed from the surface of a planet of radius R can be written as $v_{esc} = \sqrt{2gR}$, where g is the gravitational field strength on the planet's surface.

8. Consider two particles of mass m and 16m separated by a distance d.
   (a) Deduce that at point P, a distance $\frac{d}{5}$ from the particle with mass m, the gravitational field strength is zero.
   (b) Determine the gravitational potential at P.

9. Deduce that a satellite orbiting a planet of mass M in a circular orbit of radius r has a period of revolution given by $T = \sqrt{\frac{4\pi^2 r^3}{GM}}$.

10. The acceleration of free fall at the surface of a planet is g and the radius of the planet is R. Deduce that the period of a satellite in a very low orbit $(\approx R)$ is given by $T = 2\pi\sqrt{\frac{R}{g}}$.

Numerical Answers

1. 7.61×10^3 ms^{-1}; 5680 s (94.6 min)
2. 3.59×10^7 m
3. -7.63×10^{28} J
4. -1.04×10^6 Jkg^{-1}
5. -6.25×10^9 J; -1.25×10^7Jkg^{-1}
8. (b) $V = -\dfrac{25Gm}{d}$