# *Gravitational Force and Field*

1. Use Newton's Law of Gravitation to calculate the gravitational force on a 75 kg person on the surface of:
   a) Earth
   b) the Earth's Moon
   c) Mars

2. Sketch the following gravitational graphs:
   a. Force versus Mass of one of the objects
   b. Force versus the distance between the centers of the masses

3. Describe the physical limitations to the relationships shown in #2.

4. A 100. kg astronaut is standing on the moon with the Earth directly over head. Determine the ratio of the force of the Earth on the astronaut to the force of the moon on the astronaut.

5. The ***gravitation field*** of an object indicates how much the object would pull on one unit of mass when placed in that particular location. We have already used this concept by saying that the **weight = mg**. The **g** stands for the gravitational field strength. Use $F = G\frac{M_1 M_2}{r^2}$ and **weight = mg** to show that g= 9.8 N $kg^{-1}$ at the surface of the Earth.

6. Find g:
   a. on the moon
   b. on Mars
   c. 10 km above the surface of the Earth

7. Sketch the gravitational field that surrounds the Earth.

8. Determine the altitude above the Earth where the gravitational field due to the Earth would be:
   a. one fourth the g on the surface
   b. one half the g on the surface

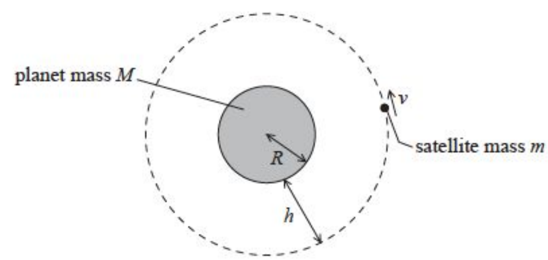
9. The International Space Station orbits at an altitude of approximately 400 km above the surface of the Earth.
   a. Calculate the gravitational field strength at the altitude of the International Space Station.
   b. Are the astronauts on the station weightless?
   c. Calculate the speed of the shuttle in orbit.
   d. Determine the number of orbits the shuttle makes each day.

10. Show that Newton's Law of Gravitation and circular motion lead to Kepler's Third Law of Planetary Motion.

11. Calculate the position between the Earth and the Moon where a satellite would be in gravitational equilibrium.

12. A geosynchronous satellite stays directly above a single point on the Earth. Assume the mass of the satellite is 2500 kg.
    a. Determine the altitude for the satellite.
    b. Calculate the potential energy for the Earth-satellite system.
    c. Calculate the total mechanical energy for the Earth-satellite system.

13. A spherical planet has radius R and mass M. A satellite of mass m orbits the planet with constant linear speed v at a height h above the planet's surface, as shown below (not to scale).




    a. Outline why:
        i. although the satellite is moving at a constant speed, it is not in equilibrium.
        ii. an object on the satellite appears to be weightless.

    b. For the satellite in its orbit,
        i. state an expression, in terms of M, m, R and h, for its potential energy.
        ii. derive an expression, using the same terms as in (b i) for its kinetic energy.

    c. The total energy of the satellite is reduced. Use your expressions in (b) to outline what change, if any, occurs in the radius of the orbit and the speed of the satellite.

    d. The force of friction between the satellite and the atmospheric air increases as the speed of the satellite increases. By reference to your answer in (c), suggest why small satellites will "burn up" as they re-enter the Earth's atmosphere.

14. a. State Newton's universal law of gravitation.

    b. The average distance of Earth from the Sun is $1.5\text{x}10^{11}$ m. The gravitational field strength due to the Sun at the Earth is $6.0\text{x}10^{-3}$ N/kg. Estimate the mass of the Sun.

    c. Deduce that the orbital period *T* of a planet about the Sun is given by the expression $T^2=KR^3$ where *R* is the radius of the orbit and *K* is a constant.