Gravity Near Earth's Surface

Consider a mass m falling near the earth's surface. Find its acceleration g in terms of the Universal Gravitation Constant G.

From the Law of Universal Gravitation

$$F_g = \frac{GM_E m}{r^2}$$

M_E = mass of Earth

r = distance from mass to center of Earth

For a body close to the surface of the earth

$$F_g = mg$$

Thus,

$$mg = \frac{GM_E m}{r^2}$$

$$\boxed{g = \frac{GM_E}{r^2}}$$

For an object near the surface of the earth, it is reasonable to use the approximation $r \cong R_E$ (radius of Earth). Therefore,

$$g = \frac{GM_E}{R_E^2}$$

Note:

1. g is independent of the mass m of the object.

2. g is approximately constant near the surface of the earth.

Example 1
Find g 1000 km above Earth's surface.

Homework
Gravitational Field Strength Worksheet

Gravitational Field Strength Worksheet

1. If the Earth began to shrink but its mass remained the same, predict what would happen to the value of g on Earth's shrinking surface.

2. If Earth were twice as massive but remained the same size, what would happen to the value of g?

3. Jupiter has about 300 times the mass of Earth and about 10 times Earth's radius. Estimate the size of g on the surface of Jupiter. ($29.5\ N/kg$)

4. The planet Jupiter has a mass of $1.9\times10^{27}\ kg$ and a radius of $7.2\times10^{7}\ m$. Calculate the acceleration due to gravity on Jupiter. ($24\ m/s^2$)

5. Find the acceleration of a falling object on Mars, given that the radius of Mars is one-half that of Earth and the mass of Mars is one-eighth that of Earth. ($4.9\ m/s^2$)

6. The planet Saturn has a mass of $5.67\times10^{26}\ kg$ and a radius of $6.3\times10^{7}\ m$. Calculate the acceleration due to gravity on Saturn. How much will the gravitational force be on a $60\ kg$ man there? ($9.5\ m/s^2,\ 5.7\times10^{2}\ N$)

7. What is the acceleration due to gravity on
   a. Venus? ($8.09\ m/s^2$)
   b. Pluto? ($4.4\ m/s^2$)
   c. the moon? ($1.62\ m/s^2$)

8. The asteroid Ceres has a mass of $7.0\times10^{20}\ kg$ and a radius of $500\ km$.
   a. What is g on the surface? ($0.19\ m/s^2$)
   b. How much would an $85\ kg$ astronaut weigh on Ceres? ($16\ N$)