Your Weight on Other Worlds

$$\mathbf{W} = \mathbf{W_E}\left(\frac{\mathbf{M}}{\mathbf{M_E}}\right)\left(\frac{\mathbf{D_E}}{\mathbf{D}}\right)^2$$

where

W	=	your weight on another world
W_E	=	your weight on the Earth
M	=	mass of the other world
M_E	=	mass of the Earth
D_E	=	diameter of the Earth
D	=	diameter of the other world

You may have read that the astronauts who walked on the Moon weighed 1/6 of their weight on Earth. How do they calculate that? Well, the method is shown in the equation listed above.

Your weight on a given planet, satellite, asteroid, etc. depends only on three things: the **mass of the object** you are standing on and its **diameter**, and of course **your weight here on Earth**, which is directly proportional to **your mass**. We are assuming here that the object you are standing on is spherical, which is a reasonable approximation for all but the smallest celestial objects.

In the equation above, you can see that your weight on another planet is proportional to {your weight on Earth} × {the mass of the planet} × {1 / the diameter of the planet}^{2}.

You can use any units you want for mass as long as you express both the mass of the Earth and the mass of the planet in the same units. Usually, we use **kilograms** (**kg**). Since we are dividing the mass of the planet by the mass of the Earth, the units cancel out and we are left with a unitless number that represents the mass of the planet in Earth units. This ratio is the same no matter what units we use.

Likewise, you can use any units you want for diameter as long as you express both the diameter of the Earth and the diameter of the planet in the same units. Usually, we use **kilometers** (**km**). Since we are dividing the diameter of the Earth by the diameter of the planet, the units again cancel out and we are left with a unitless number, and then we square it. The square of a unitless number is also a unitless number. So, the squared ratio is the same no matter what units we use.

Finally, we multiply these two dimensionless numbers times your weight on Earth in whatever units you prefer (usually **pounds** (**lbs**) in the U.S. and **kilograms** (**kg**) elsewhere), and since the other numbers are dimensionless (i.e. they have no units), your answer must necessarily have these same units of weight.

Now, let's try an example. Buzz Aldrin, the second man to walk on the Moon (Apollo 11, 1969), weighed 360 lbs. on Earth when practicing for his moon walk (half of that weight was his bulky space suit and backpack). Let's first calculate what his weight was on the Moon, and then figure what fraction this was of his weight on Earth.

Using our equation, and substituting the appropriate values, we get

$$W = W_E\left(\frac{M}{M_E}\right)\left(\frac{D_E}{D}\right)^2 = (360\text{ lbs})\bullet\left(\frac{7.349\times10^{22}\text{ kg}}{5.974\times10^{24}\text{ kg}}\right)\bullet\left(\frac{12{,}756\text{ km}}{3{,}476\text{ km}}\right)^2 = 60\text{ lbs}$$

So, Buzz Aldrin weighed only 60 lbs on the Moon. It must have felt great!

Dividing 60 lbs by 360 lbs we get 0.1666…, and since the inverse of this is 6, we see that on the Moon, you would weigh 1/6 of your weight on Earth.

$$\frac{60}{360} = \frac{1}{6}$$

David Oesper
1/31/06