#  Gravitational Motion 2

Content

The massive objects will experience a force of attraction due to their gravitational fields. This force is what keeps planets in orbits around the Sun and moons in orbit around their host planets. Just as in circular motion, we can calculate the velocity of planets orbiting around a host star using a very similar formula:

$$v=\frac{2πr}{T}$$

where $r$ is the radius of the orbit, and $T$ is the time taken for one full cycle of the orbit. This formula is for the average velocity of an object moving in a circle. While the orbits of planets are not perfectly circular, we can still approximate their orbits as circular and calculate the average velocity of their entire orbit using this formula.

Just like an object moving on the surface of the Earth, objects in orbit such as planets or satellites, have kinetic energy and gravitational potential energy. Potential energy on Earth is dependent on the mass of the object and the height/distance from the Earth. Gravitational potential energy is very similar:

$$U=-\frac{GMm}{r}$$

where $M$ and $m$ are the two masses in kg, $r$ is the distance between them, or the radius of the orbit, and $G$ is the universal gravitational constant $6.67×10^{-11}$Nm2kg-2. While this is just the gravitational potential energy, the total energy of the satellite in orbit is a combination of the gravitational potential energy and the orbital kinetic energy. It can be found using the equation:

$$E=-\frac{GMm}{2r}$$

Both these equations for the energy of the satellite or planet are very similar and combine the mass and distance of the two objects involved. This means satellites that are more massive and orbit with a smaller radius have larger gravitational potential energy and total energy.

Example

Given the Earth has a mass of $5.972×10^{24}$kg and orbits the Sun each year at an average radius of $145×10^{9}$m, what is the average velocity of the Earth’s orbit and the total energy of the orbit, assuming the Sun’s mass is $1.989×10^{30}$kg?

* We start by writing down all the variables we have and calculating the number of seconds in a year:

|  |  |
| --- | --- |
| Variable | Value |
| $$m\_{e}$$ | $5.972×10^{24}$kg |
| $$M\_{s}$$ | $1.989×10^{30}$kg |
| $$r$$ | $145×10^{9}$m |
| $$T$$ | $3.15×10^{7}$s |

* Now we can sub these values into the equation for velocity and energy:

