Gravity and Escape Speed

It would be nice if we could just jump real hard and we would suddenly be in space orbiting Earth. Fortunately it is not that easy as any Olympic High Jumper will tell you!

Because of the pull of gravity, every planet, asteroid or other object in the universe has its own speed limit. If you move slower than this speed you will stay on the body. If you move faster than this speed you will escape into space. Scientists call this the **escape speed** or **escape velocity**.

It's not just a number you guess at. It depends exactly on how much mass the planet or moon has, and how far from its center you are located. That means you can predict what this speed will be as you travel to other planets. That's very handy if you are an astronaut!

For Earth, the escape speed V in kilometers/second (km/s) at a distance R from Earth's center in kilometers, is given by

$$V = \frac{894}{\sqrt{R}}$$

Problem 1 - What is the escape speed for a rocket located on Earth's surface where R = 6378 km?

Problem 2 – An Engineer proposes to launch a rocket from the top of Mt Everest (altitude 8.9 km) because its summit is farther from the center of Earth. Is this a good plan?

Problem 3 – A spacecraft is in a parking orbit around Earth at an altitude of 35,786 km. What is the escape speed from this location?

Problem 4 – To enter a circular orbit at a distance of R from the center of Earth, you only need to reach a speed that is $2^{1/2}$ smaller than the escape speed at that distance. What is the orbit speed of a satellite at an altitude of 35,786 km?

Problem 1 - What is the escape speed for a rocket located on Earth's surface where R = 6378 km?

Answer: $V = 894/(6378)^{1/2}$ = **11.19 km/s**

Problem 2 – An Engineer proposes to launch a rocket from the top of Mt Everest (altitude 8.9 km) because its summit is farther from the center of Earth. Is this a good plan?

Answer: $V = 894/(6378+8.9)^{1/2}$ = **11.18 km/s. This does not change the required escape speed by very much considering the effort to build such a launch facility at this location**.

Problem 3 – A spacecraft is in a parking orbit around Earth at an altitude of 35,786 km. What is the escape speed from this location?

Answer: $V = 894/(6378+35{,}786)^{1/2}$ = **4.35 km/s**

Problem 4 – To enter a circular orbit at a distance of R from the center of earth, you only need to reach a speed that is $2^{1/2}$ smaller than the escape speed at that distance. What is the orbit speed of a satellite at an altitude of 35,786 km?

Answer: 4.35 km/s / (1.414) = **3.079 km/sec**.

Note: Satellites at an altitude of 35,800 orbit earth exactly once every day and are called geosynchronous satellites because they remain over the same geographic spot on Earth above the equator.

Circumference of the orbit = $2 \pi R$ = 2 x 3.141 x (42164 km) = 264,924 km.
Speed = 3.079 km/sec so
T = 264924/3.079 = 86,042 seconds or 23.9 hours – Earths rotation period.