Answer on Question 60928, Physics, Mechanics, Relativity

Question:

Explain what happens when a body is raised to a height from the surface of Earth and then given a horizontal velocity v such that:

a) $0 < v < 8.0\ km/s$

b) $v = 8.0\ km/s$

c) $8.0\ km/s < v < 11.2\ km/s$

d) $v = 11.2\ km/s$

Answer:

a) In order to orbit the Earth, the body must reach the first cosmic velocity that is equal to $v \approx 8.0\ km/s$. We can find it as follows:

$$v = \sqrt{\frac{GM_E}{R_E}},$$

here, G is the gravitational constant, M_E is the mass of the Earth, R_E is the radius of the Earth.

Then, we can calculate v:

$$v = \sqrt{\frac{GM_E}{R_E}} = \sqrt{\frac{6.67 \cdot 10^{-11}\ \frac{Nm^2}{kg^2} \cdot 5.97 \cdot 10^{24}\ kg}{6.371 \cdot 10^6}} = 7.9\ km/s \approx 8.0\ km/s.$$

So, if $0 < v < 8.0\ km/s$, then the body will return back to the Earth.

b) As we can see above, if $v = 8.0\ km/s$, then the body will orbit around the Earth.

c) In order to escape the gravitational attraction of the Earth the body must reach the second cosmic velocity that is equal to $v \approx 11.2\ km/s$. We can find it from the formula:

$$v = \sqrt{\frac{2GM_E}{R_E}} = \sqrt{\frac{2 \cdot 6.67 \cdot 10^{-11} \ \frac{Nm^2}{kg^2} \cdot 5.97 \cdot 10^{24} \ kg}{6.371 \cdot 10^6}} = 11.18 \ km/s = \approx 11.2 \ km/s.$$

So, if $8.0 \ km/s < v < 11.2 \ km/s$, then the body will still orbit the Earth but with different radiuses of orbit.

d) As we can see above, if $v = 11.2 \ km/s$, then the body will escape the gravitational attraction of the Earth.