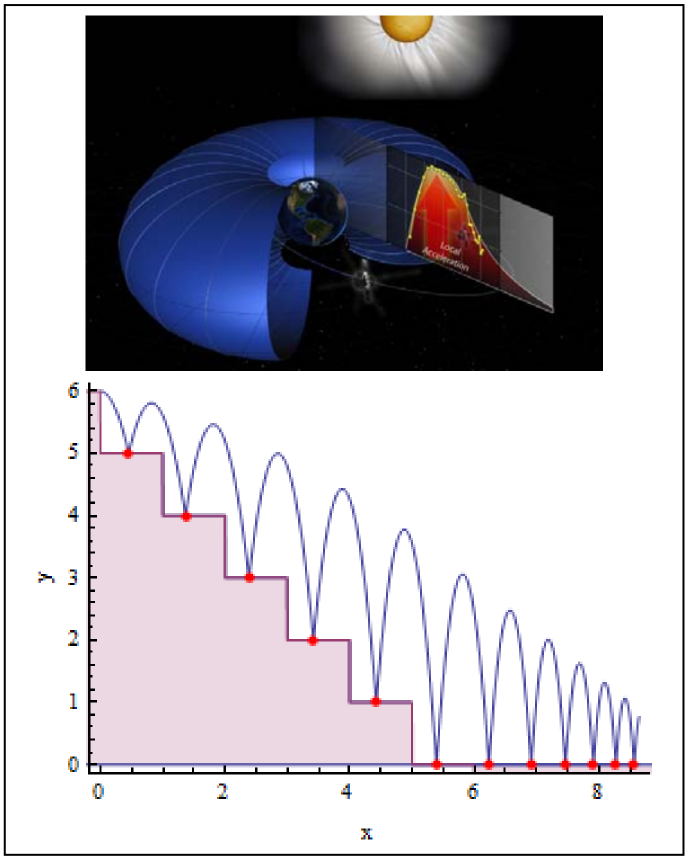

Scientists have discovered a massive particle accelerator in the heart of one of the Van Allen radiation belts. Scientists knew that something in space accelerated particles in the radiation belts to more than 99 percent the speed of light but they didn't know what that something was. New results from NASA's Van Allen Probes now show that the particles inside the belts are sped up by local kicks of energy, buffeting the particles to ever faster speeds, much like a perfectly timed push on a moving swing.

To see how this happens, imagine a ball bouncing down a long staircase as shown in the diagram to the left. Each step it falls, adds a small amount of energy to the ball so it bounces a bit higher each time. This is because gravity pulls on the ball and increases its kinetic energy after each step. As the kinetic energy increases, the ball's speed and height increases.

The formula for Kinetic Energy is K.E. = ½ m V^2 where m is the mass of the particle in kilograms, v is its speed in meters/sec and K.E. is measured in units of Joules.

Problem 1 – A small ball has a mass of 0.1 kilograms and a kinetic energy of 5 Joules, what is its speed in meters/sec?

Problem 2 – A 0.1 kilogram ball bounces down a long staircase that has 100 steps. If it gains 0.3 Joules after each step, how much kinetic energy will it have at the bottom of the staircase, and how fast will it be moving?

Problem 3 – An electron in the Van Allen belts has a mass of 9.1×10^{-31} kg. It starts out with a speed of 10,000 km/sec and reaches a speed of 150,000 km/sec after 12 hours. About how much kinetic energy does it gain every hour as it travels around the Van Allen Belts?

NASA's Van Allen Probes Discover Particle Accelerator in the Heart of Earth's Radiation Belts
July 25, 2013
http://www.nasa.gov/content/goddard/van-allen-probes-find-source-of-fast-particles/index.html

Problem 1 – A small ball has a mass of 0.1 kilograms and a kinetic energy of 5 Joules, what is its speed in meters/sec?

Answer: $5.0 = 0.5 \times 0.1 \times V^2$, so $V^2 = 100$ and V = **10 meters/sec**.

Problem 2 – A 0.1 kilogram ball bounces down a long staircase that has 100 steps. If it gains 0.3 Joules after each step, how much Kinetic Energy will it have at the bottom of the staircase, and how fast will it be moving?

Answer: 0.3 x 100 = 30 Joules, then $30 = ½ (0.1) V^2$, and V = **24 meters/sec**.

Note: The potential energy of the ball at the top of its bounce is given my E = m g h, where g = 9.8 m/sec^2 and h is the height in meters. So for this ball, m = 0.1 kg, E = 30 Joules and so its maximum bounce height is h = 30 meters.

Problem 3 – An electron in the Van Allen belts has a mass of 9.1×10^{-31} kg. It starts out with a speed of 10,000 km/sec and reaches a speed of 150,000 km/sec after 12 hours. About how much kinetic energy does it gain every hour as it travels around the Van Allen Belts?

Answer: The initial kinetic energy of the electron is
$E = ½ (9.1\text{x}10^{-31})(10{,}000{,}000)^2 = 4.6 \times 10^{-17}$ Joules.

The final kinetic energy is $E = ½(9.1\text{x}10^{-31})(150{,}000{,}000)^2 = 1.0 \times 10^{-14}$ Joules,

so the electron gained $1.0\text{x}10^{-14} – 4.6\text{x}10^{-17} = 1.0\text{x}10^{-14}$ Joules of energy.

If this was done equally over 12 hours, then the energy gained per hour was $1.0\text{x}10^{-14} / 12 =$ **$8.5\text{x}10^{-16}$ Joules each hour**.