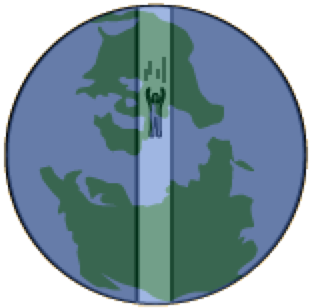
Newton’s Law of Gravitation

Quickuiz

If you drill a shaft through the Earth from one end to the other and jump through it (neglecting air resistance and the fact the core is molten!), you will

A. Fall through and exit from the other side
B. Will fall to the center and get stuck there
C. Will fall all the way to the other end then come back, then fall again, and so on
D. Will get stuck midway between the fall point and the center



Conservation of Energy

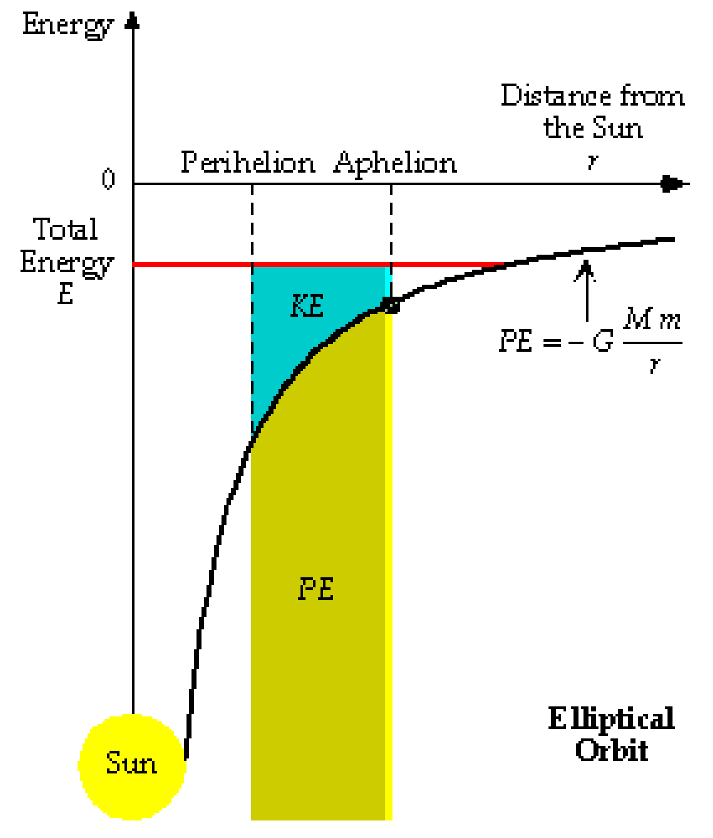
- Near the surface of Earth (with gravity only)

$$TME = GPE + KE = mgy + \frac{1}{2}mv^2$$

- In general:

$$TME = GPE + KE$$
$$= -\frac{Gm_E m}{r} + \frac{1}{2}mv^2$$

- What's the condition for creating a stable orbit?
- $TME < 0$. Why?
- Also: in such motion angular momentum L is conserved (why?)

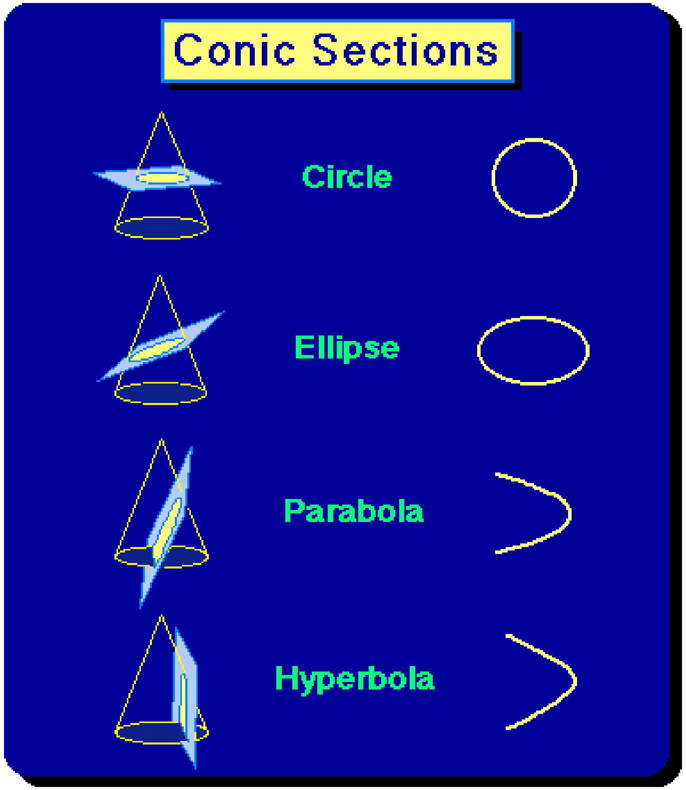


MasteringPhysics

- Some people still not registered yet!
- You were supposed to have several attempts. The option was just overlooked. Fixed for next time.
- Reading that combines text and equation is important!
- We will go over Kepler's Laws concepts, but will not go much into applications
- We're off schedule a bit, but will get back on time again. A small problem continuing work today will be posted today.
- What was the most frustrating part of the process? What do you suggest to fix it?

Elliptical, parabolic, and hyperbolic orbits

- In all cases $KE > 0$, and $GPE < 0$.
- We get different types of orbit:
- Elliptical: $TME < 0$ (bound; the shape of the ellipse; its eccentricity, depends TME and L)
- Parabolic: $TME = 0$
- Hyperbolic: $TME > 0$



Simulation: http://phet.colorado.edu/sims/my-solar-system/my-solar-system.swf

Escape Velocity

- Escape velocity is the minimum velocity needed to escape completely from the gravitational pull of a planet
- How do we find the escape velocity from a planet?
- Main condition: $TME \geq 0$

$$TME = GPE + KE = -\frac{Gm_E m}{r} + \frac{1}{2} m v_{\text{esc}}^2 = 0$$

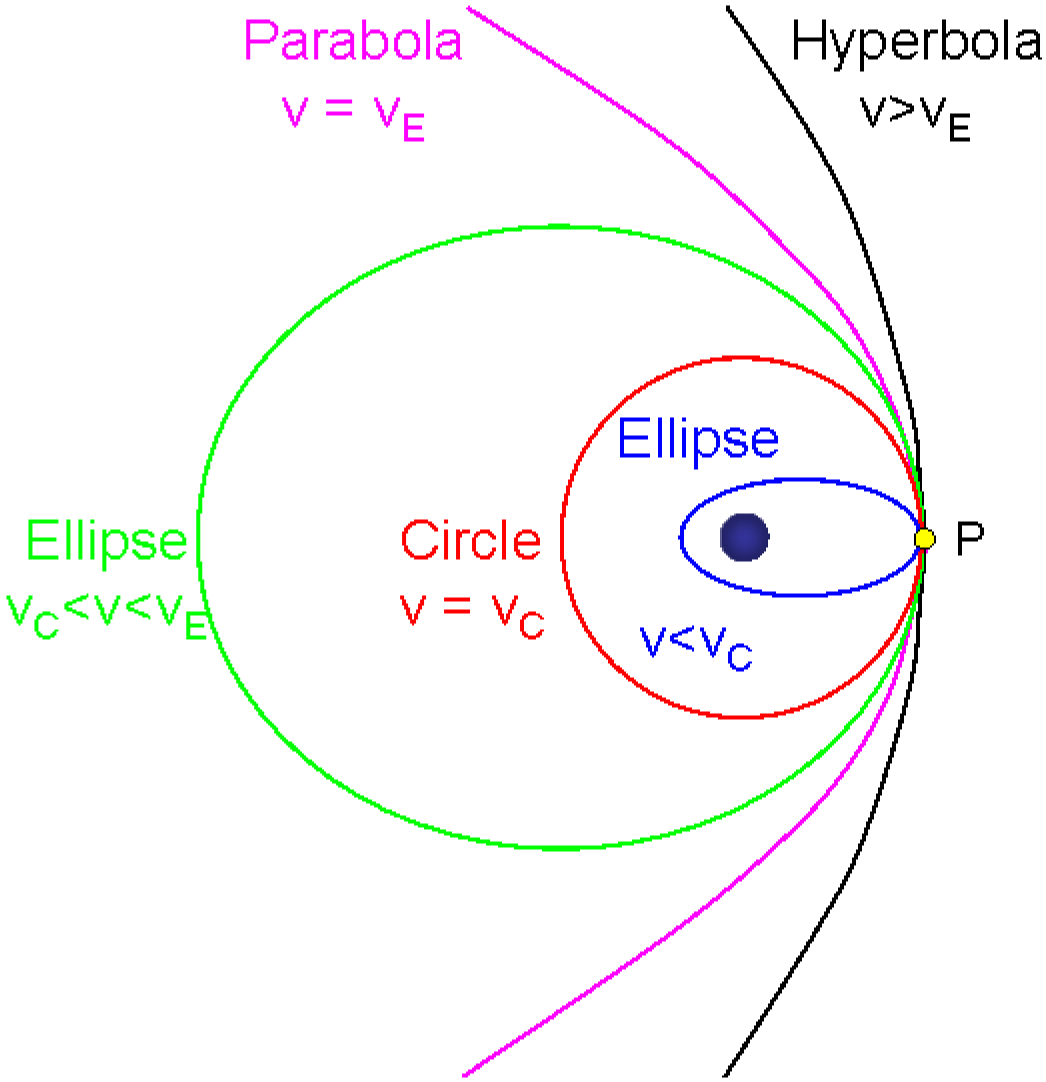
$$\Rightarrow v_{esc} = \sqrt{2Gm_E/r}$$

Calculate that for Earth.

$$v_{esc,E} \sim 11{,}000 \text{ m/s}$$

Simulation: Newton's Cannon:

- http://waowen.screaming.net/revision/force&motion/ncannon.swf



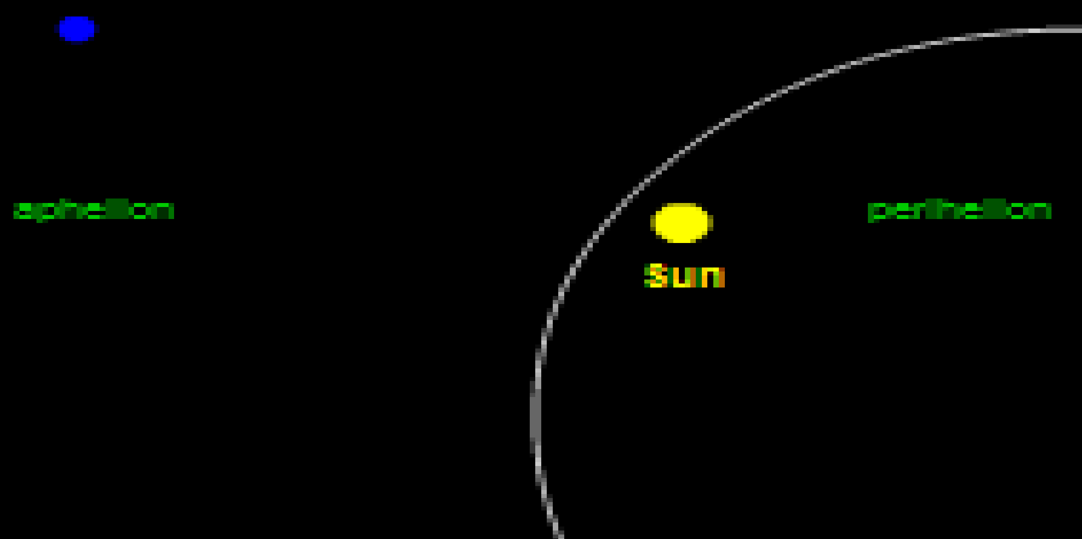
v_c is exactly circular speed (when $F_g = mv^2/r$), v_E is escape velocity

Quickuiz

Looking at astronauts in orbit, e.g. inside the International Space Station, they appear weightless. This means:

A. Their spacecraft has escaped Earth's gravity.
B. They are so from Earth that gravity is negligible.
C. Both astronauts and station are 'falling' at the same rate.

http://www.windows2universe.org/physical_science/physics/mechanics/orbit/perihelion_aphelion.html



Kepler’s Laws

1st Law: The orbit of all planets in the solar system is elliptical with the Sun at one of the foci.

2nd Law: The line connecting Sun to planet sweeps equal areas of the ellipse in equal times.

3rd: The square of the orbital period of a planet is proportional to the cube of the semi-major axis of its orbit.

Some of Kepler’s Laws Implications

- Because the planet moves in an elliptical orbit, sometimes it’s close to the Sun, sometimes far.
- When its close it’s there is less potential energy in the system, and most of it is kinetic, so the planet moves faster; the line connecting planet to Sun would have to sweep an area of the orbit faster than when the planet is far (2nd law).
- If the farthest point in the planet’s orbit is very far compared to the closest, then it would take the planet a lot of time doing a round trip (when it’s far it’s slow).

Demo Problem

- The international space station orbits the Earth at a height of about 370 km above ground. At what minimum speed should the rocket be launched if it is to reach the station?
- Answer: $v_{\min} = 2600\ \mathrm{m/s}$. Reproduce this number. It's relevant to the homework problem.