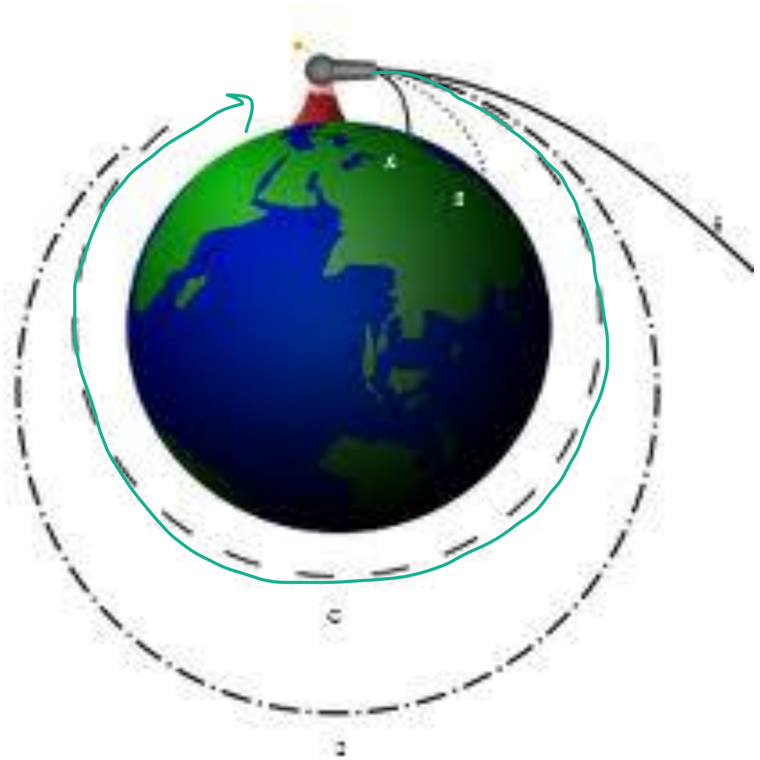
7-2

Using the Laws of Universal Gravitation

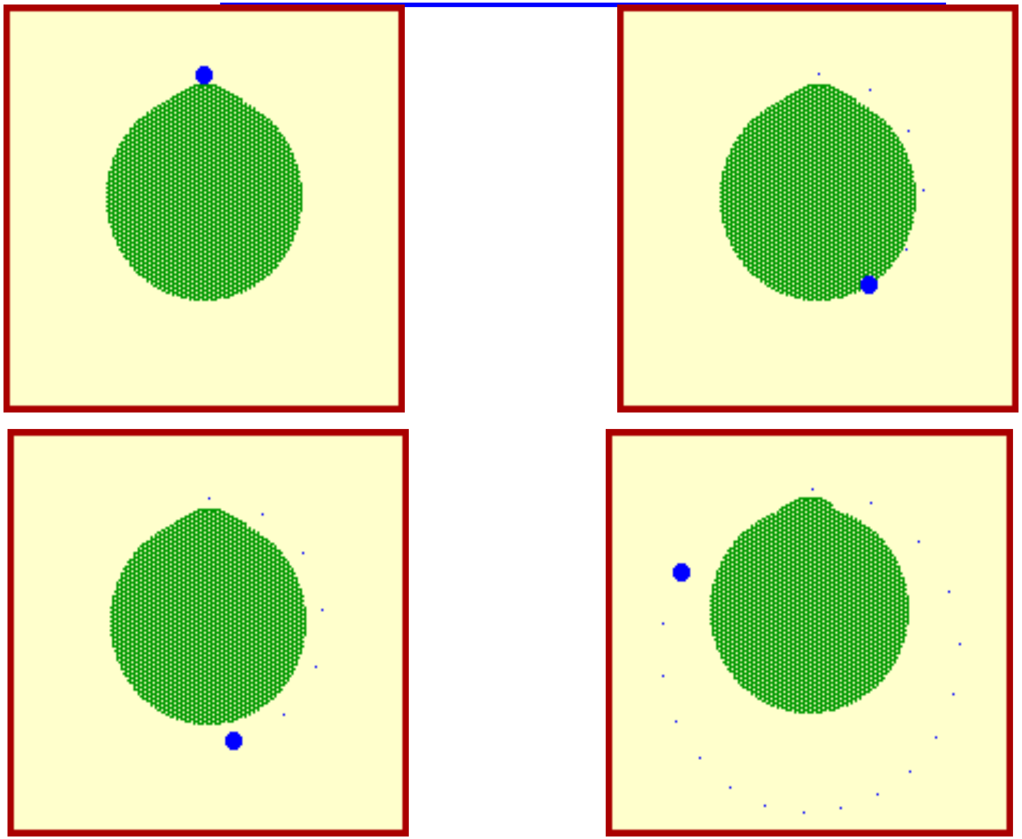
How Objects Get Into Orbit

- An object shot horizontally is a projectile – it will fall to the Earth in a parabolic path.
- The faster a projectile is shot horizontally, the father it will get horizontally.
- If a projectile is shot ___fast enough___ and ___high enough (to reduce air resistance)___, it will ___fall towards Earth___ at the same rate that the ___Earth's surface curves away___.
  - Meaning the object would ___in orbit___

* always falling towards Earth but not hitting it b/c Earth is round | curving away



- http://www.physicsclassroom.com/mmedia/vectors/sat.cfm



Speed of a Satellite Orbiting the Earth

$$v = \sqrt{\frac{G m_E}{r}}$$

$G = 6.67 \times 10^{-11}$

m = mass of center body

r = orbital radius
(center to center distance)

v = speed (in meters/second)

Period of a Satellite Orbiting the Earth

$$T = 2\pi\sqrt{\frac{r^3}{Gm_E}}$$

$G = 6.67 \times 10^{-11}$

m = mass of center body

r = orbital radius (center to center distance)

T = period (in seconds)

Launching a Satellite

- Satellites are launched by ___rockets___ that have ___accelerated___ them to a ___fast enough speed___ that will allow them to ___achieve orbit___.
- Since F = ma, a more ___massive___ satellite would require more ___force___ to accelerate it.
- Therefore, the mass of a satellite is limited by the rocket that will be used to launch it.
- http://www.youtube.com/watch?v=mbeoS0o_fNw

Uses of a Satellite

- Provides images of Earth's surface that are used to:
- Create maps
- Study land use
- Monitor resources
- Monitor global changes

EX:

- Engineers are planning to place the International Space Station (ISS) into orbit at an altitude of 450 km above the Earth's surface. What would be the orbital speed and period of the ISS?

$m_E = 5.97 \times 10^{24}$ kg

$r = r_E + 450$ km

$= 6.38 \times 10^6$ m $+ 450{,}000$ m

$r = 6.83 \times 10^6$ m

$$T = 2\pi\sqrt{\frac{(6.83\times10^6)^3}{(6.67\times10^{-11})(5.97\times10^{24})}} = \boxed{5620.3 \text{ sec}}$$

$$V = \sqrt{\frac{6.67\times10^{-11}(5.97\times10^{24})}{6.83\times10^6}} = \boxed{7635.5 \text{ m/s}}$$