

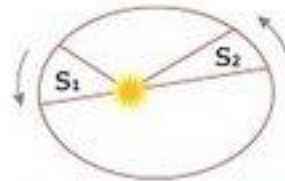
# Empirical successes of Newton's theory of gravity

- All bodies fall at same rate near earth's surface.
- Moon's acceleration is  $1/60^2$  smaller than acceleration at surface
- Explains all three of Kepler's laws of planetary motion:
  - Each planet moves in an ellipse with the sun at one focus
  - Planet moves faster when closer to the sun: equal area in equal time
  - Period<sup>2</sup> is proportional to (semi-major axis)<sup>3</sup>
- Jupiter's moons obey Kepler's 3rd law with different constant of proportionality
- Tides caused by gravity of moon, and sun: two high tides per day
- Comets move on highly elongated elliptical orbits
- Planets have a small gravitational effect on each other, e.g., Jupiter and Saturn
- Planet Uranus discovered with telescope in 1781. Planet Neptune discovered 50 years later because orbit of Uranus is perturbed by gravity of Neptune.

### 1st Law

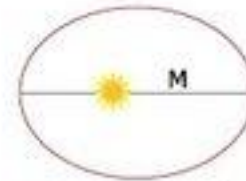


### 2nd Law



Equal area in the same time  
area  $S_1$  = area  $S_2$

### 3rd Law



$P$ : period (the time for one cycle)  
 $M$ : length of the major axis

$P^2/M^3$  is the same for all planets

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