

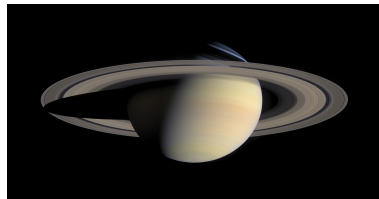
# Orbits I

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Take  $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ , where necessary.

- The space shuttle orbits at a height of 350 km above the Earth's surface. If the Earth has a mass of  $6.0 \times 10^{24} \text{ kg}$  and a radius of  $6.4 \times 10^6 \text{ m}$ , calculate
  - the speed of the shuttle in this orbit,
  - the time taken for one orbit,
  - the angular velocity of this orbit.
- The rings of Saturn consist of a vast number of small particles, each in a circular orbit. They are shown in the image below [Public Domain, from Cassini Spacecraft, NASA].



The inner edge of the inner ring is 70 000 km from the centre of the planet, and the outermost edge of the outer ring is 140 000 km from the centre. The speed of the outermost particles is  $17 \text{ km s}^{-1}$ .

- Show that the speed,  $v$ , of a particle in orbit of radius  $r$  around a planet of mass  $M$  is given by

$$v = \sqrt{\frac{GM}{r}}.$$

- Determine the mass of Saturn.
  - How long does it take for the outermost particles to complete an orbit?
  - Calculate the orbital speed of the particles nearest to Saturn.
- Use the following data about four of the moons of Uranus to plot a suitable graph to test Kepler's Law:

Orbit time / hour	60.5	99.5	209	323
Orbit radius / $10^3 \text{ km}$	192	266	436	582
    - If a further moon of Uranus were discovered with a period of 170 hours, what would be its orbital radius.
    - Use the graph to estimate a value for the mass of Uranus.