Orbits

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Warm up problems

1. Two lead spheres of radius 50 mm just touch each other. Calculate
   (a) the volume of the spheres, in m^3,
   (b) the mass of the spheres, if the density of lead is 11000 kg m^{-3},
   (c) the gravitational force of attraction between them.
2. If a satellite was placed on the surface of a planet of radius r, it would experience a force of F. Show that if it were put in an orbit at a height of $r/50$ above the planet's surface, the force on the planet would be $0.96F$.

Lesson Objectives

1. To look at some things that Newton's law explains.
2. To do some problems about orbits.
3. To start to discuss gravitational *fields*.

REMINDER: Office hours are week **1** Tuesdays 3.45–5.0 p.m. in room 19.
Next office hours: Tuesday 26 September 2012

Specification Requirement

Orbits of planets and satellites
Orbital period and speed related to radius of circular orbit.
Significance of a geosynchronous orbit.

[AQA GCE AS and A Level Specification Physics A, 2009/10 onwards]

Reproduce "proof" of Kepler 3 for circular orbits

Proof

$$F = \frac{GMm}{r^2}, \quad F = \frac{mv^2}{r}$$

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

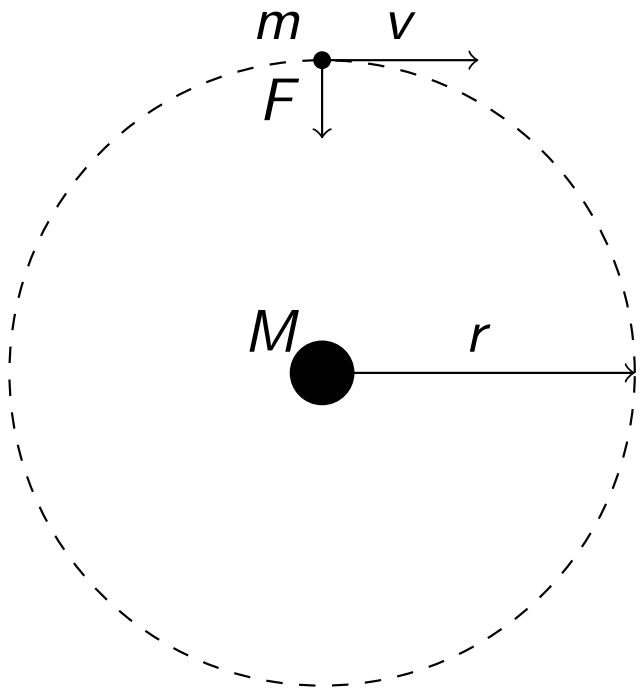
$$\frac{GM}{r} = v^2$$

For motion in a circle, $v = \frac{2\pi r}{T}$

$$\frac{GM}{r} = \left(\frac{2\pi r}{T}\right)^2$$

$$\frac{GM}{r} = \frac{4\pi^2 r^2}{T^2}$$

$$T^2 = \frac{4\pi^2}{GM} r^3$$



Newton's test

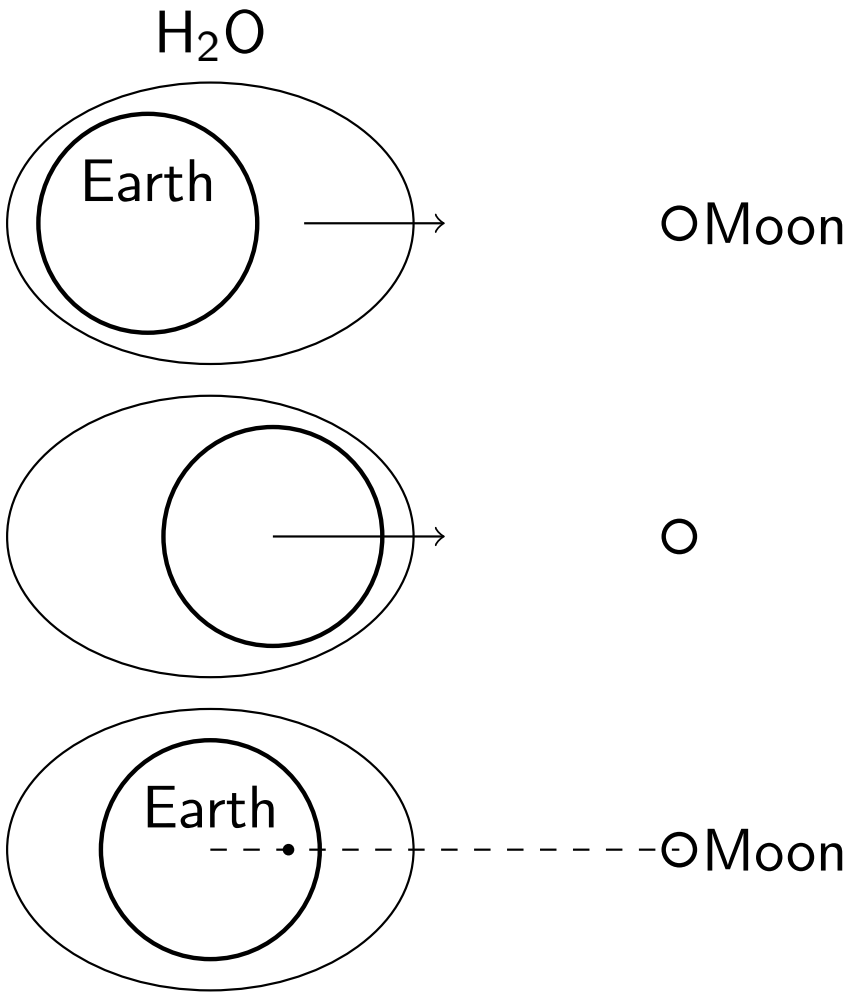
- We are 4000 miles from the centre of the Earth
- The moon is 240 000 miles away from Earth's centre, and takes 29 days to go around the Earth

1. If an object on the Earth's surface falls 16 feet in one second, how much does the Moon fall in one second?
2. Does this fit with the period of the Moon's orbit?

Tides

Another thing Newton figured out. . .

- This was thought of before Newton, but people thought if the moon pulled the water to make tides there would be only one tide per day
- Another school of thought was that the moon pulled the Earth away from the water. . .
- Newton realized that it is a combination of these two effects that causes two tidal bulges and thus two tides a day.



Orbits

1 The mass of the Earth is 6.0×10^{24} kg and its radius is 6.4×10^{6} m. Calculate the radius of a satellite in

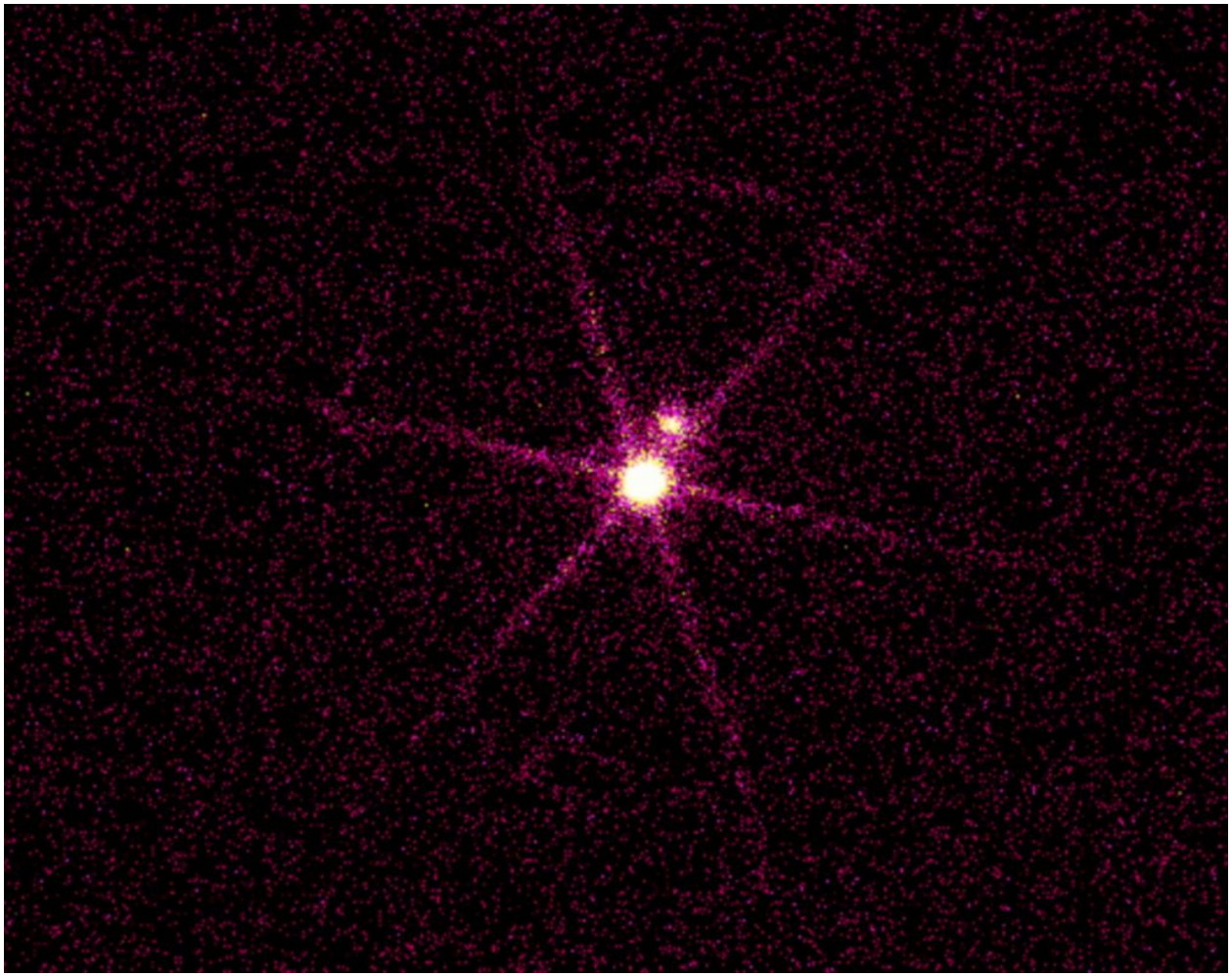
(a) a geostationary orbit

(b) an orbit with a period of 100 minutes.

2 The space shuttle orbits at a height of 350 km above the Earth's surface. If the Earth has a mass of 6.0×10^{24} kg and a radius of 6.4×10^{6} m, calculate

(a) the speed of the shuttle in this orbit,
(b) the time taken for one orbit,
(c) the angular velocity of this orbit.

Siruis binary system



Siruis binary system