

PHYS 1441 – Section 002

Lecture #13

Wednesday, Oct. 14, 2009

Dr. Jaehoon Yu

- Quick Review
- Motion in Resistive Force
- Work done by a constant force
- Work-Kinetic Energy Theorem



Announcements

- Reading Assignment
 - CH5.4, 5.5, 5.9 and 6.2
- Quiz next Monday, Oct. 19
 - Beginning of the class
 - Covers CH4.5 to CH5.10
- Colloquium today
 - Our own Dr. A. Brandt
 - Double extra credit!!!



Special Project

- Using the fact that $g=9.80\text{m/s}^2$ on the Earth's surface, find the average density of the Earth.
 - Use the following information only
 - the gravitational constant is $G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2$
 - The radius of the Earth is $R_E = 6.37 \times 10^3 \text{ km}$
- 20 point extra credit
- Due: Wednesday, Oct. 21
- You must show your OWN, detailed work to obtain any credit!! Must be far better than what was covered in the lecture Monday



**Physics Department
The University of Texas at Arlington
COLLOQUIUM**

**Proton Detectors at D0
and ATLAS**

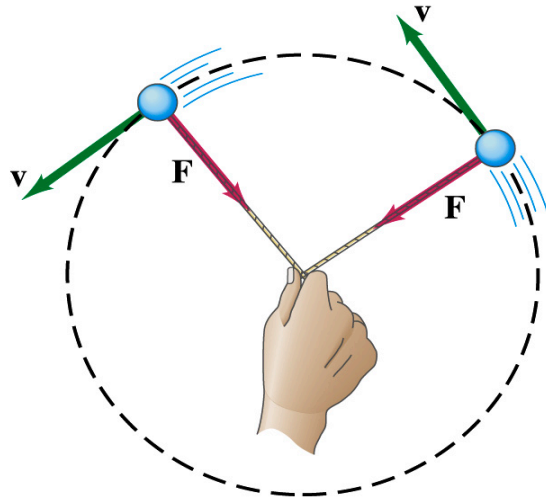
**Dr. Andrew Brandt
University of Texas-Arlington
4:00p.m Wednesday October 14, 2009
At SH Rm 101**

Abstract:

This colloquium discusses the motivation for adding proton detectors upstream and downstream of the massive multi-purpose D0 and ATLAS detectors. First results from a completed analysis of elastic scattering using the D0 Forward Proton Detector will be presented. In addition the proposed project to add proton detectors to ATLAS will be discussed, focusing on the development of a new time-of-flight detector with unprecedented resolution, on the ten picoseconds level.

Refreshments will be served in the Physics Lounge at 3:30 pm

Newton's Second Law & Uniform Circular Motion



The centripetal * acceleration is always perpendicular to the velocity vector, \mathbf{v} , and points to the center of the axis (radial direction) in a uniform circular motion.

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

Are there forces in this motion? If so, what do they do?

The force that causes the centripetal acceleration acts toward the center of the circular path and causes the change in the direction of the velocity vector. This force is called the **centripetal force**.

$$\sum F_c = ma_c = m \frac{v^2}{r}$$

What do you think will happen to the ball if the string that holds the ball breaks?

The external force no longer exist. Therefore, based on Newton's 1st law, the ball will continue its motion without changing its velocity and will fly away following the tangential direction to the circle.



Newton's Law of Universal Gravitation

People have been very curious about the stars in the sky, making observations for a long time. The data people collected, however, have not been explained until Newton has discovered the law of gravitation.

Every particle in the Universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

How would you write this law mathematically?

$$F_g \propto \frac{m_1 m_2}{r_{12}^2} \quad \xrightarrow{\text{With } G} \quad F_g = G \frac{m_1 m_2}{r_{12}^2}$$

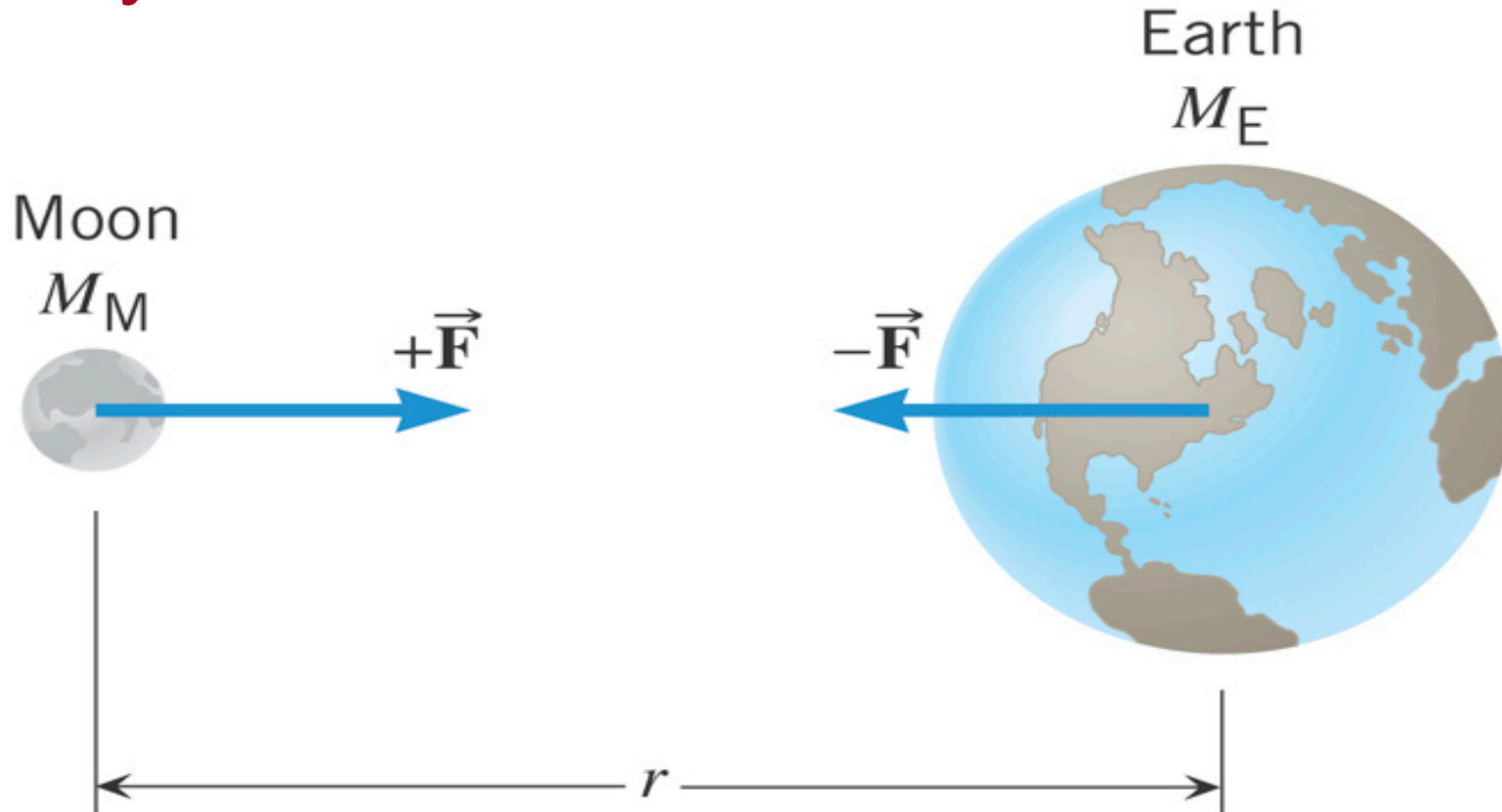
G is the universal gravitational constant, and its value is

$$G = 6.673 \times 10^{-11} \quad \text{Unit?} \quad N \cdot m^2 / kg^2$$

This constant is not given by the theory but must be measured by experiments.

This form of forces is known as the inverse-square law, because the magnitude of the force is inversely proportional to the square of the distances between the objects.

Why does the Moon orbit the Earth?



Gravitational Force and Weight

Gravitational Force, F_g

The attractive force exerted on an object by the Earth

$$\vec{F}_G = m\vec{a} = m\vec{g}$$

Weight of an object with mass M is

$$W = |\vec{F}_G| = M|\vec{g}| = Mg$$

What is the SI unit of weight?

N

Since weight depends on the magnitude of gravitational acceleration, g , it varies depending on geographical location.

By measuring the forces one can determine masses. This is why you can measure mass using the spring scale.

Gravitational Acceleration

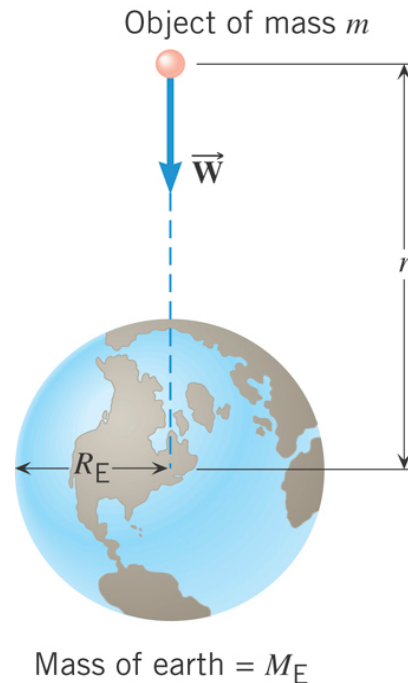
$$W = G \frac{M_E m}{r^2}$$

$$W = mg$$

$$\cancel{mg} = G \frac{\cancel{M_E m}}{r^2}$$

$$g = G \frac{M_E}{r^2}$$

Gravitational acceleration at distance r from the center of the earth!



On the surface of the Earth

$$G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2$$

$$M_E = 5.98 \times 10^{24} \text{ kg}; \quad R_E = 6.38 \times 10^6 \text{ m}$$

$$g = G \frac{M_E}{R_E^2}$$

$$= (6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2) \frac{(5.98 \times 10^{24} \text{ kg})}{(6.38 \times 10^6 \text{ m})^2}$$

$$= 9.80 \text{ m/s}^2$$

What is the SI unit of g ?

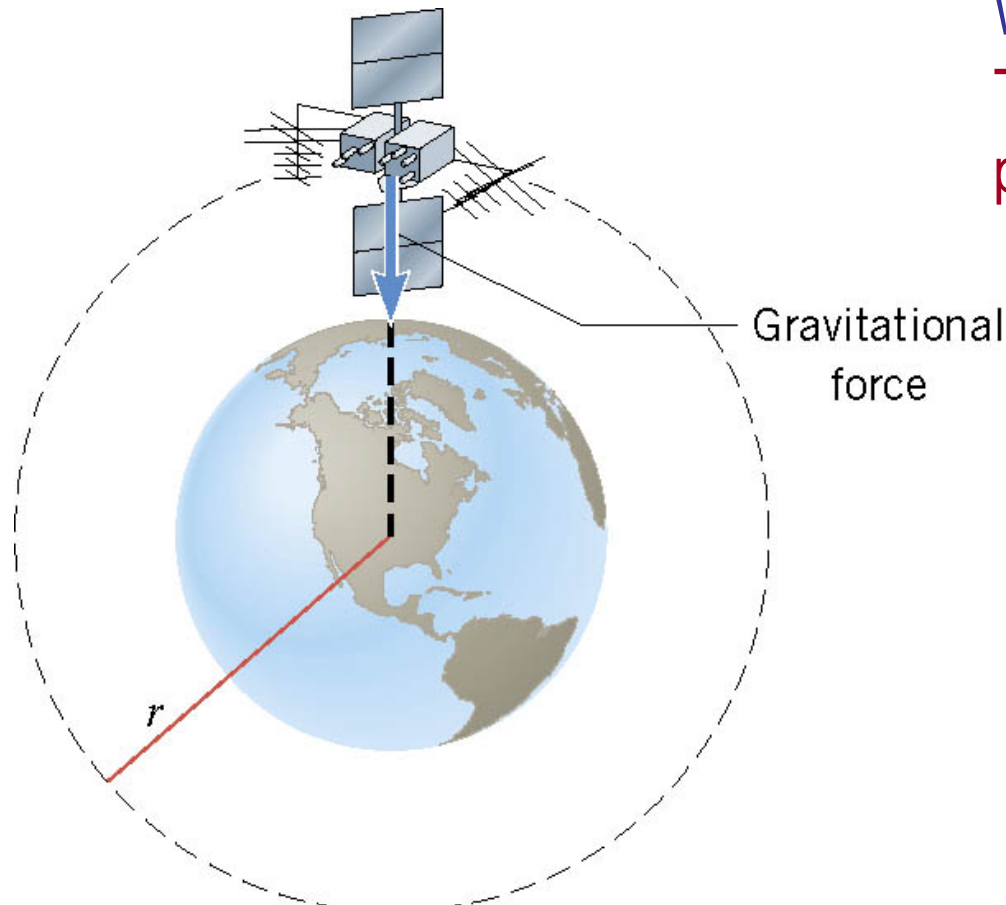
m/s^2

Satellite in Circular Orbits

There is only one speed that a satellite can have if the satellite is to remain in an orbit with a fixed radius.

What is the centripetal force?

The gravitational force of the earth pulling the satellite!



$$F_c = G \frac{mM_E}{r^2} = m \frac{v^2}{r}$$

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

$$v = \sqrt{\frac{GM_E}{r}}$$

Wednesday, Oct. 14, 2009



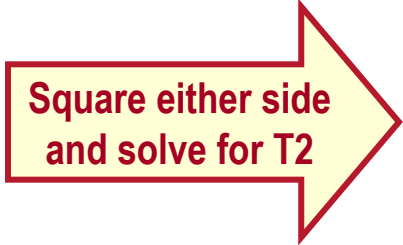
PHYS 1441-002, Fall 2009 Dr. Jaehoon Yu

10

Period of a Satellite in an Orbit

Speed of a satellite $v = \sqrt{\frac{GM_E}{r}} = \frac{2\pi r}{T}$

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



$$T^2 = \frac{(2\pi)^2 r^3}{GM_E}$$

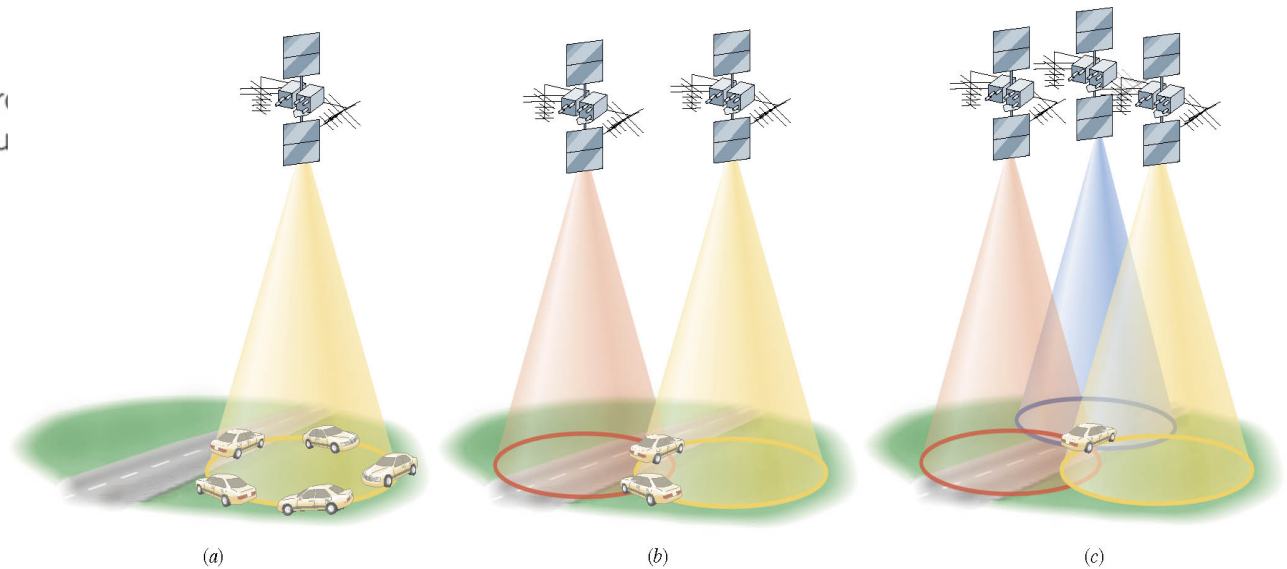
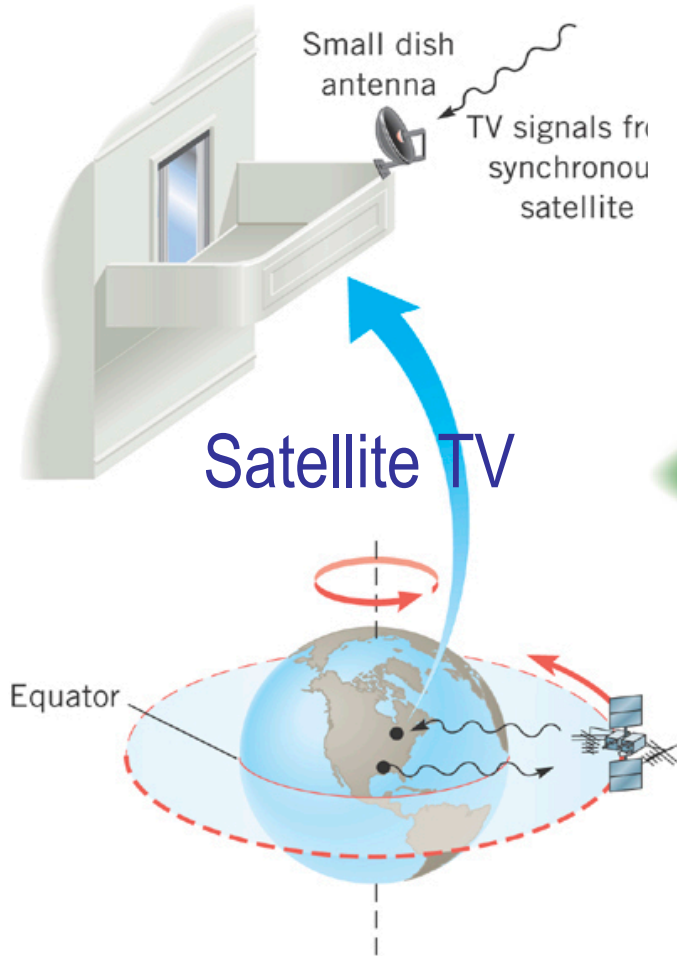
Period of a satellite $T = \frac{2\pi r^{3/2}}{\sqrt{GM_E}}$ Kepler's 3rd Law

This is applicable to any satellite or even for planets and moons.



Geo-synchronous Satellites

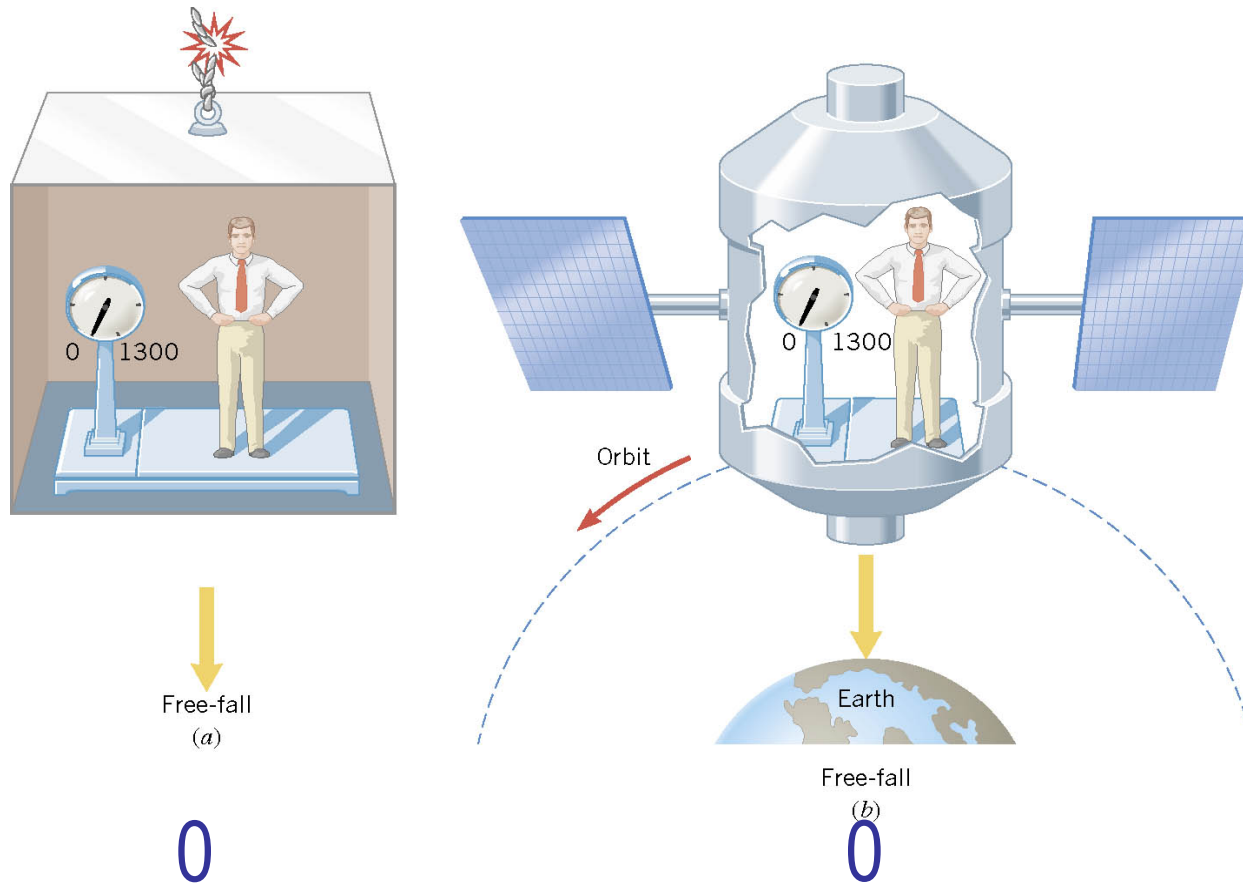
Global Positioning System (GPS)



What period should these satellites have?

The same as the earth!! 24 hours

Ex. Apparent Weightlessness and Free Fall



In each case, what is the weight recorded by the scale?

Ex. Artificial Gravity

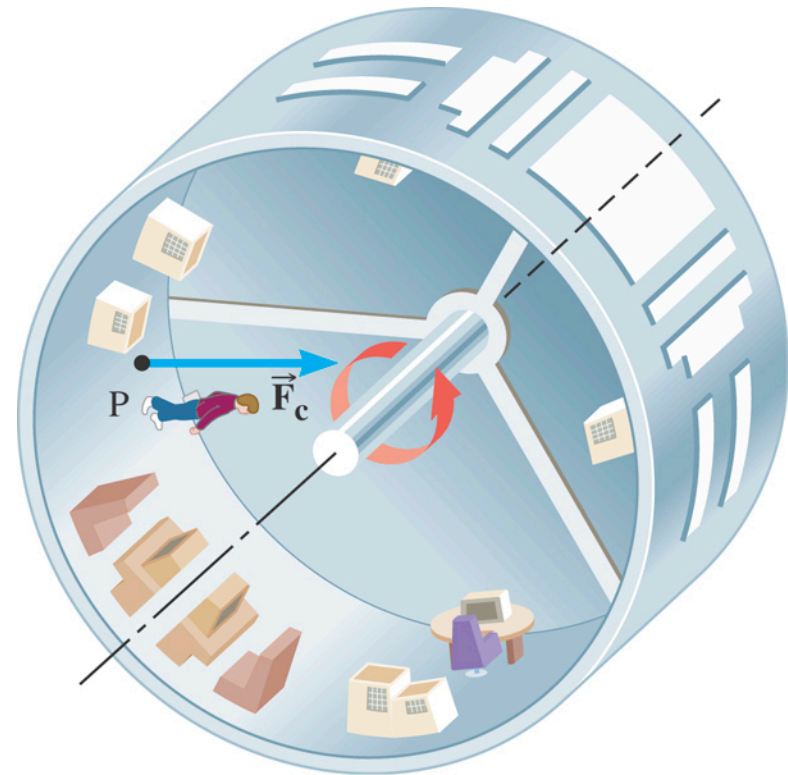
At what speed must the surface of the space station move so that the astronaut experiences a push on his feet equal to his weight on earth? The radius is 1700 m.

$$F_c = m \frac{v^2}{r} = mg$$

$$v = \sqrt{rg}$$

$$= \sqrt{(1700 \text{ m})(9.80 \text{ m/s}^2)}$$

$$= 130 \text{ m/s}$$



Motion in Resistive Forces

Medium can exert resistive forces on an object moving through it due to viscosity or other types frictional properties of the medium.

Some examples?

Air resistance, viscous force of liquid, etc

These forces are exerted on moving objects in opposite direction of the movement.

These forces are proportional to such factors as speed. They almost always increase with increasing speed.

Two different cases of proportionality:

1. Forces linearly proportional to speed:
Slowly moving or very small objects
2. Forces proportional to square of speed:
Large objects w/ reasonable speed

