March 30, 2011

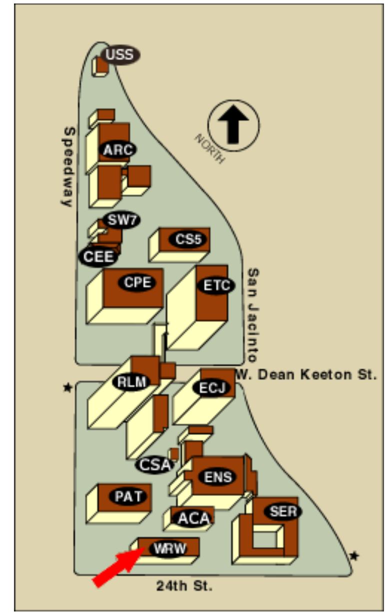
Exam 3 this Friday. Review Sheet posted.

Review session Thursday, 5 PM, Room WRW 102

Reading: Chapter 7, Chapter 8 - Sections 8.1, 8.2, 8.5, 8.6, 8.10, Chapter 9 – Sections 9.1 – 9.5.1

Sky watch, Flatland, due Friday

Astronomy in the news?

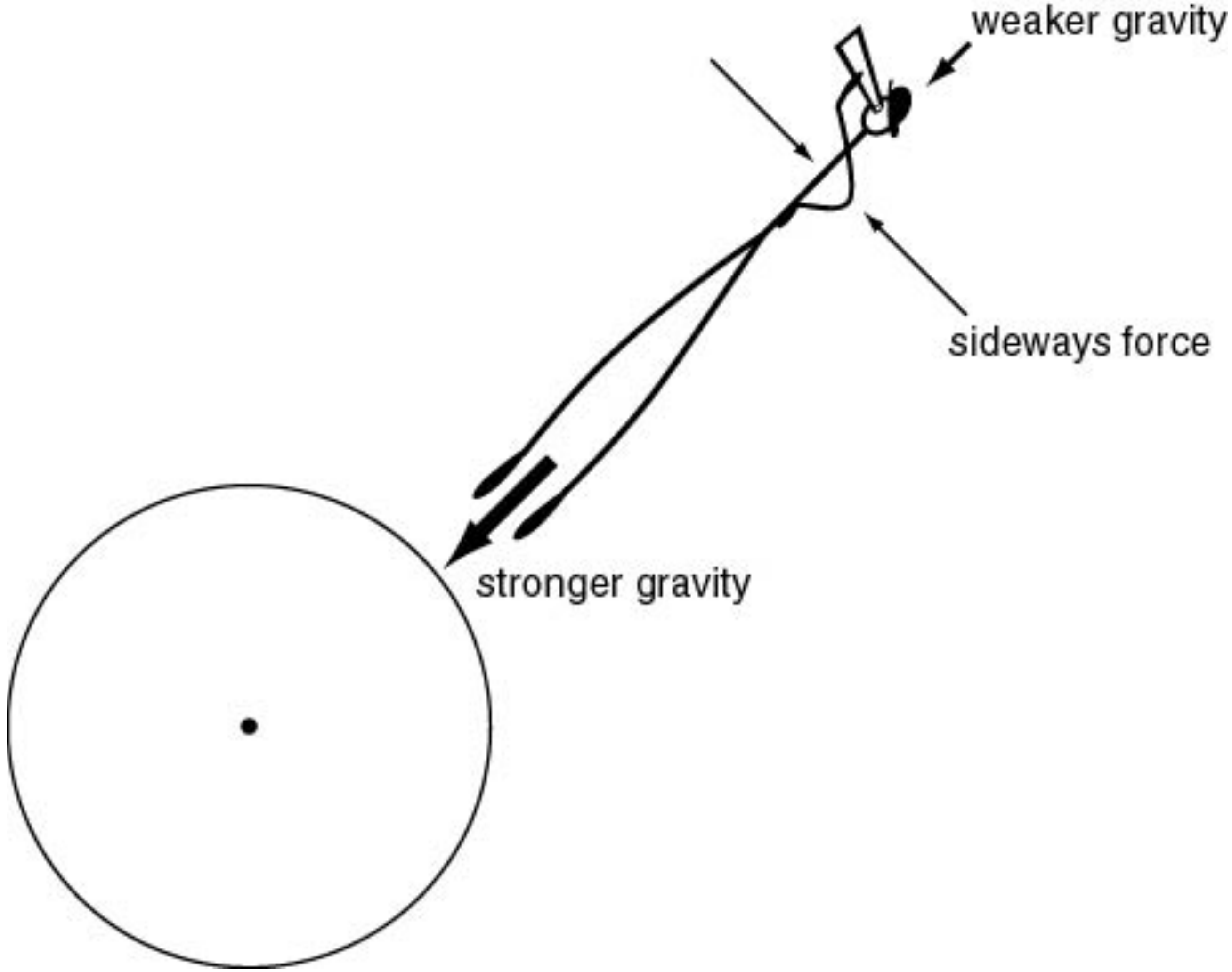



Pic of the day: NGC 5584, spiral galaxy, host to recent Type Ia supernova.

# Goal:

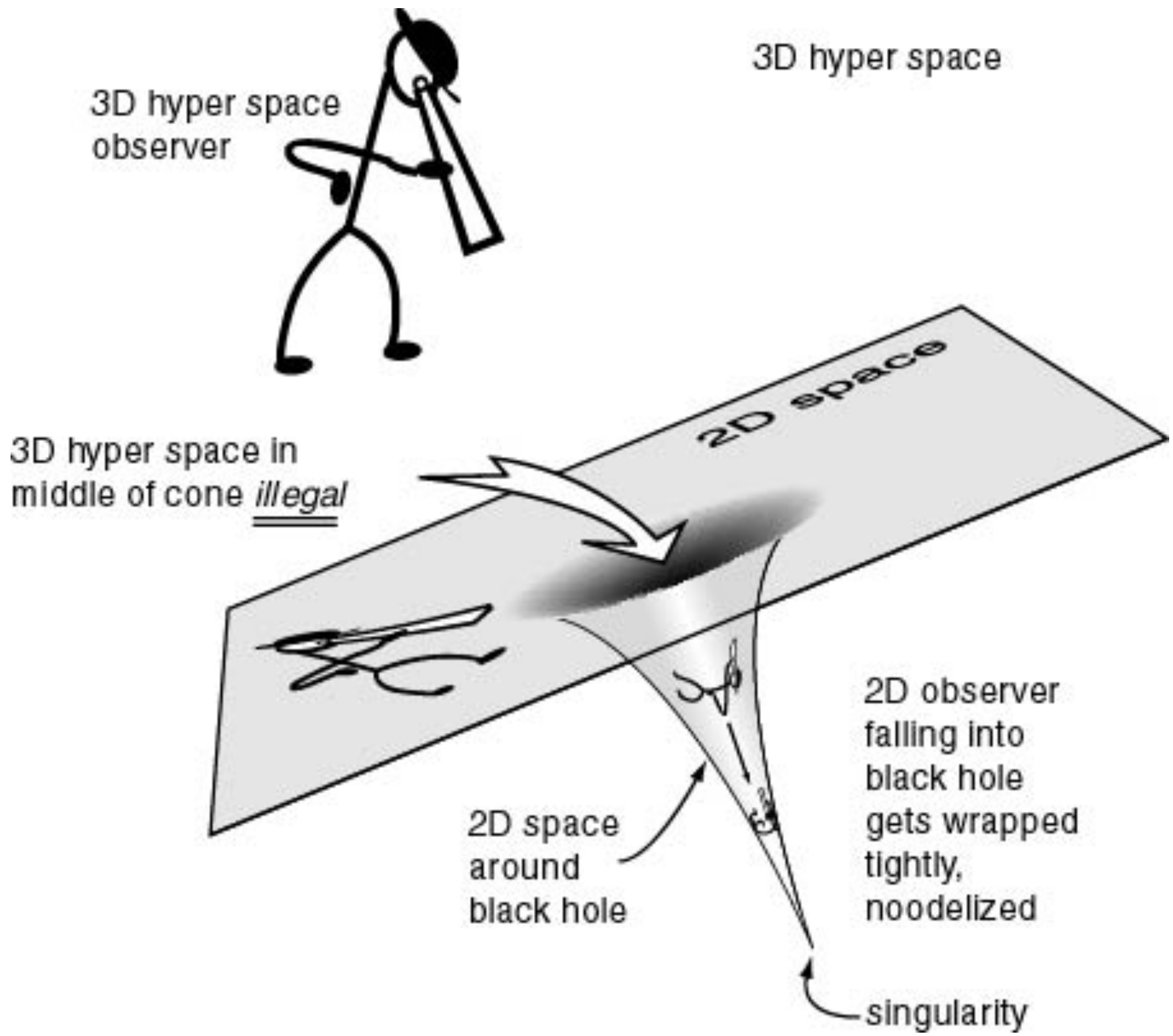
To understand what it is like to die falling into a black hole.

# Figure 9.2




Tidal Forces

# Figure 9.3




2D embedding diagram of 3D curved space around a black hole

# End of Material for Test 3

Goal:

To understand how time works in curved space and near black holes.

# Black holes and Time (Section 5.2)

What does it mean to fall? Rather deep and strange phenomenon!

Drop things, fall at same rate…

Falling involves the passage through time as well as space.

# Falling According to Einstein

According to Einstein - curved space around gravitating objects “flows” inward - ***inward escalator.*** Necessary to truly understand orbits.

If an object floats with ***no force*** in space (free fall), it will move toward the center of gravitation

⇒ falling - all objects respond to the same curvature, have the same acceleration

Like water down a drain - sit still in the water, but go down the drain.

Must exert a force to resist, to avoid free fall, to avoid the flow of space inward toward the center of the gravitating object.

**Freely falling object has no force on it. You, sitting there, do.**

# Black holes and Time (Section 5.2)

**Predictions of Einstein:**

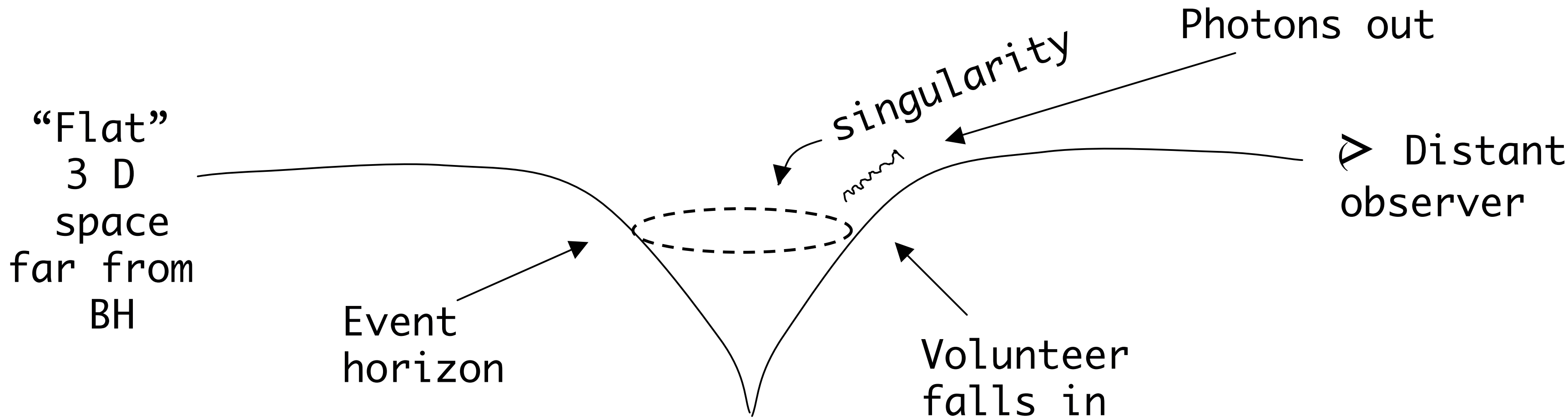
If a clock moves away from an observer it ticks more slowly.

If a clock is deep in a gravity well (the curved space around a gravitating object) it ticks more slowly according to an observer at large distance where gravity is absent (flat 3D space).

Get both effects if you drop a “clock” into a gravity well and watch it fall in from a safe distance where gravity is weak (flat 3D space).

**A distant observer will see every aspect of time slow down for an object falling into a gravity well, including the ageing of a volunteer, and the rate at which they are falling.**

# Specifically for Black Holes




Volunteer finds herself rapidly falling through event horizon, she is noodleized, and dies

Distant observer sees Doppler and gravitational redshifts

Received photons get longer, longer wavelength

Time between photons gets longer and longer

***Infinite time*** for last photon emitted just as volunteer reaches the event horizon; space is moving inward at the speed of light compared to distant observer

⇒***Distant observer never sees volunteer cross the horizon***

⇒***Photons get undetectable, very long wavelength, most of the time is between photons - absolutely black*** **- why black holes are black.**

A distant observer watching an object falling into a black hole will see it getting dimmer and dimmer and ageing more and more slowly.

A distant observer will perceive an object to turn black, stop ageing, and stop falling and never see the object fall inside the event horizon.

An observer within a gravity well will see a clock, or a human, far away (in less-gravitating, less curved space) ageing more rapidly.

One Minute Exam

From the point of view of a distant observer, a volunteer who falls into a black hole

➡ Will be noodleized and die

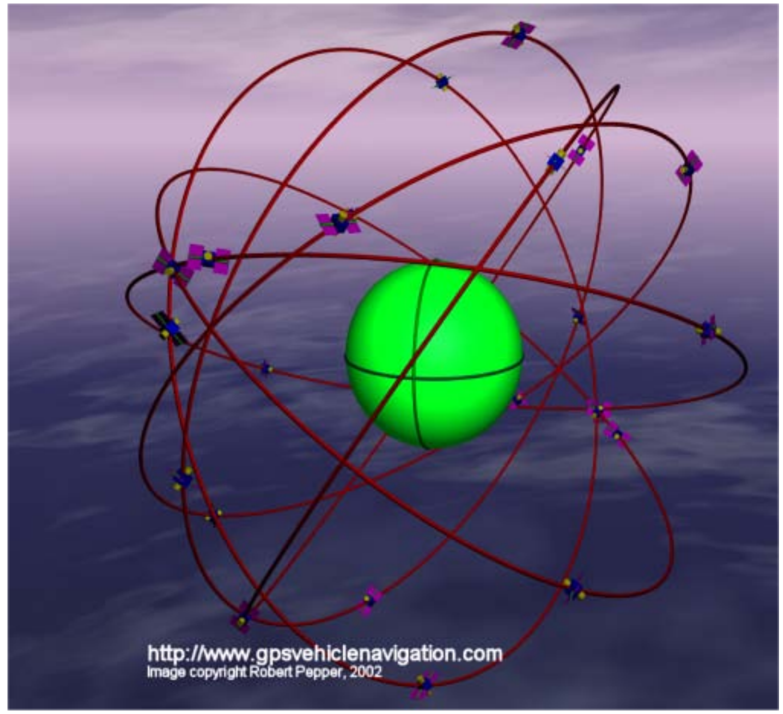
⬅ Will turn black before arriving at the event horizon

⬆ Will age more rapidly

⬇ Will shrink to a point

Device to measure the curvature of space and the different flow of time at various levels in a gravitational field.

# One especially fascinating application: the Global Positioning System



GPS depends not only on an array of satellites in orbit, but must be programmed to understand Einstein's theory of warped space and time to function properly.