Physics 130 General Relativity Seminar Week-6 Fall 2008

Readings: Woodhouse - General Relativity
Chapter 1 - Newtonian Gravity
Chapter 2 - Inertial Coordinates and Tensors
Chapter 3 - Energy-Momentum Tensors

Present Ideas and Lead Discussion:

Chapter 1	__Ben P_____
Chapter 2	__Erin_____
Chapter 3	__Robert_____

Present Problems:

1.1 - Gauss law	__Ben P_____
1.2 - Phase portraits	
1.3 - Accelerating pendulum	
1.4 - Hollow ball in a bucket	__Ben G_____
1.5 - Einstein's birthday present	
2.1 - Summation notation	__Erin_____
2.2 - Direct product	
2.3 - The alternating symbol 1	__Markus_____
2.4 - The alternating symbol 2	
2.5 - Maxwell's equations	__Eric_____
2.6 - Dual tensor	
2.7 - No magnetic field	
3.1 - Unique rest velocity	
3.2 - Symmetric tensor	__Robert_____
3.3 - EM energy-momentum tensor	__Emma_____
3.4 - Null vectors	
3.5 - Perfect fluid	

EP19. __Margaret___

Poisson's formulation of Newtonian gravity is

$$\nabla^2\phi = 4\pi\rho \quad , \quad \vec{g} = -\nabla\phi$$

where ρ is the matter density, ϕ is the gravitational potential and $\vec{g}$ is the acceleration due to gravity. Show that this gives the usual Newtonian formula for a point-like source.

EP20. __Chris_____

Tides occur because the force of gravity is slightly different at two nearby points, such as a point at the earth's surfaced and at its center.

(a) What is the difference between the gravitational acceleration induced by a mass M (the sun of the moon) evaluated at the center and at a point on the surface of a sphere of radius r (the earth) located a distance R from M (take r << R). Write the radial component of this difference at the surface as a function of the angle from the line joining the two objects. How many high/low tides are there in a day?

(b) If the earth were a perfect sphere covered with water, compute or estimate the height difference between high and low tides(ignoring complications such as rotation, friction, viscosity) for spring tides (directions of sun and moon aligned) and neap tides (sun and moon at right angles).

(c) A neutron star is a collapsed object of nuclear density with mass $M=1.4M_{Sun}$,and radius R=10 km. In Larry Niven's short story Neutron Star(1966), tidal forces in the neighborhood of the title object prove fatal to the unwary. What is the tidal acceleration across the diameter of a person (say a distance of 1 m) at a distance of 100 km from a neutron star?

EP21. __Sam_____

A hollow sphere has density ρ, inner radius a and outer radius b. Find the gravitational field in the region r < a. Suppose now that the sphere were invisible. Could an observer at the center deduce its existence without leaving the region r < a?

EP22. __Ben G_____

(a) Compute the gradient of the gravitational field $\partial g_i / \partial x_j$ (a nine component object) corresponding to a sphere of density ρ and radius R centered at the origin.

(b) Find a mass distribution $\rho(x,y,z)$ on a bounded domain, that is, zero whenever $x^2+y^2+z^2>R^2$ for some positive constant R; uniformly bounded, i.e., $|\rho(x,y,z)|<C$ for some positive constant C independent of position; and for which at least one component of the gradient of the gravitational field is infinite at some point.