SMMG: Relativity Saturday, October 8, 2005 Dr. Jack Calcut

- Often in physics, one makes _____, then formulates _____. Using _____, one then attempts to describe the motion of objects over time.
- Newton's laws of motion describe: _____ and _____, for example.
- In Newtonian physics, velocities _____ and there is absolute _____.
- Einstein is a household name, but _____ and _____ also played a major role in discovering Special Relativity (SR).
- A Law in SR: the speed of light c is _____. c is approximately _____ in a vacuum.
- _____ is not absolute in SR.
- The Lorentz Transformation gives us the SR Velocity Addition Formula as follows. Body A moves at a constant velocity a with respect to body C. Body B moves at a constant velocity b with respect to body A. Then:

$$\text{The Velocity of } B \text{ Relative to } C = \frac{a+b}{1+\frac{ab}{c^2}}.$$

1. A is a spaceship travelling with velocity $a = c/2$ with respect to spaceship C. A beam of light B is emitted in the direction of travel of ship A. How fast does ship C observe the beam to be travelling? Explain. What would Newtonian physics predict?

2. If a and b are small compared to c, then what happens? Explain.

- SR, along with mathematics, yields possibly the most famous equation: _____.
- In General Relativity, Gravity is _____.
- A _____ is a living creature with (roughly) two spacial degrees of freedom.
- A circle is a _____ dimensional object.
- Draw two examples of interesting $2D$ objects.

- Let X and Y be subspaces of $\mathbb{R}^n$ where X has dimension i, Y has dimension j, and X and Y intersect *generically*. Then:

$$\text{Dimension of } X \cap Y = \_\_\_\_\_.$$

- A simple example of this dimension formula in action is: _____.

3. Let X be a line and Y a plane in $\mathbb{R}^4$. Find $\dim(X \cap Y)$ and $X \cap Y$.

4. Let X and Y both be planes in $\mathbb{R}^4$. Find $\dim(X \cap Y)$ and $X \cap Y$.

- A knot is a loop tied in some space. Moving and bending of a knot is allowed. Cutting is not allowed.
- A knot can only be tied in $\mathbb{R}^n$ when $n =$_____.

- Draw the unknot and a knotted knot.

5. While on the beach you notice a person down the beach struggling in the water. You decide to help. Which path do you take to the swimmer?

- Light follows the path that minimizes _____.
- GR and Mathematics predicted the existence of _____ in 1915, long before there was any observational evidence for them.

Recommended Reading:

- *The Knot Book*, Colin Adams, W.H. Freeman and Co., 1994.
- *Relativity: The Special and General Theory, A Clear Explanation that Anyone Can Understand*, Albert Einstein, Crown Pub., 1951.
- *What is Mathematics?* Richard Courant and Herbert Robbins, Oxford Univ. Press, 1996.