Homework 8

Due Tuesday, February 26th in class

Readings we have done so far and topics in each book:

From Sundials to Atomic Clocks: Chapters 1-5.

- Time as a duration. Time as an interval. Time as a 'when'.
- Natural clocks from natural cycles—stars, planets, ...
- Clocks made from oscillating or repeating behaviors: pendulums, springs, ...
- Clocks require a resonator/energy source /counter.
- Quality factor (not on this exam).

The Order of Time: Chapters 1-5.

- Loss of unity. Time is not the same for everyone.
- Loss of direction. Although we experience time as "flowing" from *past* $\rightarrow$ *present* $\rightarrow$ *future*, the basic laws of physics have no such direction.
- Simultaneity is not a valid concept for two different observers.
- Aristotle & Newton's ideas of relative and absolute time, and why we know these are not valid.
- Space and time and the fields that fill them.
- Quanta of time (not on this exam).

A Brief History of the Philosophy of Time: Chapter 1.

- Zeno's paradoxes and how our resolution informs our view of time.
- Relationalism—time as a measurement of change, not the change itself.
- What is real about time? The moment 'now'? The passage of time?
  How much should we expect the reality of time to match our perceptions of it?
- Augustine's thoughts on time (not on this exam).

Lessons from labs:

- A variety of cycles as clocks—pulse, pendulums, springs, ...
  Dependability of clocks: factors that affect stability or reliability of measurements, causes of variation.
- Systems of behavior as shown by regularity—fitting data, making predictions.
- Similarities and analogies in various Restoring/Inertial oscillating systems.

- Simple Harmonc Motion: One frequency, independent of amplitude.

Time as Einstein's Special Relativity makes us think about it:
Postulates:

1. Principle of Relativity: The laws of physics are the same for all observers.
2. Universality of c: The speed of light is the same for all observers

Consequences:

1. Relativity of simultaneity: temporal order is different for different observers.
2. Time dilation: $\Delta\, t = \gamma\, \Delta\, t'$.
3. Length Contraction: $L = L' \,/\, \gamma$.
4. Einstein's velocity addition formula (see below).

Basic Physics we relied on:

- Description of motion in terms of position, velocity, acceleration.
- Explanation of motion in terms of forces, inertia, $F = ma$.
- Restoring force and how this leads to Simple Harmonic Motion.
- Examples of different oscillators.

Thought questions:

1. Every four years (almost), we add February 29^{th} to the year to keep our calendar in sync with the earth's motion around the sun. Does either the earth's position in its orbit or the calendar have a more legitimate claim to be "the real time"?
2. In Lab 3, your group used one spring and varied the mass hanging on it, then measured and plotted T^2 *vs.* m to test the inertial dependence in the model T^2 = Inertial/Restoring. Describe in detail what you would do to test the restoring dependence in this model.
3. Matt and the rest of the class are sitting in Hegeman 106 watching Hal go by on train car that is moving at $v_{AB} = \frac{1}{2}\, c$ relative to the class. Hal fires a gun that shoots an electron forward at a speed of $v_{BC} = \frac{3}{4}\, c$ relative to Hal. Find v_{AC} using

$$v_{AC} = \frac{v_{AB} + v_{BC}}{1 + \frac{v_{AB} \cdot v_{BC}}{c^2}}$$

   (a) Find a number for v_{AC} and put into words what that answer means.
   (Here: A refers to the classroom; B refers to Hal; C refers to the electron.)

   (b) What would you respond to someone who says, "Doesn't the electron have a speed greater than c?"