4 Rods and Clocks

1. The problem:
   - a. Galileo and Newton assumed measurement as invariant. Measured distances and times in one frame of reference would be the same in any frame of reference.
   - b. In special relativity, the invariant is ds, a four dimensional number that includes x, y, z, and t (time) as well as the speed of light "c".
     - i. This means that the spatial elements by themselves are no longer invariant as one moves from one frame to another. Likewise for the temporal element. Rather, it is some combination of these that is invariant (ds).
   - c. Since we start out with Newtonian notions of "measurable magnitudes, standard units, measuring, and measurement" these need to be recast in light of relativity.
   - d. What is the point of recasting? "…to reinforce the point that absolutes do not lie in the field of sensible particulars and to disassociate our account of the abstract intelligibility of Space and Time from the paradoxes that too readily have been supposed to be inherent in the Special Theory of Relativity." (170 in old text).

4.1 The Elementary Paradox

1. Laying out the context:
   - a. In reference frame K, point P is at (x_1, t_1) and Q is at (x_2, t_2)
   - b. In reference frame K', point P is at (x'_1, t'_1) and Q is at (x'_2, t'_2)
   - c. With the Lorentz-Einstein transformation equations, when can move from P in K to P in K' and Q in K to K', or vice versa. Lonergan gives one set, namely transforming K into K'.

   B. The spatial application or the temporal application
   - a. Spatial
     - i. This is where the time difference in K is zero ($t_2 – t_1 = 0$, equation 3)
     - ii. The distance is 1 ($x_2 – x_1 = 1$, equation 4)
     - iii. Using the transformation equations (1 and 2), the distance is calculated to be H (equation 5), and time becomes $–uH/c^2$ (equation 6).
   - b. Temporal
     - i. This is where the spatial difference in K is zero ($x_2 – x_1 = 0$, equation 7)
     - ii. The time is given as 1 ($t_2 – t_1 = 1$, equation 8))
     - iii. Using the transformation equations (1 and 2), the distance is then calculated to be –uH (equation 9) and H (equation 10)

   C. Three interpretations of the applications
   - a. Fitzgerald contraction
     - i. Rod has contracted

ii. Time has contracted

iii. Assumes clock time is constant, non-changing, and so simultaneity could be determined.

iv. I think this is where Ron Vardiman's corrections of the equations will help to clarify the confusion in this paragraph?

b. Special relativity

i. Synchronize clocks not by looking at them and setting them to the same time because one is reading them simultaneously but rather by presuming the constancy of the speed of light in all reference frames.

ii. Thus take each spatial-temporal pair together to develop a better interpretation.

1. In the spatial application: In K, using the equations 3 and 4, t is 0 and hence x_2 and x_1 are simultaneous but, in transposing to frame K' in equations 5 and 6, t is different, hence the readings of x_2 and x_1 are not simultaneous.

2. In the temporal application: In K, equations 7 and 8, t is different for x_2 and x_1, and the transformation to K' in equations 9 and 10 results in a different in time that is a factor both of the temporal difference in 8 as well as the us of the constant speed of light to synchronize clocks. Thus, notice that the length moves from 0 to –uH. (u = velocity)

c. Minkowski space

i. Assumptions

1. Differences of position are not merely spatial differences.

2. Differences of time are not merely temporal differences

3. Rather, such differences are both spatial and temporal.

ii. The invariants

1. spatial: s (not length)

2. temporal: ic (not duration)

3. rooted upon theoretical principles and invariant expressions.

4. Thus, in different frames of reference s and ic stay same. But the measure lengths and measured times will vary.

iii. Normal and abnormal frames

1. Normal: differences of position have no temporal difference; or temporal differences have no spatial difference.

2. Abnormal: differences in both.

3. For actual measurements, therefore, one should use the normal frame so as not to be confused by the elementary paradox.

d. Second and third complementary, first contradictory.

4.2 Meaning of Measurement

1. Measurement transitions one from descriptive knowledge to explanatory. In descriptive, one grasps things as related to our senses. In explanation one moves to things in relation to other things. Measurement helps to effect this transition, because it begins to form data in a many that allows for insights into the patterns of

things distinct from our sense impressions. However, there is still a difficulty in making this break when the measurement itself requires the use of our sense impressions. Hence the problem of simultaneity, etc…

2. In constructing a way of measuring, one turns to a **standard unit**. The unit is simply designate as one, and then all other measurements are construct in relationship to this "one." Lonergan defines a standard unit as "a physical magnitude among other similar physical magnitudes."

- a.The conventional and the arbitrary: "the standard foot is the length between notches on a bar at a certain temperature in a given place." The fact that a foot has the length it possesses is arbitrary.
  - b.The theoretical element: Meaning of length, relation of length and temperature, relation of length and position and time, relation of length and frames of reference.
    - i.If the meanings of these are discovered empirically, then new empirical results might shift what they mean.
    - ii.If the meanings of these are methodological, then revisions of basic presuppositions and presumptions will result in a shift in what these mean.
    - iii.THE POINT: ABSOLUTE RESIDES IN FIELD OF ABSTRACT PROPOSITIONS AND INVARIANT EXPRESSIONS (U), NOT ON THE LEVEL OF SENSIBLE PRESENTATIONS (E). Eg. Constancy in time of a length of a bar is not affirmed by comparing its length yesterday with its length today. Rather the constancy is a result of general knowledge. One has to ascertain all the different ways change of length can take place, then eliminate or factor these in, in order to compare. Hence, conclusion of constancy of standard is based on invariant laws, and revision in laws will result in new determination of standards.
    - iv.The Possibility of revision of standards based on the advance of data → inquiry, inquiry → insight, insight → formulation of premises → deduction of implications → material operations → fresh data → new inquiry..... eventually to higher viewpoints, and a revision of standards.

3. Actual Measurement: Applying standard units

- a.defining the magnitude
- b.defining the procedure that leads from the measurable magnitude and standard to the actual measurement. (hence a **measurement** is an actual determination of a measurable magnitude in terms of a standard).
  - c.Formed in the light of acquired knowledge, may undergo revision if leaps to higher viewpoints are made.