

SDI #2 PRE-LAB ASSIGNMENT
OPERATIONAL DEFINITIONS OF KINEMATIC TERMS^{*†}

NAME _____
Last (Print Clearly) First (Print Clearly) ID Number

LAB SECTION _____ LAB TABLE POSITION _____

*The true meaning of a term is found by observing
what a man does with it, not what he says about it.*
P.W. Bridgman

A. DEVISE OPERATIONAL DEFINITIONS OF KINEMATIC TERMS

We agree with the *The Mechanical Universe* standpoint that it is almost impossible to understand terms such as "velocity" and "acceleration" without some knowledge of the basic ideas of differential calculus. Thus, in our view, the appellation "non-calculus physics text" is a contradiction in terms. Authors of *effective* "non-calculus" physics texts must negate their own "non-calculus" claims: most of them give an expression for instantaneous velocity in one dimension:

$$v = \lim_{\Delta t \rightarrow 0} (\Delta x / \Delta t) \equiv (dx/dt), \dots\dots\dots(1)$$

but omit the right-hand side of this equation (the identification of the derivative "dx/dt"), possibly because they fear it might frighten students and/or jeopardize their book's position as a "non-calculus" text.

Satisfactory completion of this section will help to insure that you have entered into the Newtonian-Leibnitz world of differential calculus,** at least to the extent of understanding the *operational* meaning of the basic kinematic terms and thus being prepared to consider the experiments in SDI #2, *Newton's Second Law*. Please recall from the discussion in SDI Labs #0.1 and #1 that *an operational definition of a word or words specifies the experimental significance of those words in terms of **well-defined measurement methods***.

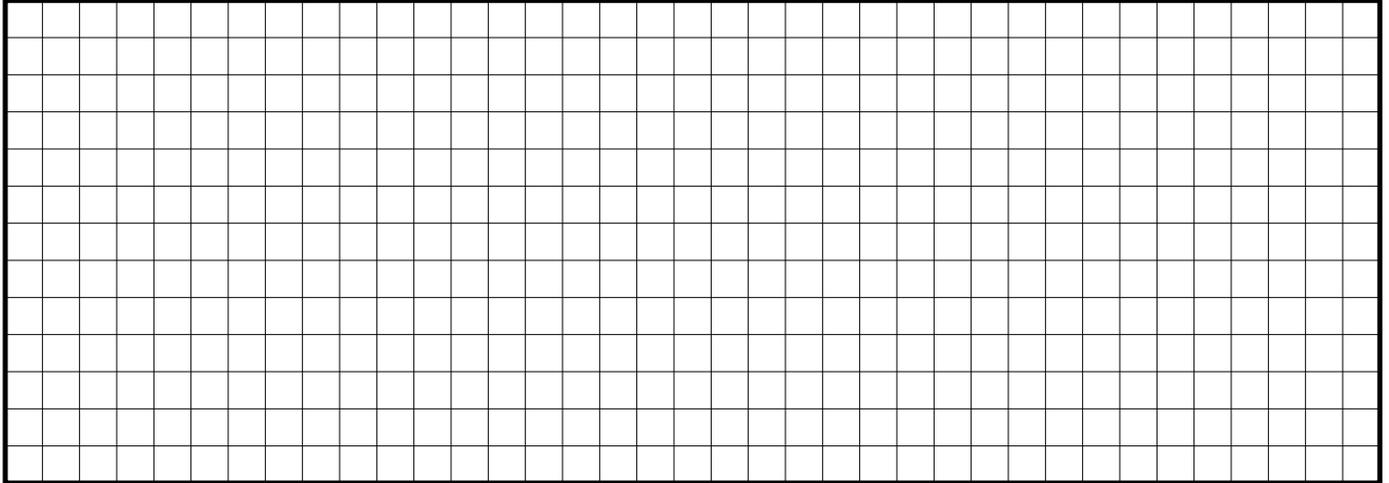
Please indicate, in your own words and/or sketches [one sketch or graph is worth a teraword (1.0 x 10¹² words)] **operational definitions** of the *crucial kinematic terms* given on the following pages.

* RRH, 6/1/97. Partially supported by NSF Grant DUE/MDR-9253965. © Richard R. Hake, 1997. (You may change, modify, copy, and distribute at will for use in your own institution, but please contact R.R. Hake before distributing your version beyond your own institution.)

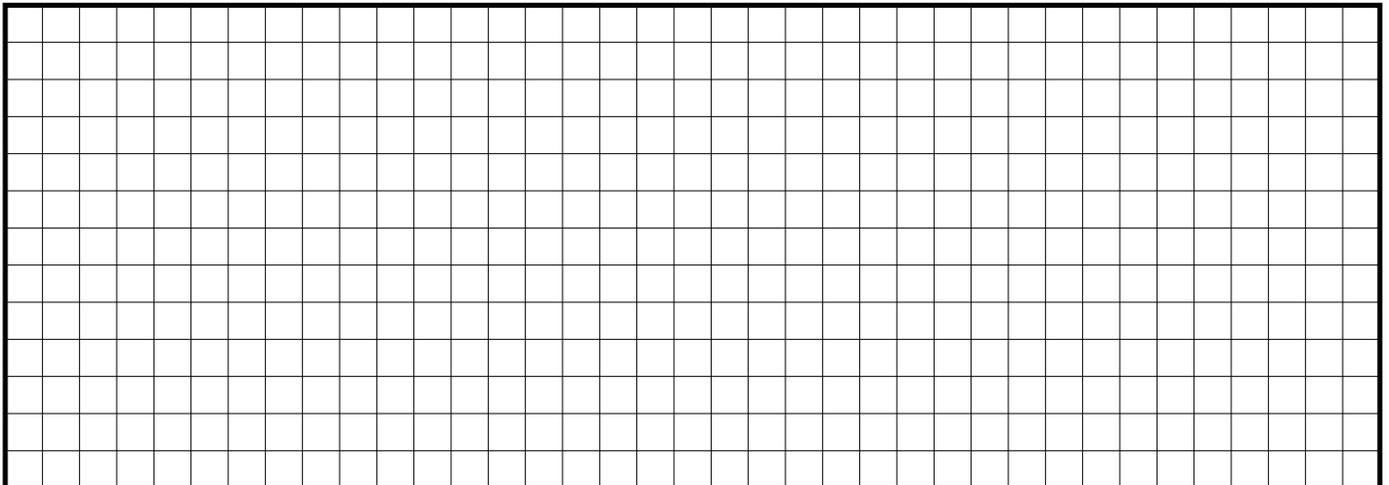
† Adapted from A.B. Arons, *A Guide to Introductory Physics Teaching* (John Wiley, New York, 1990) p. 15-17, 20-90.

** For a stunning presentation of the elements of differential and integral calculus view the *Mechanical Universe* tapes, *Derivatives* and *Integration*. For more information see <http://www.projmath.caltech.edu/mu.htm#MU_TOC1>

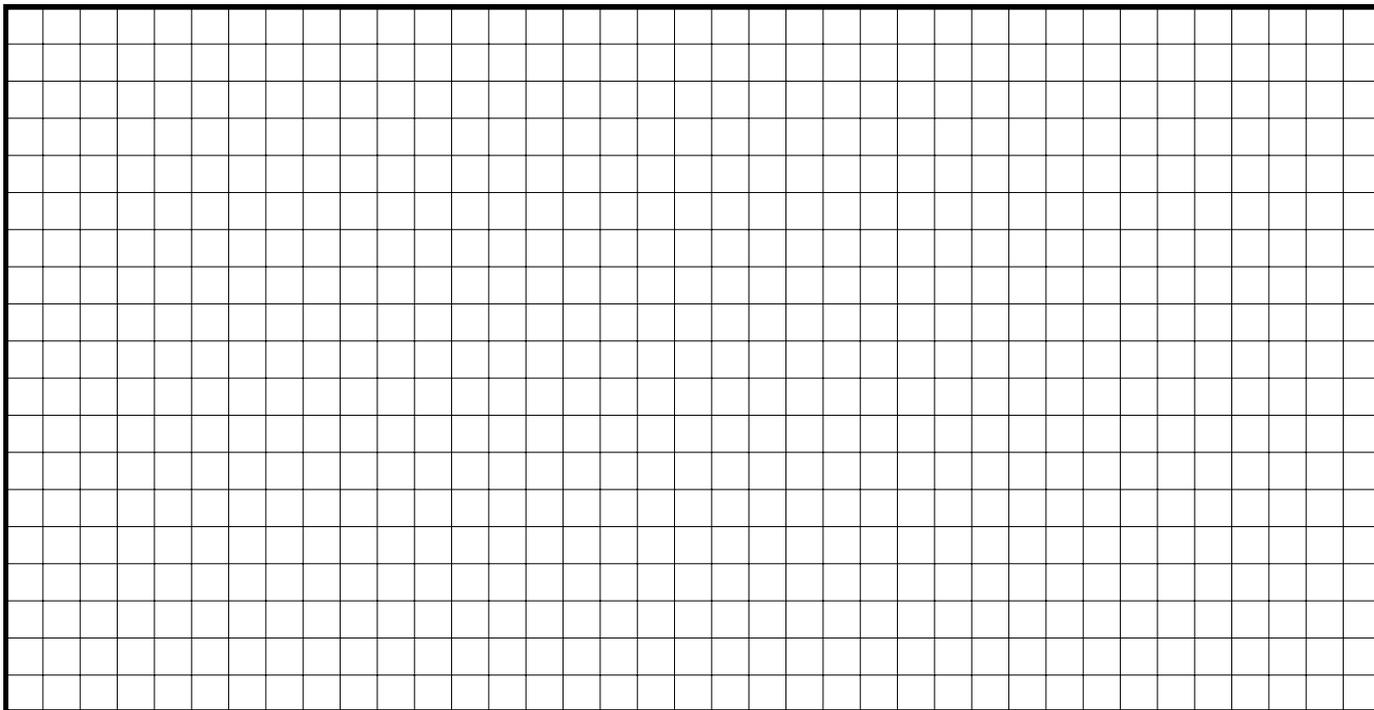
1. *Position* [HINT: Recall your work in SDI Lab #0.1. How did you *measure* your position in that lab? Recall that your operational definition of "position" was to have consisted of a sketch of a your position vector \vec{r} between an origin O and a point "P" in an xyz-coordinate reference frame, along with a statement of the operations for *marking* the coordinate scales and then *measuring* your position coordinates.]



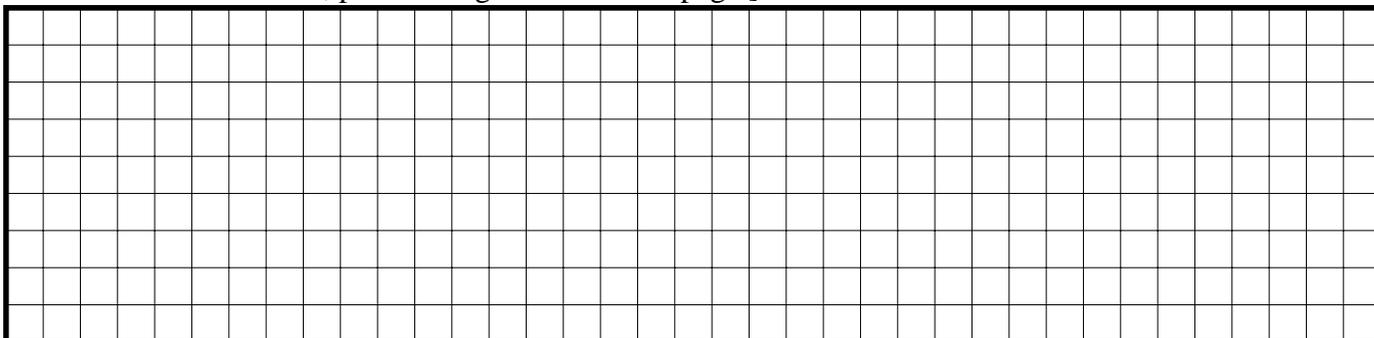
2. *Instantaneous Position* [HINT: Return to this after completing "5" below.]



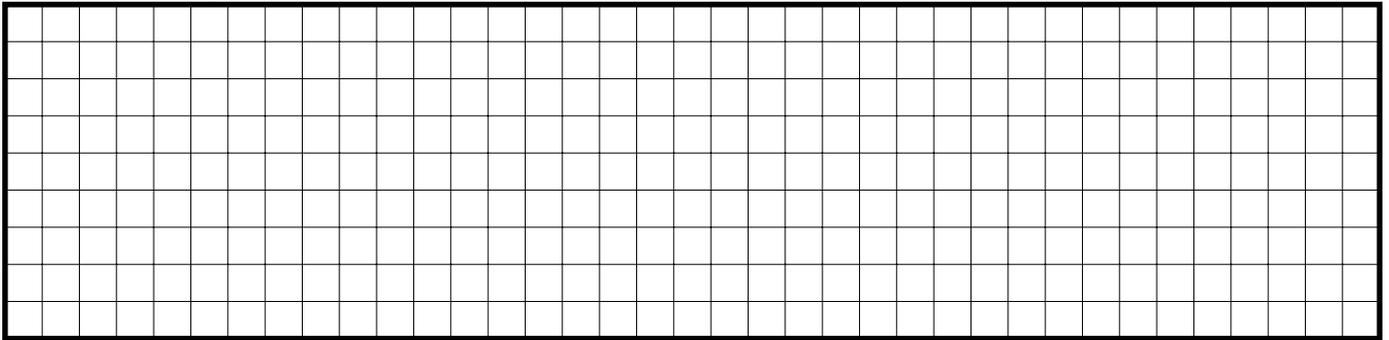
3. *Displacement* [HINT: Do you recall walking from one position to another position in the lab as part of SDI Lab #0.1? How did you define your displacement vector between your initial and final positions in terms of initial \vec{r}_i and final \vec{r}_f position vectors?] Draw a *diagram*!



4. *Time* [HINT: What instrument measures "time"? See SDI Lab Ground Rule #5 concerning snapshot sketches in SDI Lab #0.1, p. 3 and Fig. 1 on the next page.]



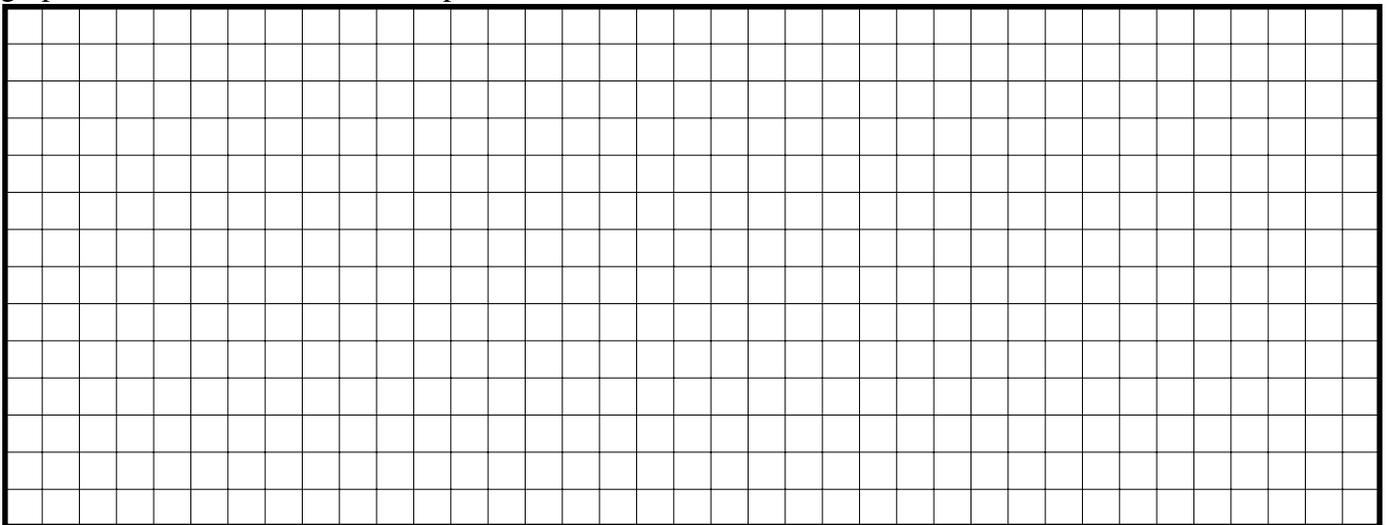
6. *Clock reading* (Its name is its definition! See also Fig. 1)



a. Considering their operational definitions, are "4," "5," and "6," all equivalent? {Y, N, U, NOT}

7. *Continuous (in time) Motion* [HINT: Recall from your previous study of mathematics that a continuous function, say y as a function of x or $y(x)$ is "continuous" if Δy approaches 0 as Δx approaches 0. In graphical term $y(x)$ is continuous if the curve $y(x)$ can be drawn with one uninterrupted motion of a pencil. Applying this to kinematics, if the displacement x is a *continuous* function of the time t , how would the curve of $x(t)$ (i.e., x as a function of t) appear on a graph? Show such a curve in the space below and label it "Continuous."

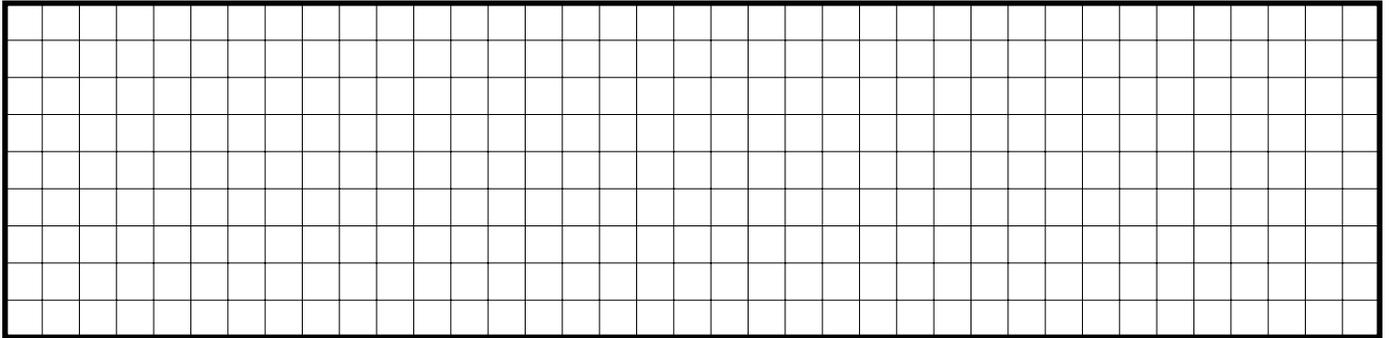
If the displacement x is a *discontinuous* function of the time t , how would the curve of $x(t)$ appear on a graph? Show such a curve in the space below and label it "Discontinuous."



How could the continuous curve $x(t)$ shown above be measured? (This, then, would be an *operational* definition of *continuous motion*.)

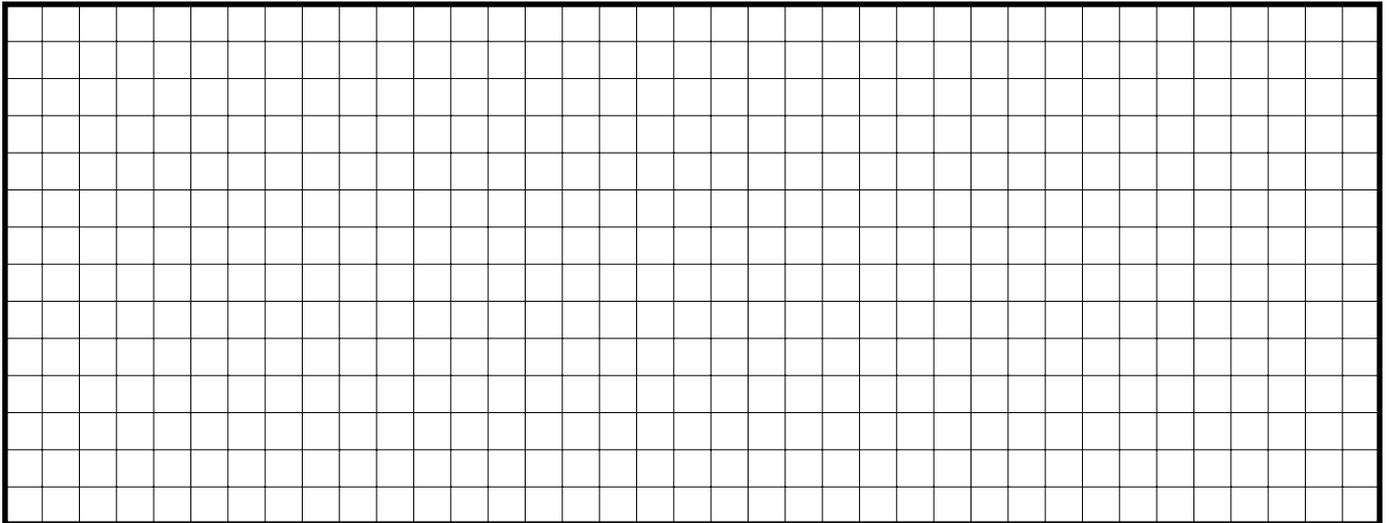
Could the discontinuous $x(t)$ curve shown above represent a physically reasonable situation?
{Y,N,U,NOT}

8. *Time Interval*

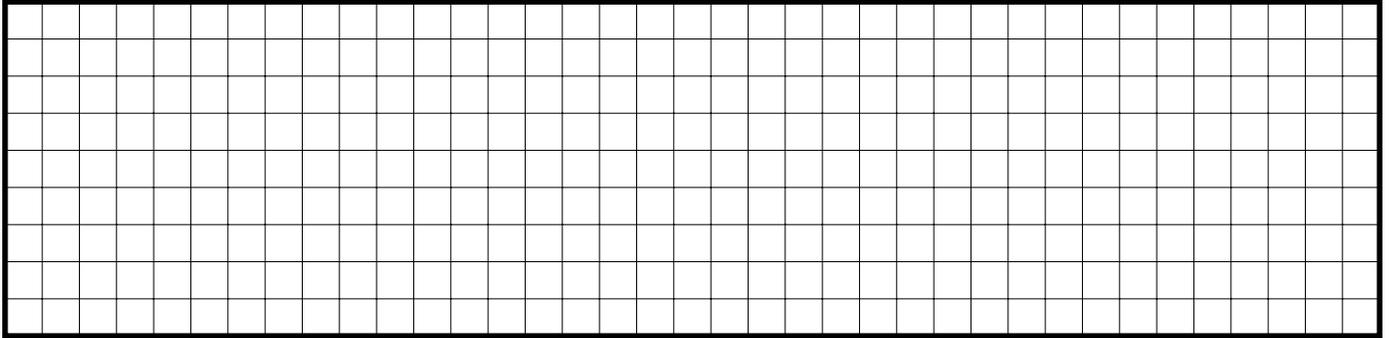


9. *Instantaneous Velocity* (Henceforth, in this lab "velocity" v will always mean "instantaneous velocity."). [HINT: For simplicity consider only one dimensional (1D) motion. For an operational definition of v in the x direction, consider the way in which you obtained your displacement x vs time t graph in SDI #0.2, *Introduction to Kinematics*. Alternatively consider taking a sequence of camera snapshots *at equal and closely spaced intervals of time*. Could such a sequence of snapshots be used to construct a graph of x vs t for 1D motion or for the x component of 3D motion?
{Y, N, U, NOT}

How could graphs of x vs t be used to define *instantaneous velocity* v in the x direction?]

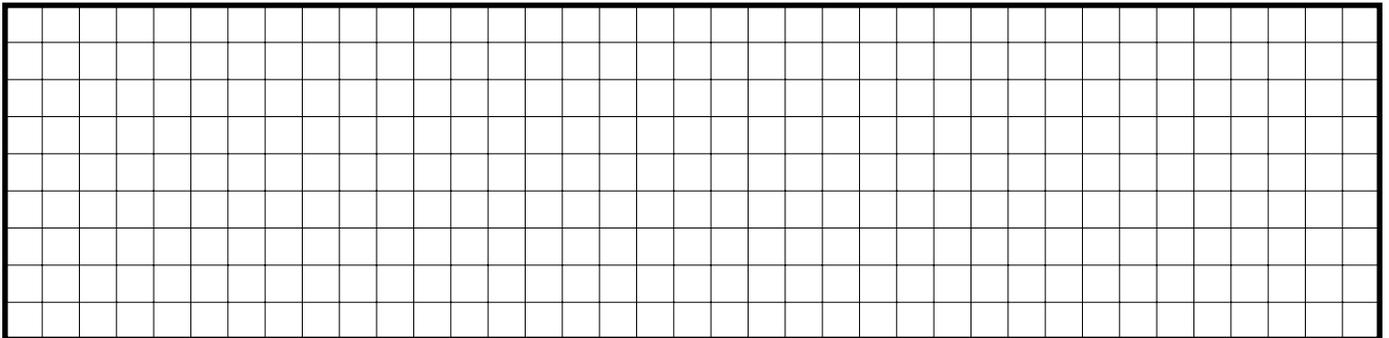


10. *Uniform Velocity* [HINT: "Uniform" simply means constant in time.]

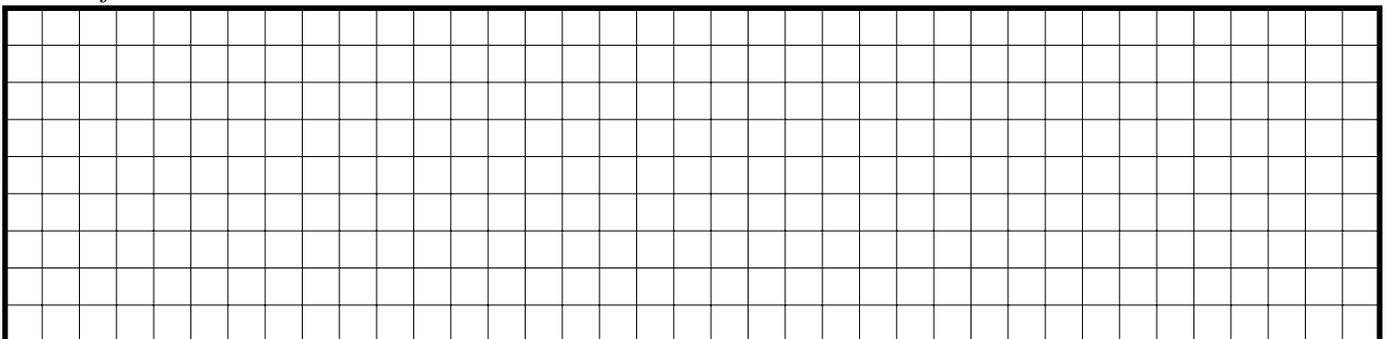


- a. Suppose an object moves at a *uniform velocity*. Does it stay at one position during some small time interval? {Y, N, U, NOT}

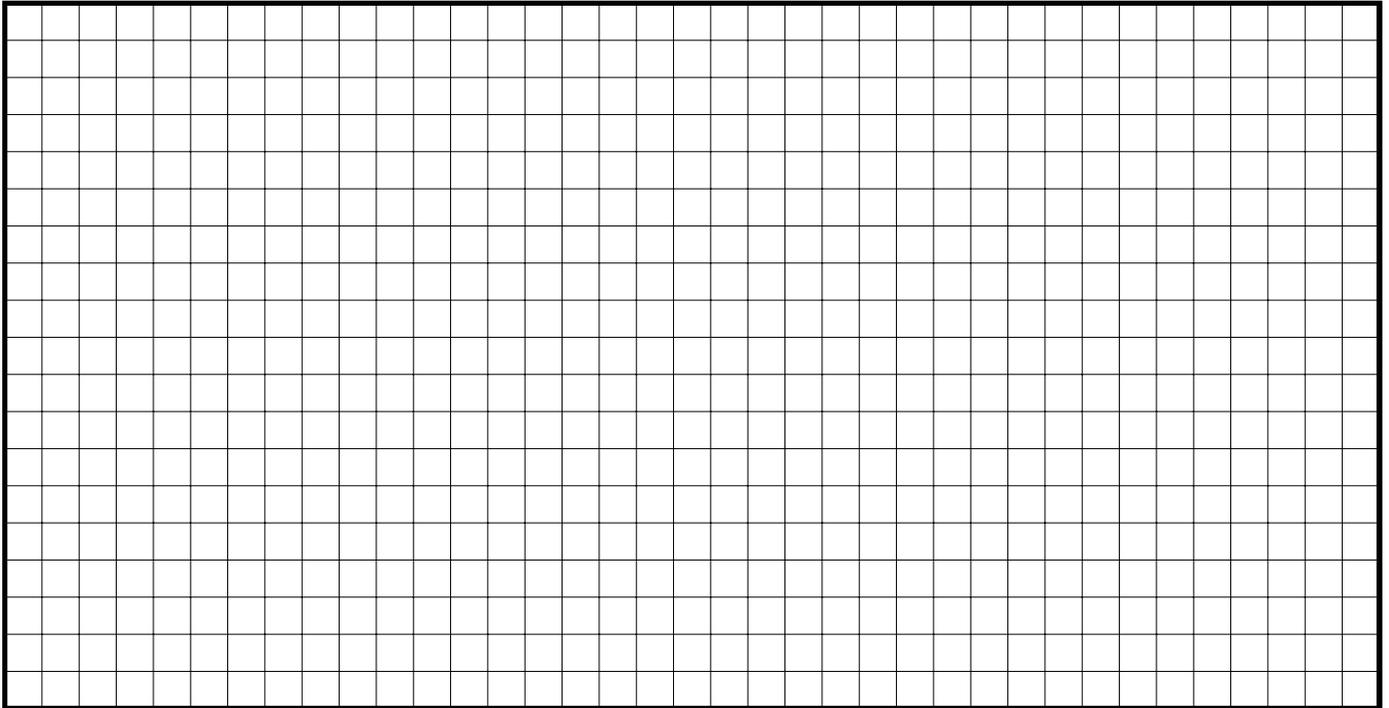
11. *Instantaneous Acceleration* (Henceforth, in this lab "acceleration" will always mean "instantaneous acceleration.") [HINT: The operations suggested to define *instantaneous velocity* v above in "9" will allow the construction of a v vs t curve. How could such a curve be used to define *instantaneous acceleration*?]



12. *Uniform Acceleration*



13. *Inertia* [HINT: Newton's first law is often called the "law of inertia."]



Do you know what property of a body gives a quantitative measure of its inertia? {Y, N, U, NOT}

14. *Inertial Reference Frame* [HINT: Recall the discussion of Inertial Reference Frames (IRF) in the Funky Winkerbean exercise of SDI Lab #1.

