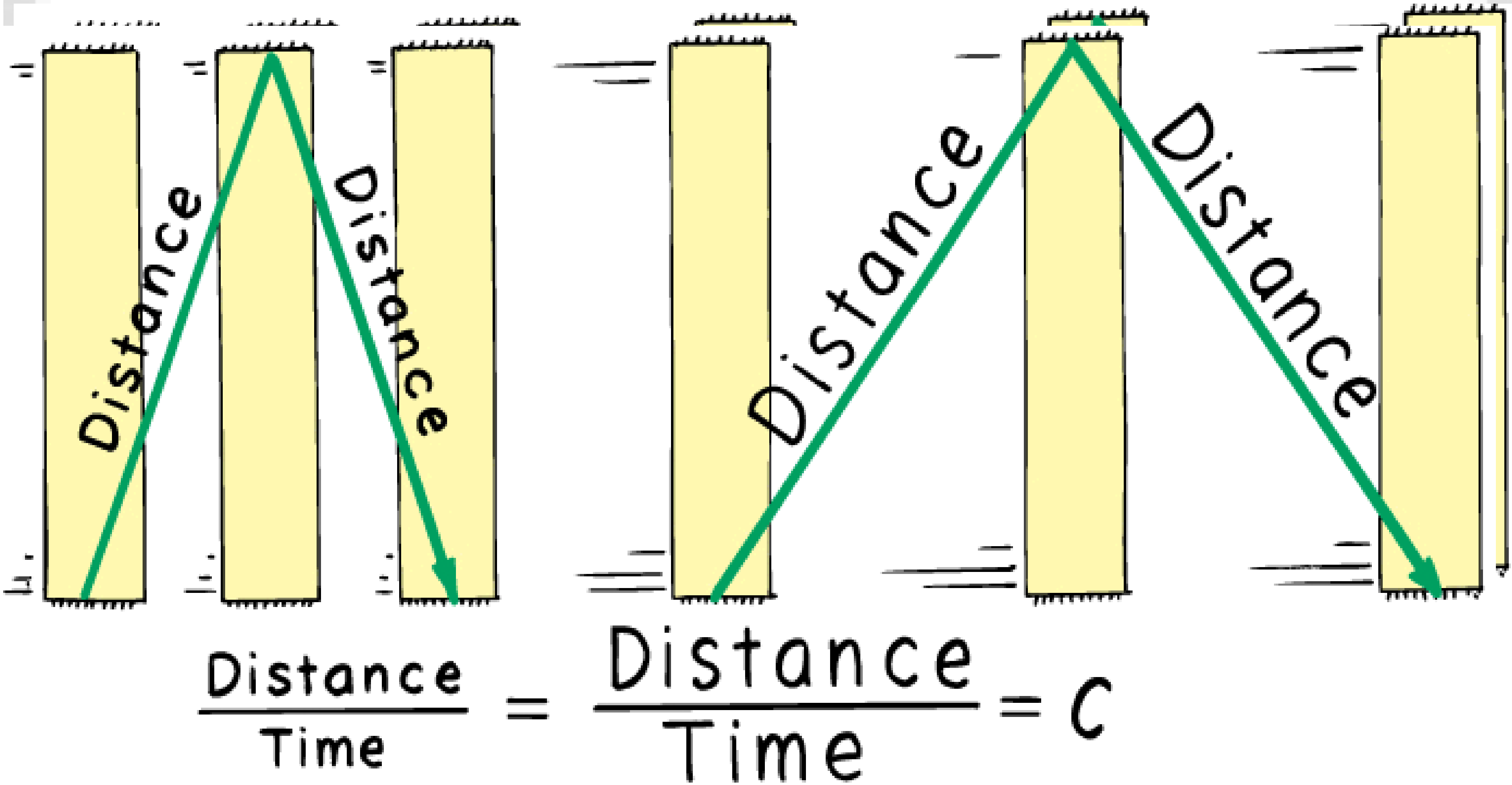
LENGTH CONTRACTION
TIME DILATION

BECAUSE THE SPEED OF LIGHT IS THE SAME IN ALL REFERENCE FRAMES (EINSTEIN'S SECOND POSTULATE)

- The flash must travel for a corresponding longer time between the mirrors in our frame than in the reference frame of the on-board observer.
- The longer diagonal distance must be divided by a correspondingly longer time interval to yield an unvarying value for the speed of light.
- This stretching out of time is called **time dilation.**

THE LIGHT CLOCK IS SHOWN IN THREE SUCCESSIVE POSITIONS



Hewitt, *Conceptual Physics*, Ninth Edition.

THE LIGHT CLOCK IS SHOWN IN THREE SUCCESSIVE POSITIONS

- Diagonal lines represent the path of the light flash as it starts from the lower mirror at position 1, moves to the upper mirror at position 2, and then back to the lower mirror at position 3.

- Distances on the diagonal are marked *ct*, *vt*, and *cto*, which follows from the fact that the distance traveled by a uniformly moving object is equal to its speed multiplied by the time.

TIMES

- t_o = time it takes for the flash to move between the mirrors as measured from a frame of reference fixed to the light clock.
- This is the time for straight up or down motion.
- Speed of light = c,
- Path of light is seen to move a vertical distance ct_o. This distance between mirrors is at right angles to the motion of the light clock and is the same in both reference frames.

- t = the time it takes the flash to move from one mirror to the other as measured from a frame of reference in which the light clock moves with speed *v*.
- Speed of the flash is c and the time it takes to go from position 1 to position 2 is t, the diagonal distance traveled is ct.
- During this time t, the clock (which travels horizontally at speed *v*) moves a horizontal distance vt from position 1 to position 2.

THREE DISTANCES MAKE UP A RIGHT TRIANGLE

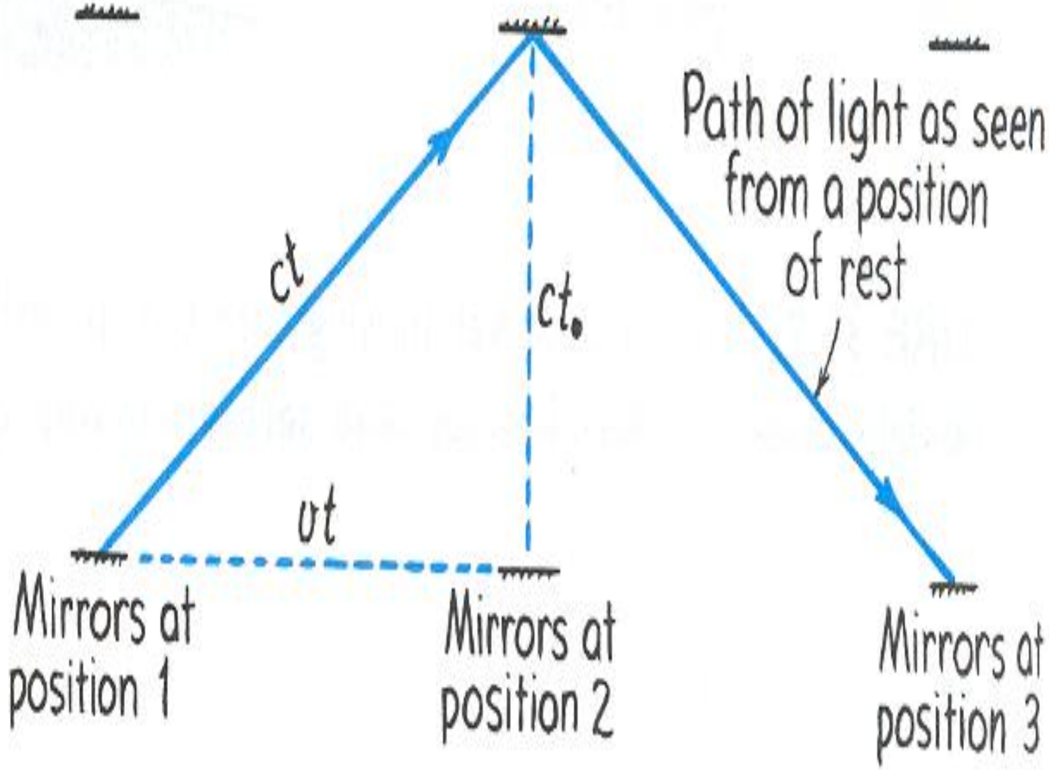
$$c^2t^2 = c^2t_0^2 + v^2t^2$$

$$c^2t^2 - v^2t^2 = c^2t_0^2$$

$$t^2[1 - (v^2/c^2)] = t_0^2$$

$$t^2 = \frac{t_0^2}{1 - (v^2/c^2)}$$

$$t = \frac{t_0}{\sqrt{1 - (v^2/c^2)}}$$



RELATIVE TIME

- The relationship between the time t_o (call it proper time) in the frame of reference moving with the clock and the time *t* measured in another frame of reference (call it the *relative time*) is:
- *v* =speed of the clock relative to the outside observer (the same as the relative speed of the two observers)
- c = speed of light

LENGTH CONTRACTION

- As objects move through space-time, space as well as time changes
- In a nutshell, space is contracted, making the objects look shorter when they move by us at relativistic speeds.
- What contracts is space itself.

LORENZ CONTRACTION

- v = relative velocity between the observed object and the observer
- c = speed of light
- L = the measured length of the moving object
- L_o = the measured length of the object at rest.

$$L = L_o \sqrt{1 - \frac{v^2}{c^2}}$$