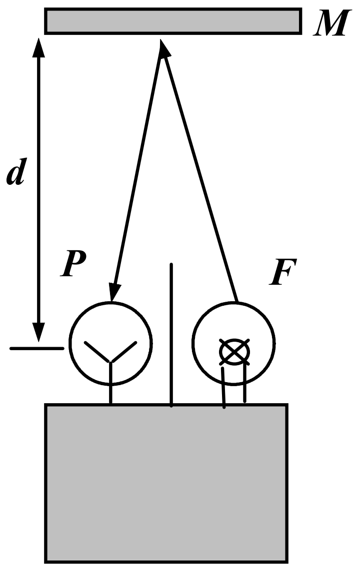
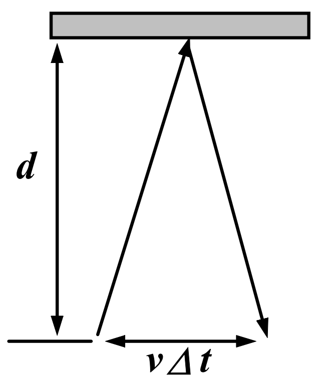
PHY 5347
Homework Set 8 Solutions – Kimel

2. 11.4 The "clock" is shown in the figure



a) To the observer the pulse travels the trajectory



Thus, if the speed of light is c in both reference frames,

$$c\Delta t = 2\sqrt{d^2 + \left(\frac{v\Delta t}{2}\right)^2}$$

or

$$\Delta t = \frac{2d}{c\sqrt{1 - v^2/c^2}} = \gamma\Delta\tau$$

b) Now let us assume the clock-mirror system is moving away from the observer with speed v. Assume the fixed and moving frames coincide when a light pulse is given off. In the moving frame the time required for the light wave to move to the mirror and then to the phototube detector is given by

$$\frac{2d}{c} = \Delta t'$$

In the rest frame, the light hits the mirror in a time determined by

$$c\Delta t_1 = \frac{d}{\gamma} + v\Delta t_1$$

where $\frac{d}{\gamma}$ comes from the fact that the moving distance d is "length contracted." Solving for Δt_1

$$\Delta t_1 = \frac{d}{\gamma\,(c - v)}$$

Similarly the time for the light to travel from the mirror to the detector is determined by

$$c\Delta t_2 = \frac{d}{\gamma} - v\Delta t_2$$

or

$$\Delta t_2 = \frac{d}{\gamma\,(c + v)}$$

So the total time in the fixed frame is given by

$$\Delta t = \Delta t_1 + \Delta t_2 = \frac{d}{\gamma}\left(\frac{1}{(c+v)} + \frac{1}{(c-v)}\right) = \frac{2d}{c\gamma\,(1 - v^2/c^2)} = \gamma\frac{2d}{c} = \gamma\Delta t'$$