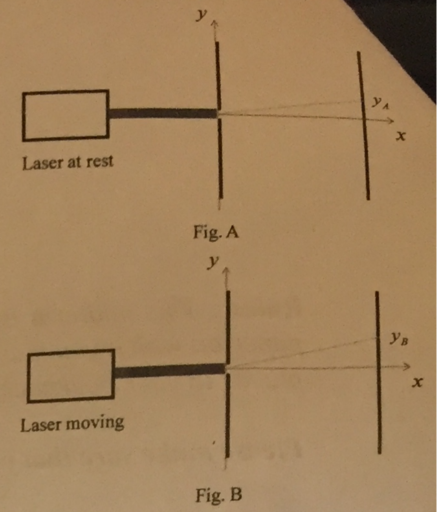
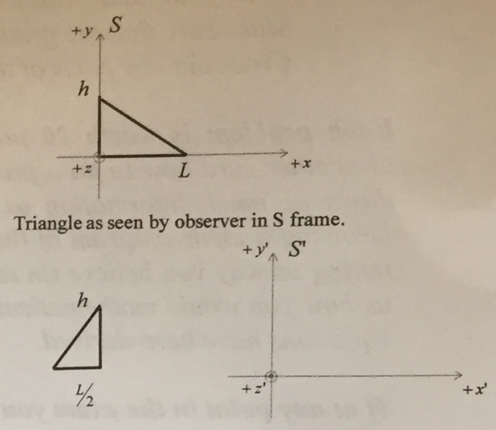
1. The figures on the right show a single slit with width D a distance L from a screen . In Fig. A a laser with frequency f_0 at rest relative to the slit is used to generate diffraction pattern on the screen. In Fig. B an identical laser is also used to generate an diffraction pattern, but this laser is moving with a speed v relative to the the slit. It is found that the location of the first minimum on screen B differs from that on screen A by $\Delta y = y_B - y_A > 0$ relative. What is v? Express it in terms of f_0, Δy, D, c, and L. Is the laser moving toward the slit or away from it? Use small angle approximations



2. Figure A on the right shows a triangle with height h and base L at rest in the stationay frame S. Is there a moving frame S' of the type shown in the figure in which an observer in this frame would see the triangle have the shape shown in Fig. B? If there is, find the velocity v of S' relative to S. If not, then show analytically that such a moving frame is not possible.



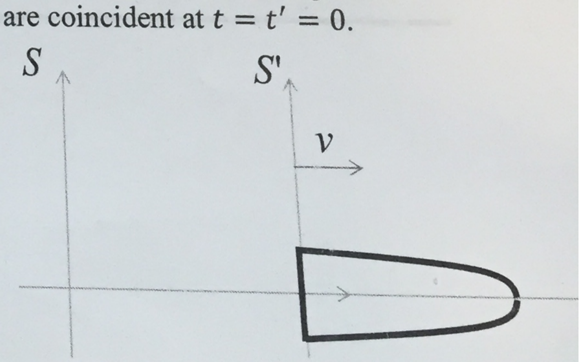
3. The figure to the right shows a spaceship moving relative to a stationary frame S. Treat the spacecraft as the moving frame S'. An observer ***on the spacecraft*** sees a moving particle enter the front tip of the spacecraft at $t'_F = 0$. An observer ***in the stationary frame*** sees the same particle exit the back of the spacecraft when the back of it is at a position $x_B = x_0$ and at a time $t_B = t_0$. The length of the spacecraft in the ***moving frame*** is L. The origins of the two frames are coincident at $t = t' = 0$.

a. What is the velocity v of the spacecraft relative to the observer in the stationary frame? Express it in terms of x_0 and t_0.

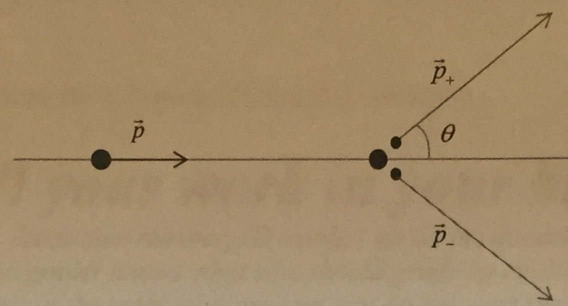
b. What is the speed u' of the particle as measured in the moving frame S'? Express it in terms of x_0, t_0, c, and L.

c. What is the speed u of the particle as measured in the ~~moving~~ frame S? Express it in terms of x_0, t_0, c, and L.

Stationary



4. A particle with mass M and a momentum with magnitude p collides and annihilates its antiparticle (which has the same mass M) that is at rest. A particle and its antiparticle, both with the same mass m, is created in the collision, and move off with momentum $\vec{p}_+$ and $\vec{p}_-$ (see figure below).You can assume that both of these particles are ultrarelativistic and approximate $E_+ \approx p_+c$ and $E_- \approx p_-c$. What is p_+ and p_-? Express it in terms of M, p, and θ. I would strongly recommend that you use the four-momentum approach.



5. Figure A on the right shows a diffraction grating with $6N+3$ slits a distance d apart in front of a screen. Starting with the center slit, every third slit is now closed so no light can pass through (see Fig. B). What is the intensity pattern, $I(\theta)$, generated by this grating? Express it in terms of I_0, the intensity of the light hitting the grating, N, d, θ, and k, the wavenumber of the incoming light.. You can use the electric field for the 6N+3 grating in Fig. A is

$$E_y = E_0 \frac{\sin(\beta(3N+3/2))}{\sin(\beta/2)} \sin(kr - \omega t),$$

where $\beta = kd\sin\theta$. (Hint: Remember the superposition principle for electric fields, and you won't have to do any of the sums you did on the homework.) You can use any of the following expressions you might find useful.

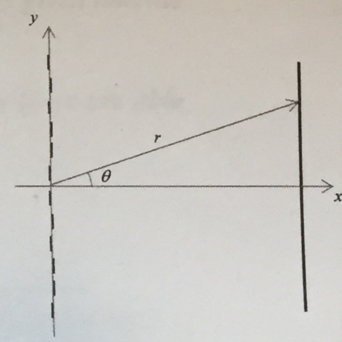


Fig. A

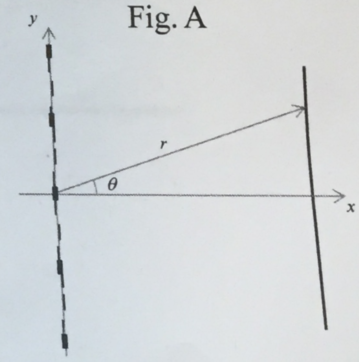


Fig. B

$$\cos a \cos b = \tfrac{1}{2}[\cos(a-b) + \cos(a+b)],$$

$$\sin a \sin b = \frac{1}{2}[\cos(a-b) - \cos(a+b)]$$

$$\sin a \cos b = \frac{1}{2}[\sin(a+b) + \sin(a-b)]$$

$$\cos(a \mp b) = \cos a \cos b \pm \sin a \sin b$$

$$\sin(a \pm b) = \sin a \cos b \pm \cos a \sin b$$

$$\langle f(t) \rangle = \frac{1}{T}\int_0^T f(t)dt,$$

$$\langle \cos^2 \omega t \rangle = \frac{1}{2}$$

$$\langle \cos^2 \omega t \rangle = \frac{1}{2}$$

$$\langle \sin^2 \omega t \rangle = \frac{1}{2}$$

$$\langle \sin \omega t \rangle = 0$$

$$\langle \cos \omega t \rangle = 0$$