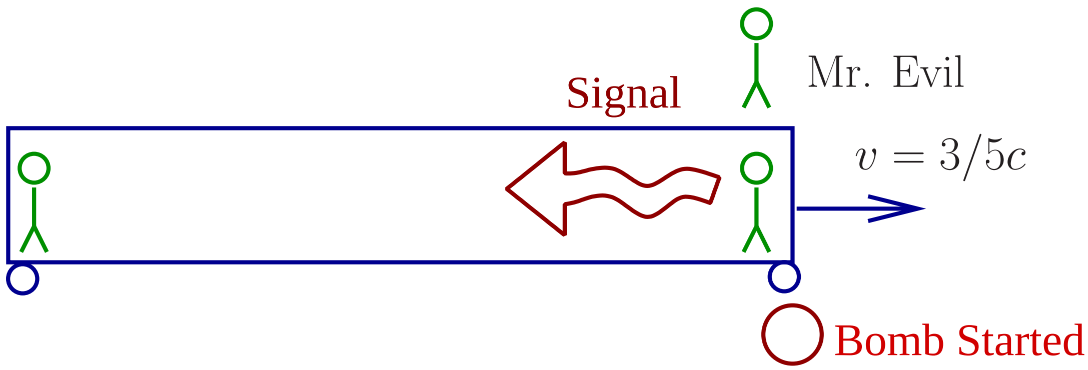
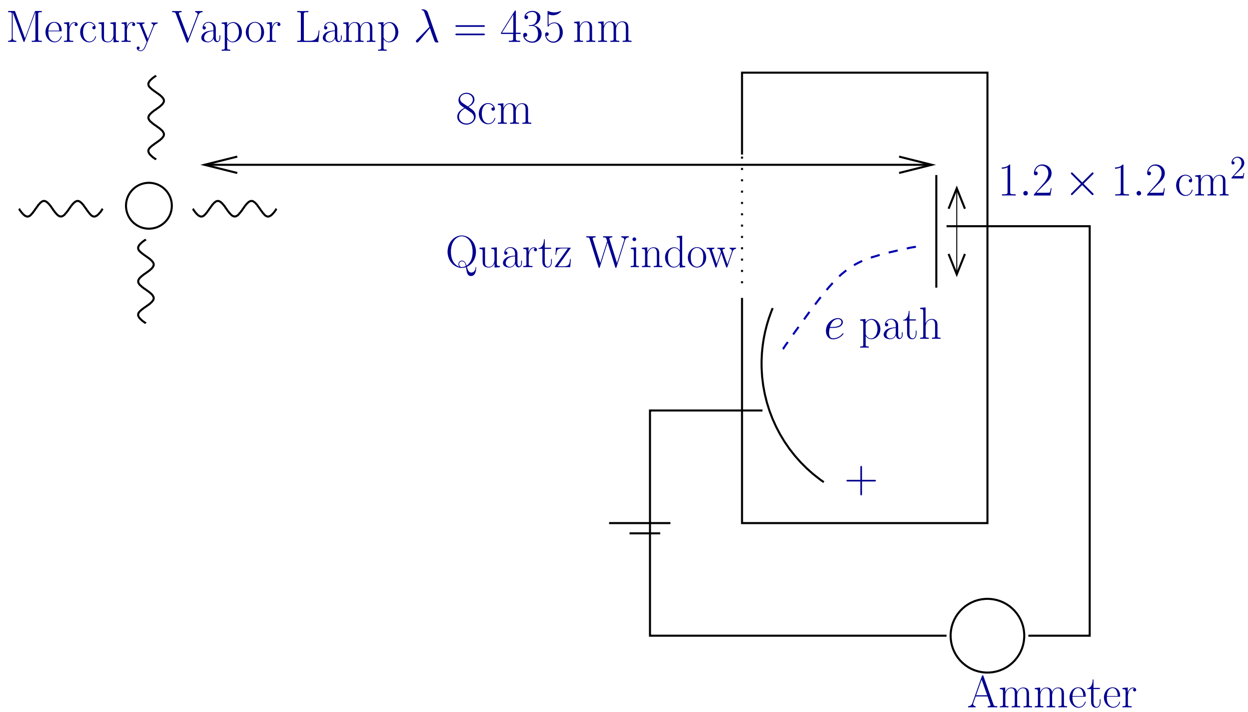
Quantity	**Symbol**	**Value**
Coulombs Constant	k_C	$8.98 \times 10^9\,\mathrm{Nm^2/C^2}$
Electron Mass	m_e	$9.1 \times 10^{-31}\,\mathrm{kg}$
Electron Charge	e	$-1.6 \times 10^{-19}\,\mathrm{C}$
Electron Volt	eV	$1.6 \times 10^{-19}\,\mathrm{J}$
Permitivity	ϵ_o	$8.85 \times 10^{-12}\,\frac{\mathrm{C^2}}{\mathrm{Nm^2}}$
Magnetic Permeability	μ_o	$4\pi \times 10^{-7}\,\mathrm{N} \cdot \mathrm{A}^2$
Speed of Light	c	$3.0 \times 10^8\,\mathrm{m/s}$
Planck's Constant	h	$6.6 \times 10^{-34}\mathrm{m^2 kg/s}$

Consider the following situation. (a) A train of proper length $2cs$ traveling at speed $3/5c$ to the right (relative to earth). (b) When the front of the train reaches the location of Mr. Evil (see below), Mr. Evil starts the internal clock of a stationary time bomb next to the track. (c) The time bomb's internal clock is set to explode after a time $2.5s$ once the clock is started. (d) The driver at the head of the train sends out a warning signal to the passenger riding in the back of the train so he can escape. (e) The warning signal travels at speed $0.75c$ (relative to the driver of the train) and is sent towards the back of the train. The signal is sent the instant the front of the train passes Mr. Evil. Mr. Evil and the train driver synchronize there clocks to $t = t' = 0$ when they cross paths.



1. When and where relative to the train driver does the signal reach the passenger?
2. Does the bomb explode before the signal arrive?
3. What is the speed of the signal according to the Mr. Evil?
4. When and where relative to Mr. Evil does the signal reach the passenger?
5. Draw a space time diagram according to the earth. Indicate the following on your graph:
    (a) The signal being sent from the front of the train, the signal arriving at the back of the train, the bomb exploding.
    (b) The world lines of the front of the train, the back of the train, and the bomb.

A mercury vapor lamp is positioned a distance of 8 cm from a $1.2 \times 1.2\,\mathrm{cm}^2$ metal foil as shown below. For simplicity, assume that the vapor lamp emits only the characteristic blue light of mercury vapor 435 nm. The lamp emits light with a total power of 1.8 mW uniformly in all directions. A metal foil is placed in the photo electric effect apparatus shown below. The work function of the metal foil is 2.1 eV. The electrons are collected by a plate biased to attract the emitted photo-electrons as shown below.



1. What is the number of photons which hit the metal foil per second? (The foil only covers a small fraction of the total area of an $R = 8\,\mathrm{cm}$ sphere surrounding the light source.)

2. Assuming that every photon which reaches the metal foil produces a photo-electron, what is the measured current in Amps? This is an upper bound of the photo current. (The first page contains a table of constants)

3. What is $\beta = v/c$ of the emitted electron?

4. Make an order of magnitude estimate for the size of relativistic corrections to the answer in part (3). Explain your reasoning.

A mysterious particle X is traveling to the right with energy of 825 MeV and momentum of 300 MeV/c. It decays symmetrically into two pions which each have a mass of $m_\pi c^2 = 140\,\text{MeV}$.

1. Determine the opening angle (*i.e.* θ) of the two pions.

2. According to an observer (Observer A) moving to the right with respect to earth, particle X was stationary before it decayed. What is the velocity of this observer?

3. According to Observer A:

   (a) What is the opening angle of the two pions?

   (b) What is the energy of these pions?