1. The relative velocity is $\boxed{\text{less than } 2v}$, since no relative velocity in any frame can exceed c.

2. $x_0, t_0 = 0 \qquad x_0', t_0' = 0$

$x_1', t_1' = 0, 1$ (second tick)

$x_1, t_1 = \gamma u, \gamma$

signal arrives @ $t_1 + \frac{\Delta x}{c}$

$= \gamma + \frac{\gamma u}{c}$

$= \gamma(1 + u/c)$

$= 2 \cdot 1 \cdot (1 + 0.865)$

$= \boxed{3.73}$

i.e. 12:03.73

(could also use Doppler shift formula)

3. a. $\gamma m v = \gamma' M v'$

b. $mc^2 + \gamma m c^2 = \gamma' M c^2$

c. $M = \sqrt{(E/c^2)^2 - (p/c)^2}$

$= \sqrt{(m(1+\gamma))^2 - (\gamma m v/c)^2}$

$= m\sqrt{(1+\gamma)^2 - (\gamma v/c)^2}$

d. $(1+\gamma)^2 = 1 + 2\gamma + \gamma^2$

$1 + 2\gamma + \gamma^2 - \gamma^2 \cdot v^2/c^2$

$= 1 + 2\gamma + (1 - v^2/c^2)/(1 - v^2/c^2)$

$= 2 + 2\gamma$

$\Rightarrow M = m\sqrt{2+2\gamma}$

$\geq m\sqrt{4}$

$= 2m$

4. Greater λ_2 means
smaller ν_2 so
smaller E per photon,
so we need $\boxed{\text{more than } N}$

5. a. $h\nu_1 = 1240/620 = 2\ eV$

$h\nu_2 = 1240/310 = 4\ eV$

$\varphi = h\nu - K_e = \boxed{1.5\ V}$

b. $\Delta E \Delta t \geq \hbar/2 = \dfrac{4 \times 10^{-15}}{4\pi}\ eV\ s$

$\Delta E = 3 \times 10^{-16} / 10^{-12}$

$= 3 \times 10^{-4}\ eV$

$\Delta E / E = \dfrac{3 \times 10^{-4}}{2.5} \sim \boxed{10^{-4}}$

6. a. $E = hc/\lambda = 1200/.0024$

$= 500{,}000\ eV$

$p = 500{,}000\ eV/c$

b. $E' = E - K_e$

$= 250{,}000\ eV$

$p' = 250{,}000\ eV/c$

c. $\lambda' = 1200/E' = .0048\ nm$

$\Delta\lambda = .0024\ nm$

$\Rightarrow \boxed{\theta = 90°}$