Chapter 3 (Relativistic Four Vectors)
Worksheet

Q1. A distant galaxy is observed to have its hydrogen-β line shifted to a wavelength of $580\,nm$, away from the laboratory value of $434\,nm$. Which of the following gives the approximate velocity of recession of the distant galaxy? (use $\frac{580}{434}=\frac{4}{3}$).

(a) $0.28c$ (b) $0.56c$ (c) $0.75c$ (d) $0.86c$

Q2. Consider a radioactive nucleus that is travelling at a speed $\frac{c}{2}$ with respect to the lab frame. It emits γ- rays of frequency v_0 in its rest frame. There are two stationary detectors, (first detector is not on the path of the nucleus in the lab .the second detector is in path of nucleus such that nucleus approach it). If a γ- ray photon is emitted when the nucleus is closest to the detector, its observed frequency at the first detector is v_1 and observed frequency at the second detector is v_2 then the value of $\frac{v_2}{v_1}$ is

(a) 2 (b) $\frac{1}{\sqrt{3}}$ (c) $\sqrt{2}$ (d) $\sqrt{\frac{2}{3}}$

Q3. Inertial frame S moving with respect to inertial frame S. The velocity of S' with respect to S is vi. The observer from S' see a photon of γ_0 emerge at angle θ_0 with x axis in $x-y$ plane. The observer from S frame measured same photon with frequency γ and emerge at angle θ with x axis in $x-y$ plane. Then which of the following is correct?

(a) $\gamma=\frac{\gamma_0\sqrt{1-\frac{v^2}{c^2}}}{1-\frac{v}{c}\cos\theta}$ (b) $\gamma=\frac{\gamma_0\sqrt{1-\frac{v^2}{c^2}}}{1+\frac{v}{c}\cos\theta}$ (c) $\gamma=\frac{\gamma_0\sqrt{1-\frac{v^2}{c^2}}}{1-\frac{v}{c}\cos\theta_0}$ (d) $\gamma=\frac{\gamma_0\sqrt{1-\frac{v^2}{c^2}}}{1+\frac{v}{c}\cos\theta_0}$

Q4. A particle of mass M decays in flight into m_1 and m_2. m_1 has momentum p_1 and total energy E_1, whereas m_2 has momentum p_2 and energy E_2. If p_1 and p_2 make angle θ then

(1) $\frac{1}{2}\left(M^2-m_1^2-m_2^2\right)$ is invariant

(2) $E_1E_2-p_1p_2\cos\theta$ is invariant

(a) only 1 is correct (b) only 2 is correct

(c) both 1 and 2 are correct (d) neither 1 nor 2 are correct