**189.**

**Problem 3.31 (R)**

*A positron and an electron at rest in frame S combine and annihilate one another, producing two photons. We have to find the energy and momentum of each photon in this frame.*

**Solution:**

As a positron is an antiparticle of an electron it has the same mass as that of an electron.

Electron mass, $m_e = 9.11\times10^{-31}$ kg. Its energy equivalent is $m_e c^2 = 9.11\times10^{-31}\times\left(3\times10^8\right)^2$ J=$8.199\times10^{-14}$ J.

We note that $1\text{ J} = 6.242\times10^{12}$ MeV.

So, $m_e c^2 = 8.199\times10^{-14}\times6.242\times10^{12}$ MeV=0.51 MeV.

In the electron-positron annihilation when each of the particles has zero momentum the combined rest mass is converted into energy. As energy and momentum are conserved at least two photons are produced in electron-positron annihilation. Each photon will carry energy

equal to the rest mass energy of electron/positron, which is 0.51 MeV.

Let the momentum of photon be $p$. For a photon as it has zero rest mass $E_\gamma = pc$.

So the momentum of each photon produced in the electron-positron annihilation will be

$$p = \frac{0.511 \times 1.6 \times 10^{-13}}{3 \times 10^{8}} \text{ kg m s}^{-1} = 2.72 \times 10^{-22} \text{ kg m s}^{-1}.$$