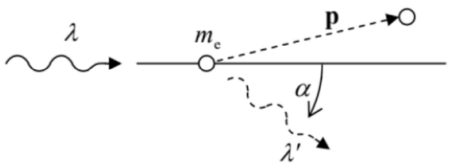
Questions for Module#33
(from Libre Text notes)

9.12. A photon with wavelength λ is scattered by an electron, initially at rest. Calculate the wavelength λ' of the scattered photon as a function of the scattering angle α – see the figure on the right.[83]



9.13. Calculate the threshold energy of a γ-photon for the reaction

$$\gamma + \mathrm{p} \to \mathrm{p} + \pi^0,$$

if the proton was initially at rest.

Hint: For protons $m_\mathrm{p}c^2 \approx 938\mathrm{MeV}$, while for neutral pions $m_\pi c^2 \approx 135\mathrm{MeV}$.

9.14. A relativistic particle with energy $\mathscr{E}$ and rest mass m, collides with a similar particle, initially at rest in the laboratory reference frame. Calculate:

(i) the final velocity of the center of mass of the system, in the lab frame,

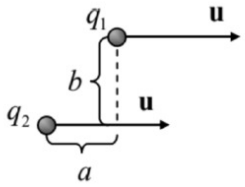
(ii) the total energy of the system, in the center-of-mass frame, and

(iii) the final velocities of both particles (in the lab frame), if they move along the same direction.

9.15. A "primed" reference frame moves, with the reduced velocity $\boldsymbol{\beta} \equiv \mathbf{v}/c = \mathbf{n}_x\beta$, relative to the "lab" frame. Use Eq. (109) to express the components T'^{00} and T'^{0j} (with $j = 1, 2, 3$) of an arbitrary contravariant 4-tensor $T^{\gamma\delta}$ via its components in the lab frame.

9.16. Static fields **E** and **B** are uniform but arbitrary (both in magnitude and in direction). What should be the velocity of an inertial reference frame to have the vectors **E'** and **B'**, observed from that frame, parallel? Is this solution unique?

9.17. Two charged particles, moving with equal constant velocities **u**, are offset by distance $\mathbf{R} = \{a, b\}$ (see the figure on the right), as measured in the lab
frame. Calculate the forces between the particles – also in the lab frame.



9.18. Each of two thin, long, parallel particle beams of the same velocity **u**, separated by distance d, carries electric charge with a constant density λ per unit length, as measured in the reference frame moving with the particles.

(i) Calculate the distribution of the electric and magnetic fields in the system (outside the beams), as measured in the lab reference frame.

(ii) Calculate the interaction force between the beams (per particle) and the resulting acceleration, both in the lab reference frame and in the frame moving with the electrons. Compare the results and give a brief discussion of the comparison.