

FYS3120 Classical Mechanics and
Electrodynamics

Problem set 8

Deadline for handing in (in canvas): **14 April**, 3pm

Problem 1 A monochromatic light source is at rest in the laboratory and sends photons with frequency ν_0 towards a mirror which has its reflective surface perpendicular to the beam direction. The mirror moves away from the light source with velocity v . Use the transformation formula for four-momentum $p^\mu = (E/c, \mathbf{p})$ and the Planck relation $E = h\nu$ to:

- Find the frequency of the emitted and reflected light in the rest frame of the mirror.
- Find the frequency of reflected light in the lab system.
- What is the change in momentum of the mirror in the lab system after being hit with a single photon?

Problem 2 Figure 1 shows a particle with mass m and (relativistic) kinetic energy K in the laboratory frame S . The particle is moving towards another particle, with the same mass m , which is at rest in S .

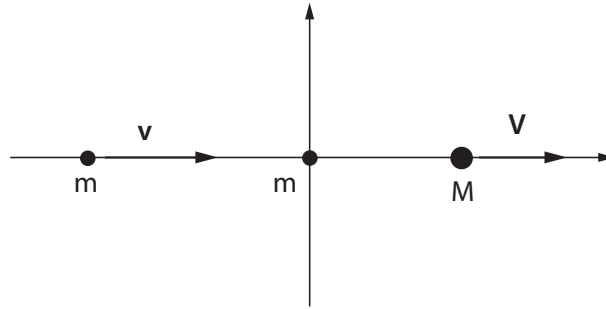


Figure 1: Collision between two particles of mass m resulting in a particle with mass M .

- Find the velocity v of the first particle expressed in terms of the dimensionless quantity $\alpha = K/mc^2$ (and the speed of light).

First we will assume that the particles collide in such a way that they form one particle after the collision (a totally inelastic collision).

- Determine the compound particle's energy E , momentum P , velocity V and mass M in terms of the velocity v (or γ). Find the change in the total kinetic energy of the system due to the collision.

In the rest of the exercise we will assume that the situation before the collision is as described earlier, but that the particles now collide elastically, *i.e.* after the collision the two particles are the same as before the collision, with no change in their masses. The collision happens in such a way that

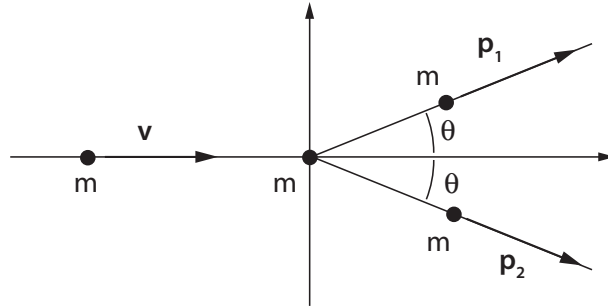


Figure 2: Collision between two particles of mass m resulting in scattering at angle θ .

the particles after the collision make the same angle, θ , with the x -axis in the lab frame S , see Fig. 2.

- c) Show that after the collision the particles have the same magnitude of momentum ($|\mathbf{p}_1| = |\mathbf{p}_2|$) and energy ($E_1 = E_2$).
- d) Determine $E \equiv E_1 = E_2$ and $p \equiv |\mathbf{p}_1| = |\mathbf{p}_2|$.
- e) Determine the angle θ . Find θ in the limiting cases when $\alpha = K/mc^2$ goes to zero and to infinity. Show that $\theta < \pi/4$.