

# Economy of Physics Problem

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Currency is fundamentally speaking an exchange of energy; with an infinite amount of energy there would be no need for an economy. This fact of energy exchange is analogous in physics when in classical mechanics, Newtonian laws are followed such as those of conservation of energy  $E = \frac{1}{2}mv^2$  and momentum  $\vec{p} = m\vec{v}$ . Einstein came along and his theory in which energy and momentum were still conservative, but the relationship between the two is different. Energy is defined to be  $E_{prot}^2 = c^2\vec{p} \cdot \vec{p} + m^2c^4$ , a photon with no mass technically still has energy and momentum which is  $E = c|p|$ . To get a better understanding of energy transfer consider the following problem:

**Problem:** A high energy proton with mass  $1.67 \cdot 10^{-27}$ kg is fired into a glass medium let the speed of light in the glass be  $c_g = 2.3 \cdot 10^8 \frac{m}{s}$ . The energy of the photon is  $E_{prot}^2 = c^2\vec{p} \cdot \vec{p} + m^2c^4$ . What is the minimum magnitude of the proton's momentum that is necessary so that the proton will release a photon with non-zero momentum upon entering the glass. The vectors shown below are momentum and the problem should be done using these vectors.

