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Protective force field

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In the science fiction novel *Dune* by Frank Herbert, people have mastered building personal force field shields, that will only slow moving objects through, while stopping fast objects like projectiles and knife strikes. This property is based on the fictional "Holtzmann effect", and the underlying physical principles are never explained in detail by the writer. In this task we will construct our own personal force field without retorting to such mysticism.

A few useful equations you might need:

The Lorentz force:

$$\bar{F} = q(\bar{E} + \bar{v} \times \bar{B}) \tag{0.1}$$

Lenz law:

$$\epsilon = -\frac{d\phi}{dt} \tag{0.2}$$

a) When thinking about force fields, one often turns to electromagnetic fields. Assuming that in the distant future weaponry is made of conducting materials, this could very well be the case. Consider a blade represented by the thin wire loop in figure 1 below. The blade is approaching our shield made out of a strong magnetic field with initial velocity v_0. You may simplify the task by setting a=b. Form the differential equation describing the velocity of the blade as a function of time.

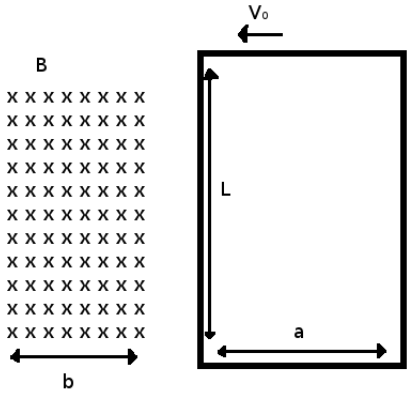

Figure 1: The magnetic shield on the left and wire loop blade on the right. The field direction is entering the paper.

b) Where does the kinetic energy of the blade go to?

c) What is the field strength B needed to reduce the velocity of the blade to $\frac{1}{10}$ of the original velocity v_0? You can take the time for deceleration to be $t = \frac{a}{v_0}$ (we want the blade to stop within the shield). Give the answer in terms of the constants.