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Physics 2—Recitation Notes April 11

20.14)
I pull a loop of square wire with width w and height h parallel to the boundary between regions with magnetic fields $B_1, B_2 < 1$. The loop has resistance R, and I apply constant force F to the right. The loop does not accelerate.

Applying force F, I know that whatever current is flowing must cause Lorentz forces to total to exactly the opposite of this force, etc. This is one approach.

Certainly, since no energy is entering the loop in terms of kinetic energy the work must be totally expended in the resistor:

$$F\frac{\partial x}{\partial t} = Fv = IV = I^2 R$$

$$v = \frac{I^2 R}{F}$$

To solve for I, I know that

$$\vec{F} = \vec{I}L \times \vec{B} \quad (straight \quad wire)$$

$$F = ILB \quad (orthogonal \quad field)$$

$$IhB_1 - IhB_2 = F$$

$$I = \frac{F}{h(B_1 - B_2)}$$

$$v = \frac{FR}{h^2 (B_1 - B_2)^2}$$

The contribution from the wires going in the orthogonal direction only oppose one another, leading to a “magnetic pressure” but contributing nothing to the net force.

20.17)
I ignore any magnetic field originating from induced charge centers.

The unipolar generator’s outermost surface rotates at speed v.

Now I consider an individual electron, $-q_e$, present on this generator at radius $0 < r < R$.

Now $F_{mag} = -(-q_e E) = -q_e \left(v\frac{r}{R}\right)B$ where the magnetic force pushes electrons inward and so the steady-state electric field must point inward also in order to oppose this. Integrating, then:

$$E = -\left(v\frac{r}{R}\right)B \quad \Delta V = -\int_R^0 -\left(v\frac{r}{R}\right)Bdr = -v\frac{R^2}{2R}B = -\frac{vRB}{2}$$

, where I have been careful to orient this properly with respect to the meter.

So I don’t want to be accused of giving busy-work again, so maybe we could talk about Chapter 20 some if you have questions. Later we could talk about Gauss’s Law.