

Physics 386

Quiz 1

Feb. 14, 2000

Ground rules:

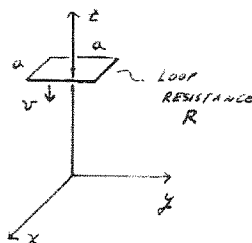
- Open book
- Open notes
- Write your answer directly on this sheet (continue onto back, if necessary)

Name: SOLUTION**Question**

A square wire loop of side a and total resistance R is falling in a magnetic field

$$\mathbf{B}(\mathbf{r}) = -\beta x \hat{x} - \beta y \hat{y} + 2\beta z \hat{z}$$

in such a way that it remains parallel to the x - y plane. It falls with constant speed v , i.e., $z(t) = z_0 - vt$.



- Show that the flux through the loop is given by $\Phi(t) = 2\beta a^2(z_0 - vt)$.
- Find the induced EMF $\mathcal{E}(t)$.
- Find the current $I(t)$ in the wire.
- Find the terminal velocity of the loop if it falls freely. (Hint: find the speed v at which the power delivered by gravity, mgv , equals the power dissipated resistively in the loop.)

$$\begin{aligned} \text{a) } \Phi &= \int_S \mathbf{B} \cdot d\mathbf{a} = \int_S B_z dx dy \\ &= 2\beta z a^2 \quad \downarrow \quad z = z_0 - vt \\ \Phi(z) &= 2\beta a^2 (z_0 - vt) \end{aligned}$$



$$\text{b) } \mathcal{E} = -\frac{d\Phi}{dt} = 2\beta a^2 v$$

$$\text{c) } I = \mathcal{E}/R = 2\beta a^2 v/R$$

$$\text{d) } mgv = I\mathcal{E} = 4\beta^2 a^4 v^2/R$$

$$mg = 4\beta^2 a^4 v/R$$

$$v = \frac{mgR}{4\beta^2 a^4}$$