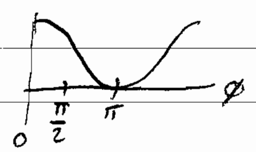
2003 Part I Q1 Exp

A. The simple model for the Paschen equation takes into account only ionization potential, which for air is lower, predicting air would have a lower breakdown voltage. However, other effects in practice give air a higher breakdown voltage, such as all the internal modes of air molecules which take energy away but do not yield ionization.

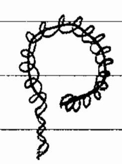
B. $\phi \sim \frac{\pi}{2}$ should be chosen, to maximize the sensitivity wrt. small changes in ϕ. If the two amplitudes are equal, $\langle P \rangle \sim \cos^2 \frac{\phi}{2}$.



$\phi_0 \sim \frac{\pi}{2}$ corresponds to where the first derivative is largest $\rightarrow$ linear relationship between P, ϕ

$\phi_0 \sim 0, \pi$ have a first derivative of $0 \rightarrow$ low sensitivity

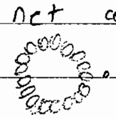
C. Rogowski Loop



n turns per unit length

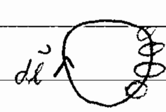
magnetic field varies little over 1 turn: $\frac{|\nabla B|}{B} << n$

The net "contour" of the loop, including the return wire, is just the loops



$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ $\quad V = \int \vec{E} \cdot d\vec{l} = -\frac{d\phi}{dt}$

$$\phi = n \oint_l \int dA \, \vec{B} \cdot d\vec{l}$$



$$= n \int dA \oint_l \vec{B} \cdot d\vec{l}$$

but $\int \vec{B} \cdot d\vec{l} = \mu_0 I$ $\quad I$ = current enclosed

$$\phi = n \mu_0 A I$$

$V = -n\mu_0 A \dot{I}$ measures the total current inside it.