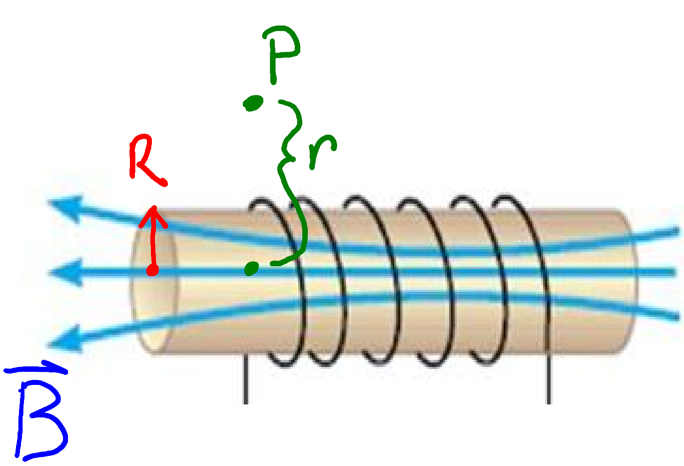
NAME: ______________________________	Quiz #3a: Phys270

1. [10 pts] An infinitely long solenoid of radius R has a magnetic field that is changing at the rate of dB/dt. Suppose the magnetic field is increasing in the direction depicted below (imagine that the depicted solenoid is infinitely long!).
   a. [2 pts]Draw the induced electric field direction at point P.
   b. [4 pts] Derive an expression for the magnitude of the electric field outside the solenoid a distance r from the axis of the solenoid (r>R).
   c. [4 pts] Derive an expression for the magnitude of the electric field inside the solenoid a distance r from the axis of the solenoid (r<R).

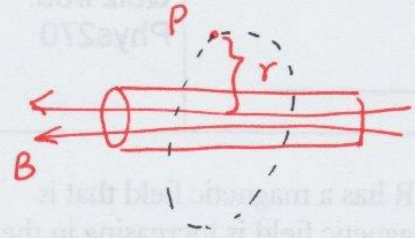


PHYS 270 : Quiz 3 : Solution.

Dated 09/23/09

Solution

(a)

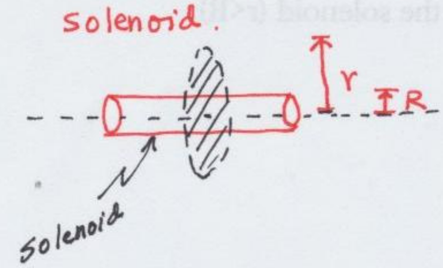


Consider a loop of radius r, concentric to the solenoid and passing from P.

Clearly Φ_B is increasing in the loop so current flows to nullify the effect, i.e. the current is coming out

Now, the current by definition is moving "+" charge which would need a field coming out of page to get the direction of current we inferred. Hence $\odot$

(b) The derivation is given on p-1060-1061. We repeat the arguments. Consider a loop of radius r concentric to the solenoid.



$$\Phi_B = B \cdot \pi R^2$$

, since there is no field outside the solenoid

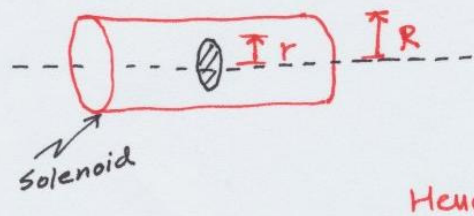
$$\int E \cdot ds = -\frac{d\Phi_B}{dt}$$

$$\Rightarrow E \cdot 2\pi r = -\pi R^2 \cdot \frac{dB}{dt}$$

$$\Rightarrow |E| = +\frac{R^2}{2r}\left|\frac{dB}{dt}\right|$$

and we determine the sign by Lenz' law etc

(c) we consider now a loop of radius $r < R$



then $\Phi_B = B \cdot \pi r^2$ since our loop is smaller

and $\int E \cdot ds = E \cdot 2\pi r$

Hence in magnitude,

$$E \cdot 2\pi r = \pi r^2 \cdot \left|\frac{dB}{dt}\right|$$

$$\Rightarrow |E| = \frac{r}{2}\left|\frac{dB}{dt}\right|$$

and direction can be deduced using Lenz's law, as in part (a).