P161 Final Part 1 - Solutions
Spring 2009

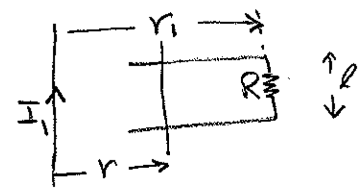
① (B)

② (A)

③ From wire, $\vec{B} = \frac{\mu_0 I_1}{2\pi r}$ into paper

$$\phi = \int \vec{B}\cdot d\vec{A} = \int_r^{r_1} \frac{\mu_0 I_1}{2\pi r}\, l\,dr \quad \text{where } dA = l\,dr,\ l = 0.20\,m$$

where



$$\phi = \frac{\mu_0 I_1 l}{2\pi}\int_r^{r_1}\frac{dr}{r}$$

But $\mathcal{E} = -d\phi/dt$ and the current induced in loop, $I_2 = \mathcal{E}/R$

(in magnitude) $I_2 = \frac{1}{R}\frac{d\phi}{dt} = \frac{\mu_0 I_1 l}{2\pi r R} v$ where $v = dr/dt$

$\underline{I = 0.06\,\mu A, \text{ clockwise}}$ (A)

④ $\phi = NBA = NB\pi r^2$

$$\mathcal{E} = -\frac{d\phi}{dt} = -N\pi r^2 dB/dt$$

So $\underline{|\mathcal{E}| = 0.055\,V}$ (A)

⑤ Along path 1, no flux change ⇒ $\underline{\Delta V = 0 \quad (A)}$

⑥ The magnetic field from the straight wire is in the direction of motion of the bar, so $\underline{\frac{d\phi}{dt} = 0 \ (A)}$

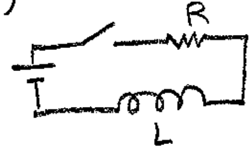
⑦ (C)

(8) $\mathcal{E}_2 = -M\, dI_1/dt$

$I_2 = \mathcal{E}_2/R = -\frac{M}{R}\frac{dI_1}{dt}$

so $\underline{|I_2| = 7.9\,\mu A}$ (A)

(9) (E)

(10) 

$I(t) = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau_L}\right)$

when $t = 2\tau_L$, $I = \frac{\mathcal{E}}{R}(1 - e^{-2}) = \underline{1.73\,A}$ (D)

(11) $U(t) = \frac{1}{2} L I(t)^2$ where $I(\tau_L) = \frac{\mathcal{E}}{R}(1 - e^{-1}) = 1.264A$

So $\underline{U(\tau_L) = 7.99\,J \quad (D)}$

(12) $\underline{w = \sqrt{1/LC} = 105\,\frac{\text{radian}}{s} \quad (B)}$

(13) $\underline{\mathcal{E} = -L\, dI/dt = 4.68\,mV}$ (C)

(14) $u = \frac{B^2}{2\mu_0} = 1.73 \times 10^7\, J/m^3$