Problem 1:

SOLUTION KEY

a) $\vec{B} = \frac{\mu_0 I}{2\pi r}\hat{k} = \frac{\mu_0 I}{2\pi d}\hat{k} \Rightarrow |\vec{B}| = \frac{\mu_0 I}{2\pi d}$

B = 2e-8*I/d; (scaled answer)

$r = d$

b) $\vec{F} = Q\vec{v}\times\vec{B} = Qv(-\hat{j}) \times \frac{\mu_0 I}{2\pi r}\hat{k} = -\hat{i}\,\frac{\mu_0 IQv}{2\pi d}$

$\Rightarrow |\vec{F}| = \frac{\mu_0 IQv}{2\pi d}$

F= abs(Q*v*B) (scaled answer)

c) $-\hat{i}$

Problem 2:

B=mt+3

$$\underset{B}{\phi} = \vec{A}\cdot\vec{B} = \pi r^2 \hat{k}\cdot B\hat{k} = \pi r^2 B$$

Phi=3.1416e-4*r1^2*(m*10+3);
scaled answer

a) $\phi = \pi r^2 B$

$$B = mt + b \Rightarrow \frac{dB}{dt} = m$$

b) $$\mathcal{E}mf = -N\frac{d\phi}{dt} = -N\frac{d}{dt}(AB) = -N\pi r^2\frac{dB}{dt}$$

emf=-3.1416e-4*r1^2*N*m

$$\mathcal{E}mf = N\pi r^2\frac{dB}{dt}$$

c) $$I_{in} = \frac{|\mathcal{E}mf|}{R} = \frac{N\pi r^2 dB/dt}{R}$$

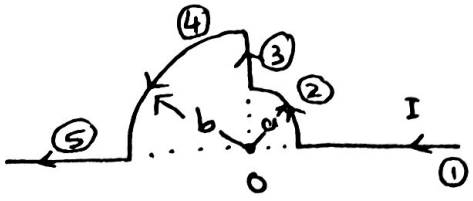
I_{in}=-emf/8

D) If $\frac{dB}{dt} > 0 \Rightarrow$ CW

If $\frac{dB}{dt} < 0 \Rightarrow$ CCW

Problem 3:

a)



$$\vec{B}_o = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 + \vec{B}_4 + \vec{B}_5$$

$$\vec{B}_1 = \vec{B}_3 = \vec{B}_5 = \vec{0} \qquad d\vec{s} \times \hat{r} = 0$$

$$\vec{B}_2 = \frac{\mu_0 I}{4\pi} \int_{②} \frac{d\vec{s} \times \hat{r}}{r^2} = \frac{\mu_0 I}{4\pi a^2} \int_0^{\pi/2} \hat{k}\, a\, d\theta = \hat{k}\, \frac{\mu_0 I}{4\pi a} \left(\frac{\pi}{2}\right) = \frac{\mu_0 I}{8a} \hat{k}$$

Same for $\vec{B}_4$: $\vec{B}_4 = \frac{\mu_0 I}{8b} \hat{k}$

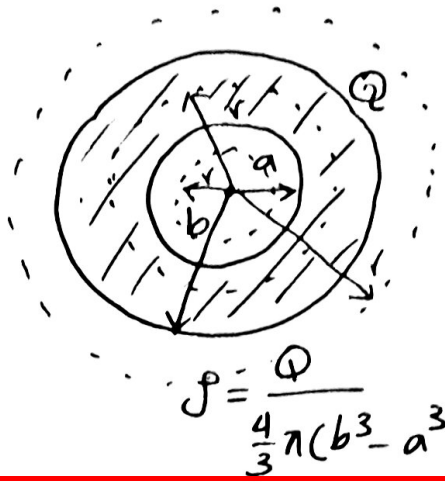
Finally: $\vec{B}_o = \frac{\mu_0 I}{8} \hat{k} \left(\frac{1}{a} + \frac{1}{b}\right)$.

b) Direction in $+\hat{k}$.

B= 3.1416e-5/2*I*(1/a+1/b);
Scaled Answer.

Problem 4:

a) $\oint_S \vec{E}\cdot d\vec{A} = 0 \Rightarrow \vec{E} = \vec{0}$
$r<a$



b) $\oint_S \vec{E}\cdot d\vec{A} = \frac{\rho \frac{4}{3}\pi(r^3-a^3)}{\epsilon_0}$,
$a<r<b$

$\rho = \frac{Q}{\frac{4}{3}\pi(b^3-a^3)}$

$\Rightarrow E4\pi r^2 = \frac{Q}{\epsilon_0}\frac{r^3-a^3}{b^3-a^3}$

E = 9e9*Q*(55^3-a^3)/(b^3-a^3)/55^2 (scaled answer)

$\Rightarrow E = \frac{Q}{4\pi\epsilon_0 r^2}\frac{r^3-a^3}{b^3-a^3} = k\frac{Q}{r^2}\frac{r^3-a^3}{b^3-a^3}$

c) $\oint_S \vec{E}\cdot d\vec{A} = \frac{Q}{\epsilon_0} \Rightarrow E4\pi r^2 = \frac{Q}{\epsilon_0} \Rightarrow E = \frac{Q}{4\pi\epsilon_0 r^2}$
$b<r$

$\Rightarrow E = k\frac{Q}{r^2}$.

E= 9e9*Q/120^2 Scaled Answer

d) $V = -\int_\infty^r \vec{E}\cdot d\vec{r} = -\int_\infty^b \vec{E}_{out}\cdot d\vec{r} - \int_b^r \vec{E}_{in}\cdot d\vec{r}$
$a<r<b$

$= -\int_\infty^b k\frac{Q}{r^2}dr - \int_b^r k\frac{Q}{r^2}\frac{r^3-a^3}{b^3-a^3}dr = +k\frac{Q}{b}$

$-\frac{kQ}{b^3-a^3}\left(\int_b^r r\,dr - a^3\int_b^r \frac{1}{r^2}dr\right) = k\frac{Q}{b} - k\frac{Q}{b^3-a^3}\left[\frac{r^2}{2}-\frac{b^2}{2}\right.$

$\left. + a^3\left(\frac{1}{r}-\frac{1}{b}\right)\right] = kQ\left[\frac{1}{b} - \frac{(r^2-b^2)}{2(b^3-a^3)} - \frac{a^3}{b^3-a^3}\left(\frac{1}{r}-\frac{1}{b}\right)\right]$

V = 9e6*Q*{a^3*(1/55-1/b)/(b^3-a^3)+1/b+(b^2-55^2)/[2*(b^3-a^3)]} (Scaled Answer);