E&M 1.

a) i. Radially outward from the line charge in region I, No E field in region II, and radially outward from the cylindrical shell in region III.

ii. + charges on the outward surface of the shell, - charges on the inward surface.

b) <u>4</u> Va <u>3</u> Vb <u>2</u> Vc <u>1</u> Vd <u>3</u> Ve

c) i. Guass' Law:

$$\oint \mathbf{E}\cdot d\mathbf{A} = \frac{Q}{\varepsilon_0}$$

$$E\cdot 2\pi rl = \frac{\lambda l}{\varepsilon_0}$$

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

ii. Guass' Law:

$$\oint \mathbf{E}\cdot d\mathbf{A} = \frac{Q}{\varepsilon_0}$$

$$E\cdot 2\pi rl = \frac{\lambda l + \rho(\pi r^2 l - \pi r_1^{\,2} l)}{\varepsilon_0}$$

$$E = \frac{\lambda + \pi\rho(r^2 - r_1^{\,2})}{2\pi\varepsilon_0 r}$$

iii. Guass' Law:

$$\oint \mathbf{E}\cdot d\mathbf{A} = \frac{Q}{\varepsilon_0}$$

$$E\cdot 2\pi rl = \frac{\lambda l + \rho(\pi r_2^{\,2} l - \pi r_1^{\,2} l)}{\varepsilon_0}$$

$$E = \frac{\lambda + \pi\rho(r_2^{\,2} - r_1^{\,2})}{2\pi\varepsilon_0 r}$$

E&M 2.

a) 20v (Kirchhoff's rules)

b) 8v (Kirchhoff's rules)

c) Ohm's law:

$$I = \frac{V}{R} = \frac{12V}{15k\Omega} = .8mA$$

$$R_2 = \frac{V}{I} = \frac{8V}{.8mA} = 10k\Omega$$

d) $E = \frac{1}{2}CV^2 = \frac{1}{2} \times 20\mu F \times (12V)^2 = 1.44 \times 10^{-3} J$

e) Current decreases exponentially from 2.0 mA and asymptotically to 0.8 mA

f) Greater than

$$V_{1\uparrow} = IR_1 = \frac{\varepsilon R_1}{R_1 + R_{2\downarrow}}$$

$$E_{\uparrow} = \frac{1}{2}CV_{\uparrow}^2$$

E&M 3.

a) $B = \frac{\mu_0 I}{2\pi r}$

$$dA = 4ldr$$

$$\Phi_B = \int B \cdot dA = \int \frac{\mu_0 I}{2\pi r} 4ldr = \frac{2l\mu_0 I}{\pi} \int_l^{3l+l} \frac{dr}{r} = \frac{2l\mu_0 I \ln 4}{\pi}$$

b) Counterclockwise. Lenz's Law and Right-hand rule

c) $\Phi_B = \frac{2l\mu_0 I \ln 4}{\pi} = \frac{2l\mu_0 \ln 4}{\pi} I_0 e^{-kt}$

Faraday's Law:

$$\varepsilon = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\left(\frac{2l\mu_0 \ln 4}{\pi} I_0 e^{-kt}\right) = \frac{2kl\mu_0 I_0 \ln 4}{\pi} e^{-kt}$$

$$I = \frac{\varepsilon}{R} = \frac{2kl\mu_0 I_0 \ln 4}{\pi R} e^{-kt}$$

d) $P = I^2 R = \left(\frac{2kl\mu_0 I_0 \ln 4}{\pi R} e^{-kt}\right)^2 R = \frac{(2kl\mu_0 I_0 \ln 4)^2}{\pi^2 R} e^{-2kt}$

$$W = \int P \cdot dt = \frac{(2kl\mu_0 I_0 \ln 4)^2}{\pi^2 R} \int_0^{\infty} e^{-2kt} = \frac{2k(l\mu_0 I_0 \ln 4)^2}{\pi^2 R}$$