Problem 1: (E)

Electrical power, Ohm's law: $P = VI = V^2/R$

Problem 2: (B)

Ampere's law: $B(r) = \mu_0 I_{through\_r}/(2\pi r)$, $B(r < a) = \mu_0 j\pi r^2/(2\pi r) = \mu_0 jr/2$ (proportional to r), $B(a < r < b) = \mu_0 j\pi R^2/(2\pi r)$ (proportional to 1/r), $B(b < r < c) = -\mu_0 j'(\pi r^2 - \pi a^2)/(2\pi r) + \mu_0 j\pi R^2/(2\pi r)$, $j = I/\pi r^2$, $j' = I/(\pi c^2 - \pi b^2)$. $B(r > c) = 0$.

Problem 3: (C)

Ampere's law, magnetic flux: $B = \mu NI/(2\pi R)$, Flux $\Phi = LI$, $L = \Phi/I = NB\pi a^2/I = \mu N^2 a^2/(2R)$.

Problem 4: (D)

Gauss' law, cylindrical symmetry: $|E| = \lambda_{inside}/(2\pi\varepsilon_0 r)$, $Q = \lambda L$. The interior of B is field free.

$Q_A = -Q_{inner}$, $Q_C = -Q_{outer}$, $Q_C + Q_A = -Q_B$

$[\lambda_A/(2\pi\varepsilon_0 r)]\int_a^b (1/r)dr + [(\lambda_A + \lambda_B)(2\pi\varepsilon_0 r)]\int_b^c (1/r)dr = 0$

$\lambda_A \ln(b/a) + (\lambda_A + \lambda_B)\ln(c/b) = 0$, $Q_A/Q_C = Q_{inner}/Q_{outer} = \ln(c/b)/\ln(b/a)$

Problem 5: (B)

Electrical power: Internal resistance of battery: $r = (10/2 - 4)\ \Omega = 1\ \Omega$

With a variable resistance R, $I = (10\ V)/(r+R)$

Power to the resistor R: $P = I^2R = (100\ V^2)R/(r+R)^2$

$dP/dR = 0 \rightarrow r - R = 0$, $R = r = 1\ \Omega$, $P_{max} = (100/4)\ W$

Problem 6: (E)

Ampere's law, cylindrical symmetry: $\mathbf{F} = I\boldsymbol{l}\times\mathbf{B} = 0$

Problem 7: (A)

Gauss' law: $\int \mathbf{E}\cdot d\mathbf{A} = Q_{inside}/\varepsilon_0$

Problem 8: (A)

Gauss' law: The electric field due to the charge on the shell is zero inside the shell.

Problem 9: (A)

Faraday's law: $|\varepsilon| = \Delta\Phi/\Delta t = (\Delta B/\Delta t)*10\ cm^2*(1m/10^{-2}\ cm)^2 = IR = (\Delta Q/\Delta t)*R$

$\Delta Q = (0.5*10^{-3}/5)\ C$

Problem 10: (D)

Resistors in series and parallel: Symmetry implies that no current flows through the horizontal resistors. $I = V/R_{eff}$, $R_{eff} = 2R/3$.

Problem 11: (E)

The Lorentz force: $F = qvB = mv^2/R$, q/m is proportional to 1/R.

Problem 12: (A)

Gauss' law, cylindrical symmetry: $|E| = \lambda_{inside}/(2\pi\varepsilon_0 r)$,

Problem 13: (B)

Dielectrics: For a parallel plate capacitor: $C = K\varepsilon_0 A/d$, $V = Q/C$.

Problem 14: (A)

LC circuits: LC circuits are resonance circuits, I oscillates. No energy is stored in the inductor at t = 0.

Problem 15: (E)

Amperes law, the right hand rule: At point P the magnetic field due to each wire has the same magnitude, but the magnetic field due to the vertical wire points up and the magnetic field sue to the horizontal wire points down.