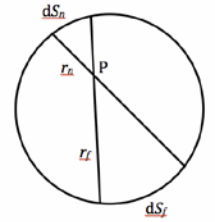
Advanced E&M, solutions

Problem 1:
(C) Electrostatic force
The electric force is a conservative force

Problem 2:
(D) The magnetic field
Magnetic field lines have no sources or sinks. There are no magnetic charges.

Problem 3:
(E) The inverse square law



Null measurements can be the most accurate measurements.

Problem 4:
(B) Relativistic E&M

Problem 5:
(C) Kirchhoff's loop rule
120 V – 100 V – 10 A*1 Ω – 10 A*R = 0, R = 1Ω.

Problem 6:
(B) Gauss' law:
$4\pi r^2 E(r) = Q_{inside}/\varepsilon_0$.
$4\pi(R^2/4)E(R/2) = (4\pi/\varepsilon_0)\int_0^{R/2} Ar^4 dr$.
$E(R/2) = A(R/2)^3/(5\varepsilon_0))$.

Problem 7:
(D) Current density and current
The number of electrons passing any point in the wire per unit time is $\rho * v_{drift} * A = 10^{28} * v_{drift} * \pi * (0.01)^2$/s. The current is $1.6*10^{-19}*10^{28}*v_{drift}*\pi*(0.01)^2$ C/s = 100 A.
$v_{drift} \sim 2*10^{-4}$ m/s.

Problem 8:
(A) Faraday's law
$\varepsilon = -\partial$flux/∂t = -BdA/dt. Here dA/dt is equal to a constant C for half a cycle, and -C for the other half of the cycle.

Problem 9:
(B) The electric potential
The distance of P to any point on the ring is $r = (R^2 + x^2)^{1/2}$. $V = kQ/r$.

Problem 10:
(A) The electric force
The force on the particle is $kQq/(R^2 + x^2)^* x/ (R^2 + x^2)^{1/2} \sim kQqx/R^3$ towards the origin.
It is a restoring force. $F = -\alpha x$, $\omega^2 = \alpha/m$.

Problem 11:
(B) Faraday's law
$emf = -(\partial B\partial/t)A = -(150T/s)0.01m^2 = -1.5V$ (Lenz's rule)
$5V - 1.5V = I*10\Omega$, $I = 0.35A$

Problem 12:
(A) Electric power
$P = IV = V^2/R$. Here V is constant.

Problem 13:
(C) Gauss' law
You can find E from Gauss' law.

Problem 14:
(D) Method of images
Method of images yields **E**, $\sigma = \varepsilon_0 E$ from Gauss' law.

Problem 15:
(C) Maxwell's equations for electrostatics
State this differently, in words, not using an equation.