Beijing Dublin International College

EEEN3006J Wireless Systems

Problem set: Electromagnetic Fields and Waves

Problem 1: Calculate the electric flux through the surface of a cube that contains 12 protons and 7 electrons.

Does the size of the cube alter the result?

Problem 2: A cube of side L m contains a flat plate with variable surface charge density of $\boldsymbol{\sigma} = -3\boldsymbol{xy}$ **C/m**^{2}. If the plate extends from $\boldsymbol{x} = 0$ to $\boldsymbol{x} = \boldsymbol{L}$ and from $\boldsymbol{y} = 0$ to $\boldsymbol{y} = \boldsymbol{L}$, what is the total electric flux through the walls of the cube?

Problem 3: What is the flux through an arbitrary closed surface surrounding a charged sphere of radius a_0 with volume charge density of $\boldsymbol{\rho} = \boldsymbol{\rho_0(r/a_0)}$, where $\boldsymbol{r}$ is the distance from the centre of the sphere?

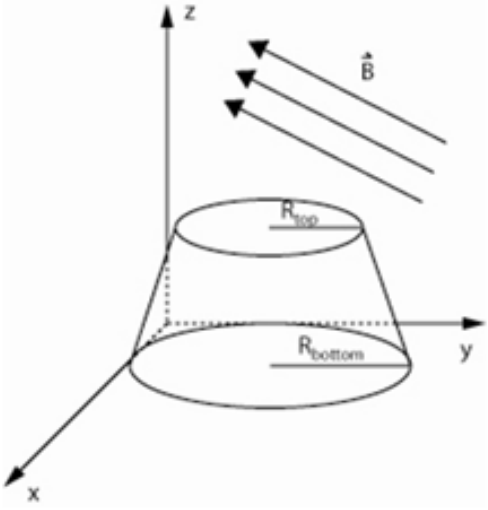
Problem 4: Use a special Gaussian surface around an infinite line charge to find the electric field of the line charge as a function of distance.

Problem 5: Find the divergence of the field given by $\vec{E} = \frac{1}{r}\hat{r}$ in spherical coordinates.

Problem 6: Find the charge density in a region for which the electric field in cylindrical coordinates is given by

$$\vec{E} = \frac{az}{r}\hat{r} + br\hat{\phi} + cr^2 z^2 \hat{z}$$

Problem 7: Find the magnetic flux produced by the magnetic field $\vec{B} = 5\hat{i} - 3\hat{j} + 4\hat{k}$ T through the top, bottom, and side surfaces of the flared cylinder shown in the figure.



Problem 8: A square loop lies in a plane perpendicular to the following magnetic field.

$$\vec{B}(t) = B_0 e^{-5t/t_0}\hat{i}$$

Find the emf induced in the loop by the field.

Problem 9: The current in a long solenoid varies as $I(t) = I_0 \sin(\omega t)$. Use Faraday's law to find the induced electric field as a function of r both inside and outside the solenoid, where r is the distance from the axis of the solenoid.

Problem 10: Find the displacement current produced between the plates of a discharging capacitor for which the charge varies as

$$Q(t) = Q_0 e^{-t/RC}$$

where Q_0 is the initial charge, C is the capacitance of the capacitor, and R is the resistance of the circuit through which the capacitor is discharging.

Problem 11: Derive the far field radiated by a Hertzian dipole.

Problem 12: A cell phone is 1 km from a receiver. It transmits at a frequency of 1.9 GHz and has a transmit power of 2 W. Its antenna has a gain of 0dB. The cell tower's antenna has a receiver gain of 17 dB. Receiver noise is 2 dBm. Calculate the received SNR.

Problem 13: A Bluetooth transceiver operates on the 2.4 GHz ISM band, with transmit power 1 mW and receiver sensitivity -90 dBm, using the onboard antenna with gain -0.5 dB. Calculate the maximum distance at which two of these transceivers could communicate, assuming ideal free-space propagation conditions.

Problem 14: A radio transmitter is being designed to operate at frequencies from 950 MHz to 1.03 GHz. The transmit antenna gain is 1.5 dB at these frequencies. The receive antenna gain is

12 dB. The receiver sensitivity is -95 dBm. The required range is 50 km over a clear line of sight path. What transmit power is required?