

PHYSICS 535, Fall 2010 – ASSIGNMENT 2

Reading

Summary of Rakov Ch. 3 (through section 3.2.5) and 2 questions about the reading. Also read Behnke 2005 (“Initial leader velocities...”). Two questions about this too. As ever, have at least tentative answers to half the questions. Reading summary for Ch. 3 and Behnke due 9/9. Questions on Ch. 3 due 9/7.

PROBLEM SET #2a – Due 9/14 :

2-1) [a] Derive closed-form expressions for Electric field at the ground vs. distance D from the point directly beneath a point charge Q at height H above flat ground. Derive both components E_r (parallel to the ground) and E_z (perpendicular).

[b] Now add an “image charge” $-Q$ a distance H below the ground. Show that E_r vanishes and that E_z (dipole) is simply $2E_z$ (monopole).

2-2) Calculate the induced surface charge $\sigma(r, \theta)$ at the ground in the middle of a dipole. Integrate $\sigma(r, \theta)$ and show that it sums to Q .

2-3) [a] Derive (Analytically) equation 3.4 for the sign reversal distance D_0 for a dipole composed of equal and opposite charges.

[b] Derive the slightly more general expression for D_0 if the dipole charges are Q_p and Q_N are not equal.

[c] Calculate D_0 for two values each of Q_p , Q_N and H_p , H_N (that's four calculations). Pick what you think are reasonable values of Q 's and H 's based on your reading.

2-4) Using the tripole model of Rakov in Fig. 3.1a, numerically calculate (Matlab or similar) and reproduce figures 3.2c and 3.2d. (Note that Rakov's “tripole” is really three dipoles (or a hexapole ...), once you take ground conductivity into account.

2-5) A balloon sonde measures Electric field vs. altitude and deduces charge vs. altitude. If you knew charge vs. altitude, you could get E-field. Assume infinite slabs of charge given below. Calculate and plot $E(z)$ vs. z . It should reproduce (roughly) Figure 3.10.

$$\rho = 0.0 \text{ nC/m}^3 \quad 0 < z < 3 \text{ km}$$

$$\rho = 0.7 \text{ nC/m}^3 \quad 3 < z < 3.7 \text{ km}$$

$$\rho = 0.0 \text{ nC/m}^3 \quad 3.7 < z < 5 \text{ km}$$

$$\rho = -5.4 \text{ nC/m}^3 \quad 5 < z < 5.15 \text{ km}$$

$$\rho = 0.0 \text{ nC/m}^3 \quad 5.15 < z < 6 \text{ km}$$

$$\rho = 1.6 \text{ nC/m}^3 \quad 6 < z < 6.55 \text{ km}$$

$$\rho = -1.0 \text{ nC/m}^3 \quad 6.55 < z < 6.90 \text{ km}$$