Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2006-2007 (2 hours)

Antennas and Propagation 6

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.** *Where a symbol is not defined it can be assumed to have its usual meaning, with which candidates should be familiar.*

1. **a.** The far zone electric field from an infinitesimal *z*-directed dipole current element of length $\Delta z'$ located on the *z*-axis carrying current $I(z')$ can be written

$$\Delta E_\theta \approx CI(z')\Delta z' \frac{e^{-jk|\underline{r}-\underline{r}'|}}{|\underline{r}-\underline{r}'|} \sin(\theta') \qquad (1.1)$$

where *C* denotes a constant. Simplify this expression for inclusion in the kernel of an integral for the evaluation of the far field of a *z*-directed wire antenna, explaining the approximations made. **(8)**

b. Hence show that the far zone electric field of a dipole antenna of length *2d* supporting the triangular current distribution shown in Figure (1.1) is given by

$$E_\theta = 2CI_o \frac{e^{-jkr}}{r} \frac{d}{1+\cos(\alpha)} Sa^2(\alpha)\sin(\theta) \qquad (1.2)$$

where $\alpha = kd\cos(\theta)$. The relation $\int u dv = uv - \int v du$ should be of use. **(10)**

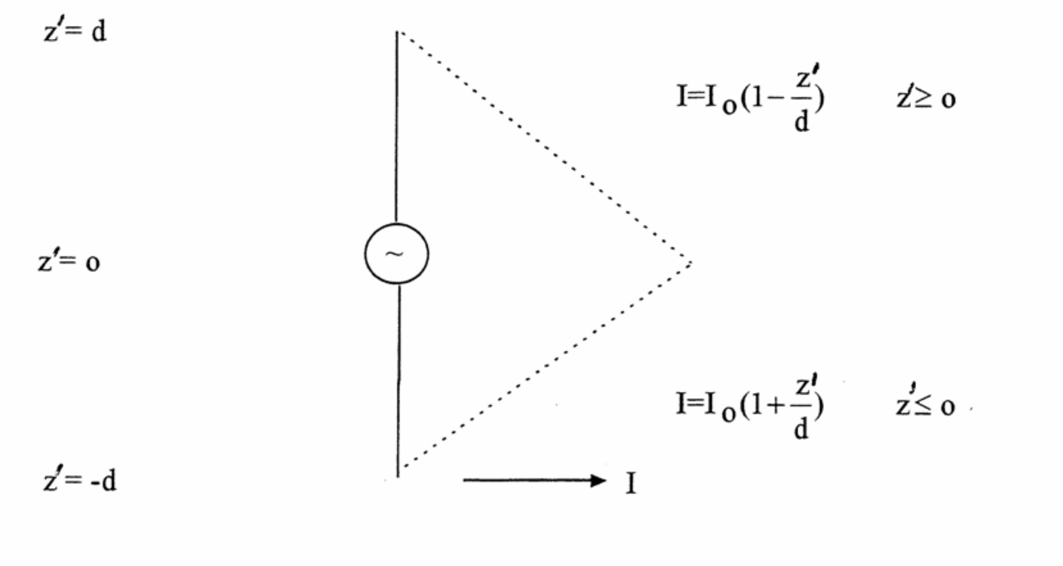

Figure (1.1)

c. Simplify the expression for the electric field in Equation (1.2) when $\theta = 90^o$. **(2)**

2. a. By considering the electric field boundary conditions at a perfectly conducting infinite groundplane, deduce the position and relative orientation of the image of a current element when it is placed (i) parallel to and (ii) normal to this groundplane. Your answer should include a diagram showing the electric field components at the groundplane. **(8)**

b.

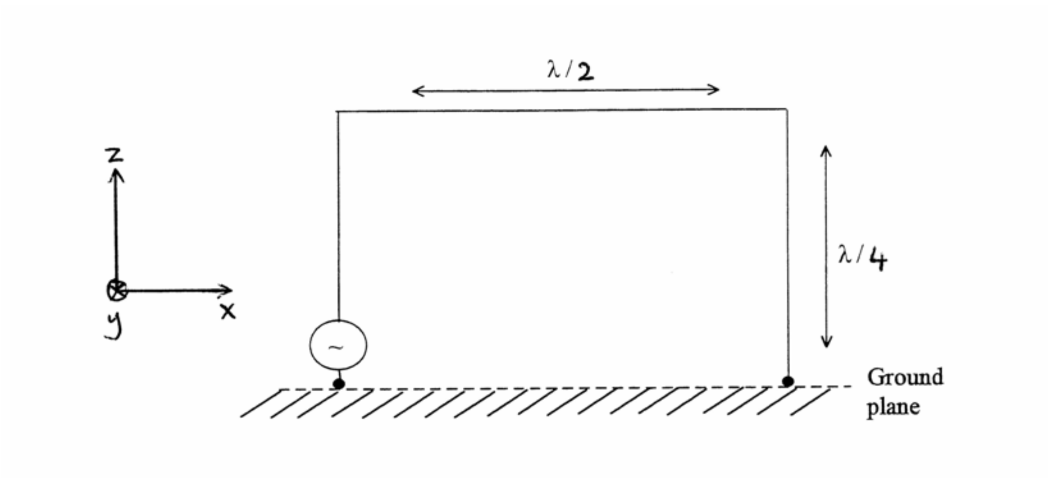

Figure (2.1)

A half loop antenna is counterpoised against a perfectly conducting infinite groundplane, as shown in Figure (2.1). Sketch the current distribution around this loop, including the image currents. Hence sketch the following radiation patterns of this antenna: (i) $E_\theta(\theta,\phi = 0^o)$, (ii) $E_\phi(\theta,\phi = 90^o)$. **(8)**

c. This half loop antenna has a gain of *5.7dBi* and an input impedance of $117 - j43\Omega$. How do these parameters change for a full loop antenna with $\lambda/2$ sides and no groundplane? (i.e. the image half loop is now replaced by a physical wire) **(4)**

3. a. Show that the modified refractive index n^* of a spherical tropospheric layer at height *h* above the earth (of radius *a*) is given by

$$n^* \approx n + h/a \qquad (3.1)$$

and explain its significance. **(9)**

b. The *standard linear atmosphere* tropospheric model assumes

$$(n-1)\times 10^6 = 289 - 39h \qquad (3.2)$$

Assuming waves are launched horizontally, calculate their radius of curvature using this model and sketch their propagation path with respect to the earth's surface. (Assume radius of earth is *6370km*). **(8)**

c. Describe the consequences if $\dfrac{dn^*}{dh} = 0$. **(3)**

4. a. Show that the gain of a centre fed full wave dipole antenna ($L = \lambda$) in free space is *3.8dBi*. The following expressions should be of use:

$$|E_\theta| = \frac{2\eta I_o}{4\pi r}\left[\frac{\cos\left(k\frac{L}{2}\cos(\theta)\right) - \cos\left(k\frac{L}{2}\right)}{\sin(\theta)}\right] \qquad (4.1)$$

$$\int_0^\pi \frac{(\cos(\pi\cos(\theta)) + 1)^2}{\sin(\theta)} d\theta = 3.318 \qquad (4.2)$$

(10)

b. Explain the advantages and disadvantages of using full wave dipoles instead of half wave dipoles in a radio communication link. **(4)**

c. Calculate the power received by a full wave dipole from a distant *400MHz* transmitter producing a *55mV/m* incident electric field. **(6)**

GGC / BC