



**Arab Academy for Science & Technology  
and Maritime Transport – Cairo Branch  
College of Engineering & technology  
Electronics & Communication Engineering Department**



**EC311 – Electronic Materials  
Problem Set No.8: Dielectrics VI  
Duration: Week# 8**

P1) (a) Prove that the imaginary part of the dielectric constant,  $\epsilon_r''(\omega)$ , has its maximum value at:-

$$\omega = \omega_d = 1/\tau.$$

(b) Prove that the loss factor  $\tan(\delta)$  has its maximum value at

$$\omega = \omega_{m\delta} = (\epsilon_r(0) / n^2)^{1/2} * 1/\tau.$$

(c) Prove that the maximum value of loss factor  $\tan(\delta)$  is

$$\tan(\delta)|_{\max} = [(\epsilon_r(0) / n^2)^{1/2} - (n^2 / \epsilon_r(0))^{1/2}] / 2.$$

P2) A certain material has a single maximum in the imaginary part of its relative permittivity,  $\epsilon_r''$ , at 1 GHz. Its static relative permittivity is 6 and its refractive index in the infra-red region is 1.732. What is the maximum value of  $\tan(\delta)$  and at what frequency,  $f_{m\delta}$ , is this maximum?

P3) At room temperature the static relative permittivity of water is 80. A plot of  $\tan(\delta)$  against frequency shows a maximum of 3.3 at frequency of 30 GHz. Deduce the refractive index of water in the visible spectral region and the relaxation time for water dipoles.