1. (20%)  
(a) Write down the time-dependent Maxwell equations in Differential and Integral Form (using $E, B, H, J, D$).  
(b) Derive the continuity equation from the Maxwell equations.  
(c) State Faraday’s law and Ampere’s Law.  

2. (15%) Given six air-filled rectangular waveguides of the following inner dimensions:  
(a) 40 cm X 40 cm (b) 20 cm X 20 cm (c) 4 cm X 4cm (d) 2cm X 1cm  
(e) 0.4 cm X 0.4 cm  (f) 0.2 cm X 0.1 cm  
Determine in which waveguides the $TE_{10}$ mode can propagate and in which waveguides only the $TE_{10}$ mode can propagate. The frequency $f = 10$GHz  
(Hint: find out cutoff frequency)  

3. (20%) Using Drawing and formula  
(a) Explain Phase velocity, group velocity (5%)  
(b) State Parallel Polarization and Perpendicular Polarization (5%)  
and write the $E, H$ expression.  
(c) Explain Brewster angle (5%)  
(d) Explain the Hall effect (5%)  

4. (20%) Consider the transmission line circuit below composed of two air-filled transmission lines of different characteristic impedances as shown. The switch has been in position A for $t < 0$ and at $t = 0$ switches to position B.  

(a) Sketch the voltage $V(z)$ on both lines ($0 < z < 2l$) for $t < 0$.  
(b) Sketch the voltage $V(z)$ on both lines ($0 < z < 2l$) for $t = l/(2v)$.  
(c) At what time $t$ will the circuit reach steady-state.
5. (25%) Two plane waves with wave-vectors $\vec{k}_1$ and $\vec{k}_2$ are incident upon a flat surface which separates the space into two regions as shown in Fig 2 below. The upper half space is free space, and the lower half space is a dielectric medium with $\varepsilon = 5\varepsilon_0$ and $\mu = \mu_0$. The total electrical field in the upper half space (Region 1) is $\vec{E}_i + \vec{E}_a$, and the total electric field in the lower half space (Region 2) is $\vec{E}_2 + \vec{E}_b$.

The incident field $\vec{E}_i$ is given by $\vec{E}_i = \hat{y}E_0 \cos(\frac{k}{\sqrt{2}}(x-z) - \omega t)$

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure2.png}
\caption{}
\end{figure}

(a) What is the incident angle $\theta_1$ for $\vec{k}_1$?

(b) Find the reflection coefficient $R_{12}$ of $\vec{E}_1$. What is the reflected field of $\vec{E}_a$?

(c) Let the field $\vec{E}_a$ be 0, and the incident field $\vec{E}_2$ be a TE wave. What are $\vec{E}_2$ and $\vec{E}_b$?

(d) Let the field $\vec{E}_a$ be right-handed circularly polarized (r. h. c. p.) and the incident field $\vec{E}_b$ be a TM wave. Write down the expression for $\vec{E}_a$. Find the incident field $\vec{E}_2$?