(1) Calculate the force per unit length on each of three equidistant, infinitely long, parallel wires 0.14(m) apart, each carrying a current of 20(A) in the same direction. Specify the direction of the force. (10%)

(2) A parallel-plate capacitor of width W, length L, and separation d is partially filled with a dielectric medium of dielectric constant ϵ_r, as shown in Fig.1. A battery of Vo volts is connected between the plates.

(a) Find electric flux density $\vec{D}$, electric field intensity $\vec{E}$ and surface charge density ρ_s in each region.

(b) Find distance x such that the electrostatic energy stored in each region is the same. (10%)

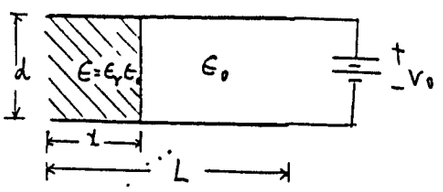

Fig. 1.

(3) A uniform sinusoidal plane wave in air with the following expression for electric intensity

$$\vec{E}_i(x,z)=\hat{a}_y\ 10\ e^{-j(6x+8z)} \quad (v/m)$$

is incident on a perfectly conducting plane at z=0

(a) Write the instantaneous expressions for $\vec{E}_i(x,z,t)$ and $\vec{H}_i(x,z,t)$, using a cosine reference.

(b) Determine the angle of incidence

(c) Find $\vec{E}_r(x,z)$ of the reflected wave and $\vec{E}_1(x,z)$ of the total field. (15%)

(4) Explain

(a) Standing wave ratio

(b) Nonuniform plane wave

(c) Double-stub matching (15%)

5. A semiconductor is characterized by the energy band diagram shown in Fig. 2. It is known that E_G=1.12eV, kT=0.026eV, $n_i=10^{10}cm^{-3}$ μ_n= 1400 cm^2/V-sec and $\tau_n=10^{-7}$sec
   a) Sketch the electric field (ξ) inside the semiconductor as a function of x.(2%)
   b) Is the semiconductor degenerate at any point? if so, where? (1%)
   c) Sketch the electron concentration as a function of position. Specifically indicating on your plot numerical values for n at x=A and x=C.(3%)
   d) Is there a electron drift current at x=A? If yes, indicate the direction.(1%)
   e) A small excess of electrons is introduced at the point C. If A-C=0.01 cm, will a significant number of the excess ever reach B? Explain. (3%)
   f) An electron at x=B with a total energy $E=E_c$ moves from x=B to x=0 without changing its total energy. What is the total kinetic energy (K.E.) of electron upon arrivig x=0? (2%)

6. An Al-gate MOS transistor is fabricated on an n-type (100) Si substrate with $N_D=10^{15}$ cm^{-3}. The thickness of the gate oxide is 400 Å. The relative dielectric constant for SiO_2 and Si are 3.9 and 11.9, respectively. The Si energy gap is 1.1 eV. ϕ_M =4.1 V and qX=4.15 eV. SiO_2 electron affinity is 0.9V.
   (a) Construct the band diagram and charge distribution for the idealized gate MOS capacitor in strong inversion. (3%)
   (b) If the surface charge density at the oxide-silicon interface is $3x10^{11}cm^{-2}$, calaculate the threshold voltage for this MOSFET.(4%)
   (c) Plot the C_G-V_G characteristics for this MOSFET of (b). Indicate the flat-band voltage, threshold voltage, C_{min} (4%)

7. Answer the following independent items briefly. (27%)
   (a) Does the avalanche breakdown voltage increase or decrease with increasing temperature? Why? (3%)
   (b) List three methods for the determination of semiconductor conduction types. (3%)
   (c) What is the meaning of single frequency laser? Can you explain how a cleaved-coupled-cavity laser works? (3%)
   (d) Based on the relation of drift velocity and electric field, explain why the existence of negative differential resistance in n-GaAs? (3%)
   (e) Construct the energy band diagram for a metal-on-p-type Schottky barrier with negligible surface state for $\phi_M > \phi_S$. Indicate whether it is a rectifying or nonrectifying junction and specify the built-in potential and barrier height.(3%)
   (f) If N_A increases, how will the following parameters vary for a n^+-p junction? τ_n, τ_p, $\xi(0)$ (3%)
   (g) Explain the orgin of three base current components for a pnp transistor?(3%)
   (h) An average electron drift velocity of 10000 cm/sec result when 2V is applied across a 1-cm long semiconductor bar. What is the electron mobility inside the bar? (2%)
   (i) Explain how generation in the depletion region affects the I-V characteristics in reverse biased diode? (2%)
   (j) List the forward conductance in order for the monolithic diodes as shown in Fig.3. (2%)

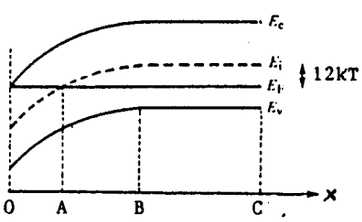

Fig. 2

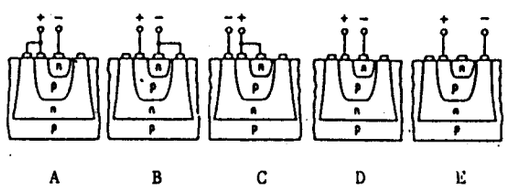

Fig.3