1. Consider an n-type Silicon photoconductor doped at $N_d=10^{15}\ cm^{-3}$ operating at T=300 K. The cross-sectional area is $A=10^{-4}cm^2$ and the length is $L=100\ \mu m$. The carrier mobilities are $\mu_n=1200\ cm^2/V\text{-}s$ and $\mu_p=400\ cm^2/V\text{-}s$, and the carrier lifetimes are $\tau_n=\tau_p=0.5\ \mu s$. The photoconductor is uniformly illuminated such that the generation rate of electron-hole pairs is $g=10^{20}\ cm^{-3}s^{-1}$. For a voltage of 5-V applied on the photoconductor,
   (a) determine the thermal equilibrium current, (6%)
   (b) determine the steady-state excess carrier concentration, (6%)
   (c) determine the photoconductivity, (6%)
   (d) determine the steady-state photocurrent (7%).
2. An abrupt Si pn junction has $N_a=10^{18}\ cm^{-3}$ on the p-side and $N_d=10^{16}\ cm^{-3}$ on the n-side. For Si, the bandgap is $E_g=1.12$ eV, the relative permittivity is $\varepsilon_r=11.8$, and the intrinsic carrier density is $n_i=1.5\times10^{10}\ cm^{-3}$. Assume that the electron effective mass in the conduction band is the same with hole effective mass in the valence band.
   (a) At T=300 K, calculate the Fermi levels and then draw an equilibrium band diagram for the pn junction. (15%)
   (b) What is the minimum n-region width such that avalanche breakdown occurs before the depletion region reaches an ohmic contact (punch-through)? The breakdown voltage is $V_{br}=100\ V$. (10%)

3. An ideal n-channel MOSFET has the following parameters:
$\mu_n = 10\ cm^2/V\text{-}s$, $W = 1000\ \mu m$, $L = 10\ \mu m$, $t_{oxide} = 100\ Å$, $V_T = 0.5\ V$, $C_{oxide} = 6.9\times10^{-8}\ F/cm^2$
(1) What are the $I_D(sat)$ for $V_{GS} = 5$, 10, 20, and 30 V, respectively? (10 分)
(2) If $V_{DS}=1$ V, what is I_D for $V_{GS} = 5$, 10, 20, and 30 V, respectively? (10 分)
(3) What is the different between enhancement mode and depletion mode devices? (5 分)
(4) Is this n-channel MOSFET enhancement mode and depletion mode? (5 分)

4. What is work function of a metal? If the work function of Ag is 5 eV, calculate the maximum wavelength of light for the photoelectric emission of electrons for Ag. (10 分)
Calculate the de Broglie wavelength for an electron with kinetic energy of 1.0 eV. (10分)