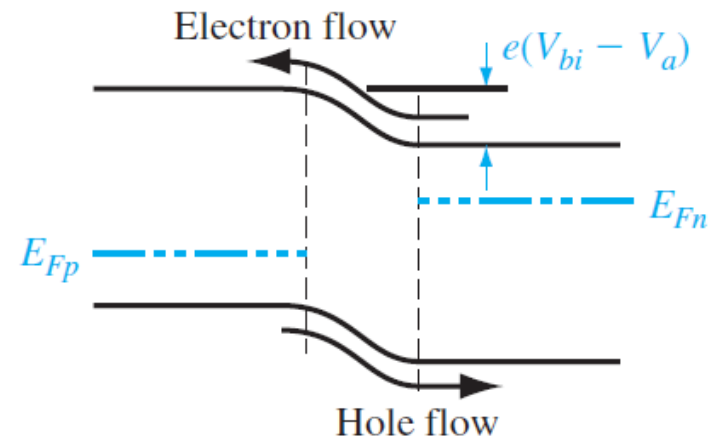
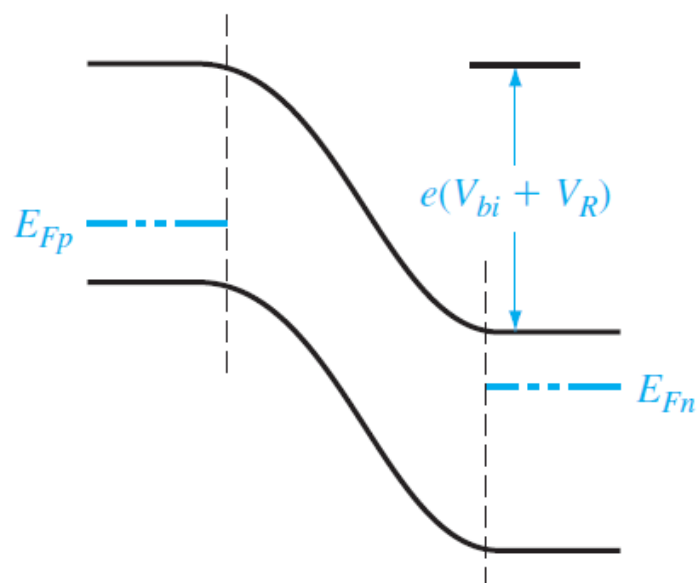
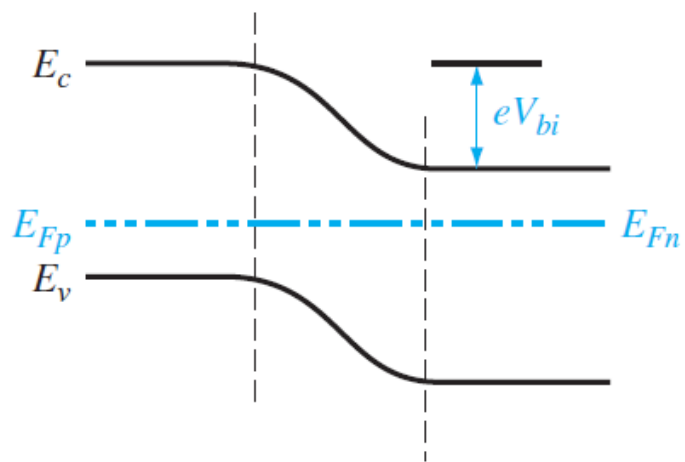
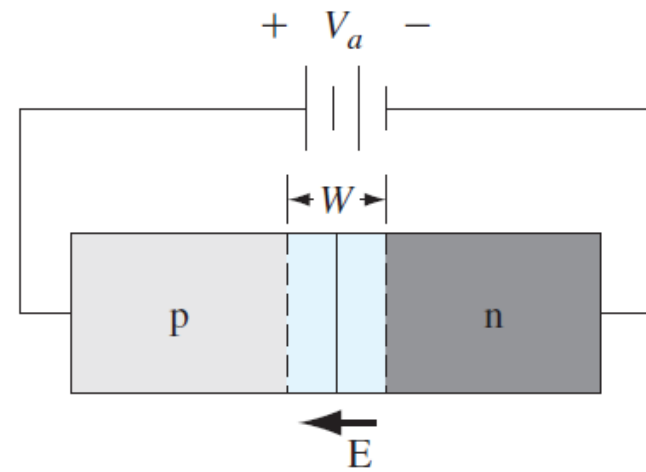
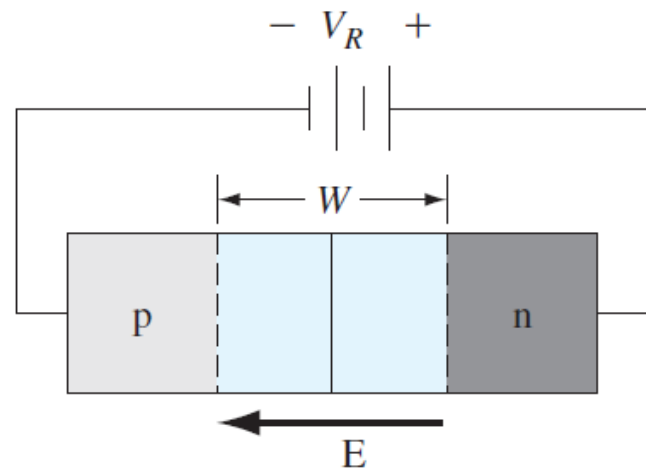
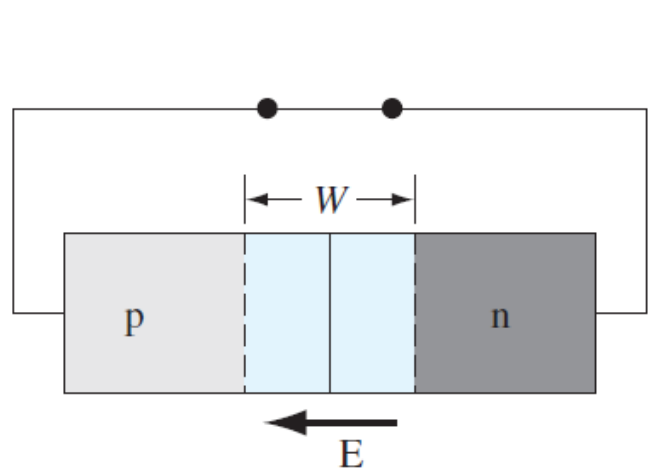
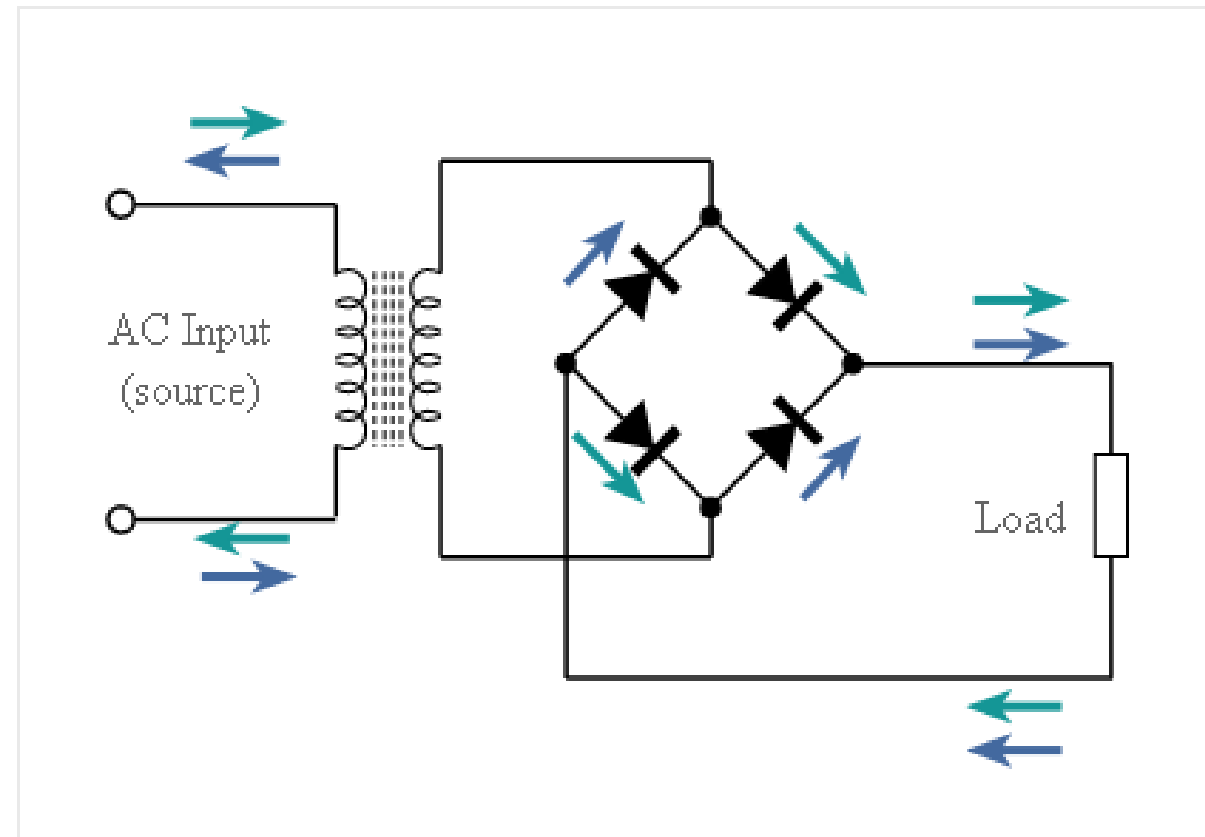
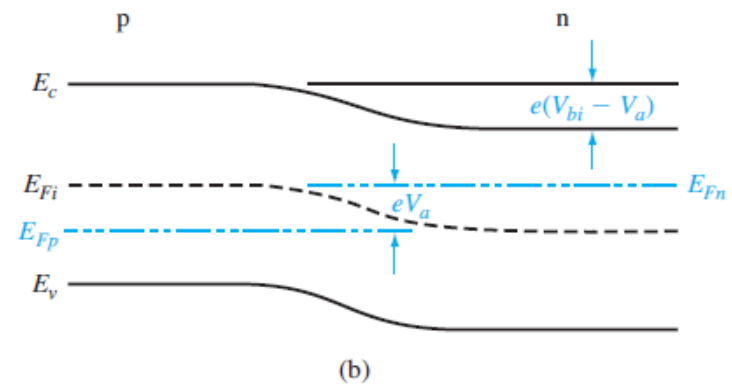
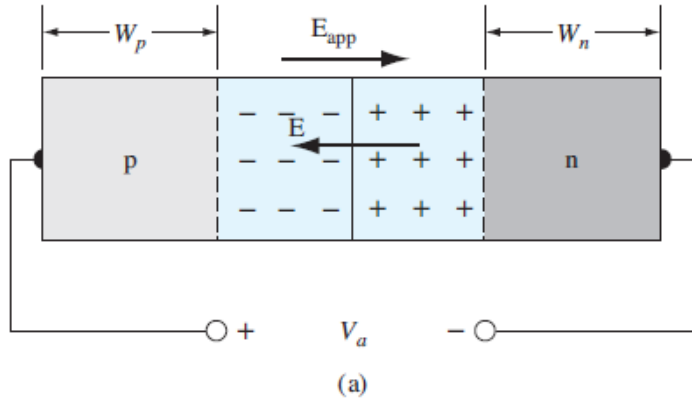


Semiconductor Devices

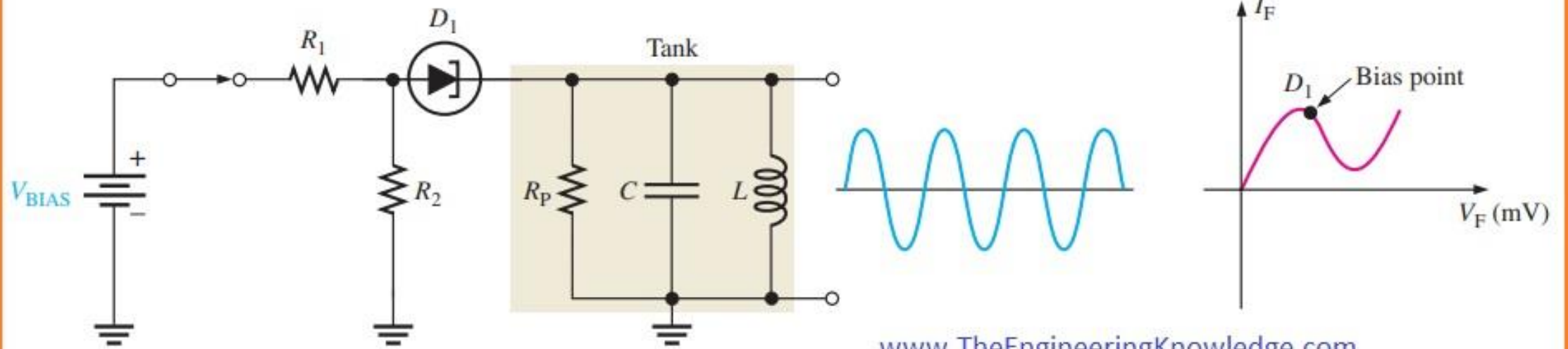
Dr Ruy Sebastian Bonilla

Hilary Term 2020

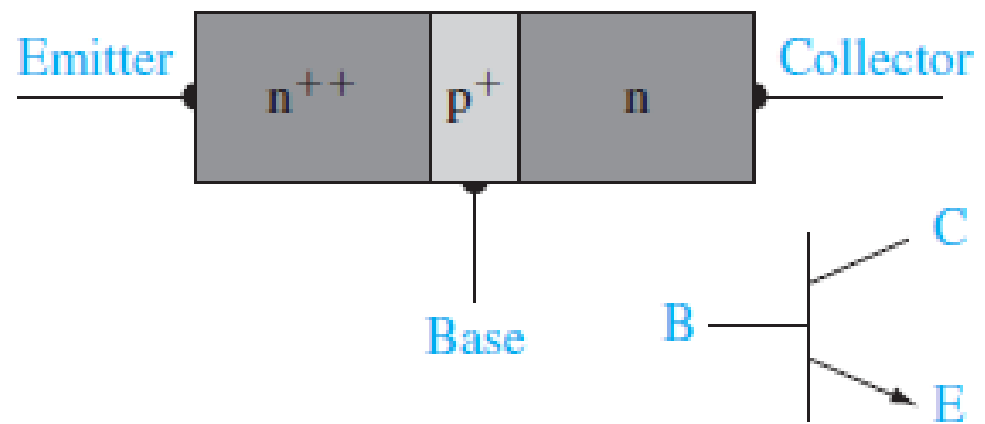




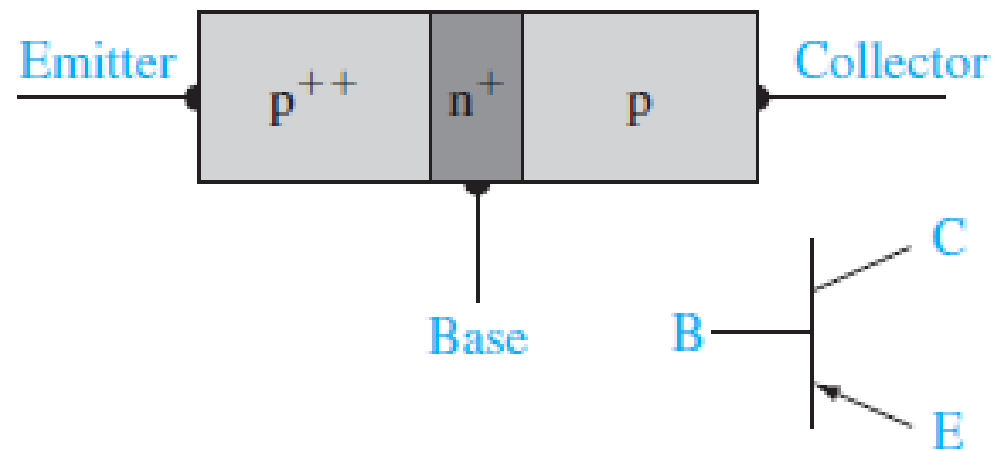
Tunnel Diode Oscillator



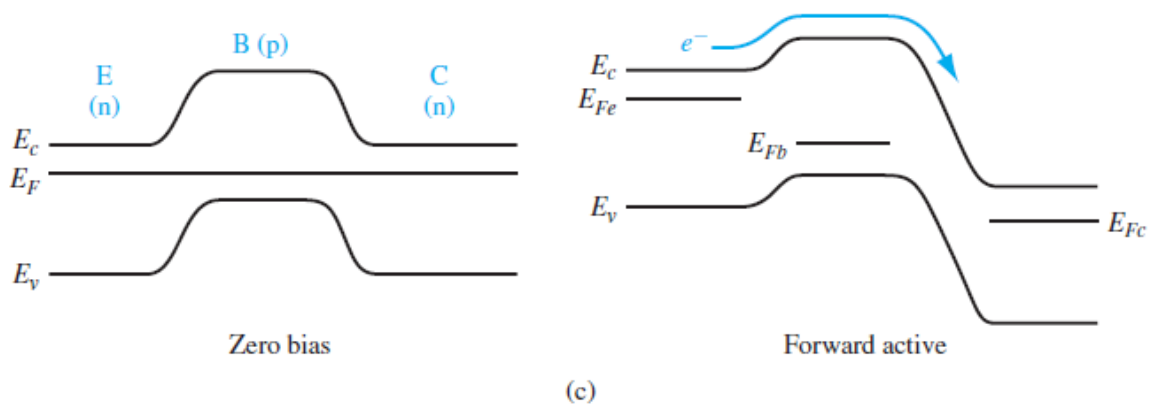
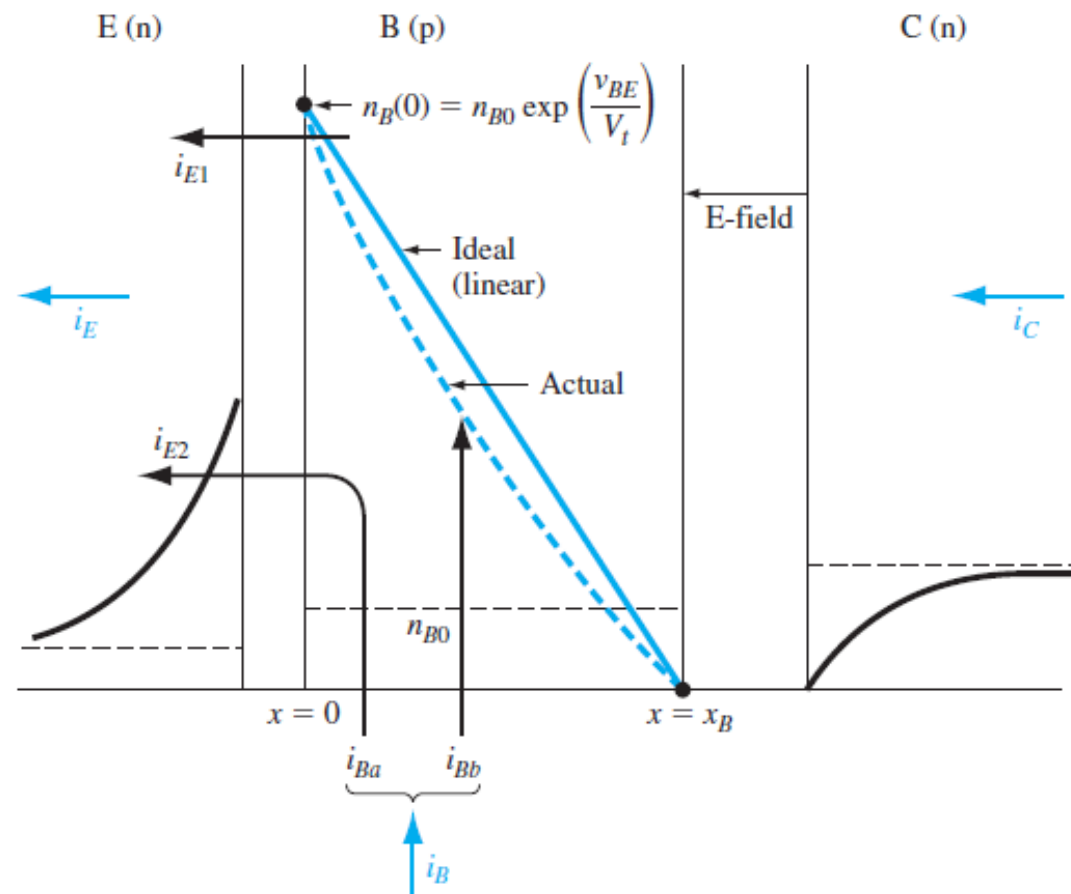
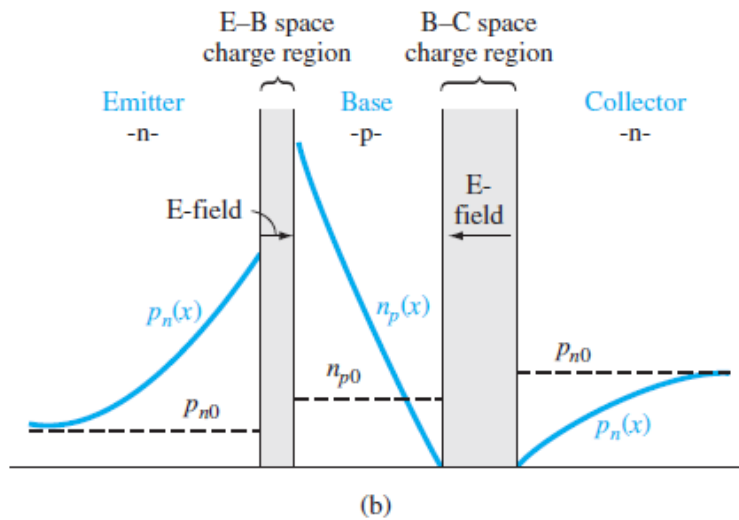
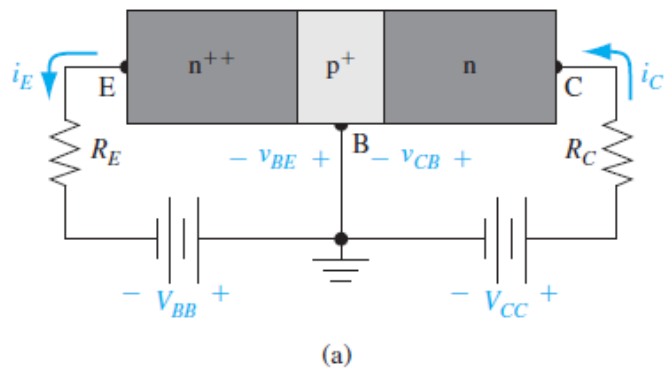
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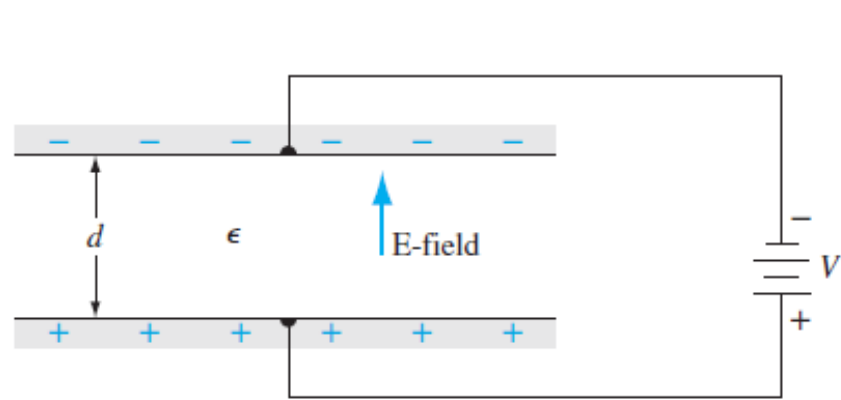


(a)

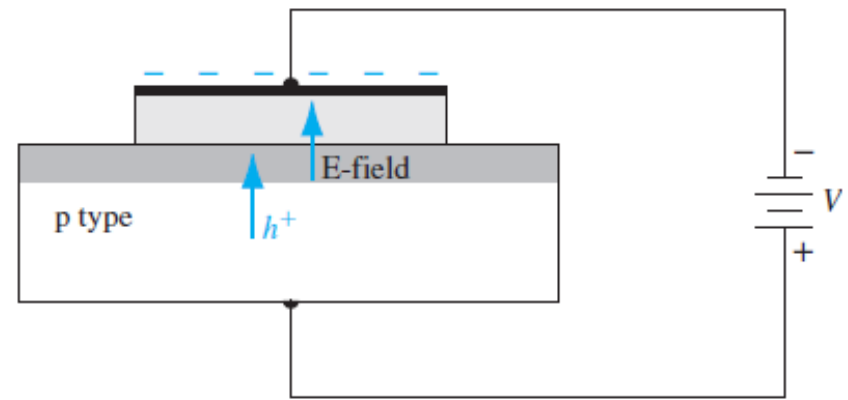


(b)

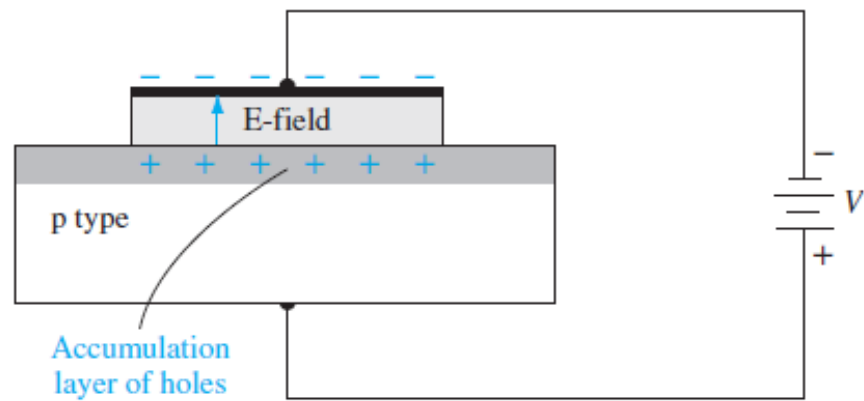




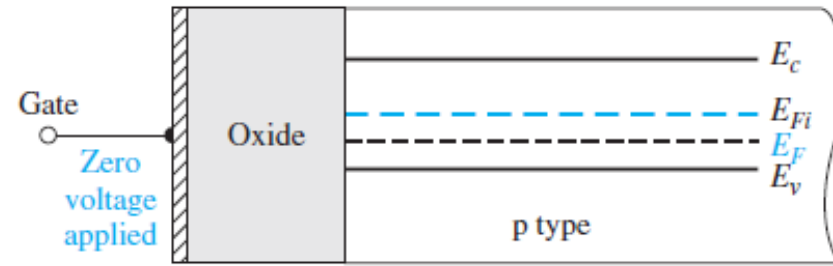
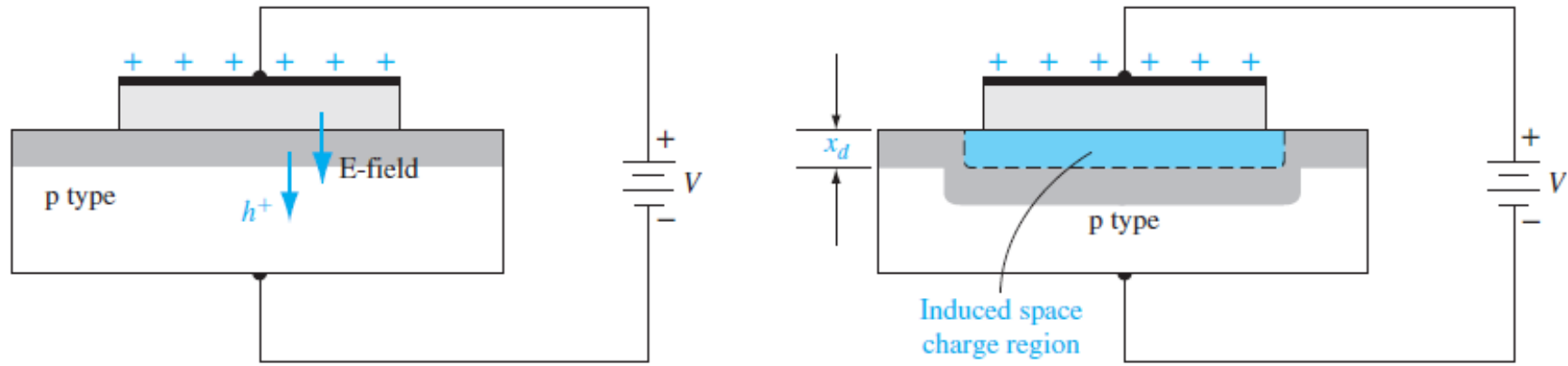
(a)



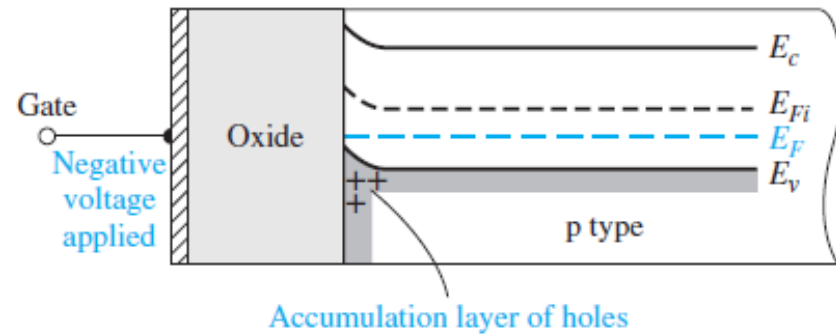
(b)



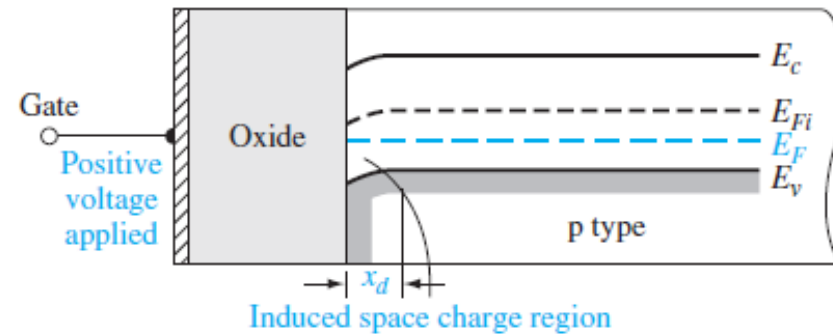
(c)



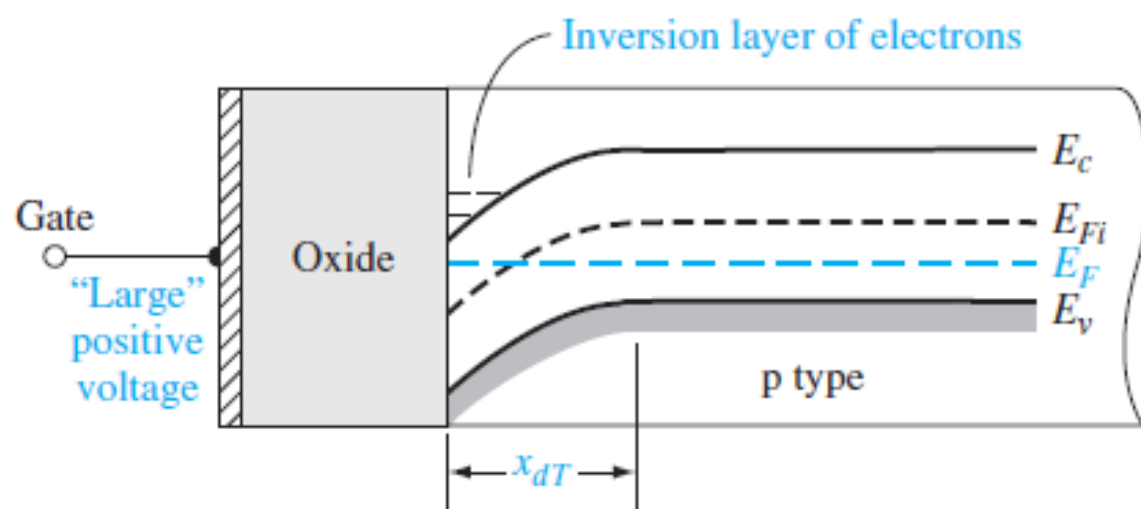
(a)

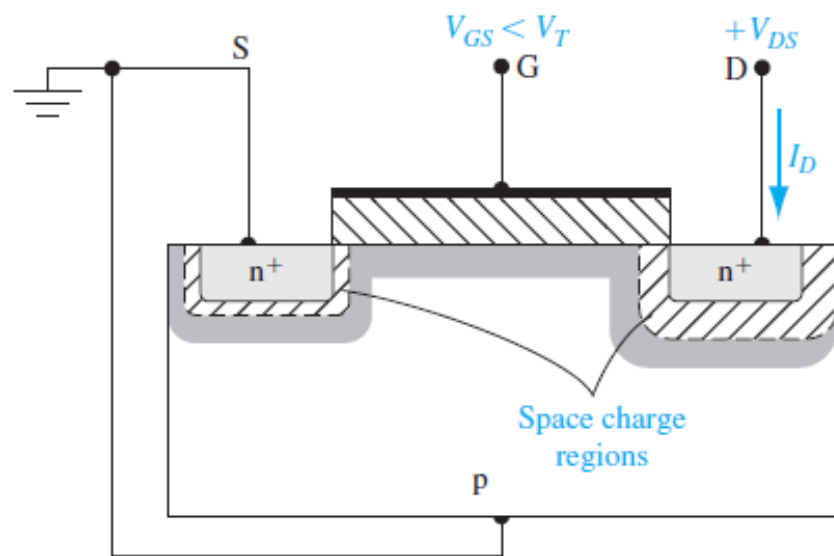


(b)

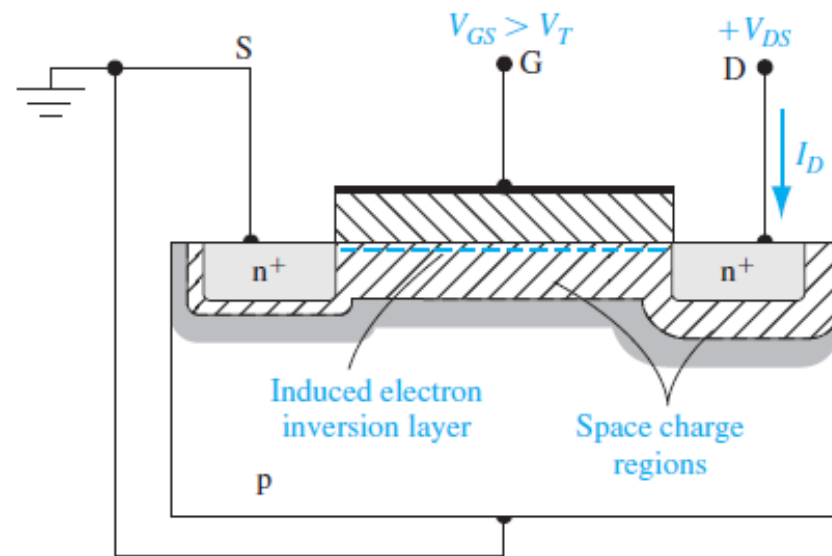


(c)



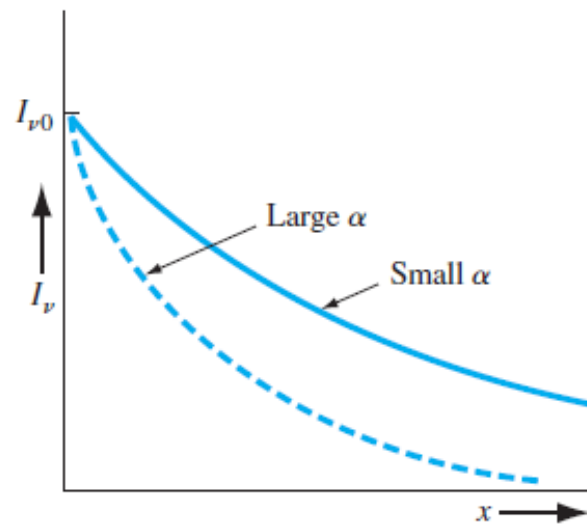
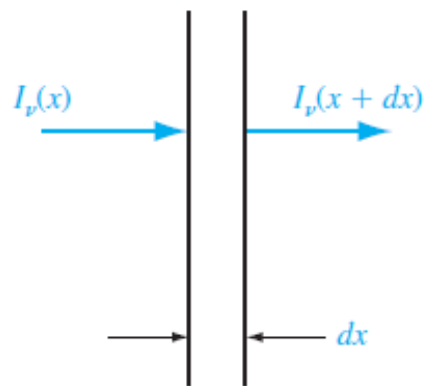
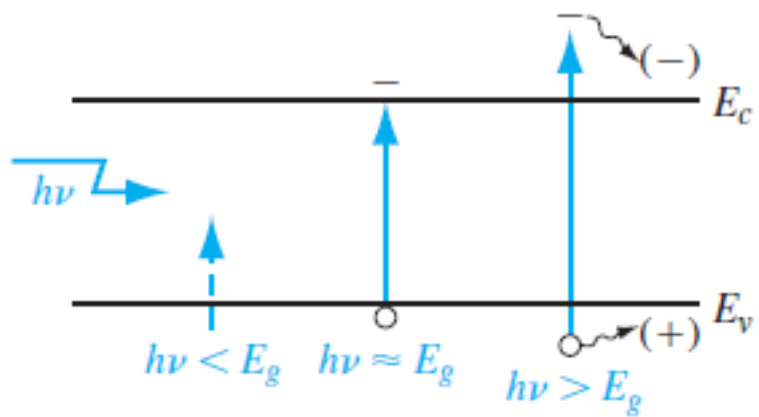


(a)

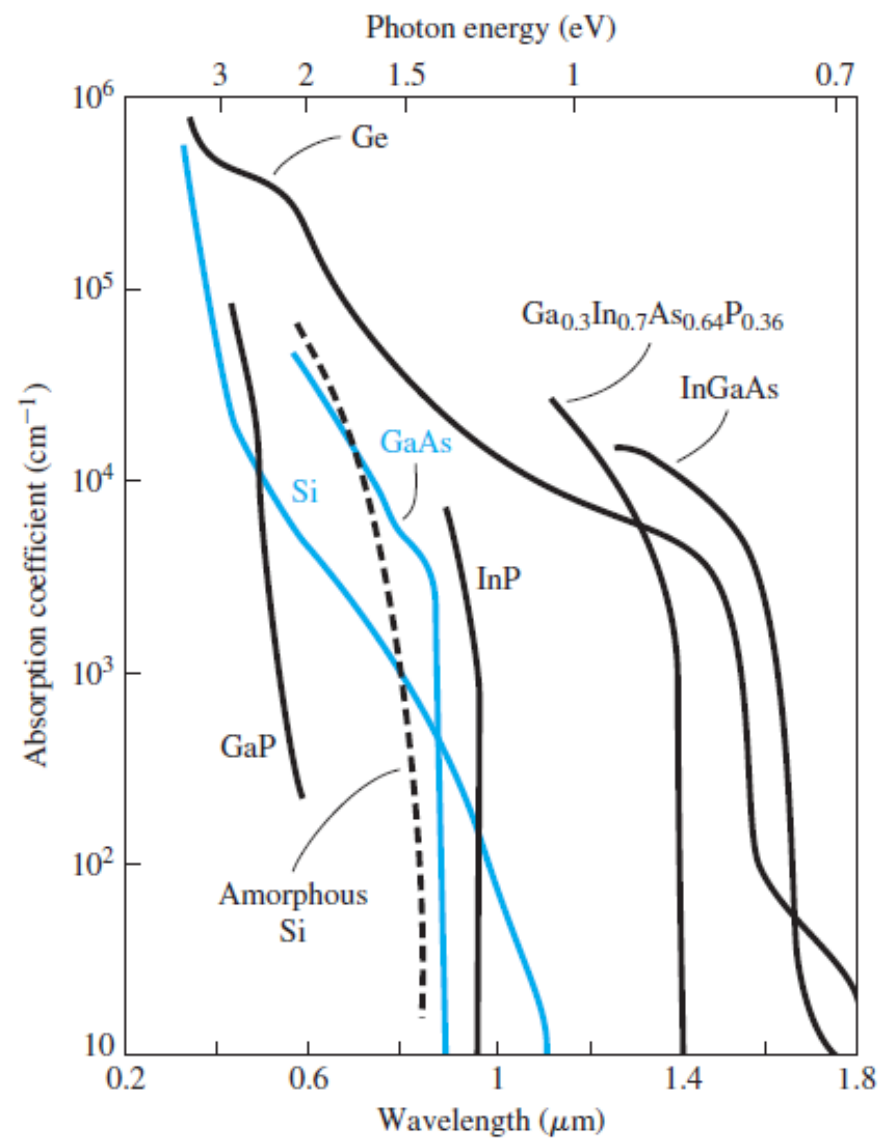
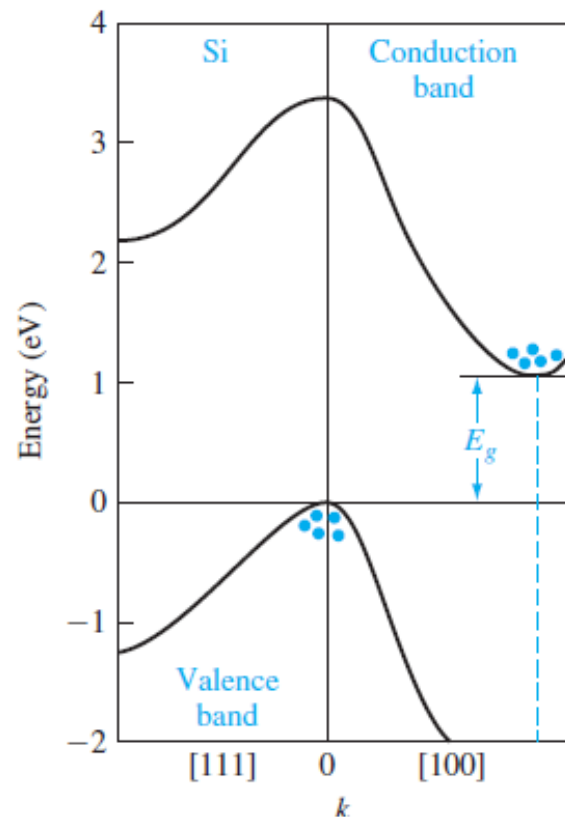
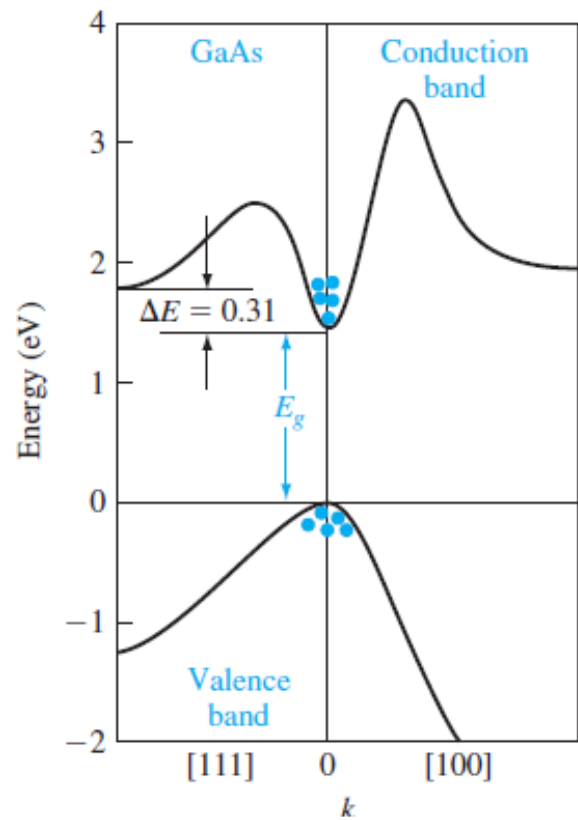


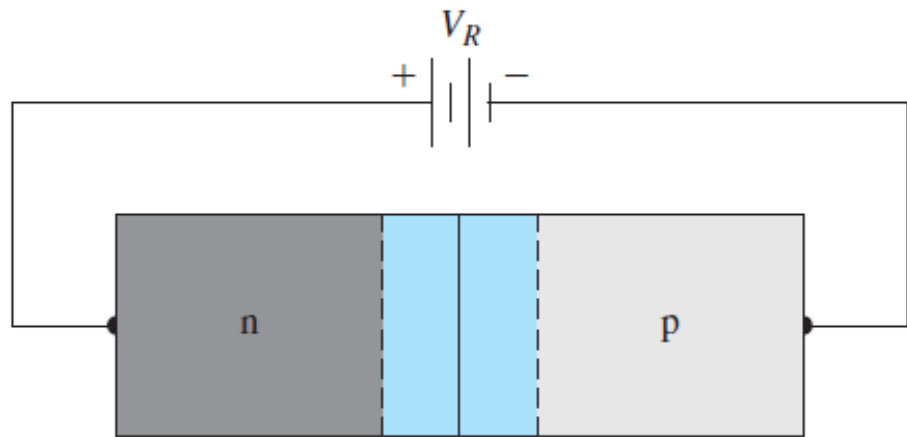
(b)

Light absorption and detection

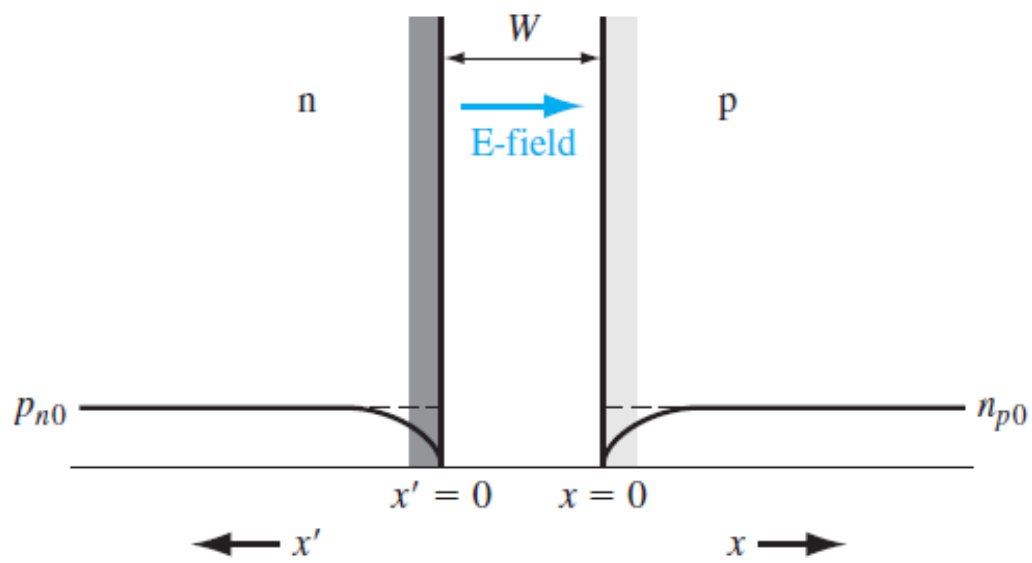


$$I_\nu(x) = I_{\nu 0} e^{-\alpha x}$$

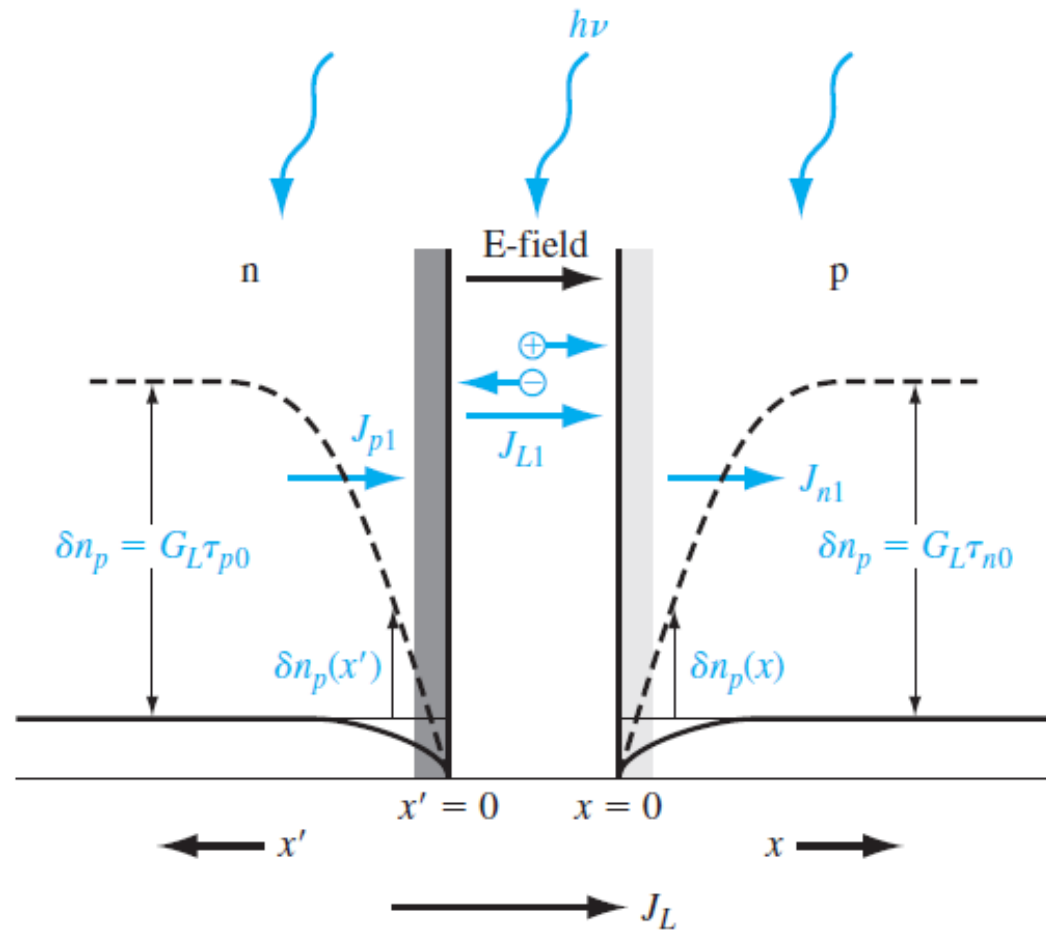




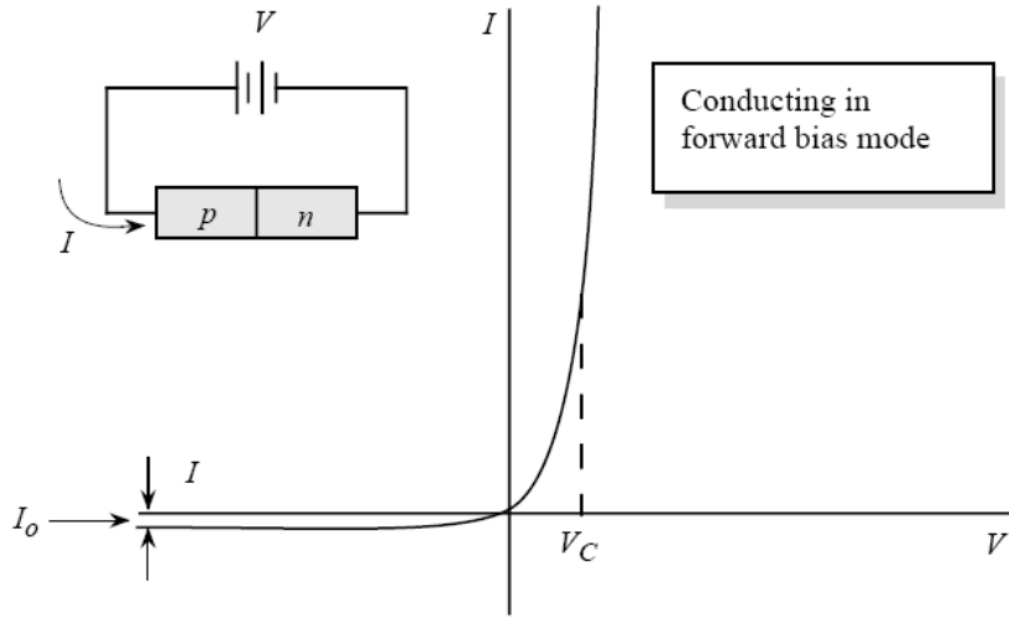
(a)



(b)

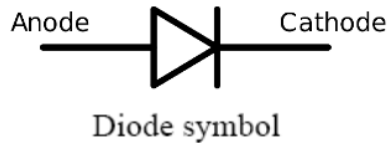


I-V characteristics of pn junction



Conducting in forward bias mode

Non-conducting in reverse bias mode



Total current is I;

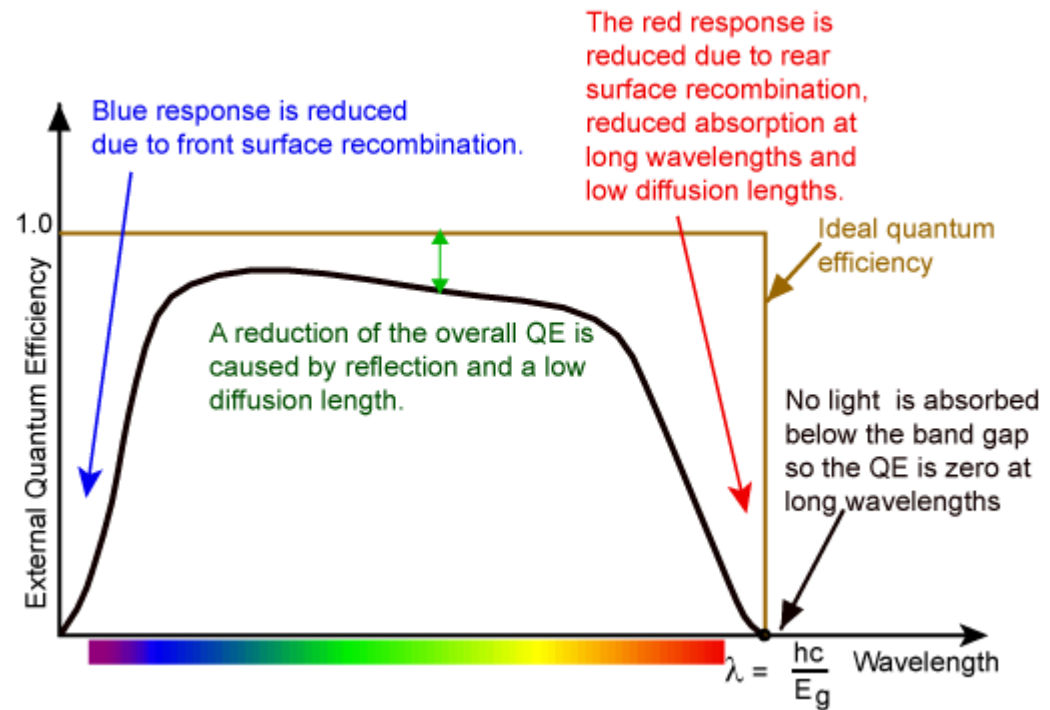
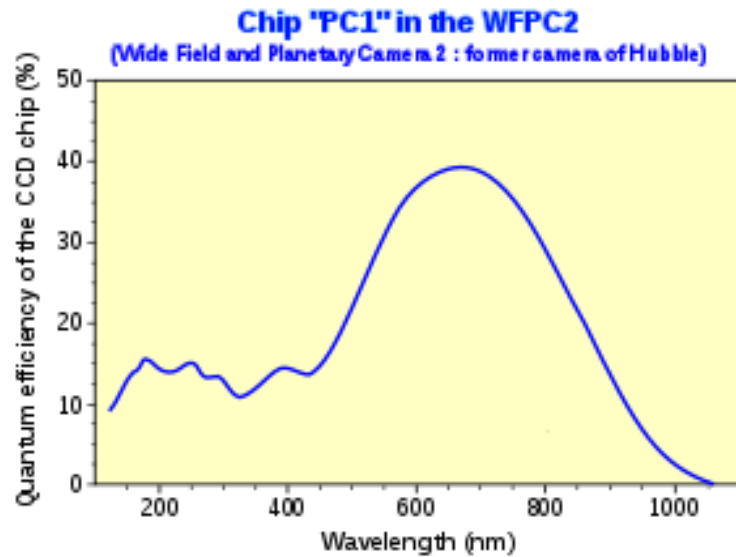
$$I = I_e(0) + I_h(0) = \left(\frac{eD_e n_{p0}}{L_e} + \frac{eD_h p_{n0}}{L_h} \right) \left(\exp\left(\frac{eV_F}{k_B T}\right) - 1 \right)$$

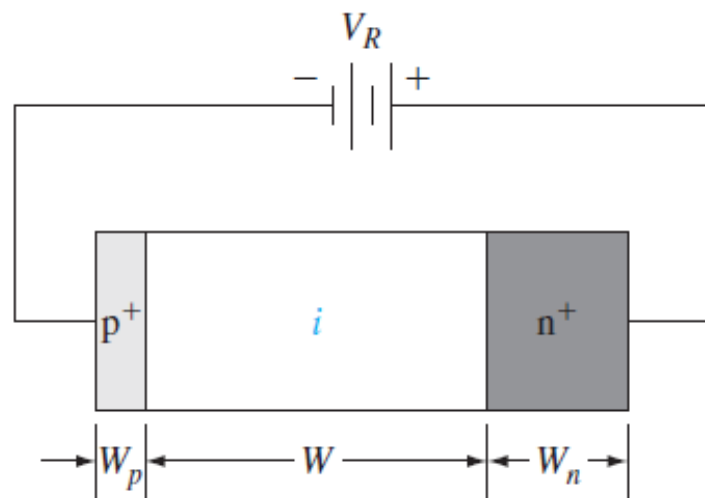
$$I = I_0 \left(\exp\left(\frac{eV_F}{k_B T}\right) - 1 \right) \quad \text{Ideal Diode equation}$$

where; $I_0 = \left(\frac{eD_e n_{p0}}{L_e} + \frac{eD_h p_{n0}}{L_h} \right)$ I_0 is the saturation current (or "dark" current).

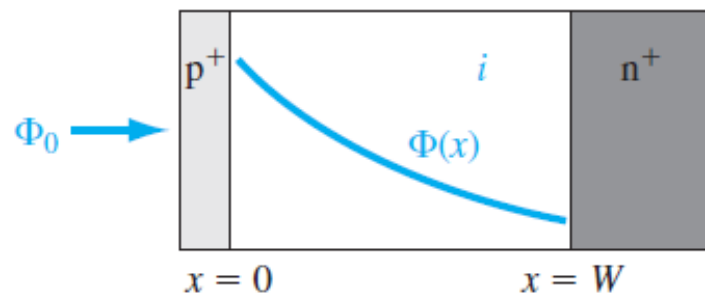
$$\text{EQE} = \frac{\text{electrons/sec}}{\text{photons/sec}} = \frac{(\text{current})/(\text{charge of one electron})}{(\text{total power of photons})/(\text{energy of one photon})}$$

$$\text{IQE} = \frac{\text{electrons/sec}}{\text{absorbed photons/sec}} = \frac{\text{EQE}}{1 - \text{Reflection-Transmission}}$$

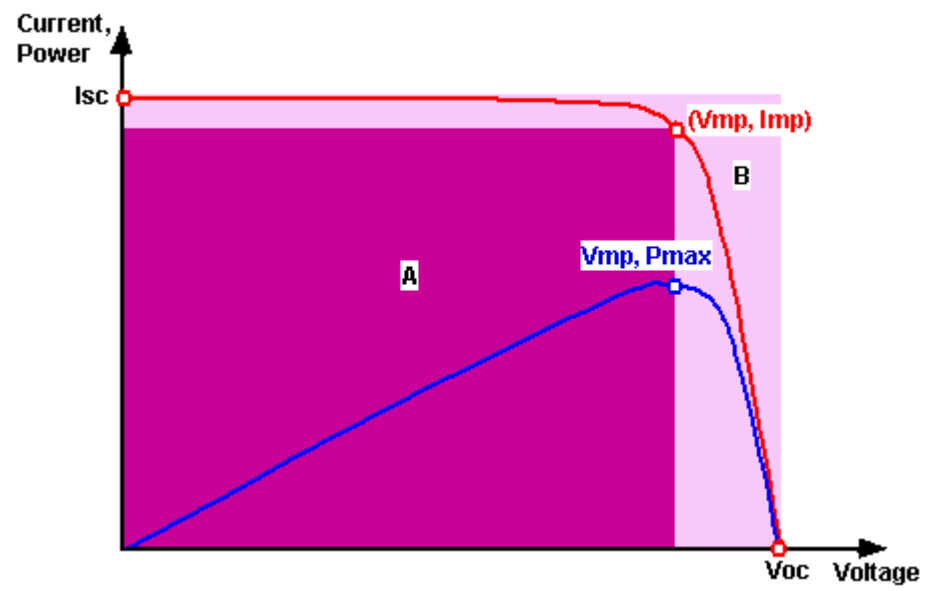
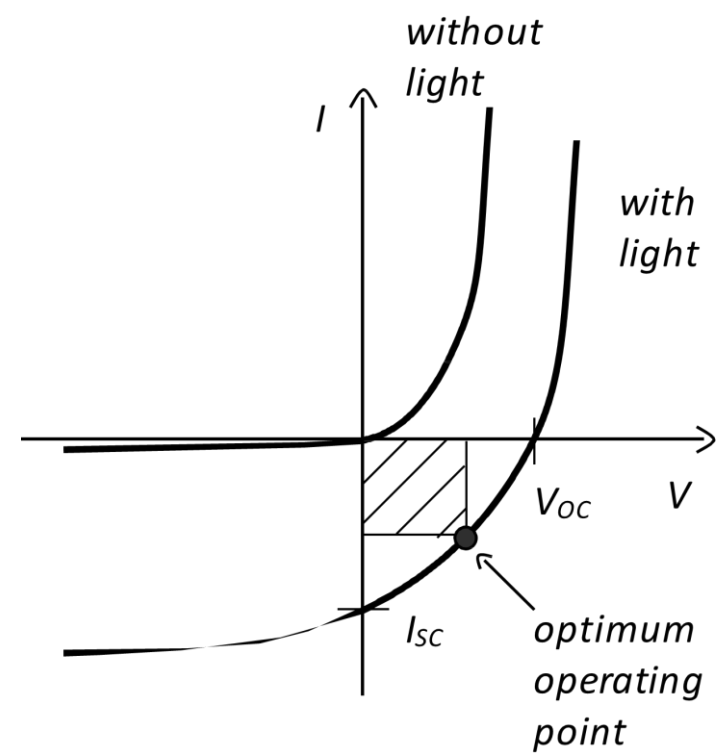
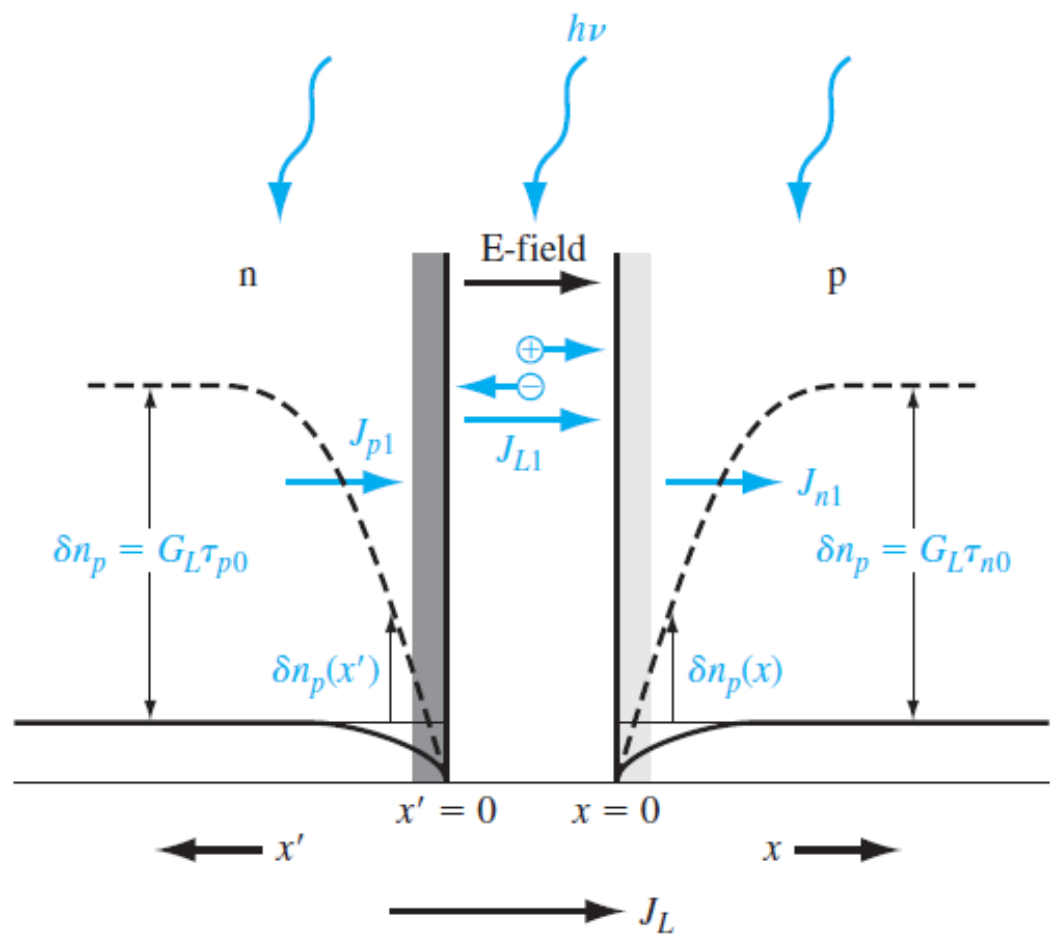


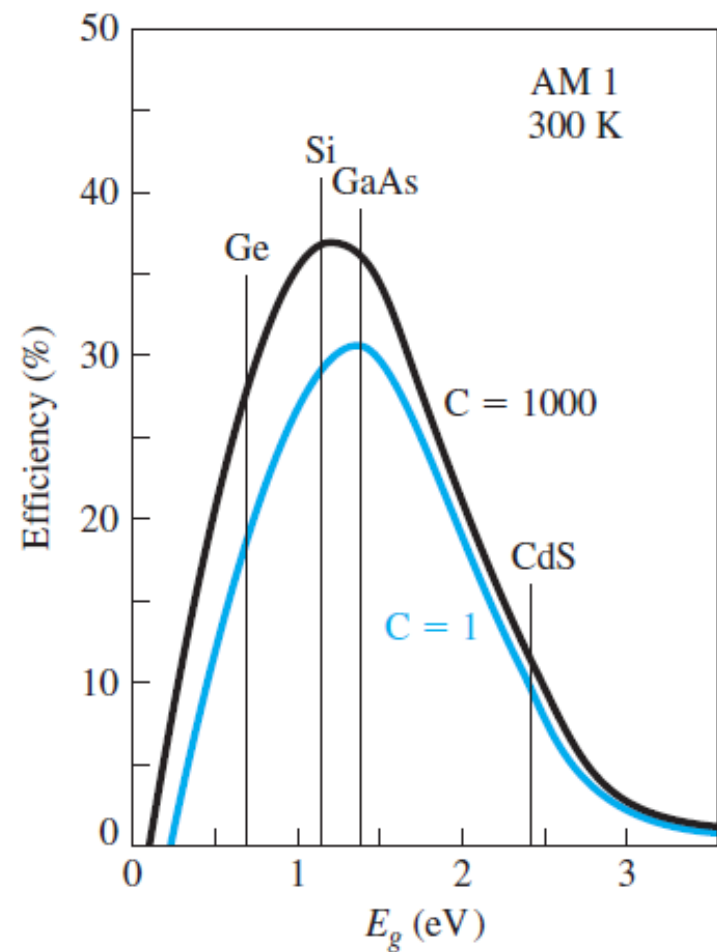
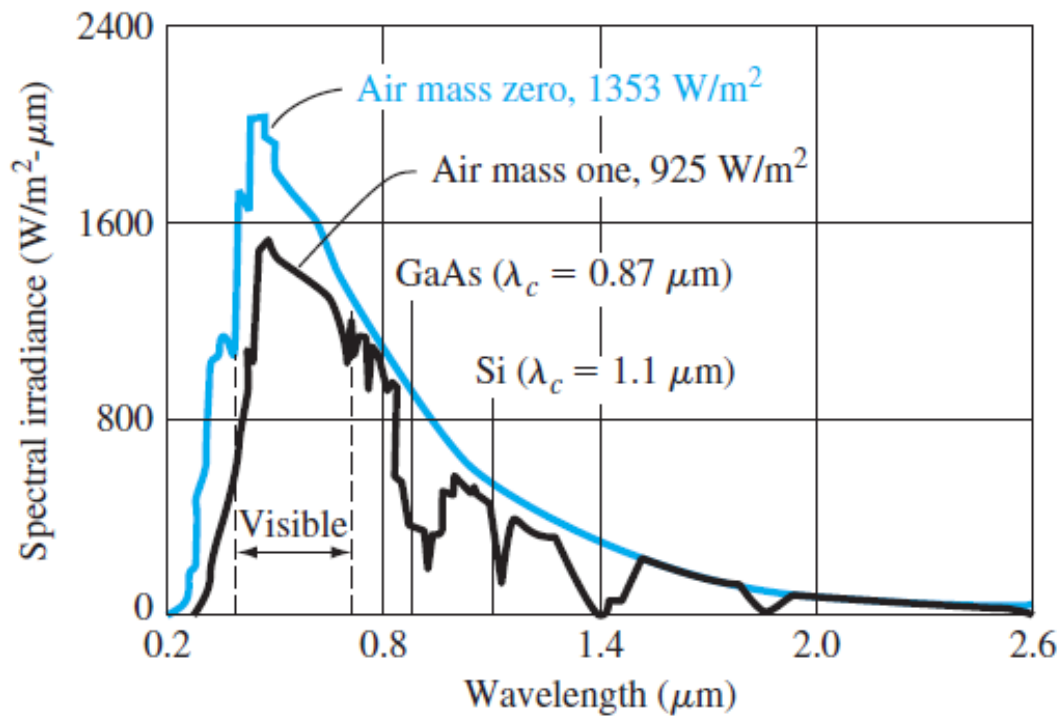


(a)

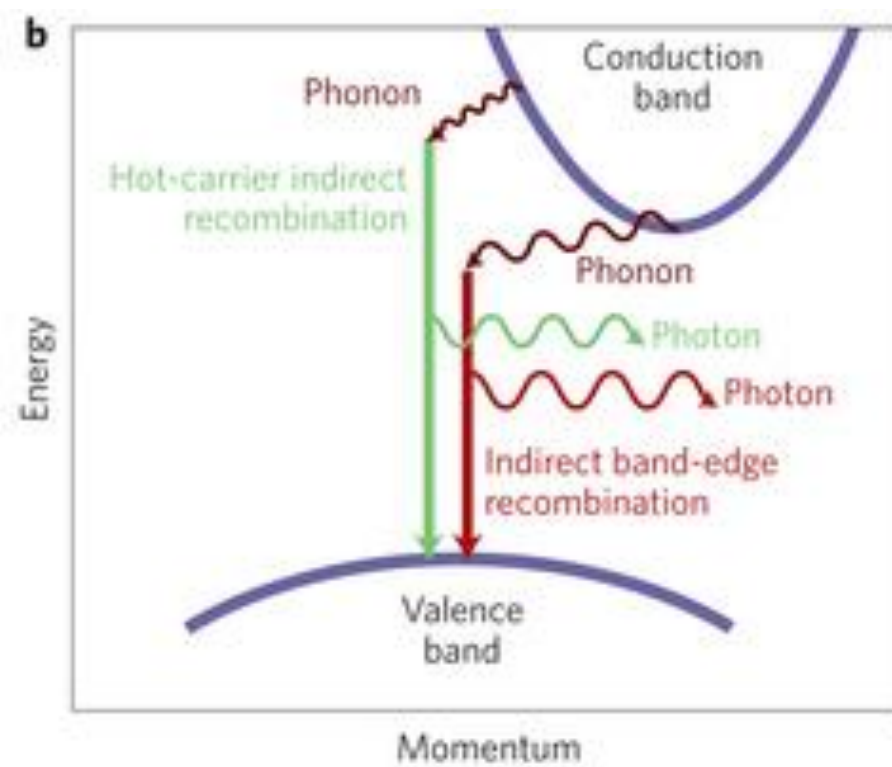
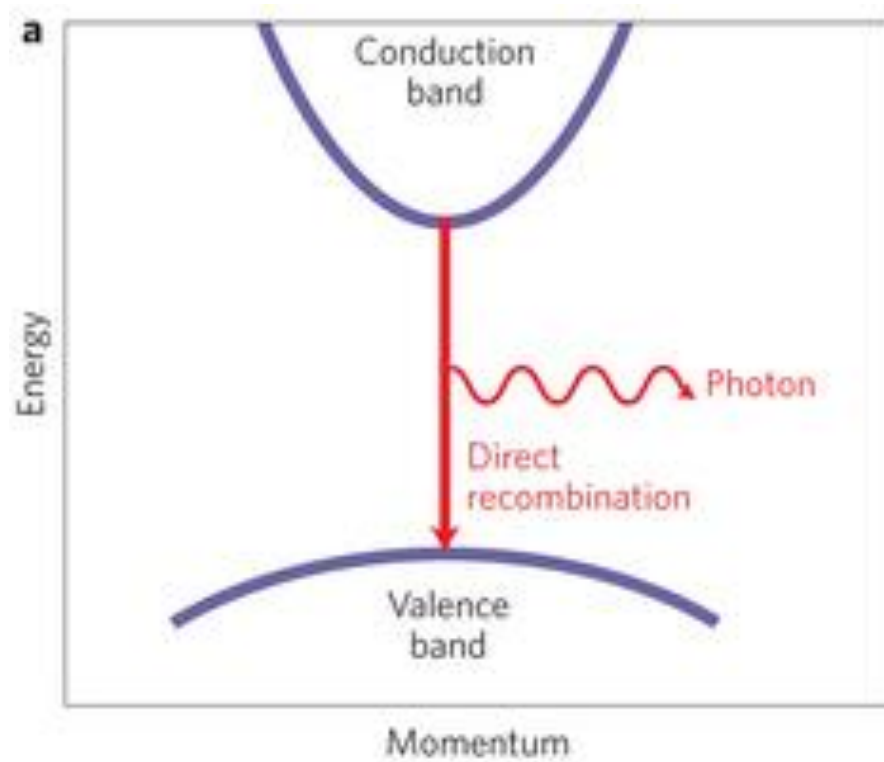


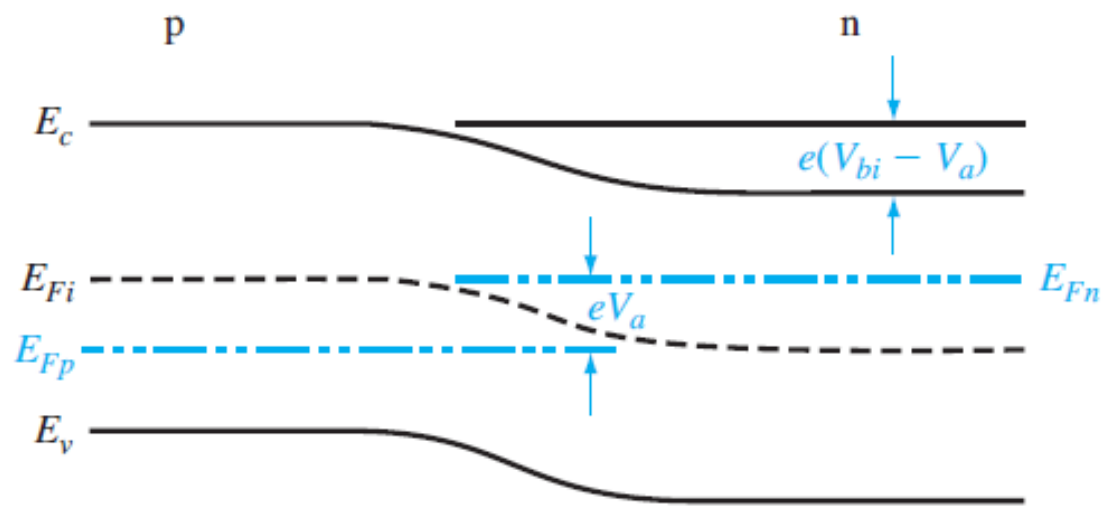
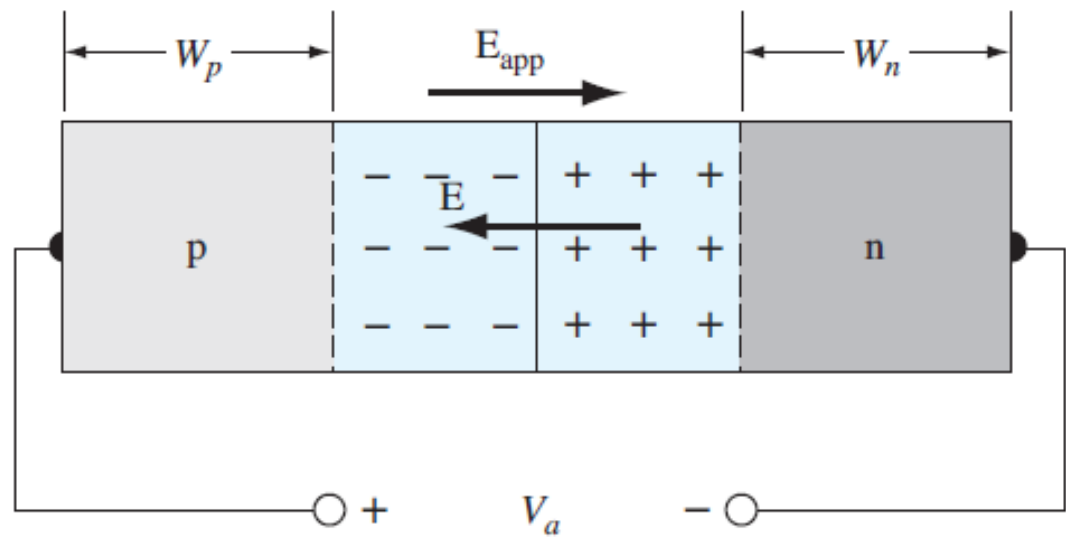
(b)

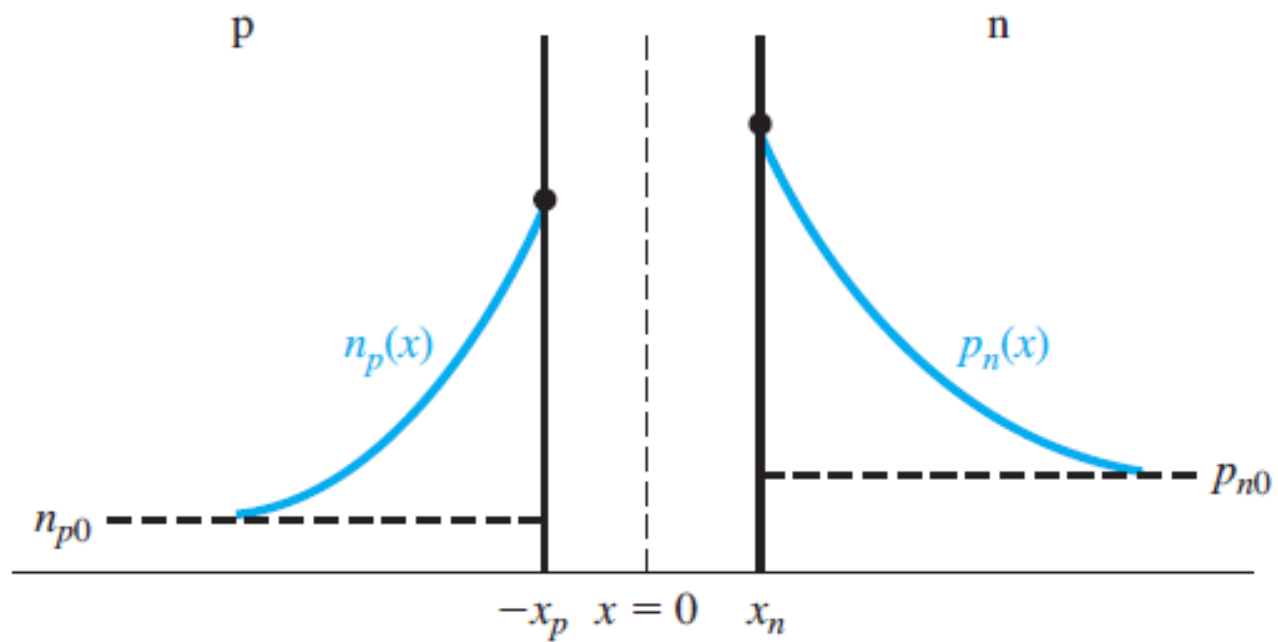
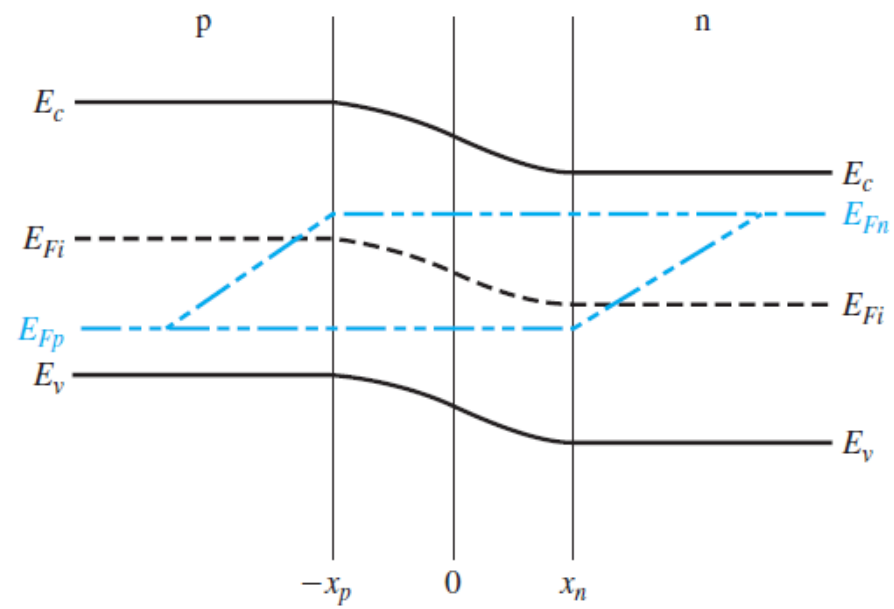


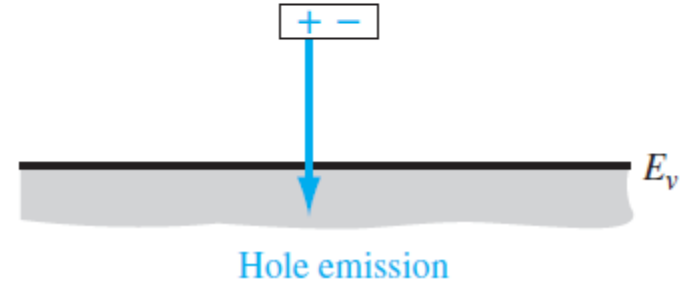
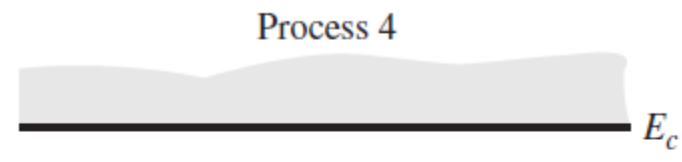
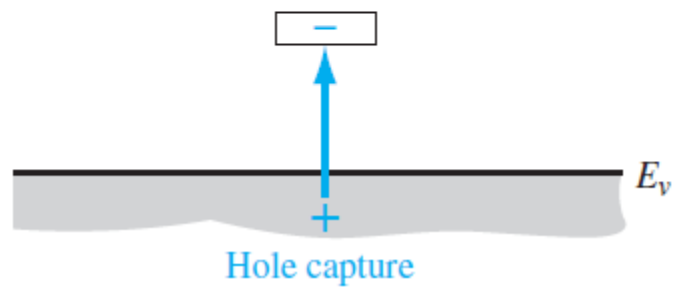
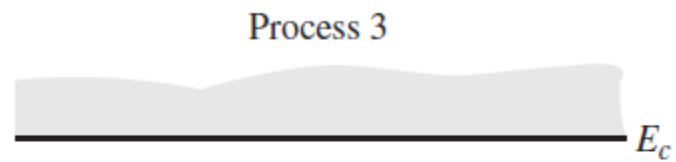
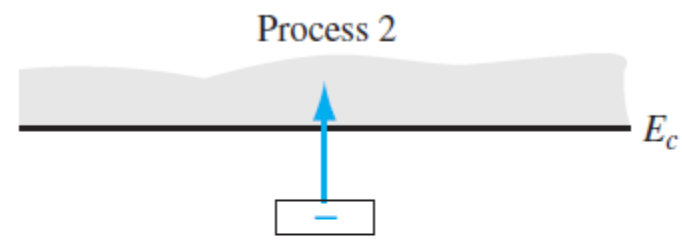
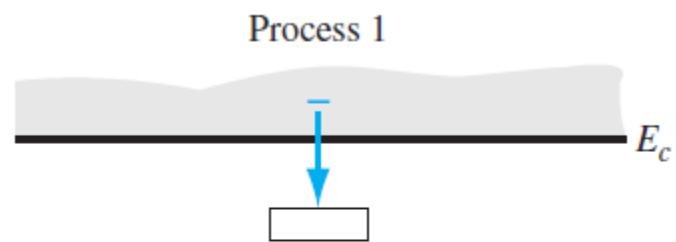


Light emitters

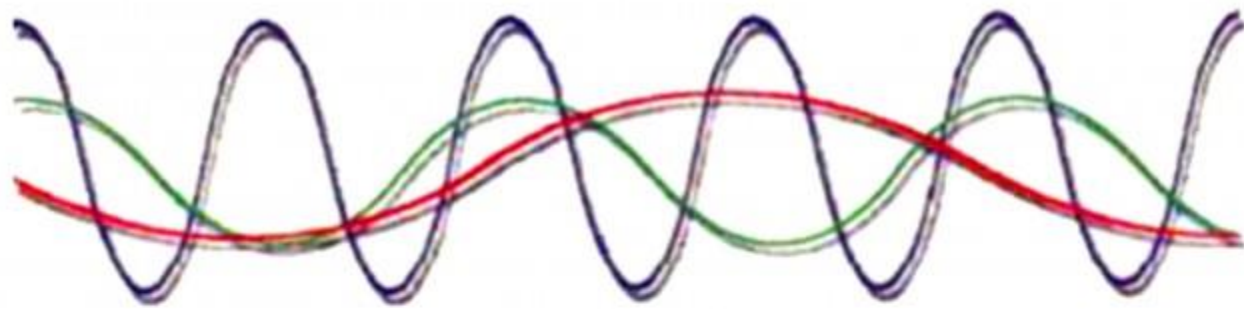








Lasers



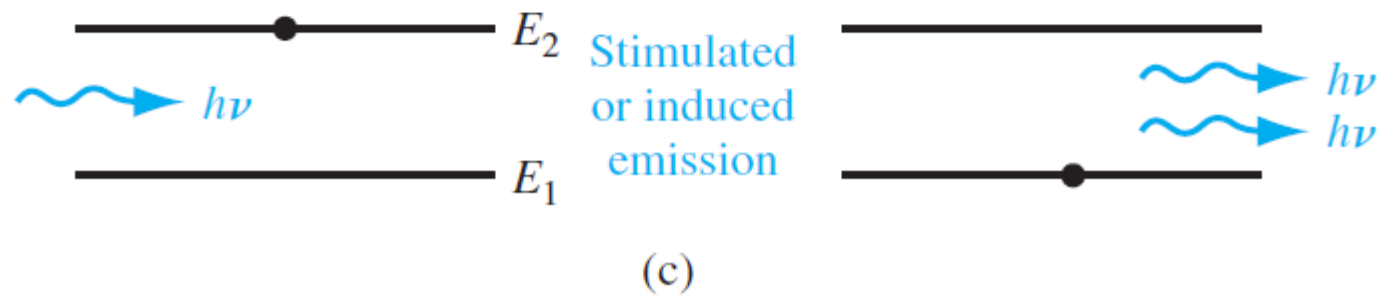
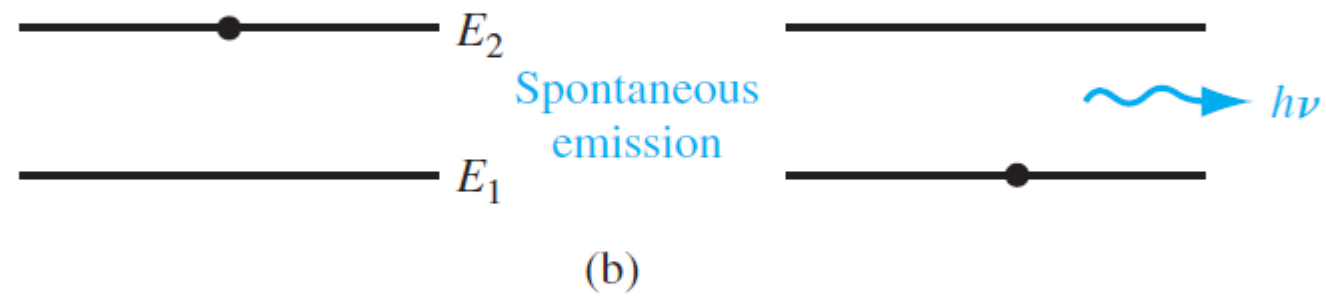
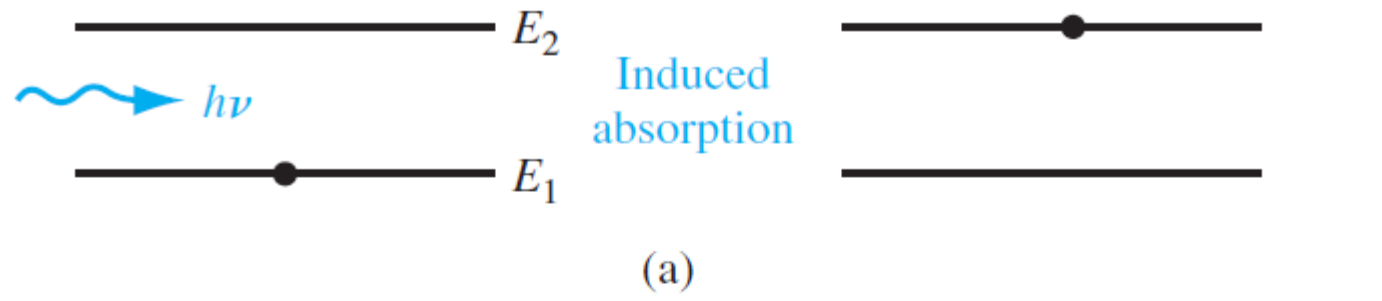
Sunlight (many different colors)

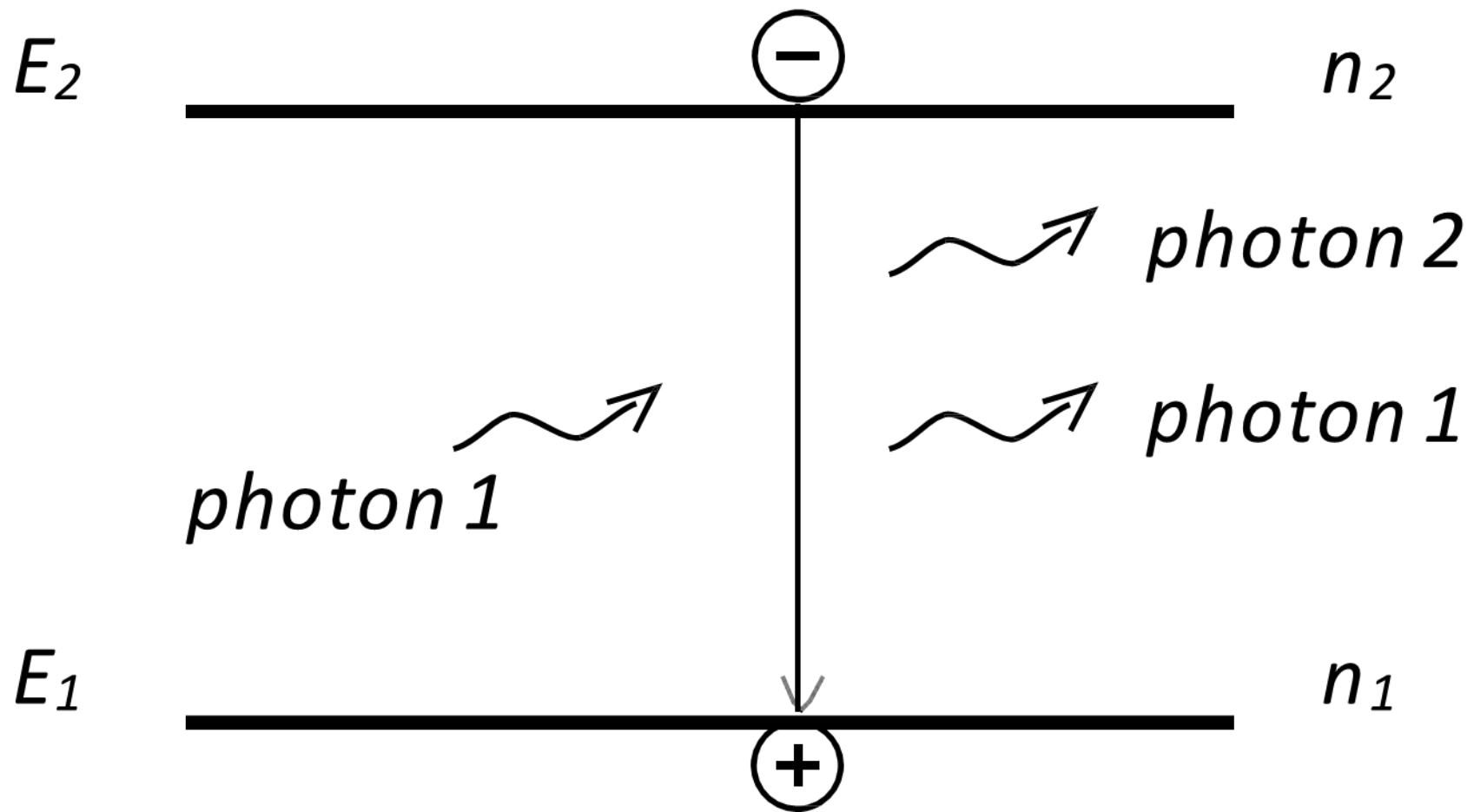


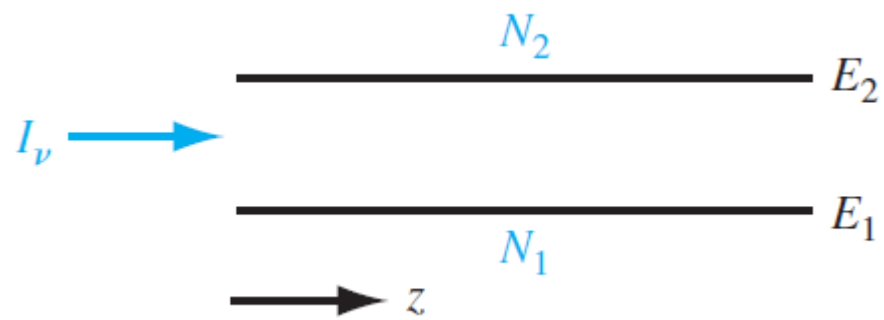
LED: one color (monochromatic) and waves not in phase (non-coherent)



LASER: One color (monochromatic) and waves in phase (coherent)





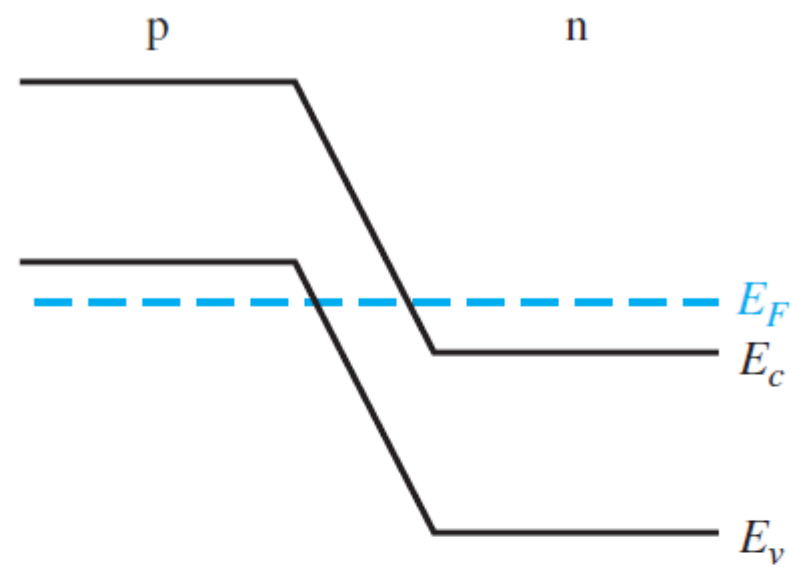


$$\frac{dI_\nu}{dz} \propto \frac{\# \text{ photons emitted}}{\text{cm}^3} - \frac{\# \text{ photons absorbed}}{\text{cm}^3}$$

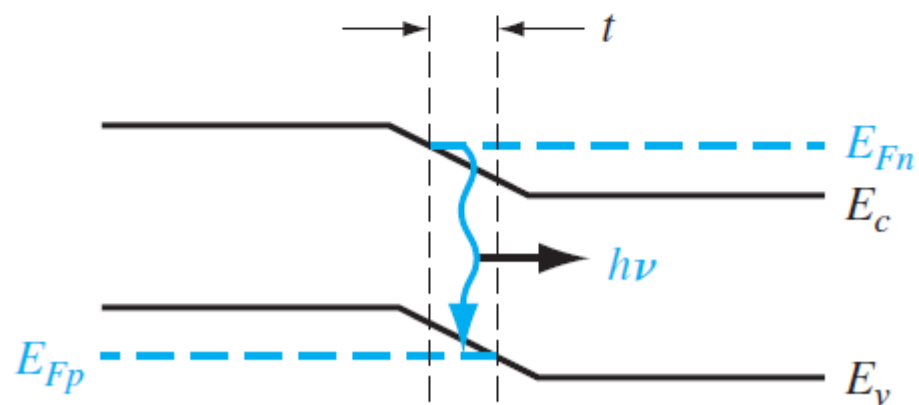
$$\frac{dI_\nu}{dz} = N_2 W_i \cdot h\nu - N_1 W_i \cdot h\nu$$

$$\frac{dI_\nu}{dz} = \gamma(\nu) I_\nu$$

$$I_\nu = I_\nu(0) e^{\gamma(\nu)z}$$



(a)



(b)

