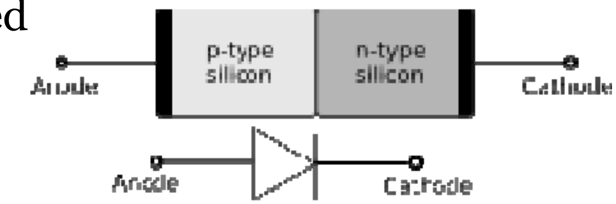
EEE-2103: Electronic Devices and Circuits

Dept. of Computer Science and Engineering
University of Dhaka

Prof. Sazzad M.S. Imran, PhD
Dept. of Electrical and Electronic Engineering
sazzadmsi.webnode.com

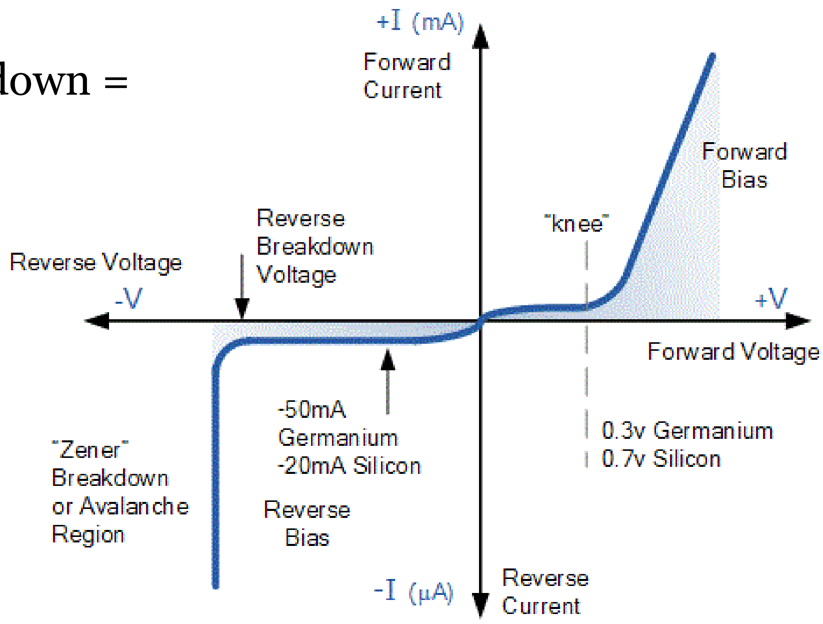
pn-Junction Diode

Diode → *pn*-junction + connecting leads
one-way device = low resistance when forward biased
open switch when reverse biased
constant forward voltage drop
constant reverse saturation current



Diode is destroyed if →
high forward current overheats device
large reverse voltage causes junction to break down = reverse breakdown

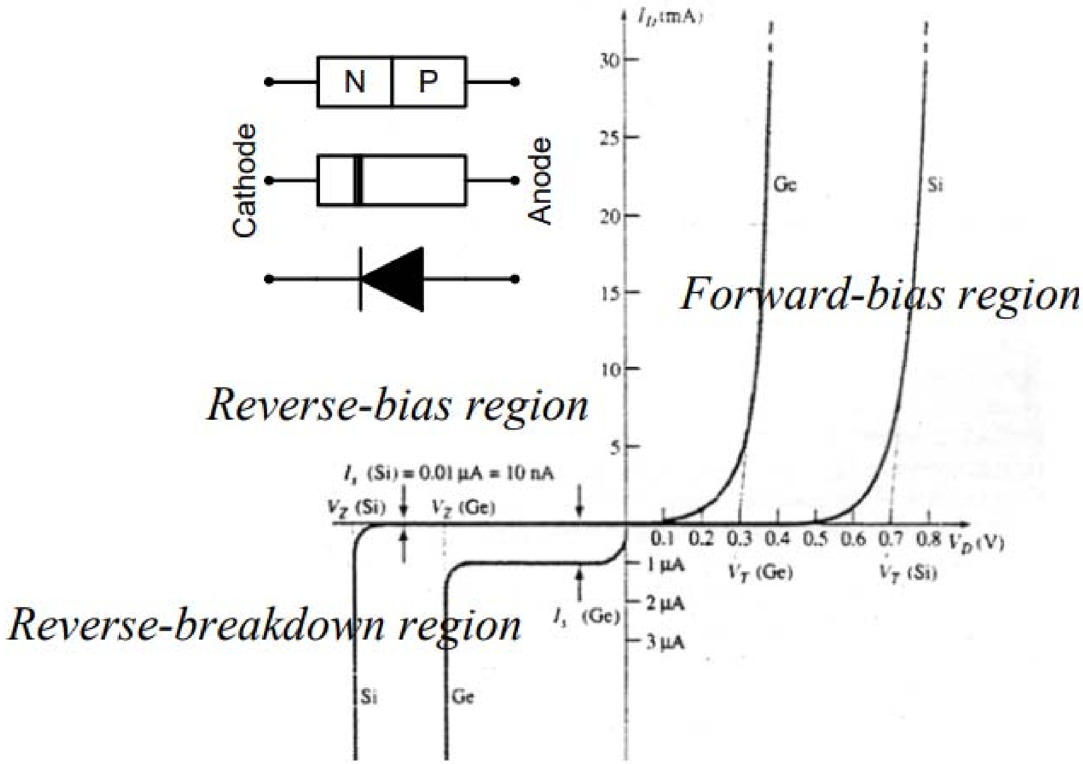
Typical forward and reverse characteristics of diode →

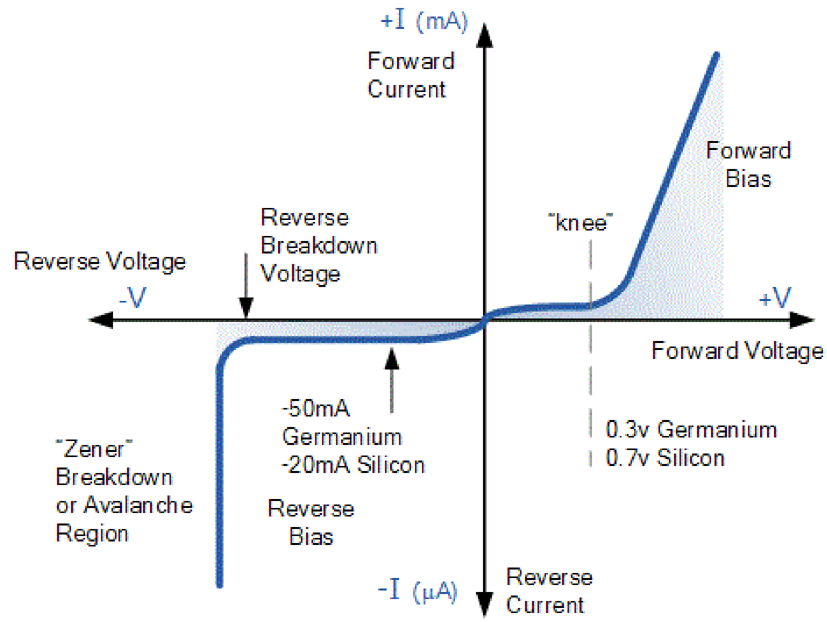


pn-Junction Diode

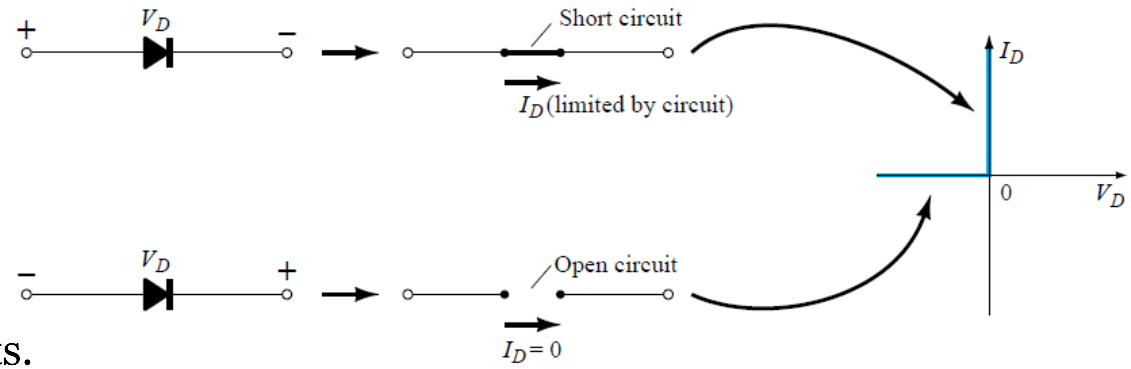
Ge diode → lower forward voltage drop

Si diode → lower reverse current
higher reverse breakdown voltage





pn-Junction Diode

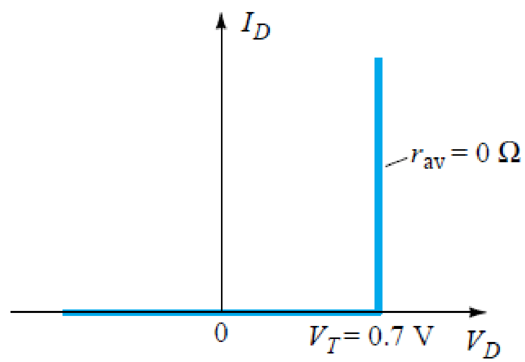


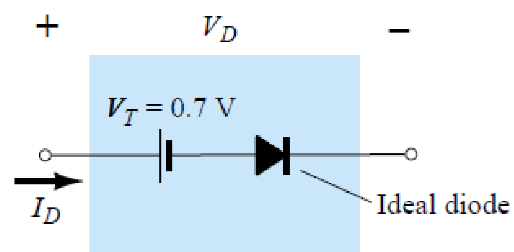
Ideal diode:
Short circuit in forward bias
Open circuit in reverse bias

DC equivalent circuits:
Represents device behavior
Made up of number of basic components.

Diode equivalent circuits are necessary →
substituted for device when investigating circuit
used as device models for computer analysis.

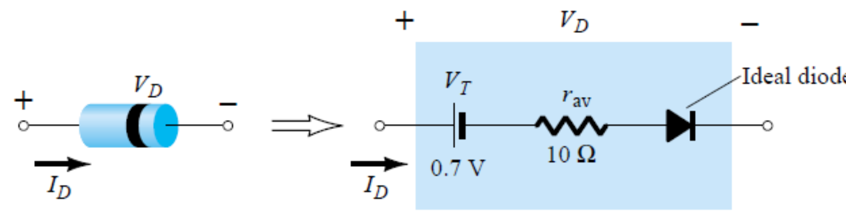
Simplified equivalent circuit:



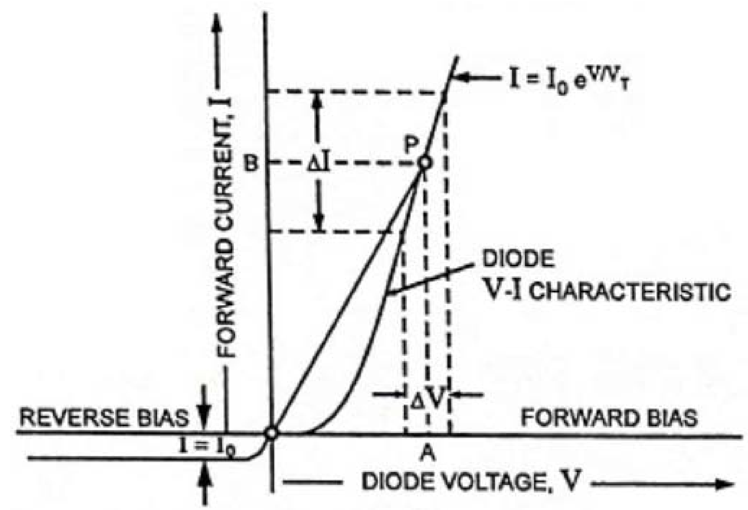


pn-Junction Diode

Piecewise-linear equivalent circuits:



r_d = r_{av} = dynamic/ac resistance
= offered to changing levels of forward voltage
= $\Delta V_F/\Delta I_F$
= 26 mV/I_F + dc resistance of semiconductor material
≈ 26 mV/I_F + 2 Ω



V_T = knee voltage
= 0.7 V for Si, 0.3 V for Ge

pn-Junction Diode

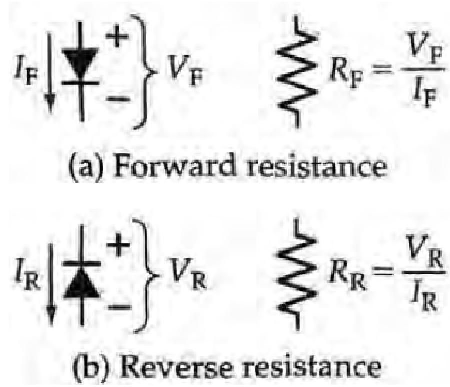
Problem-3:
Calculate the forward and reverse resistances offered by a silicon diode, with forward voltage of 0.75 V and reverse saturation current of 100 nA, at I_F = 100 mA and at V_R = 50 V.

At I_F = 100 mA, V_F = 0.75 V

$$R_F = V_F/I_F = 0.75/100\times10^{-3} = 7.5\ \Omega$$

At V_R = 50 V, I_R = 100 nA

$$R_R = V_R/I_R = 50/100\times10^{-9} = 500\ \mathrm{M}\Omega$$



(a) Forward resistance
(b) Reverse resistance

pn-Junction Diode

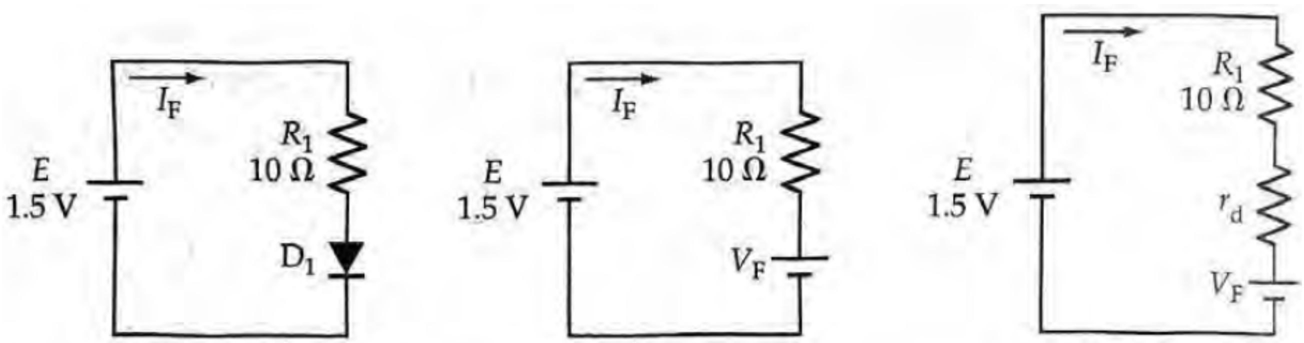
Problem-4:
Calculate I_F for the diode circuit in Fig. (a) assuming that the diode has V_F = 0.7 V and r_d = 0. Then recalculate the current taking r_d = 0.25 Ω.

Substituting V_F as the diode equivalent circuit

$$I_F = (E - V_F)/R_1 = (1.5 - 0.7)/10 = 80 \text{ mA}$$

Substituting VF and rd as the diode equivalent circuit

$$I_F = (E - V_F)/(R_1 + r_d) = (1.5 - 0.7)/(10 + 0.25) = 78 \text{ mA}$$



(a) Diode circuit

(b) Diode replaced with voltage cell

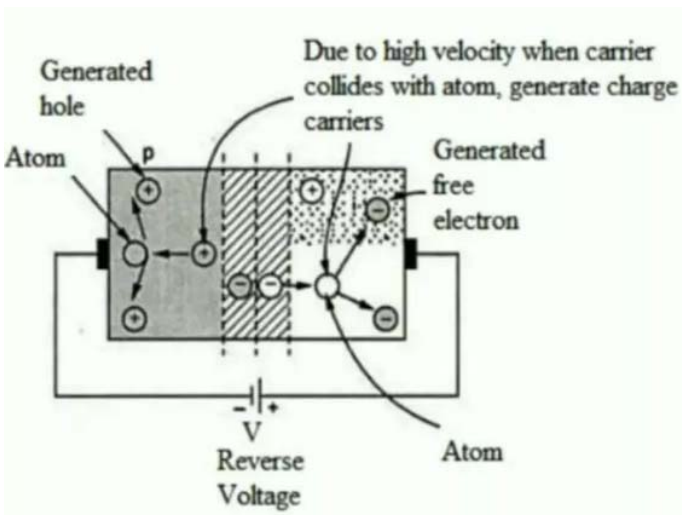
(c) Diode replaced with r_d and V_F

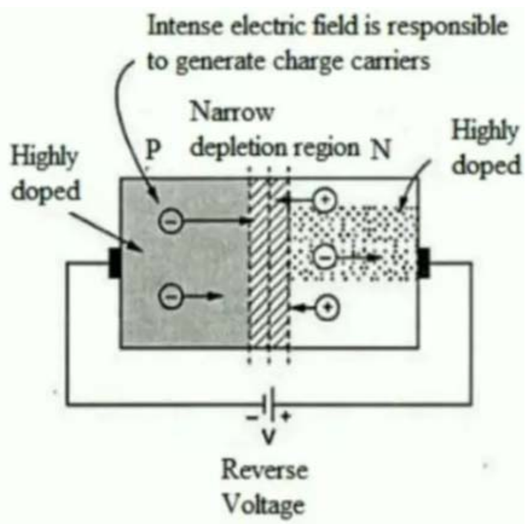
Zener Diodes

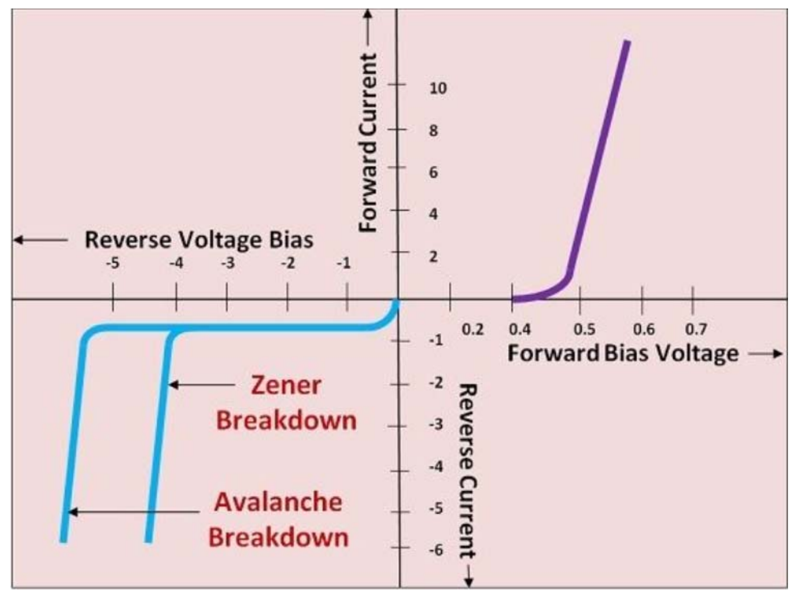
V_Z = Zener potential →

reverse-bias potential that results dramatic change in characteristics
current increases at very rapid rate
current direction is opposite to that of positive voltage region

Breakdown → Avalanche and Zener
Zener region → sharp change in characteristic at any level
Zener diode → pn-junction diodes employing this unique portion of characteristic







Zener Diodes

Location of Zener region can be controlled by varying doping levels.
Increase in doping → increase in number of added impurities → decrease Zener potential.

Zener potentials = V_Z → 1.8 to 200 V
Dynamic resistance = r_z → 8.5 Ω
Power ratings → ¼ to 50 W.

Silicon is preferred → higher temperature and current capability.

Zener equivalent circuits →