19EEE114 Electronic Circuits

2nd Semester B.Tech. EEE

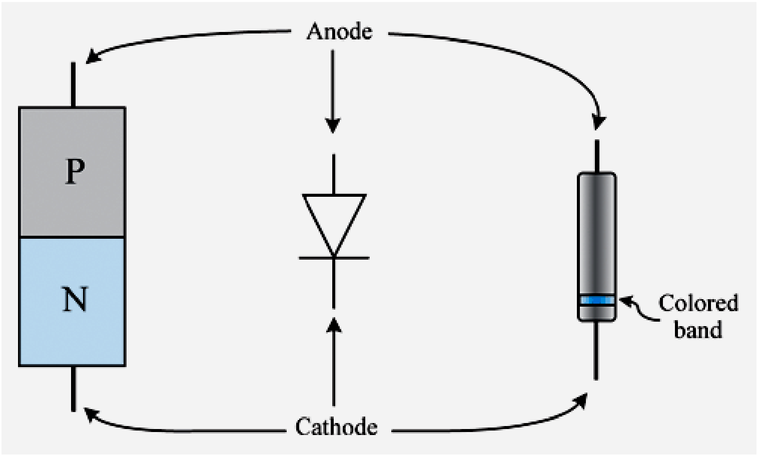
PN junction diodes

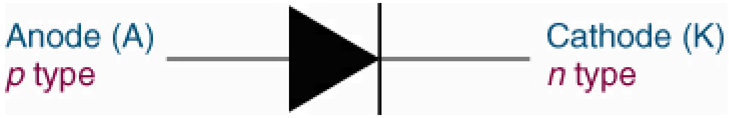
Biasing
Ideal Characteristics
Diode Current
Characteristics
Temperature Dependance

PN Junction Diode

- Allows current to flow in one direction but not the other

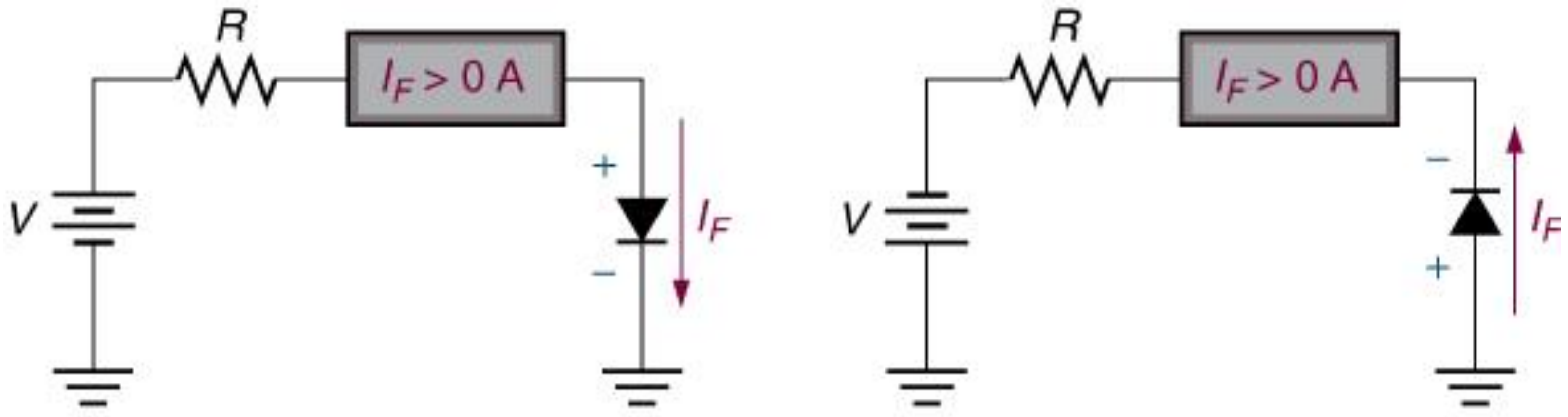
- The *anode* connects to the p-type material, the *cathode* to the n-type material of the diode.





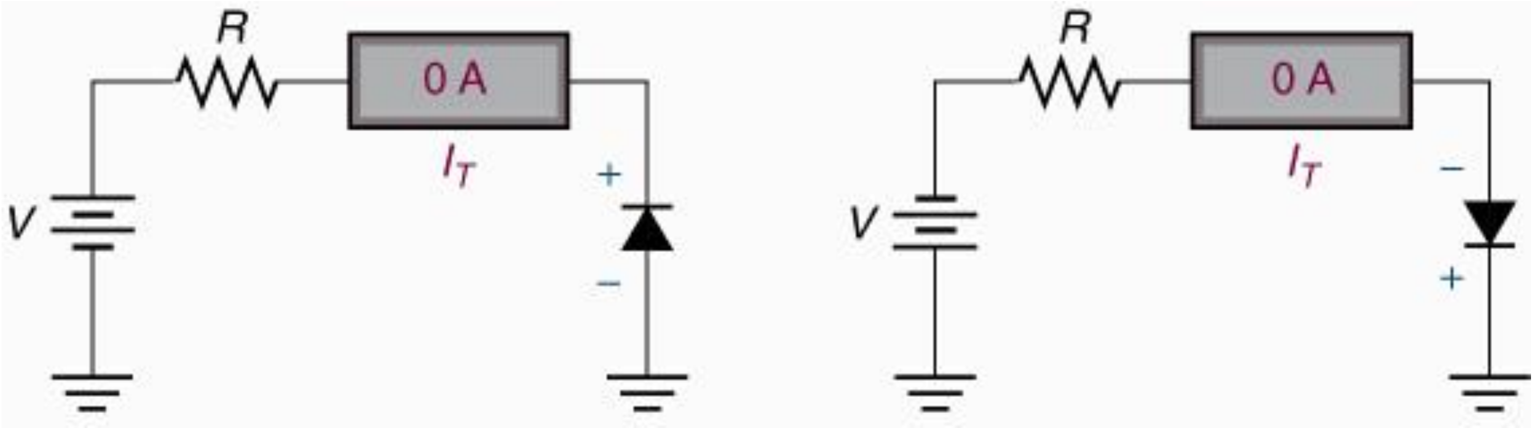
Forward Biased Diodes

- The component is biased so that the anode is more positive than the cathode.
- The diode conducts fully when V_F is approximately 0.7 V (for silicon) or 0.3 V (for germanium).
- The value of I_F depends on the circuit voltage and resistance values.



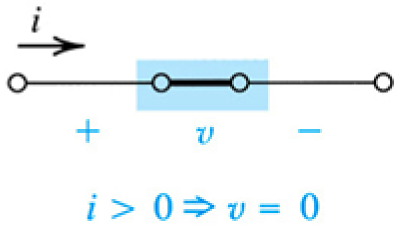
Reverse Biased Diodes

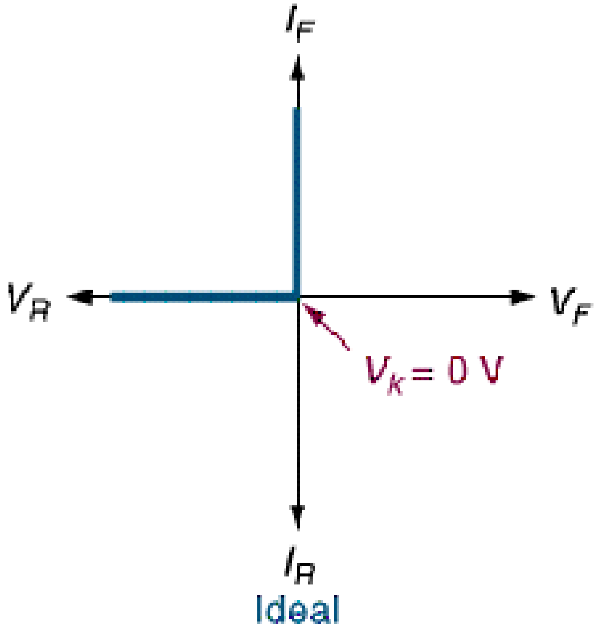
- The component is biased so that the cathode is more positive than the anode.
- The voltage across the diode is approximately equal to the applied voltage.
- The diode current is approximately 0 A (as indicated by the ammeter).



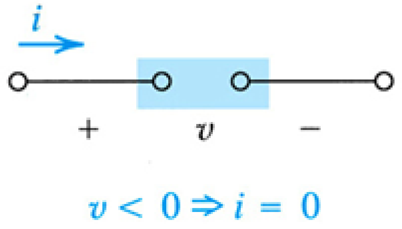
Ideal diode characteristics

- When forward biased (closed switch), the diode:
  - Has no resistance.
  - Does not limit current.
  - Has no voltage drop across its terminals.

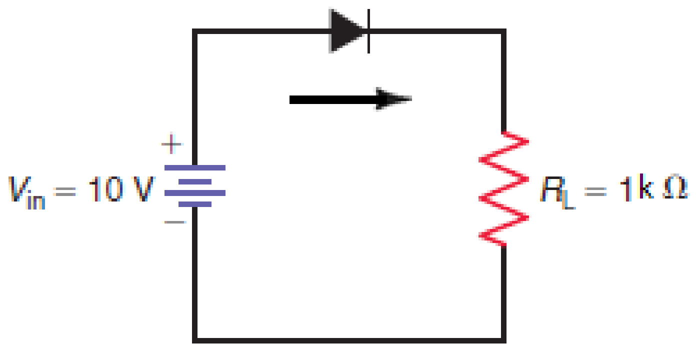




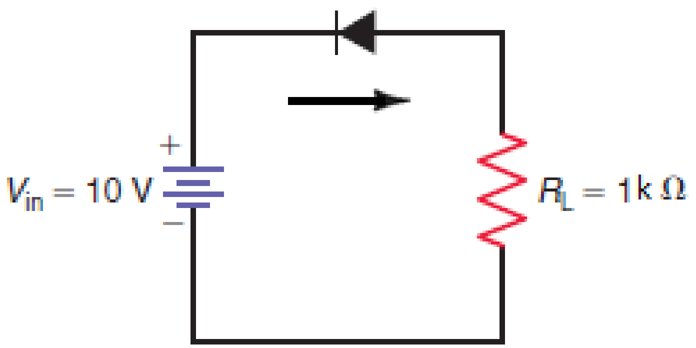
- When reverse biased (open switch), the diode:
  - Has infinite resistance.
  - Blocks current.
  - Drops the applied voltage across its terminals.



Current through Ideal diode

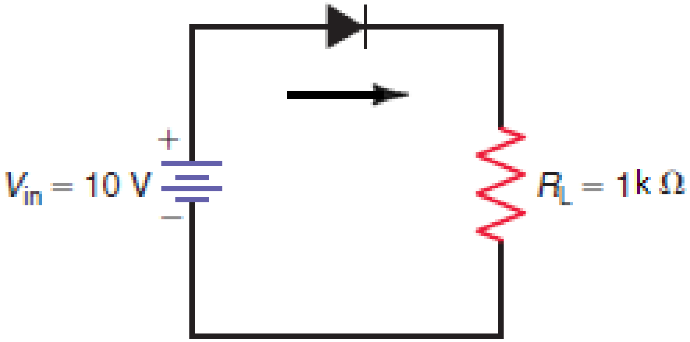


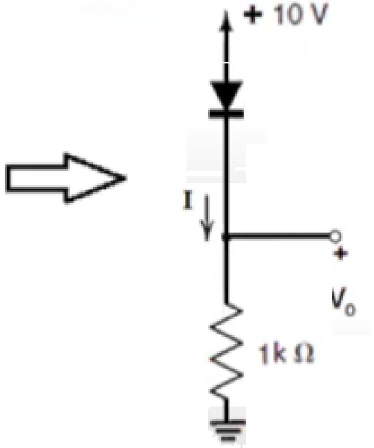
I = 10 mA



I = 0 mA

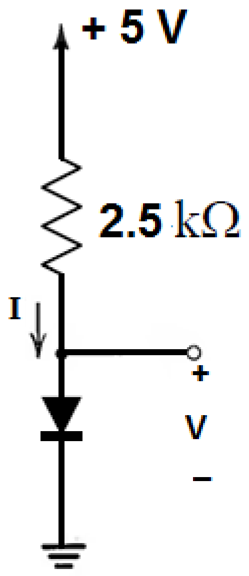
Circuit Connections



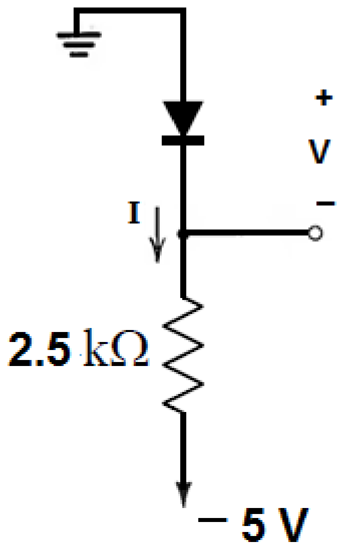


Problem #1

Find the values of I and V in the circuits shown below. Assume diodes to be ideal.



(a)



(b)

Solution: I = 2mA, V = 0V

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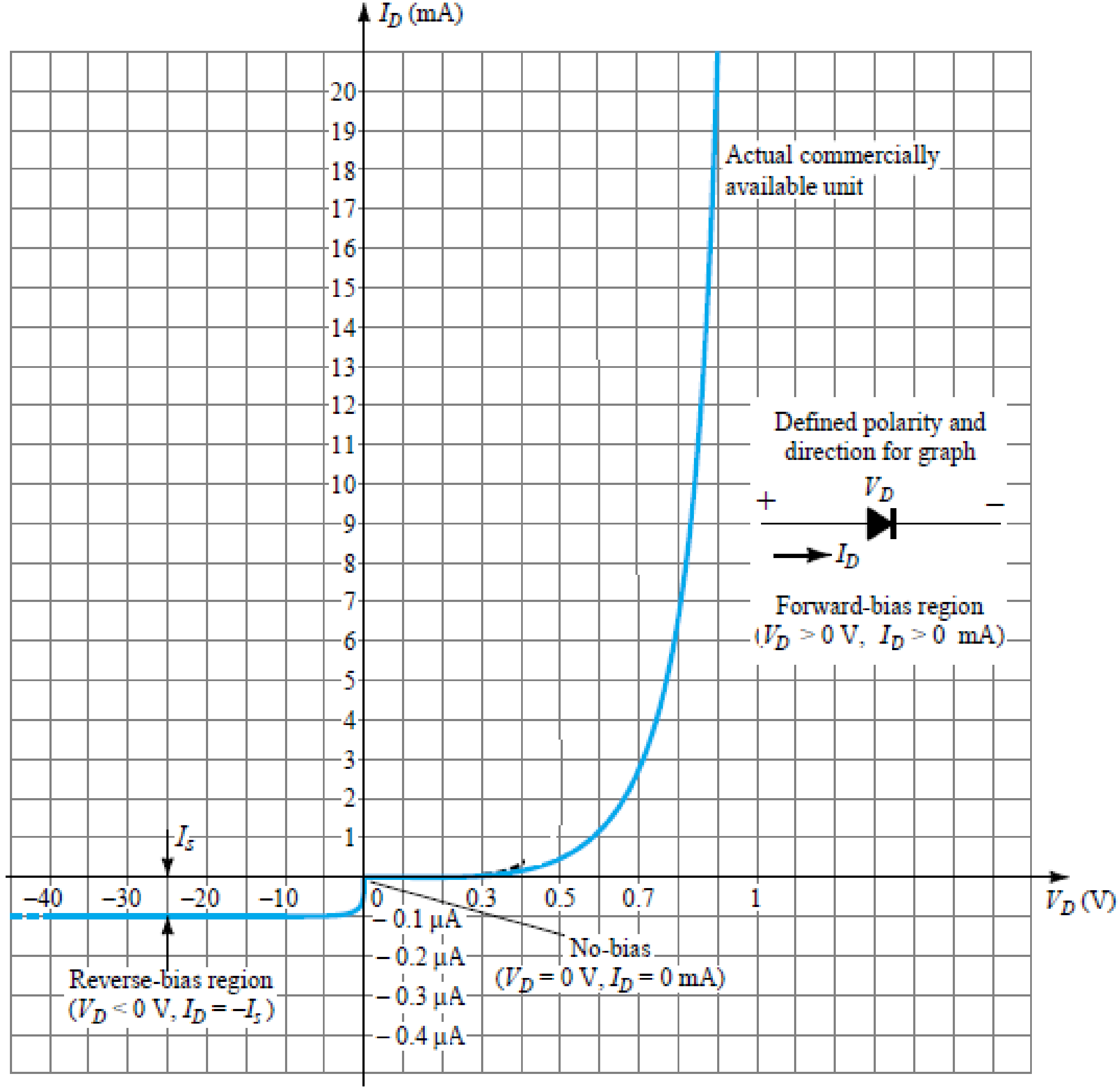
Characteristics of Junction diode



Forward-bias region

 # Cut-in voltage - below which, minimal current flows

- approximately 0.5V

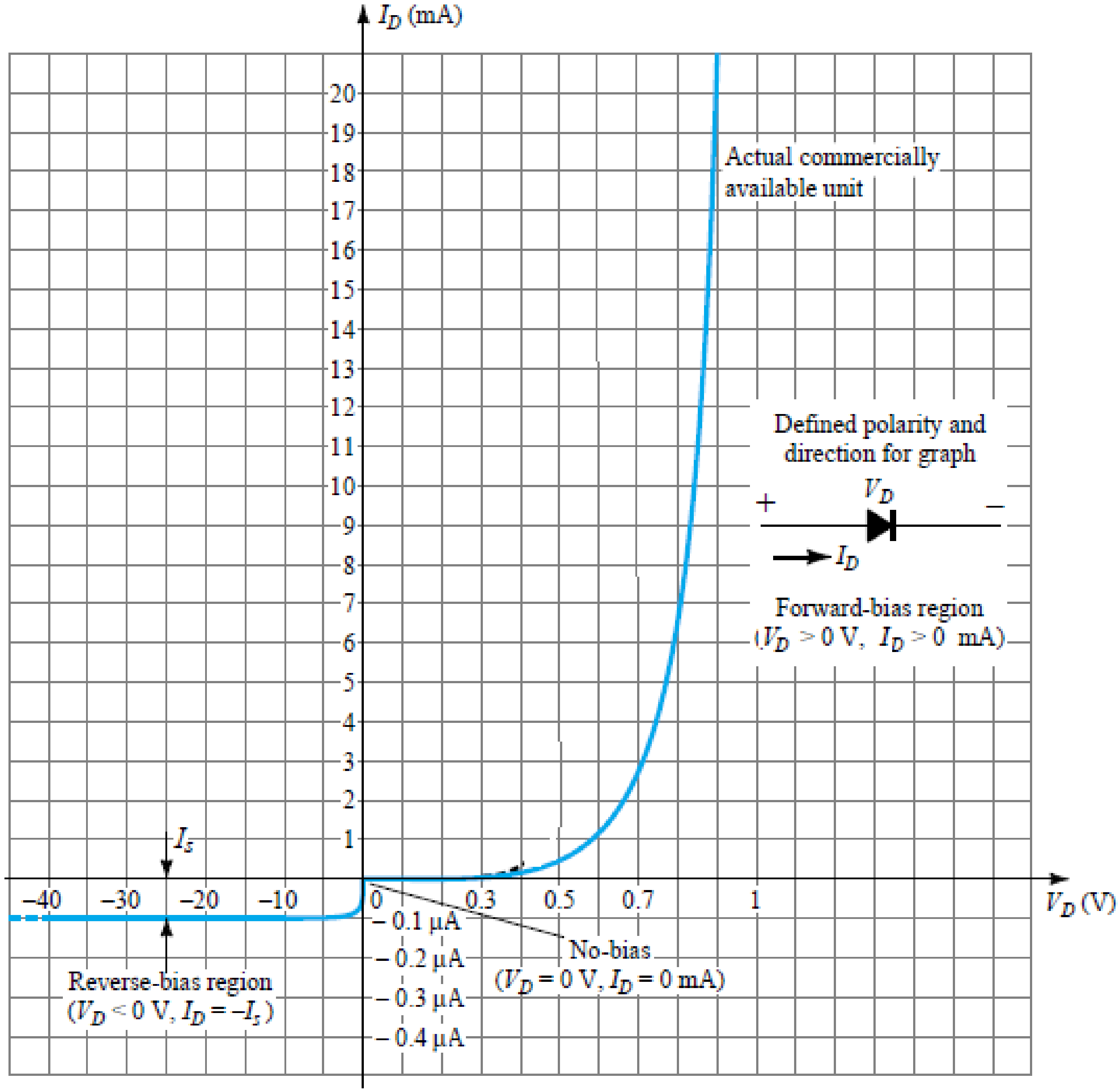
 # Fully conducting region – region where R_{diode} is approximately equal zero

– between 0.6 and 0.8*V*

Diode current,

$$i = I_s(e^{v/\eta V_T} - 1)$$

Characteristics of Junction diode



Reverse-bias region

 # Saturation current- constant current in reverse direction

$i = - Is$

 # Breakdown – when

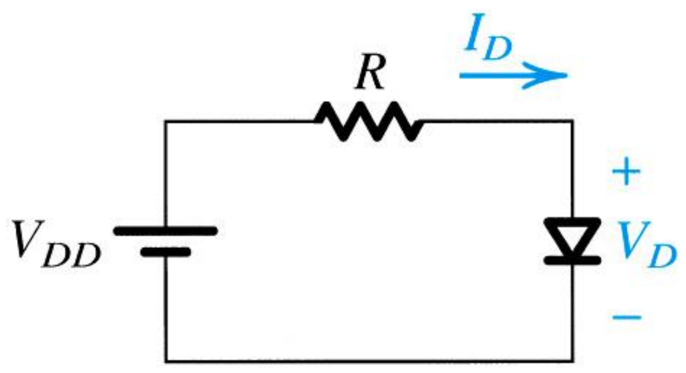
$V_D << 0$

Exponential Model

– most difficult to employ in circuit analysis
  - due to nonlinear nature

$$\underbrace{I_D = I_S e^{V_D / V_T}}$$

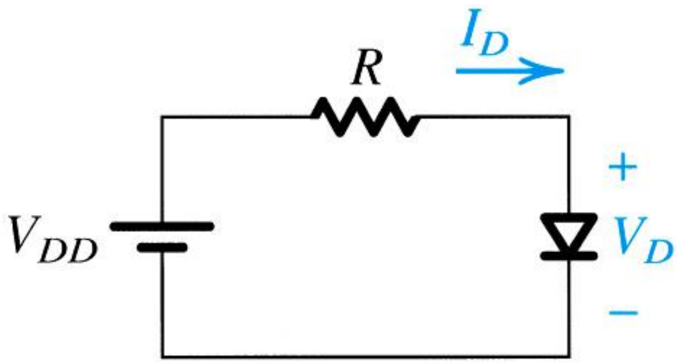
V_D = voltage across diode
I_D = current through diode



- solve for I_D in the circuit
  – $V_{DD} = 5V$
  – $R = 1\ kOhm$
  – $I_D = 1\ mA$ @ $0.7V$

- Solution…
  – **graphical method**

Graphical Analysis Using Exponential Model

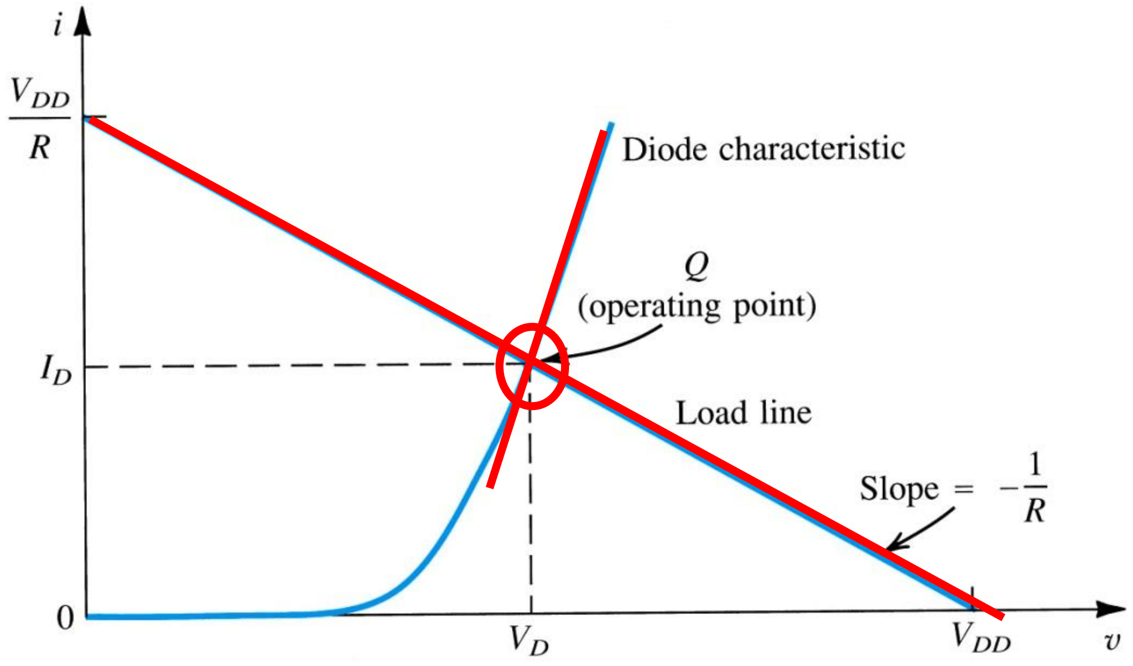


$$V_{DD} = I_D R + V_D$$

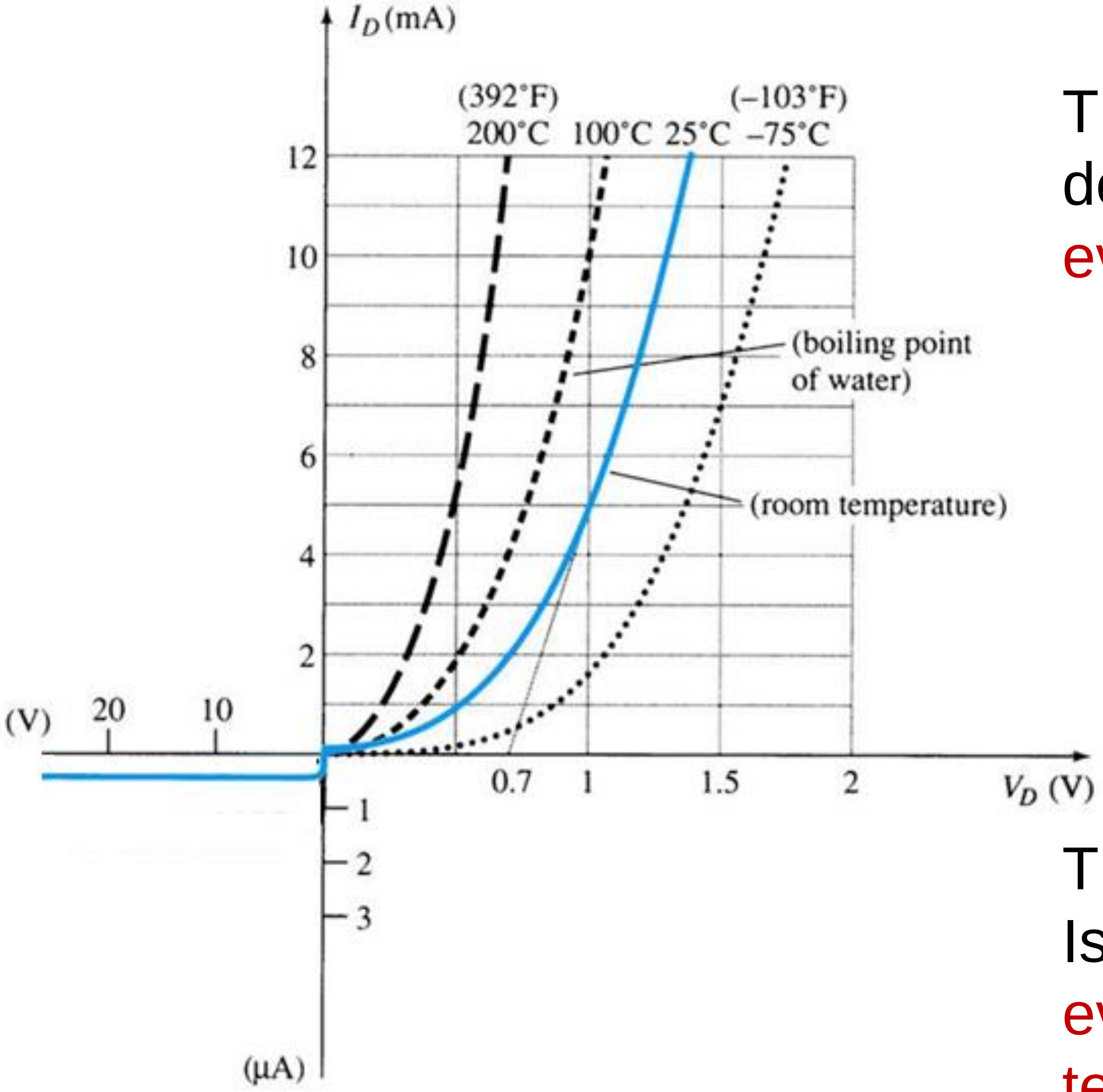
$$I_D = \frac{V_{DD} - V_D}{R}$$

$$V_D = V_{DD} - I_D R$$

- **load line** and diode characteristic intersect at **operating point**



Diode Temperature dependence



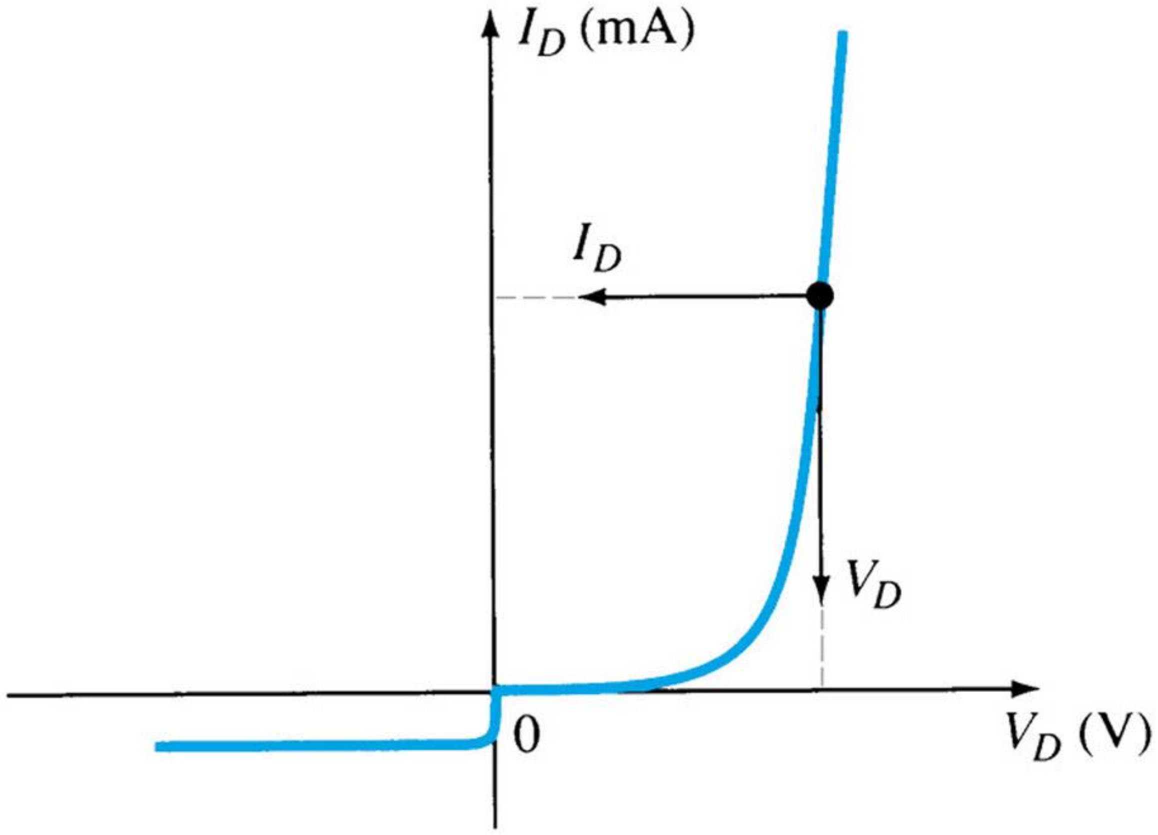
The forward voltage drop decrease by approx. 2 mV for every 1°C increase in temperature

The reverse saturation current Is will double in magnitude for every 10°C increase in temperature

Diode Resistance

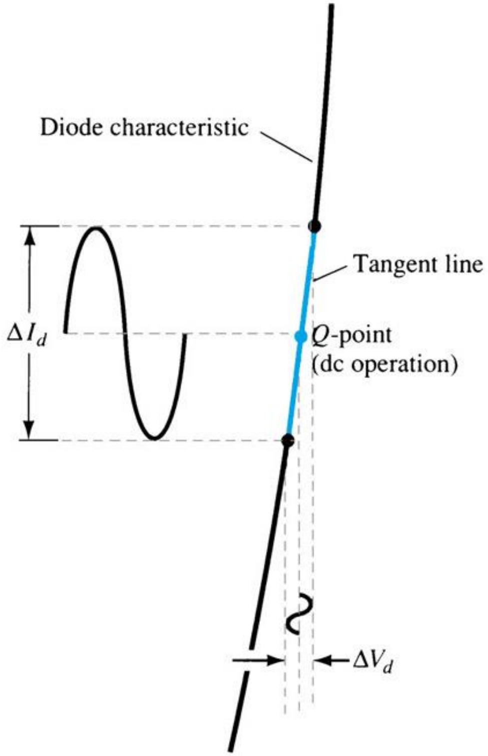
- DC or Static Resistance

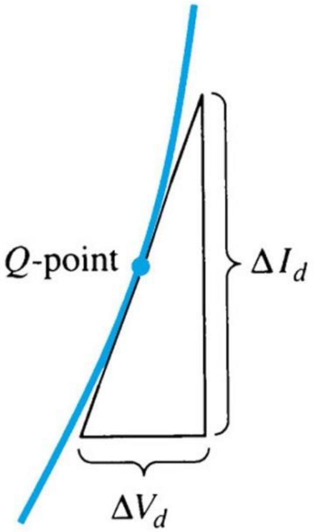
$R_D = V_D/I_D$



Diode Resistance

- AC or Dynamic Resistance





Diode Resistance

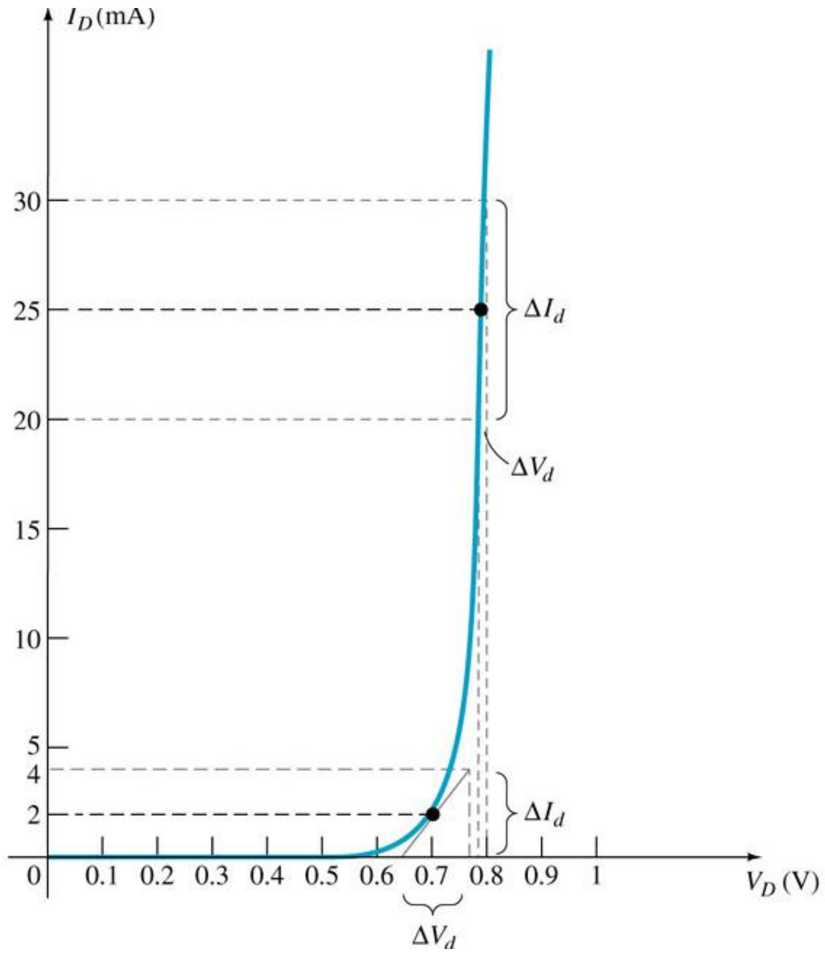
- Determining AC or Dynamic Resistance

$$r_d = \frac{\eta V_T}{I_D}$$

At room temperature

$V_T = 26$ mV

$r_d = 26\text{mV} / I_D$



i-*v* relationship

- $I_D = I_s (e^{V_D/\eta V_T} - 1)$

Current I_1 corresponding to diode voltage V_1

$I_1 = I_s (e^{V_1/\eta V_T})$

Current I_2 corresponding to diode voltage V_2

$I_2 = I_s (e^{V_2/\eta V_T})$

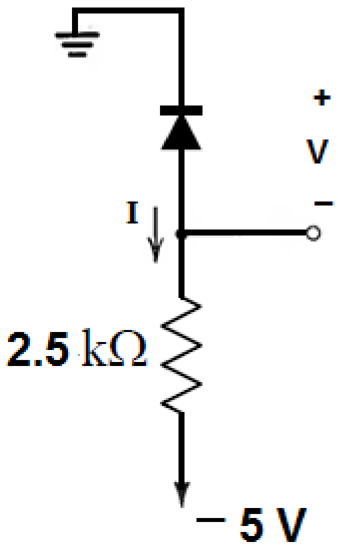
$$I_2/I_1 = e^{V_2 - V_1/\eta V_T}$$

$$V_2 - V_1 = \eta V_T \ln(I_2/I_1)$$

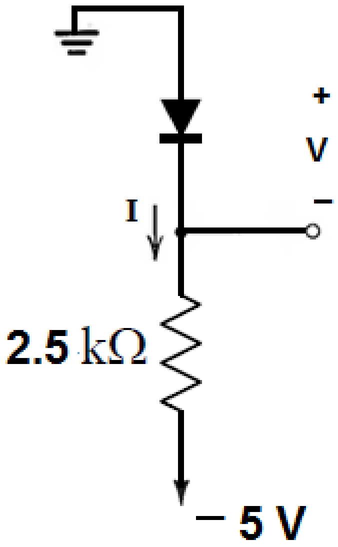
$$V_2 - V_1 = 2.3\eta V_T \, log(I_2/I_1)$$

Problem #2

Find the values of I and V in the circuits shown below. Assume diodes to be ideal.



(a)



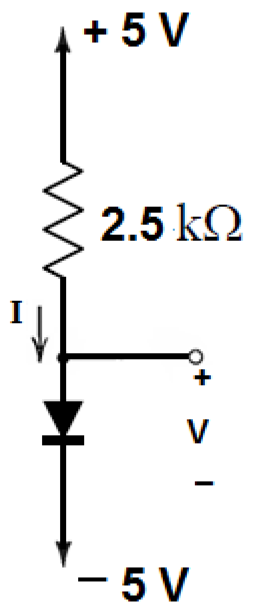
(b)

Solution: I = 0 mA, V=5 V

Solution: I=2 mA, V=0 V

Problem #3

Find the values of I and V in the circuits shown below. Assume diodes to be ideal.



Solution: I=4 mA, V= -5 V