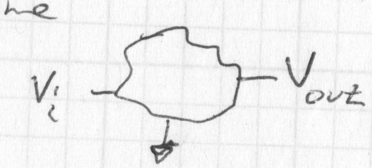
Last time



find V_I, V_{OUT} pt.

wiggle v_{out}, measure i_{out}

wiggle v_i, measure i_{out}

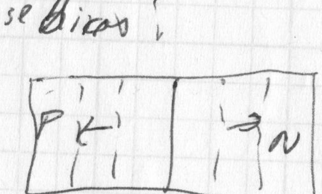
Device Models

Diode

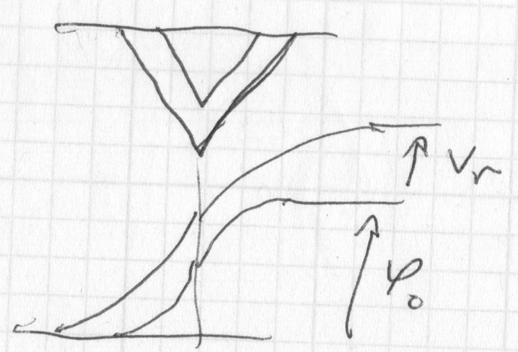
BJT (because FETs in 3v3-V_{th})

quadratic model

What if we reverse bias?

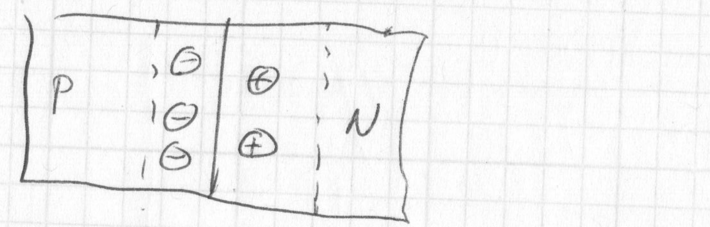


$W_1 \sim \sqrt{\varphi_0 + \varphi_R}$

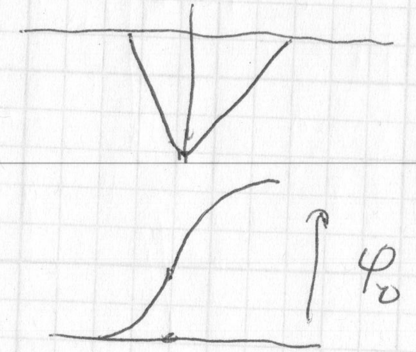


Q_{dep}, E_{max} vary same way

Diode



$\int E \cdot dA = \frac{Q}{\epsilon_{si}\epsilon_0}$



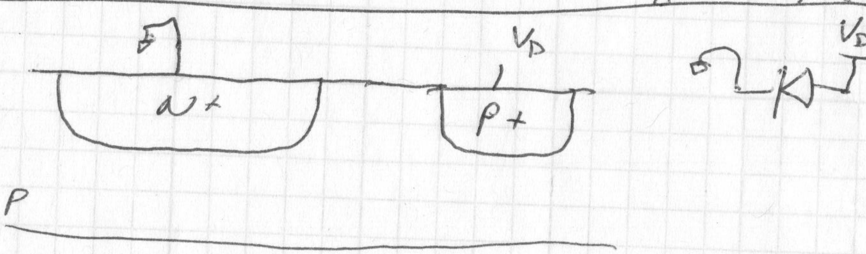
$V = -\int E \cdot dl$

Drift = Diffusion

Einstein

$\varphi_0 = V_T \ln \frac{N_A N_D}{n_i^2}$

$= \frac{k_B T}{q} \left(\ln \frac{N_A}{n_i}\right)\left(\ln \frac{N_D}{n_i}\right)$



if $V_D = 0$ - is there any net current?

- are there mobile carriers in depl reg?
- if I shine light on the junction

if $V_D < 0$ - where does leakage current come from?

- does it increase w/ reverse bias?
- is breakdown destructive?

Zener vs. avalanche, references

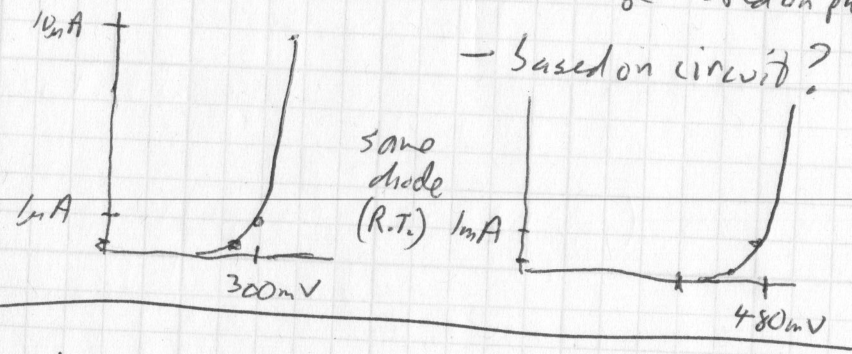
if $V_D > 0$ $\quad I_D = I_s(e^{V_D/V_T} - 1) \approx I_s e^{V_D/V_T}$

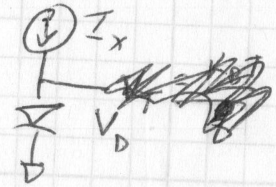
@ R.T. $\quad$ +26mV ⇒ 2.7x current

60mV ⇒ 10x current

is there a "turn on" voltage based on physics?

— based on circuit?





$V_D = V_T \ln \frac{I_D}{I_s}$ ← $\frac{k_B T}{q}$

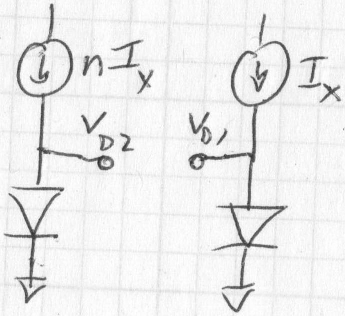
what if T goes up?

Does V_D go up or down?

$\frac{k_B}{q} \approx 80\mu V/K$

but I_s goes up way faster

result: TC of $V_D \approx -\frac{2mV}{K}$



$V_{D2} = V_T \ln \frac{nI_x}{I_s}$

$V_{D1} = V_T \ln \frac{I_x}{I_s}$

$V_{out} = V_{D2} - V_{D1} = V_T(\ln n)$

$= \frac{k_B T}{q} \ln n$

$= \left(\frac{80\mu V}{K}\right) \ln(n) \; T$

V_{out} is proportional to Abs. Temp!

PTAT