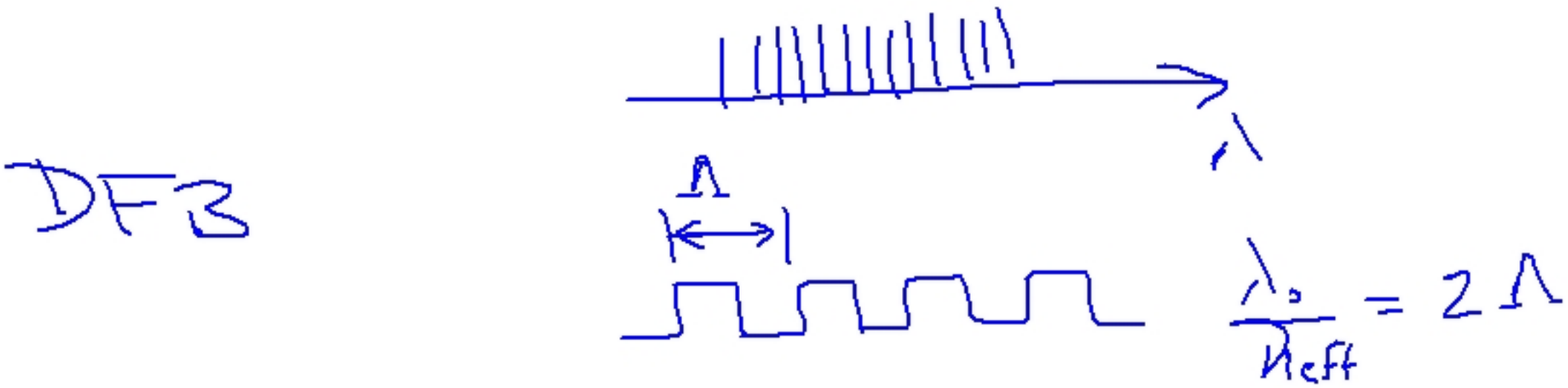
LECTURE 22

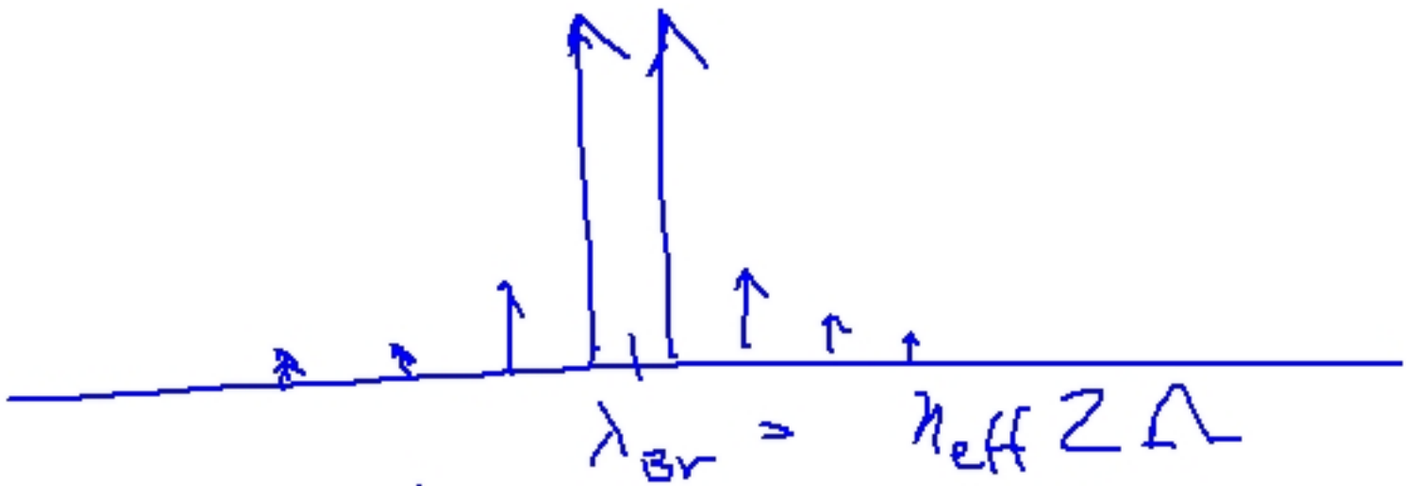
NOTICE: RECITATION WILL START AT 8 (NOT 9:30) FOR THE REST OF THE TERM (2 MORE WKS)

MODES / RESONANCES

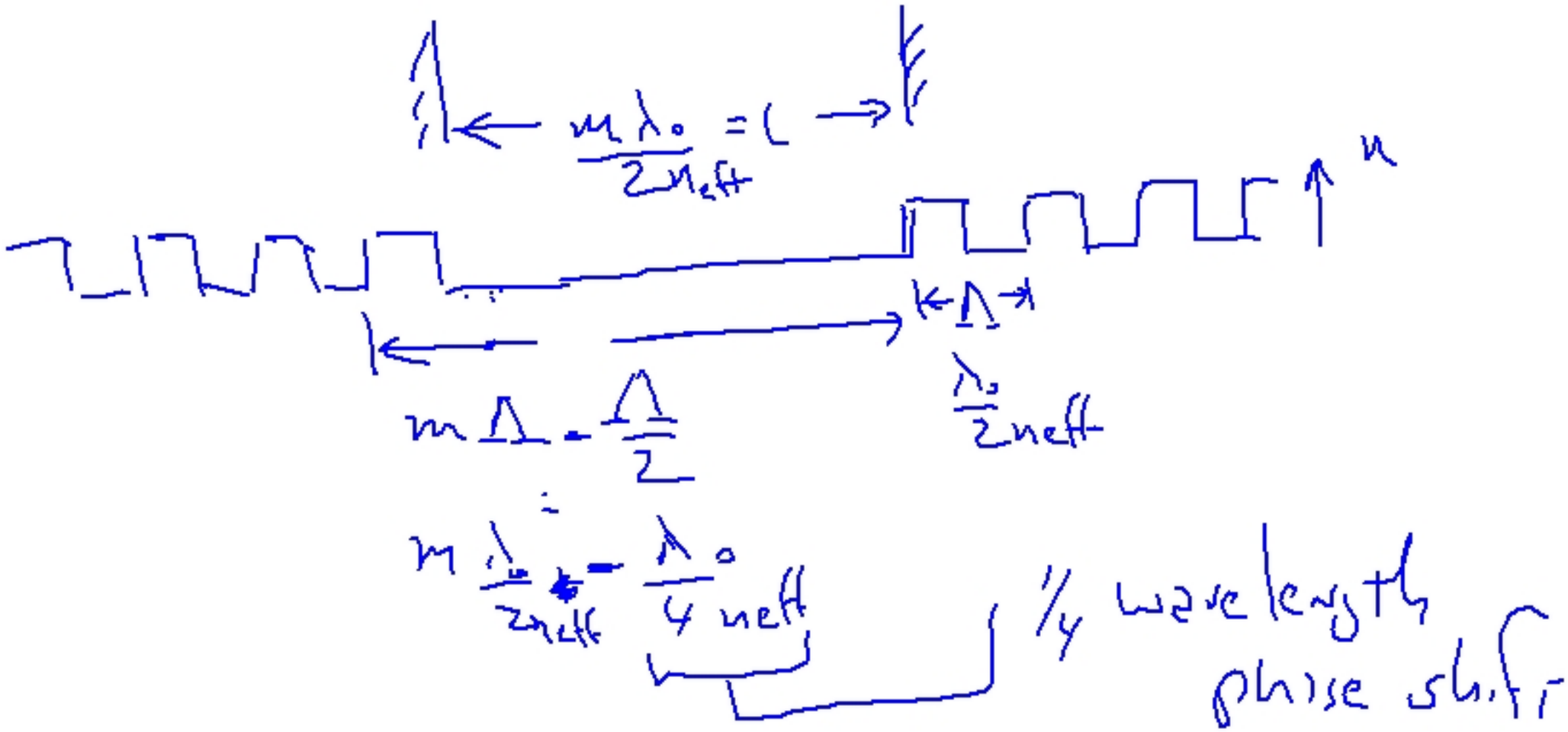
FABRY PEROT

DFB

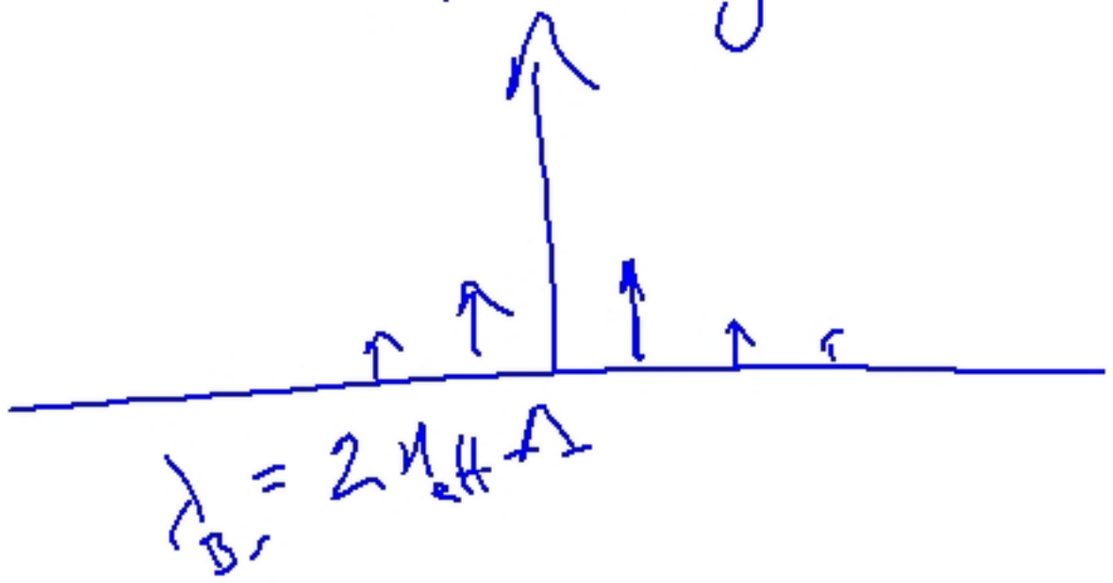




$$\Delta\lambda \sim \lambda_0^2 / 2Ln_{eff}$$



With $\lambda/4$ segment included



GENERALIZED COMPARISON OF IPL's + VCSEL's

IPL
- ✓ HIGH POWER (WATTS)
- ✓ TUNABLE; MODE LOCKED
- ✓ NOT TO DEMANDING
- ✗ HARD TO GET VERTICAL EMISSION

VCSELs
- ✓ LOW POWER (few mW)
- ✓ EASY TO TEST, PACKAGE
- ✓ SYMMETRICAL BEAM
- ✗ VERY DEMANDING OF FAB

VCSEL ISSUES

1. ACTIVE REGION — QW'S ARE NECESSARY
   TYP 3 QW layers
   (2-5)

2. SERIES RESISTANCE

3. LATERAL CAVITY DEFINITION
   i) ION IMPLANTATION
   ii) HIGH MESA
   iii) AlAs OXIDATION → Al_2O_3

4. MIRROR STACK
   + Best GaAs/AlGaAs
   - No good InP/InGaAs DBR too low
   + Also good ARE DEPOSITED DIELECTRIC STACKS

MATERIALS for SPECIFIC λ RANGE

1. SHORT λ : UV & VISIBLE : GaAlInN
   [II-VI → ZnSeTe]
2. LONG λ VISIBLE : InGaAlP / GaAs
   InGaAsP / GaAs
3. 0.8 - 1.0 μm : AlGaAs / InGaAs QWs / GaAs
4. 1.3, 1.55 μm : InGaAsP / InP
   InGaAlAs / InP
   GaInNAs / GaAs
5. 2-5 μm : AlGaAsSb / GaSb
   QUANTUM CASCADE : [Pb-SALTS]
6. 10 - 30 → beyond : [Pb-SALTS]
   QUANTUM CASCADE

FREQ RESP. OF LASER DIODE

$$\Delta V \rightarrow \Delta i \rightarrow \Delta n \underset{\text{(stim EMI)}}{\rightleftharpoons} \Delta S$$

carriers — photons

Excess carriers

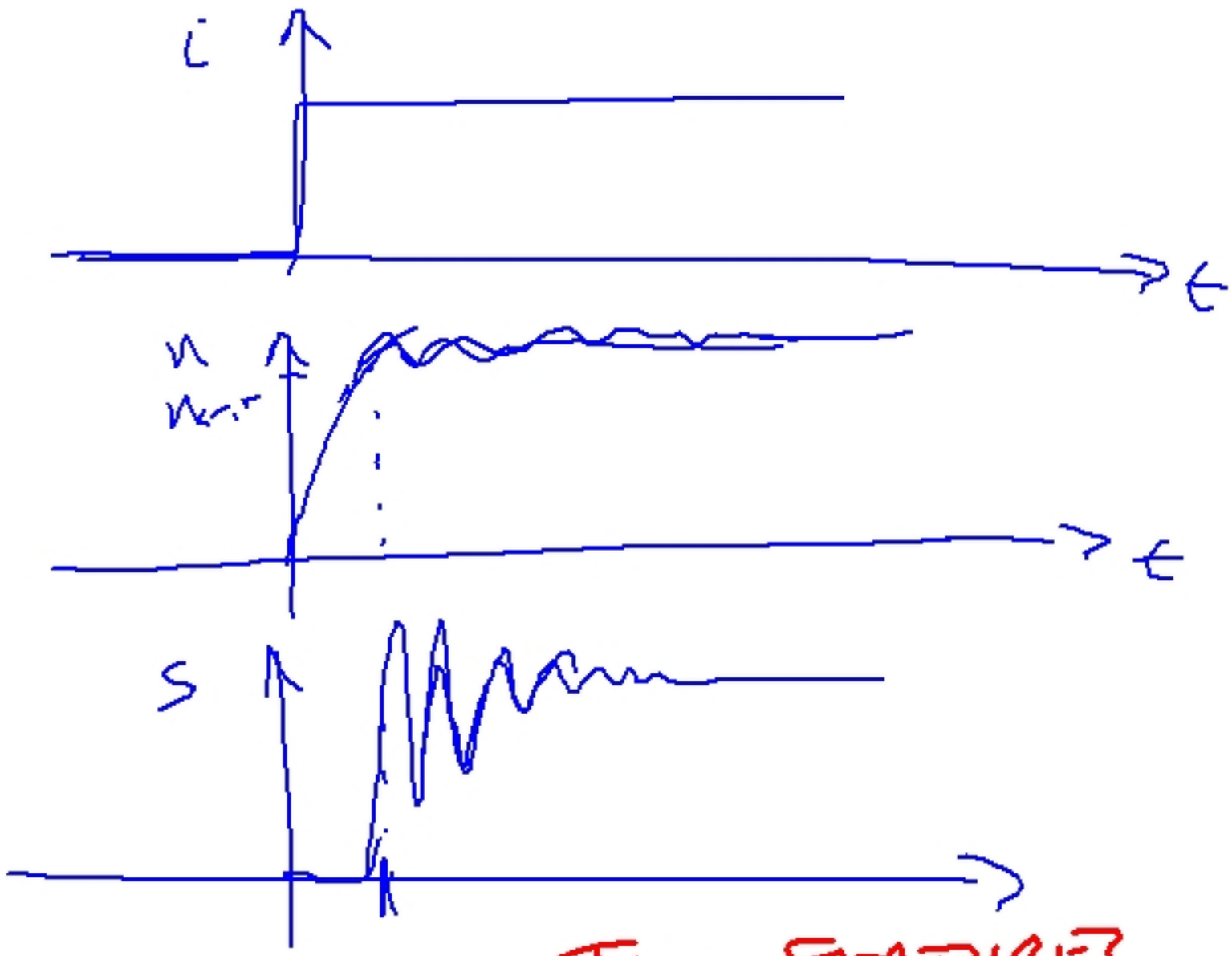
$$\frac{dn'}{dt} = \frac{\eta i}{q dA} - \frac{n'}{\tau_{sp}} - v_g G (n' - n_{tr}) S$$

Photon population

$$\frac{dS}{dt} = \Gamma v_g G (n' - n_{tr}) S + \beta \frac{n'}{\tau_{sp}} - \frac{S}{\tau_p}$$

$$\tau_p = v_g \left[\alpha_i - \frac{1}{L} \ln R \right]$$

STEP RESPONSE



TWO FEATURES

① TURN-ON DELAY ⟶ APPLY $I_S > I_{th}$ BIAS

② RINGING / OVER SHOOT

PHOTODETECTORS

✓ RESPONSIVITY — A/W — AS A FUNCTION OF λ.
CARRIERS / PHOTON
(QUANTUM EFF.)

✓ SPEED — rising edge
falling edge

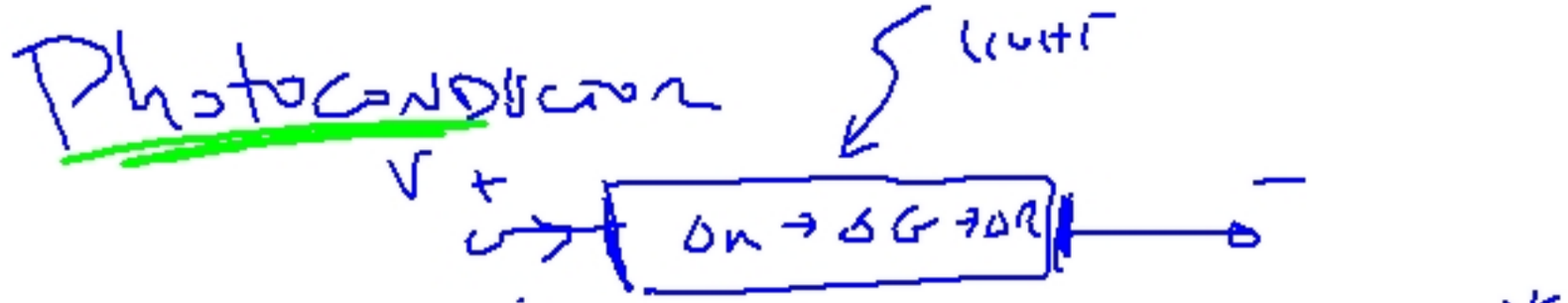
ALTERNATIVES / OPTIONS

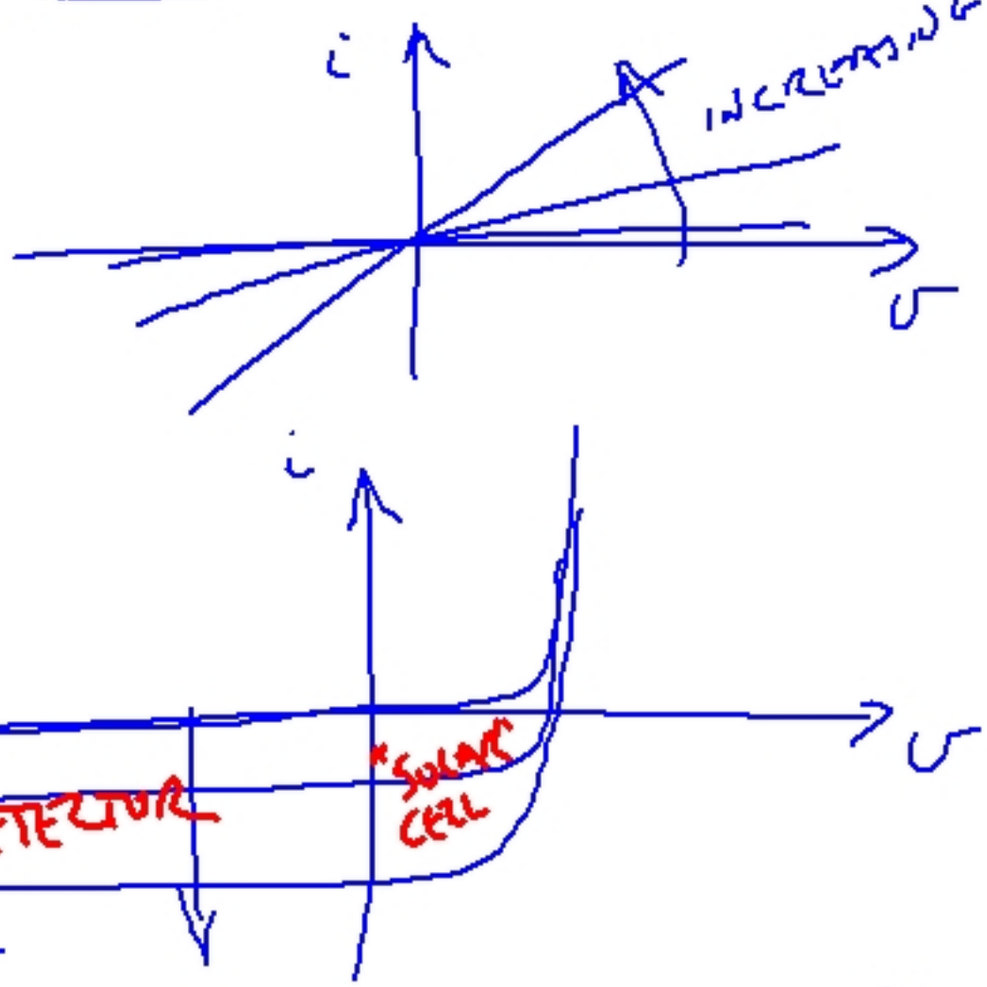
A. PHOTODIODES — Δi
- i) P-N PHOTO DIODE
- ii) P-i-N DIODE
- iii) SB DIODE
- iv) M-S-M PHOTO DIODE
- v) AVALANCHE PHOTO DIODE

B. PHOTOCONDUCTORY — ΔR
- i) BULK
- ii) QWIP

C. PHOTO CAPACITORY — ΔE
- i) MOS
- ii) CCD

PHOTOCONDUCTOR

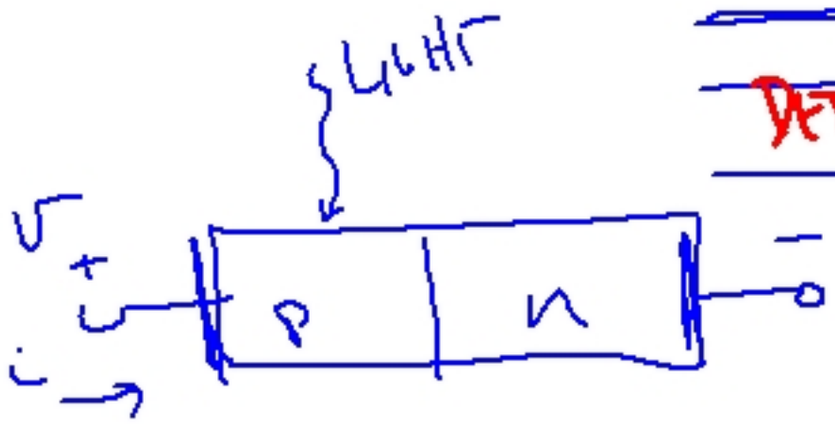




CAN HAVE GAIN $\gg 1$

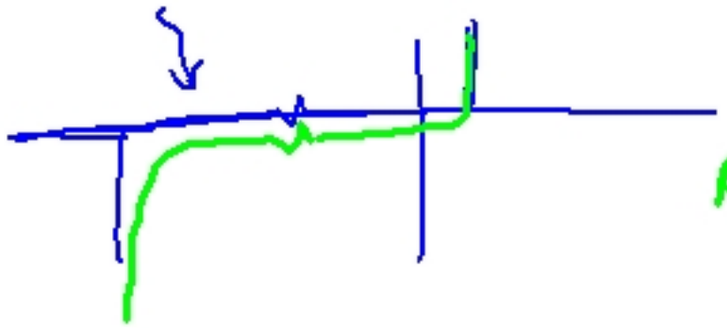
CAN BE VERY FAST

PHOTODIODE



GAIN ≤ 1

INCREASING ILLUMINATION



AVALANCHE PHOTODIODE