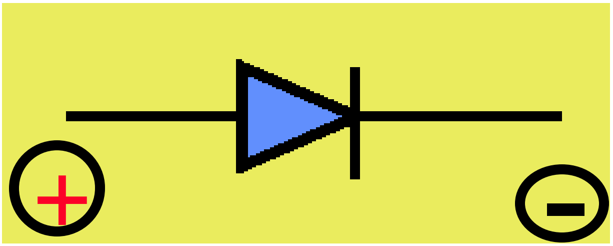
Diodes & Rectifiers



Experiment 5

EE 312

Basic Electronics Instrumentation Laboratory

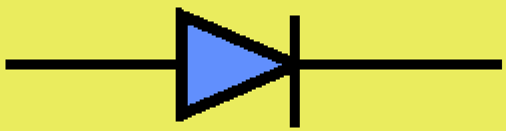
Wednesday, September 27, 2000

Objectives:

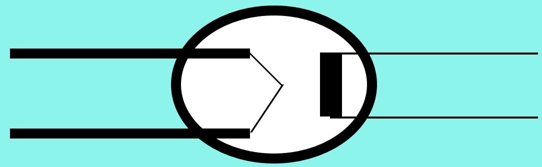
- Si Rectifier Forward I-V Characteristics
  - Forward Conduction
    - at Room Temp (T)
    - at Elevated Temp (IVT Method)
- Characteristics of Zener Diodes
  - Forward Conduction at Room Temp
  - Reverse Conduction at Room Temp

Background:

Two Types

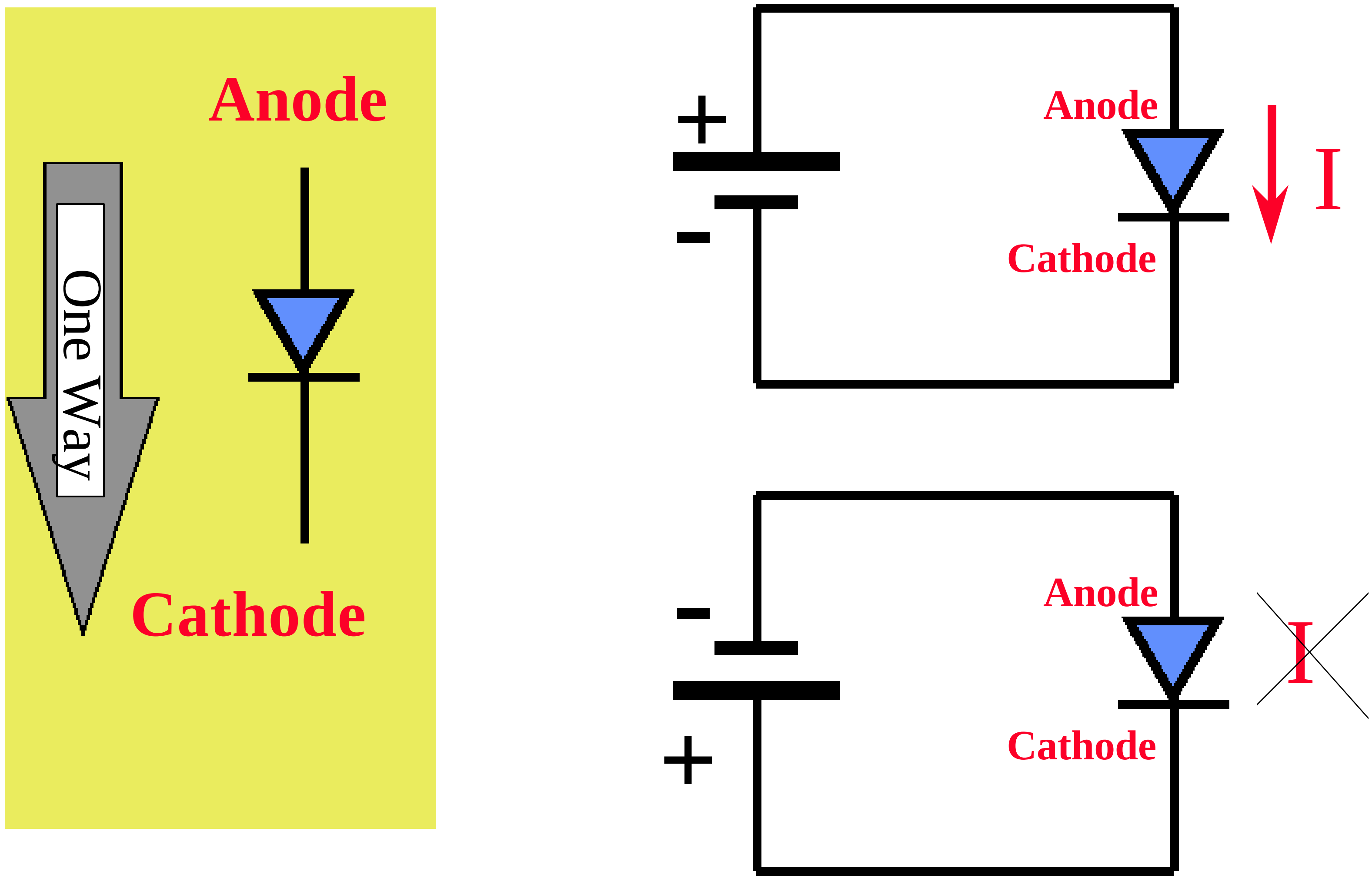


Semiconductor Diode

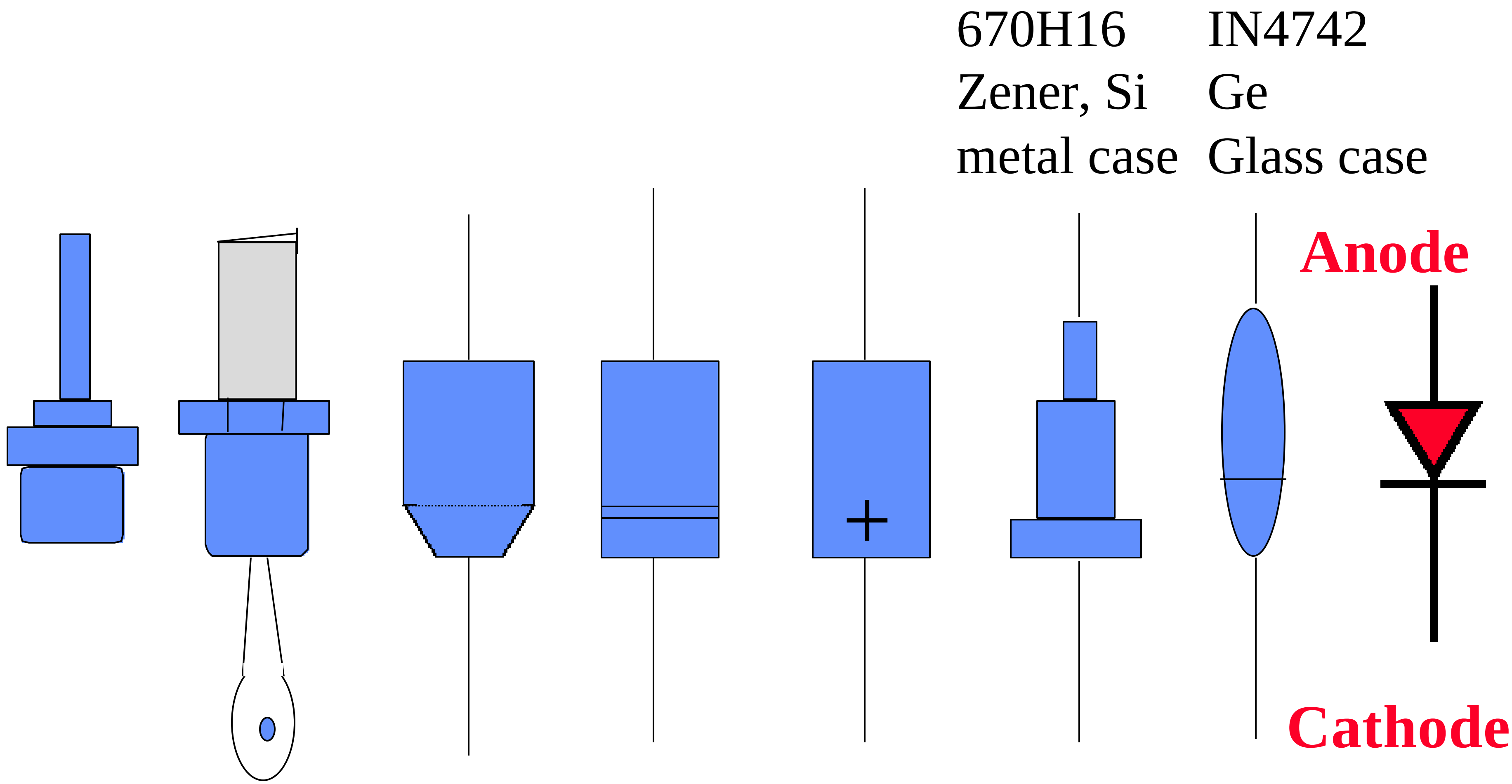


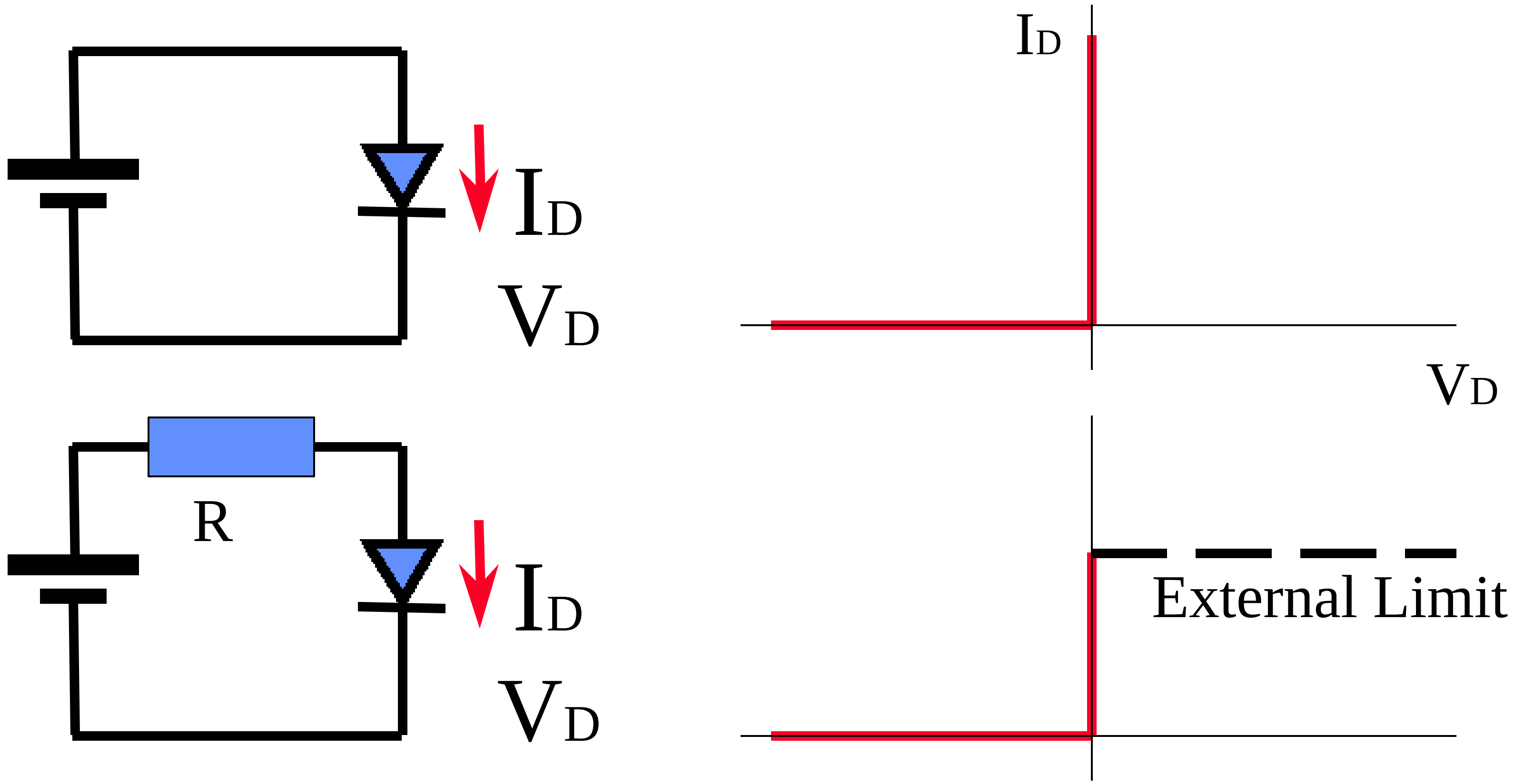
Vacuum Tube Diode

Semiconductor Diodes:

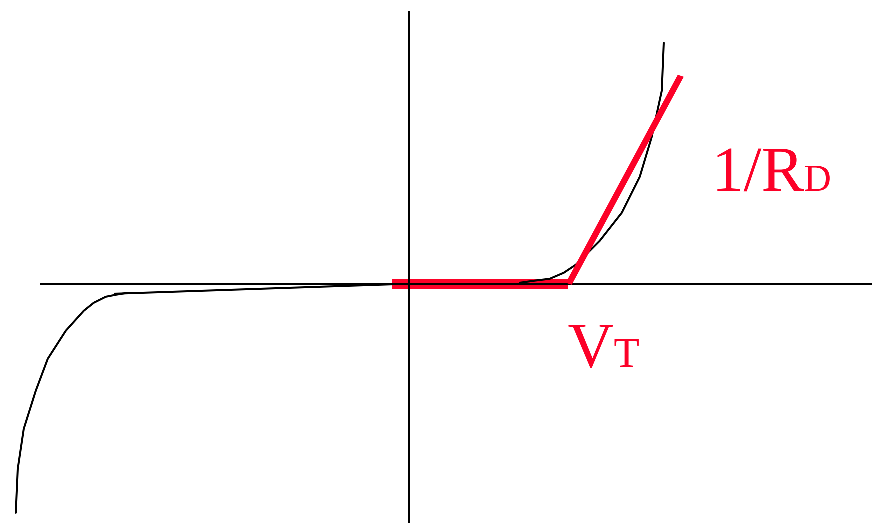


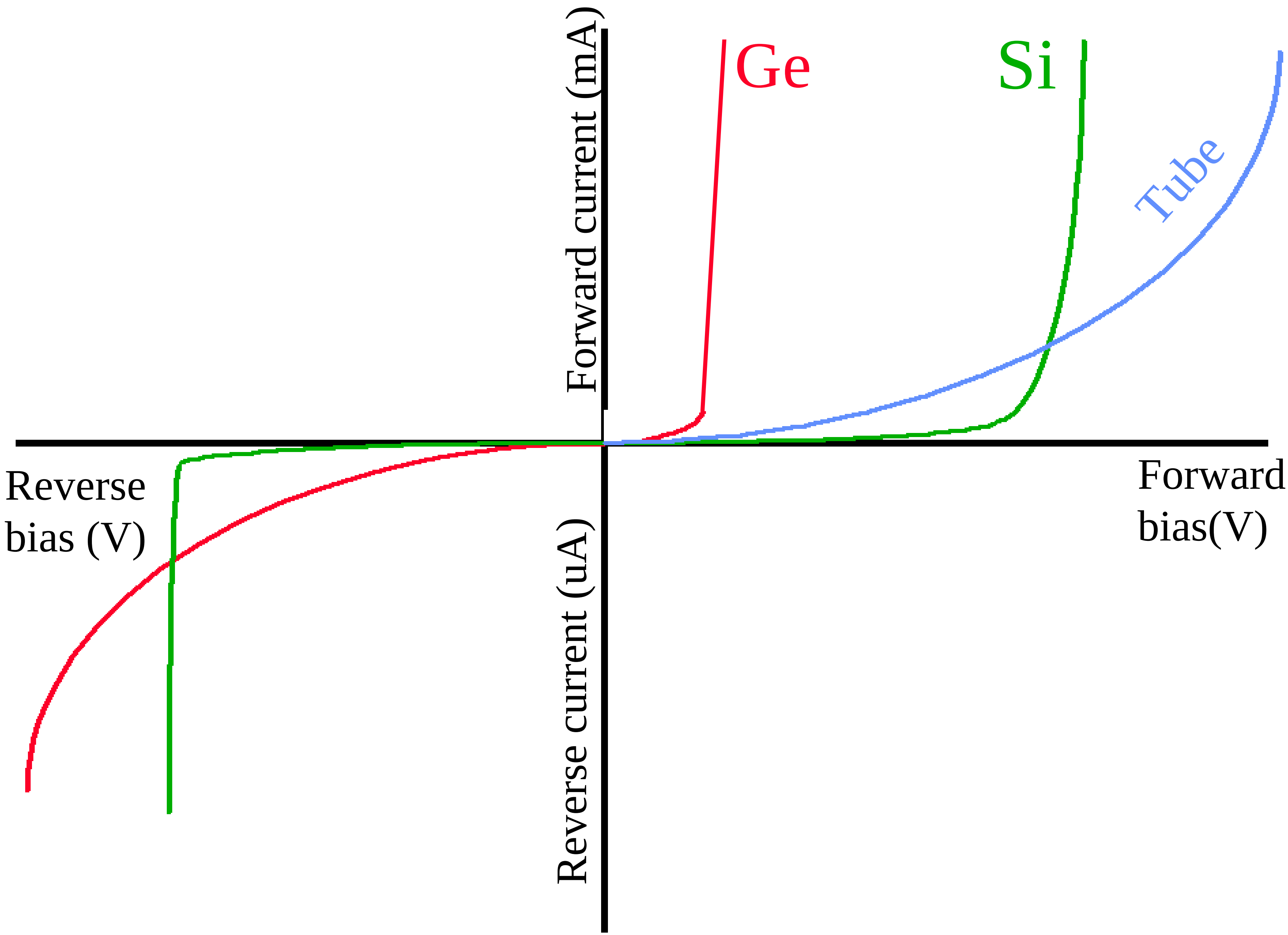
Types of diodes:





Diode Piece-wise approximation





Forward current (mA)
Ge
Si
Tube
Reverse bias (V)
Forward bias(V)
Reverse current (uA)

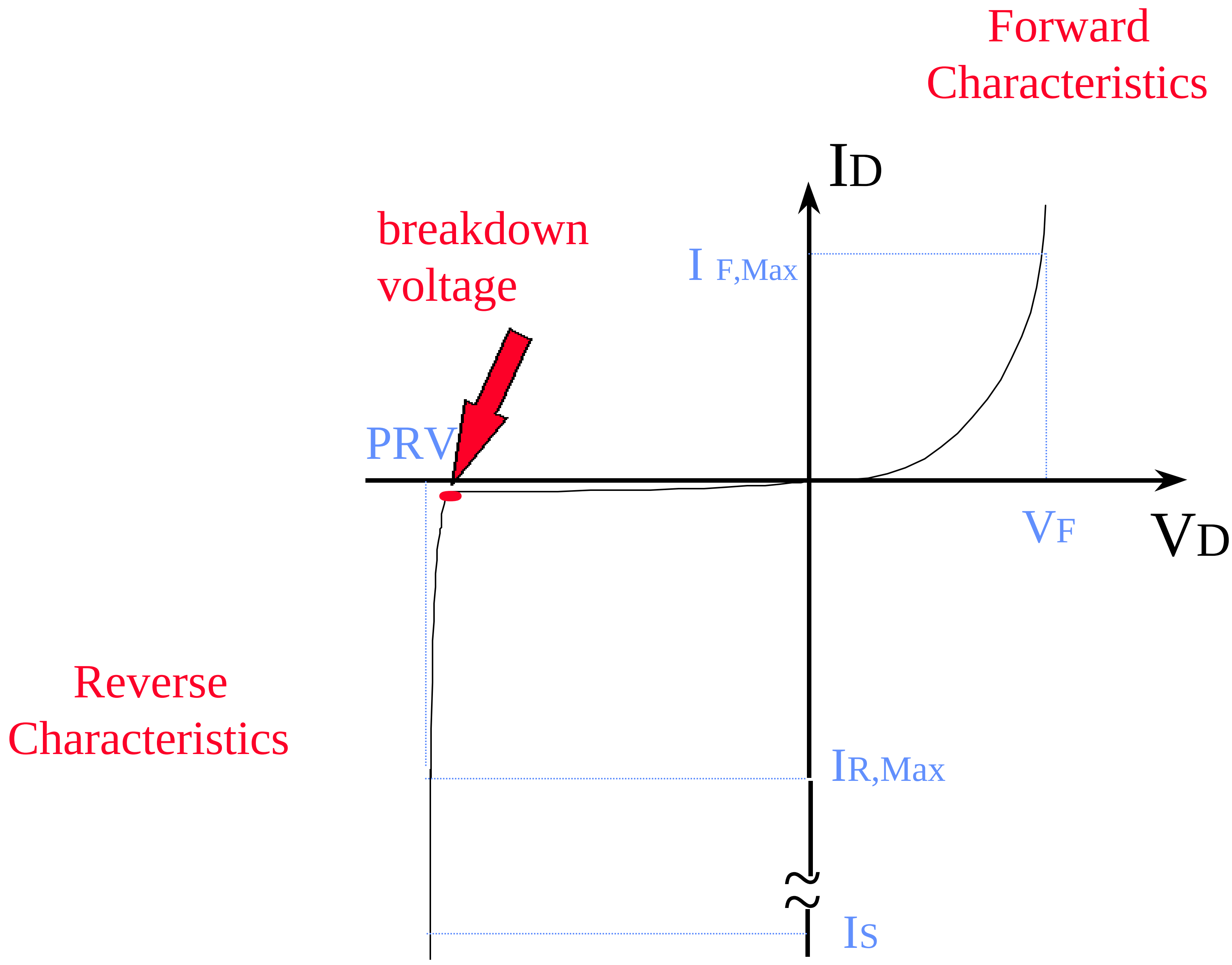
Parameters:

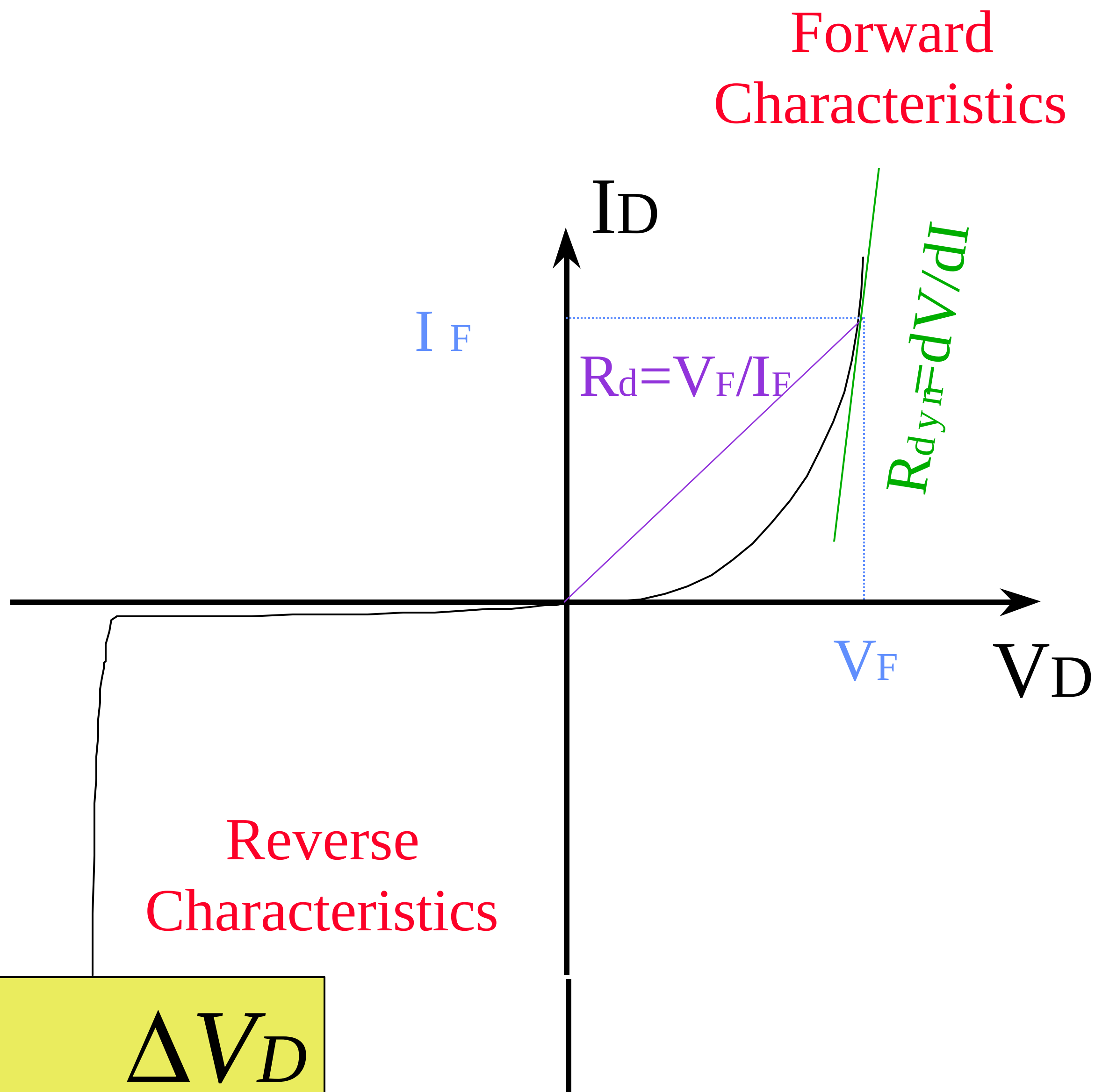
- Maximum average forward current ($I_{F,Max}$)
  - Full-cycle average current I_F that the diode can safely conduct without becoming overheated
- PRV, PIV,or VRM   All mean the same
  - peak reverse voltage
  - peak inverse voltage
  - voltage reverse, maximum

(Maximum allowable reverse-bias voltage for the diode)

PRV rating of 200 V means that the diode may breakdown & conduct & may even be destroyed, if the peak reverse voltage is greater than 200 V

- Surge or fault current (I_{Surge})
  - The amount of momentary overload current I_{surge} the diode can withstand without being destroyed
- Temperature Range
- Forward voltage drop (V_F)
  - V_F across the diode when it is conducting, given at the maximum average forward current
- Maximum reverse current ($I_{R,Max}$)
  - Maximum current I_R the diode can handle for sustained period of time when operated as a Zener Diode
- Other Parameters
  - Base diagram, total capacitance, reverse recovery time, recommended operating ranges


Forward
Characteristics
ID
breakdown
voltage
I F,Max
PRV
VF
VD
Reverse
Characteristics
IR,Max
IS



$$R_{zener} = \frac{\Delta V_D}{\Delta I_D}$$

Procedures:

1- Silicon Rectifier (IVT)

Forward I-V at 21 C

Forward I-V at ~45 C & ~70 C

2- Silicon Zener Diode (I-V)

Forward I-V at 21 C

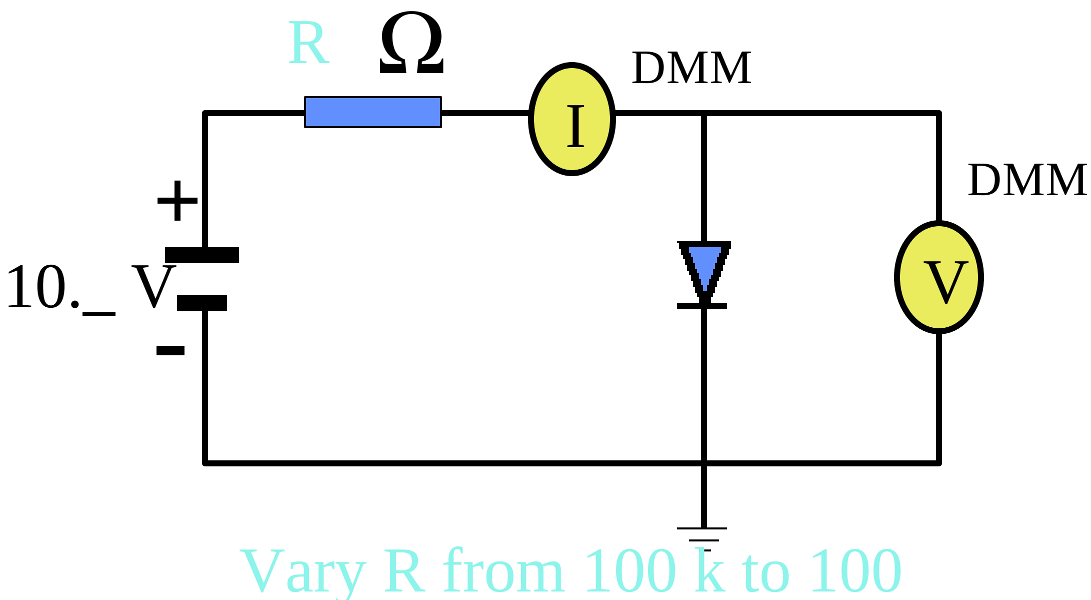
Reverse I-V at 21 C

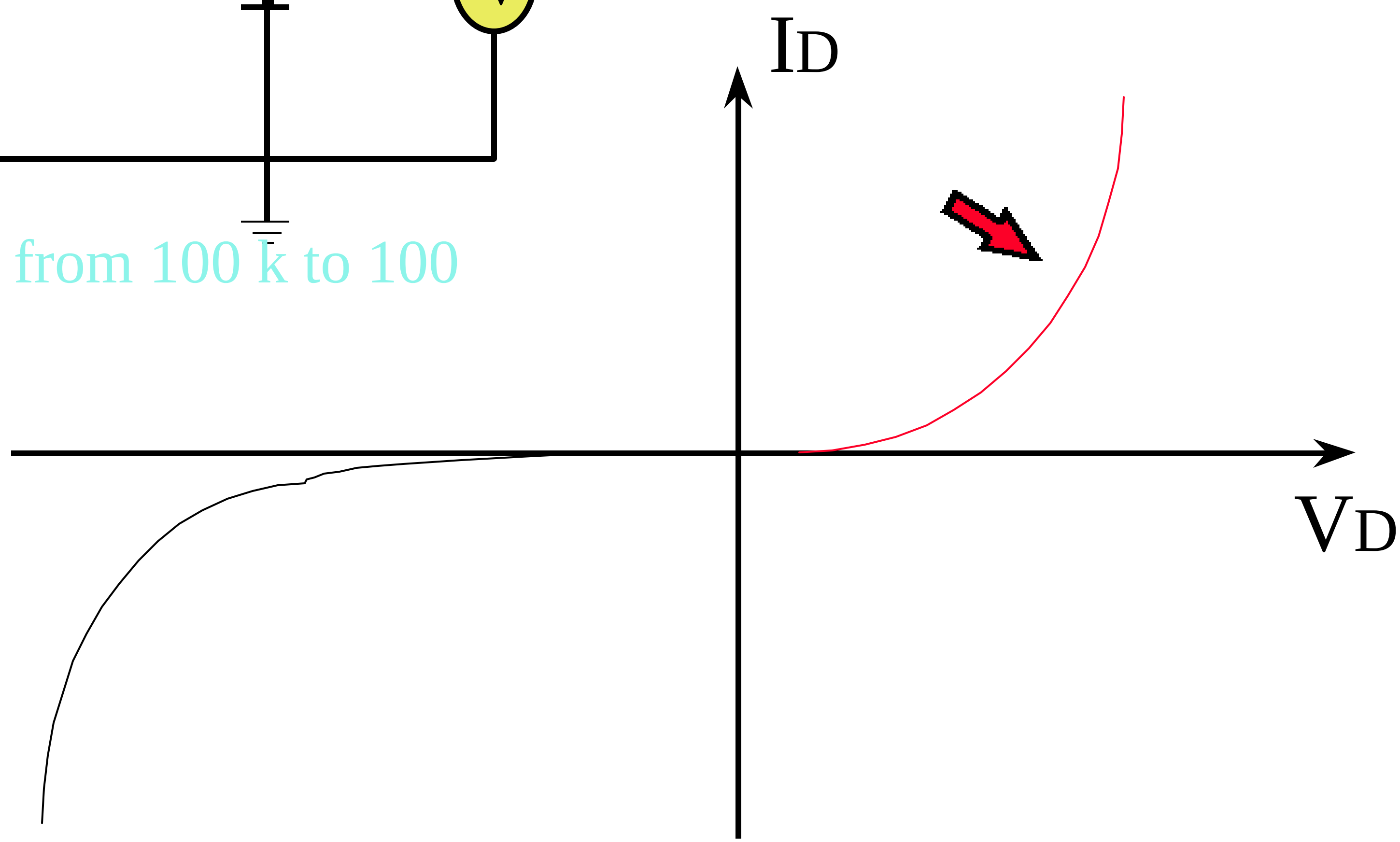
3- PSPICE Simulation (Bell 242)

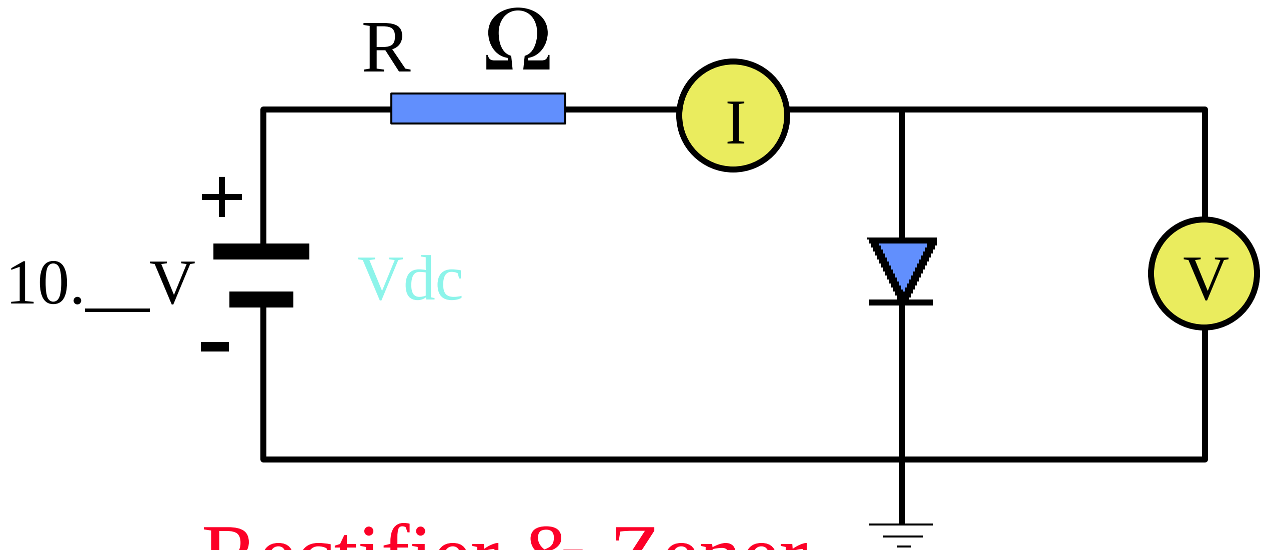
Components:

- **Silicon Rectifer (**$V_{BD} < 200$ **V)**
- **Si Diode (Zener, VBD ~ 27 V or ~ 12 V)**
- **0.1, 1.0, 4.7 kohms 2Watt Resistors**
- **Heater Block & Tube Insulator**
- **Temperature Probe**
- **Variac (Shock Warning: Not Isolated From Power Line)**

1- Forward Characteristics of Diodes





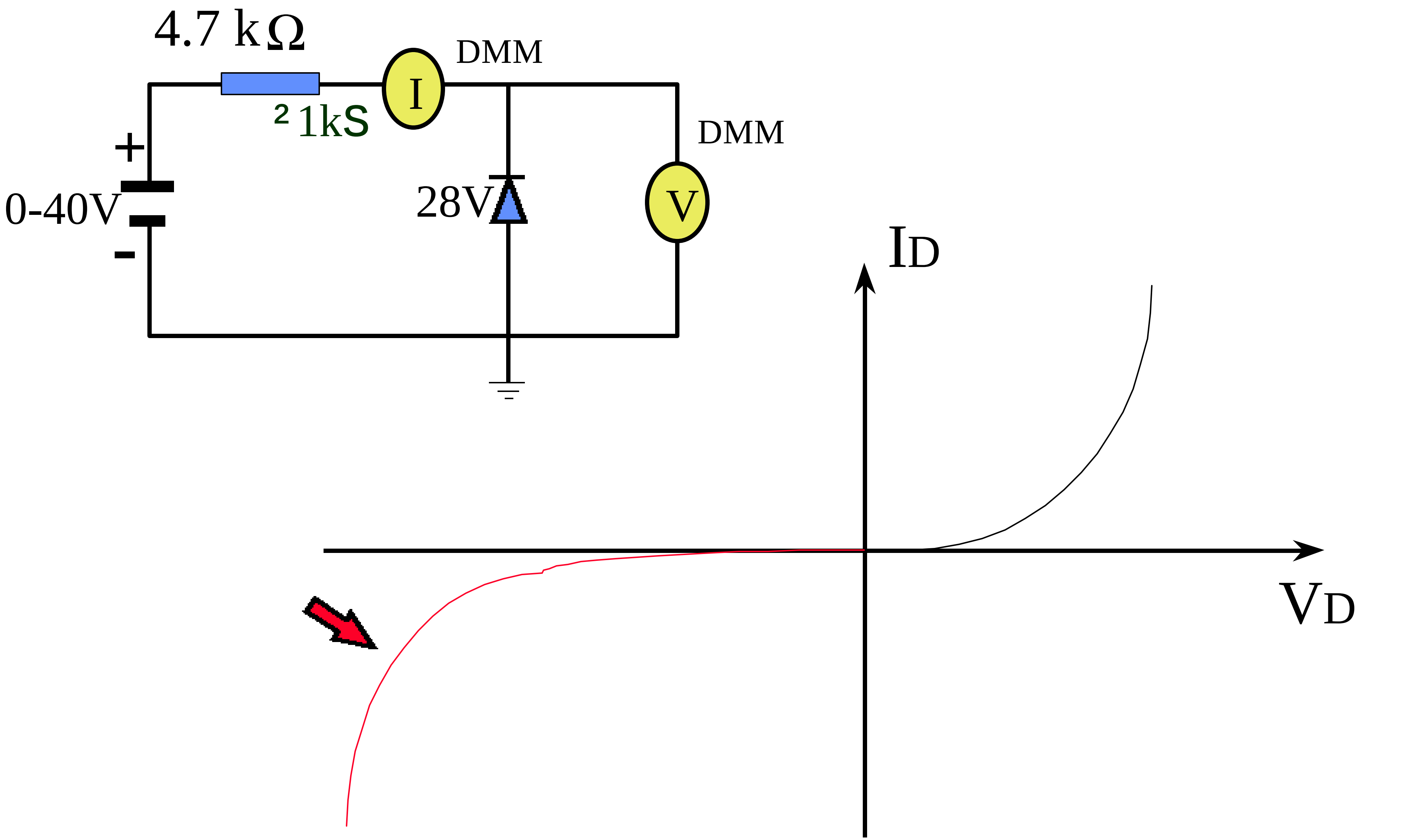


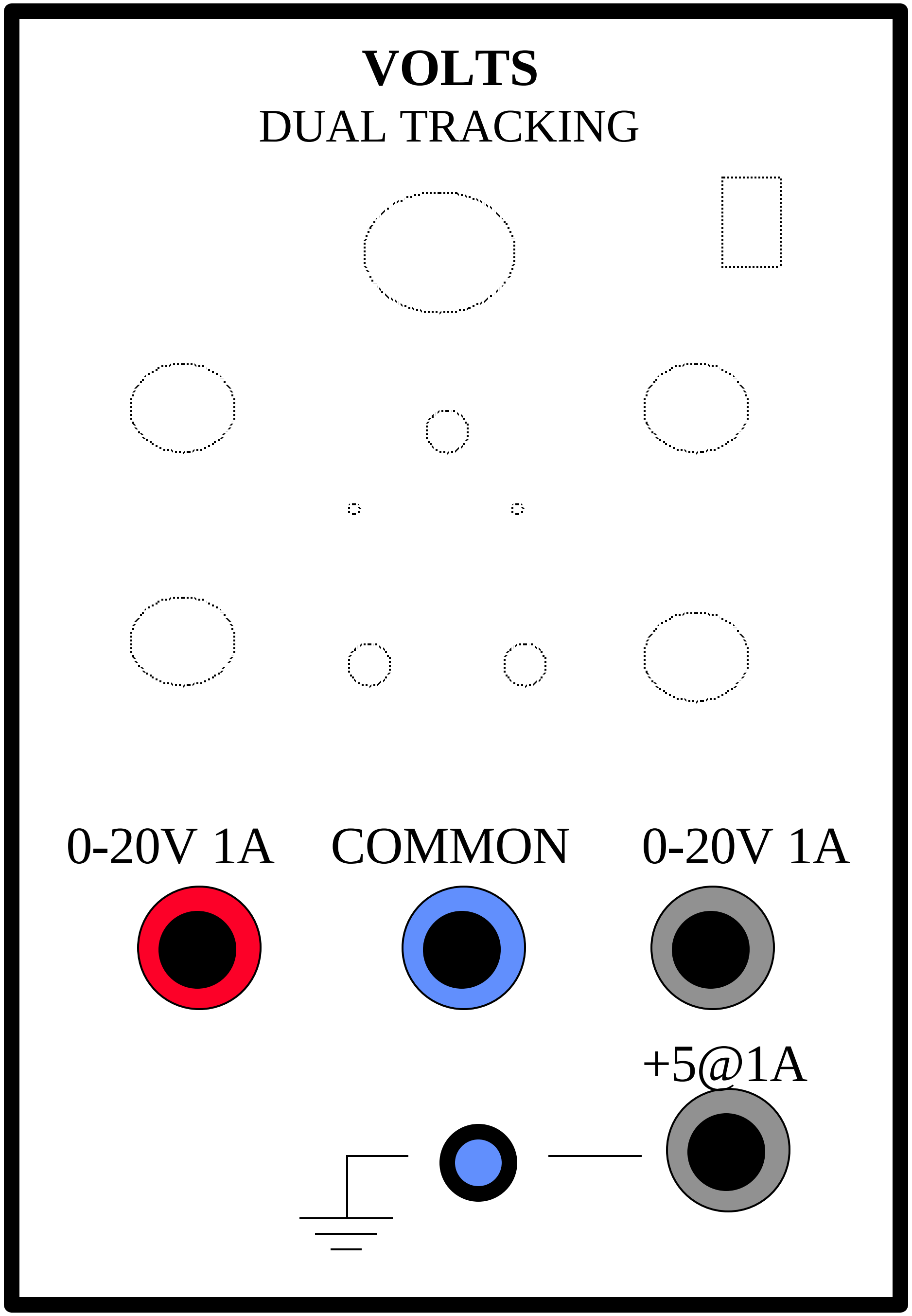
Rectifier & Zener

R [ohm]	Vdc [V]	Id [mA]	Vd [V]
100k	10.38	0.01	0.380
.	.	.	.
.	.	.	.
.	.	.	.
100	10.822	100	0.822

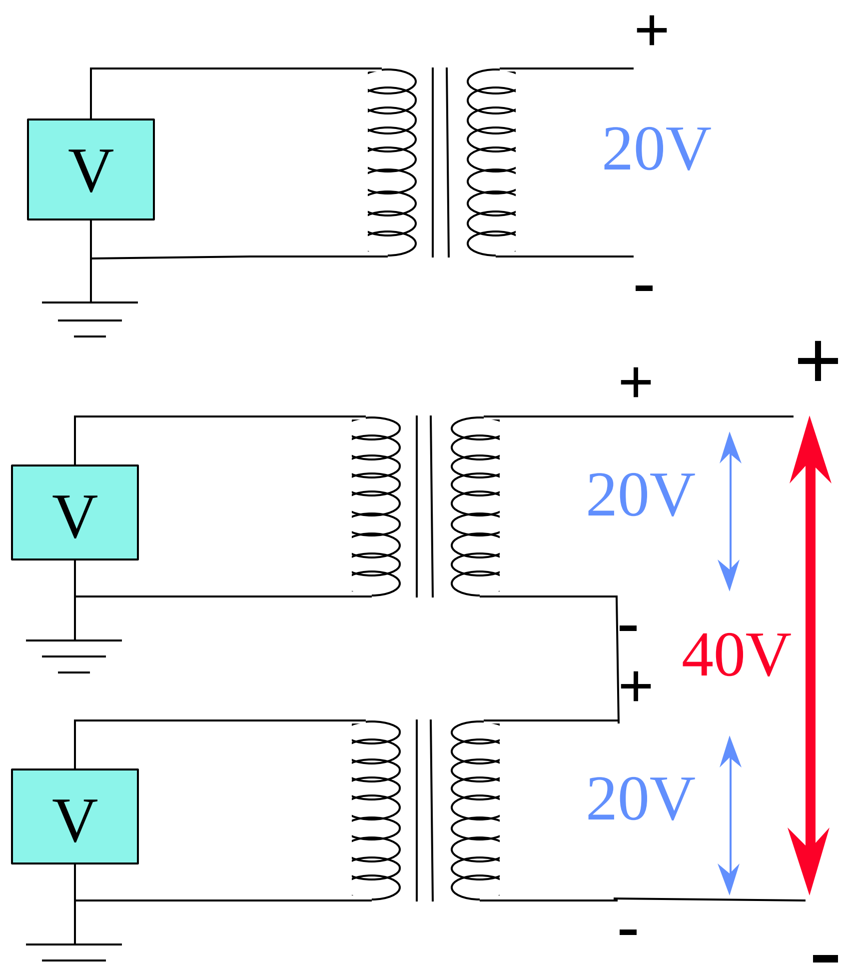
2-Reverse Characteristics of Zener Diode

(at voltages below breakdown)

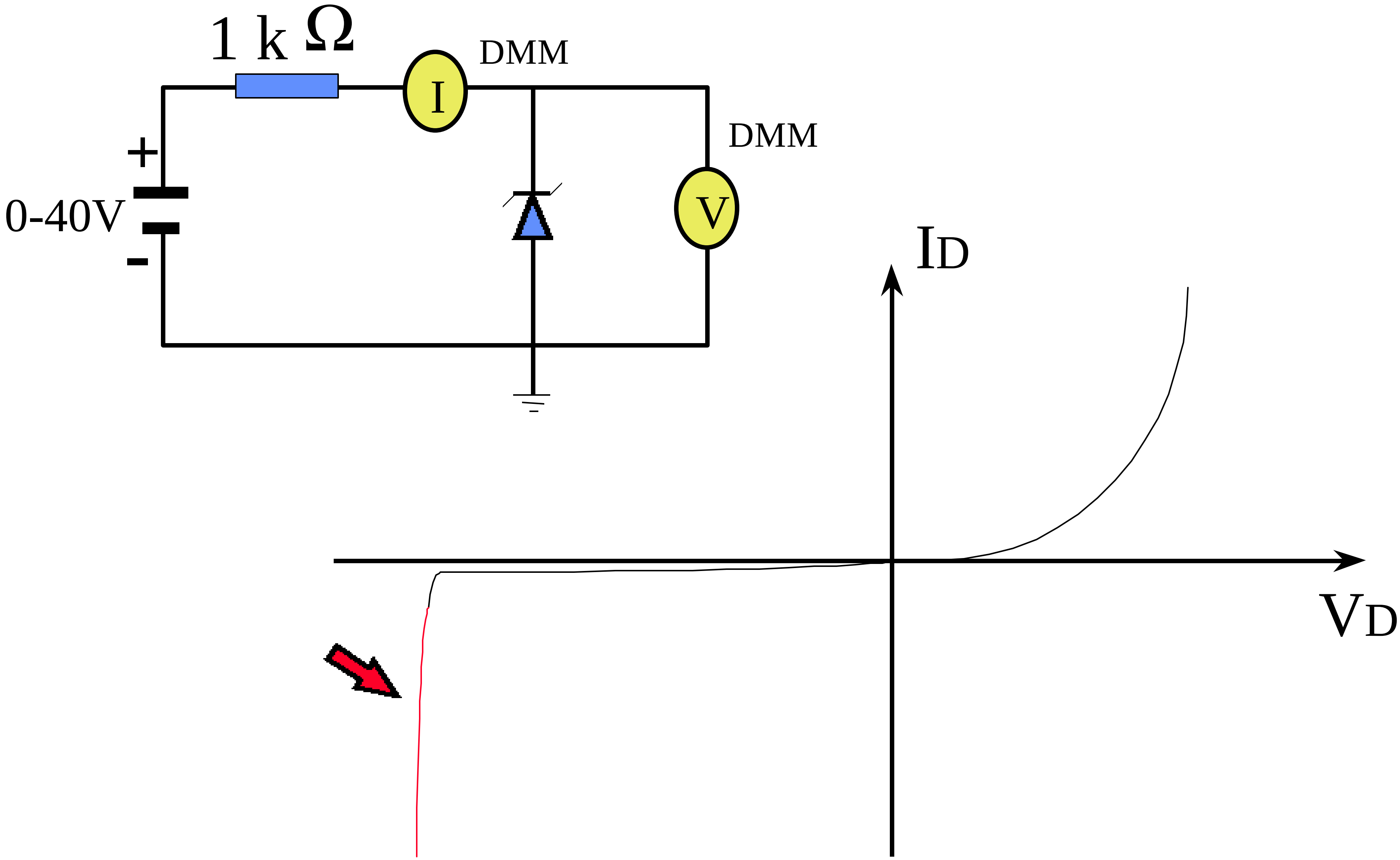


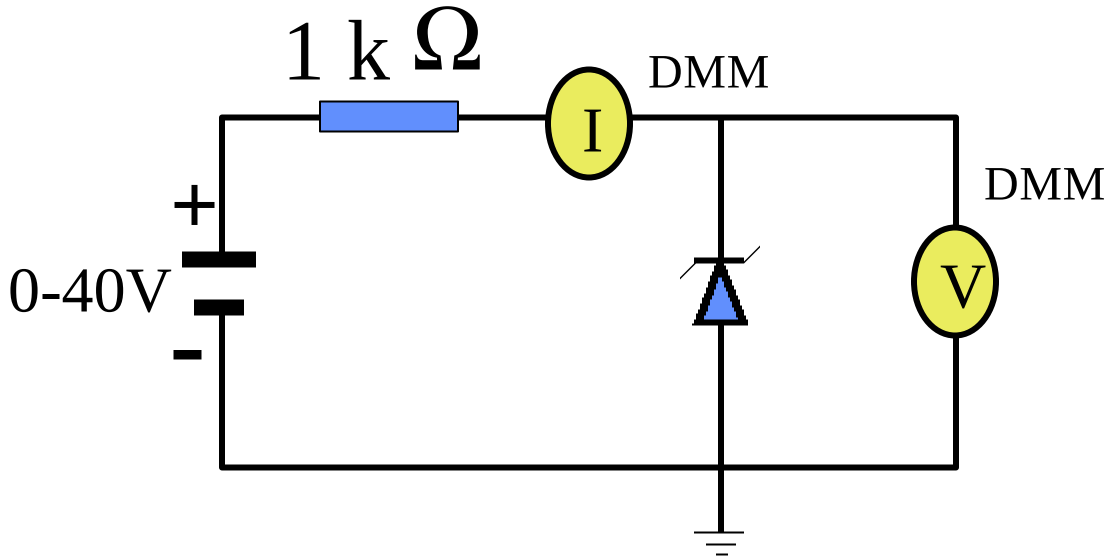


DC CONSTANT-VOLTAGE
CURRENT-LIMITED
FLOATING
POWER SUPPLY



2-Reverse Characteristics of Zener diode
(at breakdown region)





Zener

Id [A]	Vd [V]
0.1 :	0.001
.	.
.	.
.	.
9.9m	29.0

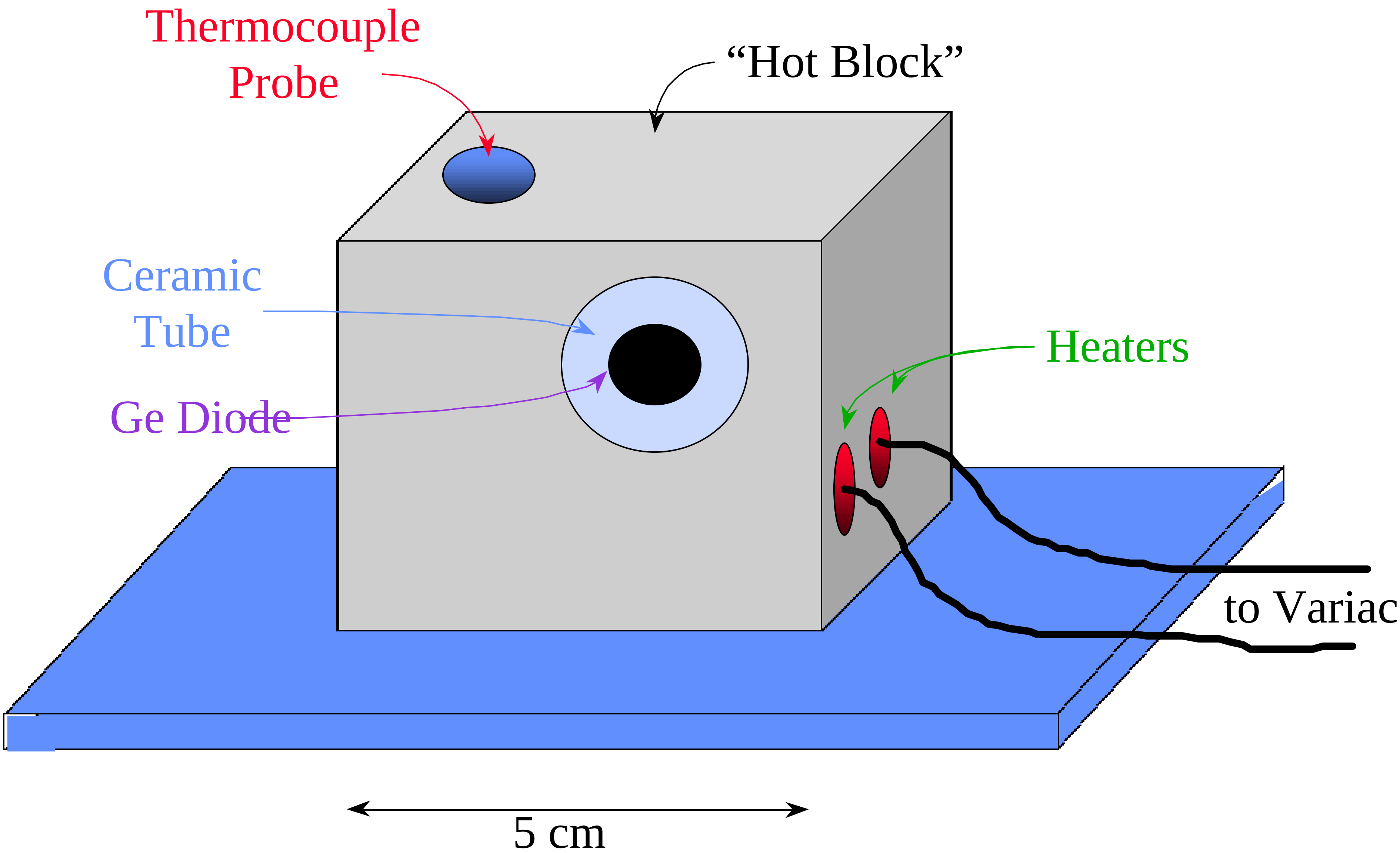
3- Simulation (PSPICE)

D1 2 0 Diode
.Model Diode D(IS=1E-14 RS=5 N=1 BV=25 IBV=1E-10)

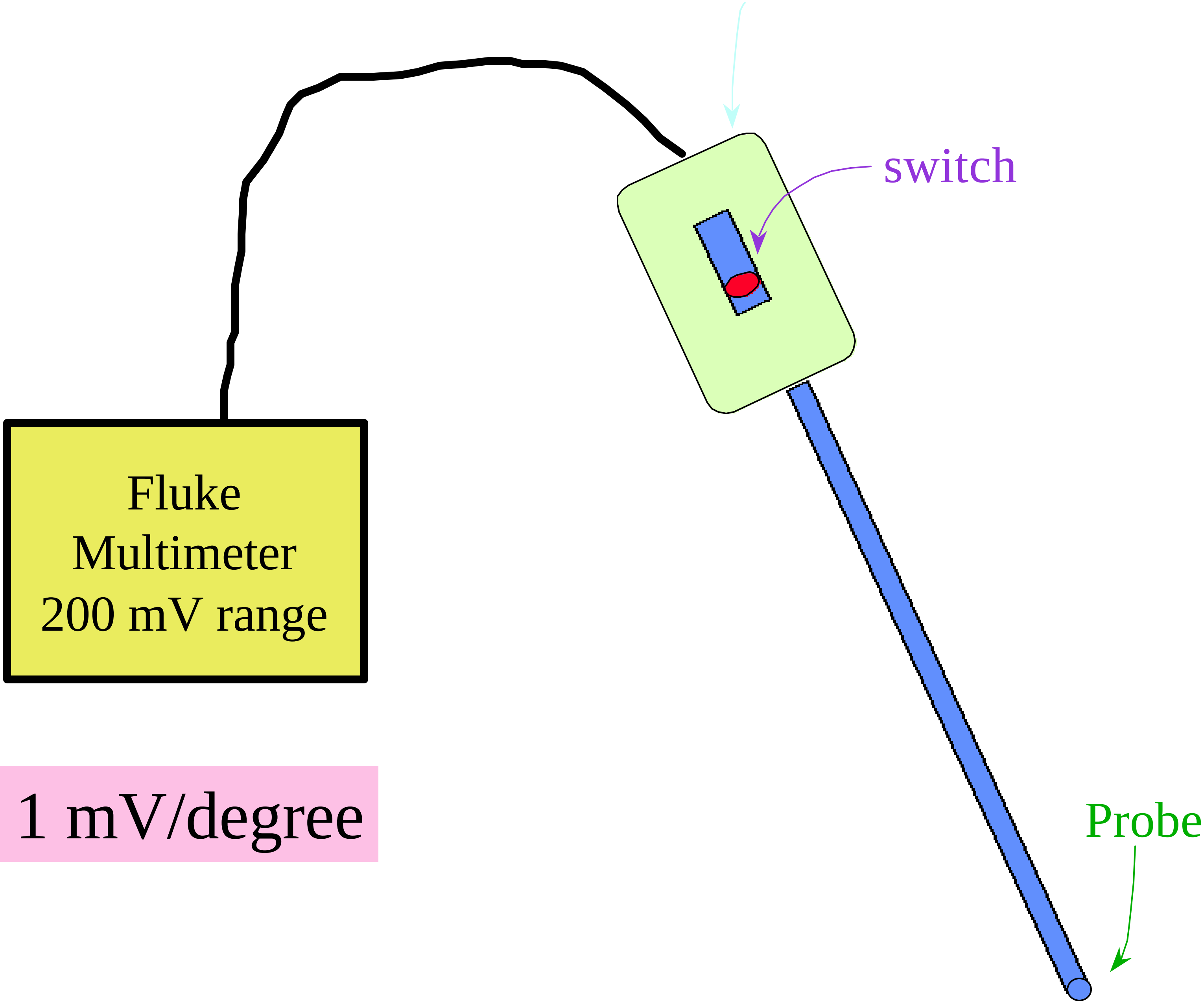
	default:	Unit:
IS Saturation current	1.0E-14	A
RS Ohmic resistance	0	Ohm
N Emission Coefficient	1	-
BV Reverse breakdown voltage	infinite	V
IBV Current at breakdown voltage	1.0E-3	A

ISR, NR, IKF, NBV, IBVL, NBVL, TT, CJO, VJ, M FC, EG, XTI, TIKF, TBV1, TBV2, TRS1, TRS2, KF, AF

5- Temperature Characteristics of Ge Diode



Temperature Probe



1 mV/degree

Temperature Dependence of I_S

See Sedra/Smith, TABLE 3-1, p. 156

Insert expression for the intrinsic carrier concentration n_i^2 into the expression for the the saturation current I_S

$I_S = C1 \times T^3 \times \exp(-E_G/kT)$ where C1 is a constant

The T^3 temperature dependence is weak compared to the exponential temperature dependence so that

$I_S = C2 \times \exp(-E_G/kT)$ where $C2 = C1 \times 300^3$

$\ln I_S = \ln(C1 \times 300^3) - E_G/kT$

Temperature Dependence of I_S

See Sedra/Smith, TABLE 3-1, p. 156

Insert expression for the intrinsic carrier concentration n_i^2 into the expression for the the saturation current I_S

$I_S = C1 \times T^3 \times \exp(-E_G/kT)$ where C1 is a constant

The T^3 temperature dependence is weak compared to the exponential temperature dependence so that

$I_S = C2 \times \exp(-E_G/kT)$ where $C2 = C1 \times 300^3$

$\ln I_S = \ln(C1 \times 300^3) - E_G/kT$

Precautions:

- Always turn off the Variac and set its dial to zero when not using it.
- At the start of the lab period, preheat the “hot block” to 40C. When you get to part 5, insert the diode into the block and allow a few minutes for the temperature to stabilize.
- Do not exceed a temperature of 75C in the “hot block.”
- Do not exceed the current rating for the diode:
  - Ge: $I_{F, Max} = 100$ mA $I_{R,Max} = 1.0$ mA
  - Si: $I_{F,Max} = 100$ mA $I_{R,Max} = 100$ mA

Report is required

Must Submit Electronic Version Using Command

submit ee312 E5ReportTuAM#

Paper Version Also Required

Team Writing

- Abstract & Report for Zener Diode reverse IV on the 1999 web
- Introduction to be provided or omitted
- One Partner does silicon rectifier IVT results & discussion for I_S & n
- Must provide results in a computer file to Partner in less than one week & submit to EE 312 Staff using submit command.

- Other Partner uses information provided by partner to determine E_G. Also include discussion and conclusions . Submit report electronically within one week of receiving partner's contribution. Paper version also.
- PSPICE Simulations Not Required.
- Late penalties are -10 points per day and the day starts at 9:00 AM.