Course: Basic Electronics (EC21101)

Course Instructor: Prof. Kapil Debnath

Tutorial Questions

(more practice problems can be found in the text book)

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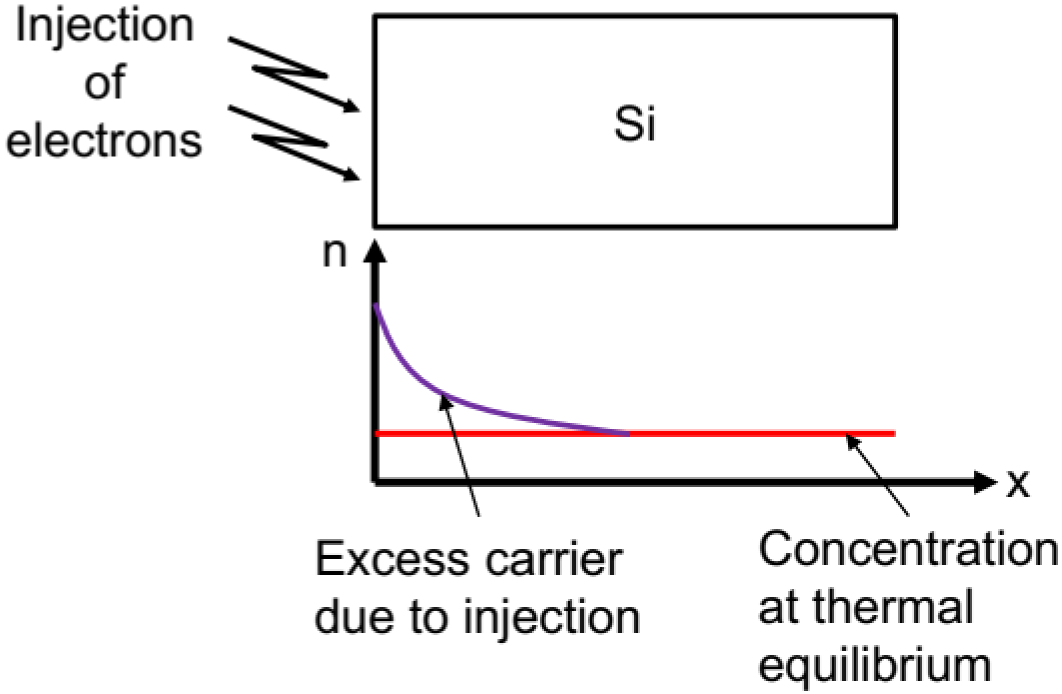
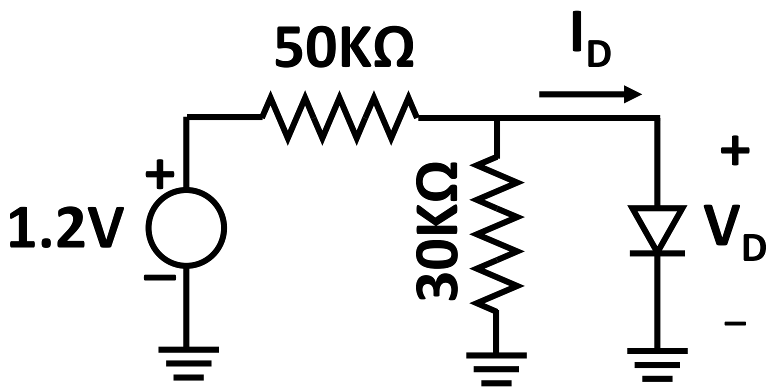
Electrons are injected into a p-type silicon slab from the left as shown in figure. The electron concentration varies as $n(x) = 10^4 + 10^{15} e^{\left(-\frac{x}{Ln}\right)}$ for $x \geq 0$. The value of L_n is 10µm. Silicon parameters: $\mu_n = 1400\ \mathrm{cm^2/V.s}$, $\mu_p = 470\ \mathrm{cm^2/V.s}$, $D_n = 34\ \mathrm{cm^2/s}$, $D_p = 12\ \mathrm{cm^2/s}$, electron charge $= 1.602 \times 10^{-19}$C.

Determine the current density at x=0, x=10µm.



Hint: only electron diffusion is present

Consider the following diode circuit. The diode has a reverse saturation current of 5×10^{-13} A. At room temperature what is the diode current and voltage? Consider $\eta = 1$.



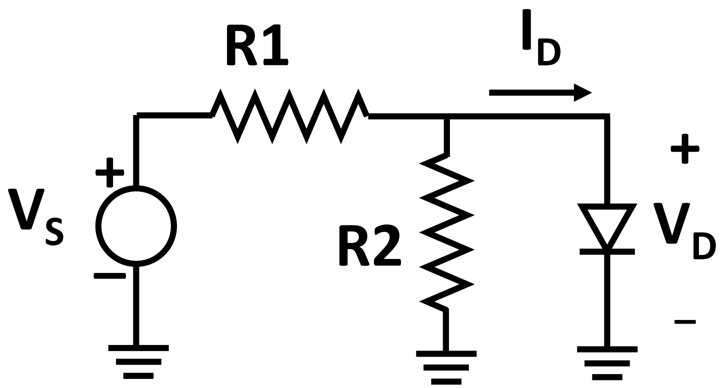
Hint: Use iteration method. Find the starting value by approximating ideal diode.

Ans: 0.402V, 2.56μA

To keep the diode ‘on’ supply voltage is kept between 5V and 10V. The minimum diode current is to be 2mA and the power dissipation in the diode should not cross 10mW.
Determine the appropriate values of R1 and R2 for the following approximation

i) $V_\gamma = 0.7\text{V}, r_f = 0$

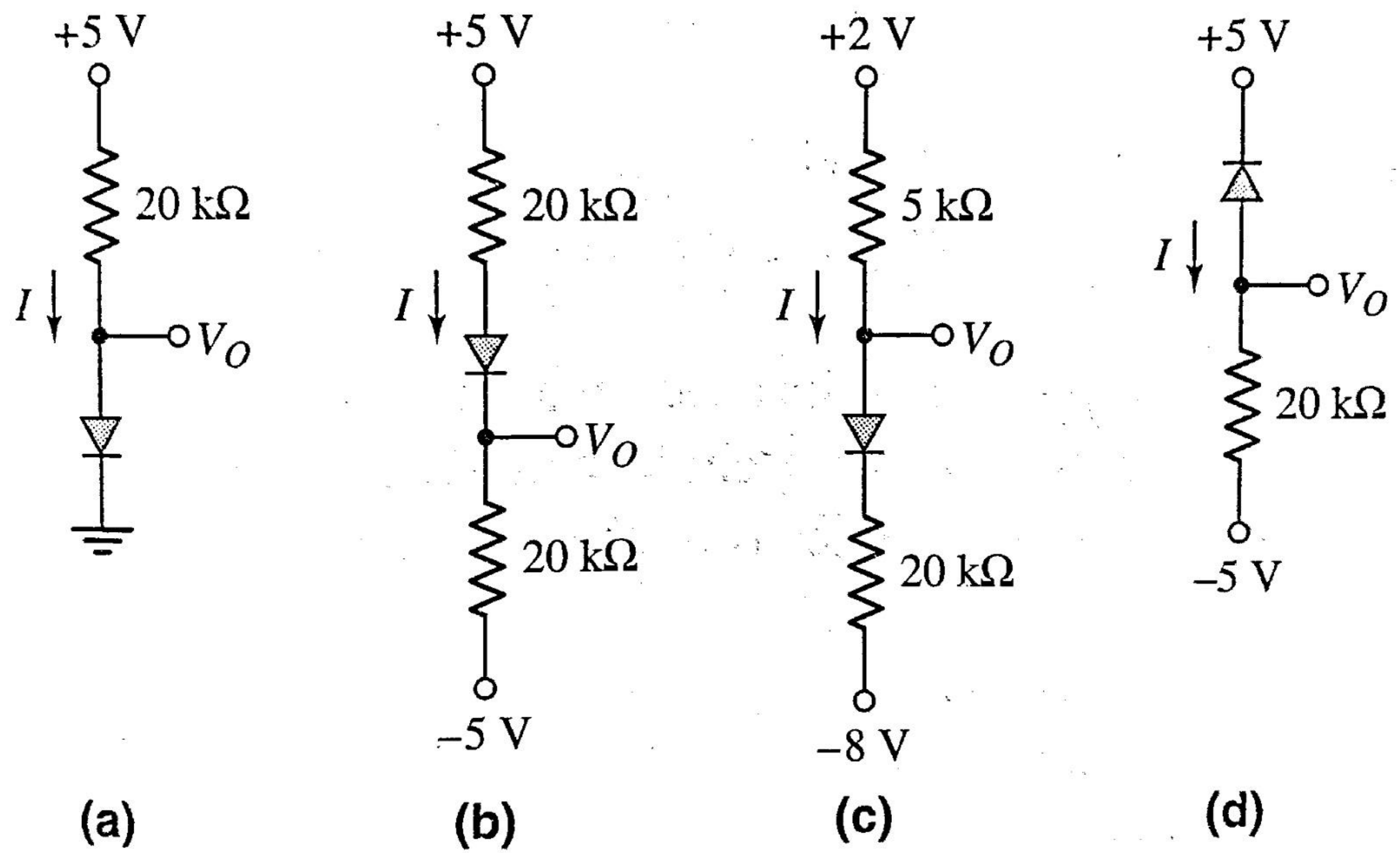
ii) $V_\gamma = 0.7\text{V}, r_f = 10\Omega$



Ans: a) 410Ω, 82.5 Ω

b) 380 Ω, 77.75 Ω

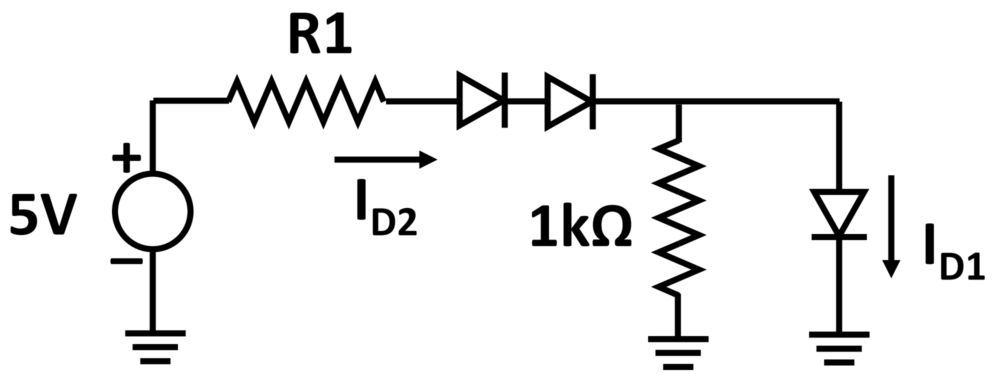
Find I and Vo for the following circuits. Consider $V_\gamma = 0.7V$



Hint: Use KVL

Ans: a) 0.215mA, 0.7V, b) 0.2325mA, -0.35V, c) 0.372mA, 0.14V, d) 0mA, -5V

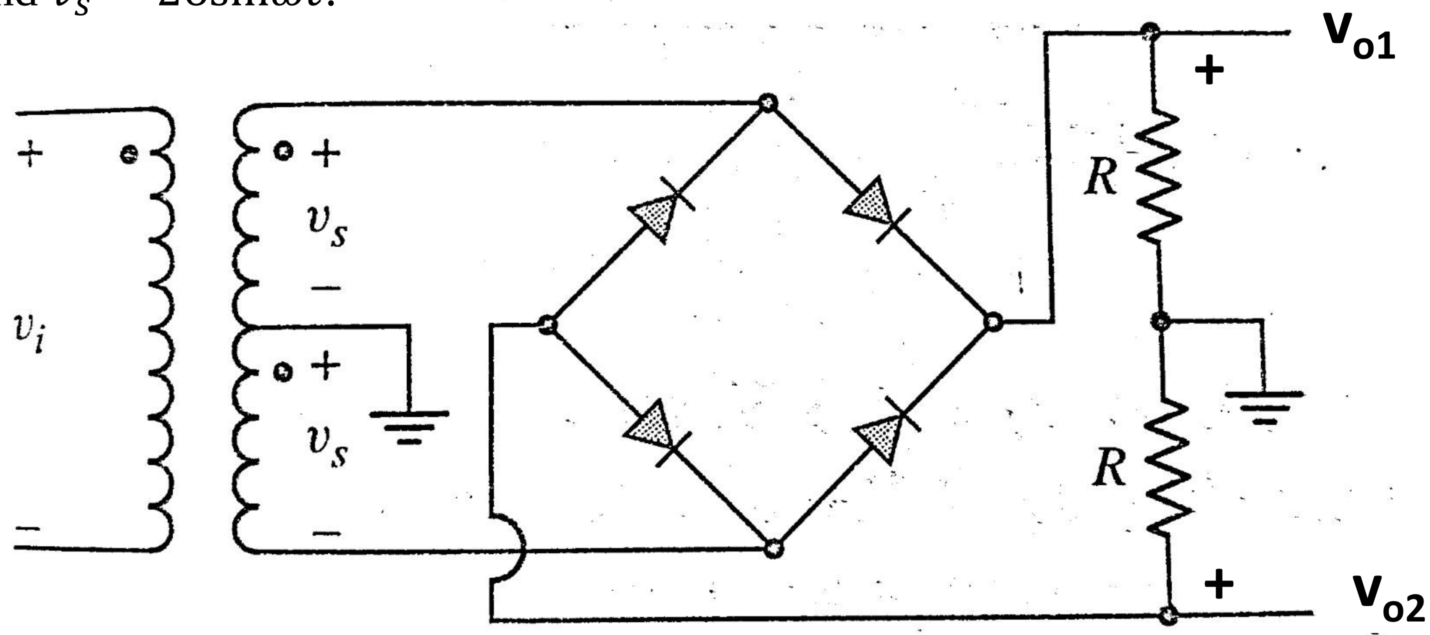
Each diode has $V_\gamma = 0.65V$. What should be value of R1 so that $I_{D2} = 2I_{D1}$. what are the values of I_{D1} and I_{D2}?



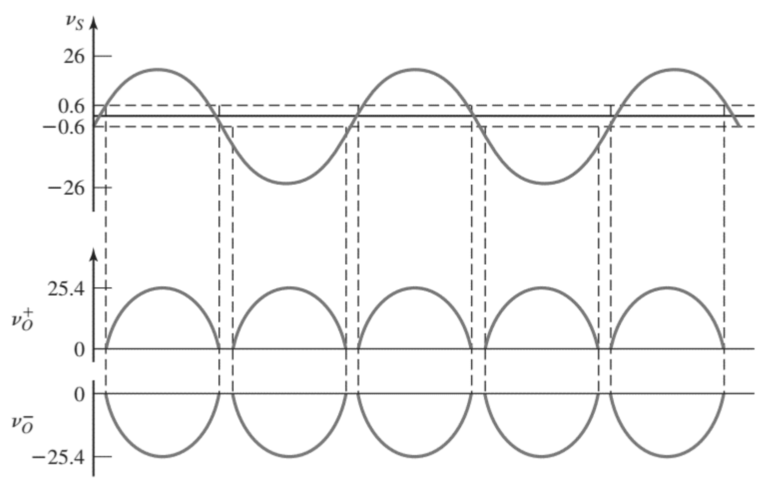
Hint: Use KCL

Ans: 2.35K, 0.65mA, 1.3mA

Sketch output waveforms (v_{o1} and v_{o2}) of the following circuit. Consider each diode has $V_\gamma = 0.6V$ and $v_s = 26\sin\omega t$.



Hint: Use KVL

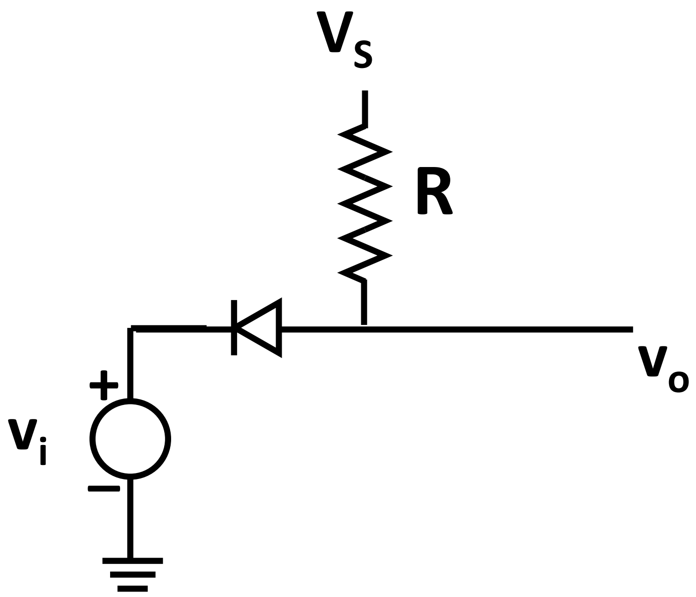


A voltage regulator is to have a nominal output voltage of 10V. The Zener diode has a rating of 1W, has a drop of 10V at I_Z=25mA, and has Zener resistance of r_z=5Ω. The input power supply has a nominal value of Vs=20V and can vary by ±25%. The output load current is to Vry between I_L=0mA and 20mA.

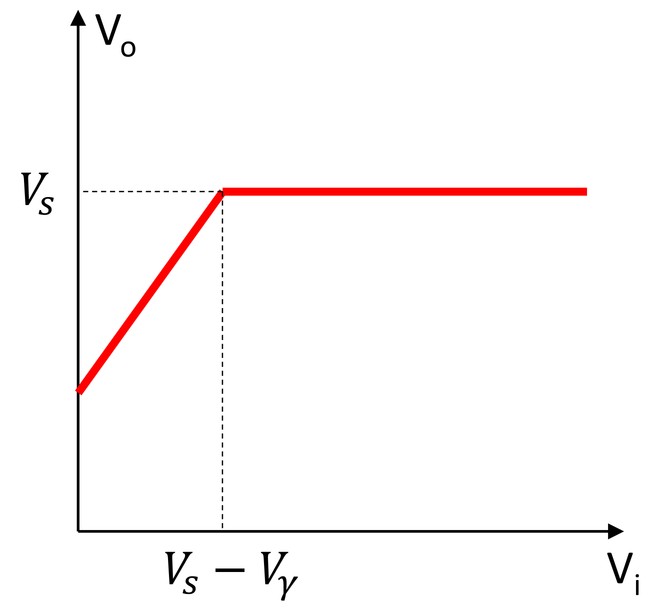
a) If the minimum Zener current is to be Iz=5mA, express the voltage across Zener diode in terms of the Zener current. Also determine the required Ri.
b) Determine the maximum variation in output voltage.
c) Determine the load percentage regulation.

Ri=200Ω, ΔVo=0.35V, % Reg=3.5%

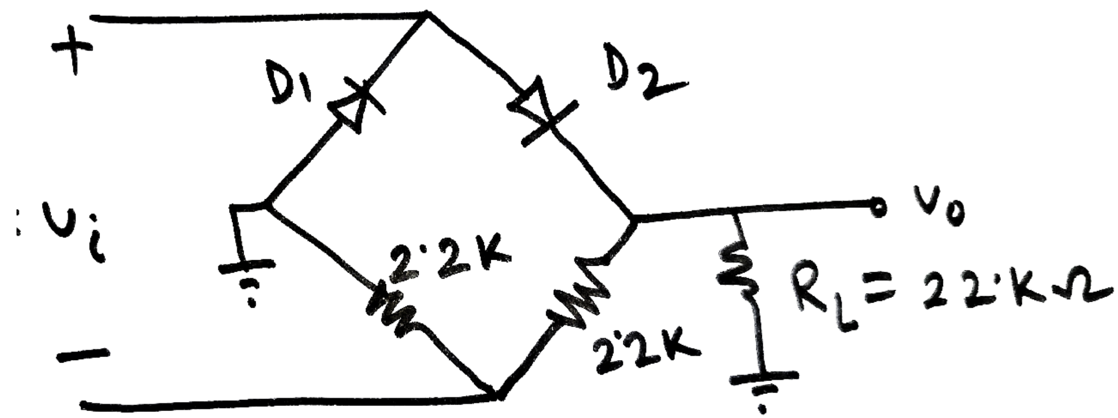
For the following circuit, draw the input-output characteristics



Hint: Diode is on until $V_s \geq V_i + V_\gamma$

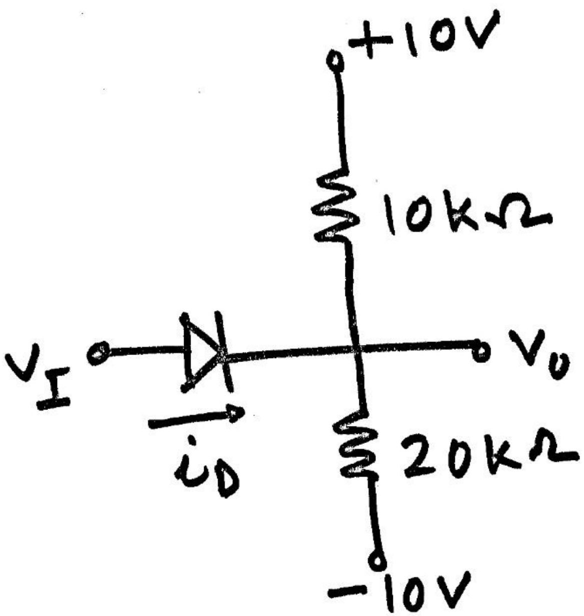


If the input signal is a sinusoid with peak voltage of 40V, draw the output voltage, assuming $V_\gamma = 0$.

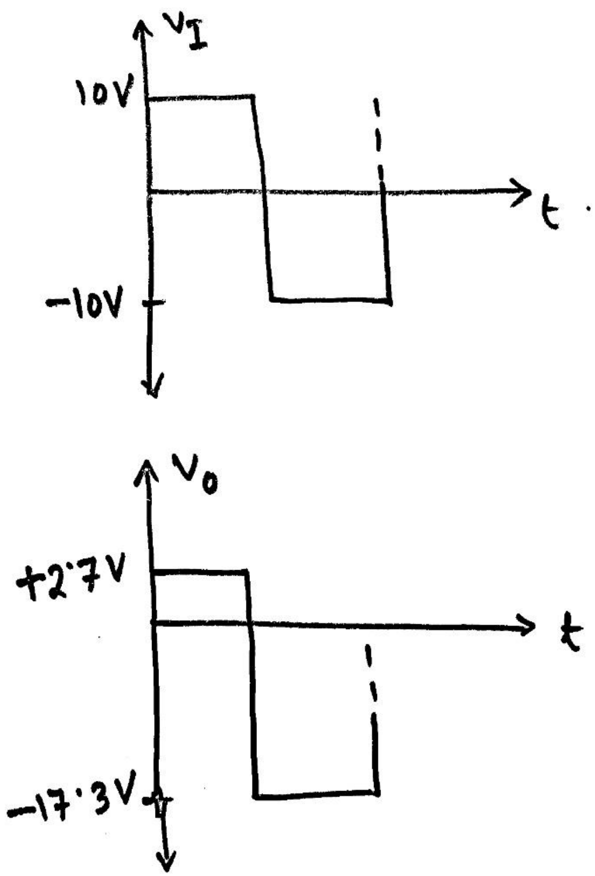


Hint: it's a full wave rectifier. Find the maximum voltage

If the input voltage varies between -10V to +10V, draw the output voltage, considering $V_\gamma = 0.7V$.

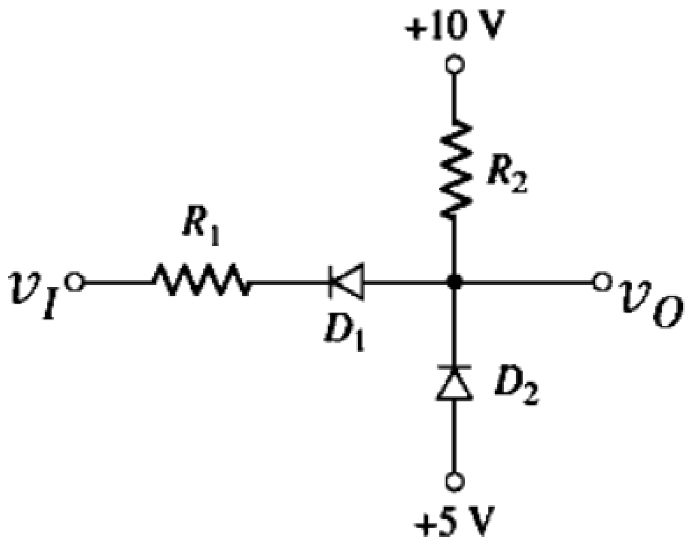


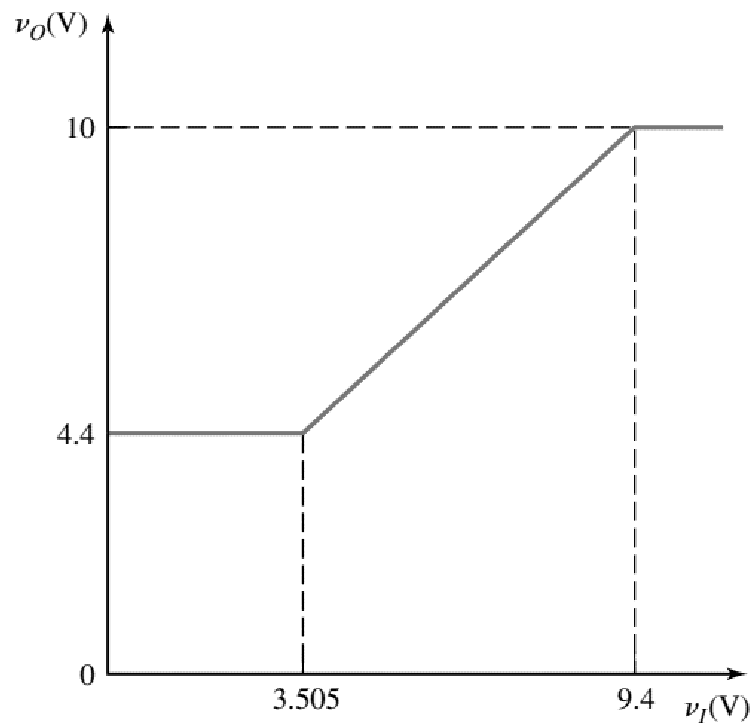
Design a clamper circuit to have the following input-output waveform.



For the following circuit, draw the input-output characteristics

R1=0.5kΩ, R2=9.5kΩ. vI varies between 0-10V, $V_\gamma = 0.6V$.

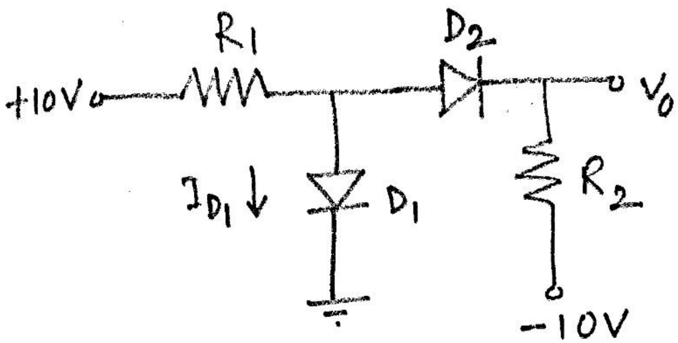




For $V_\gamma = 0.7$V, Find the values of I_{D1} and V_O for:

a) R1=5K and R2=10K

b) R1=10K and R2=5K.



Steps to solve multiple diode problem:

a) Observe the circuit and assume the status of each diode (on or off)

b) Replace the diode with equivalent circuit. i.e. if assumed 'on' replace with a voltage source (V_γ) and series resistance (r_f). Also assign proper direction of current through the diode branch, as shown below.

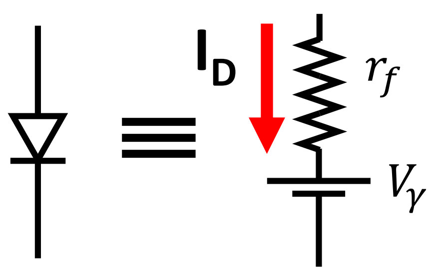
c) If the diode is assumed off, replace it with an open circuit.

d) Solve the resulting circuit using conventional linear circuit tools, such as KVL, KCL, Thevenin's theorem etc.

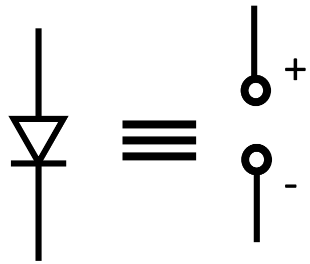
e) If the solution matches with the assumption, for example, if the diode currents (I_D) turn out to be positive (for 'on' assumption) or the open circuit voltage is less than V_γ, then the assumption is correct and proceed accordingly.

f) If on the other hand, the solution does not match with the assumption, make a different assumption and repeat the previous process again.

Assumed 'on'



Assumed 'off'



If r_f is not given, assume it to be zero.