ECE 65: Components & Circuits Lab

Lecture 4

Diode introduction

and review of circuit theory

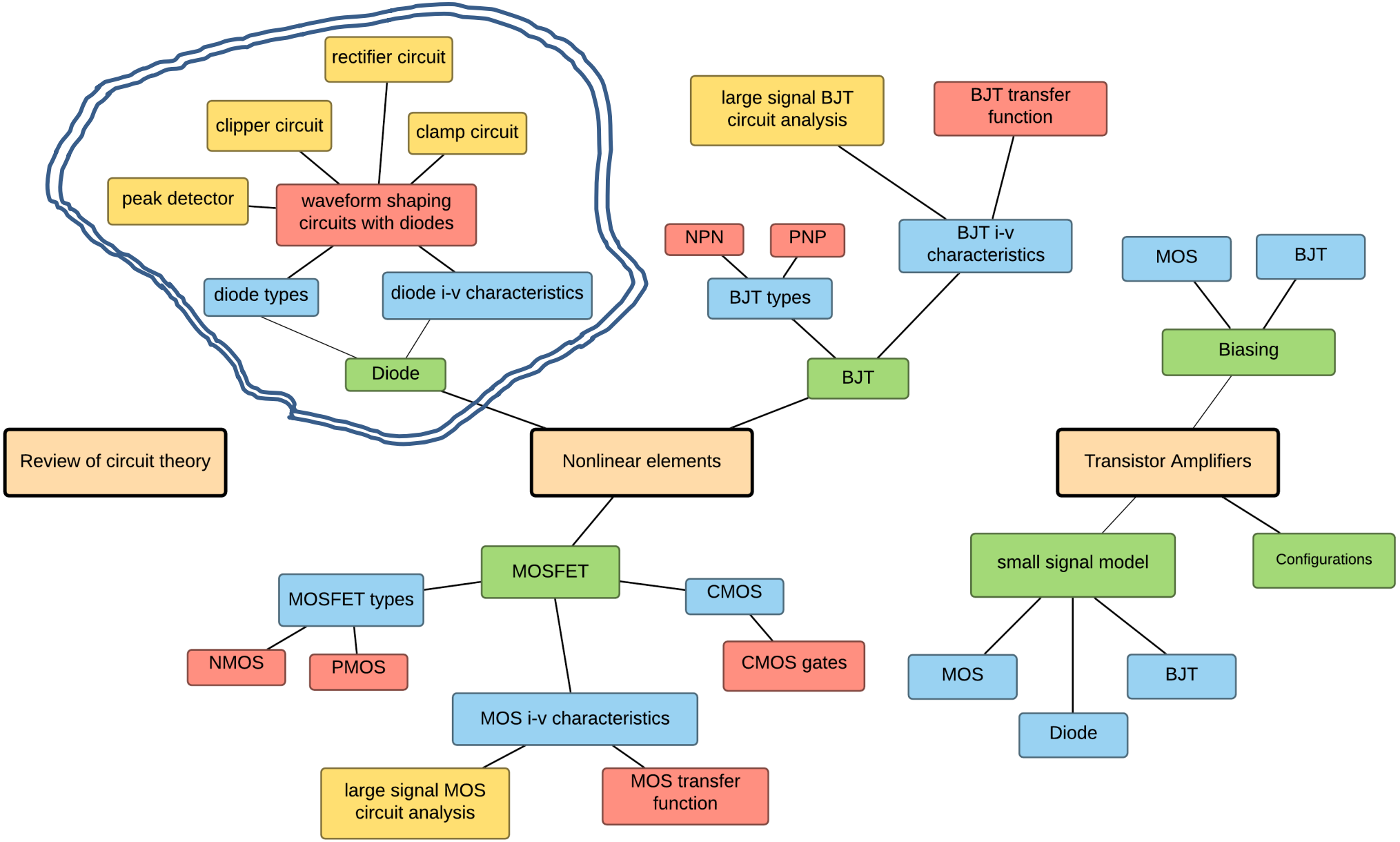
Reference notes: sections 2.1-2.8

Sedra & Smith (7th Ed): sections 4.3-4.4

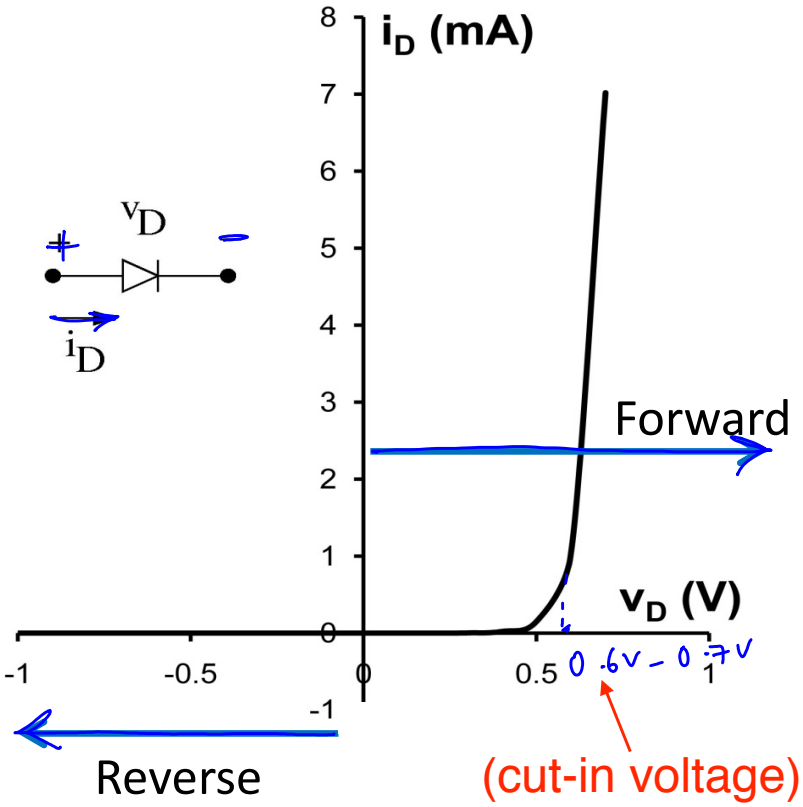
Saharnaz Baghdadchi

Course map

2. Diodes



The iv characteristics of a silicon junction diode



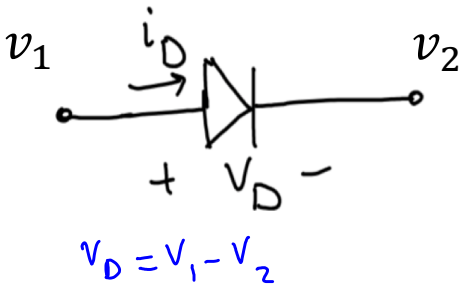
When the diode conducts, $i_D \gg I_S$ and:

$$i_D = I_S\, e^{v_D/V_T}$$

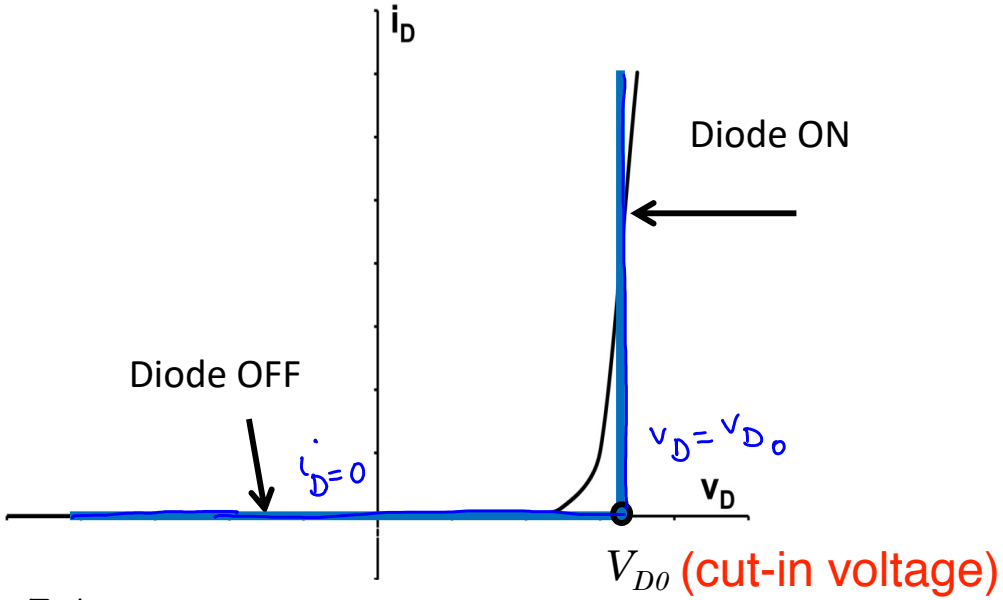
I_S : Saturation Current
(10^{-9} to 10^{-18} A)

V_T : Thermal voltage = 26mV at room temp.

Diode piecewise-linear model:



$V_D = V_1 - V_2$



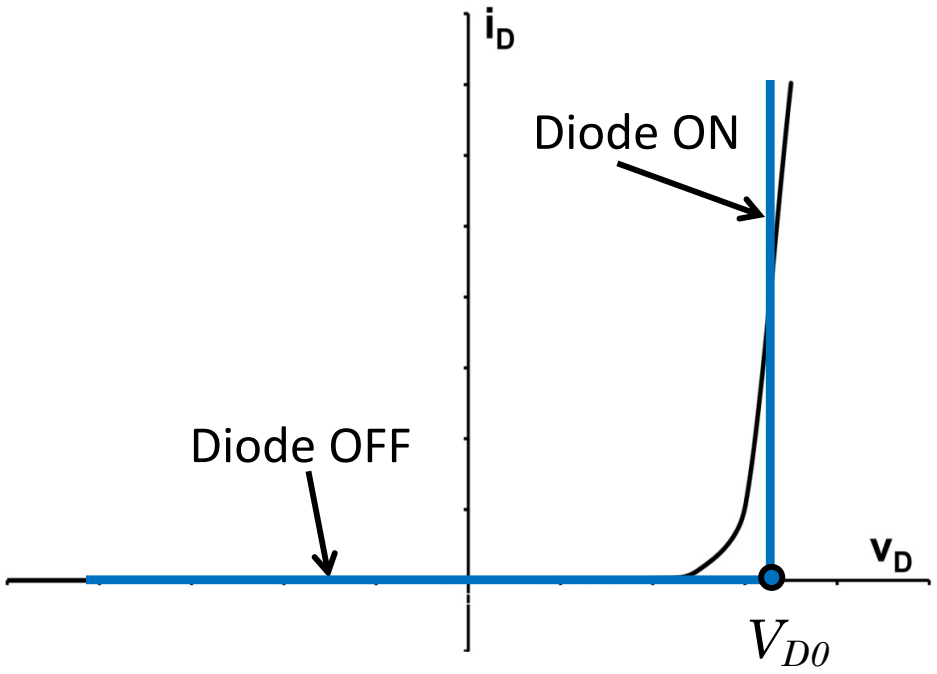
Assume Si Diode with $V_{D_0} = 0.7V$

(A) When $V_1 - V_2 < 0$ → diode is reverse-biased ⇒ $i_D = 0$

(B) When $0 < V_1 - V_2 < 0.7$ → diode is forward-biased, but it is not ON, yet ⇒ $i_D = 0$

(C) When $V_1 - V_2 = 0.7$ → diode is forward biased and it's ON ⇒ $i_D \geq 0$ & $V_D = V_{D_0} = 0.7$

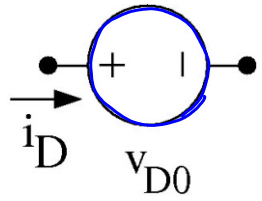
Diode piecewise-linear model:



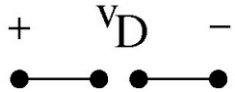
Constant Voltage drop Model:

Circuit Models:

ON:



OFF:

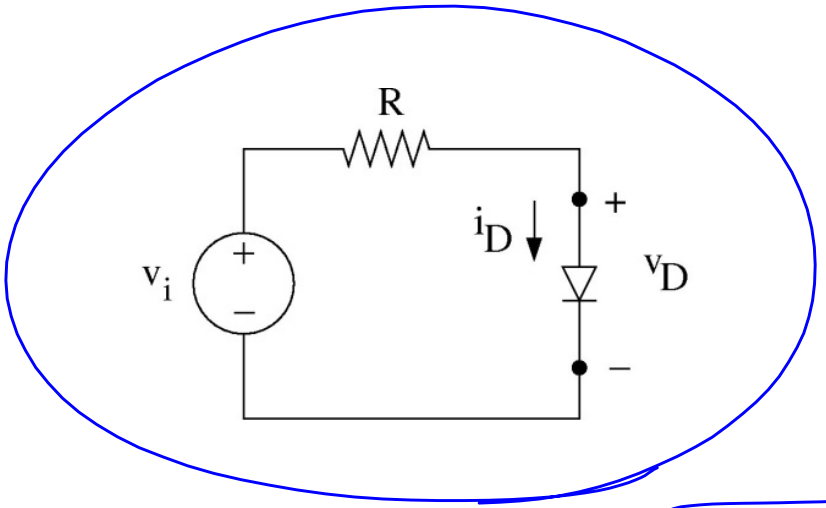


Diode ON: $v_D = V_{D0}$ and $i_D \geq 0$

Diode OFF: $i_D = 0$ and $v_D < V_{D0}$

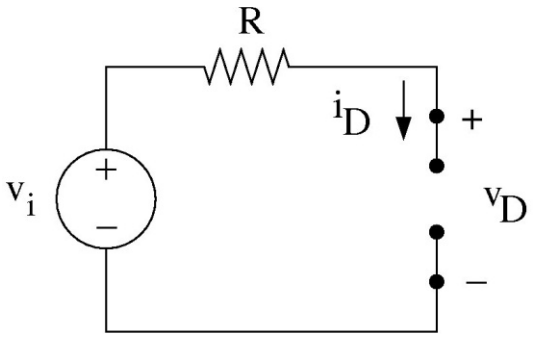
(cut-in voltage) $V_{D0} = 0.6 - 0.7\ V$ for Si

Diode circuit models:



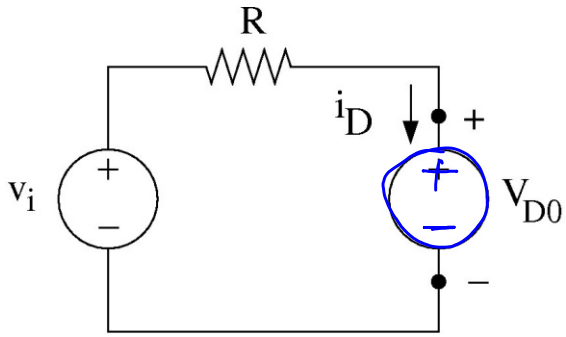
When Diode is OFF:

$i_D = 0$ and $v_D < V_{D0}$



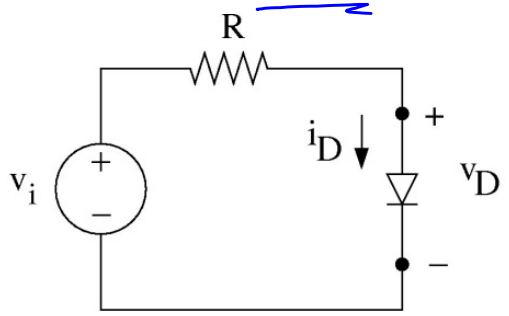
When Diode is ON:

$i_D \geq 0$ and $v_D = V_{D0}$



Example 1:

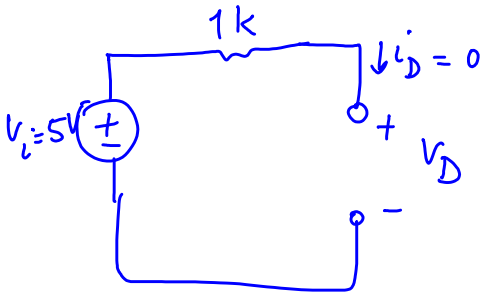
Find i_D and v_D for R = 1k, $V_i = 5$ V, and Si Diode ($V_{D0} = 0.7$ V).



Solution with diode circuit models:

Assume Diode is off

$i_D = 0$, $V_D < V_{D_0}$

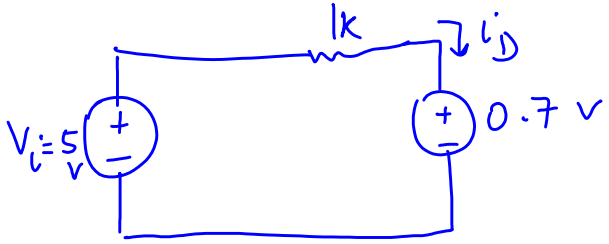


$V_i = 1k \times i_D + V_D$

$V_i = V_D = 5V > 0.7$ → Assumption was wrong.

Assume Diode is ON

$i_D \geq 0$, $V_D = V_{D_0}$



$V_i = 1k \times i_D + 0.7V$

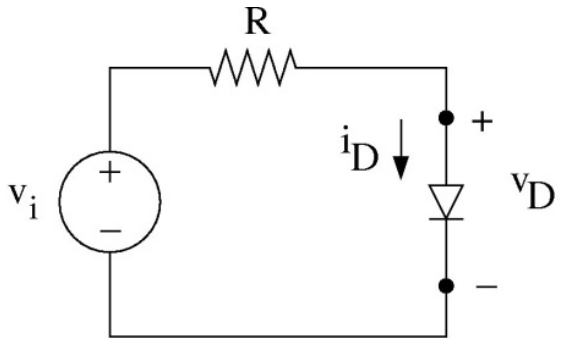
$\rightarrow i_D = \frac{5 - 0.7}{1k} = 4.3\,mA > 0$

The diode is ON.

Example 2 :

For what range of V_i the diode will be ON and for what range it will be OFF?

Find i_D and v_D for each range.



When diode is ON : $i_D \geq 0$, $V_D = V_{D_0}$

$V_i = R\, i_D + V_D = R\, i_D + 0.7$

$i_D = \dfrac{V_i - 0.7}{R} \geq 0 \longrightarrow V_i \geq 0.7\ V$

For $V_i \geq 0.7\ V$, diode is ON, $V_D = V_{D_0}$, $i_D \geq 0$

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when the diode is off : $i_D = 0$, $V_D < V_{D_0}$

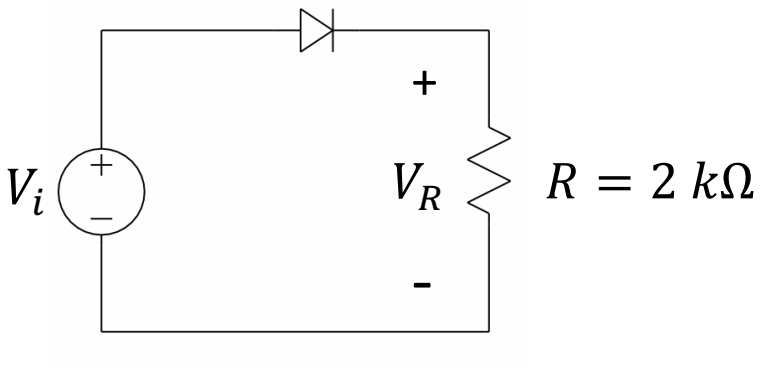
$V_i = R\, i_D + V_D \longrightarrow V_i = V_D$, $V_D < V_{D_0} \longrightarrow V_i < V_{D_0}$

For $V_i < V_{D_0}$, diode is off, $i_D = 0$, $V_D < V_{D_0}$

Lecture 4 reading quiz

In this diode circuit, what is the value of V_R for $V_i = 5\ V$ and $V_i = -5\ V$?

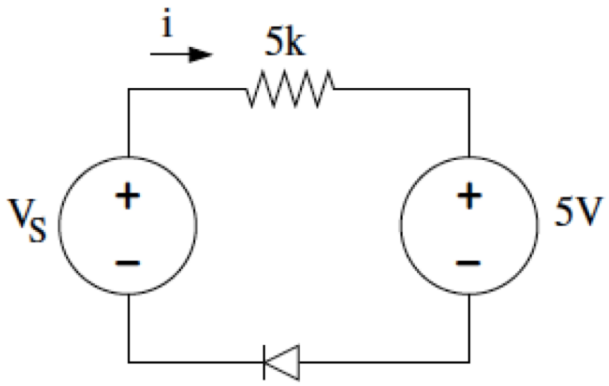
Assume $V_{D0} = 0.7\ V$



Clicker question 1.

For what range of v_s , will the diode in the following circuit be ON?

(Si diodes with $V_{D0} = 0.7\ V$)



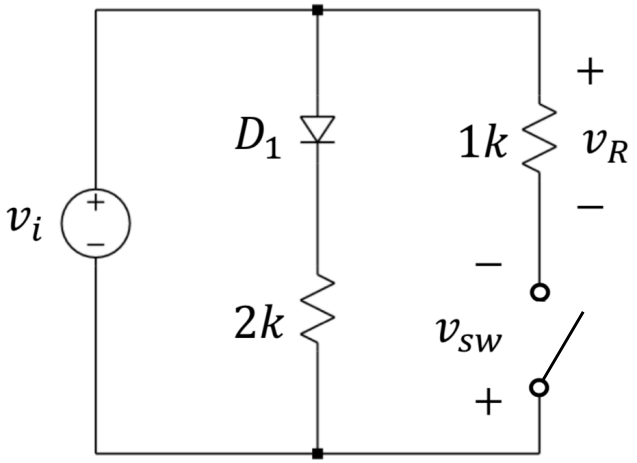
A. $v_s \geq 5\ V$

B. $v_s \geq 5.7\ V$

C. $v_s \geq 4.3\ V$

Clicker question 2.

In the below circuit, find v_{SW} and v_R when $v_i = 5\ V$.



A. $v_{SW} = 0\ V$ and $v_R = 0\ V$

B. $v_{SW} = 5\ V$ and $v_R = 0\ V$

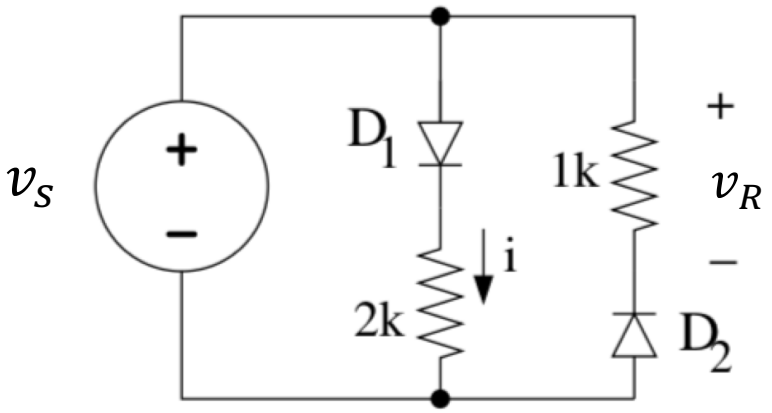
C. $v_{SW} = -5\ V$ and $v_R = 5\ V$

D. $v_{SW} = -5\ V$ and $v_R = 0V$

Clicker question 3.

Find v_R and i in the below circuit for $v_s = 3V$.

(Assume Si diodes with $V_{D0} = 0.7\ V$)



A. $v_R = 2.3\ V,\ \ i = 1.15\ mA$

B. $v_R = 0\ V,\quad i = 1.15\ mA$

C. $v_R = 0.6\ V,\ \ i = 0.3\ mA$

A. $v_R = -2.3\ V,\ \ i = 1.15\ mA$