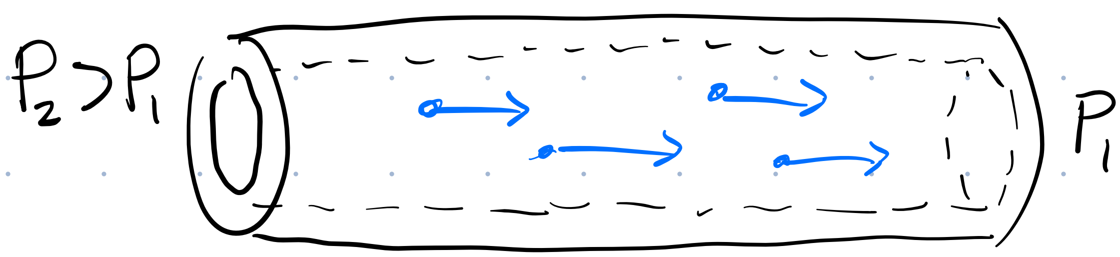
PHYS 231 Oct. 30, 2024

Assignment #4 on course website
due: Nov. 18 @ 13:00

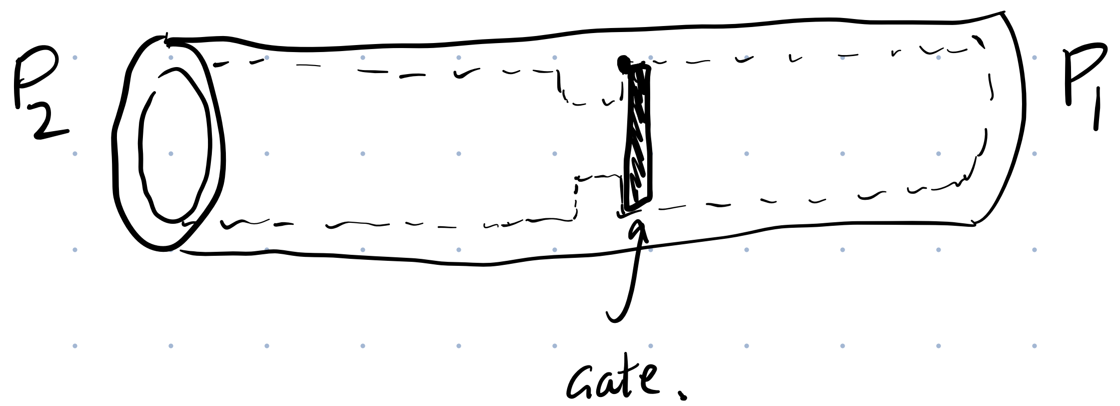
Today: Diodes & Rectifier Circuits

The diode is a semiconductor device that acts as a one-way valve ⇒ It passes current in one dir'n, but not the other.

Fluid analogy:



To flow fluid through a pipe, need to establish a pressure difference across pipe.
ΔP ⇒ drive flow of fluid.



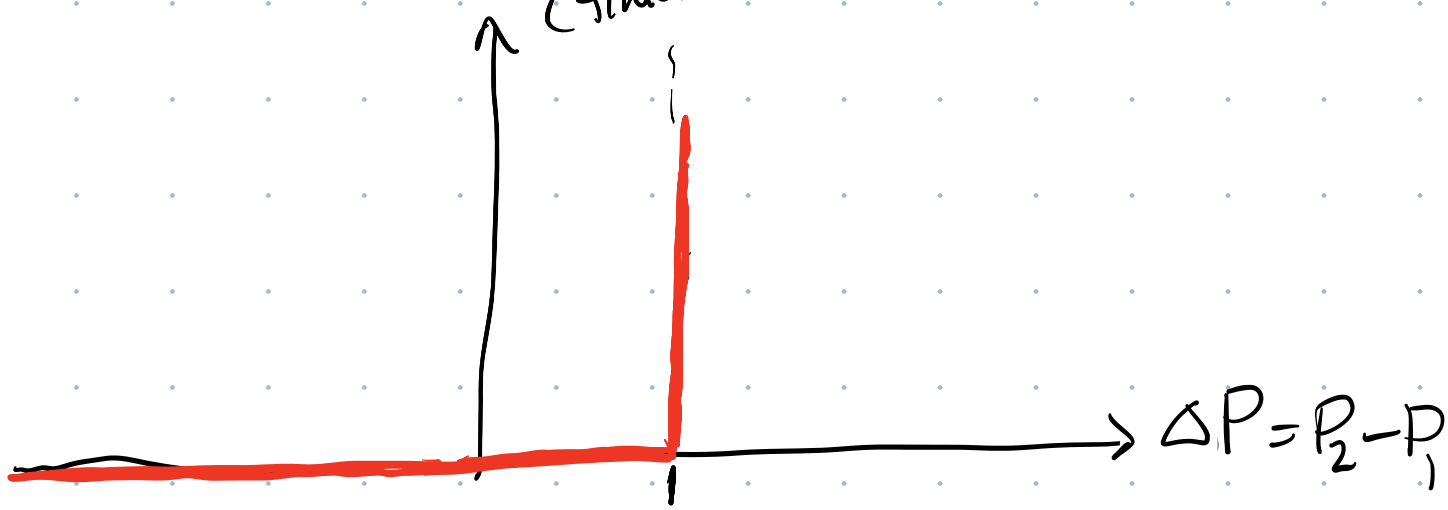
If $P_2 > P_1$, fluild flow left-to-right & gate is pushed open.

If $P_1 > P_2$, fluid tries to flow right to left, but gets block by gate

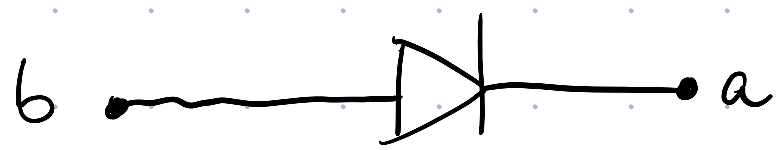
⇒ one way valve.

If $P_2 > P_1$, but by just a tiny amount, then we don't apply sufficient torque to open gate & fluid current will be zero.

Have to overcome a energy barrier to open gate & initiate the flow of fluid.



In electronics diodes act as a oneway valve of electric current.



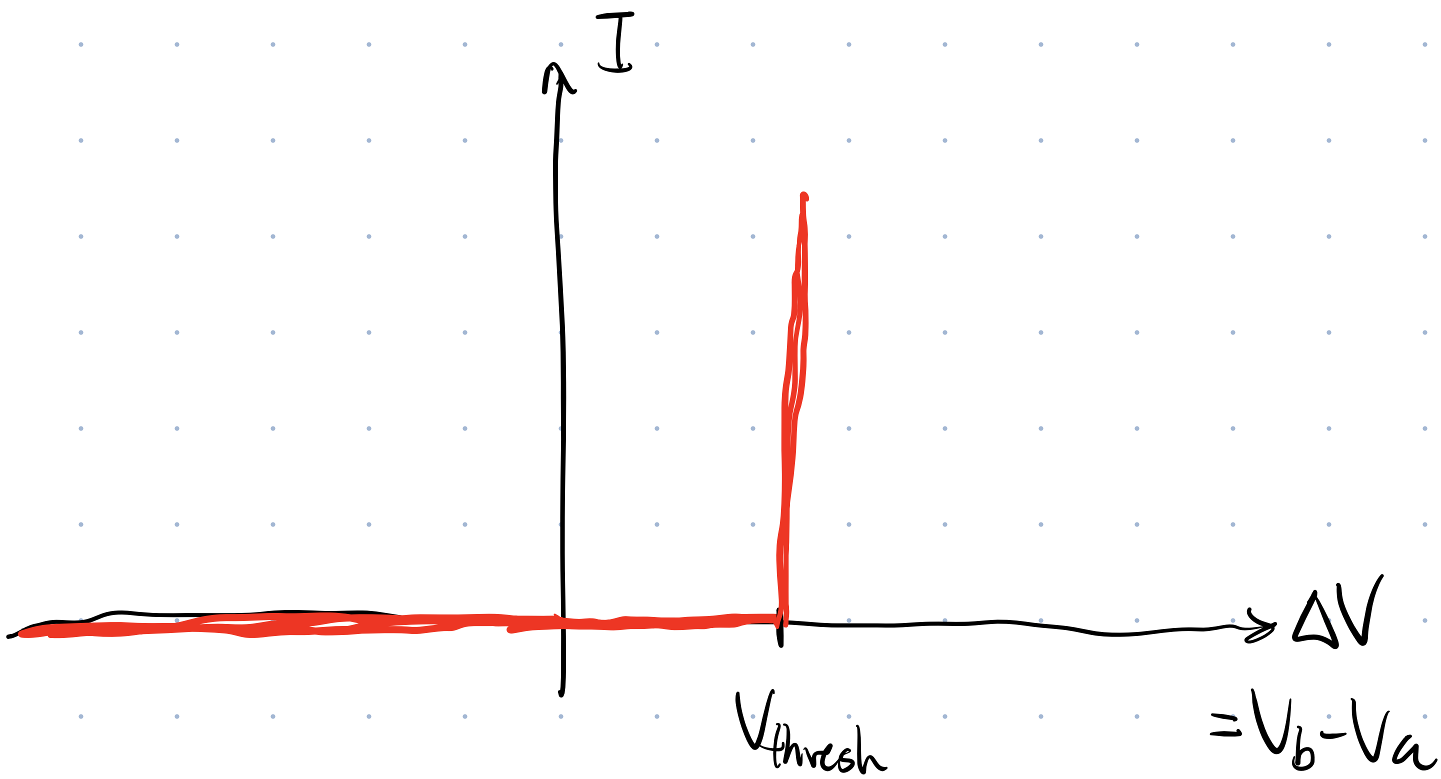
circuit symbol of diode

If $V_a > V_b$, then $I = 0$

If $V_b - V_a > V_{thersh}$, then $I \neq 0$

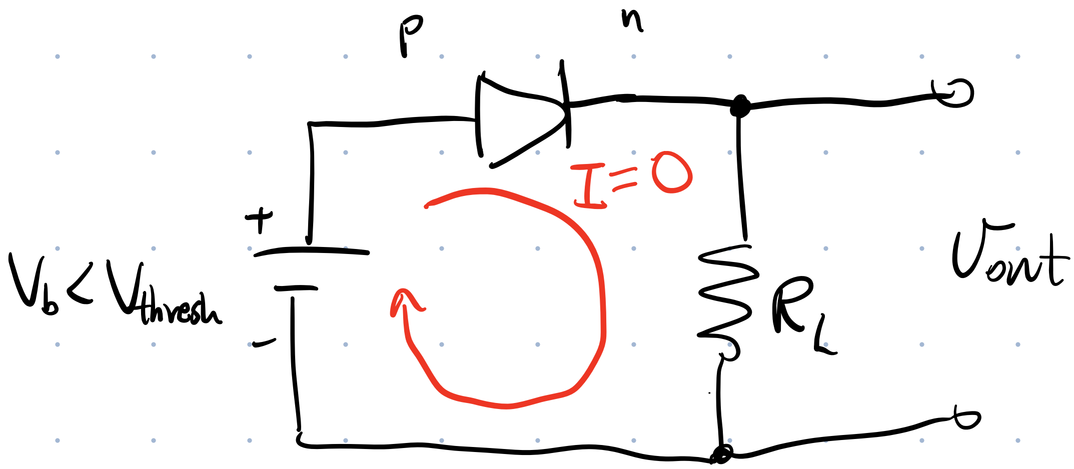
Require voltage of p-side to be greater than voltage on n-side by a least $V_{thresh} \simeq 0.7V$ for non-zero current.

Plot I-V charactistic

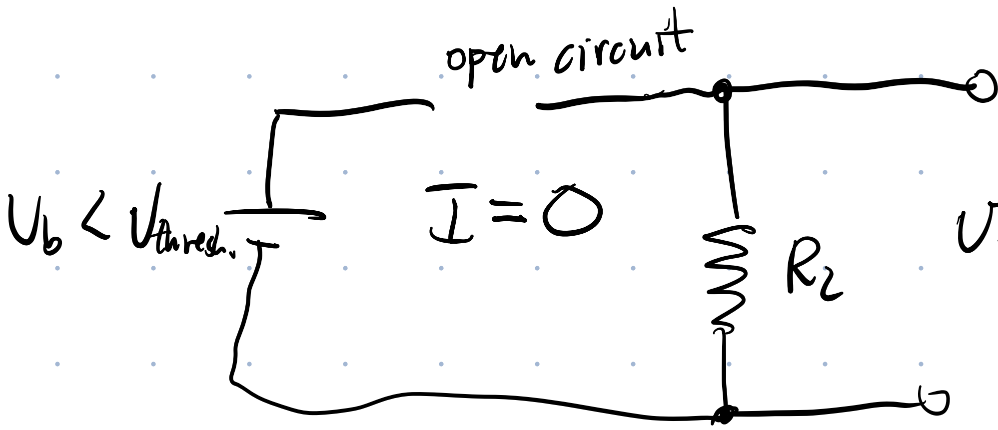


Reverse-biased diode

$V_b - V_a < V_{thresh.}$ (no current)



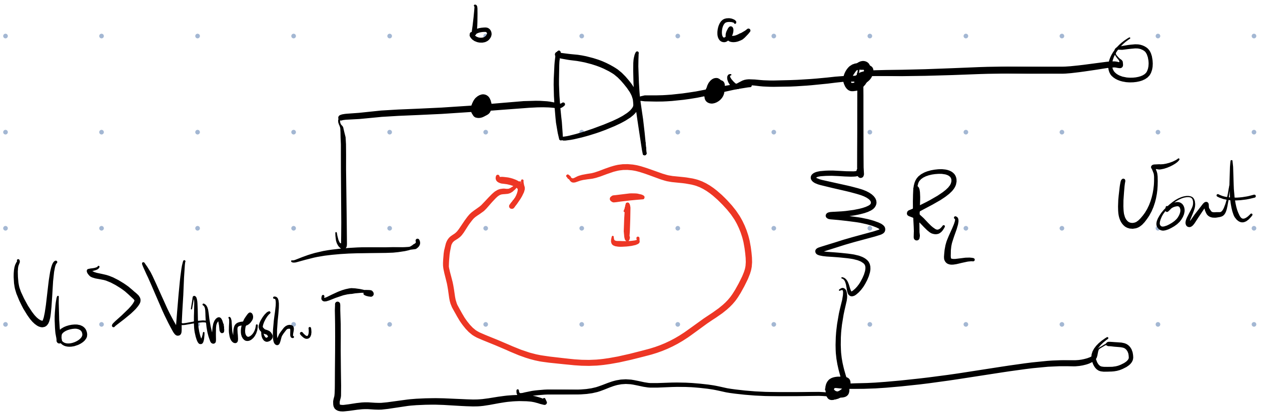
⇓ equiv. circuit



$V_{out} = \cancel{I} R_L = 0$ (I → 0)

A reverse-biased diode is equiv. to an open circuit.

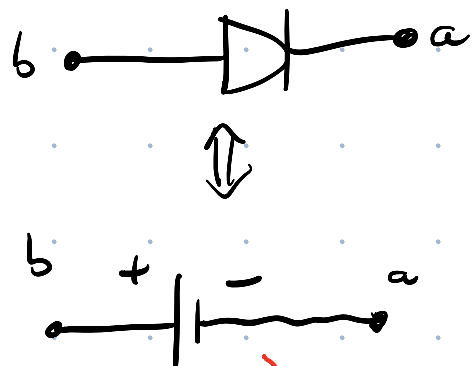
Forward Biased diode (diode is "on", $I \neq 0$)



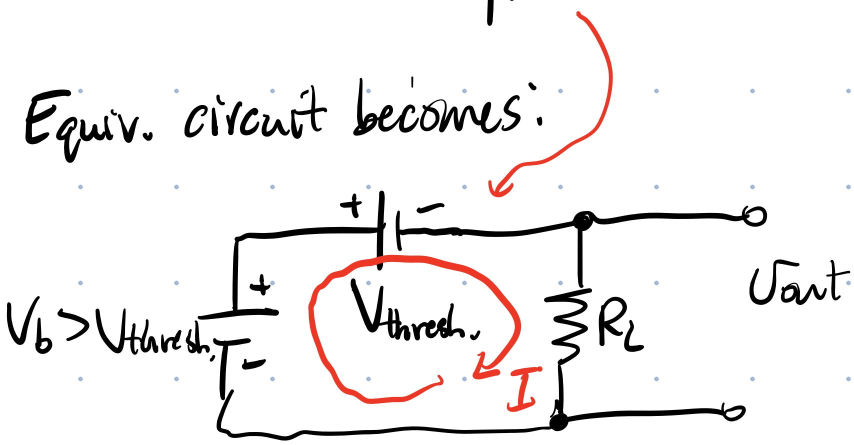
Know that a forward biased diode requires

$$V_b - V_a \approx V_{thresh.}$$

In this case, the foward-biased diode acts like a small battery



Equiv. circuit becomes:

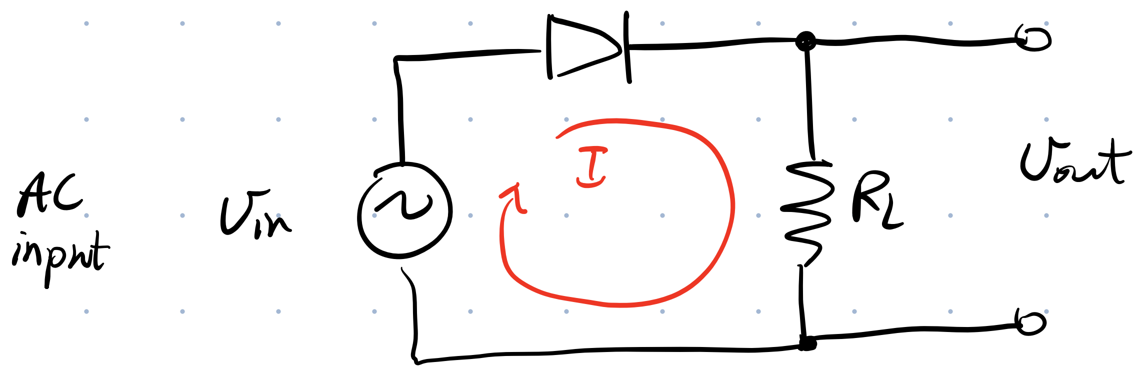


Loop analysis $V_b - V_{thresh.} - IR_L = 0$

$$\therefore \; I = \frac{V_b - V_{thresh}}{R_L}$$

$$V_{out} = IR_L = V_b - V_{thresh.}$$

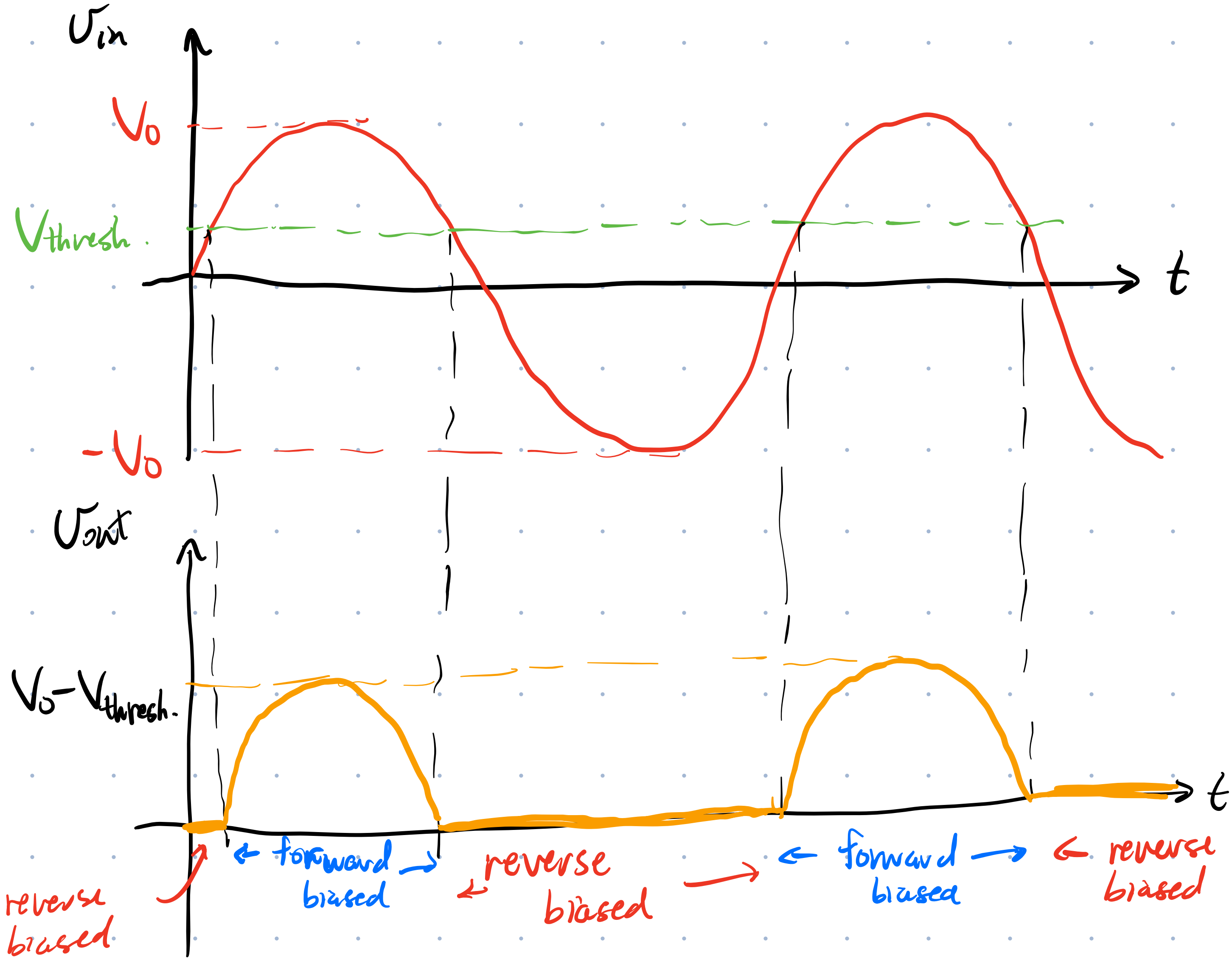
Rectifier Circuit (AC-to-DC converter)



If $v_{in} < V_{thresh.}$, $I = 0$, $v_{out} = 0$ reverse biased

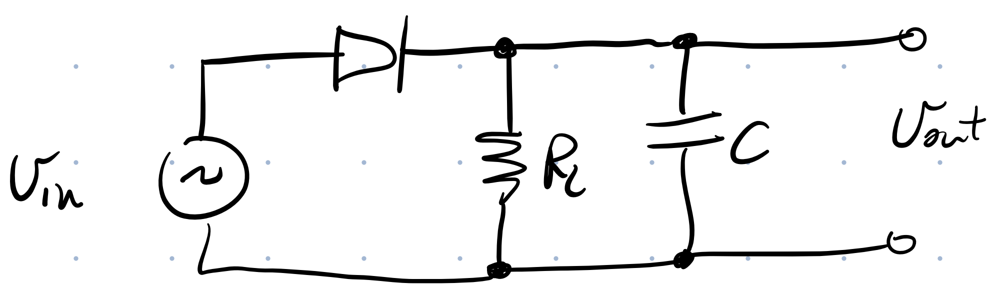
If $v_{in} > V_{thresh}$, $I \neq 0$, $v_{out} \neq 0$ forward biased.

$$v_{out} = v_{in} - V_{thresh}.$$

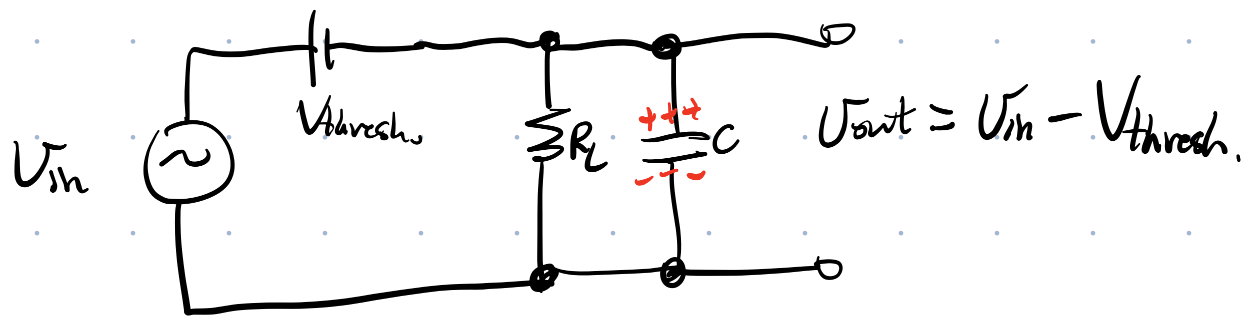


We've made some progress b/c while $\overline{v_{in}} = 0$, $\overline{v_{out}} \neq 0$ (some positive value)

To improve our AC-to-DC converter, put a cap. in parallel w/ R_L.

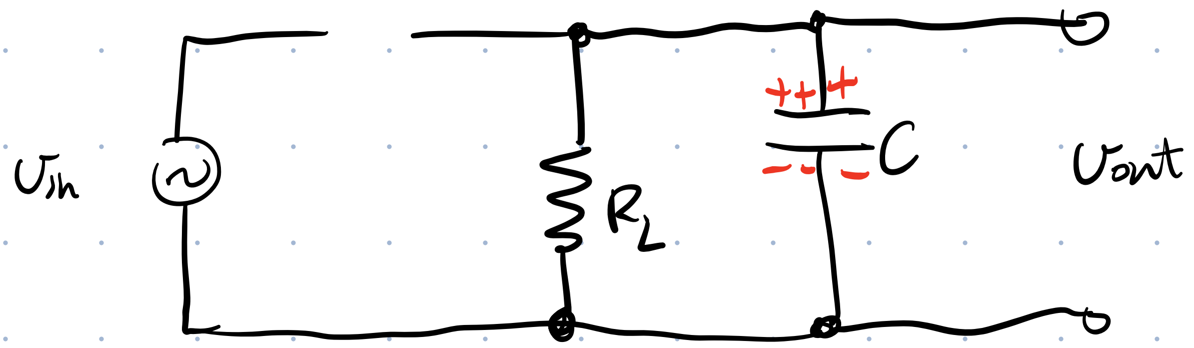


The forward biased case doesn't change, still find $U_{out} = U_{in} - V_{thresh}$.



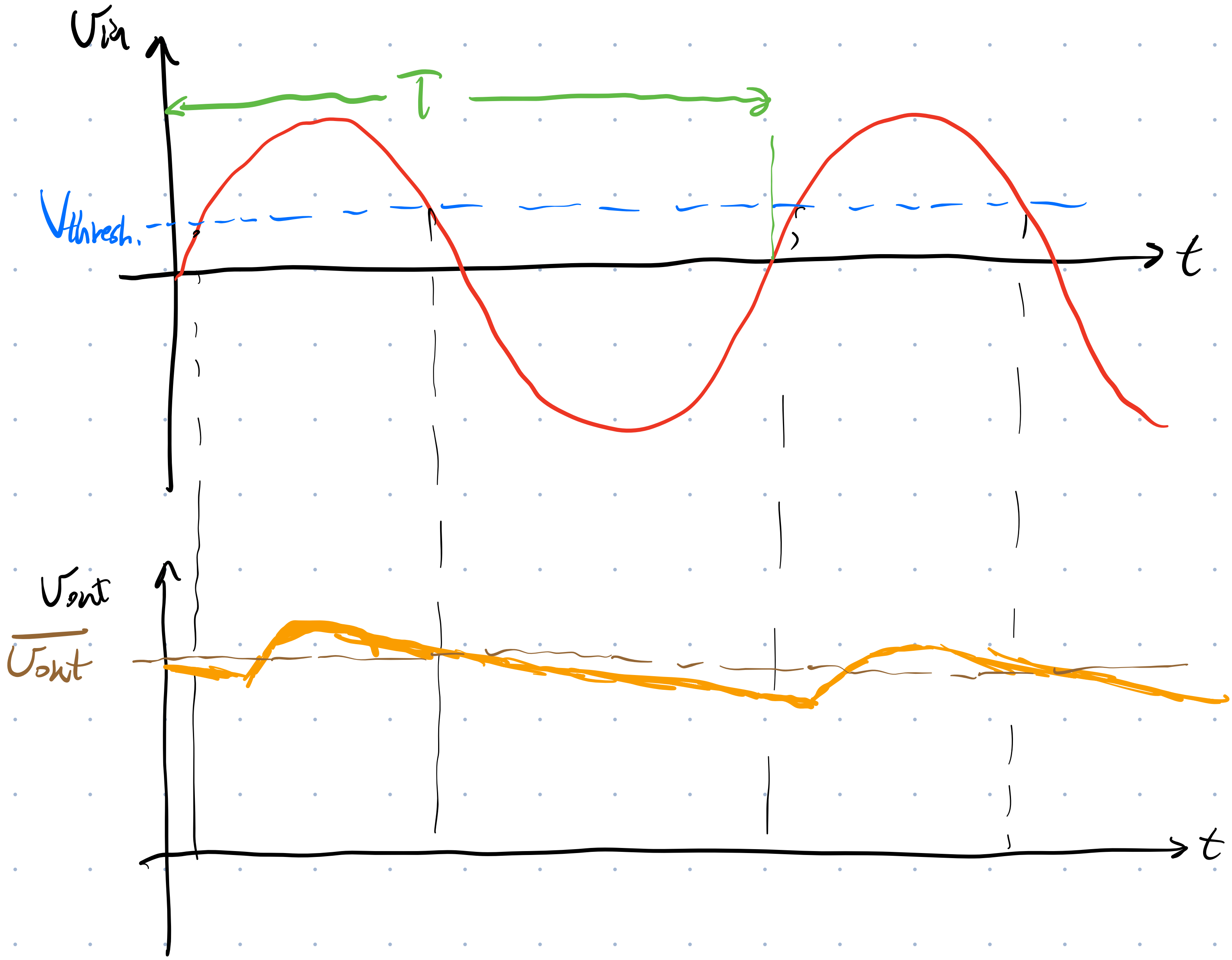
Cap. C charges to U_{out} while diode is forward biased ($I \neq 0$).

Reverse biased case



Now, the cap. C discharges through R_L with a time constant $\tau = R_L C$

Choose to make $\tau \gg T$ of U_{in}.



With the cap. in place, $\overline{V_{out}}$ increases & looks more like a constant DC voltage.