Lecture 17 - Diodes

Administrivia → Schedule for last two weeks

Monday: Finish Diodes

Wednesday:] Transistors
Friday

Next week

REVIEW & FINAL!

Project: (1) Try & finish this week

(2) Deadline: NEXT THURSDAY (08/11/05)

Requirements: (1) Get signed off by a TA (or me!)

(2) Report: Answer questions 1 & 3 in Project Guide on lab homepage

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Note: My OH this week & next will be in 140 Cory.

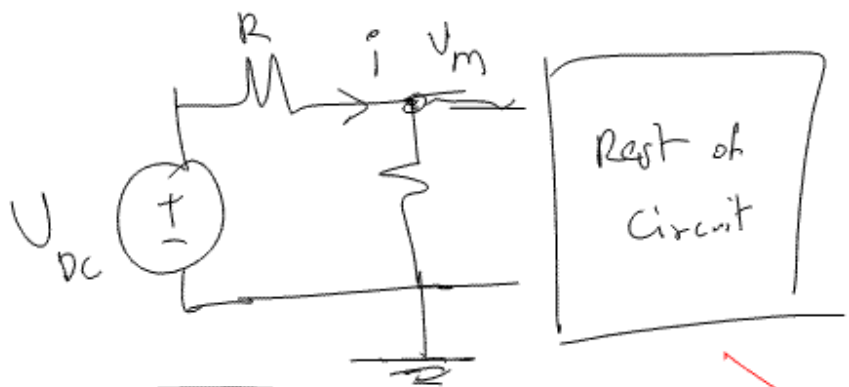
Announcement: Hmwk #4 average is $\approx 51/100$.

$\frac{1}{3}$ of class still can't do proper nodal analysis

↓

NOT GOOD FOR FINAL!

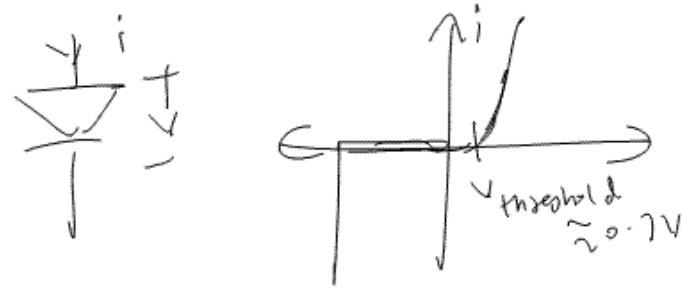
Example:



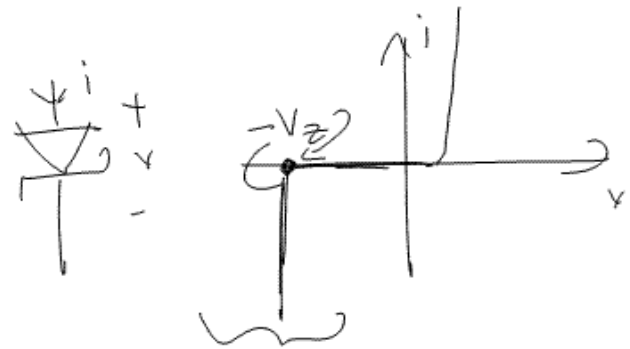
$$\boxed{i = \frac{V_{DC} - v_m}{R}}$$

NOT $\cancel{\frac{V_{DC}}{R} = i}$

Recall: Diodes



[Rectifier Diode]

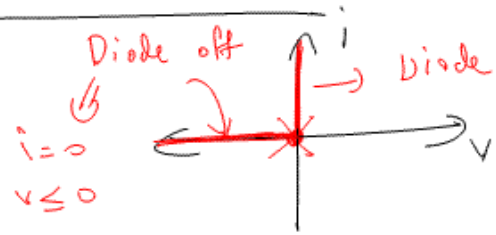


[Zener Diode]

Zeners run in breakdown

10.4 → Ideal Diode Model

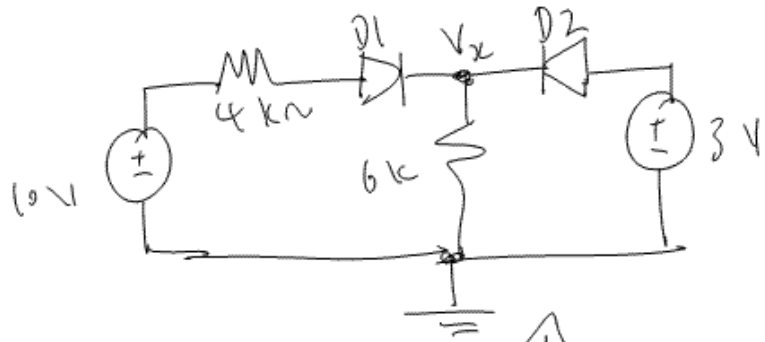
[Diode is modelled as an open circuit]



Diode on ⇒ $v = 0$, $i > 0$

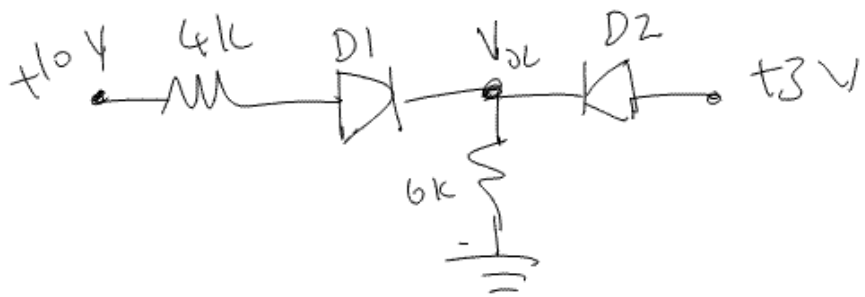
[diode is modelled as a short-circuit]

eg:



(Q:) Find V_x.
[assume diodes are ideal]

"short-hand" circuit

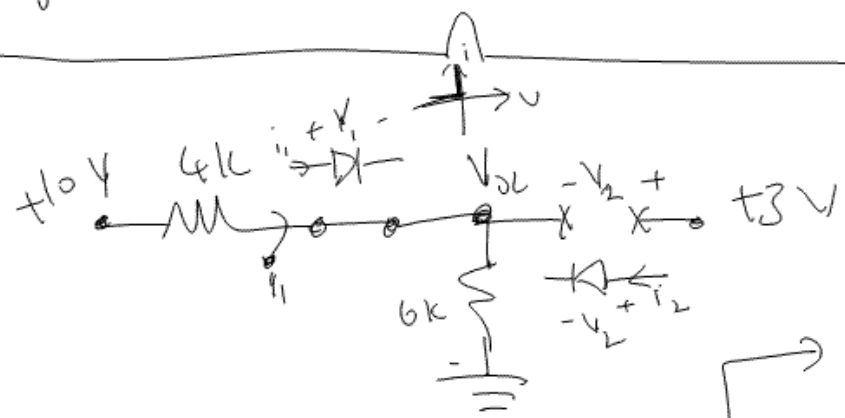


Steps: (1) Assume a state [on or off] for each diode in your circuit. If we have n diodes, 2^n states!
[Word of advice: MAKE AN EDUCATED GUESS!]

(2) Solve circuit. ⇒ find voltage across & current through each diode.

(3) Check assumptions for validity [ex: If a diode is off, $i_{diode} \simeq 0$]

(4) If results are consistent, you are done. If not, go back to Step 1 & try a different state!



(1) Guess: D1 on, D2 off

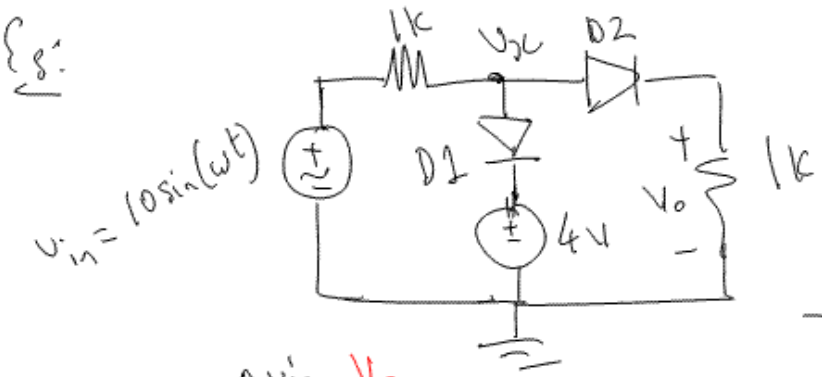
$\therefore V_x = 10 - 4\,V = \underline{\underline{6\,V}}$

$i_1 = \dfrac{10\,V}{4k + 6k} = \underline{\underline{1\,mA}}$

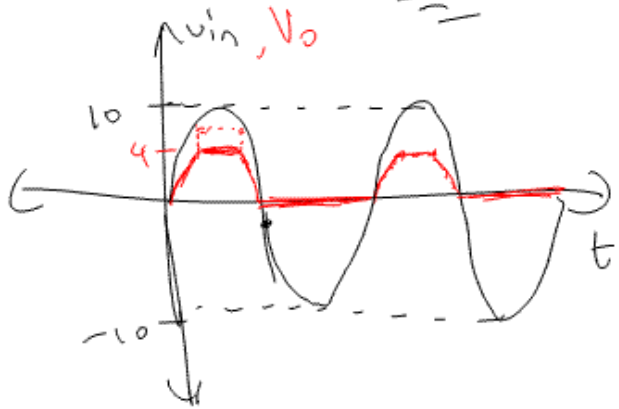
$\therefore V_2 = 3 - V_x = -3\,V < 0$

Hence, D1 is on & D2 is off ✓

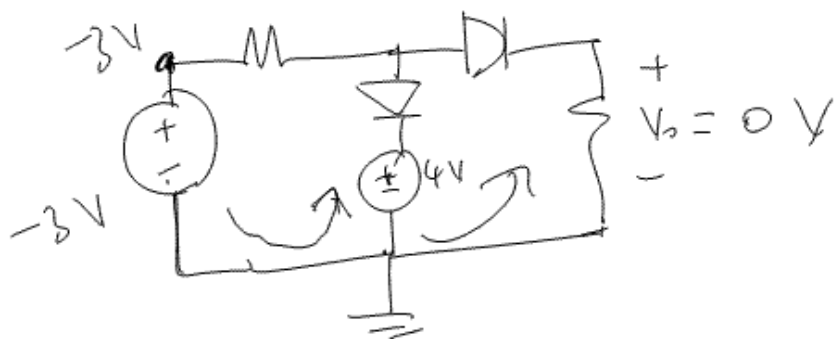
Eg:



Assuming D1 & D2 are ideal, sketch $V_o(t)$.



Notice when $V_{in} < 0$, D1 & D2 are off:



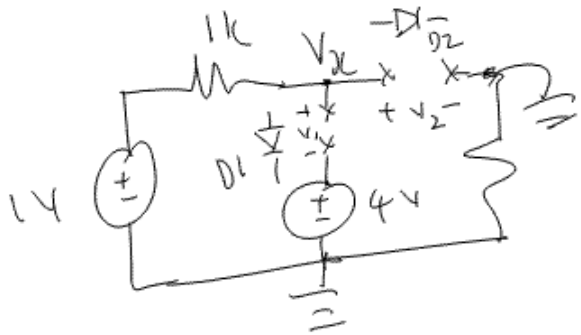
When $V_{in} > 0$, we have to be careful about D1!

(Q:) What value of V_x turns on D1?

A: $V_x = 4$ V

(Q:) For what V_{in} does D1 turn on?

(A:) V_{in} has to be at least 8 V! This is because D2 turns on before D1, i.e... if $V_{in} > 0$, D2 is on. We can check this:



Guess: D2 is off,
D1 is off

$\Rightarrow$ verify $V_2 < 0$, $V_1 < 0$.

$V_1 = V_x - 4 = 1 - 4 = -3$ ✓

$V_2 = V_x = 1V$ ✗ oops! $\Rightarrow$ turn D2 on, D1 off] check

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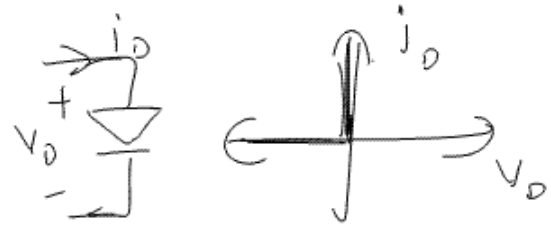
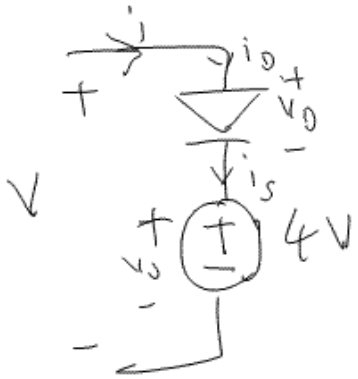
(Q:) How do you know D2 turns on before D1?

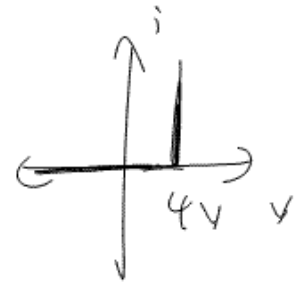
One way:



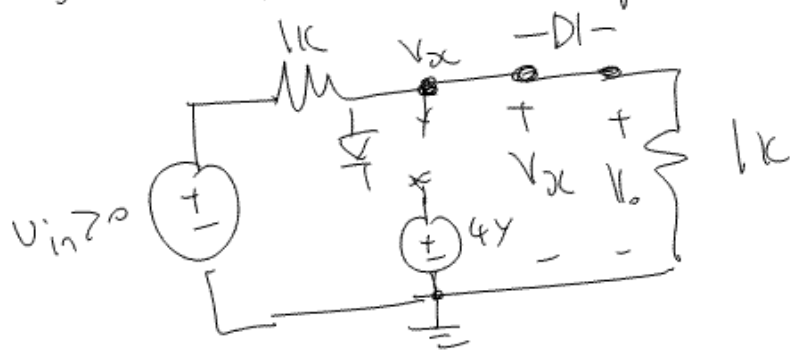
A: Experience!



$V = V_D + 4 \quad i = i_D$



Therefore, D2 turns on before D1:



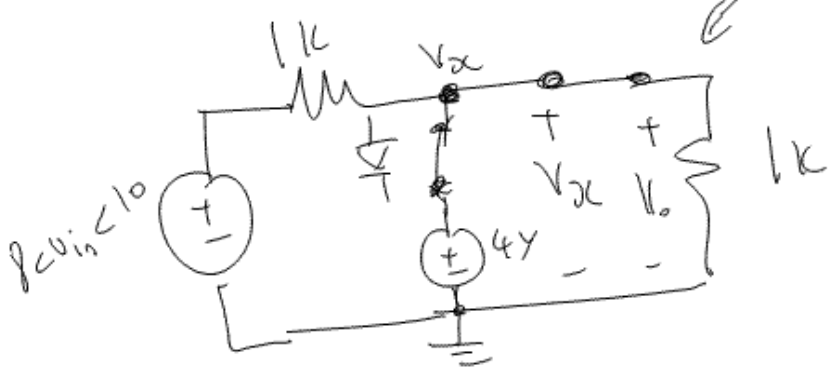
$V_x = \frac{1}{2} V_{in}$

[voltage divider]

$\therefore$ V_{in} has to be at least 8 V before D1 turns on!

∴ To sketch V_o: (1) $0 < v_{in} \le 8$ V $\Rightarrow V_o = V_x = \frac{1}{2} v_{in}$

(2) $8 < v_{in} \le 10$ V $\Rightarrow V_o = 4$ V



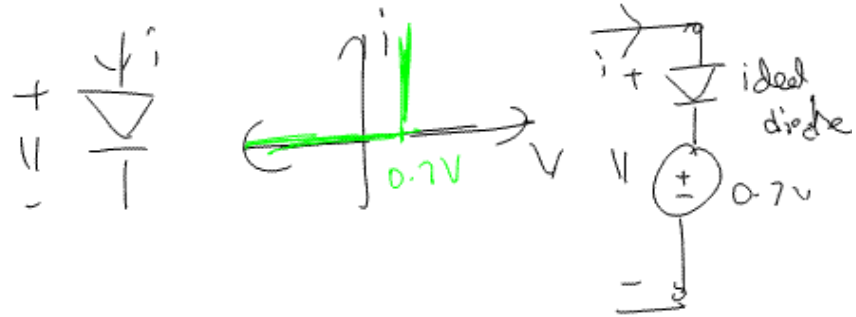
(Qi.) more difficult diode problems: Fall 04, H-wks 10 & 11.

Solutions → should be in Sp05 problem sets (H-wks 10 & 11).

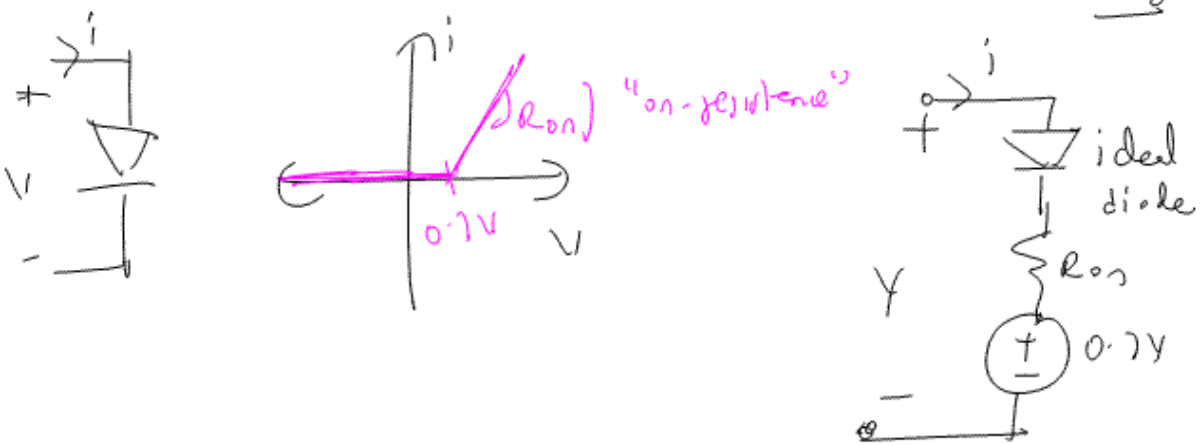
Ask us in OH for solutions.

Piecewise linear model(s):

(1)



(2)

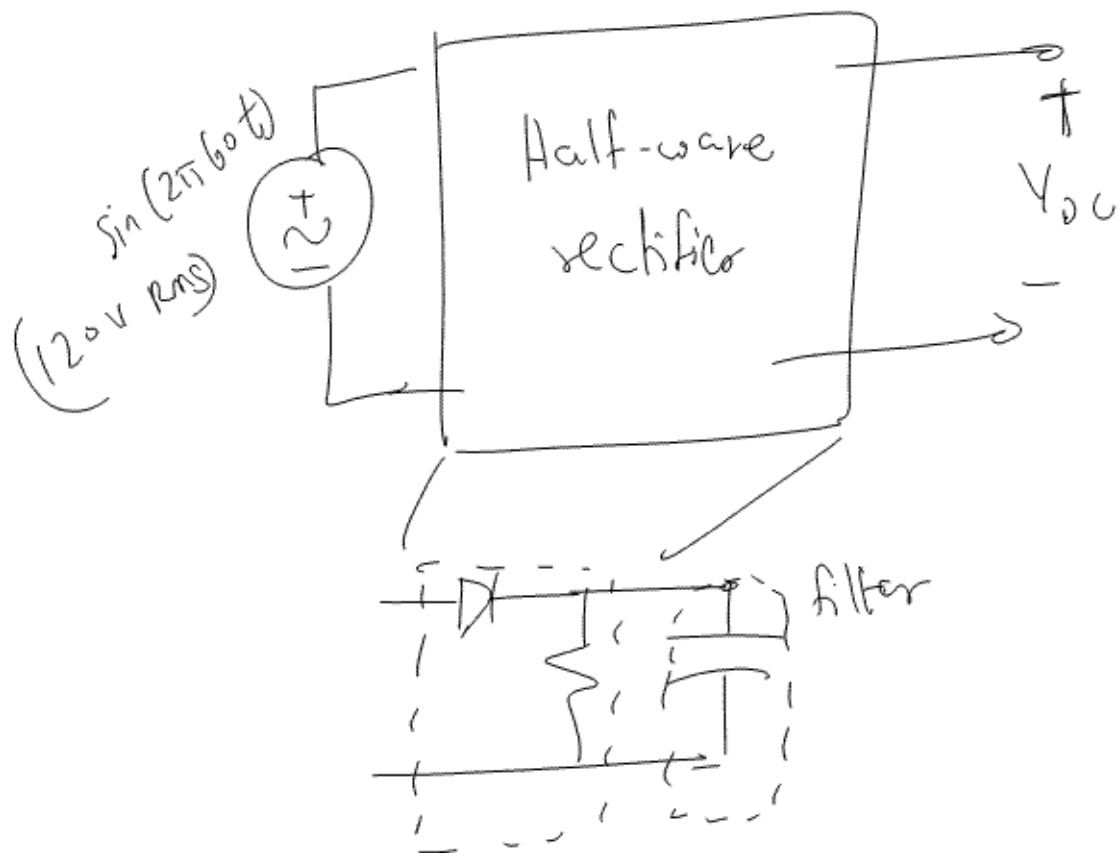


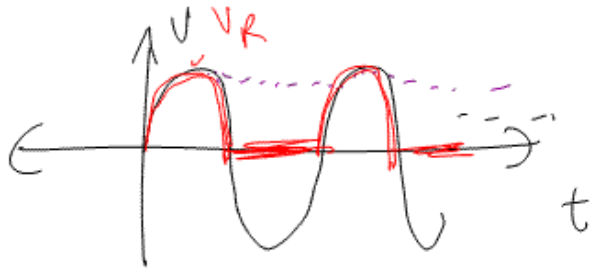
maybe on HW, don't worry about piece-wise linear model for your final.

Diode applications

(1) Rectification → converting AC to DC

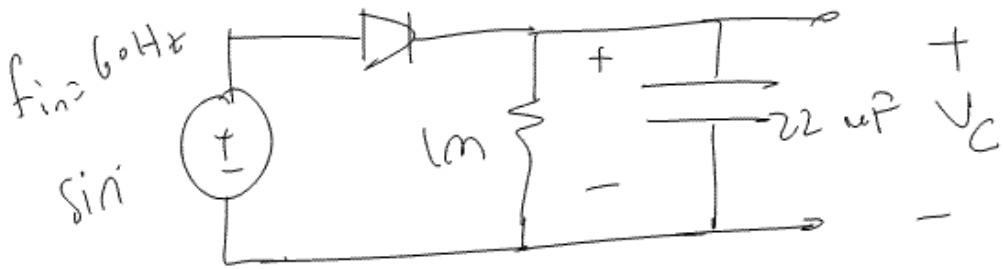
you will build a half-wave rectifier in lab tomorrow & thursday.

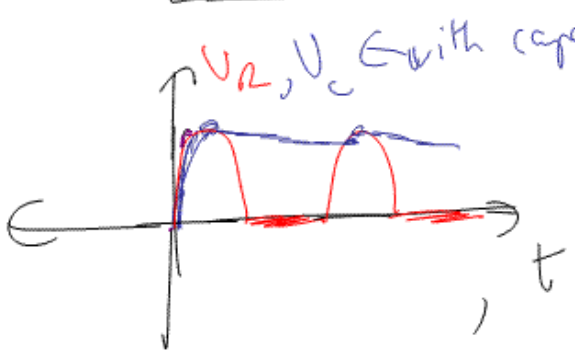




HUGE (in lab ≈ 1 m)

(2) We put a big capacitor (in lab 22 μF) at V_R:

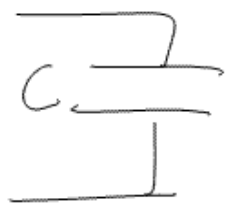




$\tau = RC = 22$ seconds.

This circuit is an example of using capacitors as filters!

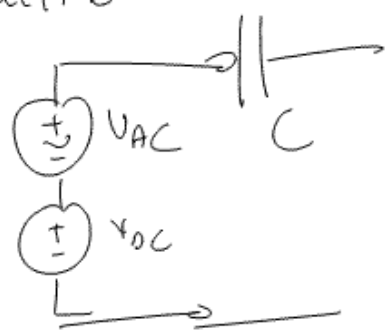
<u>Mathematically:</u>



$$Z_C = \frac{1}{j\omega C}$$

(1) Coupling capacitors is another example. You use these capacitors to eliminate DC.

<u>ex:</u>



$$Z_C = \frac{1}{j\omega C}$$

$\omega_{AC} = 2\pi 60$

$\omega_{DC} = 0$ rad/sec $\Rightarrow |Z_C| \to \infty$

So, the cap gets charged to the DC value, but you want to let the AC signal through

$$|Z_C| \approx 0. \qquad Z_C = \frac{1}{j(2\pi 60)\cdot\left(\frac{1}{2\pi 60}\right)}$$

C_{AC} value.

Finish diodes on Wednesday!