8/9/10

1.4 \cdot \sin(\omega t) \quad R \quad V_{in} \quad V_{out}

E1)

Load line for \( V_{in} = 0.7V \)

E2) w/ simple model:

ON \& V_{in} > 0.5V
OFF \& V_{in} < 0.5V

See webcast for details or email me and I'll write it up.
E3) 

For this problem, 

\[ V_K = 0.7 \text{V}. \]

**Guess 1:** Both off

\[ V_{4K} = 0 \text{V} \quad \text{since} \quad i_{5K} = 0. \]

This means \( V_{D1} = 10 \text{V} \). But this is a contradiction with our guess.

**Guess 2:** D1 off, D2 on

By similar argument, \( i_{4K} = 0 \), so \( V_{D2} = 10 - 2.4 \text{V} = 6.6 \text{V} \) - contradiction!

**Guess 3:** D1 on, D2 off

Many ways to solve!

\[ V_m = 0.98 \text{mA} \times 5k \times 10k = 4.65 \text{V} \]

Guess worked, so we can stop.

\[ V_{D2} = 3 - 4.65 \text{V} < 0.7 \text{V} \]
But since we're learning, let's do the last one:

\[ I_2 = 0.7V \]
\[ V_{ab} = 0.7V \]
\[ I_1 > 20A \]
\[ 10 > 20A \]

\[ V_p = 2.3V + 0.7V = 3V \]

\[ I_m = \frac{V_p}{5k} \]

\[ I_2 + I_m = I_n \]
\[ I_2 = I_n - I_m \]

\[ 2.3V - 7V \]

Negative, so contradiction.

Let's continue discussing our AC circuit. Let's see what happens if we add a capacitor in parallel with our output resistor.

\[ V_K = 0.7V \]

Assume \( A \gg V_K \)

\[ V = 0.5V \]

Valid if \( V < A \) (sin)
There are 2 possible configurations.

**ON:**

\[ V_{on} \]
\[ R \]
\[ C \]
\[ V_c = V_{in} - 0.7V \]

Require that:
\[ i_d \geq 0 \] or \[ b \]
\[ V_c < \frac{V_{in} - 0.7}{R} \]
\[ C \cdot \frac{d(V_{in} - 0.7)}{dt} + \frac{V_{in} - 0.7}{R} = 0 \]

\[ \frac{dV_n}{dt} \]
\[ \frac{RC}{R} \]
\[ V_c = V_{in} - 0.7V \]

**OFF:**

\[ V_c = A \sin(\omega t) - 0.7V \]

Require that:
\[ V < V_{in} \]
\[ A \sin(\omega t) \]
\[ V_{in} - 0.7 \]
\[ e^{-\frac{t}{RC}} \]

\[ V_{in} \]
\[ V(t) \]
\[ V_{in}(t) = 0.7V \]

We see: In between \( V_1 \) and \( V_2 \), LHS is getting smaller and RHS is getting larger.

At \( V_1 \),
\[ \frac{dV_n}{dt} = 0, \quad V_{in} = A \] so:
\[ 0 > 0.7 - A \]
\[ \frac{RC}{RC} \]

Yes, since 457.7.

At \( V_2 \),
\[ \frac{dV_n}{dt} < 0, \quad V_{in} = 0 \] so:
\[ negative \quad number \]
\[ 0.7 \]
\[ \frac{RC}{RC} \]

No!

Since ON at \( V_1 \) and OFF at \( V_2 \), we know it must switch to OFF at some \( V_3 \).
Between $t_3$ and $t_5$, diode cannot turn off. This would violate the principle that capacitor voltage cannot change instantly.

At $t_5$, diode cannot remain OFF, since this condition requires that $V_c > A\sin(\omega t) - 0.7V$ and if it stayed OFF it would decay below $A\sin(\omega t) - 0.7V$ which is increasing.

Thus from $t_5$ to $t_2 + T$, diode is on, and the cycle repeats itself.

Thus it looks like:

![Voltage waveform](image)

What happens if $V_c = 0$ and we start at $V_n = 0.7V$?

![Voltage waveform](image)
What happens as $C$ gets very small?

Same as before?

What happens if $C$ gets very large?

Limit as $C \to \infty$?

Half-wave rectifier:

"Rectifies" AC source to DC.
- on rising: AC restores capacitor
- on falling: AC is ignored.

Full-wave rectifier

Can also use as an envelope detector!
Assume $V_{in} \gg V_k$.

When $V_{in} > 0$,

\[
V_R = V_{in} - 2V_k \quad \text{or} \quad V_R \approx V_{in}
\]

for small $V_k$.

When $V_{in} < 0$:

\[
R_L = -(V_{in} - 2V_k) \quad \text{or} \quad \text{for small } V_k, \quad R_L \approx -V_{in}
\]

So $R_L \approx |V_{in}|$

Capacitor trick still works too.

Voltage Boost.