Last Class:  - Phasors
           - Step RC Circuits

Today:   - Electrical Safety

\[ Z_1 = \frac{1}{j\omega C_1} \quad Z_2 = R_2 + \frac{1}{j\omega C_2} \]

\[ H(\omega) = \frac{V_o}{V_i} = \frac{Z_2}{Z_1 + Z_2} = \frac{(R_2 + \frac{1}{j\omega C_2})}{(R_2 + \frac{1}{j\omega C_2} + \frac{1}{j\omega C_1})} \left( \frac{j\omega C_2}{j\omega C_1} \right) \]

\[ H(\omega) = \frac{j\omega C_2 R_2 + 1}{j\omega C_2 R_2 + 1 + \frac{C_2}{C_1}} \]

\[ \lim_{\omega \to 0} H(\omega) = \frac{1}{1 + \frac{C_2}{C_1}} \]

\[ H(\omega) = \frac{jC_2 R_2 + \frac{1}{\omega}}{jC_2 R_2 + \frac{1 + C_2}{\omega}} \]

\[ \lim_{\omega \to \infty} H(\omega) = 1 \]
Rise and Fall Times

At equilibrium, \( C = \text{open circuit} \)

At transition, \( C = \text{Battery} \)

Transition Exp:
\[ \tau = RC = 1k \Omega \times 2 \mu F = 2 \text{ms} \]

\[ V_{S} - V_{\infty} = (V_{i} - V_{\infty}) e^{-t/\tau} \]

\[ V_{f} = -10V + (10 - (-10)) e^{-1 \text{ms}/2 \text{ms}} \]

\[ = -10V + 20V e^{-1/2} = 2.13V \]

Circuit A
- Eventually: \( V_{o} = V_{i} \) (after change)
- Responds slowly to changes
V_{i} = \text{response to change} = V_{\text{after}} - V_{\text{before}} = -10 - (+10) = -20 \text{V}

V_f = 0 + (-20 - 0) e^{-k_2} = -12.13 \text{V}

\text{Circuit B:}
- Eventually \quad V_o = 0
- \text{responds immediately to change}
Electrical Safety

Biopotential Notes online (just some highlights here)

Activation of a neuron
Body produces electricity via Na & K.
Neuron only conducts in one direction & rests for a few ms.

ECG The heart is an electrical body part.
Einthouven's limb leads → Not used anymore.

EMG - Skeletal muscles (Voluntary via nerve.
  - Smooth muscles (Slow response, involuntary)
  - Cardiac muscles (Fast response, low fatigue)

Anatomy of muscles

Muscle activation → Motor neurons
  → 1 motor neuron → 10s of thousands of muscle fibres.

Know: • Motor unit vs muscle fibres
  • Spatial vs temporal recruitment
ECG vs EMG why graphs look diff.

IE. Structured vs Chaotic

\( \rightarrow \) Heart has to work in a coordinated way.

\( \rightarrow \) All muscle fibres are aligned in the same way and do not need to work in a coordinated way.

Increasing current affects the body (look at slides)

\( \rightarrow \) 1mA \( \rightarrow \) start sensing

\( \rightarrow \) Let go current \( \rightarrow \) the threshold current where you would not be able to let go of a wire.

Q1 Threshold of perception: You notice it

Diff bw fib & full contr: why? One is taking out the rhythm \( \rightarrow \) the other heart stops

Macrose shock & Microshock

Optocoupler isolation \( \rightarrow \) move next lecture.