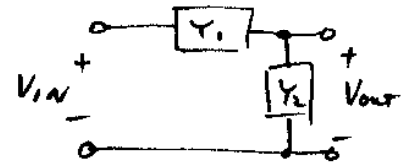
EC200 M.E. #9 NAME: CM.

① Design a passive circuit (no opamps) based on a single capacitor of size 10nF (& resistors as needed) that implements $H(s) = \frac{s+4{,}000}{s+10{,}000}$.

* Start with voltage divider expressed as admittances:



$$H(s) = \frac{Y_1}{Y_1 + Y_2}$$

* Choose parallel RC for Y_1, which then requires a resistor for Y_2:

$$H(s) = \frac{C_1 s + \frac{1}{R_1}}{\left(C_1 s + \frac{1}{R_1}\right) + \frac{1}{R_2}}$$

* Match terms to specified function after converting to same form:

$$H(s) = \frac{C_1 s + \frac{1}{R_1}}{C_1 s + \frac{1}{R_1} + \frac{1}{R_2}} = \frac{s + \frac{1}{R_1 C_1}}{s + \left(\frac{1}{R_1 C_1} + \frac{1}{R_2 C_1}\right)} = \frac{s + 4{,}000}{s + 10{,}000}$$

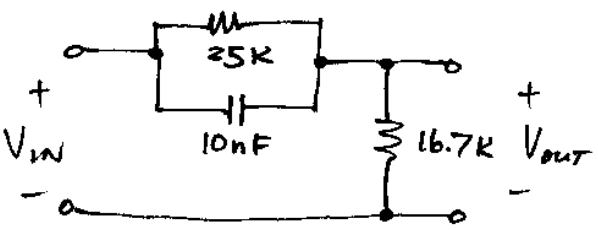
$$\Rightarrow \quad \frac{1}{R_1 C_1} = 4000 \quad \& \quad \frac{1}{R_1 C_1} + \frac{1}{R_2 C_1} = 10{,}000$$

* Choose component values (C1 already specified as 10nF):

$$R_1 = \frac{1}{4000\, C_1} = \frac{1}{(4000)(10E\text{-}9)} = 25K$$

$$R_2 = \left[\underbrace{\left(10{,}000 - \frac{1}{R_1 C_1}\right)}_{6{,}000} C_1\right]^{-1} = 16.7K$$

* Finished design:



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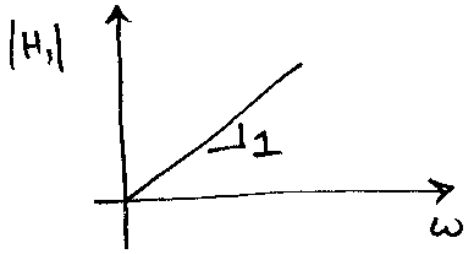
② Plot the frequency response (one plot for magnitude, another plot for phase) of the two systems below. Include some specific values to calibrate your graphs.

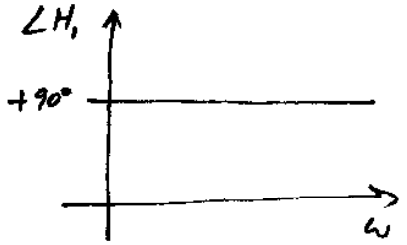
(a) A <u>differentiator</u>, with transfer function $H_1(s) = s$

(b) An <u>integrator</u>, with transfer function $H_2(s) = \frac{1}{s}$

* Part (a):

$$H_1(s)\big|_{s=j\omega} = \underbrace{j\omega}_{\text{freq. response } H_1(j\omega)} \qquad |H_1(j\omega)| = \omega \;, \quad \angle H_1(j\omega) = +90^\circ$$





* Part (b):

$$H_2(s)\big|_{s=j\omega} = H_2(j\omega) = \frac{1}{j\omega} = -j\frac{1}{\omega}$$

$$|H_2(j\omega)| = \frac{1}{\omega} \qquad \angle H_2(j\omega) = -90^\circ$$