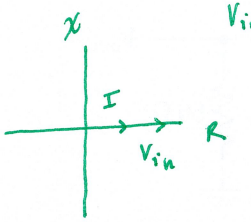
Pre-lab 4 Hand-in

Name: solutions

Pre-lab 4.1 Practice drawing a "phasor" diagram of the voltage and current across (a) a resistor and (b) a capacitor. To draw a phasor diagram, make a set of axes with imaginary components in the vertical and real components in the horizontal. The phasor is a vector that expresses the magnitude and phase of your signal. So you will want an arrow that is the length of the amplitude of the voltage signal at an angle given by its phase, and the same for current.

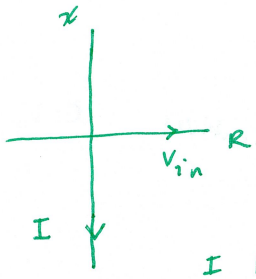
a) V_{in} — R — I $I = V/R$



V_{in} and I have the same phase

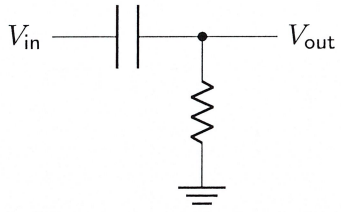
b) V_{in} — C — I $V = \sin \omega t$

$I = C \frac{dV}{dt} = C\omega \cos \omega t$



I lags V by 90°

Pre-lab 4.2 Capactors are reactive and resistors are resistive. But we can get something in between when we consider an RC circuit, or a capacitor loaded by a resistor. Use what you know about voltage dividers to calculate the output voltage of the circuit below. How does the phase of the output voltage compare to the phase of the input voltage? (*Hint: you can represent both signals as phasors in the complex plane.*)

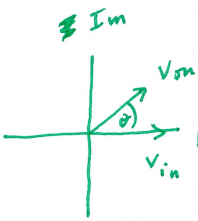


$V_{out} = \frac{Z_2}{Z_1 + Z_2} V_{in}$

$Z_1 = \frac{-j}{\omega C}$ $\quad Z_2 = R$

$V_{out} = \frac{R}{-j/\omega C + R} V_{in}$

$= \frac{R(+j/\omega C + R)}{1/\omega^2 C^2 + R^2} V_{in} = \frac{j \cdot R/\omega C + R^2}{1/\omega^2 C^2 + R^2} V_{in}$



$\tan\theta = \frac{Im(V_{out})}{Re(V_{out})} = \frac{R/\omega C}{R^2}$

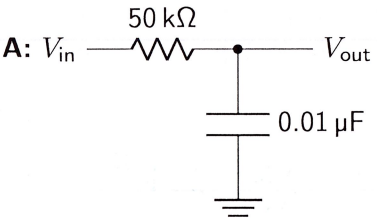
$\tan\theta = \frac{1}{R\omega C}$

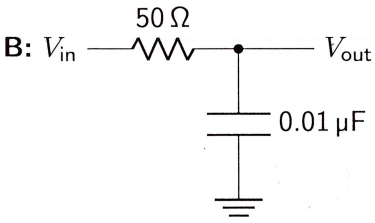
V_{out} lags by θ

From the last lab:

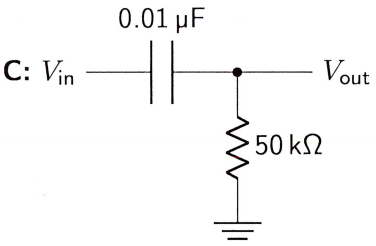
Pre-lab 4.3 Suppose your physics experiment contains a sensor that produces square voltage pulses at 10 kHz, and has an output impedance R_s of 50 Ω. You want to *differentiate* the signal in order to trigger another part of the experiment on the edges of the pulse. Which of the circuits below would you use to produce a differentiated output? Explain your choice and make a *qualitative* sketch of the expected output.

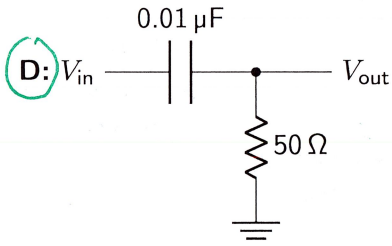
A + B integrate





C + D take derivatives





want majority of voltage drop across capacitor (small R)

$V_{out} = RC \frac{d}{dt}(V_{in} - V_R)$ → D