# BENG 186B Winter 2017

Quiz 1

Monday, January 23, 2017

Name (Last, First): _____

- This quiz is closed book and closed notes. You may use a calculator for algebra and arithmetic.

- Do not attach separate sheets. If you need more space, use the back of the pages.

- Circle or box your final answers and show your work on the pages provided.

- There are 4 problems. Points for each problem are given in **[brackets]**. There are 100 points total.

- You have 50 minutes to complete this quiz.

1. **[25 pts]** You are given a biomedical instrument that measures blood pressure from a cuff at its input and produces a digital reading on an output display. The instrument transduces the pressure into a voltage, and digitizes this voltage by an 8-bit analog-to-digital converter (ADC). The transducer voltage as a function of pressure is shown in the graph below, and the ADC full-scale voltage range is from 1 V to 4 V.
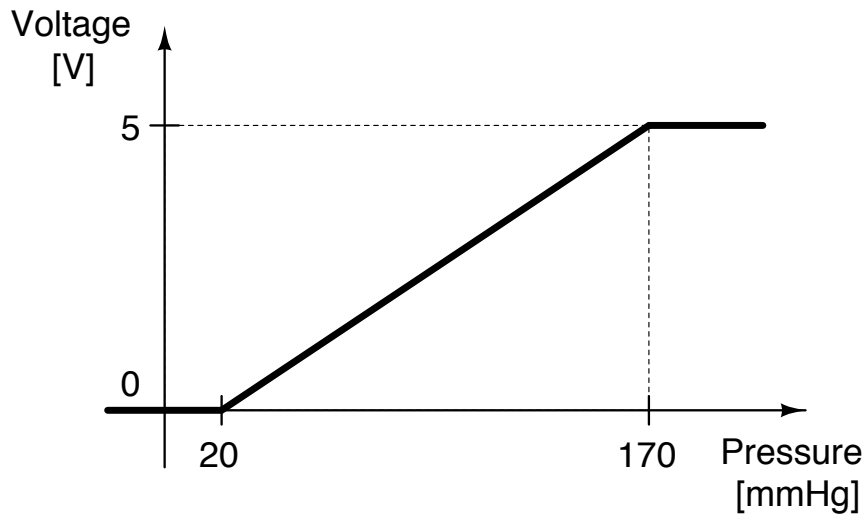

   (a) Find the sensitivity of the transducer, and the range of pressure over which it operates.

(b) Find the resolution of the instrument, and the range of pressure over which it produces a valid reading.

(c) You discover that the transducer for known pressure values produces a voltage that on average is 0.2V lower than expected, and with a standard deviation of 0.5V. Find the accuracy and precision of the instrument, in units mmHg.
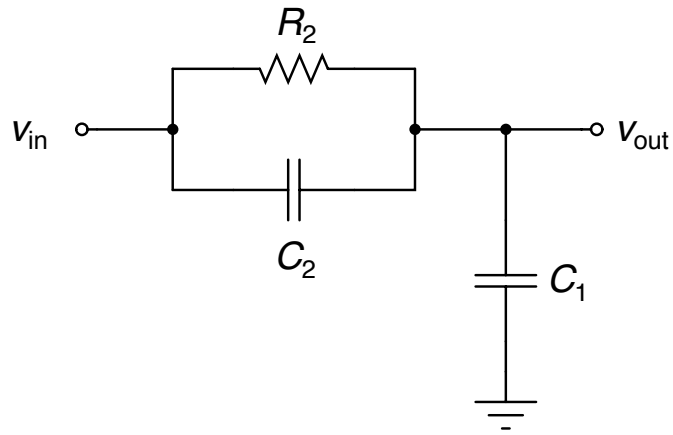
2. **[20 pts]** Consider the current-input, current-output amplifier below.
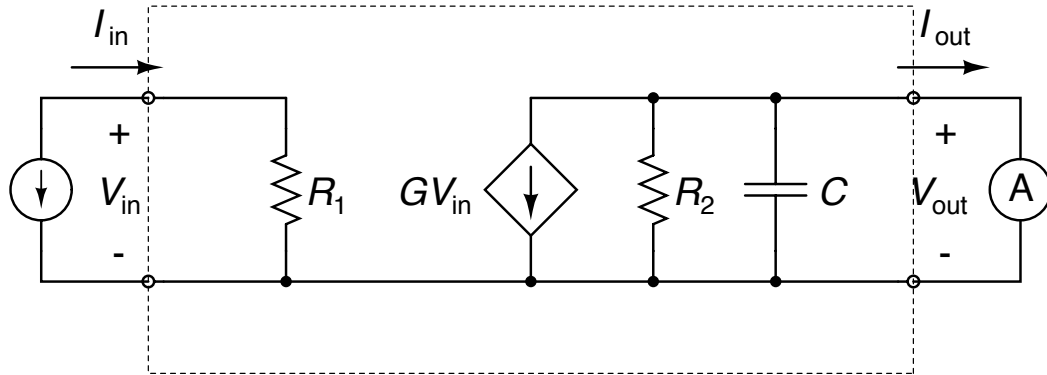
(a) Find the input impedance and output impedance.

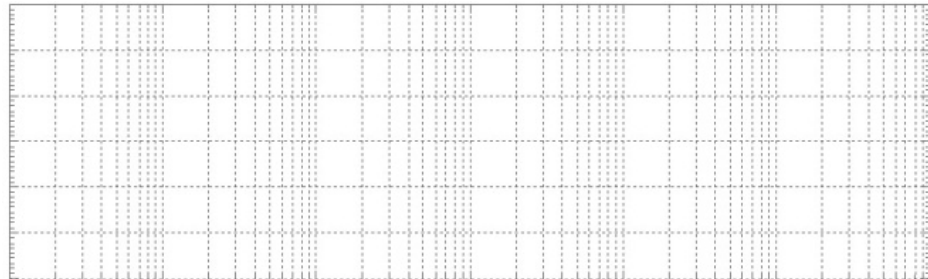(b) Find the transfer function. Does it depend on frequency?

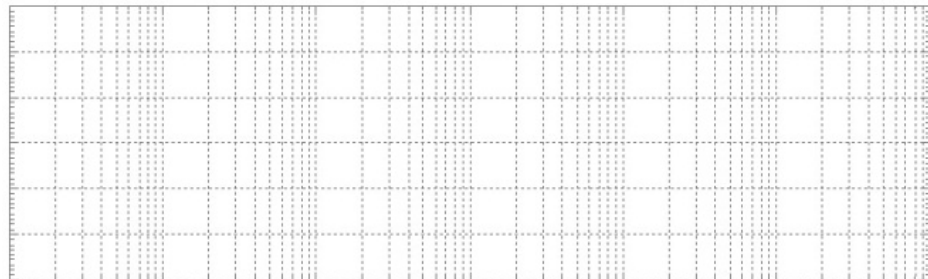3. **[35 pts]** Consider the voltage-input, voltage-output filter below.

(a) Find the transfer function $H(j\omega) = v_{out}(j\omega) \, / \, v_{in}(j\omega)$.

(b) Sketch a Bode plot of the transfer function $H(j\omega)$ for $C_1 = 1 \ \mu F$, $C_2 = 1$ nF, and $R_2 = 10$ kΩ. Be sure to label the axes and indicate the units (rad/s, dB, and degrees).

$H(j\omega)$ Magnitude

$H(j\omega)$ Phase

4. **[20 pts]** Consider the strain transducer below, with constant supply voltage $V_i = 1$ V, two constant resistors each with resistance R, and two strain gages R_{G1} and R_{G2} with identical nominal resistance R_{nom} and gage factor G that are differentially activated by complementary strain ϵ and $-\epsilon$ as shown. In addition, the two strain gages have identical temperature coefficient $k = 0.005$ K^{-1}.
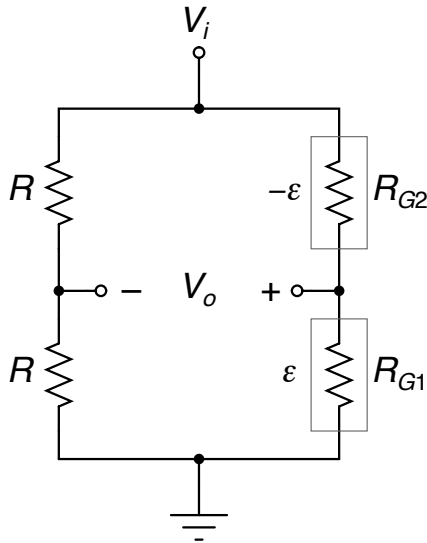
$$R_{G1} = R_{nom}\,(1 + G\epsilon)\,(1 + kT)$$
$$R_{G2} = R_{nom}\,(1 - G\epsilon)\,(1 + kT)$$

(a) Find the output voltage V_o as a function of strain ϵ and temperature T.

(b) Find the sensitivity of the transducer to strain, and its sensitivity to temperature.