BENG 186B Winter 2011

Quiz 2

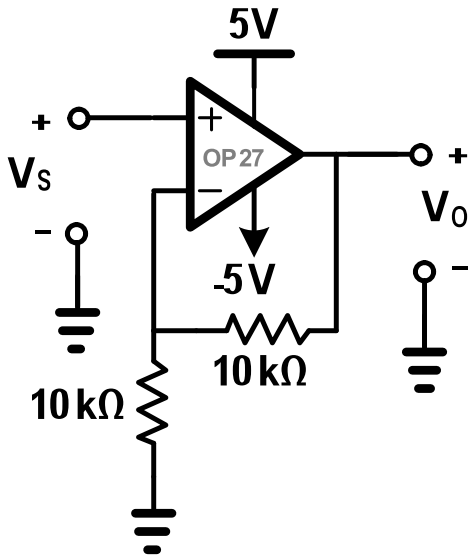
February 11, 2011

NAME (Last, First): _____

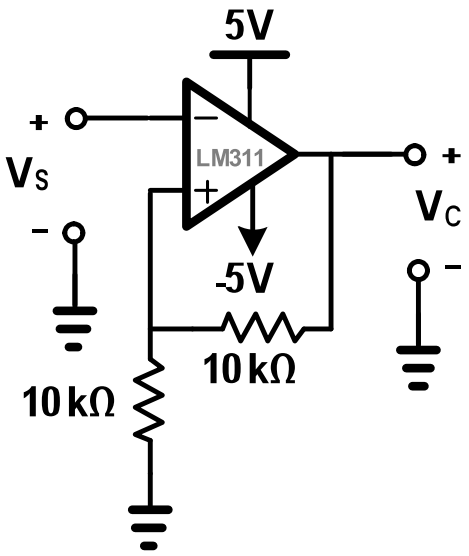
- This quiz is closed book, closed note, you may use a calculator for algebra.
- Circle your final answers in the space provided; show your work only on the pages provided.
- Do not attach separate sheets. If you need more space, use the back of the pages.
- Points for each problem are given in [brackets], 100 points total. The quiz is 50 minutes long.

1	/30
2	/30
3	/20
4	/20
Total	/100

1. [**30 pts**] Two circuits A and B are driven by the same voltage input V_S and generate voltage outputs V_O and V_C as shown below. The components OP27 and LM311 are ideal, each with positive supply 5 V and negative supply -5 V.



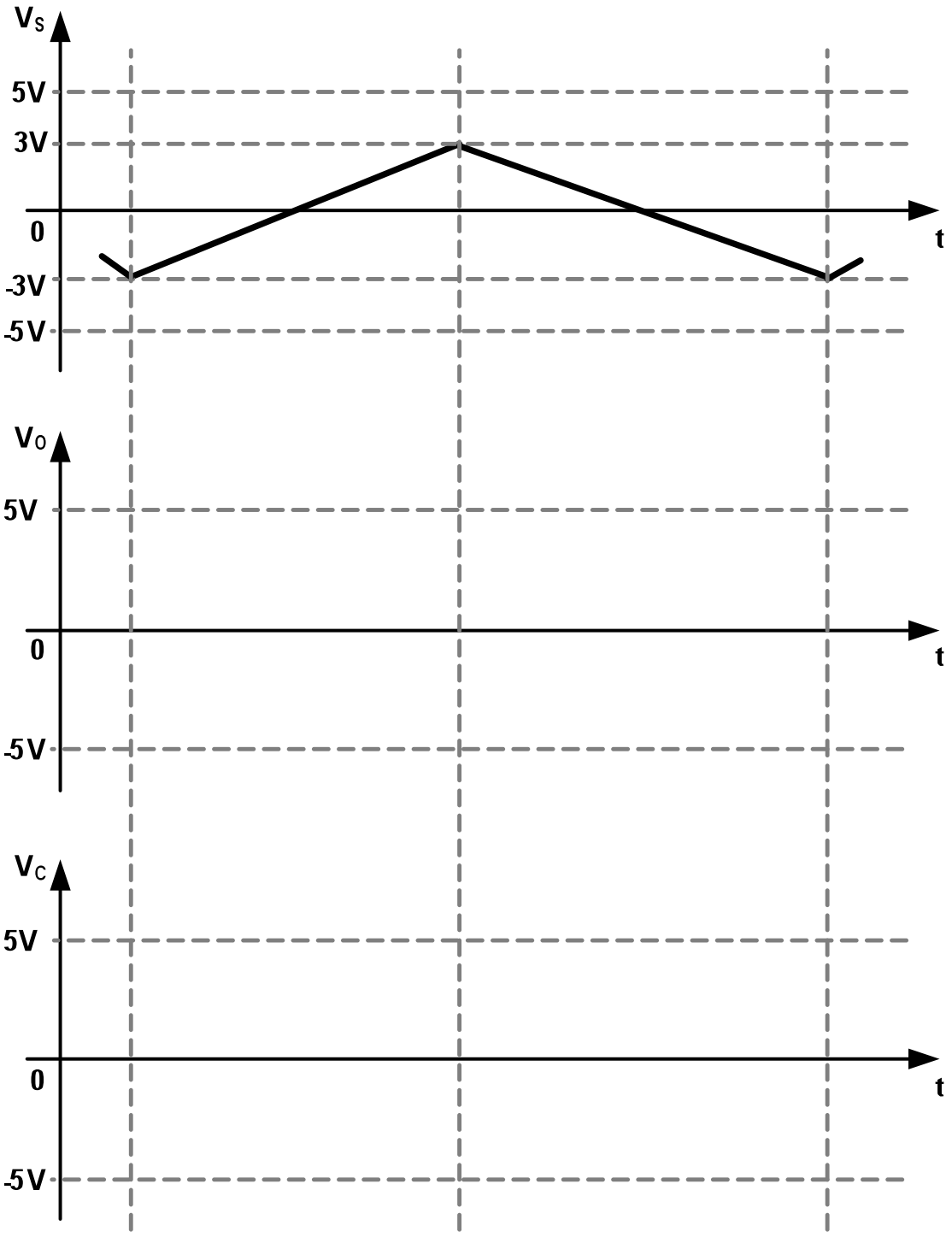
A



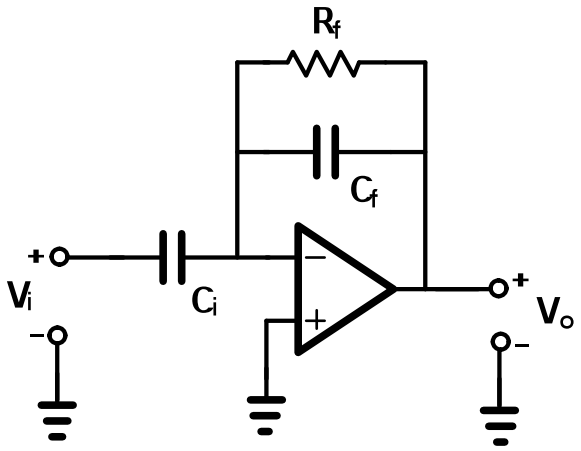
B

   a. What are the functions of circuits A and B? Give values for the parameters defining their functions. [10 pts]

b. For the input V_S over time given below, sketch the waveforms for the outputs V_O and V_C on the diagrams. [20 pts]



2. [**30 pts**] Consider the following active filter circuit with voltage input V_i and voltage output V_o. You may assume that the op-amp is ideal.



a. Derive the transfer function $H(j\omega) = V_o(j\omega)/V_i(j\omega)$ in terms of C_i, C_f and R_f. What type of filter is this? [10 pts]

b. Derive the input impedance $Z_i(j\omega)$. [5 pts]

c. Find values for C_i, C_f and R_f such that the cutoff frequency is 10 Hz, the gain at 1 MHz is -100 [V/V], and the magnitude of the input impedance at 10 Hz is 1 MΩ. [10 pts]

d. Sketch the magnitude of the transfer function as a function of frequency f. Indicate numerical values on your graph. [5 pts]

3. [**20 pts**] Circle the best answer (circle only one letter for each question).

   a. Biopotentials are produced in the body by:
      i. Implanted electrodes
      ii. Volume conduction of electrochemical currents
      iii. Extracutaneous stimulation
      iv. Connective tissue
      v. The brain and heart only

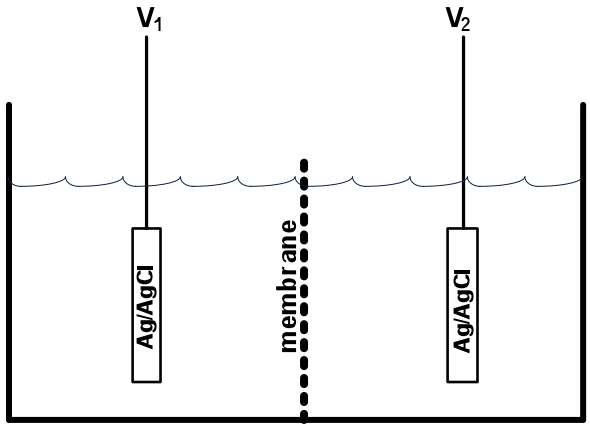
   b. Refractory period is the time during which:
      i. Bone recovers from fracture
      ii. A neuron does not respond to external inputs
      iii. A cell undergoes mitosis
      iv. Ions do not travel through membrane proteins
      v. Membrane potential equals zero

   c. EMG:
      i. Is commonly used to record the activity of smooth muscle
      ii. Measures the electromagnetic signals generated by the brain
      iii. Is related to the angular direction of the ocular dipole
      iv. Is a DC signal recorded in striated muscle
      v. Can be used to analyze biomechanics of skeletal muscle

   d. The QRS complex is:
      i. The flattest section of the ECG
      ii. Eliminated during arterial fibrillation
      iii. A group of electrically active enzymes
      iv. Between 0.6 and 0.75 seconds long
      v. Caused by rapid depolarization of the ventricles

   e. Ventricular repolarization causes:
      i. The T wave
      ii. The QRS complex
      iii. A lack of QRS complex
      iv. The PR segment
      v. A strong EMG signal

4. [**20 pts**] A membrane separates a container into two compartments as shown below. The first compartment contains a solution of 10 mmol of NaCl and 1 mmol of KCl in 1 L of water. The second compartment contains a solution of 1 mmol of NaCl and 10 mmol of KCl in 1 L of water. Two identical Ag/AgCl electrodes are immersed, one in each compartment. The voltage between the electrodes is measured with a voltmeter of infinite input impedance.



The Goldman-Hodgkin-Katz (GHK) equation:

$$E = \frac{RT}{F} \cdot \ln \frac{P_K[K^+]_o + P_{Na}[Na^+]_o + P_{Cl}[Cl^-]_i}{P_K[K^+]_i + P_{Na}[Na^+]_i + P_{Cl}[Cl^-]_o} \quad \text{where } \frac{RT}{F} = 26mV$$

a. Find the concentrations of Na^+, K^+ and Cl^- in the first and second compartments. [4 pts]

b. Assume that the membrane is permeable to Cl^- only. Find $V_1 - V_2$ at rest. [4 pts]

c. Assume that the membrane is equally permeable to Cl^- and Na^+. Find $V_1 - V_2$ at rest. [4 pts]

d. Assume that the membrane is equally permeable to Cl^- and K^+. Find $V_1 - V_2$ at rest. [4 pts]

e. Assume that the membrane is equally permeable to all ions. Find $V_1 - V_2$ at rest. [4 pts]