BENG 186B Winter 2012

Quiz 2

February 15, 2012

NAME (Last, First):

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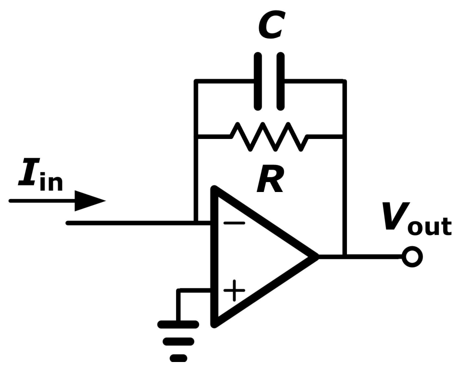
- This quiz is closed book and closed note. You may use a calculator for algebra.
- Circle your final answers in the space provided; show your work only on the pages provided.
- Do not attach separate sheets. If you need more space, use the back of the pages.
- Points for each problem are given in [brackets],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

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

1. [**20 pts**] Consider the following active filter circuit with current input I_{in} and voltage output V_{out}. You may assume that the op-amp is ideal.

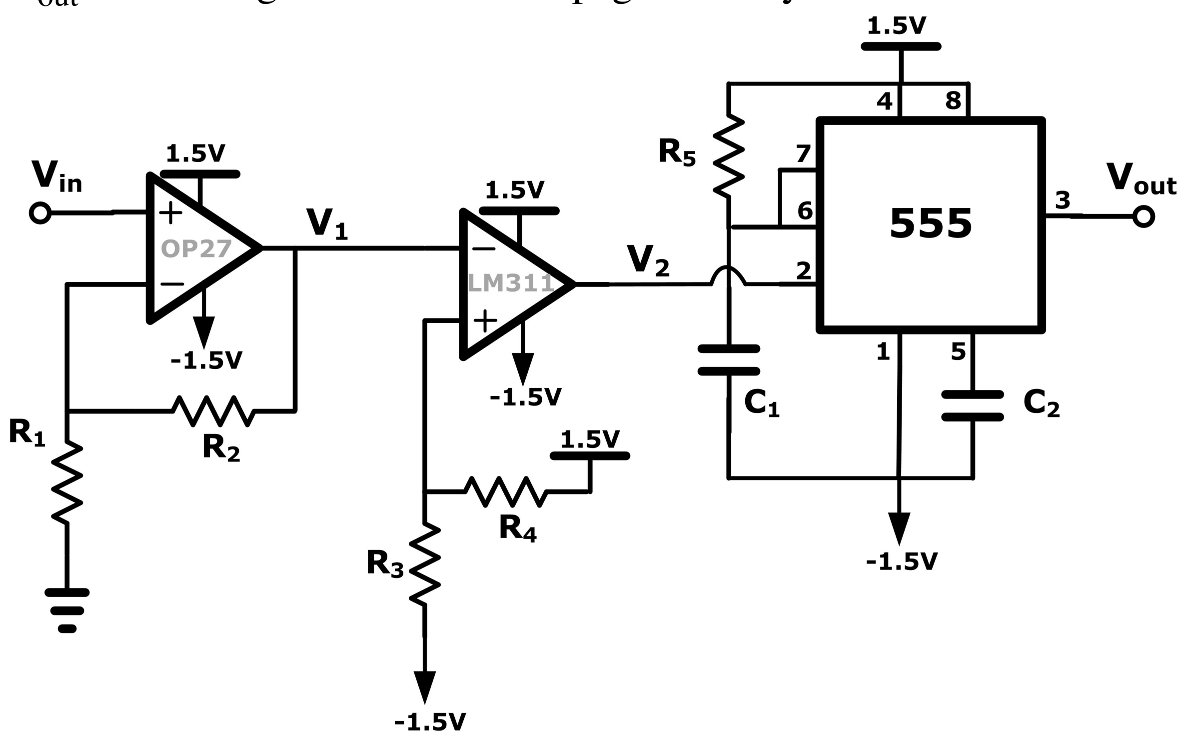


a. Derive the transfer function $H(j\omega) = V_{out}(j\omega)/I_{in}(j\omega)$ in terms of C and R. What are the units of the transfer function? What type of filter is this? [10 pts]

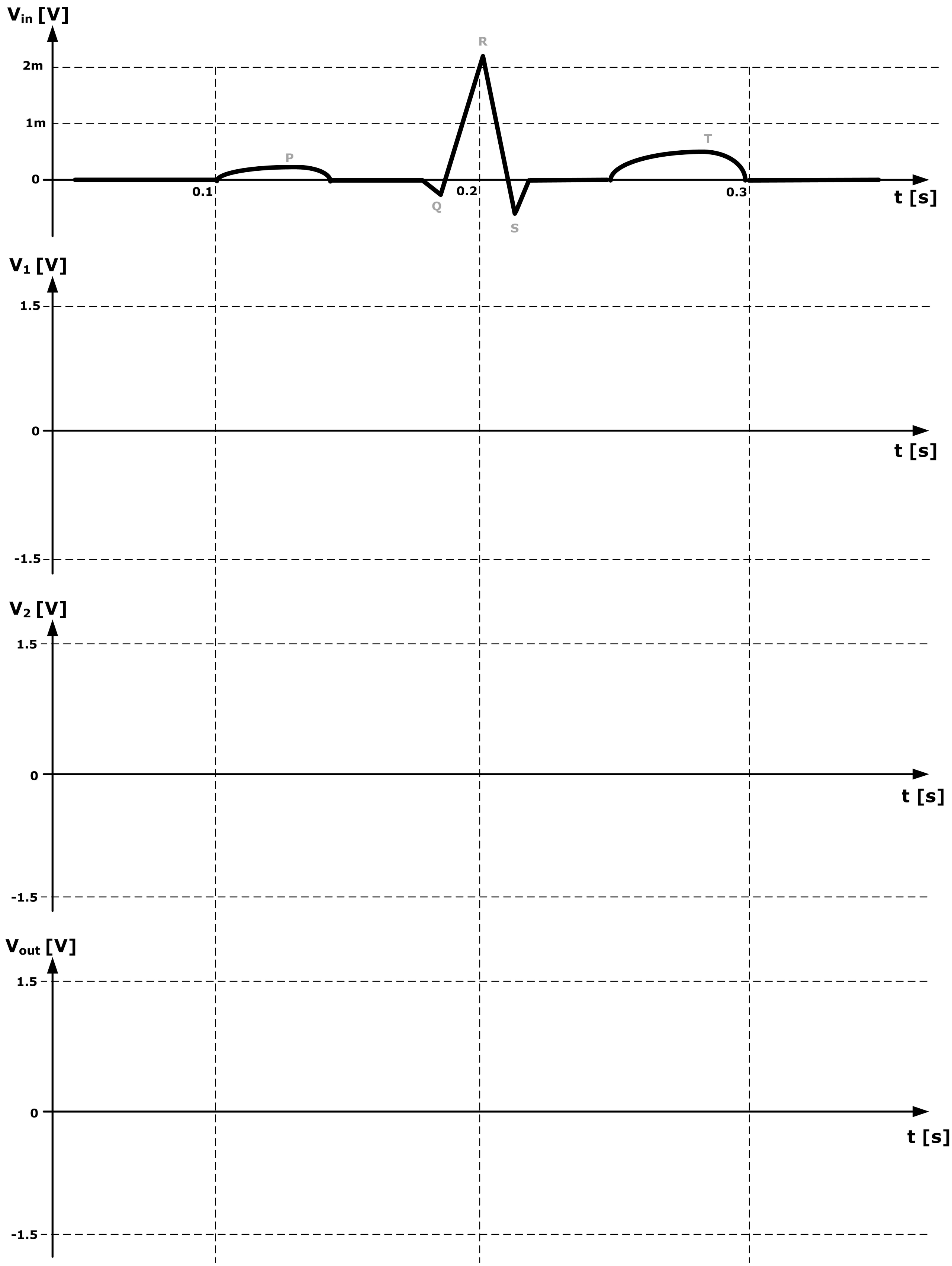
b. Derive the input impedance $Z_{in}(j\omega)$. [5 pts]

c. Derive the output impedance $Z_{out}(j\omega)$. [5 pts]

2. [**30 pts**] The following circuit is driven by voltage input V_{in} and generates voltage output V_{out} as shown below. The components OP27, LM311, 555 are assumed ideal, each with positive supply 1.5 V and negative supply -1.5 V. Sketch the waveforms for the voltages V_1, V_2 and V_{out} on the diagrams on the next page. Show your work below.



$R_1 = 1\ k\Omega$, $R_2 = 999\ k\Omega$, $R_3 = 250\ k\Omega$, $R_4 = 50\ k\Omega$, $R_5 = 100\ k\Omega$
$C_1 = 910$ nF, $C_2 = 10$ nF. The equation for the 555 is: $T = 1.1\ R_5\ C_1$.



Vin [V]
2m
1m
0
P
R
Q
S
T
0.1
0.2
0.3
t [s]
V1 [V]
1.5
0
-1.5
t [s]
V2 [V]
1.5
0
-1.5
t [s]
Vout [V]
1.5
0
-1.5
t [s]

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

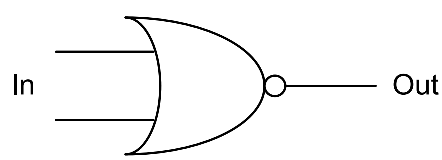
a. The Goldman-Hodgkin-Katz (GHK) equation:
   i. Solves for non-equilibrium membrane potentials
   ii. Yields zero membrane potential if impermeable
   iii. Yields a positive membrane potential for most excitable cells
   iv. Yields the inside minus outside potential at rest
   v. Yields the outside minus inside potential at rest

b. Axon myelination decreases:
   i. Membrane capacitance
   ii. Action potential propagation speed
   iii. Baseline membrane potential
   iv. QRS complex duration
   v. Heart rate

c. The highest frequency EEG wave is:
   i. Alpha, α
   ii. Beta, β
   iii. Gamma, γ
   iv. Delta, δ
   v. Theta, θ

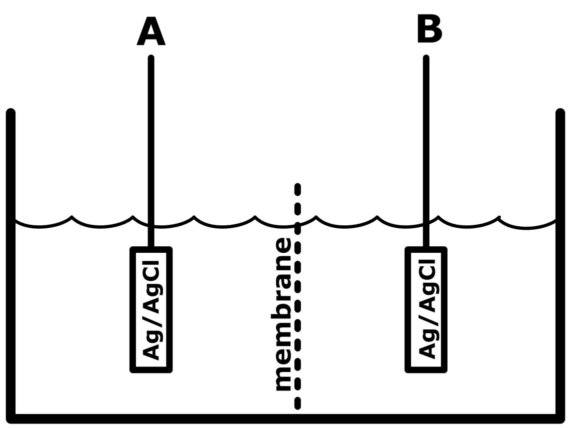
d. In an ECG, the P wave:
   i. Represents ventricular repolarization
   ii. Is missing during atrial fibrillation
   iii. Increases during epilepsy
   iv. Detects eye movement/blinking
   v. Represents depolarization after the AV node

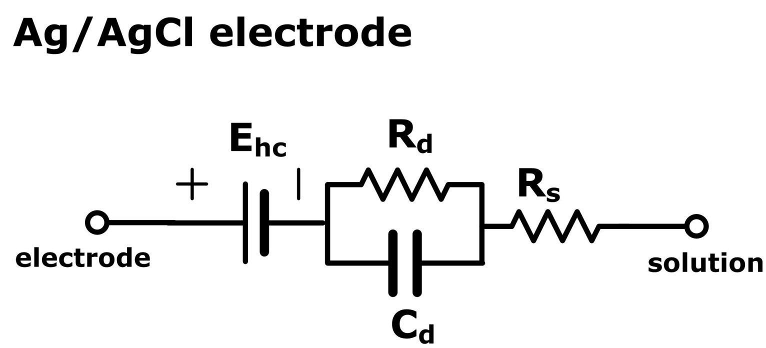
e. The following symbol represents which circuit component?



   i. AND Logic Gate
   ii. NAND Logic Gate
   iii. OR Logic Gate
   iv. NOR Logic Gate
   v. Op-Amp

4. [3**0 pts**] A membrane separates a container into two compartments as shown below. The "inside" compartment (A) contains a solution of 100 mmol of NaCl and 10 mmol of KCl in 1 L of water. The "outside" compartment (B) 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. For each Ag/AgCl electrode, the half cell potential E_{hc} is 0.223 V, and the impedance parameters are R_d = 320 kΩ, C_d = 10 pF, and R_s = 10 kΩ. The membrane has equal permeabilities to all three ions.





The Goldman-Hodgkin-Katz (GHK) equation:

$$E = (60mV) \cdot \log_{10} \frac{P_K[K^+]_o + P_{Na}[Na^+]_o + P_{Cl}[Cl^-]_i}{P_K[K^+]_i + P_{Na}[Na^+]_i + P_{Cl}[Cl^-]_o}$$

a. Find the Nernst potential of Na^+, K^+ and Cl^-. [5 pts]

b. Derive the voltage between nodes A and B at rest. [10 pts]

c. Derive and sketch the impedance $Z(j\omega)$ between nodes A and B as a function of ω. You may assume that the resistance for ion transport across the membrane R_{mem} is 1 MΩ. [15 pts]