MichiganTech

Spring 2001

BE 3600 BioInstrumentation

Final Exam: 11 May 2001, Friday

POSTED ON THE WEB AS A **STUDY AID**

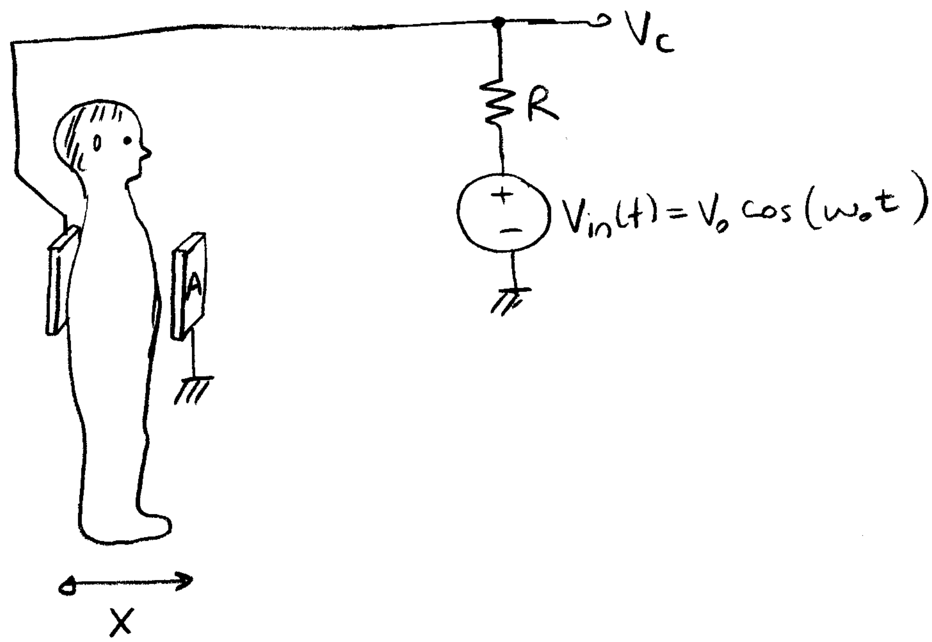
This exam:
- Consists of 12 questions,
- Score from this exam will determine 25-30 % of your grade,
- You will have 2 hours to complete the exam,
- Closed books, closed notes, but use of calculators is allowed,
- Please mark your answers on the SCORE SHEET using pencils,
- Do not forget to mark your ID NUMBER and TEST FORM code,
- Mark your FAMILY NAME, GIVEN NAME (no middle initials),
- Mark your MTU Student ID number,
- No telephone numbers.

TEST FORM CODE:

GOOD LUCK!

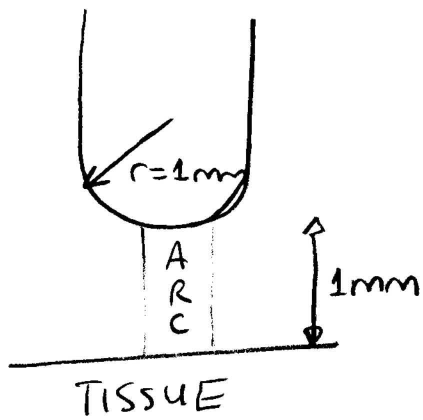
QUESTION 1.

A capacitive sensor is being used to measure the thoracic depth to monitor the respiratory activity. A circuitry is formed as shown below where the x is the distance between the plates of the capacitor, hence the thoracic depth. Determine the equation for the output voltage, V_C.



QUESTION 2.

Tip of an electrocautery instrument has a radius of curvature of $r = 1\ mm$. It is specified that the electrical arc to cut the tissue will be obtained with 300 Volts, when the tip is 1 mm away from the tissue. If the arc formed has a cross sectional area of 1 mm^2, what is the current flowing through the device?



QUESTION 3.

Input / output relationship of a sensor is given as follows:

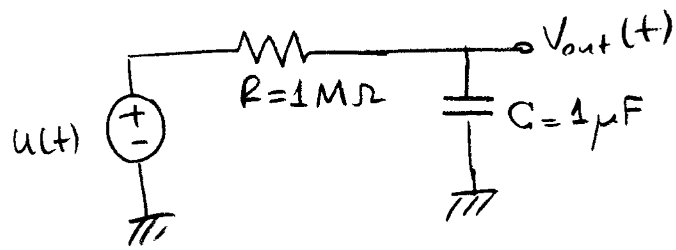
$y[k] = (0.5)\, y[k-1] + u[k]$,

where $u[k]$ is the input, and $y[k]$ is the output.

If the input $u[k]$ is an impulse function, determine the output $y[k]$

QUESTION 4.

A capacitive pressure transducer is setup as shown below



Where u(t) is a step function, R = 1 MΩ, C=1μF (fixed during the test)

If we sample the system with ΔT = 1 milli-sec time steps, what is the discrete time output of this system ($V_{out}[k]$)

QUESTION 5.

Impulse response of a sensor is given as follows:

$$h(t) = \begin{cases} 0, t < 0 \\ e^{-t}, t \geq o \end{cases}$$

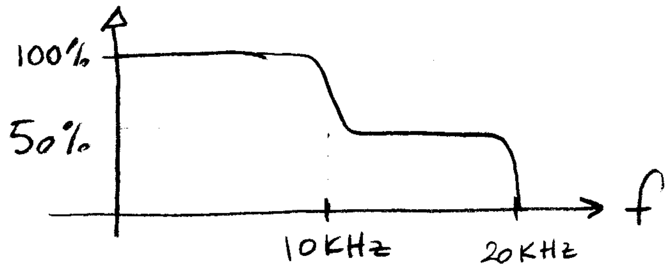
When an unknown signal *x(t)* is applied to the input, following output was observed

$$y(t) = \begin{cases} 0, t < 0 \\ t^2 e^{-t}, t \geq o \end{cases}$$

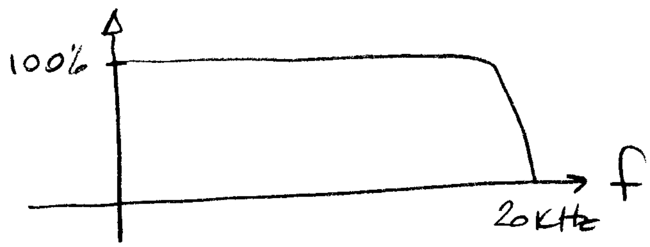
Determine *x(t)*

QUESTION 6.

A patient's audiology report shows the response of her ear is follows:

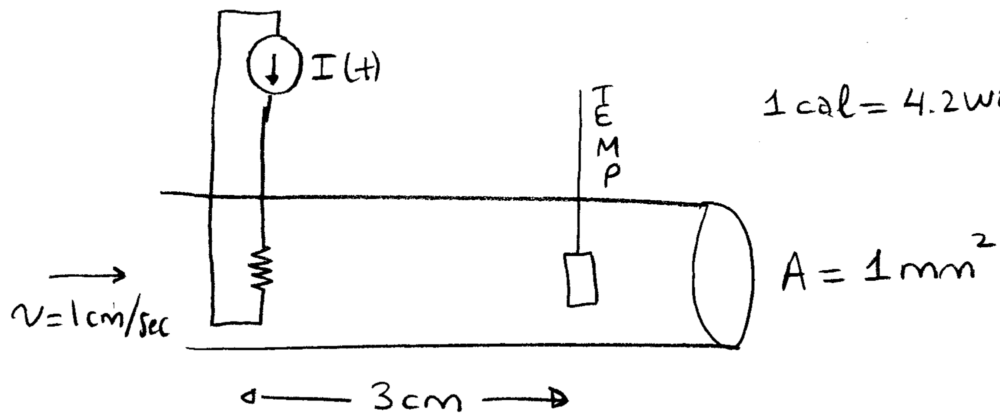


Which filter shown below would restore her hearing to a flat spectrum?



QUESTION 7.

A flow sensor was designed using the principles of thermo-dilution method. Its output is sampled at $\Delta T = 1$ second time steps. Incoming blood is at 37 °C, and has a density of 1 gram / cm^3, and specific heat of 1 cal / °C - grams. If the flow is at 3 cm / sec, heating element has a resistance of 1 Ω, the distance between the heater and the temperature sensor is 3 cm, and the cross sectional area of the artery is 1 mm^2, find the relationship between the output temperature and the current on the heating element.



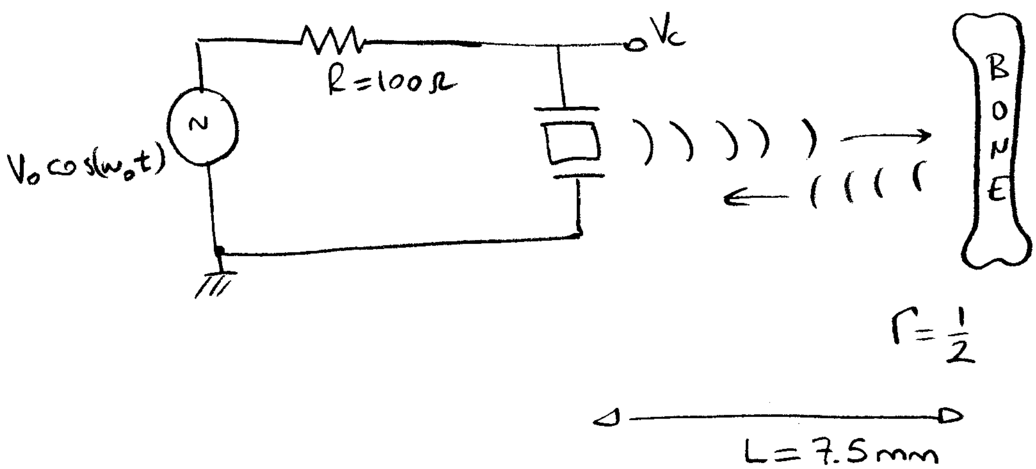
QUESTION 8.

A piezo-electric transducer works with the following equation

$V = g\,P$, where V is the voltage on the transducer, P is the pressure, and g is a constant.

This transducer is used for ultrasound imaging and can simply be modeled as a capacitor, C = 1 μF. If the entire system is configured as shown below, what is the magnitude of the voltage on the transducer, V_C

You can neglect the attenuation in the tissue. Reflection coefficient for the tissue-bone interface is given as $\Gamma = 0.5$. Voltage source generates a voltage of $V_0 \cos(\omega t)$, where f = 100 KHz. Distance between the transducer and the bone is 7.5 mm. Speed of sound in tissue is 1,500 meters per second.



QUESTION 9.

A pneumotachograph is an instrument to measure the respiration of a patient and shown in the diagram below. Pressure sensors P_1 and P_2 have gain of 1, i.e. $V=P$ (voltage output is equal to pressure input). These two transducers are placed on either side of a fine mesh with resistance to flow R. Determine the expression for $V_{OUT}(t)$.

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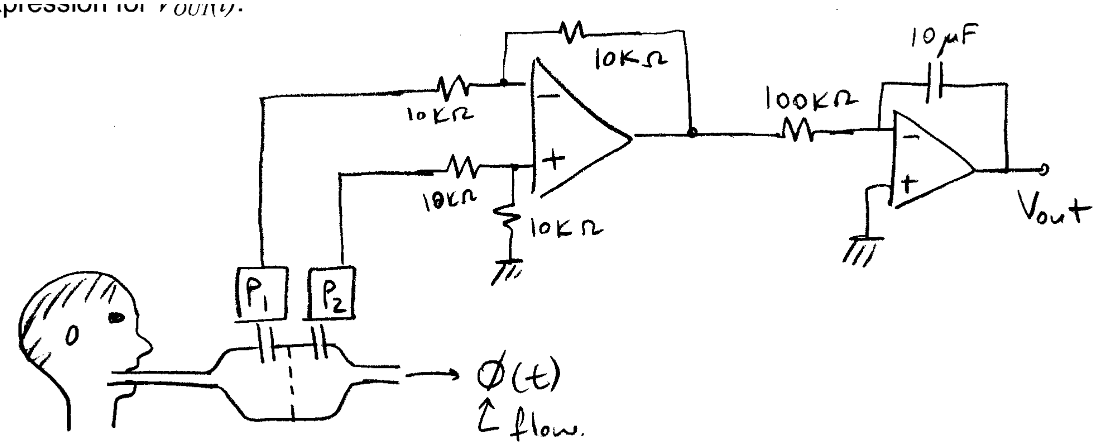


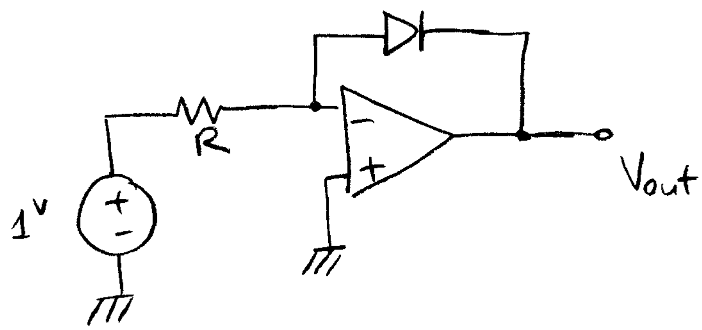
QUESTION 10.

A diode can be used as a temperature sensor. Relationship between the current and voltage is given as follows:

$$I = Ae^{\frac{qV - E_g}{kT}}$$

where I is the current, V is the voltage, E_g and k are constants and T is the temperature.

Find the output of the circuit shown below.



QUESTION 11.

A signal has a 50 Hz noise and a digital filter will be used to remove the noise. Determine the equation for the filter.

QUESTION 12.

A transthoracic impedance monitor utilizes AC excitation to measure the chest impedance. Find out the voltage drop on one of the electrode-electrolyte interfaces (V_{TE}) if the excitation is $I_0 cos(\omega t)$.