CHE 420 INSTRUMENTAL ANALYSIS **SPRING, 2005**
MARIAN COLLEGE, INDIANAPOLIS

Class Test I **Name:**

Take-home, open-book. Use additional paper as necessary.

1. (a) When a battery fails, it is usually because chemical changes within it have led to a buildup of internal resistance R_{int} to the extent that it can no longer supply sufficient power to an external load R_L. Measuring V_{cell} directly across the terminals with a voltmeter, the battery will still show a nearly normal voltage, so this is not a useful indicator of the remaining life expectancy of the battery. (i) Draw a circuit showing a 3.0V battery in series with its own internal resistance and with a 100 load resistance. (ii) Calculate the current through and power dissipated by R_L in the absence of internal cell resistance, and (iii) in the presence of an internal resistance of 25 .

   (b) Given that $V_{cell} = E_{cell} - IR_{int}$, where E_{cell} is the EMF of the cell reaction, it is clear that the operating voltage of the battery decreases for increasing current drain. The maximum current that can be drawn from the cell is $I_0 = E_{cell}/R_{int}$. Comment on the likely effects of short-circuiting (i) a 1.5V dry cell with internal resistance 15 and (ii) a 12V car battery with internal resistance 0.06 , respectively.

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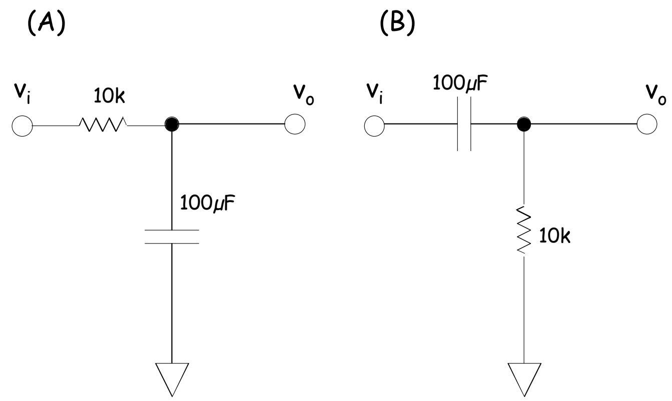
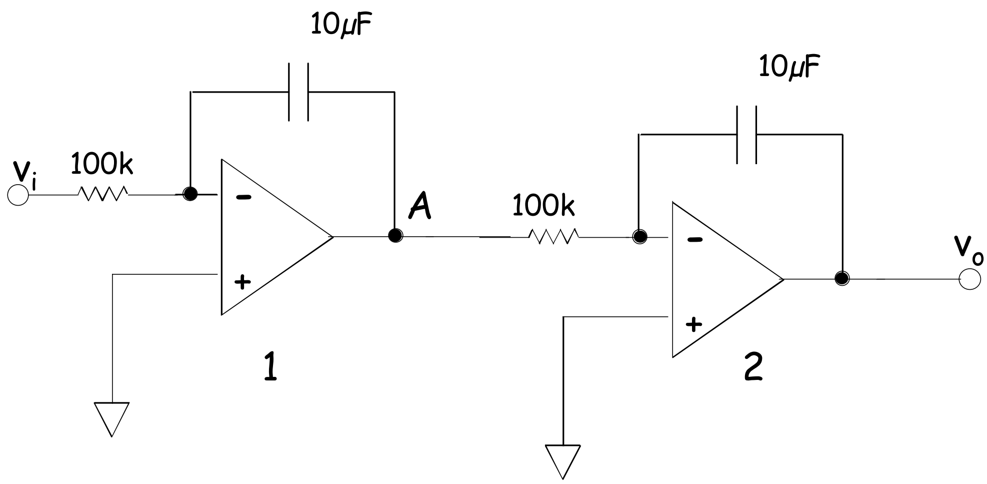


2. (a) What types of circuit are A and B, respectively?
(b) Given a square wave input v_i with amplitude +1.0V, frequency 2 Hz, and duty cycle 50%, sketch semiquantitatively (i.e. indicating maximum and minimum values) the output v_o from circuits A and B. (In each case, show v_i on the same figure to illustrate the relative timing.)
(c) Given a sinusoidal input signal with variable frequency and V_{RMS} = 1.0V, calculate the gain of circuits A and B at (i) f = 10^{-3} Hz, (ii) f = 1 Hz, (iii) f = 10^3 Hz.

(cont. over)



3. (a) If a +1.0V DC input is switched on at t=0, draw a qualitative picture of the output at A and at v_o.
(b) If the resistor and capacitor at op amp 2 are interchanged and a DC v_i of +1.0V is again used, describe the behavior of v_o as a function of time.

(cont. over)

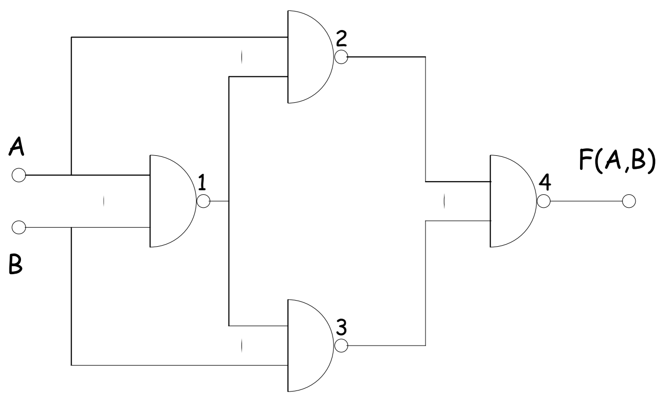
4. (a) The XOR gate has the logical transfer function

XOR(A,B) = (A.!(B)) + (!(A).B)

Write a truth table for this gate.

(b) Construct an XOR gate using two NOT gates, two AND gates, and an OR gate.

(c) Consider the figure below. Believe it or not, it too is an XOR gate. Show this by explicitly verifying the logic levels at points 1, 2, 3, and 4, and constructing a truth table.



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5. An apparatus has been designed to characterize radioactive substances by measurement of the decay energy spectrum. Each decay leads to a small voltage peak in the detector circuit, which is then amplified. The *height* of the voltage peak is proportional to the decay energy. The spectrum consists of a graph of counts (y-axis) vs decay energy (x-axis). A schematic of the device is shown below.

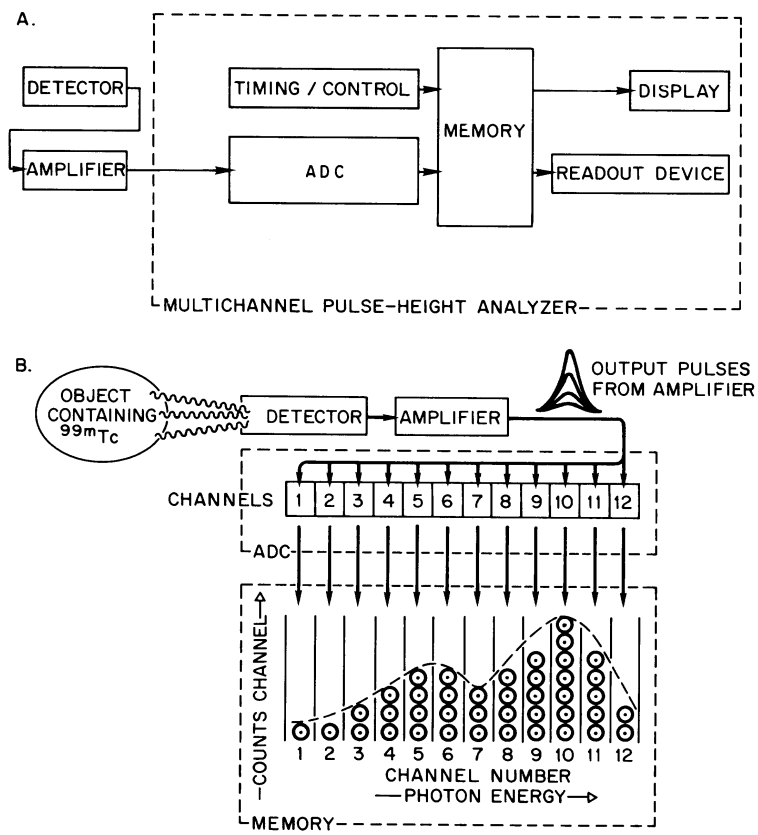

Fig. 5-9. Principles of a multichannel analyzer (MCA). (A) Basic components. (B) Example of pulse sorting according to amplitude for radiation events detected from an object containing ^{99m}Tc.

(a) Discuss the likely sources of *instrumental* and *environmental* noise in this device.
(b) Discuss the role of the ADC.
(c) Discuss the role of *coaddition* in this experiment.

(Space is provided for your answers overleaf.)

(Additional space is provided for your answers overleaf.)

END OF EXAM PAPER: 100 points total