Design an electronic thermometer using the circuit diagram shown above. The voltage $v_3$ is used to indicate temperature. Use a thermistor with a resistance described by

$$R_T = R_o e^{\frac{2000}{T} - \frac{1}{300}}$$

where $R_0 = 12$ k$\Omega$ and $T$ is temperature in °K.

a. Choose circuit components that will produce the following:

$$v_3 = 0 \text{ V when } T = 273\text{°K}$$
$$v_3 = 1 \text{ V when } T = 373\text{°K}.$$

Be sure the operational amplifier would not saturate. Explain your work carefully.

b. Using the component values you chose above, calculate $v_3$ when $T = 323\text{°K}$. Make a rough sketch of $v_3$ vs. $T$ on the basis of the values when $T = 273\text{°K}, 323\text{°K}, 373\text{°K}$. On the same axes, sketch the ideal linear response. Comment on the quality of the response compared to the desired linear response.
2. (75 points)

After having been in position c for a long time, the switch is moved to position d at \( t = t_0 \).

a. Choose either an R or C to go in box a and either an R or C to go in box b to produce the \( v_0(t) \) shown in the diagram. Specify which element goes in each box, and specify each value.

b. Sketch \( v_2(t) \), the voltage across the circuit element in box b. Show numerical values appropriately.

c. Sketch \( v_1(t) \), showing numerical values appropriately.

d. Sketch \( v_4(t) \). Show numerical values for \( t < t_0 \), for \( t_0 < t < (t_0 + 2 \text{ ms}) \), and for \( t > (t_0 + 2 \text{ ms}) \). Use the ideal model of the diode: when forward biased, its resistance is zero; when reversed biased, its resistance is infinite.

Explain your work carefully.
3. (15 points)

\[ v_x /100 \]

\[ v_1 \]

100 Ω

\[ v_2 \]

100 Ω

\[ v_3 \]

200 Ω

+ 200 Ω

- \[ 1A \]

100 V

a. Write an equation for the node voltages \( v_1 \), \( v_2 \), and \( v_3 \) in the form:

\[ g_{11} v_1 + g_{12} v_2 + g_{13} v_3 = i_1 \]

\[ g_{21} v_1 + g_{22} v_2 + g_{23} v_3 = i_2 \]

\[ g_{31} v_1 + g_{32} v_2 + g_{33} v_3 = i_3 \]

List the numerical values of \( g_{ij} \)'s and \( i_j \)'s.

4. (25 points)

\[ V_{i} /100 \]

\[ (50 + j50)\Omega \]

\[ Z_L \]

\[ V_{i} \]

50 Ω

50 jV

a. Choose the value of \( Z_L \) that will absorb maximum average power.

b. Calculate the value of that maximum average power absorbed by \( Z_L \).
5. (10 points)

Write a Matlab function called gen_RC_soln that accepts the following arguments:

i) an array called components whose first entry is an R value in Ohms and whose second entry is a C value in Farads,

ii) an array called voltages whose first entry is an initial voltage in Volts, and whose second entry is a final voltage in Volts, and

iii) a variable called tnow that represents the elapsed time in seconds.

gen_RC_soln will return a variable called vnow that represents the general solution to an RC charging problem. vnow will be the voltage across the C, at time tnow, given the initial and final voltages passed to gen_RC_soln.