Instructions:

- This quiz lasts 30 minutes. Answer all questions (on both sides of the sheet)
- You may have a 8.5" × 11" sheet of notes and a non-network-connected calculator

Q1a: (15 marks) A lung-function test involves asking a patient to make maximal breathing manoevres while the flow is measured at the mouth with a pneumotachograph.

1. (5 marks) Sketch a pneumotachograph and explain what is measured and how the air flow is calculated (1–2 sentences).
2. (5 marks) How does lung mechanics change in a *restrictive* lung disease (1–2 sentences)?
3. (5 marks) For a *restrictive* lung disease like cystic fibrosis, the maximal flows and volumes measured by a lung-function test change (compared to a normal subject). For the variables flow and volume, indicate whether it would *increase*, *decrease*, or *stay approximately the same*.

Q2a: (15 marks) In a thermal velocity probe, a resistor generates heat in the bloodstream and a thermistor, R_A, is placed downstream to measure the flow.

1. (5 marks) Sketch a configuration for a thermal velocity probe. Show how a second termistor, R_R, could be placed for temperature compensation.
2. (5 marks) Using an instrumentation amplifier, a +10 V source (and ground) and resistors, design a Wheatstone-bridge circuit for this application and indicate where thermistors R_A and R_R are placed (to achieve temperature compensation).
3. (5 marks) If your instrumentation ampifier has a gain of 100, and thermistor R_A changes by +1% and thermistor R_R changes by -1%, what is the amplifier output?

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Q1a: (15 marks) A lung-function test involves asking a patient to make maximal breathing manoevres while the flow is measured at the mouth with a pneumotachograph.

1. (5 marks) Sketch a pneumotachograph and explain why it is important to heat the flow-resistive element so that the instrument doesn't change its calibration (1–2 sentences).
2. (5 marks) How does lung mechanics change in an *obstructive* lung disease (1–2 sentences)?
3. (5 marks) For an *obstructive* lung disease like asthma, the maximal flows and volumes measured by a lung-function test change (compared to a normal subject). For the variables flow and volume, indicate whether it would *increase*, *decrease*, or *stay approximately the same*.

Q2b: (10 marks) To measure airflow at the nose, a thermistor, R_{flow}, is placed to measure the flow.

1. (5 marks) Sketch a configuration for this nasal thermistor configuration. Show how a second termistor, R_{comp}, could be placed for temperature-compensation.
2. (5 marks) Using an instrumentation amplifier, a source providing $\pm 5\,\text{V}$, and resistors, design a Wheatstone-bridge circuit for this application and indicate where thermistors, R_{flow} and R_{comp} are placed (to achieve temperature compensation).
3. (5 marks) Your instrumentation ampifier has a gain of 50 and has an output of $0\,\text{V}$ when both thermistors are at the same temperature and $R_{\text{comp}} = R_{\text{flow}} = 500\,\Omega$. To calibrate the system, thermistor R_{flow} is heated by $+1°\text{C}$ and the output changes by $1.0\,\text{V}$. What is the sensitivity of R_{flow} in $[\Omega/°\text{C}]$?