Homework 12

ME 240: Fundamentals of Instrumentation & Measurement
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1. (5 points) The variation of resistance with temperature is expressed by the relationship $R = R_0[1 + \alpha(T - T_0)]$, where R_0 is the resistance at the reference temperature T_0 and α for the resistor material has been determined to be $0.0048 \pm 0.1\%$ $(°C)^{-1}$. In the range 0 to 100°C, in which we are calibrating this resistor, temperature measurements have shown a standard deviation of 0.1°C. The systematic uncertainty of the temperature-measurement device is known to be 0.1°C. Calculate the percent uncertainty of R at a temperature of 25°C with a 95% confidence level. At 0°C, the resistance is 100.00 Ω.

2. (6 points) In using a temperature probe, the following uncertainties were determined: hysteresis ±0.1°C, linearization error ±0.2% of the reading, repeatability ±0.2°C, resolution error ±0.005°C, zero offset 0.1°C. Determine the type of these errors (random or systematic) and the total uncertainty due to these effects for a temperature reading of 120°C, assuming random errors have been determined with more than 30 samples each.

3. In a yogurt-filling line, the containers are filled with 1 kg of yogurt. The mass of the yogurt is measured while the filling nozzle is open. The nozzle flow rate is 0.25 kg/s. Several factors affect the flow rate, including the density and the viscosity of the yogurt, which combined, can introduce an uncertainty of about 1% of the flow, based on statistical analysis of the data. The dispensing time of the yogurt is controlled mechanically through a cam system. The uncertainty in the time during which the nozzle is open was established to be ±0.1 s via repeated experiments.

   (a) (2 points) Calculate the mean filling time of each container.

   (b) (4 points) Categorize each of the uncertainties as systematic or random.

   (c) (4 points) Calculate the uncertainty in the mass of the filled yogurt containers.

   (d) (2 points) If the plant managers decide to reduce the uncertainty in the mass of the yogurt, on what do you suggest they concentrate?

4. (4 points) In a cheese factory, 4.5-kg blocks of cheese are cut manually. For a large number of blocks, the standard deviation of the cutting process is measured and found to be 0.10 kg. The measurement was done with a scale with an accuracy of 1.5% of the full scale of 12 kg. Calculate the total uncertainty of the weight of the blocks of cheese at 95% confidence level.