Homework 1

Sunday, January 31, 2021 7:45 PM

"I pledge my honor I have abided by the Stevens Honor system."
- Alex Jaskins

2.2 You find a micrometer (a thickness-measuring device) of unknown origin and use it to measure the diameter of a steel rod that is known to have a diameter of 0.5000 in. You use the micrometer to make 10 independent measurements of the rod diameter, and the results are 0.4821, 0.4824, 0.4821, 0.4821, 0.4820, 0.4822, 0.4821, 0.4822, 0.4820, and 0.4822. Estimate the systematic error and the maximum random error in these measurements.

$$\frac{(4(.4821) + 2(.4820) + 3(.4822) + .4824)}{10}$$

Average: .48214

Systematic Error:

.5000 - .48214 = .24107

Random Error:

.4824 - .48214 = .00026

2.14 You need to measure a pressure, which has a value between 60 kPa and 100 kPa. Four pressure-measuring devices of comparable quality are available:

Device A, range 0–100 kPa
Device B, range 0–150 kPa
Device C, range 50–100 kPa
Device D, range 50–150 kPa

Which device would you choose? Explain your answer.

I would choose Device C, for it includes the range of expected values, and it accounts for any realistic uncertainty. Smaller range means smaller uncertainty.

2.16 Digital voltmeters often have a choice of ranges. The ranges indicated on a typical voltmeter are 0–3, 0–30, 0–300, and 0–3000 AC volts. The output is represented with four significant digits. Determine the following:

(b) If it has an accuracy of ±2% of full range for each range, determine the absolute uncertainty of measurement in each case.

0-3: $\frac{2}{100}(3) = \pm .06$

0-30: $\frac{2}{100}(30) = \pm .6$

0-300: $\frac{2}{100}(300) = \pm 6$

0-3000: $\frac{2}{100}(3000) = \pm 60$

2.18 A voltmeter with a range of 0 to 100 V reads 2 V when the leads are shorted together. The manufacturer claims an accuracy of ±4% of full scale. Estimate the maximum error when reading a voltage of 80 V in both volts and as a percentage of reading. If the voltmeter is adjusted so that the reading when the leads are shorted together is 0 V, estimate the maximum percent error when reading 80 V.

$$\frac{4}{100}(100) = \pm 4$$

$$4 + 2 = 6$$

Maximum error: ± 6 V

Maximum Percent Error:

$$\frac{6}{80}(100) = 7.5\%$$

2.38 A thermometer, initially at a temperature of 20°C, is suddenly immersed in a tank of water with a temperature of 80°C. The time constant of the thermometer is 2 s. What temperature will the thermometer read after 5 s?

$$y(t) = (y_i - x_i)e^{-t/\tau} + x_i$$

$$y(5) = (20 - 80)e^{-5/2} + 80$$

$$\boxed{y(5) = 75^\circ C}$$

2.41 A thermometer, initially at a temperature of 75°F is suddenly immersed into a tank of water with a temperature of 180°F. The time constant of the thermometer is 4 s. What are the values of the rise time and the 90% response time?

$$\frac{y}{y_e} = 1 - e^{-t/\tau}$$

$$.1 = 1 - e^{-t/4}$$

$$t_{(.1)} = .4214 \text{ s.}$$

$$.9 = 1 - e^{-t/4}$$

$$t_{(.9)} = 9.21 \text{ s.}$$

Rise time:

$$9.21 - .42 = 8.79 \text{ s.}$$

Response time:

90% or .9

$t = 9.21$ s.