Today, we will:

- Do a couple review example problems – outliers, data pairs
- Review the pdf module: **Experimental Uncertainty Analysis**
- Do some example problems – experimental uncertainty analysis

Example: Outliers – data pairs

Given: Twenty data points of (*x*,*y*) pairs are measured.

Data point	***x***	***y***
1	0	3.7
2	0.1	4.2
3	0.2	5.1
4	0.3	6.6
5	0.4	7.4
6	0.5	8.9
7	0.6	10.4
8	0.7	10.9
9	0.8	11.9
10	0.9	11.5
11	1	12.2
12	1.1	14.7
13	1.2	15.3
14	1.3	16.8
15	1.4	17.2
16	1.5	5.6
17	1.6	19.5
18	1.7	4.5
19	1.8	21.3
20	1.9	22.5

To do: Eliminate any "official" outliers, one at a time.

Solution:

See Excel spreadsheet on the website called Example_Outliers_data_pairs.xls – I will show in class how to do the analysis in Excel.

Example: Outliers – data pair measurements

Given: Omar takes 12 data pair measurements – temperature as a function of pressure. He performs a regression analysis and plots the data and the least-squares fit. One of the data pairs looks a little suspect, so he performs the standard statistical technique to determine if this data pair is an official outlier:

- The standard error (from the regression analysis) is 0.0244^{o}C.
- The residual of the suspect data pair is 0.0468^{o}C, and is the maximum residual.
- A plot of standardized residual vs. pressure reveals that the standardized residual of the suspect data pair is ***inconsistent*** with its neighbors.

To do: Is this data pair an official outlier or not?

Solution:

Example: Experimental uncertainty analysis

Given: The cutoff frequency of a simple first-order filter is $\omega = \frac{1}{RC}$, where

- ω = radian frequency (radians/s)
- R = resistance, measured to be $R = 12\underline{0}0\ \Omega \pm 5\%$ (to 95% confidence)
- C = capacitance, measured to be $C = 0.100\ \mu\text{F} \pm 1\%$ (to 95% confidence)

To do: Predict ω to 95% confidence in standard engineering format, and with the proper number of significant digits.

Solution:

Example: Experimental uncertainty analysis

Example

Given: Quantities A and B are measured, 200 times each:

- The sample mean and sample standard deviation for A are $\overline{A} = 5.20$ and $S_A = 0.252$.
- The sample mean and sample standard deviation for B are $\overline{B} = 22.32$ and $S_B = 1.05$.
- Quantity C is *not* measured directly, but it is *calculated* as $\boxed{C = A^2 + 3B}$.

To do: Report C in standard engineering format.

Solution:

Example: Experimental uncertainty analysis

Given: Jan uses a thermocouple to measure temperature. She performs a regression analysis on temperature *T* (units = °C) as a function of thermocouple voltage *V* (units = mV). The best-fit straight line is $T = b + aV$, where b = –0.8152°C and a = 23.182°C/mV. She takes her voltage data with a digital data acquisition system that has an uncertainty of +/-0.124 mV.

To do: When the voltage reading is V = 5.520 mV, calculate the temperature with its appropriate uncertainties.

Solution:

- We calculate: $\overline{T} = b + a\overline{V} = \left(-0.8152°\text{C}\right) + \left(23.182\frac{°\text{C}}{\text{mV}}\right)\left(5.520\text{ mV}\right) = 127.149°\text{C}$
- This equation for *T* is *not* of the simple exponent type, because of the plus sign. So, we *cannot* use the simpler RSS equation. We *must* use the general RSS equation with derivatives,

$$u_T = \sqrt{\sum_{i=1}^{N}\left(u_{x_i}\frac{\partial T}{\partial x_i}\right)^2}$$

Example: Experimental uncertainty analysis

Given: In a fluid mechanics experiment, the change in pressure is $\Delta P = 1.06 \rho V^2$, where

- ΔP = change in pressure (N/m^2, which is the same units as pascals, Pa)
- ρ = density, measured to be $\rho = 660. \pm 15.0$ kg/m^3 (to 95% confidence)
- V = velocity, measured to be $V = 1.52 \pm 0.028$ m/s (to 95% confidence)

To do: Write ΔP at these values of ρ and V in standard engineering format.

Solution: