Homework 11

ME 240: Fundamentals of Instrumentation & Measurement

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1. The data listed below were obtained in order to calibrate a linear load cell with a digital output.

   (a) (2 points) Determine the coefficients of linear regression.

   (b) (2 points) Determine the coefficients of linear regression if the line is forced to pass through the origin.

   Show your code if you write any.

True weight (lb)	Reading (lb)
0	-1.50
5	4.34
10	9.52
15	14.64
20	19.20
25	26.60
30	29.55

2. The following data points show the flow rate versus measured pressure drop of a liquid in a Venturi flow meter. It is expected that $Q = \alpha\sqrt{\Delta P}$, where α is a constant.

   (a) (2 points) Plot $\log_{10} Q$ versus $\log_{10} \Delta P$ along with a best-fit line.

   (b) (2 points) Determine the coefficients of linear regression.

   (c) (2 points) Determine the standard error of estimate.

   (d) (2 points) Determine the coefficient of determination.

   Show your code if you write any.

ΔP (psi)	Q (ft^3/min)
0.05	2.00
0.07	2.35
0.09	2.70
0.12	3.12
0.15	3.50
0.17	3.72
0.19	3.85
0.21	4.10
0.23	4.35
0.25	4.45

3. The independent variables x_1, x_2, and x_3 have known uncertainties w_{x1}, w_{x2}, and w_{x3},

respectively, and are related to the dependent variables R_1, R_2, R_3, and R_4 according to

$$
\begin{aligned}
R_1 &= ax_1 + bx_2 + cx_3, \\
R_2 &= dx_1 x_2 x_3, \\
R_3 &= \frac{ex_1 x_2}{x_3}, \\
R_4 &= f x_1^g x_2^h x_3^i,
\end{aligned}
$$

where $a \ldots i$ are known constants.

(a) (2 points) Determine w_{R1}, the uncertainty of R_1.

(b) (2 points) Determine w_{R2}, the uncertainty of R_2.

(c) (2 points) Determine w_{R3}, the uncertainty of R_3.

(d) (2 points) Determine w_{R4}, the uncertainty of R_4.

4. Young's modulus of elasticity, E, relates the strain, $\delta L/L$, in a solid to the applied stress, F/A, through the relationship $F/A = E(\delta L/L)$. To determine E, a tensile tester is used, and F, L, δL, and A are measured. The uncertainties in each of these quantities are 0.5%, 1%, 5%, and 1.5%, respectively, all with 95% confidence.

(a) (2 points) Calculate the uncertainty in E in percentage form.

(b) (2 points) Which of these measurements has the greatest effect on the uncertainty of E?