FY116G Problem 3.2 - Uncertainty Analysis

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Get[ "UCAnalysis.m", Path → {NotebookDirectory[]} ]
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$$\frac{p_1\,T_2}{p_2\,T_1} \;\mapsto\; \begin{pmatrix} p_1 & 2.5\ \text{atm} \pm 0.05\ \text{atm} & \text{Uniform}\mathcal{D} & \text{Pa} \\ T_1 & (7.0 + 273.15) \pm 0.05 & \text{Uniform}\mathcal{D} & \text{K} \\ p_2 & 1.0\ \text{atm} \pm 0.05\ \text{atm} & \text{Uniform}\mathcal{D} & \text{Pa} \\ T_2 & (27.0 + 273.15) \pm 0.05 & \text{Uniform}\mathcal{D} & \text{K} \end{pmatrix}$$

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atm := 101 325; (*Pa*)
ϘUCResult[ V_Style[2,Smaller] "/" V_Style[1,Smaller], , UcPrecision → 2, Precision → 12 ]
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$$V_2/V_1 = 2.67847581653 \pm 0.0832781$$
$$\in [2.595198;\ 2.761754];\ \text{Normal}\mathcal{D}$$
$$\simeq (2.678 \pm 0.084) \times 10^0 = 2.678(84)$$

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ϘAnalysisEnvironment
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$$y = \frac{x_1\,x_4}{x_2\,x_3}$$

Quantity		Estimate ± Uncertainty	Distribution	$\lvert \partial f/\partial x_i \rvert$
x_1	p_1	$(2.5331250 \pm 0.0506625) \times 10^5$	Uniform	1.05738×10^{-5}
x_2	T_1	$(2.8015 \pm 0.0005) \times 10^2$	Uniform	9.56086×10^{-3}
x_3	p_2	$(1.0132500 \pm 0.0506625) \times 10^5$	Uniform	2.64345×10^{-5}
x_4	T_2	$(3.0015 \pm 0.0005) \times 10^2$	Uniform	8.92379×10^{-3}

y	2.67847581652686061038729252186	
y_{min}	2.4990482988342	$= y - 0.179428$
y_{max}	2.8768297036773	$= y + 0.198354$
ε_{max}	0.188417539856599475390038781 46	$= 7.03\,\%$
$y \pm \varepsilon_{max}$	$(2.68 \pm 0.19) \times 10^0$	$= 2.68(19)$
u_c	0.083278053210422433541133805918 8	$= 3.11\,\%$
$y \pm u_c$	$(2.678 \pm 0.084) \times 10^0$	$= 2.678(84)$

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ϘMonteCarlo[ 10^6 ] // ϘUC
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$$2.680748 \pm 0.0834035$$
$$\in [2.597344;\ 2.764151]$$
$$\simeq (2.681 \pm 0.084) \times 10^0 = 2.681(84)$$

Sanity Check

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?DumpRelationship
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$$V_2 / V_1 == \frac{p_1\, T_2}{p_2\, T_1}$$

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?DumpQuantities
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$V_2 / V_1 = 2.678476 \pm 0.0832781$

$\in [2.595198; 2.761754];$ Normal$\mathcal{D}$

$\approx (2.678 \pm 0.084) \times 10^0 = 2.678(84)$

$p_1 = (253\,312.5 \pm 5066.25)$ Pa

$\in [248\,246.2; 258\,378.8]$ Pa; Uniform$\mathcal{D}$

$\approx (2.533 \pm 0.051) \times 10^5$ Pa $= 2.533(51) \times 10^5$ Pa

$T_1 = (280.15 \pm 0.05)$ K

$\in [280.1; 280.2]$ K; Uniform$\mathcal{D}$

$\approx (2.8015 \pm 0.0005) \times 10^2$ K $= 2.8015(5) \times 10^2$ K

$p_2 = (101\,325 \pm 5066.25)$ Pa

$\in [96\,258.75; 106\,391.2]$ Pa; Uniform$\mathcal{D}$

$\approx (1.013 \pm 0.051) \times 10^5$ Pa $= 1.013(51) \times 10^5$ Pa

$T_2 = (300.15 \pm 0.05)$ K

$\in [300.1; 300.2]$ K; Uniform$\mathcal{D}$

$\approx (3.0015 \pm 0.0005) \times 10^2$ K $= 3.0015(5) \times 10^2$ K