Problem 2.2 - Uncertainty Analysis, Case A

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Get[ "UCAnalysis.m", Path → {NotebookDirectory[]} ]
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$$v_1 \left(\frac{d_1}{d_2}\right)^2 \mapsto \begin{pmatrix} d_1 & 0.5 \times 25.4 \pm 0.5 \times 25.4 \times 0.05 & \text{Uniform}\mathcal{D} \\ d_2 & 2.0 \pm 0.05 & \text{Uniform}\mathcal{D} \\ v_1 & 2.0 \pm 0.05 & \text{Uniform}\mathcal{D} \end{pmatrix}$$

Evaluated Functional Relationship

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♀AnalysisEnvironment
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$$y = \frac{x_1^2\, x_3}{x_2^2}$$

Variable		Uncertainty Interval	Distribution	$\lvert \partial f/\partial x_i \rvert$
x_1	d_1	$(1.2700 \pm 0.0635) \times 10^1$	Uniform	1.27×10^1
x_2	d_2	$(2.00 \pm 0.05) \times 10^0$	Uniform	8.0645×10^1
x_3	v_1	$(2.00 \pm 0.05) \times 10^0$	Uniform	4.03225×10^1

y	80.645	
y_{min} y_{max}	67.5431859012493 95.8673402366864	$= y - 13.1018$ $= y + 15.2223$
ε_{max} $y \pm \varepsilon_{max}$	14.112875 $(8 \pm 2) \times 10^1$	$= 17.5\,\%$ $= 8(2) \times 10^1$
u_c $y \pm u_c$	5.3341653620201 $(8.1 \pm 0.6) \times 10^1$	$= 6.61\,\%$ $= 8.1(6) \times 10^1$

Absolute Maximum Uncertainty

$$\varepsilon_{max} = \sum_{i=1}^{n} \lvert \partial_{x_i} f[x] \rvert\, \varepsilon_i ; \quad f[x] \pm \varepsilon_{max} \quad // \text{♀UCE}$$

$$80.645 \pm 14.1129$$
$$\in [66.53;\ 94.76]$$
$$\simeq (8 \pm 2) \times 10^1 = 8(2) \times 10^1$$

Combined Standard Uncertainty

$$u_c = \left(\sum_{i=1}^{n} (\partial_{x_i} f[x])^2\, u_i^2\right)^{1/2} ; \quad f[x] \pm u_c \quad // \text{♀UCA}$$

$$80.645 \pm 5.33417$$
$$\in [75.311;\ 85.979]$$
$$\simeq (8.1 \pm 0.6) \times 10^1 = 8.1(6) \times 10^1$$

Monte Carlo Simulation

```
Block[ { data, trials = 10^6 },
  data = f @@ Table[RandomReal[fDist[i], {trials}], {i, 1, n}];
  Mean[data] ± StandardDeviation[data] ] // QUCA
```

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80.7601896443237 ± 5.34317
 ∈ [75.417; 86.103]
 ≃ (8.1 ± 0.6) × 10^1 = 8.1(6) × 10^1
```