M E 345 - Instrumentation, Measurements, and Statistics

Today, we will:

- Introduce the course and instructor: **John M. Cimbala, 863-2739, jmc6@psu.edu**
- Briefly go over the course website at **www.mne.psu.edu/me345**
- Review first pdf module: **Introduction to Mechanical Engineering Measurements**
- Do some practice questions and example problems
- If time, show some hints about plotting in Excel.

Practice Questions:

1. How many significant digits are in each of these numbers?

(no decimal point if integer)

Number	Number of sig. digits	Exponential notation
603.	3	6.03×10^2
600	∞ (integer)	6×10^2 or 600×10^0
600	2	6.0×10^2
0.007	1	$7. \times 10^{-3}$
1.005	4	1.005×10^0
7	∞ (integer)	7×10^0
7.	1	$7. \times 10^0$
50.	2	5.0×10^1
0.01070	4	1.070×10^{-2}
732,000	∞ (integer)	732×10^3
732,000	5	7.3200×10^3
732,000	3	7.32×10^3
732,000.	6	7.32000×10^3

2. What is 2.00/3.0?

2 sig. digits

3 sig. digits

Our answer is limited to 2 sig. digits for multiplication / division

Ans = 0.666666... But must round to 2 digits

★ ANSWER = 0.67

NOTE:
- Do not use 0.67 for any subsequent calculations, since it is rounded
- To avoid round-off error, use more digits for further calculations, e.g., use 0.666667

Example: Significant digits

Given: 3 measurements with 3 different instruments

i) 134,290 (5 significant digits)
ii) 0.2875 (4 significant digits)
iii) 29.473 (5 significant digits)

(*a*) To do: Round each number to 3 significant digits.

Solution: i) $134,000$ or 1.34×10^5

ii) 0.288 (following convention, round up since 7 is odd)

iii) 29.5

(*b*) To do: Add the 3 numbers and report the answer to the appropriate number of significant digits.

i) 134,290 (5 significant digits)
ii) 0.2875 (4 significant digits)
iii) 29.473 (5 significant digits)

Solution:

- Align the decimal places
- Add
- Answer reported to left-most least significant digit

$$\begin{array}{r} 134,290. \\ 0.2875 \\ 29.473 \\ \hline 134,319.7605 \end{array}$$

Answer: $134,320$ or 1.3432×10^5

(*c*) To do: Multiply the first two numbers and report the answer to the appropriate number of significant digits.

i) 134,290 (5 significant digits)
ii) 0.2875 (4 significant digits)
iii) 29.473 (5 significant digits)

$134,290 \times 0.2875 = 38608.375$

(134,290: 5 digits; 0.2875: 4 digits)

Answer must be limited to 4 sig. dig.

Solution:

Answer: 38610

Notes:

- Again, do not use this for any further calculations to avoid round-off error. Instead, use 38608.375
- Other answers, like 38608.4, are okay since you clearly indicate 4 sig. digits in your answer.

Example: Significant digits – Gas mileage calculations

(*a*) **Given**: You travel 210.0 miles in your new car, and use 7.00 gallons of gas.

To do: Calculate your gas mileage in units of miles per gallon. Give your answer to the appropriate number of significant digits.

Solution:

$$\text{mpg} = \frac{210.0 \text{ mi}}{7.00 \text{ gal}} = 30.0000 \text{ mpg}$$

(4 sig. digits; 3 sig. digits)

→ But, answer is limited to 3 significant digits

Answer = **30.0 mpg**

(More properly, write 28.)

(*b*) **Given**: You estimate that your car gets 28 miles per gallon. Gas costs $3.899 per gallon.

To do: How much does it cost to travel 455 miles? Give your answer to the appropriate number of significant digits.

Solution:

Note: Need to create an equation based on the units

$$\text{Cost} = \frac{(455 \text{ miles})\left(\$3.899 \text{ / gal}\right)}{28. \text{ miles / gal}} = \$63.3588$$

But, 28. is only 2 sig. digits (it is not an integer).

So, Answer should be given to 2 sig. digits also.

Answer = **$63.** or **$63** [$63.4 also ok]

(*c*) **Given**: You fill up your tank, drive 316.5 miles, and pay $44.89 to fill up your tank again. Gas costs $3.799 per gallon. [Assume we fill the tank to exactly the same level.]

To do: Calculate your gas mileage in units of miles per gallon. Give your answer to the appropriate number of significant digits.

Solution:

- Again, use units to create the equation

$$\text{mpg} = \frac{(316.5 \text{ miles})(\$3.799/\text{gal})}{\$44.89}$$

$$= 26.78511 \text{ mpg}$$

- But limit final answer to 4 digits

Answer = **26.79 mpg**

Example: Significant digits – pressure

Given:

- Atmospheric pressure $P_{atm} = 101.3$ kPa
- Gage pressure at point 1 is 1,350 Pa
- Gage pressure is defined as $P_{gage} = P - P_{atm}$, where P = absolute pressure

To do: Calculate the absolute pressure at location 1, taking into account the appropriate number of significant digits.

Solution:

$$P_{gage,1} = P_1 - P_{atm} \rightarrow P_1 = P_{atm} + P_{gage}$$

$$\begin{array}{rr} P_1 = & 101.3 \text{ kPa} \\ + & 1.350 \text{ kPa} \\ \hline & 102.650 \text{ kPa} \end{array}$$

← Align decimal pts

Converted to kPa so we can add !!

Finally, limit answer to the left-most least significant digit

Ans. $\boxed{P_1 = 102.6 \text{ kPa}}$

Note: Use $P_1 = 102.65$ kPa for all subsequent calculations to avoid round-off error