

ME 301-Analysis and Instrumentation of Physical Systems

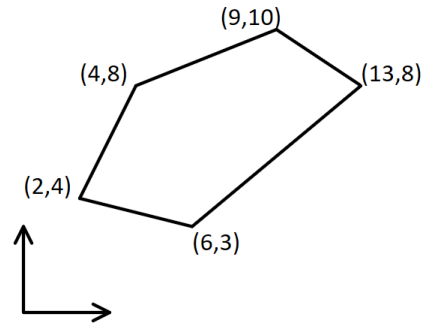
Final Exam- Spring 2021

Instructions:

- a. Open Book/Open Notes.
- b. Use one side of paper.
- c. Show all your work on the spaces provided.
- d. Show all your work for credit.
- e. Work neat organized and legible.
- f. Upload your exam before the due time.
- g. EMAIL SUBMISSIONS ARE NOT ACCEPTED UNDER ANY CIRCUMSTANCES

Question 1. (25 points)

Calculate the area of the irregular shape shown, numerically by using a tabular form of trapezoidal rule. Express your answer in square units. Use the table shown below as a guide.



| i | X_i | Y_i | | | |
|-----|-------|-------|--|--|--|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| | | | | | |

Question 2. (25 points)

Ideal Gas equation is given by $\frac{p}{\rho} = RT$. Where p is pressure measured in Pascals $\left(\frac{N}{m^2}\right)$

ρ is the density measured in $\left(\frac{kg}{m^3}\right)$, T is the temperature measured in $^{\circ}K$ and R is the specific gas constant given by $R = 288.33 \frac{N.m}{kg.^{\circ}K}$. In a certain experiment pressure of air is measured with an instrument to be $103,325 \pm 100 \frac{N}{m^2}$ and temperature is measured with a thermocouple to be $T = 29.75 \pm 1\% ^{\circ}C$

Determine the percent uncertainty in measurement of density, ρ .

Question 3. (25 points)

The data set shown in the table is linear and fits the equation:

$$y = ax + b$$

Calculate the values for a and b using least square regression analysis.

| i | x_i | y_i | | |
|---|-------|-------|--|--|
| 1 | 0.00 | 6.40 | | |
| 2 | 0.25 | 8.00 | | |
| 3 | 1.00 | 10.00 | | |
| 4 | 1.75 | 14.00 | | |
| 5 | 3.00 | 21.00 | | |
| 6 | 3.50 | 22.00 | | |
| 7 | 3.75 | 23.00 | | |
| 8 | 5.00 | 28.00 | | |
| | | | | |

Question 4. (25 points)

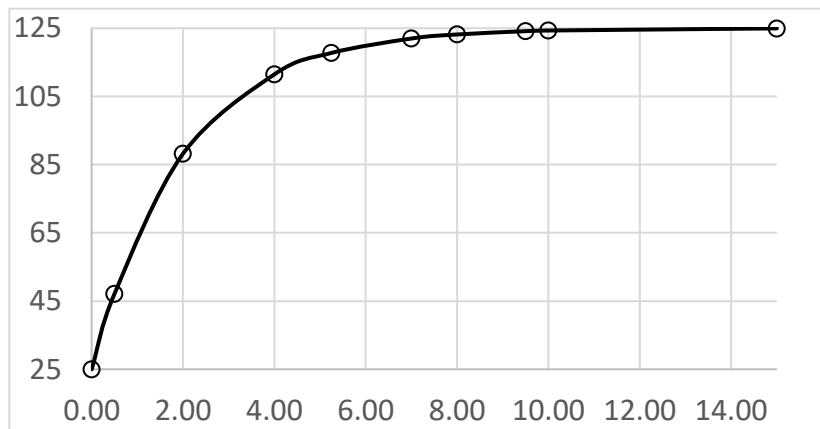
An experimental data set fits the equation:

$$\frac{y - y_0}{y_\infty - y_0} = 1 - e^{-\frac{t}{\tau}}$$

shown in the table and also shown graphically.

Using this data, determine the time constant, τ . Show your work and justify your answer.

| t | y |
|-------|--------|
| 0.00 | 25.00 |
| 0.50 | 47.12 |
| 2.00 | 88.21 |
| 4.00 | 111.47 |
| 5.25 | 117.76 |
| 7.00 | 121.98 |
| 8.00 | 123.17 |
| 9.50 | 124.13 |
| 10.00 | 124.33 |
| 15.00 | 124.94 |



Question 5. (25 points)

An experimental Data set fits the equation:

$$y = ax^3 + bx$$

Use the method of least squares to find expressions for the constants a, and b. Show all your work for credit.

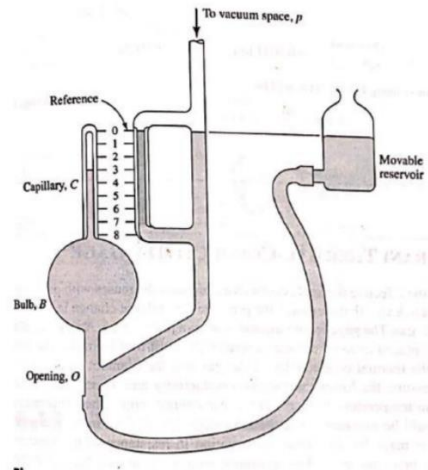
Hint: Start with

$$S = \sum (y_i - ax_i^3 - bx_i)^2 = 0$$

Question 6. (25 points)

A McLeod Gage is available which has a volume, V_B of 58.9 cm^3 and a capillary diameter of 1 mm.

The gage reading on the device is 15 cm. Calculate the pressure corresponding to this gage reading in micrometer of water.



Question 7. (25 points)

A U-tube manometer employs a special fluid having specific gravity of 8.25. One side of the manometer is open to the standard atmospheric pressure of 750 mm-Hg and the difference in column heights is measured as 94 mm when exposed to air source at 25° C. Calculate the pressure of the air source in Pascals. Assume density of water to be $1000 \frac{kg}{m^3}$

Question 8. (25 points)

Determine the mean free path for air at 300°C and pressures of $0.0163 \mu\text{m}$.