ME 321: Mechanical Measurements

This class is in-person instruction

Course Syllabus (Second Semester 1447/1448 H)

Instructor: Dr. Mohammed Alanazi

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Class Time: Mondays (8:00 am to 9:50 am)

Lab Time: By TA

Office Hours: Wednesdays (12:00 pm to 1:00 pm) or by email

Number of Credit: 2 (1,1,2) (X, Y, L)

Texts:

1. Bechwith, T, Marangoni, R. and Lienhard V, J. "Mechanical Measurements" 5th edition. Addison Wesley. 1995.
2. R. Figliola, and D. Beasley "Theory and Design for Mechanical Measurements" 4th Edition, J. WILEY, 2006.

Course Description: Measuring concepts; Data collection and analysis; Uncertainty analysis; Analog and Digital signal analysis; Time constant of measurement system; Sensing, Data modifying and data presentation; Applications of measurements for different mechanical properties.

Course Objectives: Measurement of physical variables: Force vector (N), Velocity vector (m/sec.), T(°C or K), P (Pascal), Frequency (Hz=cycle/sec).

- Measurement of Mechanical Parameters: $Re=\rho vd/\mu$, *Mach No.*$= v/c$, $PD=0.5\ \rho V^2$
- Accurate and Reliable Measurements: *Real value – vs – Measured value*

(Entries in brackets are links to program educational objectives)
Students who complete this course shall:

1. Possess the necessary basic knowledge of using methodologies for measurement of basic mechanical and electrical parameters. [1].
2. Have the ability to work in teams with individual responsibility and present reports and term papers in a professional manner [2].

Attendance: Attendance at every class meeting is expected.

Objectives of Mechanical Measurements

- **Measurement of physical variables:**

Force vector (N), Velocity vector (m/sec.), Temperature (^oC), Pressure (Pascal), Frequency (Hz=cycle/sec), Strain (μ strains), flow rate (kg/s, m^3/s)

- **Measurement of Mechanical Parameters**:

Reynolds Number $Re=\rho vd/\mu$, Mach No. $M = v/c$, Dynamic Pressure $=0.5\ \rho V^2$and other non-dimensional parameters

- **Application of Mech. Measurements**

Monitoring of a process

Operation of a process

Control of a process

- **Experimentation**

- Testing and performance operation

- Verification of properties or theory

- Information needed for analysis

Examples:

Checking or evaluation of: Oil viscosity variation with temp, Pump performance curve, Piping head loss, Lift and drag of new airfoil shape etc.

- **Calibration using Primary or/and Secondary Standards**

Known input signal and find the output.

- To establish the correct output scale.

- To find instrument reliability.

- To eliminate bias error (systematic error)

For linear relation $o/p \propto I/p$ needs single point calibration.

For non-linear relation needs multi-point calibrations.

Static calibration – vs – Dynamic calibration

- **Primary Standards for Comparison and Calibration**

SI System: Meter – Kg -- Sec.– Kelvin – volt - Mole – Ampere – Radian

Length (meter): Distance traveled by light in vacuum during *1/299792458* of a sec.

Mass (Kg.): International prototype *(alloy of platinum and iridium)* kept near Paris.

Time (Sec.): Duration of *9192631770* periods of the radiation emitted between two excitation levels of Cesium-133

Temperature (Kelvin): $K = {}^{o}C + 273$

- **Dimensional Analysis**

Data presented in dimensionless form.

Dimensional analysis helps in experimental planning and similitude

It reduces number of experimental variables.

№ of variables - № of dims. = № of π groups

Use pi method or by inspection

Basic dimensions: M L T θ (kg, m, sec, K)

COURSE LEARNING OUTCOMES

CLO1: Ability to comprehend different measurement systems, their functional elements, responses and apply knowledge of basic science and engineering for understanding their function.
ClO2: Ability to carry out analysis for replicated and repeated data, use uncertainty analysis for selecting proper sensor selection, understand measurement of different variables.
CLO3: Ability work in team to conduct an experiment, collect experimental data with replication, present, interpret and discuss experimental results with the aid of governing laws and write laboratory report as team with individual responsibility.

WEEK	LECTURE	CHAPTER	
		BOOK (1)	**BOOK (2)**
1	Introduction and fundamental concepts.	**1**	**1**
2	Standard and units, Calibration, Reporting of exp.	**2**	**1**
3,4	Assessing experimental data and Uncertainty analysis	**3**	**4,5**
5	Characteristics of signals, Frequency spectrum and sampling.	**4**	**2**
6, 7	Measurement system behavior and response, Sensors	**5,6**	**3,12**
8, 9	Signal conditioner, filters, amplifiers and bridge circuits	**7,8**	**6,7**
10	Digital data acquisition systems.	**9**	**7**
11	Measurement of displacement, strain, force, torque.	**11,12,13**	**11,12**
12,13	Measurement of pressure, flow and temperature	**14,15,16**	**8,9,10**
14,15	Acoustics measurements.	**18**	

GRADING

S. No	COMPONENT	PERCENTAGE
1	MID TERM EXAM	20
2	Quizzes	10
3	Group LABORATORY	15
4	Term Project	10
5	Individual LABORATORY	5
7	FINAL EXAMINATION	40
TOTAL	100	

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Laboratory Report

Read the experiment before laboratory class.

Lab. Report should be of maximum 5 pages without figures and tables. The report should be written in WORD and it should include:

- Title of Exp., Date, Lab., Students Names (max. 3).
- Objective: data analysis, planning of expt., uncertainty.
- Sketch apparatus, test rig, instrumentation.
- Describe the procedure, dimensional analysis, calibration.
- Record exp. data with replications and note the observations.
- Discuss results and analyze data and uncertainty.

Attach a copy of your lab. notebook pages.

Lab. Report Grading: depends on, presentation of objective, instrument and sensor used, clarity, dimensional analysis, error analysis, results and discussion.

CONTENTS OF A LABORATORY REPORT

Objective

Theoretical background

Description of instrument and sensor

Dimensional analysis

Error analysis

Presentation of results using sketches graphs and tables

Discussion of results

Laboratory report should have maximum of five pages without figures and tables.
Laboratory report should have actual copy of note book page of results attached to it.

DESCRIPTION OF COMMUNICATION PART

Laboratory:

Get the laboratory Note book signed by T. A.

Read over the experiment before laboratory Hour

Understand the procedure clearly

Make good sketches of experimental setup

Obtain experimental data with replications and record observations

Lab. Report grading depends on effective communication and clarity of report.

CONTENTS OF A LABORATORY REPORT

Objective: Here the main objectives of the experiment are spelled out.
Introduction: The basic definitions of the property being are clearly defined. Also, the background introduction to measurement system and the property being measured is given here.
Theory: The theoretical back ground consisting of assumptions and evolution of basic equations is sought in this section.
Planning of Experiment: This section has two parts, dimensional analysis to decrease number of variables involved in the experiment and consideration of alternative method of measurement is carried out.

Description of instrument and sensor: This section deals with showing the layout of experimental facility and main sensors used in the measurement.
Procedure: The step wise methodology of experiment is discussed in this section.
Presentation of results: This section deals with presentation of results from the experiment using graphs and tables. The uncertainty analysis of the main result is also shown and reported in this section. Here trends of changes if any are discussed and reasons for the same are also discussed. Presentation of the results and discussion can be separated also as different sections.
Conclusions: The main conclusions of the experiment are listed out in this section.
Appendix: In this section the detailed derivation of formulas are presented here.

MEASUREMENT LABORATORY

TOPIC OF EXPERIMENT
First: Basics of Measurement Techniques
Second: Discussion about Laboratory Procedure and Report Writing
Third: Measurement of Uncertainty and its propagation.
Fourth: Writing of First Report
Fifth: Calibration of Thermocouple
Sixth: Calibration of a Deflection Sensor
Seventh: Calibration of a Force Sensor
Eight: Response of First order Measuring System
Ninth: Calibration of a Flow Sensor
Tenth: Calibration of Velocity Sensor
Eleventh: Calibration of a Pressure Sensor
Twelfth: Basics of Data Acquisition- Lab View