Pokhara University
Faculty of Science and Technology

Course Code: ELE 172 (3 Credits)	Full Marks: 100
Course Title: Instrumentation (3-1-2)	Pass Marks: 45
Nature of the course: Theory & Practical	Total Lectures: 45 hours
Level: Bachelor	Program: BE

1. Course Description

This course is designed to provide students with basic concepts of Instrumentation and Measurements. After completion of this course the students will understand the fundamental concept of Analog and Digital instrumentation with signal conditioning, wave shaping and filtering. The theory part shall provide instruction on instrumentation and the practical part would be validation of most of the analyses and calculations covered in theory.

2. General Objectives

The course is designed with the following general objectives:

- To provide comprehensive idea about Analog and Digital Instrumentation.
- To provide comprehensive idea about signal conditioning and Data Acquisition System.

3. Methods of Instruction

3.1 **General Instructional Techniques:** Lectures, Tutorials, discussion, question-answer, brain storming, etc.

3.2 **Specific Instructional Techniques:** All the units of the course are practical oriented. Both the theory and practical classes are to be synchronized and a practical work shall be assigned for every theory unit.

4. Contents in Detail

Specific Objectives	Contents
Explain the Basic of Instrumentation, Bridge Measurement and Transducers	**Unit 1: Introduction to Instrumentation System (10 hrs)** 1.1 Typical applications of Instrument systems 1.2 Functional elements of Instrumentation and Measuring systems i.e., Input elements (Transducers and Electrodes), intermediate elements (signal conditioning) and output elements (Data display and storage). 1.3 Errors and uncertainties in Measurements and Static performance characteristics of instruments: 1.3.1 Introduction to errors and uncertainties in the measurement of performance parameters of instruments.

	1.3.2 Static performance parameters: Accuracy, Precision, Resolution, Threshold, Sensitivity, Linearity, Hysteresis, Dead band, Backlash, Drift, Span 1.3.3 Impedance loading and matching 1.3.4 Errors: Statistical analysis of error in measurement 1.3.5 Standards of measurement 1.4 Bridge Measurement: 1.4.1 DC bridges- Wheat-stone bridge 1.4.2 AC bridges – Kelvin, Hay, Maxwell, Schering and Wien bridges 1.4.3 Wagner ground Connection 1.5 Physical Variable and Transducer 1.5.1 Physical Variable and their types (Electrical, Mechanical, Process and Biophysical) 1.5.2 Transducer principle and operation 1.5.3 Input and output characteristics and application of transducers 1.5.3.1 Resistive 1.5.3.2 Capacitive 1.5.3.3 Inductive 1.6 Measurement of mechanical variables, displacement, strain. velocity. acceleration and vibration 1.7 Measurement of process variables - temperature pressure, level, fluid flow, chemical constituents in gases or liquids, pH and humidity 1.8 Measurement of bio-physical variables blood pressure and myoelectric potentials 1.9 Calibration and error in transducers 1.10 Measurement of voltage & current (moving coil & moving iron instruments 1.11 Measurement of low, high & medium resistances
Explain the basis of Analog instruments and Principle of equipment used in measurement of electrical quantities	**Unit II: Principle of Analog Instruments (7 hrs)** 2.1 Review of DC/AC voltmeter and Ammeter: The D' Arsonval Principle 2.2 DC Multirange Ammeters and Extending Ammeter ranges 2.3 DC Multirange Voltmeters and Extending Voltmeters ranges 2.4 AC voltmeter and multi range voltmeter 2.5 Ohm Meter and Multirange 2.6 Electronic Multimeter 2.7 Multimeter as a micro ammeter and dc ammeter Types pf voltmeter: Differential type and True rms

	2.8 Wattmeter: Types and Working principles 2.9 Energy Meter: Types and Working Principle 2.10 Power Factor Meter 2.11 Instrument Transformer
Explain about the Signal conditioning and transmission system	**Unit III: Electrical Signal Processing and Data Acquisition (7 hrs)** 3.1 Basic Op-amp characteristics 3.2 Instrumentation amplifier 3.3 Signal amplification, attenuation, integration, differentiation, network isolation, wave shaping 3.4 Effect of noise, analog filtering, digital filtering 3.5 Data Acquisition System 3.5.1 Analog Data Acquisition System 3.5.2 Digital Data Acquisition system 3.5.3 Single channel Data Acquisition system: 3.5.4 Multi-channel Data Acquisition system 3.5.5 PC based Data acquisition system 3.6 Series and Parallel transmission: 3.6.1 Features and application of RS232 cable 3.6.2 Features and application of IEEE 1248 B 3.7 Optical communication, fibre optics, electro-optic conversion devices
• Explain about the analog to Digital and Digital to Analog converter in depth	**Unit IV: Date Converter and Connectors (8 hrs)** 4.1 Analog to Digital Converter (ADC) and Digital to analog Converter (DAC): Principle and Specification 4.2 Quantization Error 4.3 Types of ADC 4.3.1 Flash type ADC 4.3.2 Counter type ADC 4.3.3 Successive Approximation Type ADC 4.3.4 Dual Slope ADC 4.3.5 Introduction to Delta-Sigma ADC 4.4 Types of DAC 4.4.1 Weighted Resistor DAC 4.4.2 R-2R Ladder DAC 4.4.3 PWM Type DAC 4.5 Probes and Connectors 4.5.1 Test Leads: Twisted pair unshielded test leads 4.5.2 Shielded Cables 4.5.3 Connectors 4.5.4 Low Capacitive Probes 4.5.5 High Voltage Probes 4.5.6 Current Probes

• Compare different types of wave analyzer and principle of Digital instrumentation.	**Unit V: Wave Analyzers and Digital Instruments (8 hrs)** 5.1 Wave Analyzer 5.1.1 Frequency Selective Wave Analyzer 5.1.2 Heterodyne Wave Analyzer 5.2 Spectrum Analyzer 5.2.1 Basic Spectrum Analyzer using Swept Receiver Design 5.2.2 IRF Spectrum Analyzer 5.3 Distortion Analyzer: Harmonic Distortion Analyzer-Fundamental Suppression Type 5.4 Measurements of Frequency and Time: Decimal Count Assembles 5.5 Frequency Counter 5.6 Period Counter 5.7 Error: Counter Error and Signal Related Error 5.8 Digital Voltmeter 5.8.1 Ramp type digital voltmeter 5.8.2 Integrating type digital voltmeter 5.8.3 Servo Potentiometer type digital Voltmeter 5.8.4 Successive Approximation type digital Voltmeter 5.9 Vector Voltmeter 5.10 Digital Multimeter 5.11 Computer Based Digital Instruments: IEEE 488 GPIB Instrument
Differentiate different types of output devices used in instrumentation	**Unit VI: Recorders, Displays and Storage Devices (5 hrs)** 6.1 Oscilloscopes: 6.1.1 Cathode Ray Tube, Vertical and Horizontal Deflection Systems, Delay lines, Probes and Transducers, 6.1.2 Specification of an Oscilloscope 6.1.3 Oscilloscope measurement Techniques 6.2 Special Oscilloscopes – Storage Oscilloscope, Sampling Oscilloscope 6.3 Recorders Basic recording systems. Strip chart recorders. Galvanometer and Potentiometer type recorders (direct and null type) 6.4 Indicators and display Devices - Nixie, LED, LCD and seven segment and dot matrix displays. 6.5 Magnetic tape and disc recorders 6.6 Data loggers, Dot matrix and laser printers 6.7 Compact disc/Optical disc recorders

5. List of Tutorials

The following tutorial activities of 15 hours per group of maximum 24 students should be conducted to cover all the required contents of this course:

Unit	Tutorial
I	Error Calculation Calculation of Dynamic behavior of instrumentation Calculation of Different Bridge Measurements Calculation of Transducers
II	Torque calculation of Wattmeter and Energy Meter Range Extension of Analog Voltmeter and Ammeter
III	Calculation and Design of Signal conditioning circuits Calculation and design of wave shaping circuits and filters
IV	Calculation of Resolution and Quantization error Calculation for ADC and DAC
V	Calculation on Counter Error and Signal Related Error

6. Laboratory Works

1. Accuracy test in Analog Meter
2. Operational amplifier in circuits: Use of Op-amp as
3. summer, inverter, integrator and differentiator
4. Use of Capacitive, inductive transducer to measure displacement
5. Use strain gauge transducer to measure force
6. Study of Various transducer for measurement of angular displacement. angular Velocity, pressure and flow
7. Use optical, Hall effect and inductive transducer to measure angular displacement
8. Use tacho-generator to measure angular velocity
9. Use RTD transducers to measure pressure and flow
10. Digital to Analog Conversion to Perform static testing of D/A converter
11. Analog to Digital Conversion to Perform static testing of A/D converter

7. Evaluation System and Students' Responsibilities

Evaluation System

In addition to the formal exam(s), the internal evaluation of a student may consist of quizzes, assignments, lab reports, projects, class participation, etc. The tabular presentation of the internal evaluation is as follows.

Internal Evaluation	**Weight**	**Marks**	**External Evaluation**	**Marks**
Theory		30		
Attendance & Class Participation	10%			
Assignments	20%			
Presentations/Quizzes	10%			
Internal Assessment	60%			
Practical		20		

Attendance & Class Participation	10%		Semester-End examination	50
Lab Report/Project Report	20%			
Practical Exam/Project Work	40%			
Viva	30%			
Total Internal		50		
Full Marks: 50 + 50 = 100				

Student Responsibilities

Each student must secure at least 45% marks in internal evaluation with 80% attendance in the class in order to appear in the Semester End Examination. Failing to get such score will be given NOT QUALIFIED (NQ) and the student will not be eligible to appear the Semester-End Examinations. Students are advised to attend all the classes, formal exam, test, etc. and complete all the assignments within the specified time period. Students are required to complete all the requirements defined for the completion of the course.

8. Prescribed Books and References

Text Book

Helfrick, A. D. & Cooper, W. D. *Modern Electronic Instrumentation and Measurements Techniques*. Prentice Hall of India

Reference Books

1. Nihal Kularatna, Digital and Analogue Instrumentation testing and measurement, The Institution of Engineering and Technology, London, United Kingdom n First published 2003 Reprinted 2008
2. A K. Sawhney, A Course in Elec. & Electronics Measurements & Instrumentation, Dhanpat Rai and Sons India, 1998
3. Joshph J.Carr,Elements of Electronics Instrumentation and Measurement-3rd Edition by.Pearson Education.