# General Characteristics of Measurement Systems

- Apply the rules for significant digits and unit conversions to problems involving English or SI units (including all definitions for gc).
- State and discuss in terms a bright high school student would understand the following definitions related to instrumentation: analog, digital, error (bias and random), uncertainty, precision, range, accuracy, resolution, repeatability, linearity, null (zero), and sensitivity.

## Indicating and Recording Devices

- Use analog and digital oscilloscopes to determine amplitude, frequency, and phase of periodic signals (sine, triangle, square).
- Use digital multimeter (DMM) to measure voltage, current and resistance.

## Statistics and Experimental Uncertainty Analysis

- Calculate uncertainty for results computed from several uncertain measurements using the partial derivative form and the simplified method for polynomial expressions.
- Determine the mean and standard deviation (of sample and population) for a set of experimental data and use to determine the uncertainty of the mean value (for large samples).
- Use the modified Thomson’s τ-test to reject questionable data points.

## Written Reports

- Write individual formal lab reports with required sections and follow modified APA style for formatting of figures, tables, references, and equations.
- Write formal lab reports in a 2 or 3 person groups with assigned roles, including editing and revision of rough drafts.

## Signal Conditioning and Operational Amplifiers

- Sketch wiring diagrams and select components for standard op-amp circuits (single input inverting, single input non-inverting, voltage follower, summing, difference, integrator, differentiator, comparator).
- Design an op-amp circuit using two or more op-amps to provide specified amplification characteristics (gain, offset).
- Verify theoretical equations with experimental data for two or more of the following op-amp circuits: single input (inverting and non-inverting), voltage follower, summing, and difference.

## Data Acquisition

- Convert between equivalent digital and analog values for 8, 10, and 12 bit analog-to-digital converters using offset binary notation.
- Determine from experimental data the time constant for a first order system subjected to a step input.
- Use a LabView™ data acquisition module to simultaneously collect data from multiple sensors and write data to text file for off-line plotting and analysis.
- Modify a LabView™ data acquisition module to provide desired gain and offset correction for load cell measurements.
- State and discuss in terms a bright high school student would understand the following definitions related to data acquisition: ADC, DAC, bits, resolution, range, sampling frequency, aliasing, multiplexing, single-ended input, differential input.
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<tr>
<th>Strain Gages, Force and Torque Measurement</th>
<th>Evaluation</th>
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<tr>
<td>• Install strain gage on beam and/or thin walled cylinder and wire into the appropriate Wheatstone bridge</td>
<td>Lab</td>
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<tr>
<td>• Sketch four common Wheatstone bridge arrangements (quarter, half – same strain, half – opposite strain, full) and relate measured output voltage to sensed strain</td>
<td>HW, Test, Lab</td>
</tr>
<tr>
<td>• Develop theoretical relationship between applied load and strain for uniaxial stress conditions: pure bending, axial tension, axial compression</td>
<td>HW, Test, Lab</td>
</tr>
<tr>
<td>• List the steps required to calibrate a load cell</td>
<td>Test</td>
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<td>• Use a load cell to measure dynamic torque in an electric dynamometer</td>
<td>Lab</td>
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<tr>
<td>• Determine operating range, sensitivity, accuracy/linearity, repeatability, and an estimate of uncertainty of force and torque sensors from manufacturer’s literature</td>
<td>HW, Test</td>
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<tr>
<th>Displacement, Velocity, and Acceleration Measurement</th>
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<tr>
<td>• List displacement transducers suitable for given measurement task and describe the advantages and disadvantages of each selection</td>
<td>HW, Test</td>
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<tr>
<td>• Calibrate displacement transducers with a higher accuracy device</td>
<td>Lab</td>
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<tr>
<td>• List velocity transducers or velocity measurement techniques suitable for given measurement task and describe the advantages and disadvantages of each selection</td>
<td>HW, Test</td>
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<tr>
<td>• Measure the angular velocity of a rotating shaft with several velocity transducers and determine the relative advantages and disadvantages of each transducer</td>
<td>Lab</td>
</tr>
<tr>
<td>• Determine operating range, sensitivity, accuracy/linearity, repeatability, and an estimate of uncertainty of displacement, velocity, and acceleration sensors from manufacturer’s literature</td>
<td>HW, Test</td>
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<th>DC Motors and Speed Control</th>
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<tr>
<td>• Use the steady-state operating equations for a permanent magnet, DC motor to solve for one or more of the following: armature resistance, armature current, operating speed, motor efficiency, output torque, input power, output power, power dissipated in windings (in both U.S. engineering and S.I. units)</td>
<td>HW, Test</td>
</tr>
<tr>
<td>• Experimentally determine the motor constants and the speed-torque curve for a DC motor with a dynamometer and a tachometer</td>
<td>Lab</td>
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<tr>
<td>• List methods for controlling the armature voltage (and speed) of DC motors and discuss the advantages and disadvantages of each method</td>
<td>HW, Test</td>
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<th>AC Motors and Speed Control</th>
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<tr>
<td>• Sketch typical speed-torque curves for single-phase (split capacitor, shaded pole, …) AC motors and describe the operating characteristics and limitations of each motor type</td>
<td>HW, Test</td>
</tr>
<tr>
<td>• List methods for controlling the speed of AC motors and discuss the advantages and disadvantages of each method</td>
<td>HW, Test</td>
</tr>
<tr>
<td>• Experimentally determine the speed-torque relationships for an AC motor with a dynamometer and a tachometer</td>
<td>Lab</td>
</tr>
<tr>
<td>• Justify your selection of an electric motor (AC or DC) for a given industrial or commercial application</td>
<td>HW, Test</td>
</tr>
</tbody>
</table>
### Proximity Sensors and Electrical Control Components

- **Describe** the operational characteristics (range, target sensitivity, environmental sensitivity) and limitations of the following types of proximity sensors: inductive, photoelectric, magnetic, micro-switch.

  - HW, Test

- **Sketch** the wiring diagram, connect, and use proximity sensors with conventional current “sinking” (NPN) and “sourcing” (PNP) outputs.

  - HW, Test, Lab

- **Sketch** the wiring diagram, connect, and use switches and pushbuttons with SPST, SPDT, and DPDT contact configurations.

  - HW, Test, Lab

### Industrial Pneumatic Components

- **Identify** and label fluid power components (list) from their NFPA schematic symbols.

  - HW, Test

- **List** the three classifications of fluid power valves and describe the operation of one valve from each classification in detail.

  - Test

- **Sketch** the pneumatic system diagram using NFPA symbols for an actual system consisting of regulators, filters, lubricators, manual valves, solenoid valves, flow control valves, cylinders, etc.

  - HW, Test, Lab

### Logic Control and Programmable Logic Controllers

- **Describe** the following components of a ladder logic diagram:
  - N.O. and N.C. contacts,
  - control relay,
  - inputs,
  - outputs,
  - “AND” logic,
  - “OR” logic,
  - timer,
  - counter,
  - “hold” circuit.

  - HW, Test

- **List** the ME 360 “rules” for ladder logic and describe the reason why each rule is used.

  - Test

- **Describe** the operation of a ladder logic diagram (given the associated fluid power system) in either PLC format.

  - HW, Test

- **Debug** a given ladder logic diagram and modify so that it works correctly.

  - HW, Test, Lab

- **Design** a ladder logic diagram (using the components listed above) for a specified industrial automation task.

  - HW, Test, Lab

### Industrial Hydraulic Components

- **Identify** and label fluid power components (list) from their NFPA schematic symbols.

  - HW, Test

- **Describe** the operation of hydraulic circuits including pressure relief, pressure reducing, sequence, counterbalance, and directional control valves.

  - Test

- **Sketch** a hydraulic system diagram using NFPA symbols for an actual system consisting of pumps, solenoid valves, flow control valves, cylinders, etc.

  - HW, Test