

UNIVERSITY OF RUHUNA – FACULTY OF TECHNOLOGY

BACHELOR OF ENGINEERING TECHNOLOGY

Level II (Semester II) Examination, April 2019.

ENT2232 Instrumentation and Calibration

Time Allowed Two Hours

[Answer All (4) Questions]

Semester : Level II, Semester II

Module : Instrumentation and Calibration (ENT 2232)

Time : 2 hours

Instructions

- This question paper consists of 4 questions in 5 pages. All questions must be answered.
- All answers to new questions should start in a new page, and all the answers to each question should be organized together.
- Do NOT write answers in the question paper itself.
- All calculations should be shown, and all assumptions stated clearly.
- This is a closed book examination and therefore no study material is allowed.
- Non programable calculators are allowed, while cell phones and other mobile devices are strictly prohibited.

Q1.

a) Given below is internationally accepted definition of "calibration", according to the International vocabulary of metrology (VIM).

"operation that, under (i) specified conditions, in a first step, establishes a relation between the (ii) quantity values with measurement uncertainties provided by (iii) measurement standards and (iv) corresponding indications with associated measurement uncertainties and, (v) in a second step, uses this information to establish a relation for obtaining a measurement result from an indication"

Given below are the main steps followed during the calibration of a 0 - 160mm inside groove digital Vernier caliper (external measuring faces).

- Check the Vernier caliper for any damages.
- Measuring faces are inspected and cleaned properly, caliper is checked for smooth movement of the parts.
- Check the parallelism of the external faces.
- Both the Vernier caliper and the caliper checker are left in a 20 °C environment for several hours to bring both to 20 °C.
- The Caliper zero point is set.
- The 20 mm, 50 mm, 100 mm, and 150 mm caliper checker lengths are measured with the caliper and the following readings were recorded.

Caliper Checker length	Digital caliper reading
20.00 mm	20.010 mm
50.00 mm	50.025 mm
100.00 mm	100.05 mm
150.00 mm	150.075 mm

Referring to the steps of the digital Vernier caliper calibration, mentioned above, explain the meaning of each of the terms below (used in the definition of calibration).

- I. "Specified conditions"
- II. "Quantity values"
- III. "Measurement standard"
- IV. "Corresponding indications"
- V. "in a second step, uses this information to establish a relation for obtaining a measurement result from an indication", (according to the table of values)
what is this relationship in this calibration?

- a) A caliper is made from steel that has a linear expansion coefficient of $11 \times 10^{-6} \text{ K}^{-1}$. It is designed to work properly at 20°C (nominal temperature) and has a measuring range of 150 mm. Assume the caliper was used in the north pole (-40°C) to measure a ceramic rod. The rod is used in a precision machine, and has a length of 120.000 mm at 20°C and its linear expansion coefficient is $11 \times 10^{-8} \text{ K}^{-1}$. If this rod was measured in the -40°C environment using the above-mentioned caliper what value will the caliper indicate? (Assume that Vernier caliper has a digital display and the readability (resolution) of it is 0.005 mm).
Using this calculation, explain why certain calibration labs need to be maintained at a specific temperature.

- b) Explain the meaning of "metrological traceability", and importance of having an unbroken traceability chain in an accredited calibration.

Q2.

- a) Thermocouples are a temperature sensor type widely used in the industry, that is based on the thermo electric effect.
(You may use the thermocouple table provided at the back of the paper to answer this question)

- I. Using a diagram of a thermocouple temperature measurement arrangement, explain/indicate the meaning of (a) hot junction and (b) reference junction.
- II. Say a chromel-constantan thermocouple is used for a temperature measurement. If the reference junction is maintained at 0°C , and the voltage (electromotive force (e.m.f.)) measured is 10.20 mV, calculate the temperature at the hot junction of the thermocouple.
- III. For the same thermocouple mentioned in part (ii), if the reference junction was maintained at 90°C , and the measured Voltage (e.m.f.) is 21.70 mV, what is the temperature at the hot junction.

- b) Resistance Temperature Detectors (RTDs) are a highly accurate type of temperature sensors. Given below is a calibration table of a (RTD) DIN43760 100 Ω , Platinum, 385 alpha RTD. Check if the RTD under test meets the allowable tolerance, by completing the calibration table below, if the allowable tolerance specified is 0.1 % of reading.
(The RTD table is provided at the back of the question paper).
(Hint : $T(0C) = (T(0F) - 32) * (5/9)$)

Test Point (°F)	Temperature Standard Reading (°F)	Conversion To (°C)	Expected RTD Resistance (Ω)	Actual RTD resistance (Ω)	Error (Ω)
50	50			103.88	
100	100			114.70	
150	150			125.40	
200	200			136.00	
250	250			146.50	

Q3.

a) Assume that you work for a manufacturing company in Sri Lanka. A thermometer used for the testing of a manufacturing process needs to be calibrated through an accredited calibration laboratory and needs to be adjusted to function within the manufacturer specifications.

- I. What institute in Sri Lanka is responsible for providing accreditation for calibration labs?
- II. What are the BIPM (Bureau international des poids et mesures) recognized national organizations that maintain the national level standards in Sri Lanka?
- III. What is the most reliable method to find the list of accredited calibration laboratories in Sri Lanka?
- IV. Apart from accreditation what is the next most important information about the calibration lab you would need to pay attention to when choosing a suitable calibration lab.
- V. What are the two main types of calibrations performed by calibration labs, what type of calibration should you perform in this particular scenario (given that the operation of the instrument within specifications is important).
- VI. What requirements should you specify to the calibration lab.

b)

- I. Assume you are tasked with setting up of a new measuring instrument at a manufacturing plant, give at least 4 attributes that should be considered when choosing the right measuring system/instruments for a given task. Explain what each of them mean in no more than 3 sentences.
- II. Readings obtained for the measurement of a 5Ω resistor with 3 different multimeters is shown in Figure Q3(b) below. Fill in the blanks with the correct word High/ Low.

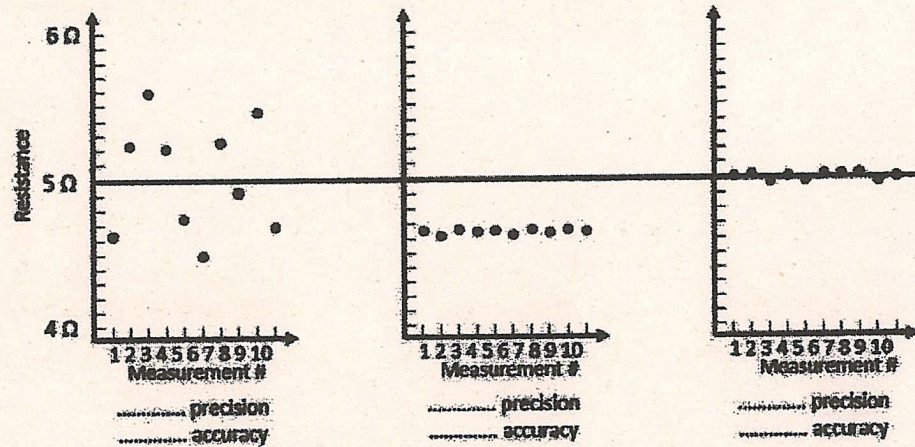


Figure Q3(b)

Q4.

Periodic calibration is an important aspect any engineer/technician in charge of measurement systems, would have to pay attention to.

- a) Give at-least 4 main reasons why periodic calibration is important in the manufacturing industry.
- b) Say you are the in charge of a newly installed pressure measuring instrument used in a manufacturing plant. Explain how you would decide a good calibration interval for the instrument.
- c) Normally, two set of values are reported when a calibration is performed, "As Found" readings and "As Left" readings. Explain the meaning of each of these terms and why it is important to report the "As Fond" readings.