# Metrology Qualifier Exam (sample questions)

Answer the first question and 4 of the remaining 5 questions (answer 5 total)

1. (Required)
   a) Following the ISO/IEC Guide to the Expression of Uncertainty in Measurement (GUM), define uncertainty in measurement.

   b) According to the GUM, what are Type A and Type B evaluations of uncertainty contributions? Give examples.

   c) What circumstances determine if Type A or Type B evaluation be used?

   d) Define traceability for a dimensional measurement.

   e) Are all traceable dimensional measurements traceable to a National Measurement Institute (NIST, PTB, NIM, etc.)?   Why or why not?

2. Machine tools and measuring equipment

Corrected Bidirectional Linear Accuracy Indications
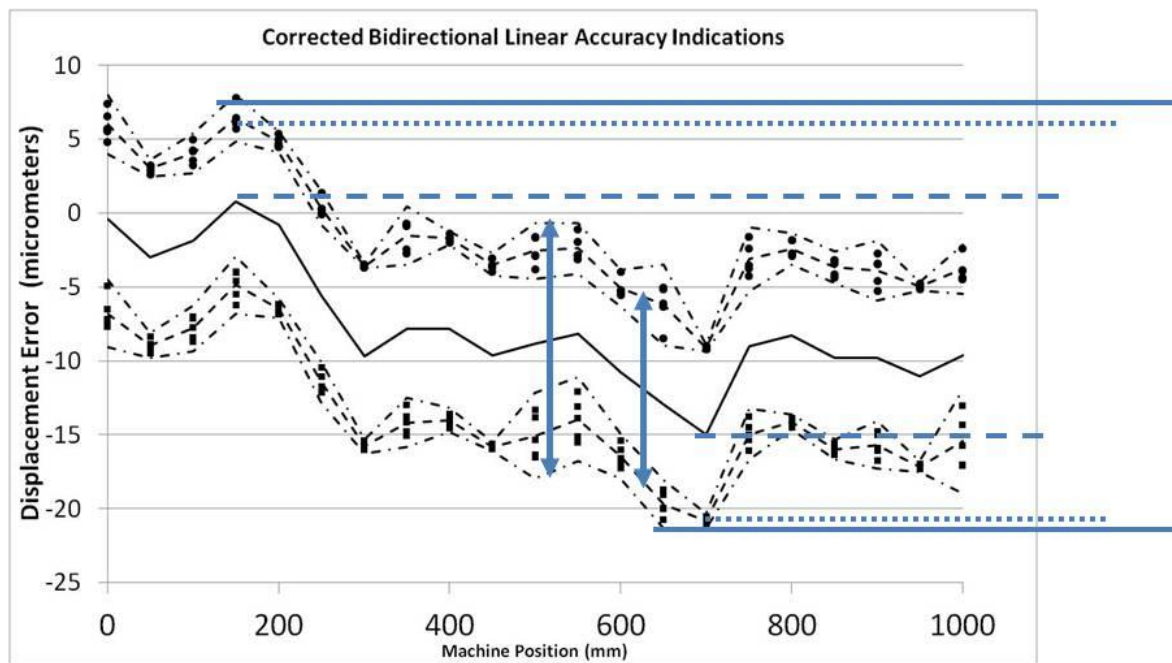
The linear displacement accuracy has been measured for a machine tool. Using the nomenclature of the ISO 230 standard series:
1. Label the chart with the symbols A,E,R,B,M
2. Name/define what is represented by the symbols.
3. Give the mathematical equations to calculate values for the symbol

3. Describe in your own words testing of the length measuring error (the E-test) for CMMs according to ASME B89.4.10360.2 and/or ISO 10360-2. Describe the different reference artifacts that can be used as test lengths, the orientations of these lengths, and how the errors are reported.

4. Thermal effects on instruments

    a) What is the internationally agreed upon temperature for the definition of the unit of length and why is this necessary?

    b) With respect to measurements made with a CMM, how do the temperature at which the CMM was calibrated, the temperature of the CMM during part measurement, the part temperature when manufactured, and the part temperature when measured influence the measurement results? How are these typically accounted for when reporting the measurement results?

    c) Give any equations relevant to the thermal effects in their symbolic form.

    d) Describe how thermal gradients influence workpiece measurements and the current state-of-the-art with respect to their correction.

5. You perform a measurement of an aluminum rod and your instrument indicates a length value of 128.75 mm. The MPE for the instrument is stated as ±0.10 mm and the resolution of the instrument is 0.05 mm. The rated conditions for the instrument include a temperature range of 15 – 25 °C. The thermometer in the room reads 24.5 °C and you believe that this reading has a k=2 expanded uncertainty of 1.0 °C.

    Given a "textbook" value for the CTE of aluminum to be 23 x 10-6 / °C, state the length of the rod corrected to 20 °C and the expanded uncertainty of this measurement result.

    Clearly state any assumptions made in your calculations.