

## EP 122 Measurement Techniques and Calibration, EK Exam Questions

*These are the retest exam questions (starting from next page) of the course.  
Here is the instructions for sending your solutions after downloading this file.*

- S1. Print this document
- S2. Write your solution steps clearly in the space provided.
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- S4. Send this file to EmailAddress [bingul@gantep.edu.tr](mailto:bingul@gantep.edu.tr)
- S5. Subject (konu) of your email must be ep122 but yourIdNo

***Deadline date / time : 03 Sep 2021 / 11:00***

**If you do not obey one of the rules above, your paper won't be considered as an exam paper!**

**Good Luck,  
Prof. Dr. Ahmet Bingül**

**Fill in the blanks below:**

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**EP 122 Measurement Techniques and Calibration, EK Exam Questions****Question 1**

A sound measurement element has an input pressure range of  $P = 1$  Pa to  $P = 1000$  Pa. The output of the element (milli-volts) is measured under standard conditions and the following calibration function is obtained.

$$V(P) = 21 + 2000/P$$

(a) Write down the ideal linear response equation

(b) What is the non-linearity function,  $N(P)$ ?

(c) What is the numerical value of maximum non-linearity?

**EP 122 Measurement Techniques and Calibration, EK Exam Questions****Question 2**

Two independent measurements of pH value of a coffee are given by  $\text{pH} = 4.77 \pm 0.33$  and  $\text{pH} = 4.82 \pm 0.21$ . What is the result of the combined measurement?

**Question 3**

A thermistor is a type of resistor whose resistance varies significantly with temperature, more than in standard resistors. Thermistors are widely used as inrush current limiter, temperature sensors (NTC type typically), self-resetting overcurrent protectors, and self-regulating heating elements. Assume that the relation between resistance ( $R$ ) in ohms and temperature ( $T$ ) in Celsius of the thermistor is given by:

$$R = (1 + 0.3T)/2$$

By using error propagation formula, calculate the temperature and associated error if  $R = 15 \pm 1 \Omega$ .

**EP 122 Measurement Techniques and Calibration, EK Exam Questions****Question 4**

Suppose a machine manufactures screws whose diameters,  $D$ , are normally distributed. The mean diameter and standard deviation of the population are given by  $\mu = 3.0$  mm and  $\sigma = 0.1$  mm respectively. A screw is considered to be defective if its diameter  $D < 2.9$  mm or  $D > 3.1$  mm. A sample of 3000 screws are selected randomly.

Estimate the number of defective screws in this sample.

**Question 5**

An array of six sensors monitors a machine for an error. If an error occurs each sensor independently has a 90% chance of detecting it. To verify that the error is real, the error should be detected by at least three sensors.

What is the probability of an error being not verified?

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### Question 6

In the calibration of a caliper, the following table has been created after measuring a standard sample length of  $L = 16.40$  mm. Five repeated measurement results (in mm) are reported as follows:

16.41, 16.43, 16.40, 16.39, 16.62

Fill the blanks (indicated by ...) in the table and write down the final measurement result and corresponding uncertainties.

Sample length  $L = 16.4$  mm

Input Quantities	Estimated Values	Probability Distribution	Standard Uncertainty	Variance
1.Certificate error	10.4 $\mu\text{m}$	Normal	...	...
2.Resolution error	5.0 $\mu\text{m}$	Rectangular	...	...
3.Mechanical error	10.0 $\mu\text{m}$	Rectangular	...	...
4.Repeatability	...	Normal	...	...

sum = ...

Total measurement uncertainty  $u = \text{sqrt}(\text{sum}) = \dots$

Expanded Measurement Uncertainty  $U = 2*\text{sqrt}(\text{sum}) = \dots$

Final Result = ...

Note: for a rectangular distribution:

$$\sigma = a/\sqrt{3}$$