Final exam 1st semester Date 29/12/2019 Time allowed: 3 hours full mark 90 marks Measuring instruments (MDP3113)		Kafrelsheikh University Faculty of Engineering Mechanical Engineering Dept. 3rd year Production Eng.

Answer all questions
No of Questions 4, No of pages 10
Use the back of the paper if required

Question 1 [20 marks]

(i) **Select the best choice for each of the following 10 statements:-** *[10 marks]*

1) Which of the following is wrong:-
   a) Measurement system is a tool used for quantifying the measured variable.
   b) Measurement is the act of assigning a specific value to the variable being measured.
   c) Calibration is act of applying an unknown input value to a system so as to observe the system output value.
   d) Standard is the known or reference value used as the basis of a calibration.
   e) Calibration establishes the relationship between the input and output values

2) For a working standard, which of the following is true?
   a) It would be calibrated using the primary standard
   b) It is used to calibrate the laboratory standard
   c) It is used on a more regular basis to calibrate everyday measurement devices
   d) All of the above
   e) None of the above

3) When using different methods to measure the same variable, this is called:
   a) Repetition
   b) Replication
   c) Calibration
   d) Concomitance

4) When measured values during a single test run are repeated, this is called:
   a) Interference
   b) replication
   c) concomitant
   d) repetition

5) The difference between the lower and higher values that an instrument is able to measure is called
   a) accuracy
   b) range
   c) span
   d) error

6) Accuracy is defined as
   a) a measure of how often an experimental value can be repeated
   b) the closeness of a measured value to the real value
   c) the number of significant figures used in a measurement
   d) none of the above

7) Variables that are not or cannot be controlled during measurement but that affect the value of the variable measured are called:

a) Deterministic variables
b) Dependent variables
c) Independent variables
d) Extraneous variables

8) The ------represents the smallest increment in the measured value that can be detected
a) Accuracy
b) Uncertainty
c) Resolution
d) Hysteresis

9) ---- error causes ----- in measured values found during ----measurements of a variable
a) Random, a random variation, repeated
b) Systematic, a random variation, repeated
c) Random, an offset, repeated
d) None of the above

10) The ------- is a numerical estimate of the possible range of the error in a measurement
a) Accuracy
b) Resolution
c) Hysteresis
d) Uncertainty

(ii) What are the main elements in a measurement system and what are their functions. Which elements are not needed in some measurement systems and why are they not needed? *[3marks]*

(iii)A displacement transducer has the shown specifications. The system is to be used at room temperature, which can vary by ±10°C.
Estimate the transducer uncertainty (in terms of mm and volts) in a nominal displacement of 20mm. "FOS" in the table means full scale operating range.
[7 marks]

Linearity error	±0.25% FSO
Drift	±0.05%/°C reading
Sensitivity error	±0.20% reading
Hysteresis error	±0.15% FSO
Excitation:	10-25 V dc
output	0-5 V dc
Range	0-50 mm

Question 2 [23 marks]

(i) **For a measurement system modeled as $\frac{dy}{dt} + 4y = F(t)$, select the best choice for each of the following statements (1-5):-** *[5 marks]*

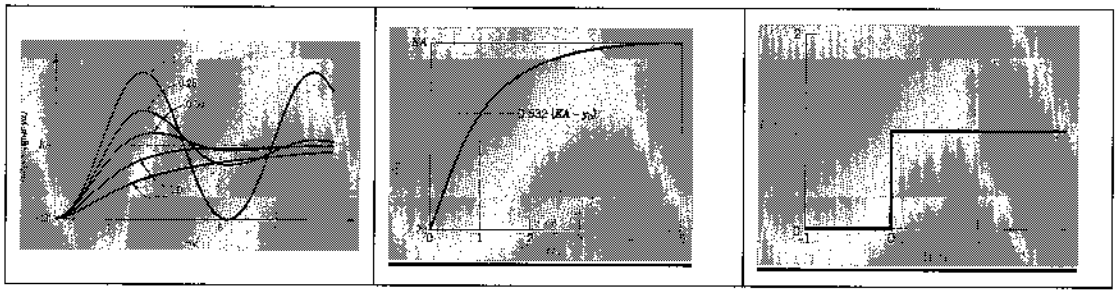
1. The system is :-
   a) zero order system
   b) second order system
   c) first order system
   d) None of the previous

2. The system is called----- order measurement system because it is modeled as ----- order -------equation
   a) 2^{nd} - 2^{nd} - ordinary differential
   b) 2^{nd} - 2^{nd} - partial differential
   c) 1^{st} - 1^{st} - ordinary differential
   d) 1^{st} - 1^{st} - partial differential

3. The time constant of the system is:-
   a) 4.0 ms
   b) 0.25 ms
   c) 1.0 ms
   d) None of the previous

4. An example of this system may be:-
   a) Pencil type pressure gauge
   b) Thermometer
   c) Accelerometer
   d) Diaphragm type pressure gauge

5. Which graph represents the step response of the system:-



(ii) Select the best choice for each of the following statements:- ***[5 marks]***

1. Because ---- signals vary with time, the measurement system must be able to respond---- enough to keep up with the ---- signal.
   a) Static, slow, input
   b) Dynamic, slow, output
   c) Dynamic, fast, output
   d) Dynamic , fast, input

2. For static calibration, which of the following is not true?
   a) The frequency of the signal is important
   b) The term "static" implies that the values of the variables involved remain constant
   c) Only the magnitudes of the known input and the measured output are important
   d) It is the most common type of calibration

3. Which of the followings is true?
   a) Systems with a storage or dissipative capability but negligible inertial forces may be modeled using a first-order differential equation
   b) A thermocouple can be modeled as a first order measurement system
   c) The time constant provides a measure of the speed of system response
   d) All of the above
   e) None of the above

4. Second order instruments are generally designed to have a damping ratio (ζ) somewhere in the range of :-

   a) 0-1
   b) 0.6–0.8
   c) 0.9-2
   d) 1-2

5. Which of the following is not true?
   a) When the variables of interest are time dependent and such varying information is required, we need dynamic information.
   b) In a broad sense, dynamic variables are time dependent in both their magnitude and frequency content.
   c) Static calibration usually involves applying either a sinusoidal signal or a step change as the known input signal.
   d) All of the above
   e) None of the above

(iii)Use "√" or "X" in the appropriate places according to the characteristics of each of the listed signals :-*[4 marks]*

Determine the amplitude A_o, the angular frequency (ω), cyclic frequency (f) and period (T) for <u>each periodic signal</u> in the shown table. ***[3marks]***

Signal	Characteristics		
	static	Dynamic	Periodic
10sin 2t			
5t			
2cos 60			

(iv) Determine the 90%, response time for the systems given (assume the initial conditions y_0=0.5). Show your answer using simple sketch. ***[6marks]***

$$2\frac{dy}{dt} + 5y = 4U(t)$$

Remember that the following equation describes the behavior of the system to a step change in input

$$y(t) = KA + (y_0 - KA)e^{-t/\tau}$$

Question 3 [20 marks]

(i) **Briefly explain the four ways in which measuring instruments can be subdivided into different classes according to their mode of operation, giving examples of instruments that fall into each class. [5 marks]**

(ii) **Explain what is meant by:[5 marks]**
(a) active instruments and
(b) passive instruments.
Give examples and discuss the relative merits of these two classes of instruments.

(iii) **Discuss the advantages and disadvantages of null and deflection types of measuring instruments. What are null types of instruments mainly used for and why? [5 marks]**

(iv) **What are the differences between analog and digital instruments? What advantages do digital instruments have over analog ones? [5 marks]**

Question 4 [27 marks]

(i) Select the best choice for each of the following 10 statements:-*[10marks]*

1) Which of the following represents the type of fit for a hole and shaft pair, given that hole = $50^{+0.06}_{+0.00}$ mm and shaft = $50^{+0.060}_{+0.041}$ mm?

a) Clearance fit
b) Transition fit
c) Interference fit

2) In a shaft basis system, the upper deviation of the size of shaft is
a) 1
b) less than 0
c) not related to size
d) 0

3) In the hole and shaft pair designation of 40 H7/ d9, the numbers 7 and 9 indicate
a) nothing of importance
b) tolerance grade
c) accuracy of manufacture
d) ease of assembly

4) MML corresponds to the
a) higher limit of a hole and lower limit of the shaft
b) lower limit of a hole and lower limit of the shaft
c) higher limit of a hole and higher limit of the shaft
d) lower limit of a hole and higher limit of the shaft

5) LML corresponds to the
a) lower limit of a hole and higher limit of the shaft
b) higher limit of a hole and lower limit of the shaft
c) lower limit of a shaft and lower limit of the hole
d) higher limit of a shaft and higher limit of the hole

6) Limit gauges are used to
a) measure flatness of the component
b) measure exact size of the component
c) check if the component dimension lies within permissible limits
d) measure surface roughness of the component

7) According to Taylor's principle, GO gauges are designed to check
a) maximum metal condition
b) minimum metal condition
c) both of these
d) none of these

8) The relationship that results between the two mating parts before assembly is called
a) tolerance
b) allowance
c) allowance
d) fit

9) Which of the following symbols indicates circular runout?

(a)
(c)
(b)
(d)

10) When the tolerance distribution is only on one side of the basic size, it is known as

a) Unilateral tolerance
b) Compound tolerance
c) Bilateral tolerance
d) Geometric tolerance

(ii) Calculate the limits, tolerances, and allowances on a 25 mm shaft and hole pair designated H7/g6 to get a precision fit. The fundamental tolerance is calculated by the following equation: [5 marks]

$i = 0.453\sqrt[3]{D} + 0.001D$

The following data is given:

Upper deviation of shaft = $-2.5D^{0.34}$

25 mm falls in the diameter step of 18–30 mm

IT7 = $16i$

IT6 = $10i$

In addition, determine the maximum and minimum clearance.

(iii)Design a general type of GO and NO GO gauge for components having 50 H7/d9 fit. The fundamental tolerance is calculated by the following equation: [12 marks]

$i = 0.453\sqrt[3]{D} + 0.001D$

The following data is given:

Upper deviation of shaft $= -16D^{0.44}$

50 mm falls in the diameter step of 30–50 mm

(c) IT7 = 16i

(d) IT9 = 40i

(e) Wear allowance = 10% of gauge tolerance

End of exam paper

Best wishes- Dr. M. Eltaib