FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY
DEPARTMENT OF MATERIALS AND METALLURGICAL ENGINEERING
2017/2018 RAIN SEMESTER EXAMINATIONS.

MME 514: INSTRUMENTATION AND MEASUREMENT Date: TUESDAY, 28/08/2018

Instruction: Answer any five (5) questions with at least one question from section B. Use separate answer booklet for each section. Time allowed is three (3) hours.

SECTION A: ANSWER AT LEAST THREE (3) QUESTIONS.

1. (a) Give three reasons why measurements are done and state three factors upon which the accuracy of any measurement may depend.
   (b) With an appropriate diagram, describe a generalized measurement scheme with controller.
   (c) Explain the term precision as used in measurement and instrumentation studies, and state any three methods for expressing the precision of a set of data.

2. (a)What is accuracy? Why is precision not sufficient to ascertain the accuracy of a measurement?
   (b) Identify the types and sources of errors in measurements.
   (c) i. Explain the term sensitivity. ii. An Atomic Absorption Spectrophotometer was used to measure the concentrations of a metal ion in solution based on the principle of absorption of the light emitted by the metal vapour. The concentrations given by the AAS at different values of absorbance is presented below:

Conc. (mg/l)	8.15	10.08	13.52	20.02	32.84
Absorbance (au)	0.003	0.006	0.016	0.030	0.060

   Use the least-square method to determine the linear relationship between absorbance, A and concentration, C. What is the sensitivity of the instrument for any change in concentration?

3. (a) The step-forced first-order systems have dynamic characteristic and are governed by the relationship,

$$P = P_\infty + (P_A - P_o)e^{-\frac{t}{\tau}}.$$

   Identify every term in the equation and give three examples of systems that obey this law.
   (b) If a first-order system is subjected to step functions during which the following time-magnitude data are determined: (i) $t = 0$, when $P_A = 12$ units, (ii) $t = 5\,sec$, when $P = 25$ units, (iii) $t \to \infty$ as $P \approx P_o = 50$ units. What is the value of the time constant?
   (c) Use an appropriate diagram to illustrate the process-time characteristics of a step-excited first-order progressive system.

4. (a) What is a transducer and what role does it play in measuring instruments?
   (b) A temperature-sensitive transducer is subjected to a sudden temperature change. It takes 15 sec for the transducer to reach equilibrium. How long, in seconds, will it take for the transducer to read half of the temperature difference?
   (c) Suppose that a temperature probe exhibiting single-time constant behaviour and having a time constant of 2.5 seconds is quickly taken from water at 0°C and plunged into water at 100°C. Determine what temperature should be indicated 2.0 sec after the process is initiated?

SECTION B: ANSWER AT LEAST ONE (1) QUESTION

1. The table below shows the hardness values(H_v) of 100 heat treated medium carbon steel samples:

75	112	100	116	99	111	85	82	108	85	94	91	118	103	102	133	98	106	92	102
115	109	100	57	108	77	94	121	100	107	104	67	111	88	87	97	102	98	101	88
90	93	85	107	80	106	120	91	101	103	109	100	127	107	112	98	83	98	89	106
79	117	85	94	119	93	100	90	102	87	95	109	142	94	93	72	98	105	122	104
104	79	102	104	107	97	100	109	103	107	106	96	83	107	102	110	102	76	98	88

   (i) Layout the above data in a grouped frequency table, showing class marks, class boundaries, class mid-marks and tally marks, then find the mean and standard deviation of the hardness values. (ii) Draw a histogram for the data. What is the range of the hardness values?

2. (a) Discuss the statistical treatment of experimental data.
   (b) The important thing about a navigator's watch is not whether it gains or losses but whether it makes a uniform gain or loss regularly. If the rate of gain or loss is consistent, it is easy to allow for. If it is irregular, the watch is useless for the job. The following show the daily losses and gains for two watches. Is one significantly more variable than the other?
   WATCH A GAINS (Sec/day): 54 63 49 50 62 54 58 57 60 61
   WATCH B LOSSES (Sec/day): 116 108 116 122 112 118 123 114 111 117

Table I: The 0.95 and 0.975 fractiles of the t distribution associated with degrees of freedom (d.f)

d.f.	t_o.95	t_o.975
1	6.314	12.706
2	2.920	4.303
3	2.353	3 .182
4	2.132	2.776
5	2.015	2.571
6	1.943	2.447
7	1.895	2.365
8	1.860	2.306
9	1.833	2.262
10	1.812	2.228
11	1.796	2.201
12	1.282	2.179
13	1.771	2.160
14	1.761	2.145
15	1.753	2.131
16	1.746	2.120
17	1.7401	2.110
18	1.734	12.101
19	1.725	2.093
20	1.725	2.086
38	1.697	2.042
40	1.684	2.021

Table 2: 5% and 1% levels of the F-distribution associated with n_1 and n_2 degrees of Freedom.

5% Level

Number of degree of freedom in lesser variance Estimates	Number of degree of freedom in the greater varience estimate							
	1	2	3	4	5	10	20	
1	161	200	216	225	230	242	248	254
2	18.5	19	19.2	19.2	19.3	19.4	19.4	19.5
3	10.1	9.6	9.3	9.1	9.0	8.8	8.7	8.5
4	7.7	6.9	6.6	6 .4	6.3	6.0	5.8	5.6
5	6.6	5.8	5.4	5.2	5.0	4.7	4.6	4.4
10	5.0	4.1	3.7	3.5	3.3	3.0	2.8	2.5
20	4.3	3.5	3.1	2.9	2.7	2.3	2.1	1.8
	3.8	3.0	2.6	2.4	2.2	1.8	1.6	1.0

1% Level

Number of degree of Freedom in lesser variance Estimates								
1	4,100	5,000	5400	5600	5800	6000	6200	6400
2	98	99	99	99	99	99	99	99
3	34	31	29	29	28	27	27	26
4	21	18	17	16	16	15	14	13
5	16	13	12	11	11	10	9.6	9.0
10	10	7.6	6.6	6.0	5.6	4.8	4.4	3.9
20	8.1	5.8	4.9	4.4	4.1	3.4	2.9	2.4
	6.6	4.6	3.8	3.3	3.0	2.3	1.9	1.0

15x5

75%