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Student name:_____I.D._____

King Mongkut's University of Technology Thonburi

Midterm Examination

Semester 1, Academic Year: 2018

INC 331 Industrial Process Measurement

For Automation Engineering (3rd Year, International Program)

Date: Tuesday 9 October 2018   Time: 9.00 – 12.00

Instructions

1. The examination paper consists of 15 pages (including this front page).

2. Documents, text books, dictionary are **not** allowed in the examination room.

3. Calculators approved by the university are allowed.

4. Student must complete the student name and I.D in every page.

Cautions

1. Students are not allowed to take examination scripts, answer booklets or any materials out of the examination room. Violation of the rule shall result in a penalty of student receiving a zero in that examination.

2. Students who are caught cheating in the examination shall be penalized by receiving Fail grade (F) in that subject and is forced to withdraw (W) from all remaining subjects in that semester. The maximum penalty may include expulsion.

Wanchak Lenwari

(Assoc.Prof.Dr. Wanchak Lenwari)

Course Coordinator

This examination paper has been approved by Department of Control System and Instrumentation Engineering.

Sudchai Boonto

(Asst.Prof.Dr. Sudchai Boonto)

Head of Department

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Section 1: System and Applications (Assoc.Prof.Dr. Wanchak Lenwari)

1. In process industries explain the meaning of process control, batch control and manufacturing system. Also give two names of industries for each system. (6 marks)

2. Draw the structure of a typical large process control system. (5 marks)

3. From a given figure, answer the following questions.
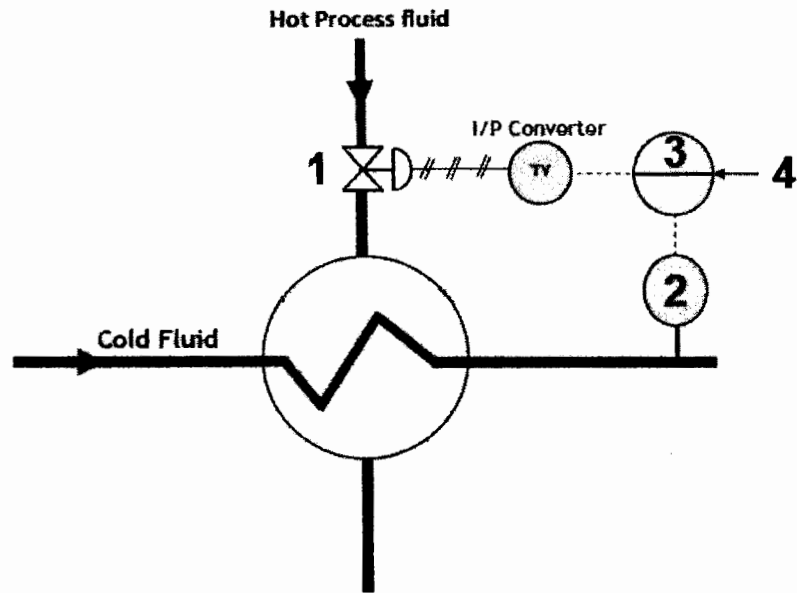
3.1 What is PV (Process Variable) of this system? _____(1 mark)

3.2 What is MV (Manipulated Variable) of this system? _____(1 mark)

3.3 What is the function of the device No.1? _____ (1 mark)

3.4 What is the function of the device No.2? _____ (1 mark)

3.5 What is the function of the device No.3? _____ (1 mark)

3.6 What is the name of variable No.4? _____ (1 mark)

3.7 Write down the block diagram of this control system and also explain its working process.

(6 marks)

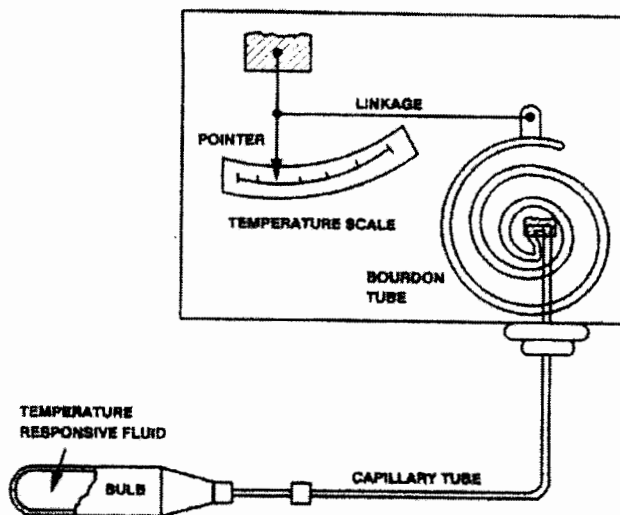## Section 2: Temperature Measurement (Assoc.Prof.Dr. Wanchak Lenwari)

Note. One page of thermocouple table is attached in the last page.

1. What is the SI unit for temperature? _____ (1 mark)

2. Explain the meaning of thermal equilibrium. (2 marks)

3. What is the absolute zero temperature? (2 marks)

4. From a figure below, answer the following questions.

4.1 What is the name of this device? _____ (1 mark)

4.2 Explain the principle of this device and its applications. (5 marks)

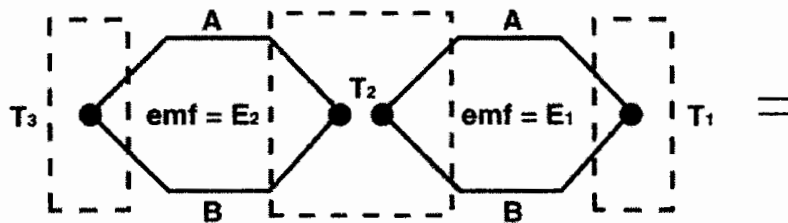5. Explain the Seebeck effect and write down its equation. (3 marks)

6. For each of thermocouple circuits given below, 1. Draw the reduced form of circuit 2. Write down the equation of the output voltage and 3. Answer which law is applied to obtain the reduced form? (3 marks for each circuit)

6.1
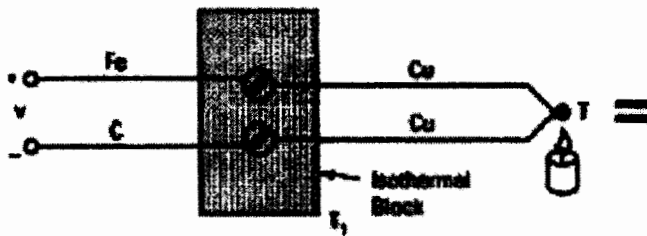
Law of _____

6.2

Law of _____

6.3

Law of _____

5
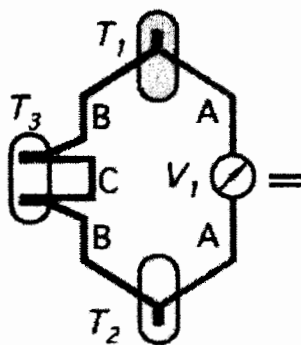
7. When using thermocouple for temperature measurement the reference junction may not be held at 0°C, but at the surrounding temperature of T1°C instead. Without any compensation, the thermocouple output will be reduced by T1°C. One of the methods is an electronic or electrical reference compensation. Explain this method in detail. (6 marks)

8. What is the main difference between thermocouple wire and extension wire? (2 marks)

9. From a figure below, if the measured voltage (V) is between -1 mV and 5 mV, calculate the temperature range of this measurement in degrees Celsius. (5 marks)
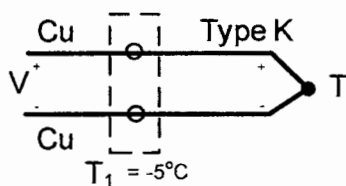
10. From a given figure, thermocouple type K is used to measure temperature between -10 °C to 250 °C , explain the procedure to calibrate the transmitter using millivolt source. (5 marks)
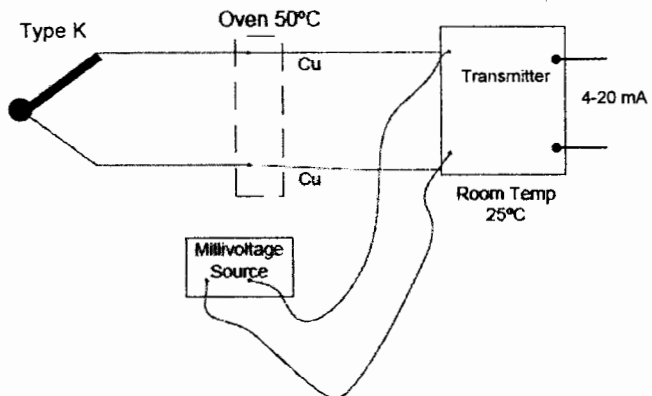
11. From a given figure, thermocouple type K is used to measure temperature between -10 °C to 250 °C , explain the procedure to calibrate the transmitter using millivolt source. (5 marks)
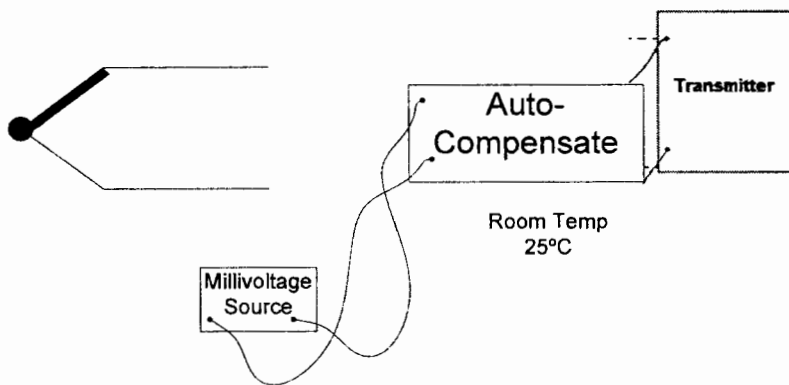
12. Which type of RTD connection is the most popular type used in process control? Also draw that connection for temperature measurement. (3 marks)

13. RTD (PT-100) is used to measure the temperature of one material. If the measured resistance of RTD is 109.625 Ω, calculate the temperature of this material. Assume $R_t = R_0(1+\alpha t)$ and $\alpha = 0.00385$ $\Omega/\Omega/°C$ (5 marks)

14. Which applications are suitable for non-contact temperature measurement? (3 marks)

15. For temperature measurement with non-contact technology explain the meaning of the following factors. (6 marks)

15.1 Distance to Target (Spot) Ratio

15.2 Emissivity

Section 3: Instrument Characteristic (Dr. Tanagorn Jennawasin)

1. Given the base quantities with their corresponding SI base units as in the table below:

Base quantity	Name of Base Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Express the units of the following quantities in terms of SI base units. (3 points)

Quantity	Unit
Frequency	_____
Power	_____
Electric resistance	_____

2. Three voltmeters (A, B and C) of the same model are used to measure the standard source of 12.00 volts. Each voltmeter was measured for 4 times and the displayed voltages are recorded in the table below:

Voltmeter A (Volt)	Voltmeter B (Volt)	Voltmeter C (Volt)
12.10	15.10	14.18
11.70	10.15	14.15
12.25	16.20	14.20
12.40	11.80	14.16

Fill in the blanks with appropriate meter names. (3 points)

2.1 Voltmeter_____ is precise but not accurate.

2.2 Voltmeter_____ is accurate.

2.3 Voltmeter_____ is neither precise nor accurate.

3. A pressure gauge of range 0-10 bar has a quoted inaccuracy of $\pm 1.0\%$ of full-scale reading.

Answer the following questions. (3 points)

3.1 Calculate the maximum possible error in any reading.

Answer = _____ bar.

3.2 Determine the minimum reading value such that the error does not exceed 2.5% of the

reading value.

Answer = _____ bar.

4. Consider a spring balance with the following deflection/load characteristic:

Load (kg)	0	1	y	3
Deflection (mm)	5	x	38	71

Suppose that the deflection/load characteristic is linear. Answer the following questions.

4.1 Find the values of x and y. (3 points)

x=_____ mm, y=_____ kg

4.2 Determine the sensitivity of the spring balance in m/kg. (2 points)

Answer=_____

5. Briefly explain the meaning of the following keywords. (6 points)

5.1 Measurement standards_____

_____

5.2 Calibration_____

_____

5.3 Zero drift_____

_____

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Section 4: Signal Conditioning and Noise Reduction Techniques (Assoc. Prof. Dr. Ake Chaisawadi)

This examination contains 4 questions with 30 marks. Do all of them in the provided space.

1. What is an instrumentation? Why do we have to use instrumentation in process system?

(5 marks)

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2. What is signal conditioning? Give 3 of signal conditioning functions used for industrial process measurement and control engineering. (5 marks)

_____

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_____

3. From figure 1, explain the following terms by writing to the space provided for each term.
(10 marks)
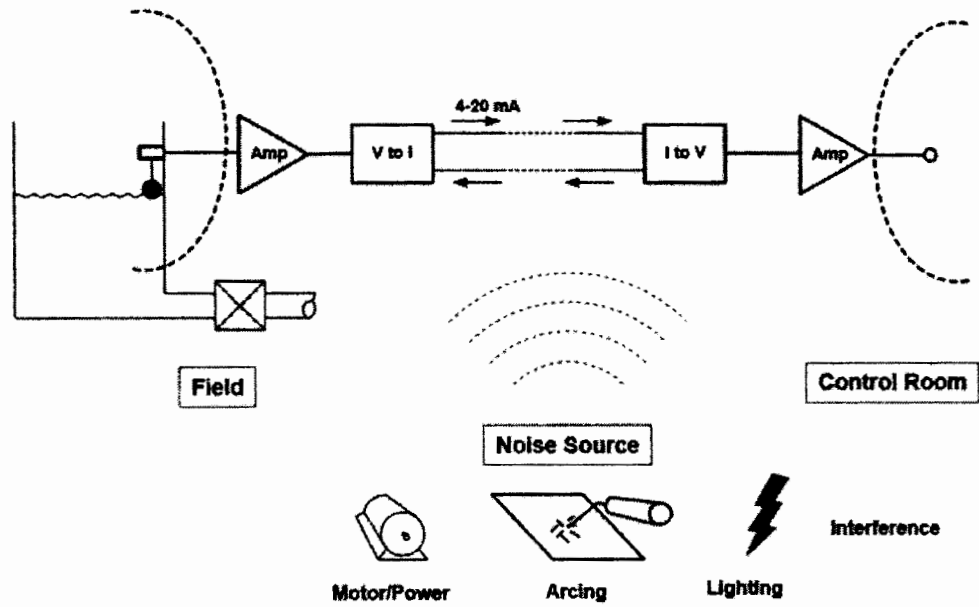
Figure 1

- Process system

_____
_____
_____
_____

- Industry standard signal

_____
_____
_____
_____
_____

- Measurement range

_____
_____
_____
_____
_____

12

- Current transmission

_____
_____
_____
_____
_____

- Measurement accuracy

_____
_____
_____
_____
_____

4. What is noise and interference? What is the coupling mechanism of electromagnetic interference and how to reduce their effects? Answer by explaining the following terms using the space provided for each term. (10 marks)

- Noise

_____
_____
_____
_____

- Interference

_____
_____
_____
_____
_____

- EMI coupling mechanism

_____
_____
_____
_____
_____

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- Reduction Techniques

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K°C

TABLE 9 *Type K Thermocouple* — *thermoelectric voltage as a function of temperature (°C); reference junctions at 0 °C*

Thermoelectric Voltage in Millivolts

°C	0	1	2	3	4	5	6	7	8	9	10	°C
-270	-6.458											-270
-260	-6.411	-6.444	-6.446	-6.448	-6.450	-6.452	-6.453	-6.455	-6.456	-6.457	-6.458	-260
-250	-6.404	-6.408	-6.413	-6.417	-6.421	-6.425	-6.429	-6.432	-6.435	-6.438	-6.441	-250
-240	-6.344	-6.351	-6.358	-6.364	-6.370	-6.377	-6.382	-6.388	-6.393	-6.399	-6.404	-240
-230	-6.262	-6.271	-6.280	-6.289	-6.297	-6.306	-6.314	-6.322	-6.329	-6.337	-6.344	-230
-220	-6.158	-6.170	-6.181	-6.192	-6.202	-6.213	-6.223	-6.233	-6.243	-6.252	-6.262	-220
-210	-6.035	-6.048	-6.061	-6.074	-6.087	-6.099	-6.111	-6.123	-6.135	-6.147	-6.158	-210
-200	-5.891	-5.907	-5.922	-5.936	-5.951	-5.965	-5.980	-5.994	-6.007	-6.021	-6.035	-200
-190	-5.730	-5.747	-5.763	-5.780	-5.797	-5.813	-5.829	-5.845	-5.861	-5.876	-5.891	-190
-180	-5.550	-5.569	-5.588	-5.606	-5.624	-5.642	-5.660	-5.678	-5.695	-5.713	-5.730	-180
-170	-5.354	-5.374	-5.395	-5.415	-5.435	-5.454	-5.474	-5.493	-5.512	-5.531	-5.550	-170
-160	-5.141	-5.163	-5.185	-5.207	-5.228	-5.250	-5.271	-5.292	-5.313	-5.333	-5.354	-160
-150	-4.913	-4.936	-4.960	-4.983	-5.006	-5.029	-5.052	-5.074	-5.097	-5.119	-5.141	-150
-140	-4.669	-4.694	-4.719	-4.744	-4.768	-4.793	-4.817	-4.841	-4.865	-4.889	-4.913	-140
-130	-4.411	-4.437	-4.463	-4.490	-4.516	-4.542	-4.567	-4.593	-4.618	-4.644	-4.669	-130
-120	-4.138	-4.166	-4.194	-4.221	-4.249	-4.276	-4.303	-4.330	-4.357	-4.384	-4.411	-120
-110	-3.852	-3.882	-3.911	-3.939	-3.968	-3.997	-4.025	-4.054	-4.082	-4.110	-4.138	-110
-100	-3.554	-3.584	-3.614	-3.645	-3.675	-3.705	-3.734	-3.764	-3.794	-3.823	-3.852	-100
-90	-3.243	-3.274	-3.306	-3.337	-3.368	-3.400	-3.431	-3.462	-3.492	-3.523	-3.554	-90
-80	-2.920	-2.953	-2.986	-3.018	-3.050	-3.083	-3.115	-3.147	-3.179	-3.211	-3.243	-80
-70	-2.587	-2.620	-2.654	-2.688	-2.721	-2.755	-2.788	-2.821	-2.854	-2.887	-2.920	-70
-60	-2.243	-2.278	-2.312	-2.347	-2.382	-2.416	-2.450	-2.485	-2.519	-2.553	-2.587	-60
-50	-1.889	-1.925	-1.961	-1.996	-2.032	-2.067	-2.103	-2.138	-2.173	-2.208	-2.243	-50
-40	-1.527	-1.564	-1.600	-1.637	-1.673	-1.709	-1.745	-1.782	-1.818	-1.854	-1.889	-40
-30	-1.156	-1.194	-1.231	-1.268	-1.305	-1.343	-1.380	-1.417	-1.453	-1.490	-1.527	-30
-20	-0.778	-0.816	-0.854	-0.892	-0.930	-0.968	-1.006	-1.043	-1.081	-1.119	-1.156	-20
-10	-0.392	-0.431	-0.470	-0.508	-0.547	-0.586	-0.624	-0.663	-0.701	-0.739	-0.778	-10
0	0.000	-0.039	-0.079	-0.118	-0.157	-0.197	-0.236	-0.275	-0.314	-0.353	-0.392	0
0	0.000	0.039	0.079	0.119	0.158	0.198	0.238	0.277	0.317	0.357	0.397	0
10	0.397	0.437	0.477	0.517	0.557	0.597	0.637	0.677	0.718	0.758	0.798	10
20	0.798	0.838	0.879	0.919	0.960	1.000	1.041	1.081	1.122	1.163	1.203	20
30	1.203	1.244	1.285	1.326	1.366	1.407	1.448	1.489	1.530	1.571	1.612	30
40	1.612	1.653	1.694	1.735	1.776	1.817	1.858	1.899	1.941	1.982	2.023	40
50	2.023	2.064	2.106	2.147	2.188	2.230	2.271	2.312	2.354	2.395	2.436	50
60	2.436	2.478	2.519	2.561	2.602	2.644	2.685	2.727	2.768	2.810	2.851	60
70	2.851	2.893	2.934	2.976	3.017	3.059	3.100	3.142	3.184	3.225	3.267	70
80	3.267	3.308	3.350	3.391	3.433	3.474	3.516	3.557	3.599	3.640	3.682	80
90	3.682	3.723	3.765	3.806	3.848	3.889	3.931	3.972	4.013	4.055	4.096	90
100	4.096	4.138	4.179	4.220	4.262	4.303	4.344	4.385	4.427	4.468	4.509	100
110	4.509	4.550	4.591	4.633	4.674	4.715	4.756	4.797	4.838	4.879	4.920	110
120	4.920	4.961	5.002	5.043	5.084	5.124	5.165	5.206	5.247	5.288	5.328	120
130	5.328	5.369	5.410	5.450	5.491	5.532	5.572	5.613	5.653	5.694	5.735	130
140	5.735	5.775	5.815	5.856	5.896	5.937	5.977	6.017	6.058	6.098	6.138	140
150	6.138	6.179	6.219	6.259	6.299	6.339	6.380	6.420	6.460	6.500	6.540	150
160	6.540	6.580	6.620	6.660	6.701	6.741	6.781	6.821	6.861	6.901	6.941	160
170	6.941	6.981	7.021	7.060	7.100	7.140	7.180	7.220	7.260	7.300	7.340	170
180	7.340	7.380	7.420	7.460	7.500	7.540	7.579	7.619	7.659	7.699	7.739	180
190	7.739	7.779	7.819	7.859	7.899	7.939	7.979	8.019	8.059	8.099	8.138	190

°C	0	1	2	3	4	5	6	7	8	9	10	°C

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