Question 01 [10 Points]

A. Suppose a liquid level ranging from $5.5\ to\ 8.6\ m$ is linearly converted to pneumatic pressure ranging from $3\ to\ 15\ psi$. What pressure will result from a level of $7.2\ m$? What level does a pressure of $4.7\ psi$ represent?

B. A pressure sensor has a resistance that changes with pressure according to $R = 0.15\ P + 2.5\ k\Omega$. This resistance is then converted to a voltage with the transfer function $V = \frac{10R}{R+10}\ volts$. The sensor time constant is $350\ ms$. At $t = 0$, the pressure changes suddenly from $40\ psi\ to\ 150\ psi$.

(i) What is the voltage output at $0.5\ s$? What is the indicated pressure at this time?

(ii) At what time does the output reach $5.0\ V$?

Question 02 [10 Points]

A. A sensor measures temperature linearly with a static transfer function of $33\ mV/°C$ and has a $1.5\ s$ time constant. **Find the output signal (in Volt) 0.75 s** after the input changes from **20° to 41 °C** Find the error in temperature this represents.

B. Suppose each bit change in a **4-bit ADC** represents a level of **0.15 m.**

(a) What would the **4 bits** be for a **level of 1.7 m**?

(b) Suppose the **4 bits were** 1000_2. What is the **range** of possible levels?

Question 03 [15 Points]

A. A temperature sensitive transducer used to measure the temperature of a furnace has been idealized as a first-order system subjected to ramp input. If the maximum permissible error in temperature measurement is limited to $3.9°C$, calculate the time constant of the transducer when the furnace temperature increases at the rate of $0.2°C/s$

B. Suppose that the reference junction of a chromel–constantan thermocouple (**Type E**) is maintained at a temperature of $20°C$ and the output e.m.f. measured is $6.808\ mV$ when the hot junction is immersed in a fluid. what is the liquid temperature?

C. The output voltage from a translational motion potentiometer of stroke length 0.1 meter is to be measured by an instrument whose resistance is $10\ k\Omega$. The maximum measurement error, which occurs when the slider is positioned two-thirds of the way along the element must not exceed 1% of the full-scale reading. The highest possible measurement sensitivity is also required. A family of potentiometers having a power rating of $1\ watt\ per\ 0.01$ meter and resistances ranging from $100\ \Omega\ to\ 10\ k\Omega\ in\ 100\ \Omega$ steps is available. Choose the most suitable potentiometer from this range and calculate the sensitivity of measurement that it gives.

Temp. (°C)	*Type E*	*Type J*	*Type K*	*Type N*	*Type S*	*Type T*
−40	−2.254	−1.960	−1.527	−1.023	−0.194	−1.475
−30	−1.709	−1.481	−1.156	−0.772	−0.150	−1.121
−20	−1.151	−0.995	−0.777	−0.518	−0.103	−0.757
−10	−0.581	−0.501	−0.392	−0.260	−0.053	−0.383
0	0.000	0.000	0.000	0.000	0.000	0.000
10	0.591	0.507	0.397	0.261	0.055	0.391
20	1.192	1.019	0.798	0.525	0.113	0.789
30	1.801	1.536	1.203	0.793	0.173	1.196
40	2.419	2.058	1.611	1.064	0.235	1.611
50	3.047	2.585	2.022	1.339	0.299	2.035
60	3.683	3.115	2.436	1.619	0.365	2.467
70	4.329	3.649	2.850	1.902	0.432	2.908
80	4.983	4.186	3.266	2.188	0.502	3.357
90	5.646	4.725	3.681	2.479	0.573	3.813
100	6.317	5.268	4.095	2.774	0.645	4.277
110	6.996	5.812	4.508	3.072	0.719	4.749
120	7.683	6.359	4.919	3.374	0.795	5.227
130	8.377	6.907	5.327	3.679	0.872	5.712
140	9.078	7.457	5.733	3.988	0.950	6.204
150	9.787	8.008	6.137	4.301	1.029	6.702
160	10.501	8.560	6.539	4.617	1.109	7.207
170	11.222	9.113	6.939	4.936	1.190	7.718
180	11.949	9.667	7.338	5.258	1.273	8.235
190	12.681	10.222	7.737	5.584	1.356	8.757
200	13.419	10.777	8.137	5.912	1.440	9.286
210	14.161	11.332	8.537	6.243	1.525	9.820
220	14.909	11.887	8.938	6.577	1.611	10.360
230	15.661	12.442	9.341	6.914	1.698	10.905
240	16.417	12.998	9.745	7.254	1.785	11.456
250	17.178	13.553	10.151	7.596	1.873	12.011
260	17.942	14.108	10.560	7.940	1.962	12.572
270	18.710	14.663	10.969	8.287	2.051	13.137
280	19.481	15.217	11.381	8.636	2.141	13.707
290	20.256	15.771	11.793	8.987	2.232	14.281
300	21.033	16.325	12.207	9.340	2.323	14.860
310	21.814	16.879	12.623	9.695	2.414	15.443
320	22.597	17.432	13.039	10.053	2.506	16.030
330	23.383	17.984	13.456	10.412	2.599	16.621
340	24.171	18.537	13.874	10.772	2.692	17.217
350	24.961	19.089	14.292	11.135	2.786	17.816
360	25.754	19.640	14.712	11.499	2.880	18.420
370	26.549	20.192	15.132	11.865	2.974	19.027
380	27.345	20.743	15.552	12.233	3.069	19.638

Question 04 [15 Points]

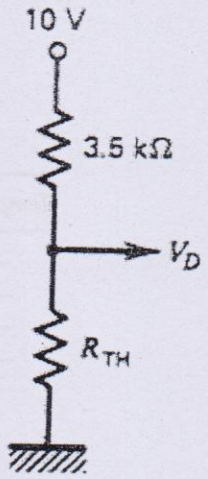
A. A pressure-measurement system uses a sensor that converts pressure into voltage according to the transfer functions, $V_p = 0.5\sqrt{p}$. This voltage is then converted into a current. As the pressure varies from 0 *to* $100\ psi$, the current varies from 4 *to* $20\ mA$.

(i) Find the transfer function equation for the conversion of voltage to current.

(ii) What pressure change, Δp , will cause the current to change by $1\ mA$ from $19\ mA$ *to* $20\ mA$?

(iii) What pressure change, Δp , will cause the current to change by $1\ mA$ from $4\ mA$ *to* $5\ mA$? Why is the pressure change not the same as in the previous case, even though the current changed by $1\ mA$ in both cases?

B. A thermistor is to monitor room temperature. It has a resistance of $3.5\ k\Omega$ at $20\ °C$ with a slope of $-10\ \%/°C$. The dissipation constant is $P_D = 5\ mW/°C$. It is proposed to use the thermistor in the divider of Figure below to provide a voltage of $5.0\ V$ at $20\ °C$. Evaluate the effects of self-heating.



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