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1. Min Sampling frequency:

$$F_s \geq 2(F_{max})$$
$$= 2 \times 150\,Hz = \boxed{300\,Hz}$$

2. Min voltage if expected range is $40° - 80°F$

$$R_f(80) = 161 \cdot e^{-0.013(80)}\ k\Omega$$
$$= \boxed{56.9062}\ k\Omega$$

3. Max voltage if expected range is $40° - 80°F$.

$$R_f(40) = 161 \cdot e^{-0.013(40)}\ k\Omega$$
$$= \boxed{95.7178}\ k\Omega$$

4. Buffer without optimization:

$$BW = Fs \times \text{Sample Size}$$

$$\text{Sample Size} = 12\text{ bits} = (12/8)\text{ Bytes}$$
$$\approx 1.5\,B \approx 2\,B \text{ per Sample.}$$

$$BW = 300\,Hz \times 2\,Bps = 600\,Bps$$

$$\text{Time} = \frac{\text{memory}}{BW} = \frac{8000\,B}{600\,Bps} = \boxed{13.3333}\,s$$

⑤ Buffer with optimization:

$$BW = 300\,Hz \times 1.5\,B = 450\,Bps$$

$$Time = \frac{9000\,B}{450\,Bps} = \boxed{20s}$$

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⑥ Quantization step:

$$\Delta = \frac{V_+ - V_-}{2^n - 1} = \frac{2.5V - 0V}{2^{12} - 1} = \frac{2.5}{4095}$$

$$\Delta = (6.1050 \times 10^{-4})\,V = \boxed{0.6105\,mV}$$

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⑦ 8 data bits + 1 start bit + 1 stop bit
= 10 bits.

$$T_s = \frac{10\,bits}{115200} = 0.086\,ms. = 1/F_s$$

$$\therefore F_s = 1 \cdot 0.086\,ms = 0.086\,Hz$$

$$F_s \geq 2(F_{max}) \therefore F_{max} = 0.086/2$$
$$= \boxed{0.043}$$

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8 Output when temp = 60° F

$$R_f(60) = 161 \cdot e^{-0.013(60)} \; k\Omega$$
$$= 73.8034 \; k\Omega$$

$$V_{in} = \frac{73.8034}{73.8034 + 70 \, k\Omega} \cdot 3V = 1.5397 V$$

$$N_{ADC} = \frac{V_{in} - V_-}{\Delta} = \frac{1.5397 V - 0V}{0.0006105}$$

$$= \boxed{2522}$$

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9 Clock speed = 10 MHz
240 cycles per sample.
data acquisition time = 0.2ms.
Freq = 40 Hz ; 12,000 instructions every 1024.

$$F_s = 1/40 = 0.025$$

$$Avg = 12{,}000 + \left(\frac{240}{10MHz}\right) \cdot 1024 + (0.2 \times 1024)$$
$$= 12204.82$$

$$\therefore \frac{12204.82}{1024} = 11.9188 \Rightarrow \frac{11.9188}{0.025}$$
$$\approx 476.7520$$

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10 System can run in real time.

(11) Magnitude: LPF

$R = 4.7k\Omega$; $C = 0.1\mu F$

$$\frac{1}{\sqrt{1+(\omega . R . C)^2}} = \frac{1}{\sqrt{1+(500 \times 4.7\times10^{3} \times 0.1\times10^{-6})^2}}$$

$$= \boxed{0.9735}$$

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(12) Calculated manually & PLOTTED :

$$x[n] = [\overset{0}{0.1}, \overset{1}{0.3}, \overset{2}{0.24}, \overset{3}{0.39}, \overset{4}{0.41}, \overset{5}{0.3}, \overset{6}{0.23}, \underset{7}{-0.2}, \underset{8}{-0.15}, \underset{9}{0.2}, \underset{10}{0.4}]. \quad (M=11)$$

$$h[n] = [\overset{0}{-0.1}, \overset{1}{0.2}, \overset{2}{-0.05}] \Leftarrow B \quad (N=3).$$

Samples $= M+N-1 = 11+3-1 = 13.$

$$y[n] = \sum_{k=-\infty}^{\infty} x(k) . h(n-k)$$

$$y[0] = B(0) \cdot x(0) = -0.1 \times 0.1 = \boxed{-0.01}$$

$$y[1] = B(0) \cdot x(1) + B(1) \cdot x(0)$$
$$= (-0.1 \times 0.3) + (0.2 \times 0.1) = \boxed{-0.01}$$

$$y[2] = B(0) \cdot x(2) + B(1) \cdot x(1) + B(2) \cdot x(0)$$
$$= (-0.1 \times 0.24) + (0.2 \times 0.3) + (-0.05 \times 0.1)$$
$$= -0.024 + 0.06 + (-5e^{-3})$$
$$= \boxed{0.031}$$

$$y[3] = B(0)\cdot x(3) + B(1)\cdot x(2) + B(2)\cdot x(1) + B(3)\cdot x(0).$$

$$= (-0.1 \times 0.39) + (0.2 \times 0.24) + (-0.05 \times 0.3) + 0 = \boxed{-0.006}$$

$$y[4] = B(0)\cdot x(4) + B(1)\cdot x(3) + B(2)\cdot x(2) + B(3)\cdot x(1) + B(4)\cdot x(0)$$

$$= (-0.1 \times 0.41) + (0.2 \times 0.39) + (-0.05 \times 0.24) + 0 + 0 = \boxed{0.025}$$

$$y[5] = B(0)\cdot x(5) + B(1)\cdot x(4) + B(2)\cdot x(3) + B(3)\cdot x(2) + B(4)\cdot x(1) + B(5)\cdot x(0)$$

$$= (-0.1 \times 0.3) + (0.2 \times 0.41) + (-0.05 \times 0.39) + 0 + 0 + 0 = \boxed{0.0325}$$

$$y[6] = B(0)\cdot x(6) + B(1)\cdot x(5) + B(2)\cdot x(4) + B(3)\cdot x(3) + B(4)\cdot x(2) + B(5)\cdot x(1) + B(6)\cdot x(0)$$

$$= (-0.1 \times 0.23) + (0.2 \times 0.3) + (-0.05 \times 0.41) + 0 + 0 + 0 + 0 = \boxed{0.0165}$$

$$y[7] = B(0)\cdot x(7) + B(1)\cdot x(6) + B(2)\cdot x(5) + B(3)\cdot x(4) + B(4)\cdot x(3) + B(5)\cdot x(2) + B(6)\cdot x(1) + B(7)\cdot x(0)$$

$$= (-0.1 \times (-0.2)) + (0.2 \times 0.23) + (-0.05 \times 0.3)$$

$$= \boxed{0.051}$$

$$y[8] = B(0)\cdot x(8) + B(1)\cdot x(7) + B(2)\cdot x(6) + B(3)\cdot x(7) + 0 \ldots$$

$$= (-0.1 \times (-0.15)) + (0.2 \times (-0.2)) + (-0.05 \times 0.23)$$

$$= \boxed{-0.0365}$$

$$y[9] = B(0)\cdot x(9) + B(1)\cdot x(8) + B(2)\cdot x(7) + 0$$
$$= (-0.1 \times 0.2) + (0.2 \times (-0.15)) + (-0.05 \times -0.2)$$
$$= \boxed{-0.04}$$

$$y[10] = B(0)\cdot x(10) + B(1)\cdot x(9) + B(2)\cdot x(8) + 0$$
$$= (-0.1 \times 0.4) + (0.2 \times 0.2) + (-0.05 \times -0.15)$$
$$= \boxed{0.0075}$$

$$y[11] = B(0)\cdot x(11) + B(1)\cdot x(10) + B(2)\cdot x(9) + 0$$
$$= 0 + (0.2 \times 0.4) + (-0.05 \times 0.2)$$
$$= \boxed{0.07}$$

$$y[12] = B(0)\cdot x(12) + B(1)\cdot x(11) + B(2)\cdot x(10)$$
$$= 0 + 0 + (-0.05 \times 0.4)$$
$$= \boxed{-0.02}$$

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13 $F = mg$; $K = \frac{mg}{L}$; $L = \left(\frac{10}{17}\right)m$

$m = 1m$; $g = 10\ m/s^2$; $c = 2$.

$$\therefore K = \frac{1m \times 10\ m/s^2}{\left(\frac{10}{17}\right)m} = 17\ N/m.$$

$x(t) = Ae^{-(ct/2)} \cdot \cos(\omega t)$. ; $A = 1$.

$$\omega = \sqrt{17 - \frac{2^2}{4}} = \sqrt{16} = 4\ rad/s.$$

$$x(t) = 1 \cdot e^{-(2t/2m)} \cos(4t)$$
$$= e^{-t} \cos(4t) \text{ m}$$

If $t = 1.8$; $e^{-1.8} \cos(4 \times 1.8)$

$$= 0.1006$$

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(14) Steady-state = 0 because at any given time : $m\ddot{x} + kx = 0$

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(15) 5 pt Averager:

$$\tfrac{1}{5} x(n) + \tfrac{1}{5} x(n-1) + \tfrac{1}{5} x(n-2) + \tfrac{1}{5} x(n-3) + \tfrac{1}{5} x(n-4).$$

$A[0] = \boxed{1}$

(16) $B[3] = 1/5 = \boxed{0.2}$

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(17) Frequency resolution: ($F_s = 500$ Hz)
$N = 2048$

$$\Delta f = F_s / N_{FFT} = \frac{500}{2048} = \boxed{0.2441}$$

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18 & 19 SOLVED IN MATLAB.

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