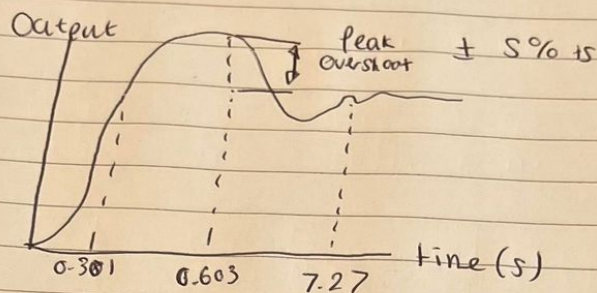


4)c)



d)

$$\text{So } 12.5 = \left\{ e^{\left(\frac{-\pi \zeta}{\sqrt{1-\zeta^2}} \right)} \right\} \times 100$$

$$\ln 0.125 = \frac{-\zeta \pi}{\sqrt{1-\zeta^2}}$$

$$-2.08 \left(\sqrt{1-\zeta^2} \right) = -\zeta \pi$$

$$4.3264 (1-\zeta^2) = 9.87 \zeta^2$$

$$4.3264 = 9.700 \zeta^2$$

$$\zeta = \cancel{5.18} 0.537$$

Required value for 12.5% Peak Overshoot.

4) a) Convert system d.e. into standard form

$$\frac{d^2x}{dt^2} + \frac{c}{m} \frac{dx}{dt} + \frac{k}{m} x = \frac{f}{m}$$

$$= 2\zeta \omega_n = \frac{c}{m} \quad \text{and} \quad \omega_n^2 = \frac{k}{m}$$

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{400}{14.5}} = 5.25 \text{ Hz}$$

$$\text{Now, } \zeta = \frac{c}{2\omega_n m} = \frac{200}{2 \times 5.25 \times 14.5} = 1.31$$

Hence the system is overdamped.

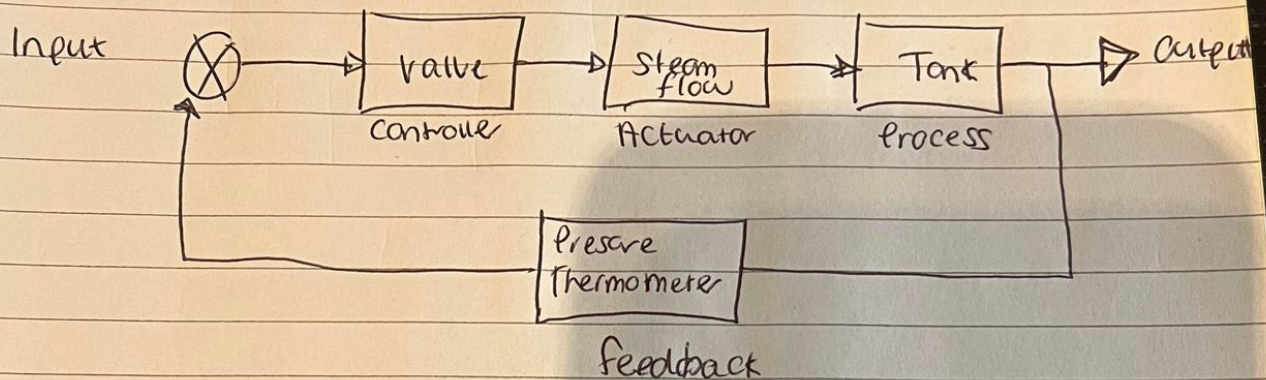
$$\begin{aligned} \text{b) \% peak overshoot} &= \left(\exp \left(\frac{-1.31\pi}{\sqrt{1-1.31^2}} \right) \right) \times 100\% \\ &= 23.9\% \end{aligned}$$

$$\text{Rise time} = t_r = \frac{\pi}{2\omega_n \sqrt{1-\zeta^2}} = 0.308 \text{ s}$$

$$\text{Peak time} = \frac{\pi}{\omega_n \sqrt{1-\zeta^2}} = 0.603 \text{ s}$$

$$5\% \text{ settling time} = 7.27 \text{ s}$$

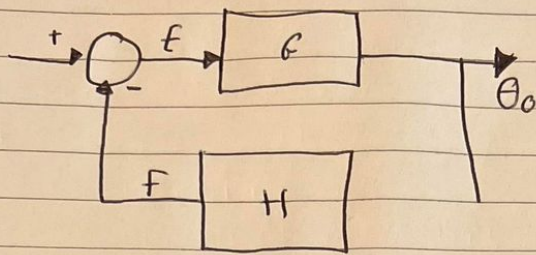
2e) Temperature Control System



Another closed loop system would be a
inverter AC.



2.c)



$$G = \frac{\Theta_0}{E} = E = \frac{\Theta_0}{G}$$

$$H = \frac{F}{\Theta_0} = F = H \cdot \Theta_0$$

$$E = \Theta_i - F$$

$$\therefore \frac{\Theta_0}{G} = \Theta_i - H \cdot \Theta_0 = \frac{\Theta_0}{G} + H \cdot \Theta_0 = \Theta_i$$

$$\text{so, } \Theta_0 \left(\frac{1 + G \cdot H}{G} \right) = \Theta_i = \frac{\Theta_0}{\Theta_i} = \frac{G}{1 + G \cdot H}$$

$$d) \frac{\Theta_0}{\Theta_i} = \frac{G_1 G_2}{1 + G_1 G_2 H} = \frac{(10 \times 2.5)}{1 + (10 \times 2.5 \times 0.15)}$$

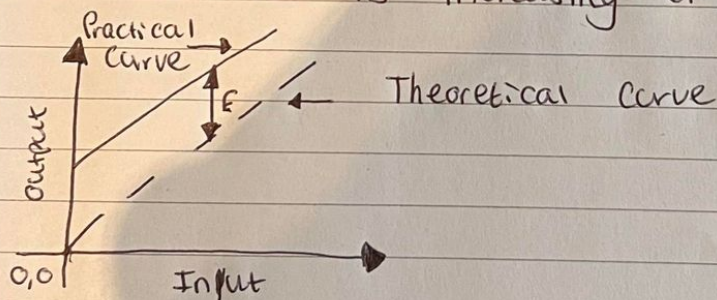
$$= \frac{\Theta_0}{\Theta_i} = 5.3 \frac{\text{mm}}{\text{V}}$$

e) Two examples of closed loop systems are Temperature Control System

1) a) Transducers convert the physical measurement into an electrical signal. These can then be converted into a digital signal.

Although the relationship is not perfectly linear and it is necessary to find a way of using the device to get the most accurate results.

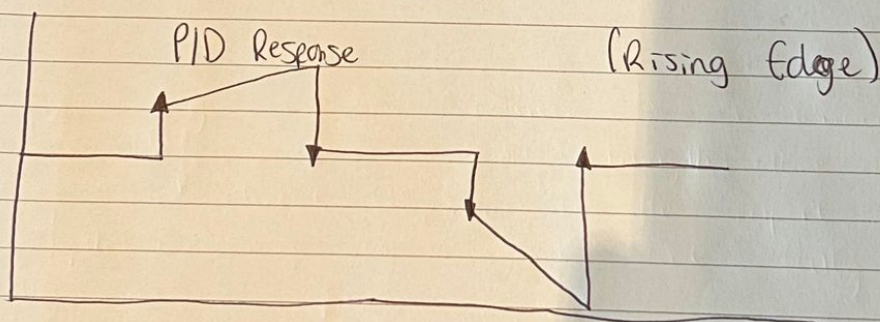
b) All transducers are affected by hysteresis. An output of a transducer depends on the input quantity but also on previous inputs. This means a different output is obtained when the same value of input quantity is applied. This change depending on if it is increasing or decreasing.



c) A resistance strain gauge will be applied to measure pressure. It measures external force that is applied to a fine wire. The wire is formed into a grid. When the pressure changes it causes a resistance change because the fine wire gets distorted. The value of pressure can be found by measuring the change in resistance of the wire grid.

a) A control system manages and commands a set of devices or systems using control loops. It also regulates behaviour. Using automatic process control you can increase production rates and productivity. You can cut down on waste, Improved Safety as manual work is no longer needed. It can also improve better product quality and factory lead times.

b) A proportional - integral - derivative (PID) controller is a control loop mechanism that employs feedback that is used in control systems.



A everyday example of a PID controller is cruise control on a car. When a car goes up a hill the speed will lower if constant engine power was applied. A PID controller will restore the measured speed with the desired speed that is set and with a slight delay will increase the power output of the engine to match the desired speed.

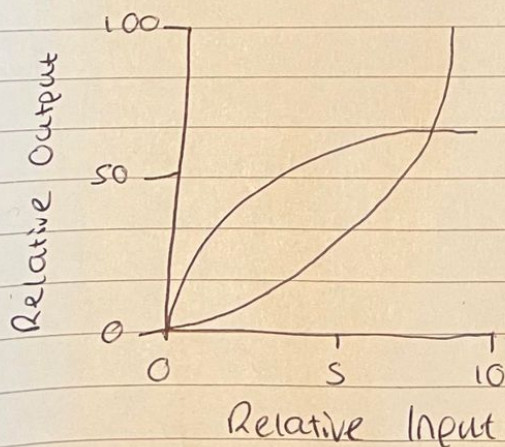
d) i) $\frac{C}{R} = (75 \times 10^{-3}) \times (150 \times 10^{-3}) \times 100 \times 1.78$

$$\frac{C}{R} = 2.0025 \text{ cm/rad}$$

ii) Angular Displacement = $R = \frac{12.75}{2.0025} = 6.37 \text{ rad}$

iii) A Wheatstone Bridge is a divide bridge circuit that is used for the measurement of static or electrical resistance. In this system it is measuring the electrical resistance of the circuit.

e) Nonlinearity is the behavior of a circuit, where the output signal strength does not vary in direct proportion to the input signal strength. Meaning the signals are fully on or fully off.



X Midpoint Equation

$$x_m = \left(\frac{x_{\max} - x_{\min}}{2} \right) + x_{\min}$$

Y Midpoint Non-linearity

$$\% \text{ linearity} = \left| \frac{\left(\frac{y_{\max}}{2} \right) - y_s}{\left(\frac{y_{\max}}{2} \right)} \right| \times 100\%$$