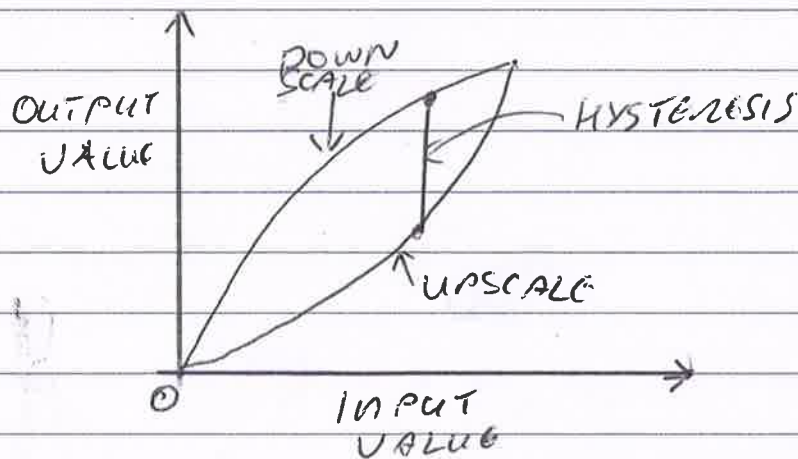


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① THE MEASUREMENT AND OUTPUT SHOULD BE PROPORTIONAL (IN GENERAL)

② HYSTERESIS IS WHERE A TRANSDUCER CAN GIVE A DIFFERENT OUTPUT VALUE DEPENDING ON WHETHER THE SYSTEM IS BEING LOADED OR UNLOADED, IN TERMS OF QUANTITY BEING MEASURED.



OR DIAMETER
③ CHANGE IN LENGTH OF THE GAUGE WIRE CAUSES A PROPORTIONAL CHANGE IN RESISTANCE OF THE DEVICE.

ULTIMATELY THE CHANGE IN THE PHYSICAL SIZE OF THE GAUGE PROPORTIONALLY CHANGES THE RESISTANCE OUTPUT.

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(i) (d) $K_1 = 75 \text{ m}\Omega/\text{mm} \quad \therefore 75 \times 10^{-3}$
 $K_2 = 150 \text{ mV}/\Omega \quad \therefore 150 \times 10^{-3}$
 $K_3 = 100 \text{ V/V}$
 $K_4 = 1.78 \text{ cm/V}$

$$\frac{C}{R} = K_1 \times K_2 \times K_3 \times K_4$$
$$= 75 \times 10^{-3} \times 150 \times 10^{-3} \times 100 \times 1.78$$

$$\frac{C}{R} = 2.0025 \frac{\cancel{\text{m}\Omega}}{\cancel{\text{mm}}} \times \frac{\cancel{\text{mV}}}{\cancel{\Omega}} \times \frac{\cancel{\text{V}}}{\cancel{\text{V}}} \times \frac{\cancel{\text{cm}}}{\cancel{\text{V}}}$$

$$\frac{C}{R} = 2.0 \frac{\text{cm}}{\text{mm}} \leftarrow \text{O.K. OUTCOME?}$$

ii $\frac{C}{R} = 2$

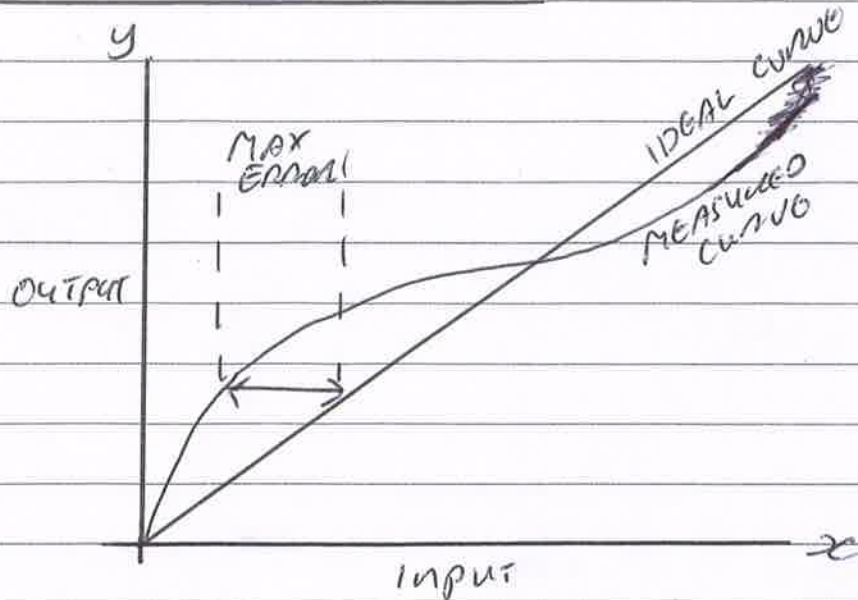
Now $C = 12.75$

so $\frac{12.75}{R} = 2$

$$R = \frac{12.75}{2} = 6.375 \text{ mm}$$

iii A WHEATSTONE BRIDGE CONVERTS RESISTANCE INTO A VOLTAGE TO BE READ BY A RECORDER.

① e



NON LINEARITY IS THE RELATIONSHIP OF THE OUTPUT/INPUT CURVE. THE RELATIONSHIP IS RARELY PERFECT. WHEN THE OUTPUT CURVE PRODUCES MAX ERROR IS DETERMINED FOR EITHER INPUT OR OUTPUT QUANTITY AS A PERCENTAGE

②a

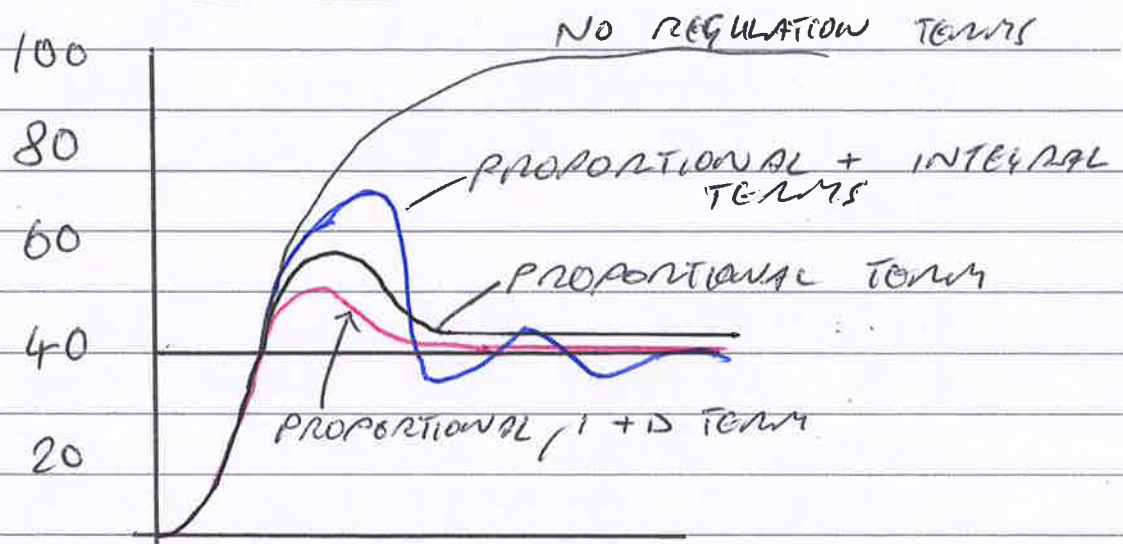
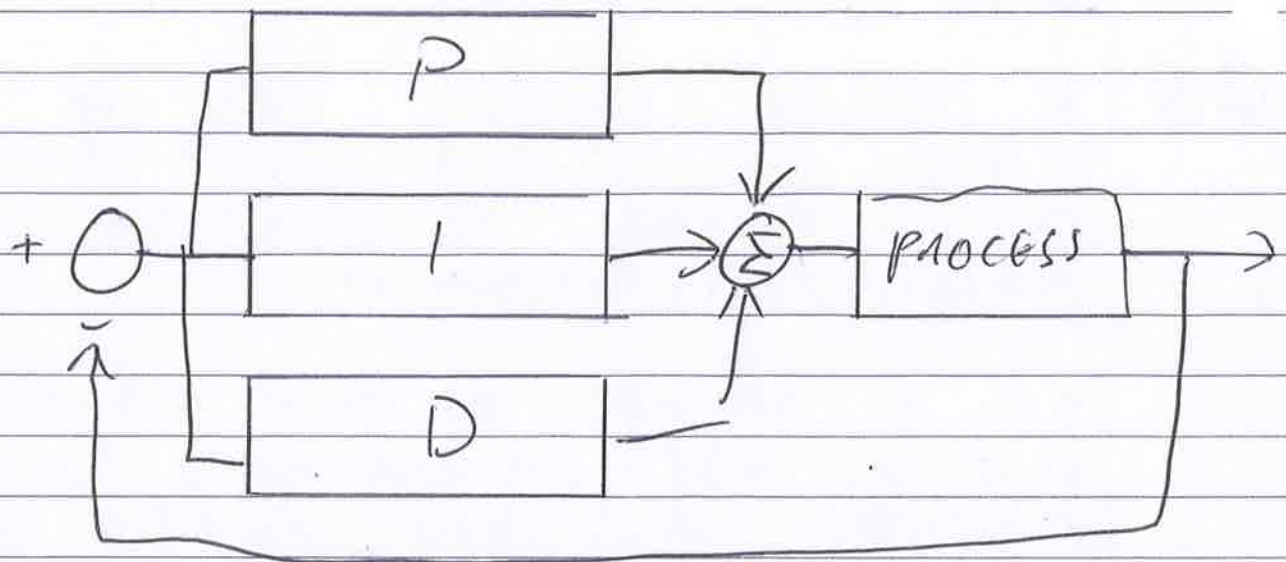
A CONTROL SYSTEM CAN BE EITHER OPEN OR CLOSED LOOP. AND CAN BE UTILISED TO CONTROL MOST MACHINES/OUTPUTS/INPUTS

SO A CONTROL SYSTEM COMPRISES OF SUB SYSTEMS OR ELEMENTS AND PROCESSES ASSEMBLED FOR THE PURPOSE OF CONTROLLING THE OUTPUTS OF PROCESSES. THEY ARE INTEGRAL FOR THE FUNCTIONING OF ALL LIFE.

AUTOMATIC CONTROL AIDS EFFICIENCY AND REMOVES THE NEED FOR HUMAN INPUT. OTHER BENEFITS INCLUDE MORE EFFICIENT ENERGY USE, BETTER PRODUCT QUALITY, IMPROVED SAFETY AND HIGHER PRODUCTION.

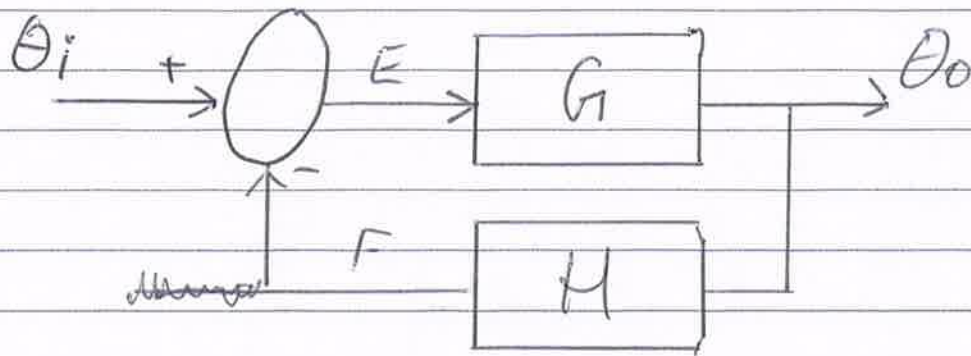
⑥

A PID (PROPORTIONAL, INTEGRAL, DERIVATIVE) CONTROLLER COMBINES 3 CONTROL MODES WHICH ENABLES A CONTROLLER TO HAVE NO OFFSET ERROR AND REDUCES TENDENCY FOR OUTPUT OSCILLATIONS.



AS CAN BE SEEN IN THE GRAPH THERE IS A FAR MORE STABLE AND CONTROLLED RESPONSE WITH PID CONTROL. THERE IS MINIMAL OVERSHOOT, OSCILLATION AND SETTLING TIME. IT IS ALSO FAR MORE ACCURATE.

2 (c)



$$G = \frac{\theta_o}{E} \rightarrow E = \frac{\theta_o}{G}$$

$$H = \frac{F}{\theta_o} \rightarrow F = H \times \theta_o$$

Now $E = \theta_i - \text{~~ANY~~ } F$

$$\therefore \frac{\theta_o}{G} = \theta_i - H \times \theta_o \rightarrow \frac{\theta_o}{G} = H \times \theta_o = \theta_i$$

$$\text{so } \theta_o \left(\frac{1 + G \times H}{G} \right) = \theta_i$$

HENCE

$$\frac{\theta_o}{\theta_i} = \frac{G}{1 + GH}$$

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② (d)

$$\frac{\theta_o}{\theta_i} = \frac{g_1 \times g_2}{1 + (g_1 \times g_2 \times H)} = \frac{10 \times 2.5}{1 + (10 \times 2.5 \times 150 \times 10^{-3})}$$

$$\frac{\theta_o}{\theta_i} = \frac{250}{1 + 3.75} = \frac{250}{4.75} = \frac{52.63}{1} \text{ m/v}$$

(e)

FURNACE ~~CONT~~ TEMPERATURE CONTROL

MOTOR SPEED CONTROLLER eg PRODUCTION LINE

④ a) CONVERT SYSTEM de INTO STANDARD FORM

$$\text{ie } \frac{d^2 x}{dt^2} + \frac{C}{M} \frac{dx}{dt} + \frac{K}{M} x = \frac{F}{M}$$

$$\text{so } 2\zeta \omega_n = \frac{C}{M} \text{ and } \omega_n^2 = \frac{K}{M}$$

$$\therefore \omega_n = \sqrt{\frac{K}{M}} = \sqrt{\frac{4000}{14.5}} = 16.609 \text{ Hz}$$

$$\text{Now } \zeta = \frac{C}{2\omega_n M} = \frac{200}{2 \times 16.609 \times 14.5} = 0.415$$

THE SYSTEM IS UNDER DAMPED.

$$\text{⑤ PERCENTAGE PEAK} = \left[\exp\left(\frac{-0.415 \times \pi}{\sqrt{1-0.415^2}}\right) \times 100 \right]$$

~~exp~~

~~exp~~

$$= 0.238 \times 100$$

$$= 23.8\%$$

$$\text{PEAK TIME} = t_p = \frac{\pi}{\omega_n \sqrt{1-\zeta^2}}$$

$$= \frac{\pi}{16.609 \times \sqrt{1-0.415^2}}$$

$$= 0.207 \text{ s}$$

4B
~~4B~~

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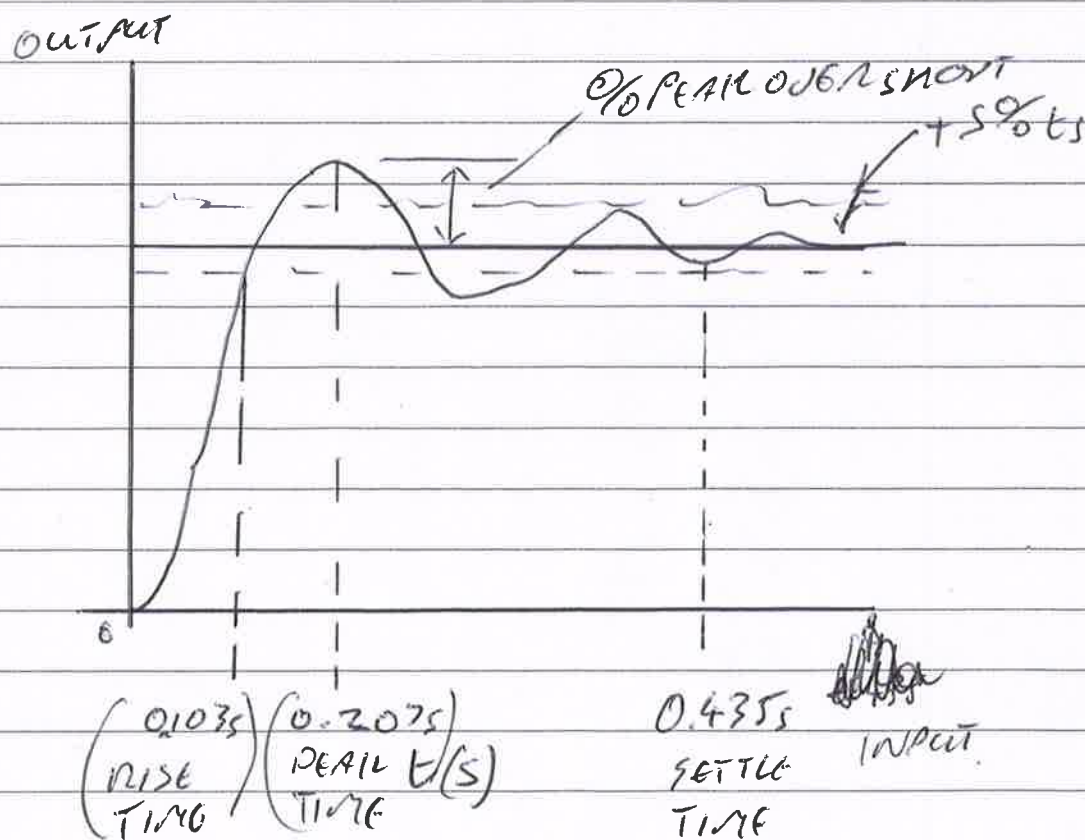
RISE TIME

$$t_r = \frac{\pi}{2 \omega_n \sqrt{1-\zeta^2}} = \frac{\pi}{2 \times 16.609 \times \sqrt{1-0.415^2}} \\ = 0.103s$$

5% T_s

$$t_s = \frac{3}{\zeta \omega_n} = \frac{3}{0.415 \times 16.609} = 0.435s$$

(C)



(4d)

$$\text{so } 12.5 = \left[e^{\left(\frac{-\pi z}{\sqrt{1-z^2}} \right)} \right] \times 100$$

logs of both sides

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