

Exam

1) a) For measurement, this is the act of determining the values or a value of a given function. i.e. measure the temperature increase of water on a hob after 10 seconds of max heat.

Monitoring is simply the act of watching closely/observing/surveillance in order to record or detect a specific value from the function.

1(b) at the end. b) Steady State error is the difference between the desired value and the actual output value of a system when the response has reached the steady state.

Transient errors are defined as the longitudinal response variations measured ~~value~~ in the output response.

(c) The length of the ~~metal~~^{wire} on the strain gauge is the indicator of the resistance applied to it. $\therefore$ the change in length is proportional to the resistance applied by the pressure.

(d) i) $0.75 \cancel{\Omega/\text{rad}}$, $150 \cancel{\text{m}} \times 10^{-3} \cancel{\Omega}$, $500 \cancel{\text{V/V}}$, 1 cm/V

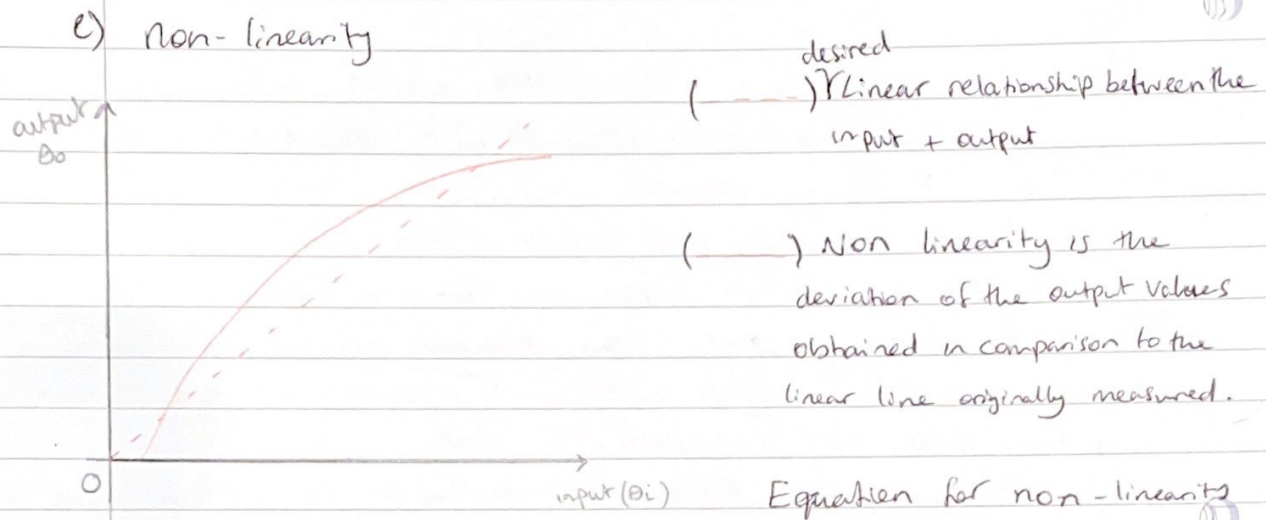
$$\therefore \text{OTF} = 0.75 \times 150 \times 10^{-3} \times 500 \times 1 \\ = \underline{56.25 \text{ cm/rad}}$$

ii) $\therefore$ if $C = 8.5 \text{ cm}$

$$\text{Then } \frac{8.5 \text{ cm}}{R} = \frac{56.25 \text{ cm}}{\text{rad}} \rightarrow \frac{8.5 \text{ cm}}{56.25 \text{ cm/rad}} = R$$

$$\therefore \underline{R = 0.15 \text{ rad}}$$

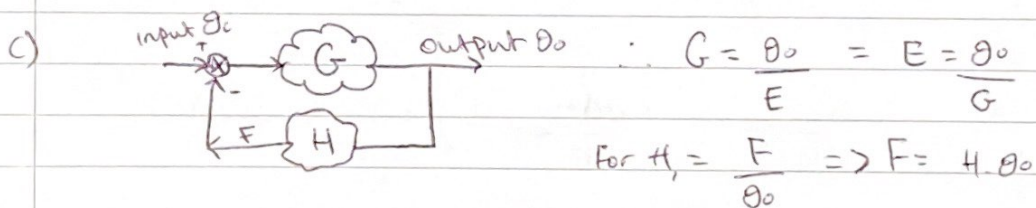
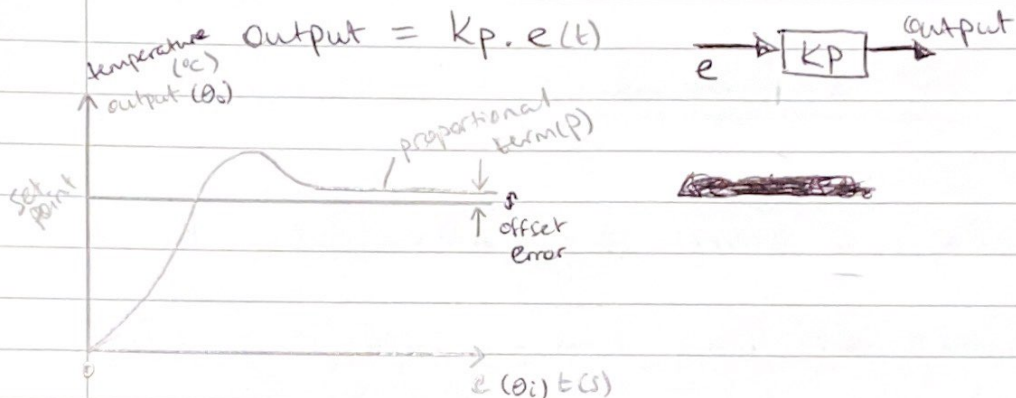
iii) Function of wheatstone bridge is to change the resistance value into voltage for the recorder to read a value.



2. (a) An open loop control system consists of 3 functional elements where one element becomes the input into the next. In an open loop system the input is not affected by the output e.g. heat transfer cannot affect this system.

A closed loop control system is the same as an open loop system but with ~~an~~ added element known as the feedback measuring system. This added element provides an error signal back into the input that allows the system to maintain its desired input value. It is a reliable system that offers a small steady state error whereas an open loop system will have a larger margin for error.

- (b) proportional control strategy is a control action that is proportional to the error signal. ~~more~~ The greater the error = greater output.



Now Sub in for $E + F$,

$$\therefore \frac{\theta_o}{G} = \theta_i - 4 \cdot \theta_o \rightarrow \frac{\theta_o}{G} + 4\theta_o = \theta_i \quad (1)$$

$$\therefore (1) = \theta_o \left(\frac{1}{G} + 4 \right) = \theta_i \rightarrow \frac{1 + 4G}{G} = \frac{\theta_i}{\theta_o}$$

$$\therefore \text{flip and hence, } \frac{\theta_o}{\theta_i} = \frac{G}{1 + 4G}$$

(d) OSTF, $\overset{G_1}{5.0 \text{ mA/V}}$, $\overset{G_2}{0.25 \text{ mm/mA}}$, $\overset{H}{150 \text{ mV/mm}}$

$$\therefore \text{OTF} = \frac{\theta_o}{\theta_i} = \frac{\overset{G_1}{5} \times \overset{G_2}{0.25}}{1 + \overset{G_1}{5} \times \overset{G_2}{0.25} \times \overset{H}{150 \times 10^{-3} \text{ V/mm}}}$$

$$\underline{\text{OTF} = 1.05 \text{ mm/V}}$$

(e) Temperature control of a reheat furnace for steel slabs

Speed control of a conveyor belt

width control of steel rolling guides.

4. (a) $7.5 \frac{d^2 \theta_o}{dt^2} + 40 \frac{d\theta_o}{dt} + 300 \theta_o = 800 \theta_i$

$\therefore$ Convert to standard form, $\frac{d^2 \theta_o}{dt^2} + \frac{40}{7.5} \frac{d\theta_o}{dt} + \frac{300}{7.5} \theta_o = \frac{800}{7.5} \theta_i$

① So, $2\zeta \omega_n = \frac{40}{7.5} = 5.33$

② and $\omega_n^2 = \frac{300}{7.5} \Rightarrow \sqrt{\frac{300}{7.5}} = \omega_n \therefore \omega_n = 2\sqrt{10}$

$\therefore$ Sub back in ① ~~to find~~ to find ζ

$$2\zeta(2\sqrt{10}) = 5.33 \therefore \zeta = 0.422$$

This value shows the system is underdamped.

(b) $\zeta = 0.422$ So, for POS

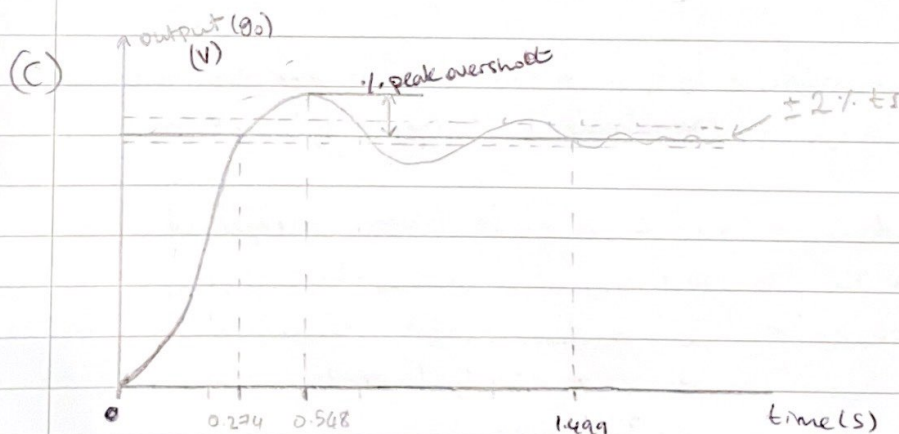
$$\left(\exp\left(\frac{-0.422\pi}{\sqrt{1-0.422^2}} \right) \right) \times 100$$

$$\therefore \% \text{ overshoot} = \underline{23.2 \%}$$

for t_r , $\frac{\pi}{2(2\sqrt{10} \cdot \sqrt{1-0.422^2})} = \underline{0.274 \text{ s}}$

for t_p , $\frac{\pi}{2\sqrt{10} \cdot \sqrt{1-0.422^2}} \therefore = \underline{0.548 \text{ s}}$

for $2\% t_s$, $\frac{4}{0.422 \cdot 2\sqrt{10}} \therefore = \underline{1.499 \text{ s}}$



d) 15% max, $\therefore 15 = \left(\exp\left(\frac{-\zeta \pi}{\sqrt{1-\zeta^2}} \right) \right) \times 100$

$\therefore$ taking natural logs of both sides

$$\ln 0.15 = -1.897 = \frac{-\zeta \pi}{\sqrt{1-\zeta^2}}$$

$$\therefore -1.897(\sqrt{1-\zeta^2}) = \zeta\pi$$

Square both sides $\therefore 3.599(1-\zeta^2) = 9.869\zeta^2$

$$3.599 - 3.599\zeta^2 = 9.869\zeta^2$$

$$\therefore 3.599 = 13.468\zeta^2$$

$$\therefore \zeta = \sqrt{\frac{3.599}{13.468}}$$

$$\therefore \zeta = \underline{0.517} \quad \approx 0.52$$

$\therefore$ This value of the damping ratio would achieve a 15% max overshoot in the circuit.

1(b) Systematic errors - occur due to poor experimental methodology or design of measurement system (biased readings obtained)

Random errors - occur from unexpected causes hence must be treated using Statistic techniques. To determine magnitude of the random error, standard deviation about the mean value is specified. (readings dispersed around a mean value representing its true value).