

1a) Measurement is in reference a method to determine the actual characteristics of something.

Monitoring is to observe something so ~~that~~ you can detect or record.

b) Two types of error:

- Systematic error - Usually caused due to deficient experiment methods or design in regards of the measurement system.

- Random error - Due to unexpected causes.

c) The change in length of the gauge wire creates proportional change to the resistance of the device.

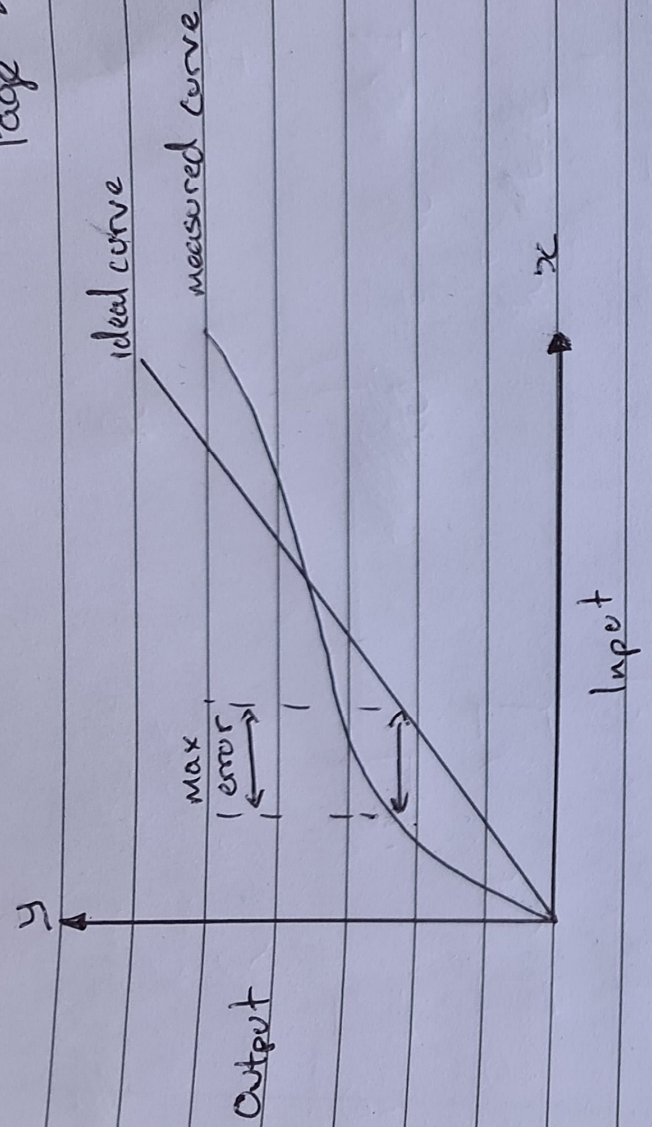
$$\begin{aligned} d) i) C/R &= K_1 \times K_2 \times K_3 \times K_4 \\ &= 0.75 \times 0.15 \times 500 \times 1 \\ &= 56.25 \text{ cm/rad} \end{aligned}$$

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

$$R = C / 56.25$$

$$R = 8.5 / 56.25 = 0.15 \text{ rad}$$

iii) The element alters the resistance value into voltage which can then be read by the recorder.



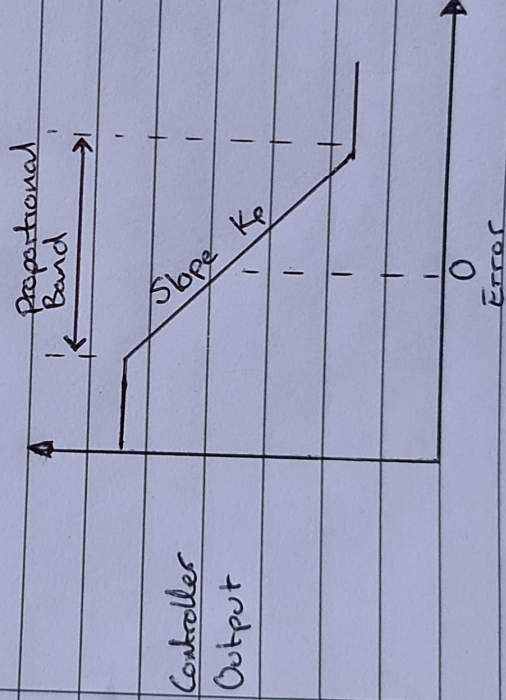
2a)

Open loop - Has no error signal to account for differences in output value compared to the desired output.

It usually contains three functional elements: controller, output and process.

Closed loop - This system has a feedback signal with measurement device and comparison element. This ~~is~~ is all on top of the features of the open loop system.

b) A Proportional ~~control~~ control produces a control action that is proportional to the error signal. The larger the error the larger resultant output.



$$G = O_o / E \rightarrow E = O_o / G$$

$$H = F / O_o \rightarrow F = H \times O_o$$

$$E = O_i - F \rightarrow O_o / G = O_i - H \cdot O_o$$

$$\frac{O_o}{G} + H \cdot O_o = O_i$$

$$\text{So, } \theta_o \left(\frac{1 + G.H}{G} \right) = \theta_i$$

$$\text{Hence, } \frac{\theta_o}{\theta_i} = \left(\frac{G}{1 + G.H} \right)$$

$$\begin{aligned} \text{d) } \frac{\theta_o}{\theta_i} &= \frac{G_1 \times G_2}{1 + (G_1 \times G_2 \times H)} & G_1 &= 5.0 \text{ mA/V} \\ & & G_2 &= 0.25 \text{ mm/mA} \\ & & H &= 0.15 \text{ V/mm} \end{aligned}$$

$$\frac{\theta_o}{\theta_i} = \frac{5 \times 0.25}{1 + (5 \times 0.25 \times 0.15)}$$

$$\frac{\theta_o}{\theta_i} = 1.05 \text{ mm/V}$$

- e) . The speed control of a conveyor belt
 . The temperature control of a heat treatment furnace.

3a) $G_1 = 15$ $G_2 = 0.35$
 $E_{ss} = 0$

$$E_{ss} = O_i \left(\frac{G_1 \times G_2}{1 + (G_1 \times G_2 \times H)} - 1 \right)$$

Zero steady-state error: $\left(\frac{G_1 \times G_2}{1 + (G_1 \times G_2 \times H)} \right) = 1$

$$1 = \frac{15 \times 0.35}{1 + (15 \times 0.35 \times H)}$$

$$1 = \frac{5.25}{1 + 5.25 H}$$

$$1 + 5.25 H = 5.25$$

$$H = 4.25 / 5.25$$

$$H = 0.81 \text{ V/rpm}$$

ii) closed loop system:

$$E_{ss} = O_i \left(\frac{G_1 G_2}{1 + (G_1 G_2 H)} - 1 \right)$$

Controller function is 15% reduced:

$$G_1 = 15 \times 0.85 = 12.75$$

$$H = 0.81$$

$$E_{ss} = O_i \left(\frac{G_1 \times G_2}{1 + (G_1 \times G_2 \times H)} - 1 \right) = O_i \left(\frac{12.75 \times 0.35}{1 + (12.75 \times 0.35 \times 0.81)} - 1 \right)$$

$$E_{ss} = 0.033 O_i \quad \text{or} \quad 0.33\%$$

b) i) ~~Time~~ Time = 15 secs ~~R~~

$$C = 0.015$$

$$R = ?$$

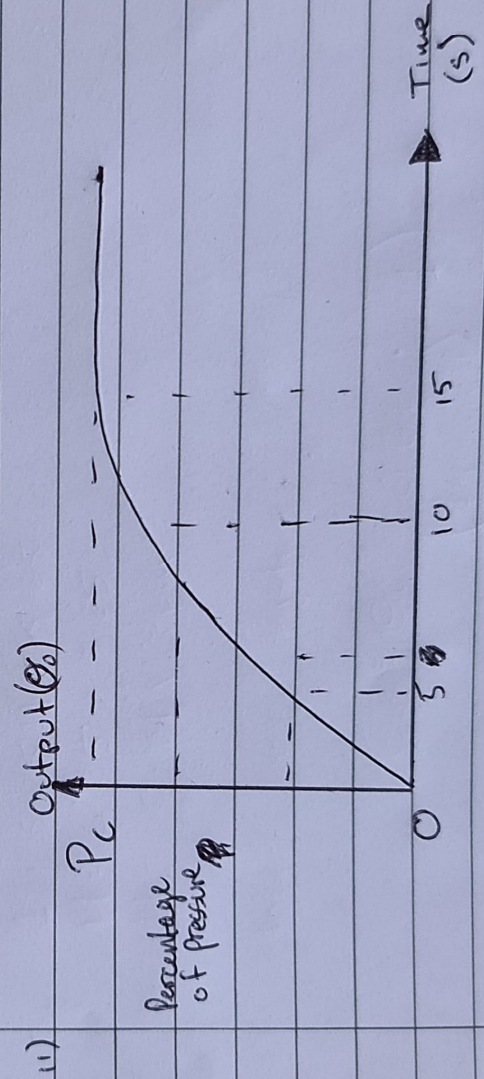
$$P_c = P [1 - e^{-t/RC}] \quad \text{not } RC \quad -t/RC = 1$$

$$P_c = P [1 - e^{(-15/0.015)R}] \quad \downarrow \quad R = -t/C$$

$$P_c = P [1 - e^{(-1000)R}] \quad R = -15/0.015$$

$$R = -1000$$

~~Pressure~~



c) Transient response - occurs as a result of a change in the system input and generally dies away after a short interval of time.

Steady-state response - that which remains after all transient responses have died down completely.

