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(1)(a) A measurement transducer is used to take an instant "snap shot" of the quantity being measured, whereas a monitoring transducer is used to take short term but continuous readings.

(b) The two types of error typically found in a measurement system are :-

Systemic error

This is an error that exists within a system due to an inaccuracy. An example might be a poorly calibrated flow meter.

Random error

A random error is an error that results from an unexpected cause. An example might be momentary non laminar flow through a flow meter causing a bad reading.

(c) A resistance strain gauge can be used to measure pressure by laying the gauge across a diaphragm that is exposed to the pressure source. As the pressure increases, the diaphragm distorts and stretches the strain gauge. As the gauge wires ~~is~~ length changes, a proportional change in the wire's resistance occurs.

(d)(i) $C/R = 0.75 \times 0.150 \times 500 \times 1 \quad \frac{\Omega}{rad} \times \frac{V}{\Omega} \times \frac{V}{V} \times \frac{cm}{V}$

$C/R = 56.25 \quad cm/rad$

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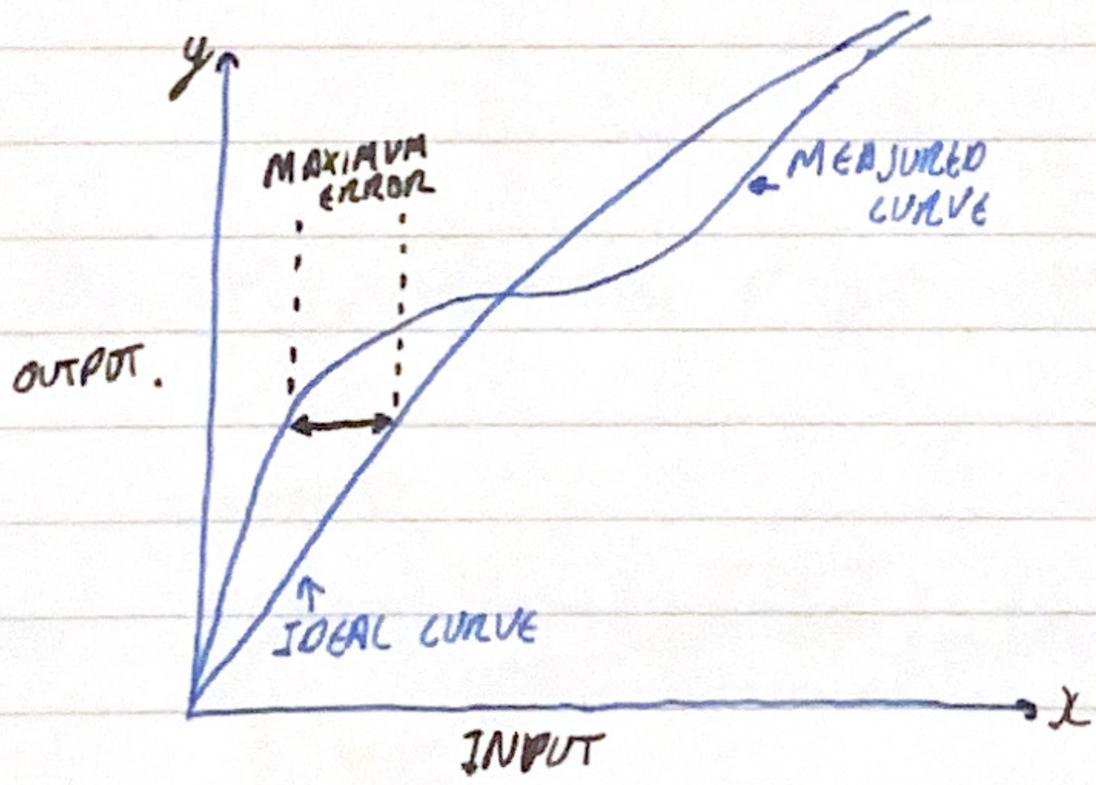
(1)(d)(ii) $C = 8.5\,cm$

$\therefore R = \frac{8.5}{56.25}$

$= 0.142$ rads.

(iii) A Wheatstone bridge is used to change a value of resistance into a voltage value. This voltage can then be read by a recording device.

(e)

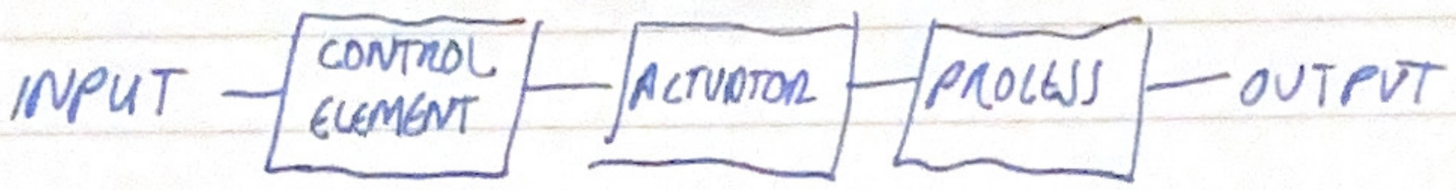


Non linearity is when the measured curve deviates from the ideal curve. The maximum error is determined as a percentage of full range for either input or output.

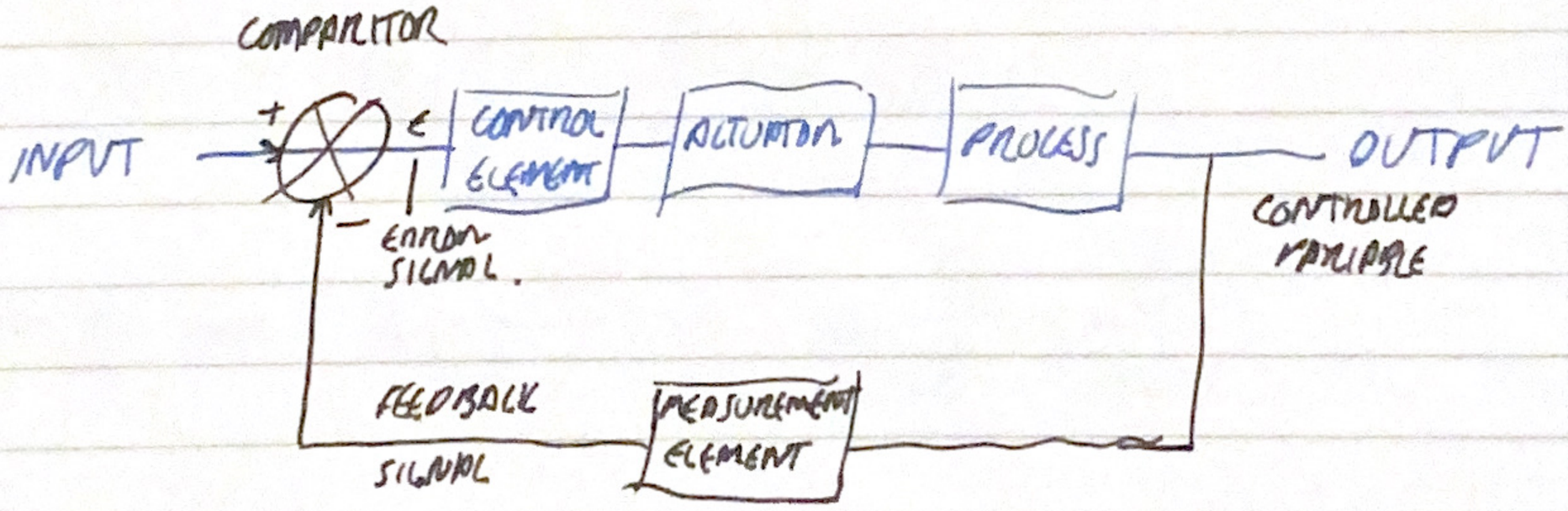
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(2)(a) The fundamental difference between open & closed loop systems is has no error signal feedback. A closed loop system has an error signal feedback element. The closed loop system uses this signal, compares it against the desired output and adjusts accordingly.

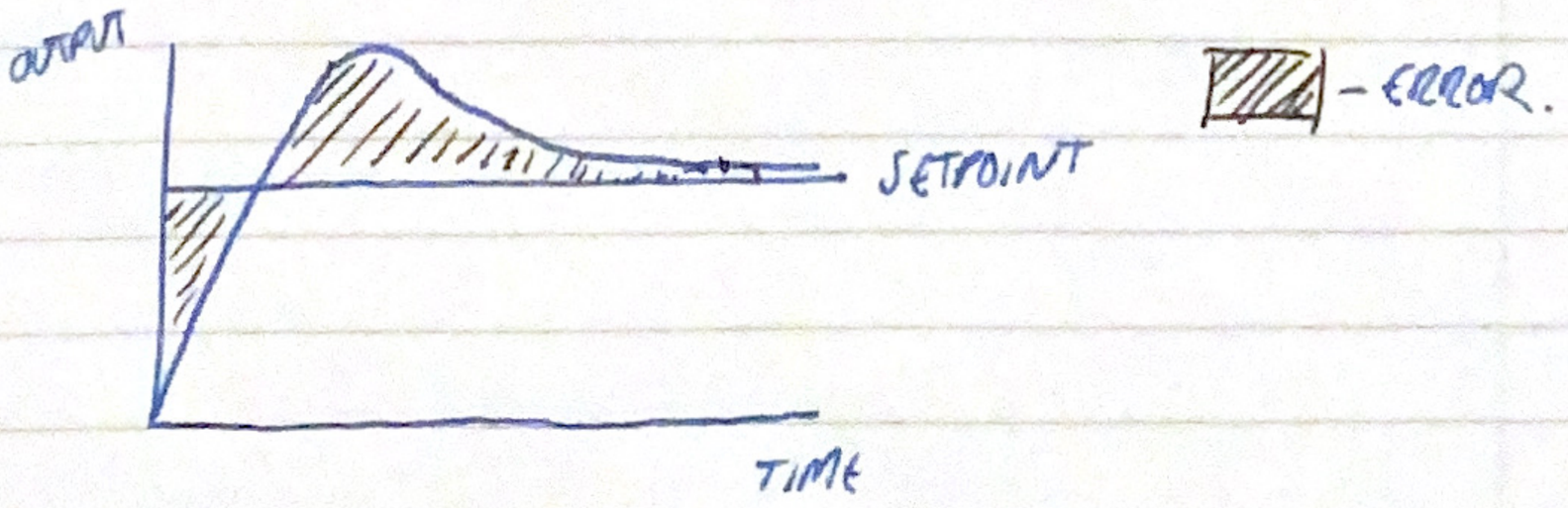
OPEN LOOP



CLOSED LOOP (fundamentals of open loop, plus feedback)

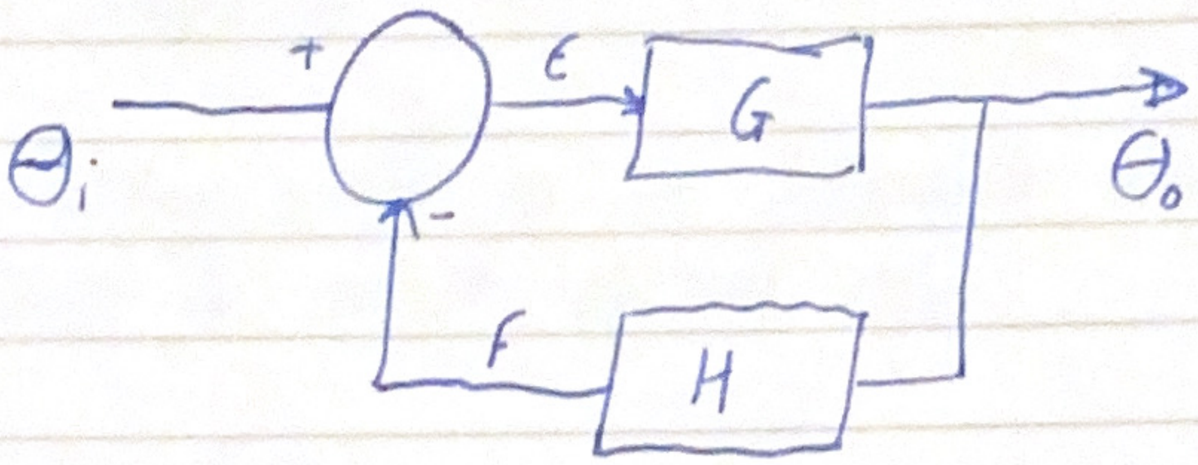


(b) Proportional control strategy creates a control action that is proportional to the error signal. The larger the error, the greater the output.



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(2)(c)



$G = \frac{\theta_o}{E}$ so E must equal $\frac{\theta_o}{G}$.

and $H = \frac{F}{\theta_o}$ so F must equal $H \times \theta_o$

$\epsilon = \theta_i - F$

$\therefore \frac{\theta_o}{G} = \theta_i - (H \times \theta_o) = \frac{\theta_o}{G} + (H \times \theta_o) = \theta_i$

From the above, $\theta_o \left(\frac{1+GH}{G}\right) = \theta_i$ so $\frac{\theta_o}{\theta_i} = \frac{G}{1+GH}$

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

$= \frac{1.25}{1.1875}$

$= 1.053 \text{ mm/V}$

(e) P.T.O.

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CONTROL SYSTEMS

(2)(e) Example (1)

Fuelling system on an automobile, using an exhaust lambda sensor to correct air/fuel ratio.

Example (2)

Domestic central heating system, using a thermostat to regulate temperature.

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(3)(a)(i)

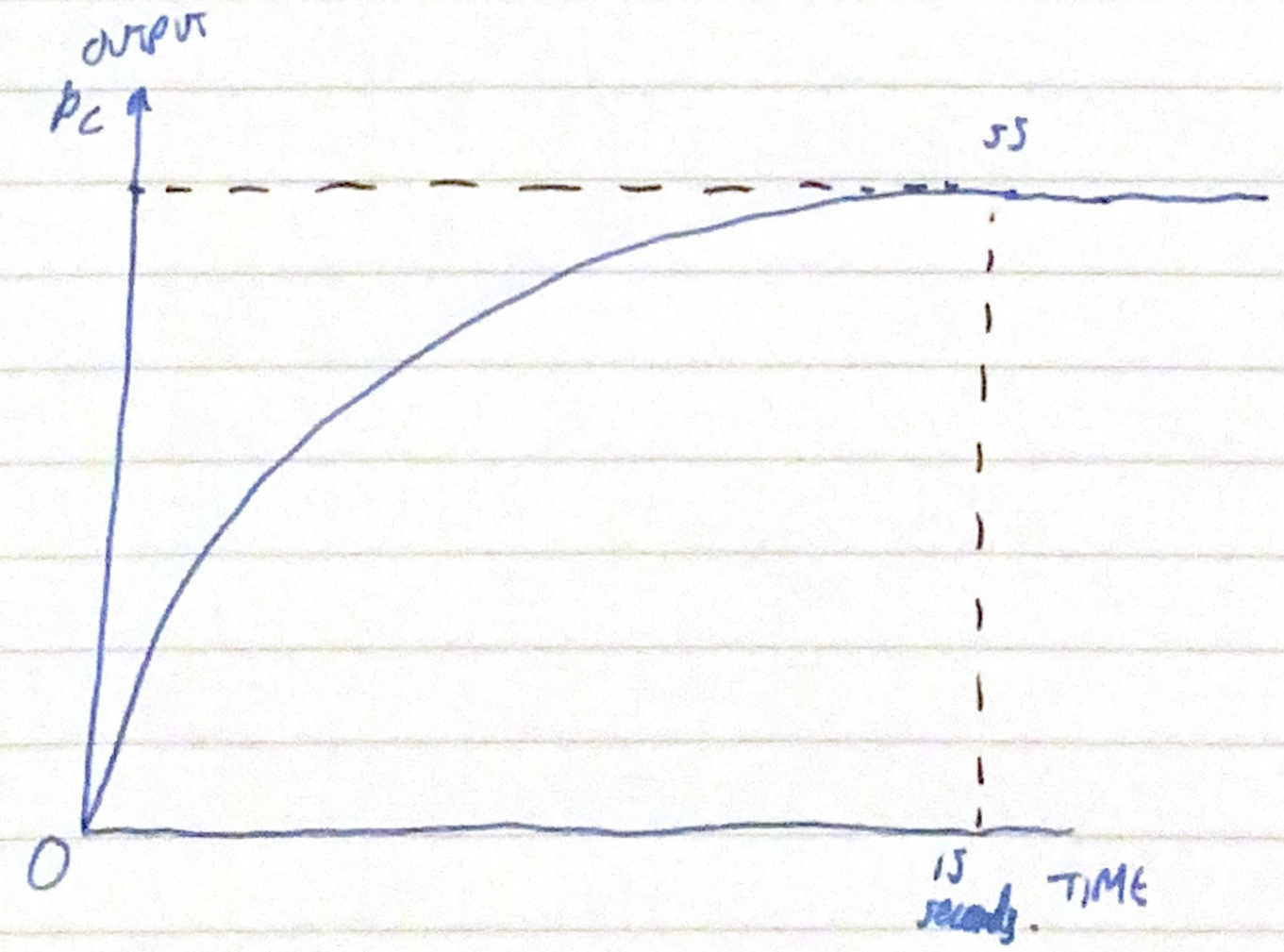
$$E_{SS} = \theta_i \left(\frac{G}{1+GH} - 1 \right)$$

$$\phi = \theta_i \left(\frac{15 \times 0.35}{1+(15 \times 0.35 \times H} - 1 \right)$$

(b)(i) $p_c = p\left(1 - e^{-t/\tau_c}\right)$

where

(b)(ii)



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(3) (c) $\tilde{y}(t)$ is transient response

$\bar{y}(t)$ is steady state response.

