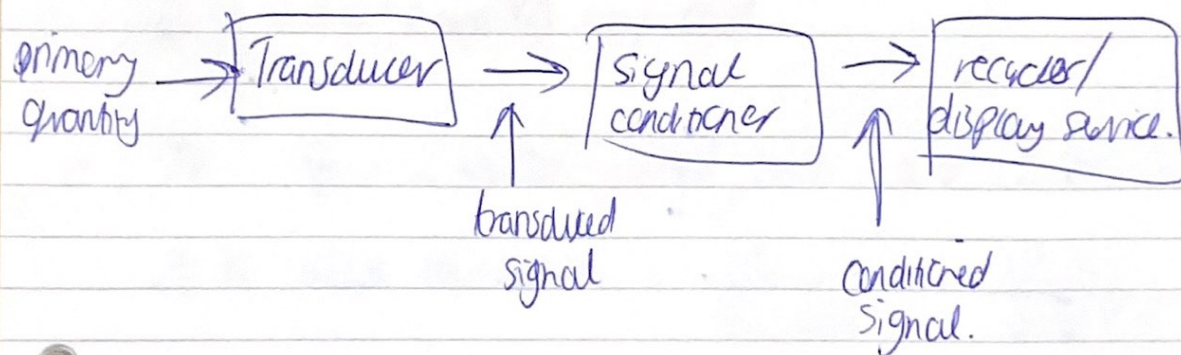


One (a) The ideal relationship between the transducer output and measurand is that transducers convert the physical measurand into an electrical signal that can be converted into a digital signal.

(b) Hysteresis is the difference between two separate measurements taken at the same point. The first is taken during a series of increasing measurement values and other during a series of decreasing



(c) change in length of gauge wire causes proportional change in resistance of device.

It converts the applied force, pressure, torque etc. into an electrical signal which can be measured.

force causes strain, which is measured by the strain gauge by way of a change in electrical resistance. Its attached to a diaphragm. Pressure causes diaphragm to deform which turns strain to resistance.

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$$\begin{aligned} (d) \quad & 0.075 \text{ } \Omega / \text{mm} \\ & 0.15 \text{ V} / \Omega \\ & 100 \text{ V/W} \\ & 1.78 \text{ cm/V} \end{aligned}$$

(i) overall system sensitivity.

$$K_1 \times K_2 \times K_3 \times K_4 =$$
$$0.075 \times 0.15 \times 100 \times 1.78 = 2.0025 \text{ cm/}^\circ\text{C}.$$

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

ii) If $\frac{C}{R} = 2.0025 \text{ cm/rad}$ and $C = 12.75 \text{ cm}.$

$$\therefore R \text{ input increment} = \frac{C}{2.0025} = \frac{12.75}{2.0025}.$$

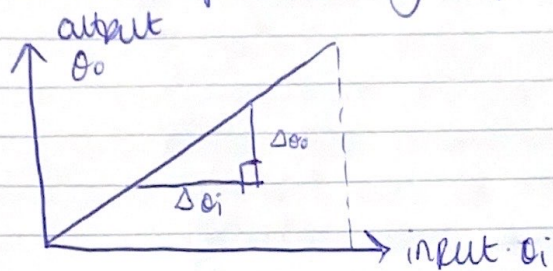
$$\text{So, } \underline{R = 6.367 \text{ mm.rad.}}$$

iii) changes resistance value into voltage to be ultimately read by receiver.

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(e) Maximum deviation from linear input/output relationship normally expressed by %.



So, $\Delta \theta_o \propto \Delta \theta_i$

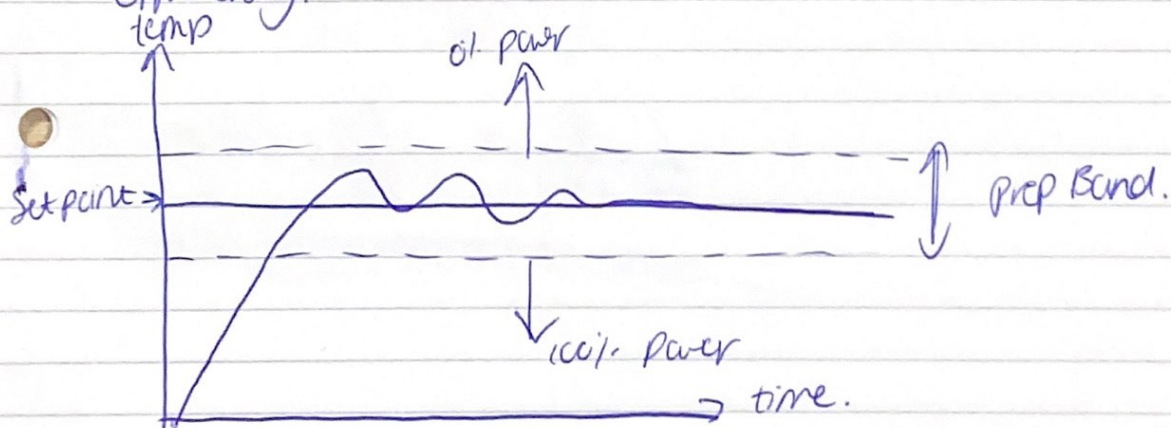
Hence, gradient of straight line yields a proportional relationship, so possible to find input quantity from recorded output value.

two) (a) A control system manages, commands, directs, or regulates the behaviour of other devices or systems using control loops.

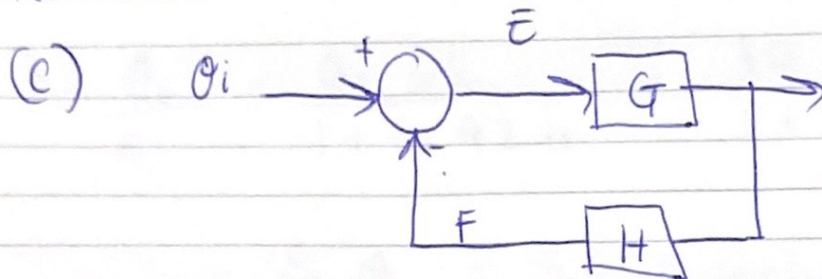
Advantages include higher production rates and increased productivity, more efficient use of materials, quality and reduced lead times.

It can automatically deal with system disturbance.

(b) PID is a proportional, integral, derivative. It provides a continuous variation of output within a control loop feedback mechanism to accurately control the process, removing oscillation and increasing efficiency.



It's the controlled variable (CV). ~~that reacts~~
to the parameter that reacts to CV change
is the process variable (PV).



Now, $E = \theta_i - F$

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

$$H = \frac{F}{\theta_o} \Rightarrow F = H \cdot \theta_o$$

~~Not~~ $\therefore \theta_o = \theta_i - H \cdot \theta_o \Rightarrow \frac{\theta_o}{G} + H \cdot \theta_o = \theta_i$

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

$$\text{Hence, } \frac{\theta_o}{\theta_i} = \frac{G}{1 + G \cdot H}$$

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$$(d) \frac{\theta_o}{\theta_i} = \frac{G1 \cdot G2}{1 + G1 \cdot G2 \cdot H} = \frac{10 \times 2.5}{1 + (10 \times 2.5 \times 0.15)}$$

$$\therefore \lim_{\omega \rightarrow 0} \frac{\theta_o}{\theta_i} = \underline{\underline{5.263 \text{ mm/v.}}}$$

- (e) . Speed control of conveyor belts
 . Temperature control of brewing process.

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$$4 \ a) \ m \frac{d^2 x}{dt^2} + c \frac{dx}{dt} + kx = F$$

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

$$\frac{d^2 \theta_0}{dt^2} + 2\zeta \omega_n \frac{d\theta_0}{dt} + \omega_n^2 \theta_0 = b_1 \omega_n^2 \theta_0$$

$$\omega_n^2 = \frac{k}{m} \quad \theta_0 = x \quad 2\zeta \omega_n = \frac{c}{m}$$

$$\omega_n^2 = \frac{4000}{14.5} \quad \omega_n = \sqrt{275.862}$$

$$\omega_n = 16.6$$

$$2\zeta \omega_n = \frac{c}{m} = \frac{200}{14.5}$$

$$\zeta = \frac{200}{14.5 \times 16.6 \times 2}$$

$$= 0.42 \quad \text{so... its underdamped.}$$

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$$b) P_0 = e^{\left(\frac{-0.42\pi}{\sqrt{1-0.42^2}} \right)} \times 100.$$

$$= e^{\left(\frac{-1.319}{0.9} \right)} \times 100.$$

$$= e^{-1.465} = 23.10\%.$$

Peak overshoot.

$$\text{Rise time} = W t_r = \pi/2.$$

$$W = 16.6 \sqrt{(1-0.42^2)}.$$
$$= 15.06$$

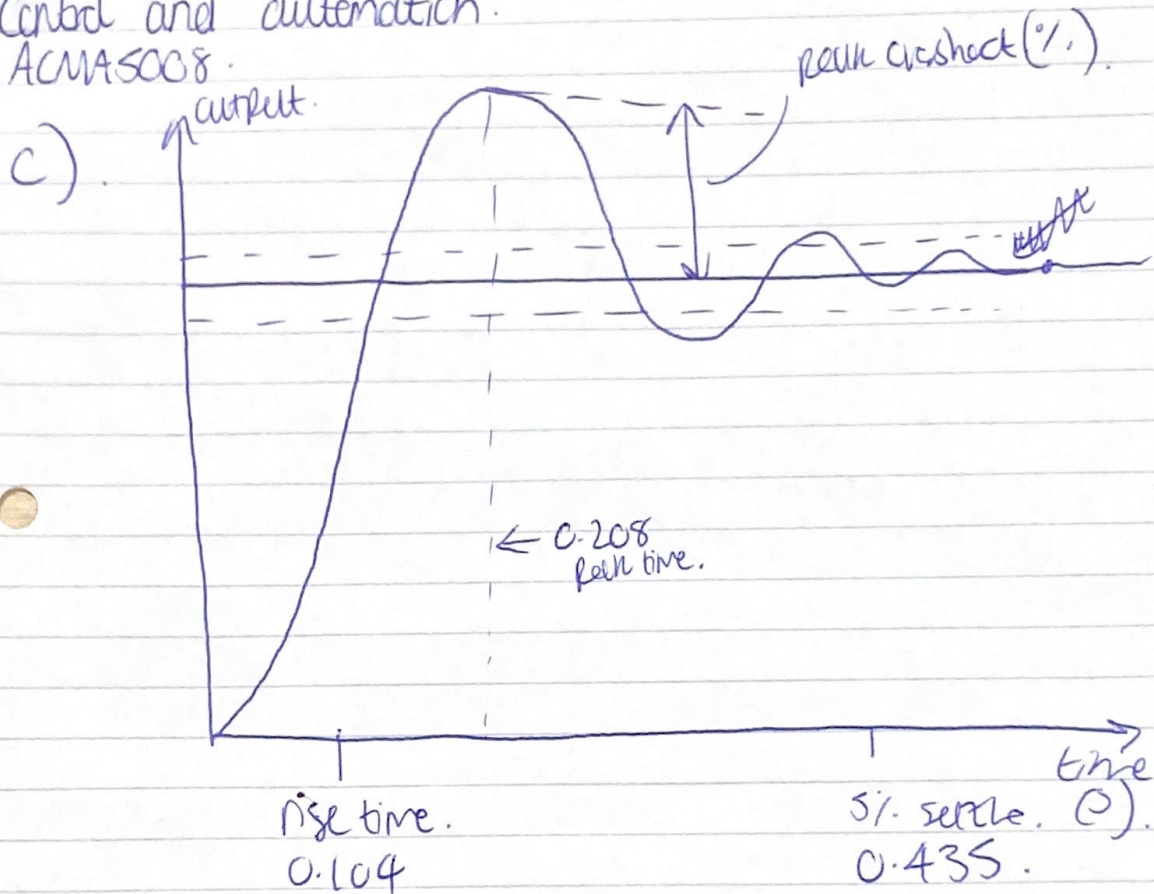
$$t_r = \frac{\pi}{15.06 \times 2} = 0.104.$$

$$\text{Peak time} = \frac{\pi}{\omega_d} = 0.208.$$

$$\text{5\% } t_s = \frac{3}{0.42 \times 16.6} = 0.435.$$

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$$d) 12.5 = e^{\left(\frac{1-\pi z}{\sqrt{1-z^2}}\right)} \times 100.$$

$$\ln = 0.125 = \frac{-3\pi}{\sqrt{1-z^2}}$$

$$-2.079(\sqrt{1-z^2}) = 3\pi$$

$$4.324(1-z^2) = 9.8z^2$$

$$4.324 - 4.324z^2 = 9.8z^2$$

$$\sqrt{0.30} = \underline{\underline{0.5477.}}$$