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①

BASIC LINEAR CONTROL SYSTEM:

Q1) Linear time-invariant systems (LTI) are a class of system used in signals and systems that are both linear and time invariant.

→ Linear systems are systems whose outputs for a linear combination of inputs are the same as linear combination of individual responses to those inputs.

→ Time-invariant systems are systems where the output doesn't depend on when an input was applied.

Properties:

① $H(k\,y(t)) = kH(y(t))$ // scaling property.

② $H(y_1(t) + y_2(t)) = H(y_1(t)) + H(y_2(t))$ // superposition property.

③ $H(y(t-T)) = y(t-T)$ // time-invariant system property.

P.T.O

Q2) $\dot{y} - 2y = 2x$, $x(t) = u(t)$
$y(0) = -1.$

$$-2y(s) = 2u(s)$$

$$\frac{dy(s)}{dt} = 2/s + 2y(s)$$

$$\Rightarrow sY(s) - Y(0) = 2/s$$

$$\Rightarrow sY(s) + 1 - 2Y(s) = 2/s.$$

$$\Rightarrow Y(s)(s-2) + 1 = 2/s$$

$$\Rightarrow Y(s) = \left(\tfrac{2}{s} - 1\right) / (s-2)$$

$$\Rightarrow Y(s) = 2-s / s(s-2).$$

$$\Rightarrow Y(s) = -(s-2)/s(s-2)$$

$$\Rightarrow Y(s) = -1/s.$$

$$\Rightarrow Y(s) = -\frac{1}{s}$$

$$\Rightarrow \boxed{Y(s) = -u(t)}$$

Q3)

i) $y(s) = m\frac{d^2 v(s)}{ds^2} + b\frac{dv(s)}{ds} + k\,v(s).$

→ Transfer function of

$$y(s) = ms^2 v(s) + b\,sv(s) + Kv(s)$$

$$y(s) = ms^2 v(s) + b\,s\,v(s) + k\,v(s)$$

$$\boxed{\frac{y(s)}{v(s)} = Ms^2 + bs + K.}$$

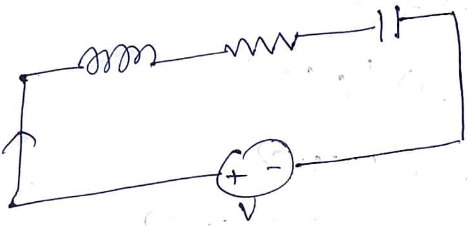
P.T.O.

(c) Force- voltage analogy: $\circ$ 2

$$V = L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C}$$

or,

$$V = L\frac{dI}{dt} + RI + \frac{1}{C}\int I\,dt.$$



Q4) $G(S) = K/s(s+6)$

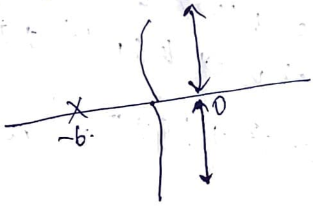
poles, $s = 0$
$s = -6.$

Asymtotes.

$$\theta = \frac{(2q+1)\,180}{P-Z}, \quad q = 0,1,2 \ldots$$

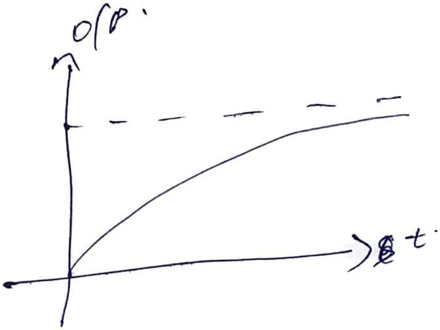
$\theta = 90, 270^\circ$

So, root locus is



P.T.O.

a) over damped with $\xi = 1.5$



$\xi = 1.5$;

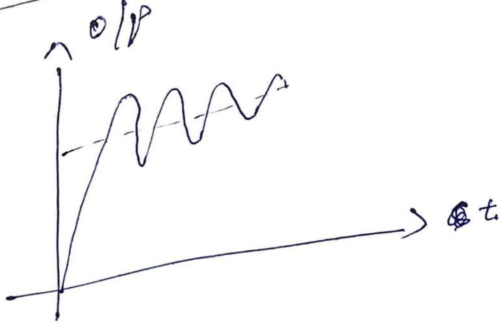
$\Rightarrow 1.5 = 3/\sqrt{K}$.

$\boxed{K = 4.}$

$\xi = 0.75$; $\Rightarrow 0.75 = \frac{3}{\sqrt{K}}$.

$K = \left(\frac{3}{0.75}\right)^2 = 16 \Rightarrow \boxed{K = 16.}$

b) under damped.



c) Critically damped.

$\xi = 1$;

$\Rightarrow 1 = \frac{3}{\sqrt{K}} \Rightarrow \boxed{K = 9}$