Name : Muhammad Saqib Khalil

ID : 13342

Program : BE (Electrical)

Subject : LCS (Theory)

Exam : Summer (2020) Final

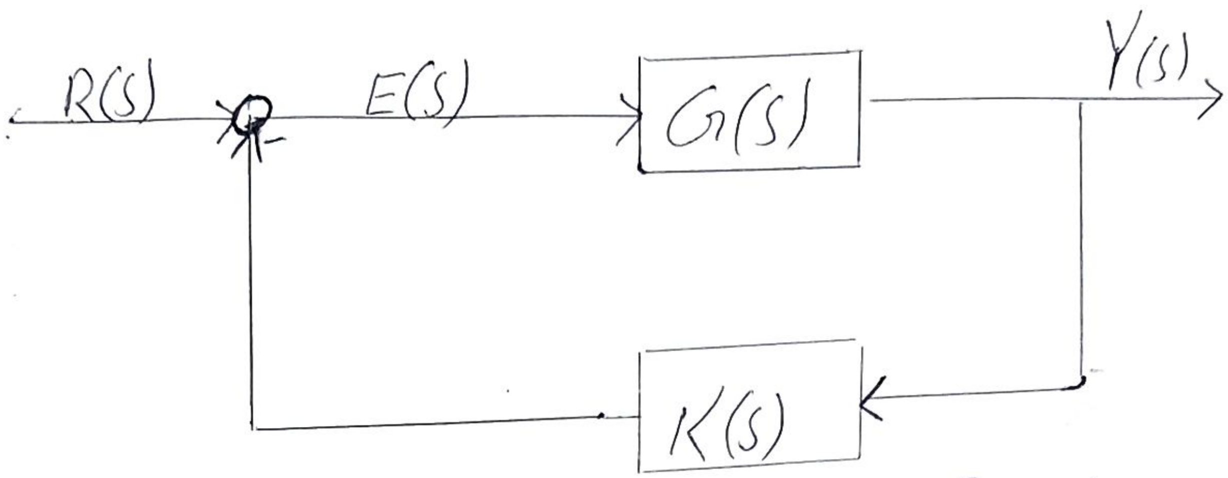
Date : 23/09/2020

Submitted to: Dr. Rafiq Mansoor

ID: 13342

(1)

Q#(1) Find Transfer function by using feedback loop

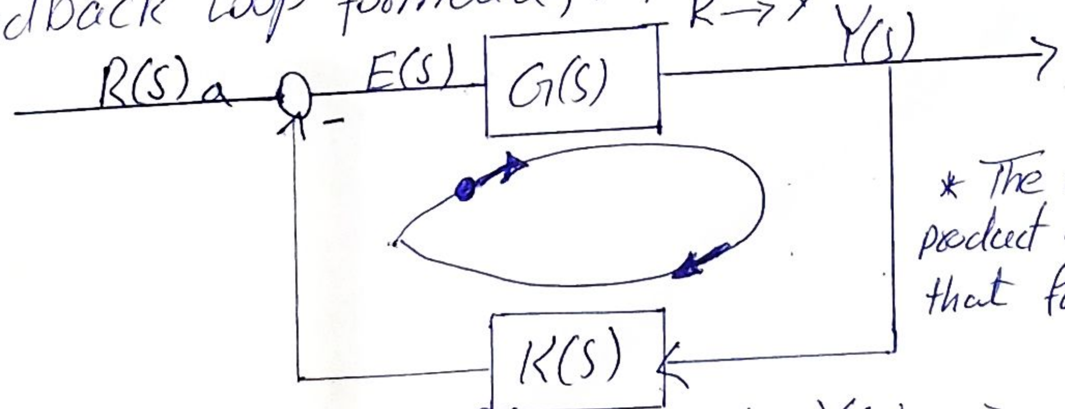


* when we computing Transfer functions from outside to inside the feedback:

$$E(s) = R(s) - K(s)G(s)E(s) \Rightarrow \frac{E(s)}{R(s)} = \frac{1}{1+G(s)K(s)}$$

$$Y(s) = G(s)E(s) \Rightarrow \frac{Y(s)}{R(s)} = \frac{G(s)}{1+G(s)K(s)}$$

Feedback Loop formula, $TF_{R \to Y}$

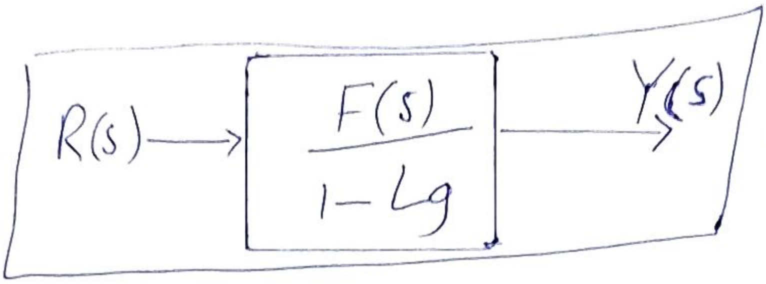


* The loop gain is the product of all TF that from the loop

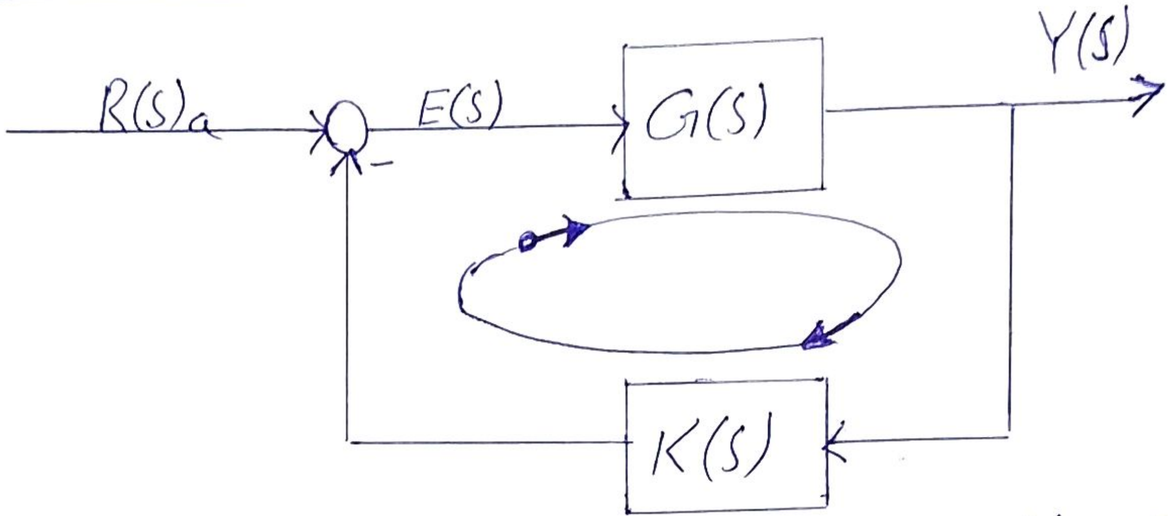
F_g: Forward gain from $R(s)$ to $Y(s) \Rightarrow G(s)$

L_g: Loop gain : $G(s) \Rightarrow K(s)(-1)$

ID: 13342 (2)

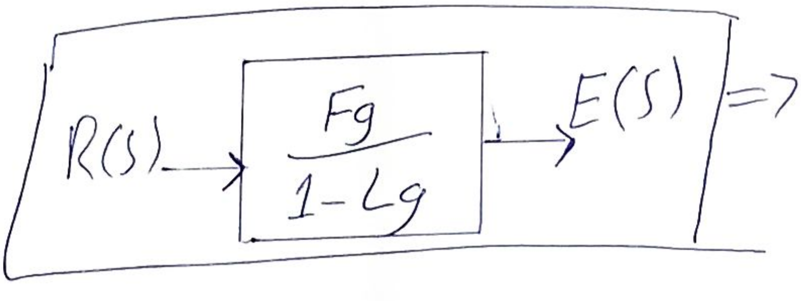


$$\Rightarrow \frac{Y(s)}{R(s)} = \frac{G(s)}{1+G(s)K(s)}$$



Fg : Forward gain from R(s) to E(s) $\Rightarrow 1$

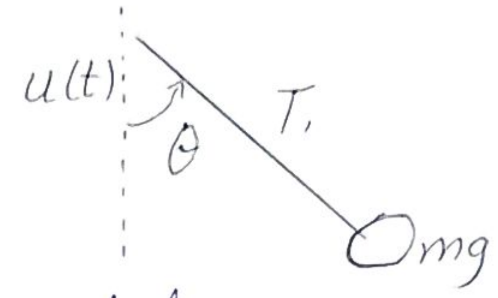
Lg : Loop gain : $G(s) \Rightarrow K(s)(-1)$



$$\Rightarrow \frac{E(S)}{R(S)} = \frac{1}{1+G(s)K(s)}$$

ID: 13342 (3)

Q#2 (a): Find linearization of following diagram:



Motion of Pendulum:

$$mL^2\ddot{\theta}(t) + mgL\sin\theta(t) = u(t)$$

$$\underbrace{\ddot{\theta}(t) + \frac{g\sin\theta(t)}{L} - \frac{u(t)}{mL^2}}_{f(\theta,u)} = 0$$

Linearize it at $\theta_0 = \pi$

Find u_0 $\quad \ddot{\pi} + \frac{g\sin\pi}{L} - \frac{u_0}{mL^2} = 0 \longrightarrow u_0 = 0$

New coordinates:

$$\theta = \theta_0 + \delta\theta = \pi + \delta\theta$$

$$u = u_0 + \delta u = 0 + \delta u$$

Tylor series expension of

$$f(\theta,u) \text{ at } \theta = \pi,\ u = 0$$

ID : 13342 (4)

$$\partial f(\theta,u) \Big|_{\substack{\theta=\pi \\ u=0}} = \frac{g\cos\theta}{L} \Big|_{\theta=x} = \frac{g}{L}$$

$$\frac{\partial f(\theta,u)}{\partial u} \Big|_{\substack{\theta=\pi \\ u=0}} = \frac{-1}{mL^2}$$

$$\delta\theta + \frac{\partial f(\theta,u)}{\partial \theta} \Big|_{\substack{\theta=\pi \\ u=0}} \delta\theta + \frac{\partial f(\theta,u)}{\partial u} \Big|_{\substack{\theta=\pi \\ u=0}} = 0$$

$$\boxed{\delta\ddot{\theta} - \frac{g}{L}\delta\theta - \frac{1}{mL^2}\delta u = 0}$$

ID : 13342

Q# (2) (b)

Linear System:-

A System having principle of superposition

$$u(t) \longrightarrow \boxed{\text{System}} \longrightarrow y(t)$$

$$\left.\begin{aligned} u_1(t) &\rightarrow y_1(t) \\ u_2(t) &\rightarrow y_2(t) \end{aligned}\right\} \Rightarrow a_1 u_1(t) + a_2 u_2(t) \rightarrow a_1 y_1(t) + a_2 y_2(t)$$

why do we Linearization:-

* Real system are inherently nonlinear. (Linear Systems do not exist!) Ex. $f(t) = Kx(t)$, $V(t) = Ri(t)$

* Transfer Function models are only for Linear time-invariant (LTI) systems.

* Many control analysis/design techniques are available for linear systems.

ID: 13342 (6)

* Nonlinear systems are difficult to deal with mathatically
* often we linearize nonlinear system before analysis and design

ID: 13342 (7)

Q#3 (a)

s^4	1	2	3
s^3	1	2	
s^2	1	2	
s^1	$\cancel{0}$	2	
s^0	2		

- No sign changes in the first column
- No Roots in RHP But some roots are on imag axis
- If zero row appears in Routh array, Q has roots either on the imaginary axis or in RHP

ID : 13342 (8)

- Take derivation of an auxiliary polynomial (which is a factor of $Q(s)$) s^2+2