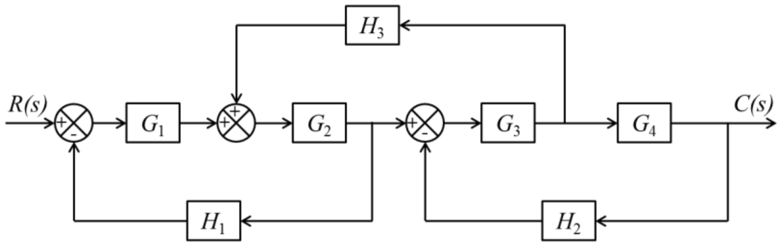
FYSS311 Fundamentals of control engineering Exam 22.11.2013

1. Explain / define briefly
   (a) Laplace transform
   (b) Transfer function
   (c) Root locus
   (d) Test signal
   (e) PID controller
   (f) Phase margin

2. Simplify the following block diagram that represents a system.
   Determine the closed loop transfer function C(s)/R(s).

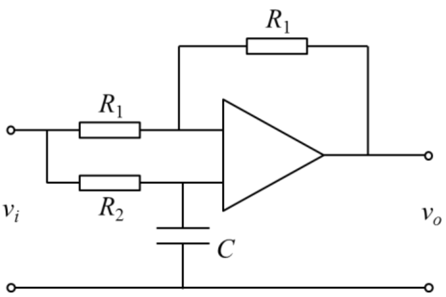


3. A system is represented by a transfer function $G(s) = \frac{1}{s^2+4s+1}$.
   Sketch
   (a) Nyquist plot
   (b) Bode diagram for the amplitude and phase

4. A characteristic equation of a system is given by $4s^6 + s^5 + 3s^4 + 2s^2 + s + K = 0$.
   At which values of K the system is stable?

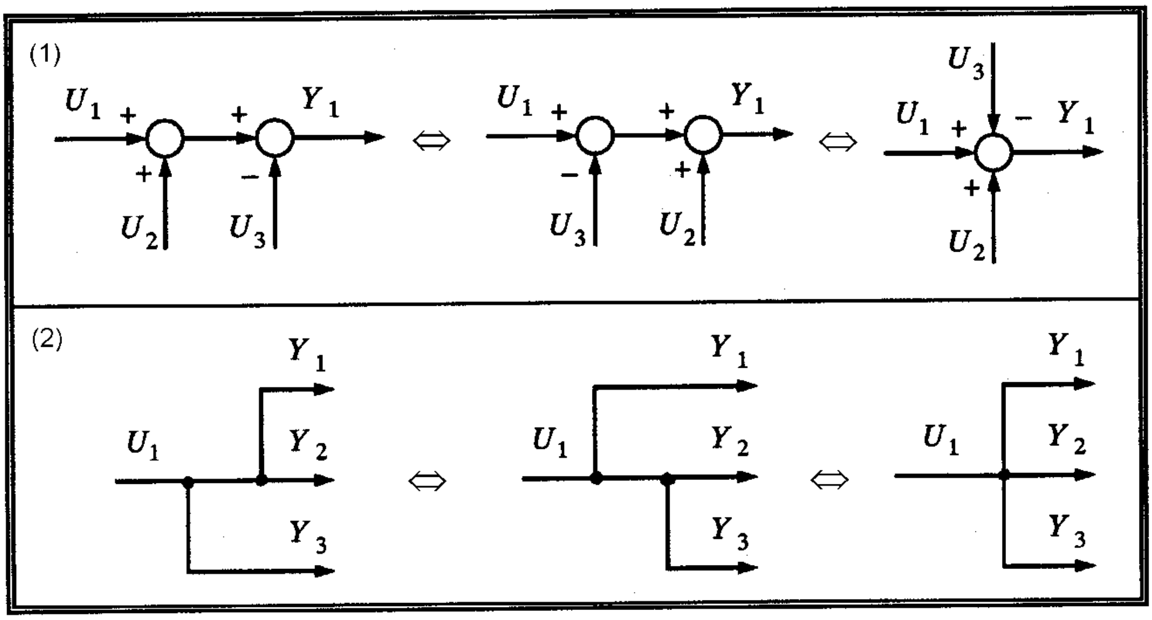
5. A process is described by a differential equation $2\ddot{y}(t) + 5\dot{y}(t) + 2y(t) = 4u(t)$.
   Solve $y(t)$ as a function of time when $u(t)$ is a step function and $y(t)$ has the initial values of $y(0) = 4$ ja $\dot{y}(0) = 1$.

6. Determine (a) unity impulse response and (b) unity step response for the operational amplifier circuit illustrated in the following figure, when $R_1 = R_2 = C = 1$.

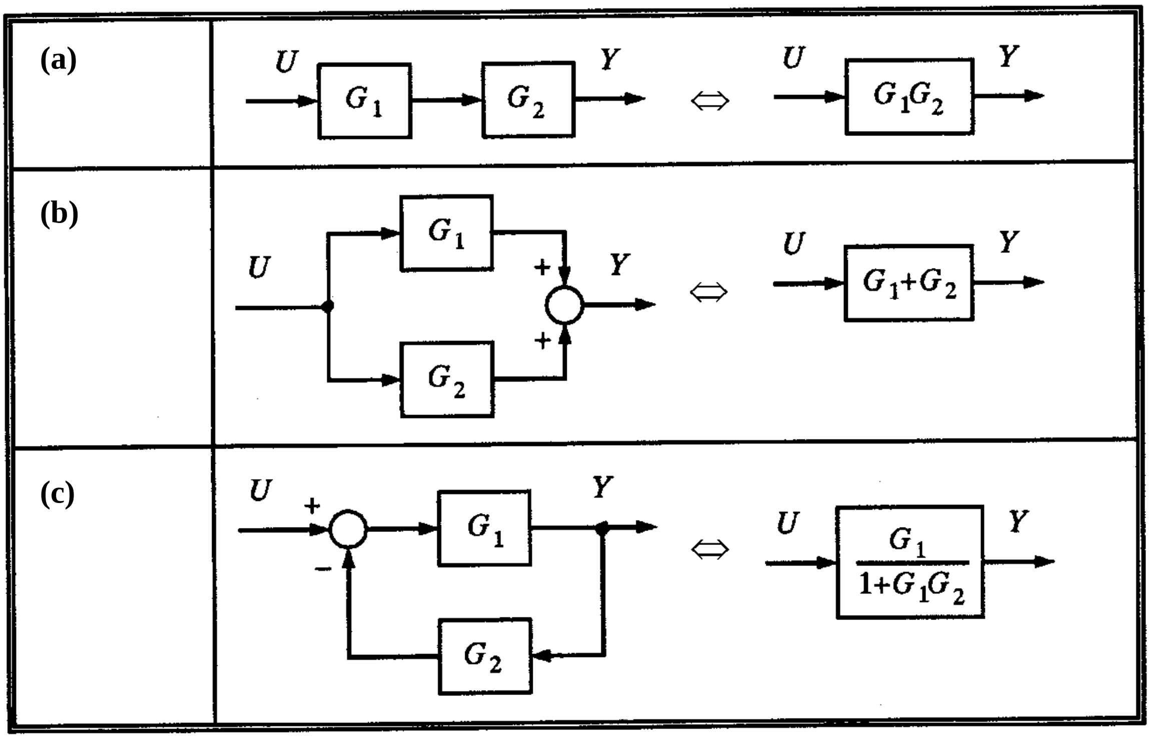


Laplace transform	Function of time	
1	$\delta(t)$	M1
$\frac{1}{s}$	1	M2
$\frac{1}{s^2}$	t	M3
$\frac{1}{s^{n+1}}$	$\frac{t^n}{n!}$	M4
$\frac{1}{s+a}$	e^{-at}	M5
$\frac{1}{(s+a)^2}$	te^{-at}	M6
$\frac{1}{(s+a)^{n+1}}$	$\frac{t^n e^{-at}}{n!}$	M7
$\frac{1}{s(s+a)}$	$\frac{1}{a}(1-e^{-at})$	M8
$\frac{1}{(s+a)(s+b)}$	$\frac{1}{a-b}(e^{-bt}-e^{-at})$	M9
$\frac{1}{s(s+a)(s+b)}$	$\frac{1}{ab}+\frac{1}{ab(b-a)}(ae^{-bt}-be^{-at})$	M10
$\frac{a}{s^2+a^2}$	$\sin(at)$	M11
$\frac{s}{s^2+a^2}$	$\cos(at)$	M12
$\frac{a}{(s+b)^2+a^2}$	$e^{-bt}\sin(at)$	M13
$\frac{s+b}{(s+b)^2+a^2}$	$e^{-bt}\cos(at)$	M14
$\frac{s+a}{s+b}$	$\delta(t)+(a-b)e^{-bt}$	M15

Summing points and Branch points:



(a) Cascaded system, (b) parallel system and (c) feedback system:



$$
\begin{array}{r|cccccc}
n: & a_0 & a_2 & a_4 & a_6 & \dots \\
n-1: & a_1 & a_3 & a_5 & a_7 & \dots \\
n-2: & b_1 & b_2 & b_3 & b_4 & \dots \\
n-3: & c_1 & c_2 & c_3 & c_4 & \dots \\
n-4: & d_1 & d_2 & d_3 & d_4 & \dots \\
\vdots & & & & & \\
2: & e_1 & e_2 & & & \\
1: & f_1 & & & & \\
0: & g_1 & & & &
\end{array}
$$

$$
b_1 = \frac{a_1 a_2 - a_0 a_3}{a_1} \quad c_1 = \frac{b_1 a_3 - a_1 b_2}{b_1} \quad d_1 = \frac{c_1 b_2 - b_1 c_2}{c_1}
$$

$$
b_2 = \frac{a_1 a_4 - a_0 a_5}{a_1} \quad c_2 = \frac{b_1 a_5 - a_1 b_3}{b_1} \quad d_2 = \frac{c_1 b_3 - b_1 c_3}{c_1}
$$

$$
b_3 = \frac{a_1 a_6 - a_0 a_7}{a_1} \quad c_3 = \frac{b_1 a_7 - a_1 b_4}{b_1} \quad d_3 = \frac{c_1 b_4 - b_1 c_4}{c_1}
$$

$$
\vdots \qquad\qquad \vdots \qquad\qquad \vdots
$$