EE324 - Control Systems Lab

PROBLEM SHEET 1

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Question 1:

From EE302 - Control Systems theory, we know:

- Two transfer functions: **G1** and **G2** cascaded, or in **series** have effective as **G1*G2**
- Two transfer functions: **G1** and **G2** in **parallel**, have effective as **G1+G2**
- Given two transfer functions: **G1** and **G2**, the **closed loop feedback** of **G2** on **G1** is obtained by the **/. operator**

Initialization Code:

```
--> s = poly(0, 's');
--> n1 = 10; d1 = s^2+2*s+10;
--> G1 = n1/d1;
--> n2 = 5; d2 = s+5;
--> G2 = n2/d2;
--> sys_G1 = syslin('c', G1); sys_G2 = syslin('c', G2);
```

- Part (a)

```
--> sys_series = sys_G1*sys_G2
 sys_series  =
          50
   ----------------
   50 +20s +7s² +s³
```

- Part (b)

```
--> sys_parallel = sys_G1+sys_G2
 sys_parallel  =
    100 +20s +5s²
   ----------------
   50 +20s +7s² +s³
```

- Part (c)

```
--> sys_feedback = sys_G1/.sys_G2
 sys_feedback  =
        50 +10s
   -----------------
   100 +20s +7s² +s³
```

- Part (d)

We use the **csim command** to plot the unit step response of continuous time system G1

```
--> t = 0:0.01:10;
--> y = csim('step', t, sys_G1);
--> plot(t, y)
```

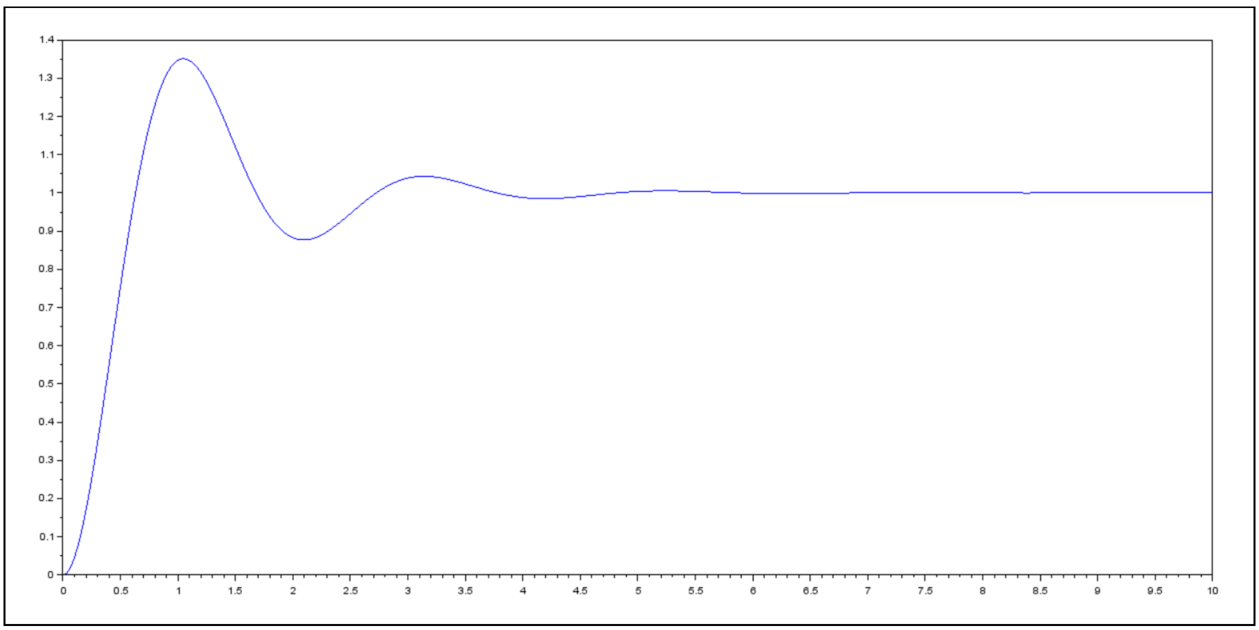


Figure 1: Unit Step Response of **G1**

Question 2:

I used the command tf2zp to get the poles, zeros and gain representations of the transfer functions. The Scilab code for the same is as follows.

```
--> [z1, p1, k1] = tf2zp(sys_series);
--> z1
 z1  =
    []
--> p1
 p1  =
  -5. + 0.i
  -1. + 3.i
  -1. - 3.i
```

```
--> [z2, p2, k2] = tf2zp(sys_parallel);
--> z2
 z2  =
  -2. + 4.i
  -2. - 4.i
--> p2
 p2  =
  -5. + 0.i
  -1. + 3.i
  -1. - 3.i
```

```
--> [z3, p3, k3] = tf2zp(sys_feedback);
--> z3
 z3  =
  -5.
--> p3
 p3  =
  -6.3347665 + 0.i
  -0.3326167 + 3.9592004i
  -0.3326167 - 3.9592004i
```

```
--> [z, p, k] = tf2zp(sys_G1);
--> z
 z  =
    []
```

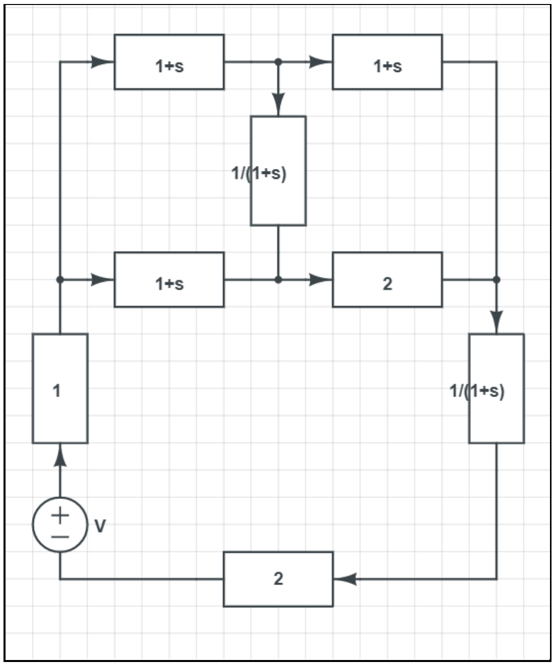
```
--> p
 p  =
  -1. + 3.i
  -1. - 3.i
```

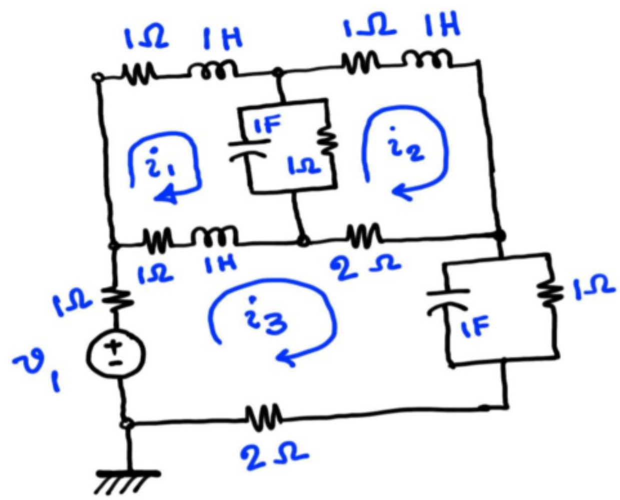
Basic Matrix Operations in SciLab:

```
--> A = [1 2; 3 4];
--> B = [-s^2-1 -3*s^2-5*s+1; 4*s^2+5*s-5 4*s^2+5*s+3];
--> C = [-2*s^2+3*s+5 5*s^2+5*s-1; s^2-s-1 s^2+2*s-1];

--> ADD = B+C
 ADD  =
  4 +3s -3s²   2s²
  -6 +4s +5s²  2 +7s +5s²

--> MINUS = B-C
 MINUS  =
  -6 -3s +s²   2 -10s -8s²
  -4 +6s +3s²  4 +3s +3s²

--> MULT = B*C
 MULT  =
  -6 +s +6s² -5s³ -s⁴      2s -10s² -16s³ -8s⁴
  -28 +2s +39s² +3s³ -4s⁴  2 -29s +5s² +58s³ +24s⁴

--> DET = det(B)
 DET  =
  2 -35s -s² +30s³ +8s⁴

--> INV = inv(B)
 INV  =
        3 +5s +4s²              -1 +5s +3s²
   ---------------------  ---------------------
   2 -35s -s² +30s³ +8s⁴  2 -35s -s² +30s³ +8s⁴

        5 -5s -4s²                -1 -s²
   ---------------------  ---------------------
   2 -35s -s² +30s³ +8s⁴  2 -35s -s² +30s³ +8s⁴
```

Question 3:

First we find the equivalent impedance of the given circuit diagram:





Next, using mesh analysis, we write the Z_eff matrix for the circuit in Laplace-domain:

```
--> Z_eff = [2+2*s+(1/(1+s)) -1/(1+s) -1-s;
-1/(1+s) 3+s+(1/(1+s)) -2;
-1-s -2 6+s+(1/(1+s))]

 Z_eff  =
   3 +4s +2s²     -1        -1 -s
   ----------     ----      -----
      1 +s        1 +s        1

     -1       4 +4s +s²      -2
     ----     ---------      --
     1 +s       1 +s         1

    -1 -s         -2       7 +7s +s²
    -----         --       ---------
      1           1          1 +s
```

And the V matrix would be, simply:

```
--> V = [0; 0; 1]
 V  =
   0.
   0.
   1.
```

Since **Z_eff I = V, I** is given by **I = Z_eff^(-1) V**

```
--> I = (inv(Z_eff))*V
 I  =
       6 +14s +13s² +6s³ +1s⁴
   ------------------------------
   57 +144s +147s² +74s³ +17s⁴ +s⁵

         7 +16s +13s² +4s³
   ------------------------------
   57 +144s +147s² +74s³ +17s⁴ +s⁵

      11 +28s +27s² +12s³ +2s⁴
   ------------------------------
   57 +144s +147s² +74s³ +17s⁴ +s⁵
```

So our final answer is:

$$\frac{I_1(s)}{V(s)} = \frac{s^4 + 6s^3 + 13s^2 + 14s + 6}{s^5 + 17s^4 + 74s^3 + 147s^2 + 144s + 57}$$

$$\frac{I_2(s)}{V(s)} = \frac{4s^3 + 13s^2 + 16s + 7}{s^5 + 17s^4 + 74s^3 + 147s^2 + 144s + 57}$$

$$\frac{I_3(s)}{V(s)} = \frac{2s^4 + 12s^3 + 27s^2 + 28s + 11}{s^5 + 17s^4 + 74s^3 + 147s^2 + 144s + 57}$$