PROBLEM SHEET 5

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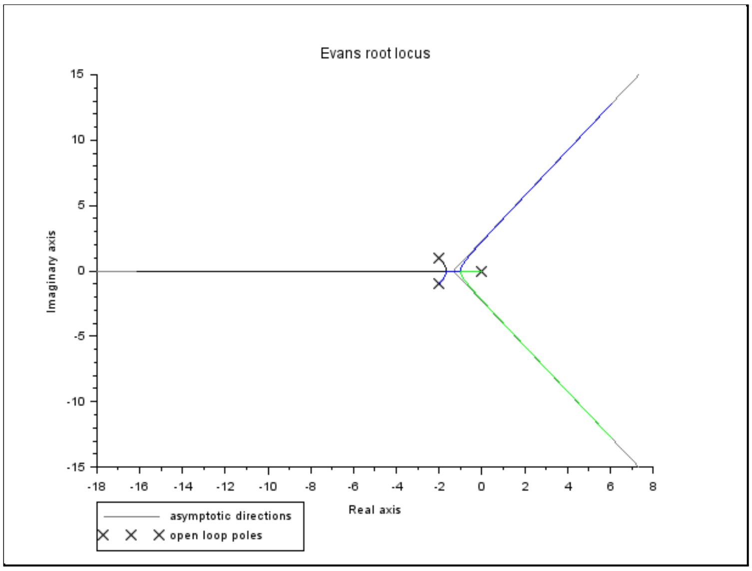
Question 1:

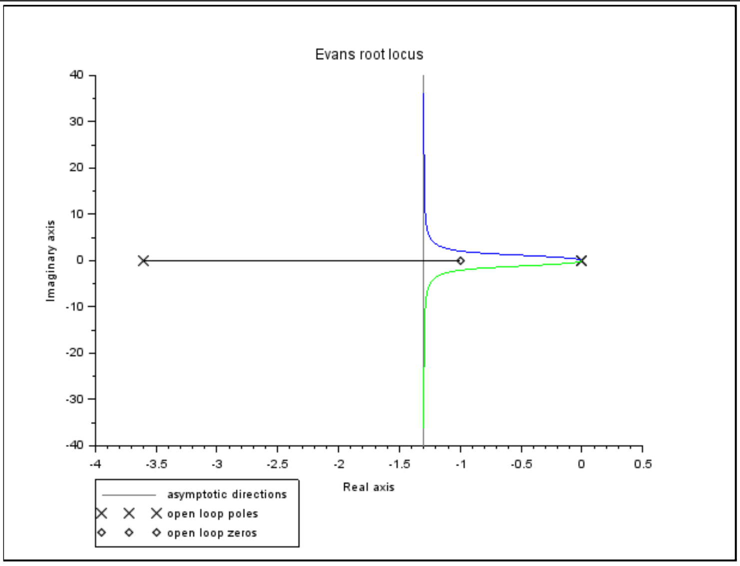
a. Here is the code:

```
--> s = poly(0, 's');
--> G1 = 10/(s^3+4*s^2+5*s+10);
--> G = G1/(1-G1);
--> sys = syslin('c', G);
--> evans(sys)
--> xs2png(gcf(), 'Q1a.jpg');
```



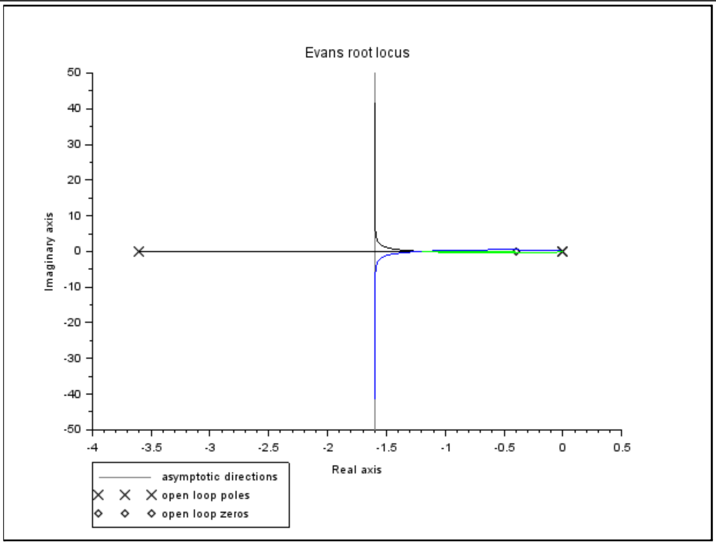
b. Here is the code:

```
--> s = poly(0, 's');
--> G = (s+1)/(s^2*(s+3.6));
--> sys = syslin('c', G);
--> evans(sys)
--> xs2png(gcf(), 'Q1b.jpg');
```



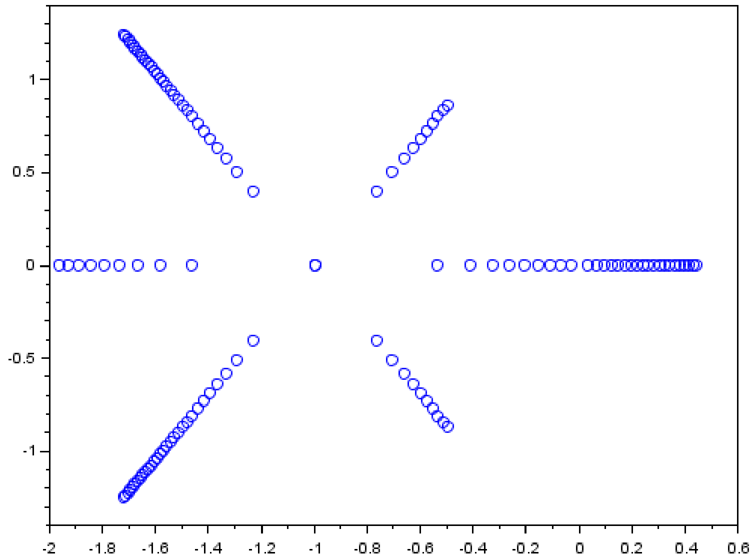
c. Here is the code:

```
--> s = poly(0, 's');
--> G = (s+0.4)/(s^2*(s+3.6));
--> sys = syslin('c', G);
--> evans(sys)
--> xs2png(gcf(), 'Q1c.jpg');
```



d. Here is the code:

```
--> s = poly(0, 's');
--> for p = -2:0.1:2
  > G = (s+p)/(s*(s+1)*(s+2));
  > G = G/(1+G); //k=1 for these deductions
  > poles = roots(simp(G).den);
  > scatter(real(poles), imag(poles));
  > end
--> xs2png(gcf(), 'Q1d.jpg');
```

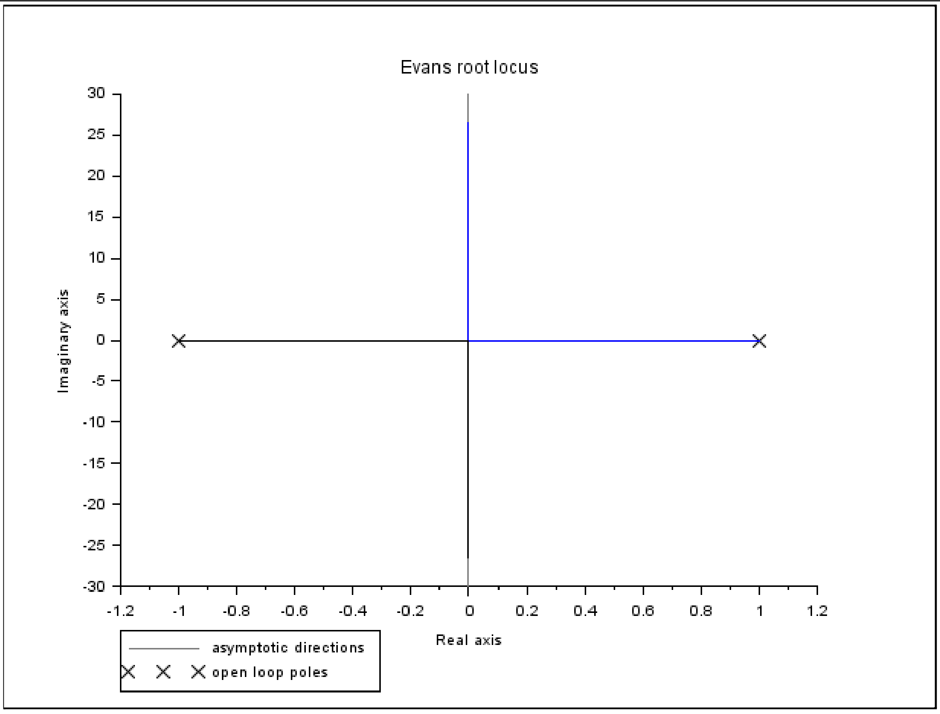


On by-hand analysis of the denominator of G/(1+G) we see that for all values of p<0 we have instability and p>0 are stable, while there is marginal stability (Non-decaying sinusoidal) at p=0. This also matches the scatter plot of the system shown.

Question 2:

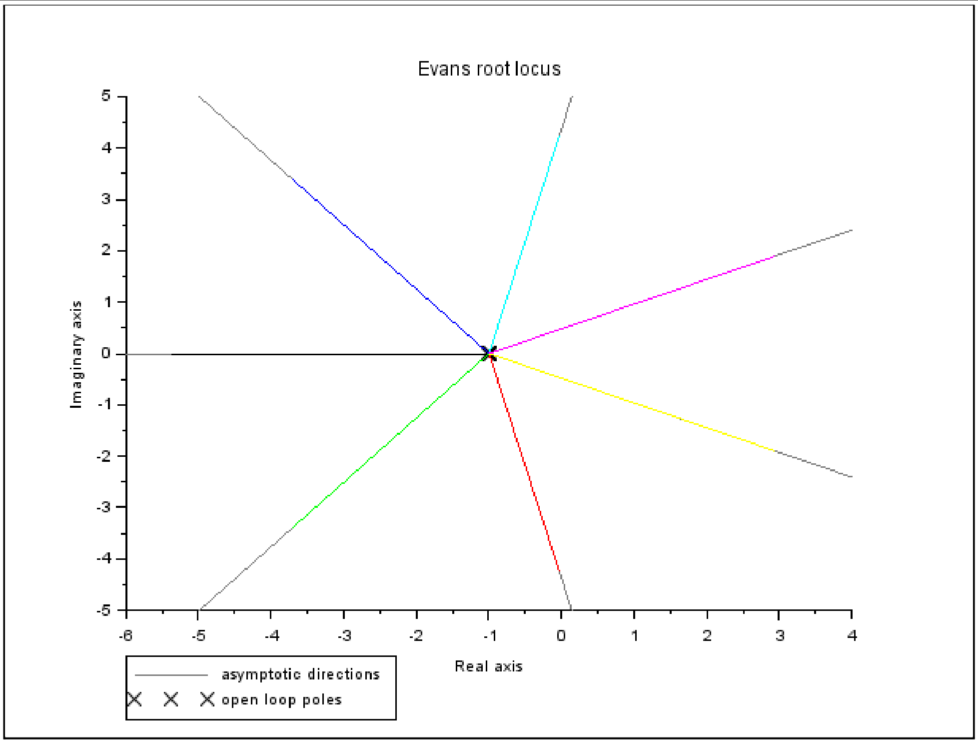
a. Here is the code:

```
--> s = poly(0, 's');
--> G = 1/(s^2-1);
--> sys = syslin('c', G);
--> evans(sys)
--> xs2png(gcf(), "Q2a.jpg");
```



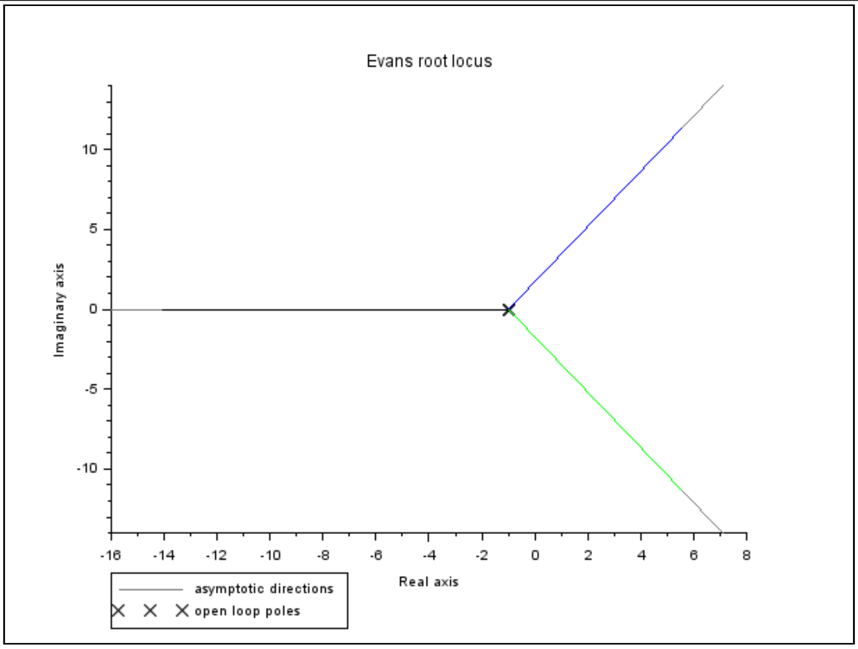
b. Here is the code:

```
--> s = poly(0, 's');
--> G = 1/((s+1)^7);
--> sys = syslin('c', G);
--> evans(sys);
--> xs2png(gcf(), "Q2b.jpg");
```



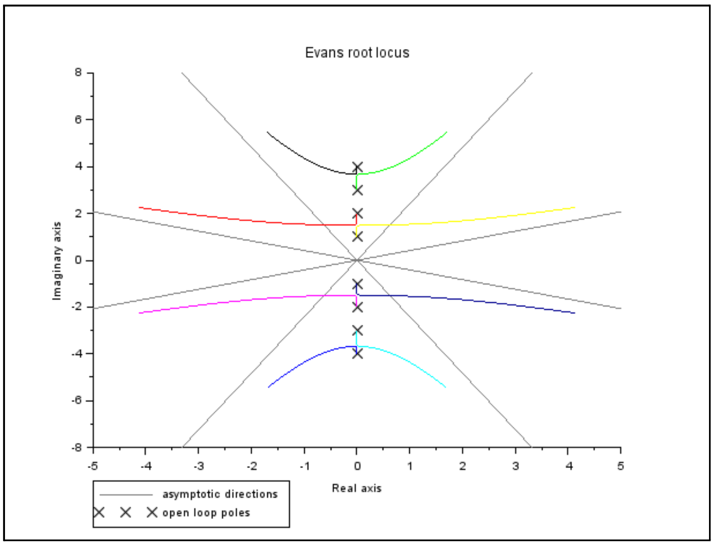
c. Here is the code:

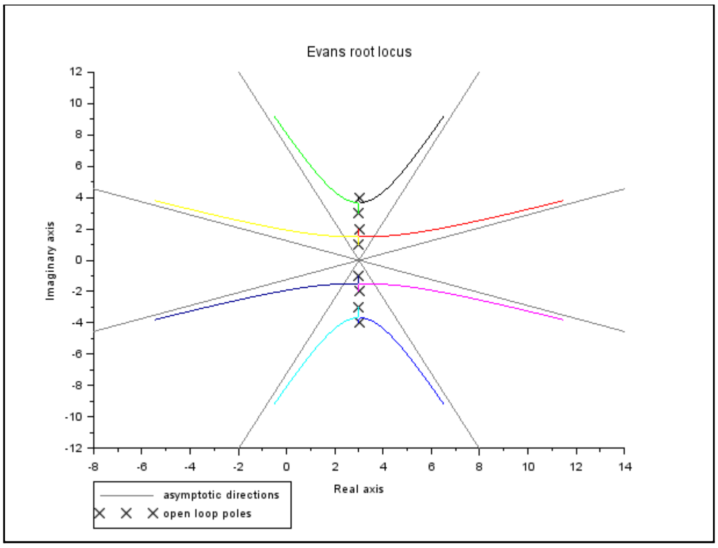
```
--> s = poly(0, 's');
--> G = 1/((s+1)^3);
--> sys = syslin('c', G);
--> evans(sys);
--> xs2png(gcf(), "Q2c.jpg");
```



d. Here is the code:

```
--> s = poly(0, 's');
--> G1 = 1/((s^2-1)*(s^2-4)*(s^2-9)*(s^2-16));
--> G2 = 1/((s^2+1)*(s^2+4)*(s^2+9)*(s^2+16));
--> G3 = 1/(((s-3)^2+1)*((s-3)^2+4)*((s-3)^2+9)*((s-3)^2+16));

--> sys2 = syslin('c', G2);
--> evans(sys2)
--> xs2png(gcf(), "Q2d_1.jpg");

--> sys3 = syslin('c', G3);
--> evans(sys3)
--> xs2png(gcf(), "Q2d_2.jpg");
```

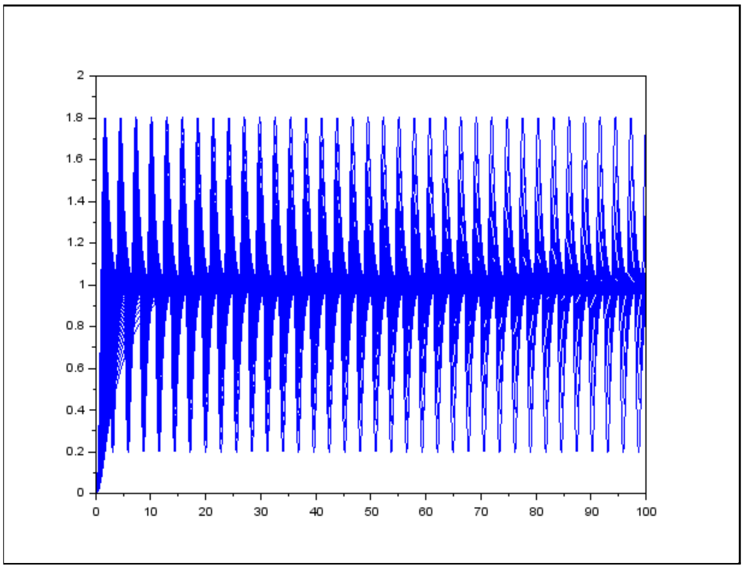




Question 3:

a. Here is the code:

```
--> s = poly(0, 's');
--> function tf = cltf(K)
  > G = 1/(s*(s^2+3*s+5));
  > tf = (K*G)/(1+K*G);
  > endfunction

--> function rt = risetime(sys, t, l)
  > steady_state = mean(sys(l*0.8:l));
  > t_idx = 1;
  > while sys(t_idx) < 0.1*steady_state
  > t_idx = t_idx+1;
  > end
  > rt_start = t(t_idx);
  > while sys(t_idx) < 0.9*steady_state
  > t_idx = t_idx+1;
  > end
  > rt_end = t(t_idx);
  > rt = rt_end - rt_start;
  > endfunction

--> for kp = 1:0.1:25
  > G = cltf(kp);
  > t = 0:0.01:100;
  > sys = syslin('c', G);
  > y = csim('step', t, sys);
  > plot(t, y);
  > l = length(y);
  > disp(risetime(y, t, l), kp)
  > end
 1.52 3.7
 1.47 3.8

 0.58 14.9
--> xs2png(gcf(), "Q3.jpg");
```

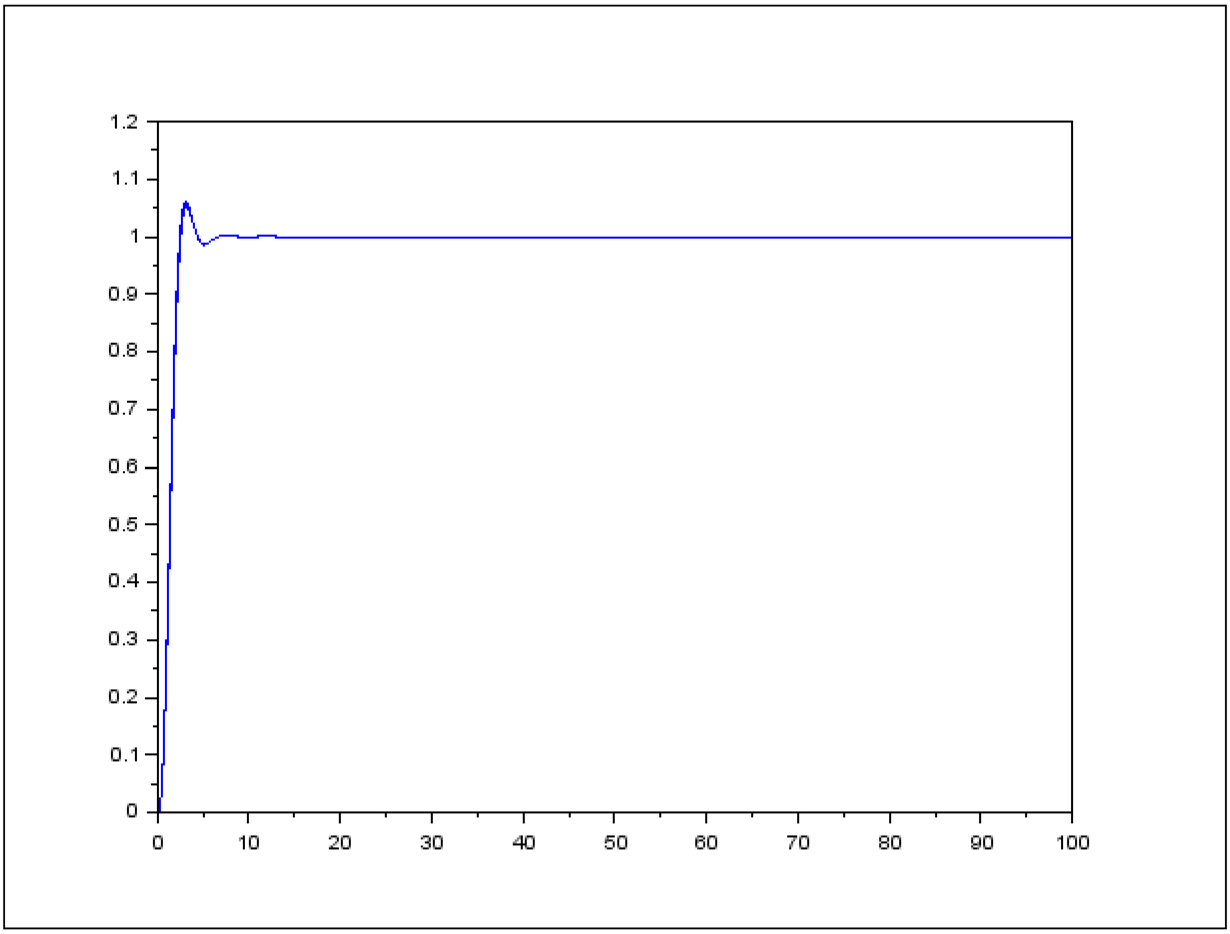


By constructing a hand routh table, it is found that the system becomes marginally stable at kp=15 and is unstable for all values beyond that. This was confirmed experimentally by noting the sinusoidal graph formed at kp=15 precisely; as shown above.

As it is known, that rise time reduces up till the point the system reaches marginal stability, the minimum rise time we can obtain for a stable system is around 0.58 milliseconds. (in pink)

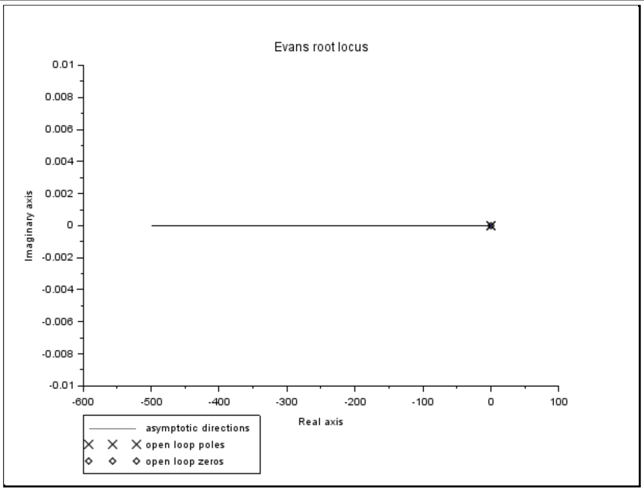
Finally, for rise time equal to 1.5 seconds, the value lies between kp=3.7 and kp=3.8, so we run the code:

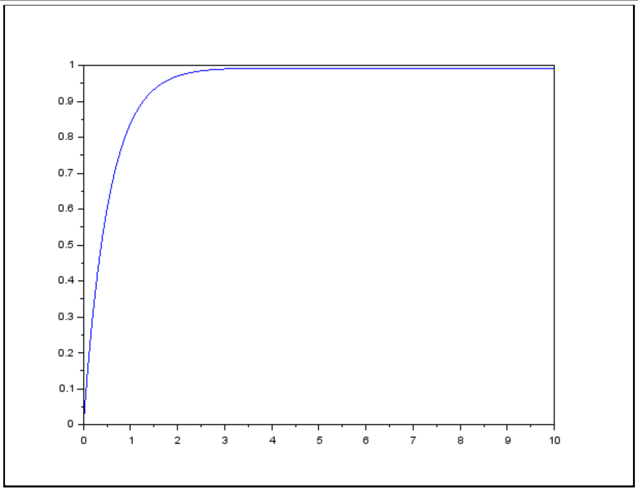
```
--> for kp = 3.7:0.01:3.8
  > G = cltf(kp);
  > t = 0:0.01:100;
  > sys = syslin('c', G);
  > y = csim('step', t, sys);
  > plot(t, y);
  > l = length(y);
  > disp(kp, risetime(y, t, l))
  > end

   3.74 1.5
   3.75 1.5
   3.76 1.49
```

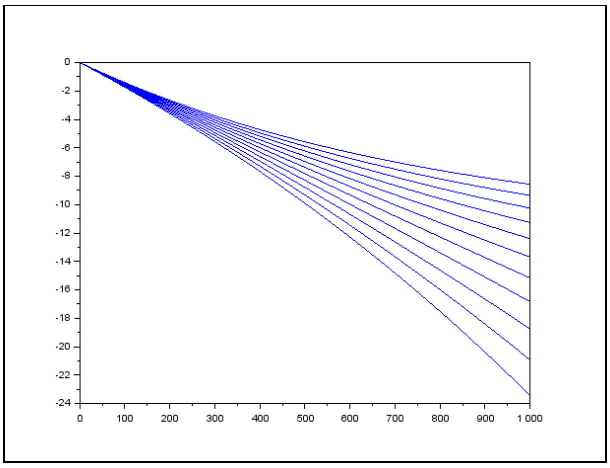


Question 4:

```
--> s = poly(0, 's');
--> G = (0.11*(s+0.6))/(6*s^2+3.6127*s+0.0572);
--> sys = syslin('c', G);
--> evans(sys);
--> xs2png(gcf(), "Q4_1.jpg");

--> function tf = cltf(K)
  > G = 0.11*(s + 0.6)/(6*s^2 + 3.6127*s + 0.0572);
  > tf = (K*G)/(1+K*G);
  > endfunction

--> G = cltf(100);
--> t = 0:0.01:10;
--> sys = syslin('c', G); y = csim('step', t, sys);
--> plot(t, y);
--> xs2png(gcf(), "Q4_2.jpg");

--> for kp = -0.9:0.01:-0.8
  > G = cltf(kp);
  > t = 0:10:1000;
  > sys = syslin('c',G);
  > y = csim('step',t,sys);
  > plot(t, y)
  > end
--> xs2png(gcf(), "Q4_3.jpg");
```





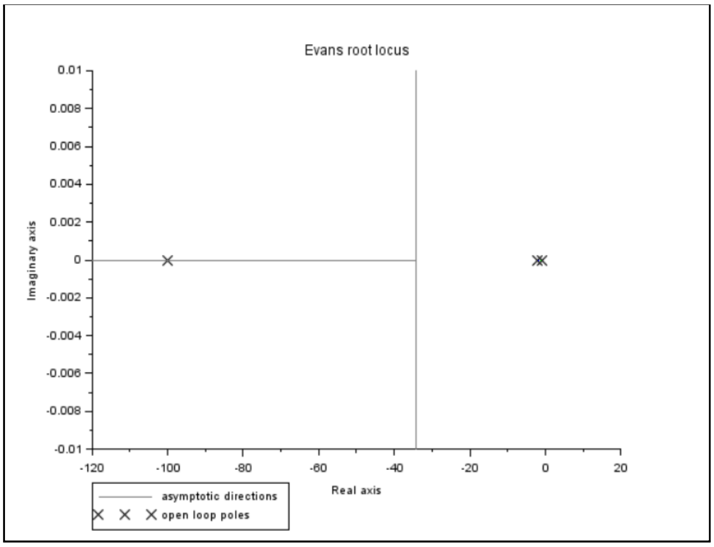


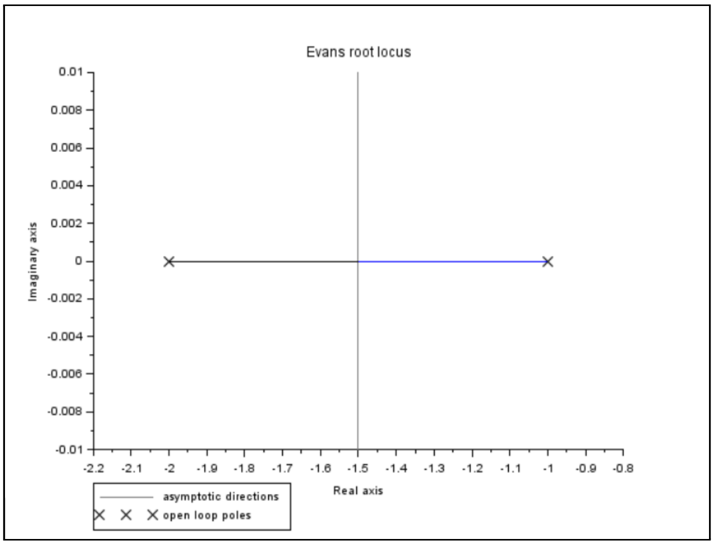
On routh analysis, we find that at kp=-0.86 the system loses stability.

Question 5:

Here is the code:

```
--> s = poly(0, 's');
--> function tf = cltf(K, G)
  > tf = (K*G)/(1+K*G);
  > endfunction

--> G1 = 1/((s+1)*(s+2)*(s+100));
--> sys1 = syslin('c', G1);
--> G2 = 1/((s+1)*(s+2));
--> sys2 = syslin('c', G2);

--> scf(0); evans(sys1)
--> scf(1); evans(sys2)
```






```
--> for kp = 1:1:100
  > G2_new = cltf(kp, G2);
  > appr_poles = roots(G2_new.den);
  > G1_new = cltf(kp, G1);
  > actual_poles = roots(G1_new.den);
  > difference = abs(actual_poles(2)-appr_poles(1))/abs(actual_poles(1))
  > disp(difference, kp)
  > end
```

The difference in actual and approximated poles starts at 0.01 (1% error) initially (kp=1) and approaches 0.09 at kp=100.
Setting 0.05 as the minimum for which the systems are reasonably similar (5% error), we get that Kp should be : (kp < 26)

```
26    difference  = 0.0495617
27    difference  = 0.0501663
```