TP4 :

- VIN Charles
- RECHAK LAMBERT Dorian

Exercice 1 :

Instanciation des constantes :

```
w_p = 0.2*pi;
w_s = 0.3*pi;
R_p = 7; % db
A_s = 16;
```

Question 1 :

Calcul de N

```
N = floor(log10( ...
        ((10^(R_p/10) - 1 )*(10^(A_s/10) - 1))...
        / ...
        (2*log10(w_p/w_s)) ...
       )) + 1;
N = real(N);
N
```

```
N = 3
```

Calcul de w_c

```
w_cp = w_p / (10^(R_p/10) - 1)^(1/(2*N));
w_cs = w_s / (10^(A_s/10) - 1)^(1/(2*N));
w_c = (w_cp + w_cs)/2;
w_c
```

```
w_c = 0.5053
```

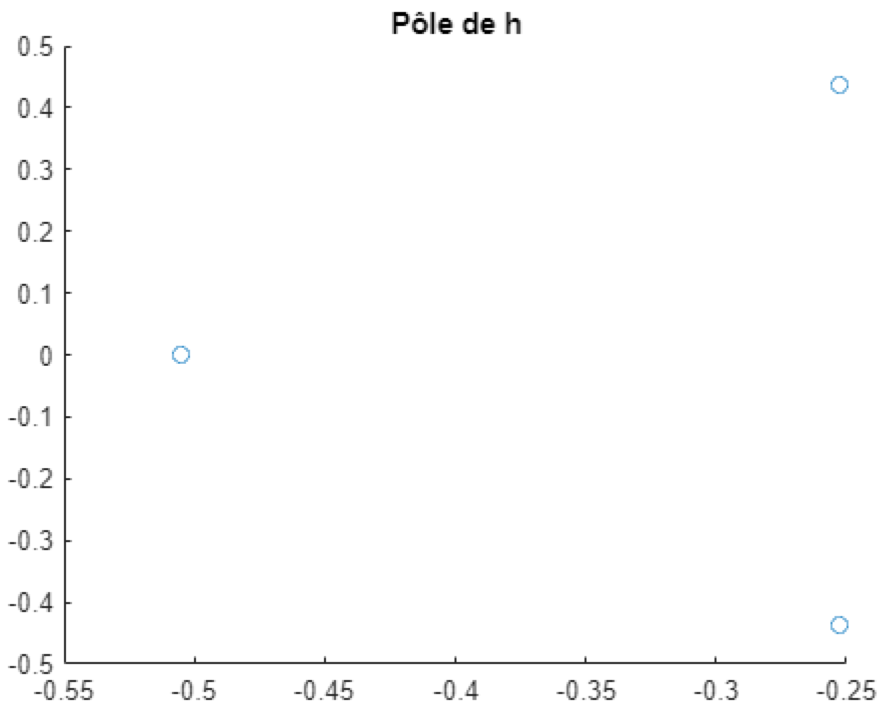
Question 2 :

On a donc $N = 3$, donc 3*2=6 pôles. Dont 3 instables. Les pôles stables ont pour argument : 2pi/3, pi, 4pi/3

```
%Calcul des pôles
p_1 = w_c * exp(1i*2*pi/3);
p_2 = w_c * exp(1i*pi);
p_3 = w_c * exp(1i*4*pi/3);
p_1, p_2, p_3
```

```
p_1 = -0.2527 + 0.4376i
p_2 = -0.5053 + 0.0000i
p_3 = -0.2527 - 0.4376i
```

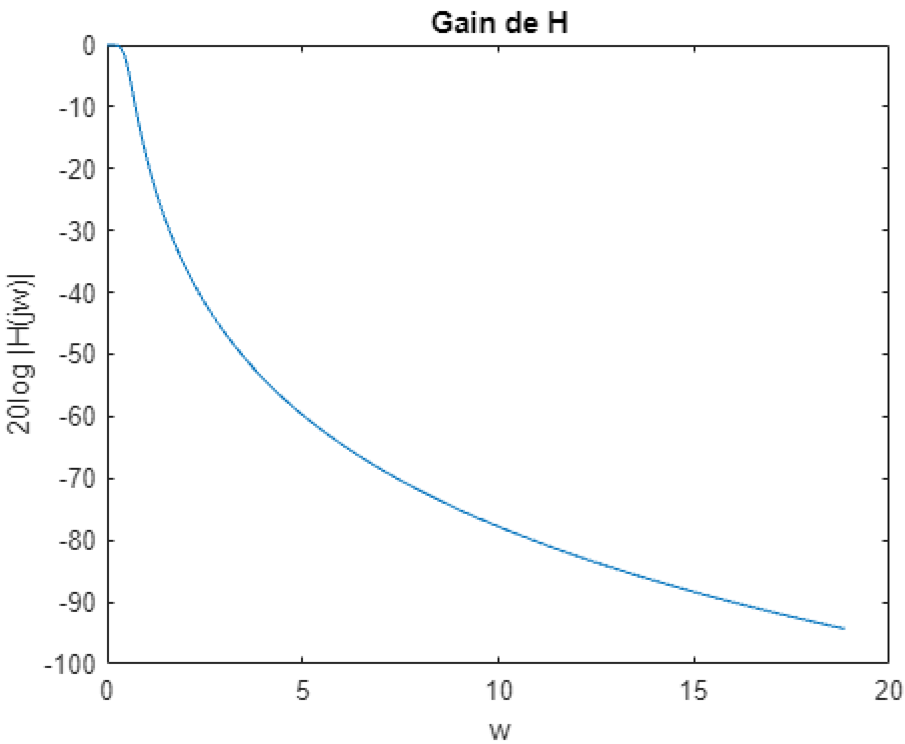
```
% Plot des pôles
x = real([p_1 p_2 p_3]);
y = imag([p_1 p_2 p_3]);
scatter(x,y);
title('Pôle de h');
```



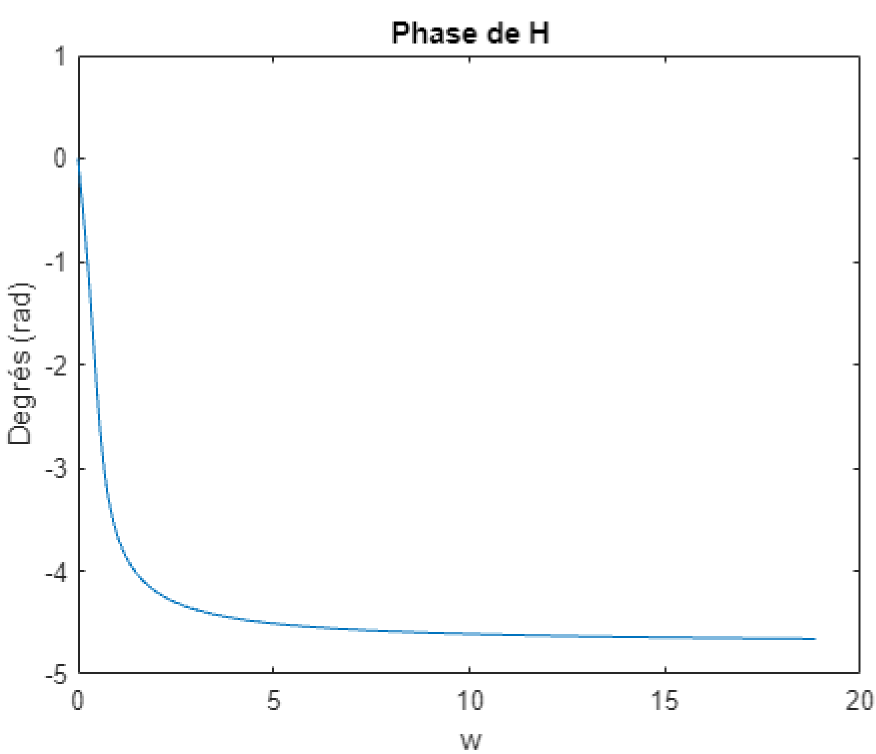
Question 3, 4:

```
f = 0 : 0.01 : 3;
w = 2*pi*f;
S = 1i*w;
H = w_c.^N ./ ((S - p_1).*(S - p_2).*(S - p_3));
```

```
%Plot
module = 20*log10(abs(H));
phase = unwrap(angle(H));
% IL FAUT VERIFIER ENTER 0.2pi et 0.3pi si on descend bien de r_p a_s
figure('name', 'Gain de H');
plot(w, module);
title('Gain de H');
xlabel('w');
ylabel('20log |H(jw)|');
```




```
figure('name', 'Phase de H');
plot(w, phase);
title('Phase de H');
xlabel('w');
ylabel('Degrés (rad)');
```



Vérifions les caractéristiques du filtre :

Pour cela je vais regarder le du module à 0.2π et 0.3π. Il doit valoir respectivement $R_p = 7\text{db}$ et $A_s = 16\text{db}$

```
disp("=======0.2pi======")
```

```
=======0.2pi======
```

```
w(11)
```

```
ans = 0.6283
```

```
disp("L'indice 11 de w represente 0.2pi = 0.6283185307")
```

```
L'indice 11 de w represente 0.2pi = 0.6283185307
```

```
module(11)
```

```
ans = -6.7165
```

```
disp("On a le module de 0.2pi qui vaut environ -6.7165")
```

```
On a le module de 0.2pi qui vaut -6.7165
```

```

disp("")
disp("=======0.3pi======")
```

```
=======0.3pi======
```

```
w(16)
```

```
ans = 0.9425
```

```
disp("L'indice 16 de w represente 0.3pi = 0.9424777961")
```

```
L'indice 16 de w represente 0.3pi = 0.9424777961
```

```
module(16)
```

```
ans = -16.3438
```

```
disp("On a le module de 0.3pi qui vaut environ -16.3438")
```

```
On a le module de 0.3pi qui vaut -16.3438
```

On peut voir que les caractéristiques du filtre sont respecté. On a une légère approximation du au coté discret de la génération graphique.

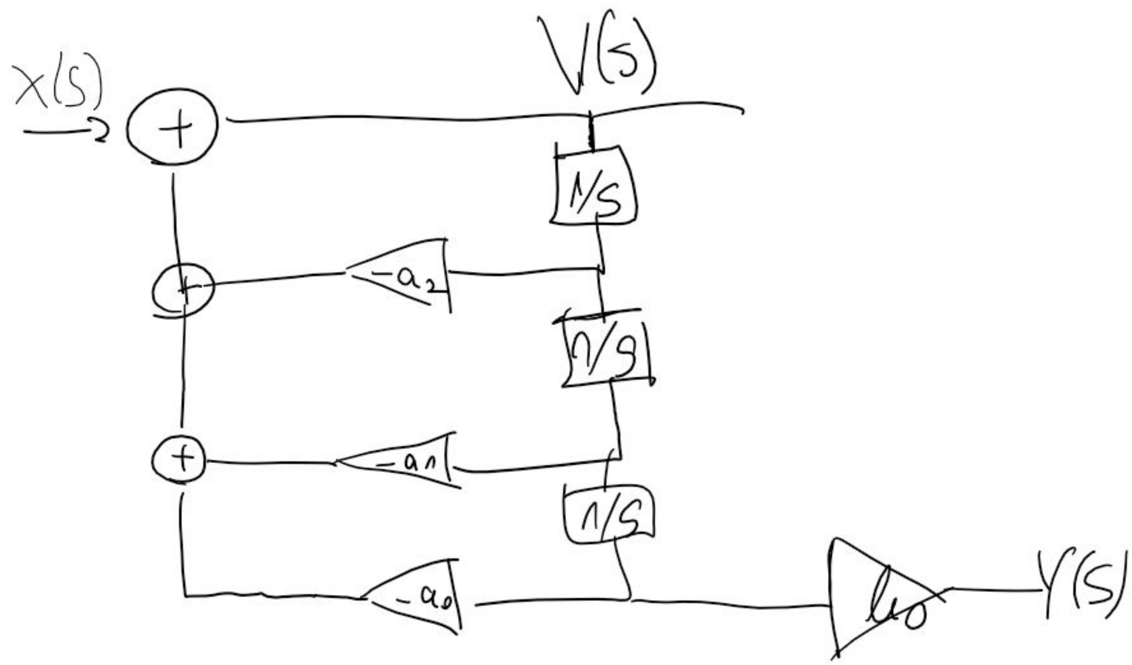
Question 5 :

Soit

$$H(S) = \frac{w_c^N}{(S-p_1)(S-p_2)(S-p_3)}$$
$$= \frac{w_c^N}{-p_1S^2 - p_2S^2 - p_3S^2 + p_1p_2S + p_1p_3S + p_2p_3S - p_1p_2p_3 + S^3}$$
$$= \frac{w_c^N}{S^3 + S^2(-p_1 - p_2 - p_3) + S(p_1p_2 + p_1p_3 + p_2p_3) - p_1p_2p_3}$$
$$= \frac{b_0}{S^3 + S^2a_2 + Sa_1 + a_0}$$
$$= \frac{b_0S^{-3}}{1 + a_2S^{-1} + a_1S^{-2} + a_0S^{-3}}$$

On a donc
$$\begin{aligned} a_2 &= -p_1 - p_2 - p_3 \\ a_1 &= p_1p_2 + p_1p_3 + p_2p_3 \\ a_0 &= -p_1p_2p_3 \\ b_0 &= w_c^N \end{aligned}$$

Finalement le circuit vaut :



Exercice 2 :

Conversion des paramètres

```
T = 1
```

```
T = 1
```

```
W_p = 0.2 * pi;
W_s = 0.3 * pi;

w_p = (2/T) * tan(W_p/2); % Conversion des paramètres
w_s = (2/T) * tan(W_s/2); % Conversion des paramètres
R_p = 7;
A_s = 16;
```

Question 1 :

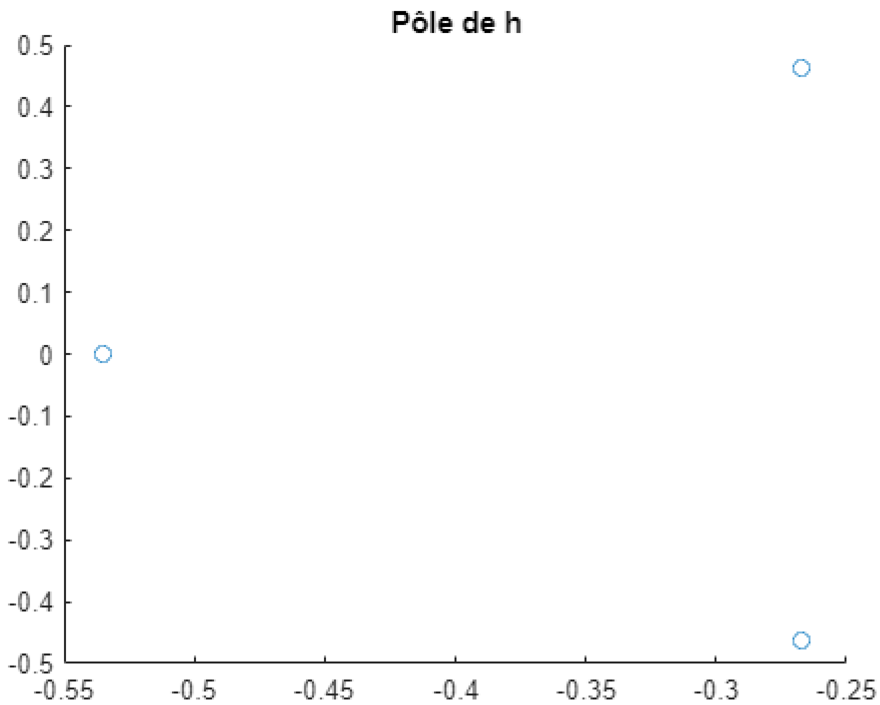
```
N = floor(log10( ...
        ((10^(R_p/10) - 1 )*(10^(A_s/10) - 1))...
        / ...
        (2*log10(w_p/w_s)) ...
       )) + 1;
N = real(N);
N
```

```
N = 3
```

On a également N=3, donc 3*2=6 pôles. Dont 3 instables. Les pôles stables ont encore une fois pour argument : 2pi/3, pi, 4pi/3

```
w_cp = w_p / (10^(R_p/10) - 1)^(1/(2*N));
w_cs = w_s / (10^(A_s/10) - 1)^(1/(2*N));
w_c = (w_cp + w_cs)/2;
```

```
p_1 = w_c * exp(1i*2*pi/3);
p_2 = w_c * exp(1i*pi);
p_3 = w_c * exp(1i*4*pi/3);
x = real([p_1 p_2 p_3]);
y = imag([p_1 p_2 p_3]);
scatter(x,y);
title('Pôle de h');
```




```
p_1, p_2, p_3
```

```
p_1 = -0.2673 + 0.4630i
p_2 = -0.5347 + 0.0000i
p_3 = -0.2673 - 0.4630i
```

Question 2 :

Transformation bilinéaire

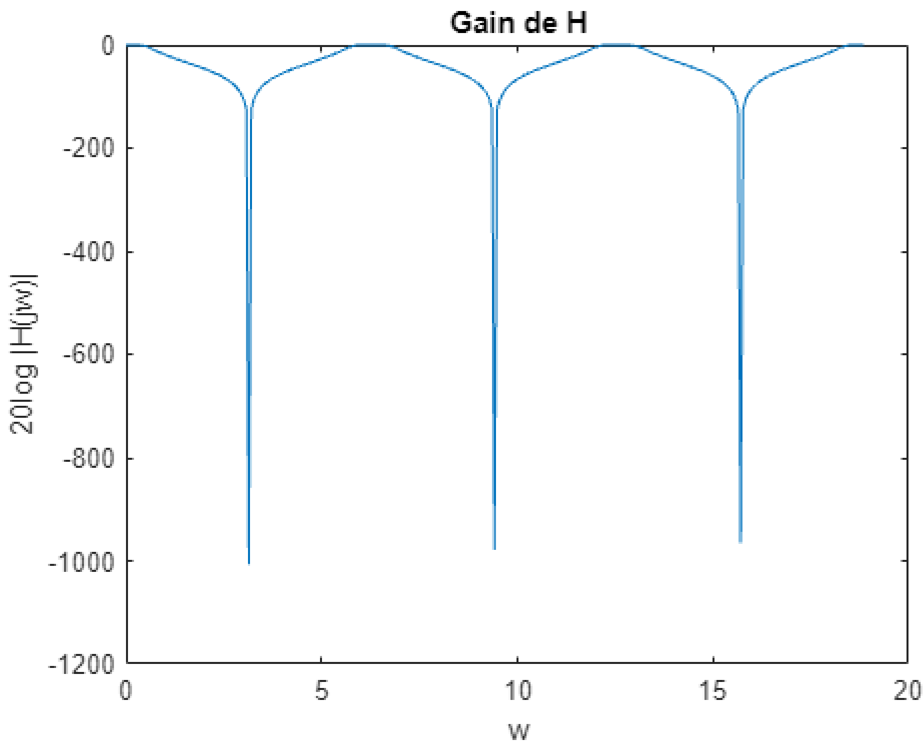
```
f = 0 : 0.01 : 3;
w = 2*pi*f;
Z = exp(1i*w);

S = (2/T) * (1-Z.^(-1))./(1 + Z.^(-1)); % Transformation bilinéaire
H = w_c.^N ./ ((S - p_1).*(S - p_2).*(S - p_3));
```

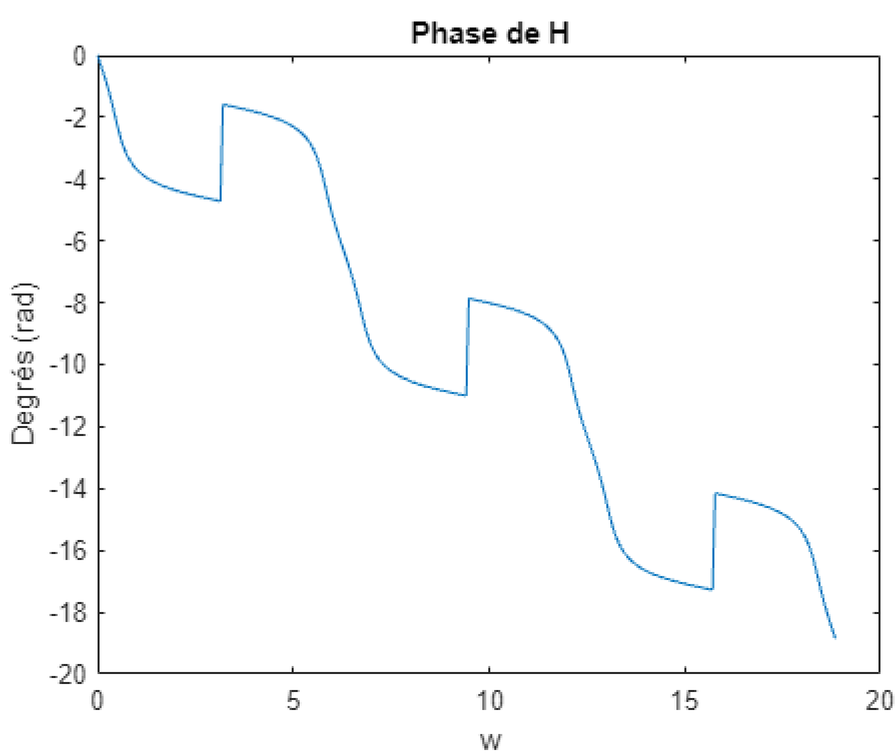
Plot du module et de la phase

```
module = 20*log10(abs(H));
phase = unwrap(angle(H));

figure('name', 'Gain de H');
plot(w, module);
title('Gain de H');
xlabel('W');
ylabel('20log |H(jw)|');
```




```
figure('name', 'Phase de H');
plot(w, phase);
title('Phase de H');
xlabel('W');
ylabel('Degrés (rad)');
```



Vérifions les caractéristiques du filtre :

Pour cela je vais regarder le du module à 0.2π et 0.3π. Il doit valoir respectivement $R_p = 7\text{db}$ et $A_s = 16\text{db}$

```
disp("=======0.2pi======")
```

```
=======0.2pi======
```

```
w(11)
```

```
ans = 0.6283
```

```
disp("L'indice 11 de W represente environ 0.2pi = 0.6283185307")
```

```
L'indice 11 de w represente 0.2pi = 0.6283185307
```

```
module(11)
```

```
ans = -6.2566
```

```
disp("On a le module de 0.2pi qui vaut environ -6.2566")
```

```
On a le module de 0.2pi qui vaut environ -6.7165
```

```

disp("")
disp("=======0.3pi======")
```

```
=======0.3pi======
```

```
w(16)
```

```
ans = 0.9425
```

```
disp("L'indice 16 de W represente environ 0.3pi = 0.9424777961")
```

```
L'indice 16 de w represente 0.3pi = 0.9424777961
```

```
module(16)
```

```
ans = -16.8961
```

```
disp("On a le module de 0.3pi qui vaut environ -16.8961")
```

```
On a le module de 0.3pi qui vaut environ -16.3438
```

On peut voir que les caractéristiques du filtre sont respecté. On a une légère approximation du au coté discret de la génération graphique.