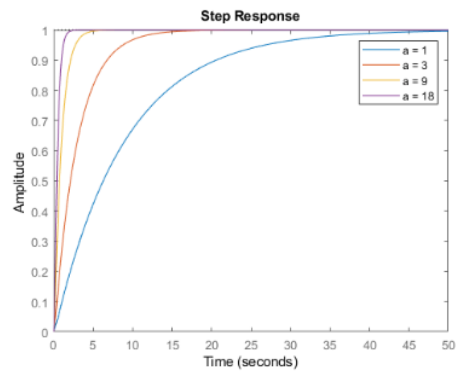
Question 1

```
clear all;

syms a;

a = 1;
hold on
sys = tf([a],[1 9 a]);

step(sys, 50)


a = 3;
sys = tf([a],[1 9 a]);
step(sys, 50)

a = 9;
sys = tf([a],[1 9 a]);
step(sys, 50)

a = 18;
sys = tf([a],[1 9 a]);
step(sys, 50)
hold off;
```

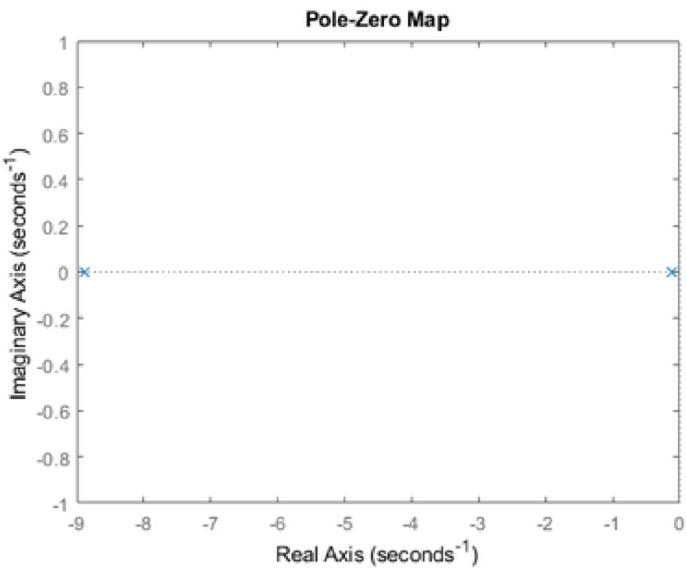


Matlab code for plotting the pole map

```
a = 1;
sys = tf([a],[1 9 a]);
roots([1 9 a])
pzmap(sys)

a = 3;
sys = tf([a],[1 9 a]);
roots([1 9 a])
pzmap(sys)

a = 9;
sys = tf([a],[1 9 a]);
roots([1 9 a])
pzmap(sys)

a = 18;
sys = tf([a],[1 9 a]);
roots([1 9 a])
pzmap(sys)
```

Poles at a = 1

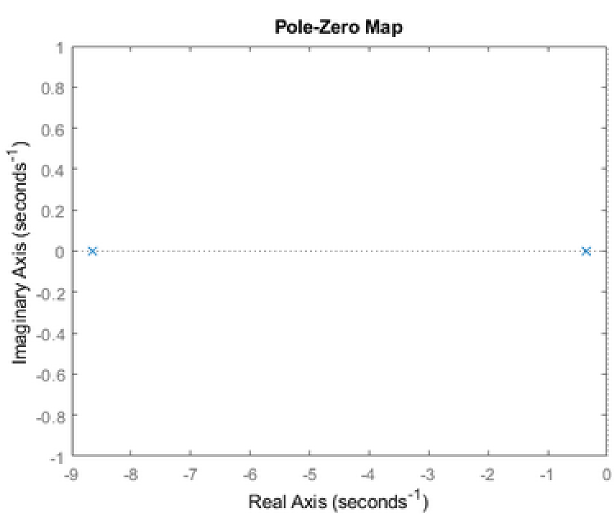
```
ans = 2×1
    -8.8875
    -0.1125
```



Time constants at a = 1. tau1 = 0.11251758087s and tau2 = 8.88889s. 2nd order time constants are given as sqrt(tau1 * tau2) = 1s Settling time is 4 * time constant therefore, it’s 4s

Poles at a = 3

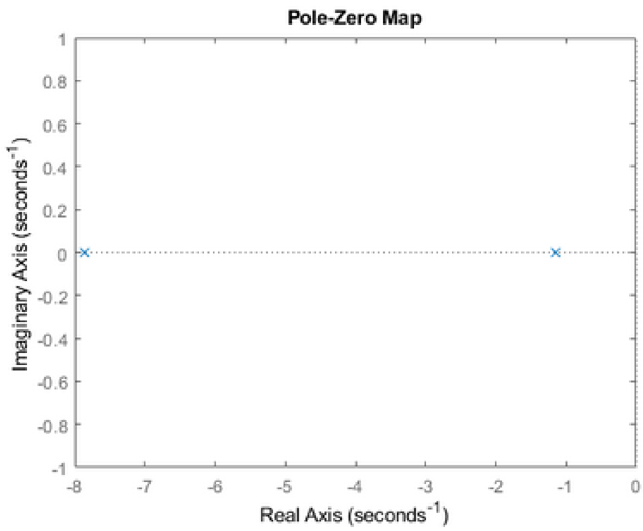
```
ans = 2×1
    -8.6533
    -0.3467
```



Time constants at a = 3. tau1 = 0.1156s and tau2 = 2.8843s. 2nd order time constant is given as sqrt(tau1 * tau2) = 0.5774s Settling time is 4 * time constant therefore, it’s 2.3097s

Poles at a = 9

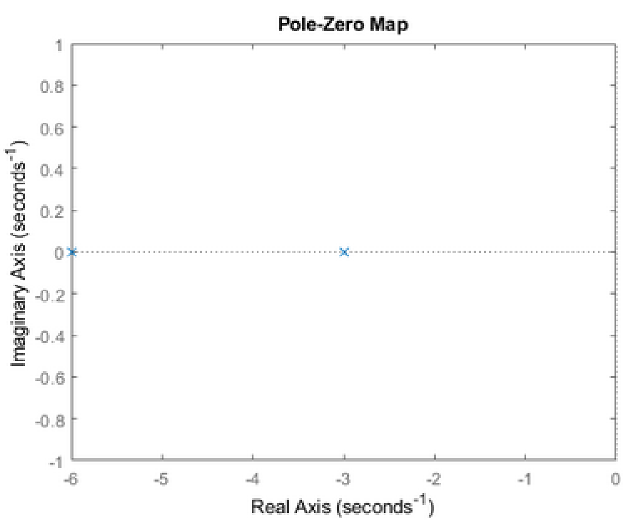
```
ans = 2×1
     -7.8541
     -1.1459
```



Time constants at a = 9. tau1 = 0.12732s and tau2 = 0.87267s. 2nd order time constant is given as sqrt(tau1 * tau2) = 0.333s Settling time is 4 * time constant therefore, it's 1.33332s

Poles at a = 18

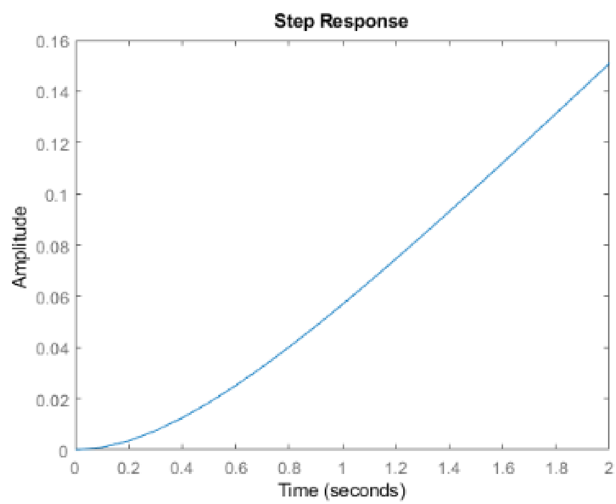
```
ans = 2×1
      -6
      -3
```



Time constants at a = 18. tau1 = 0.1667 and tau2 = 0.333s. 2nd order time constant is given as sqrt(tau1 * tau2) = 0.2357s Settling time is 4 * time constant therefore, it's 0.9428s

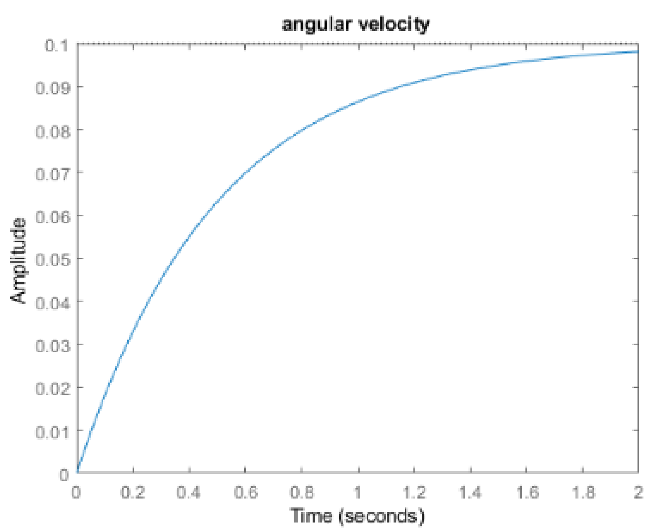
Question 2

```
sys =

    0.04
  ---------
  s^2 + 2 s

Continuous-time transfer function.
```



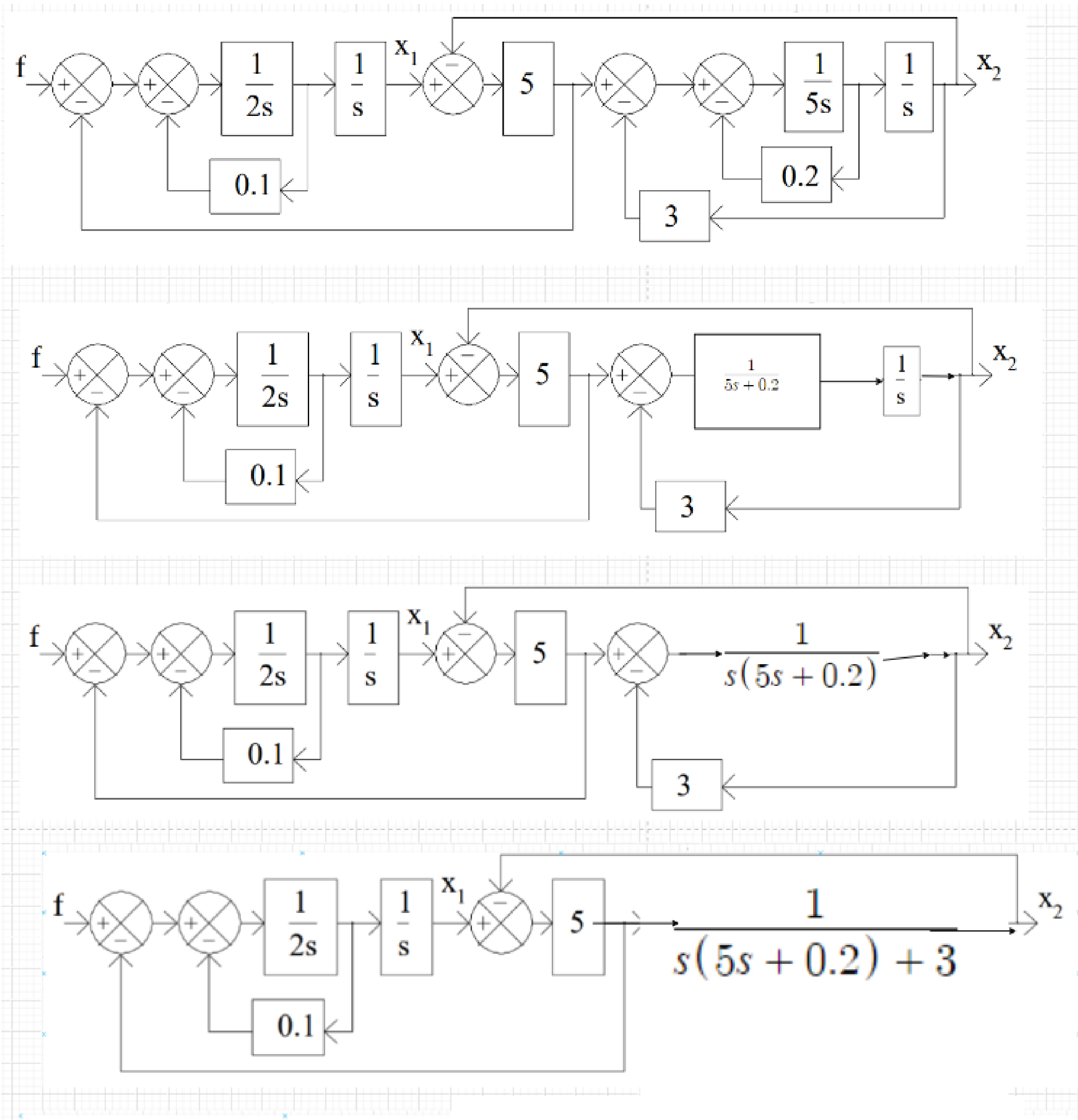
This is the output of the response of the motor to a 5v step input response. It gives a ramp output as expected from a 2nd order system.

```
sys =

  0.04
  -----
  s + 2

Continuous-time transfer function.
```

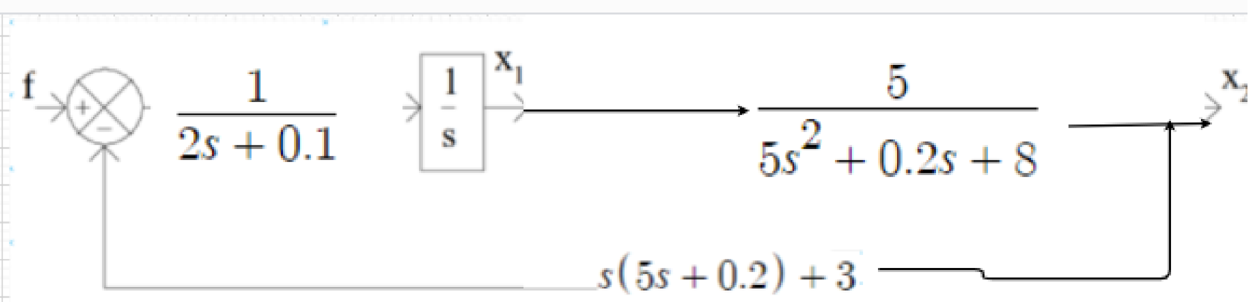


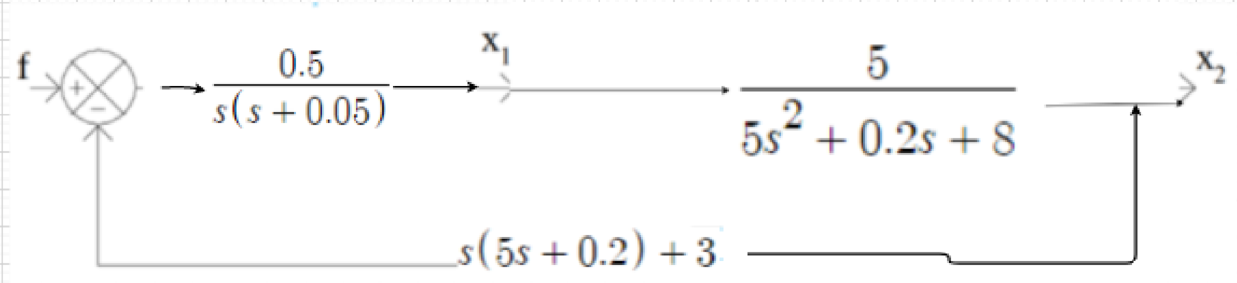
This is the angular velocity of the motor. To obtain the transfer function, the previous transfer function must be multiplied by **s** in order to derive it in time to achieve a function for velocity.

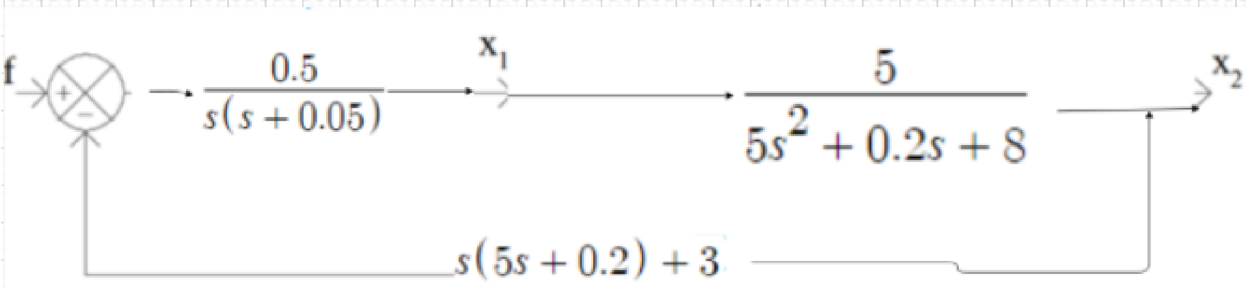
Question 3

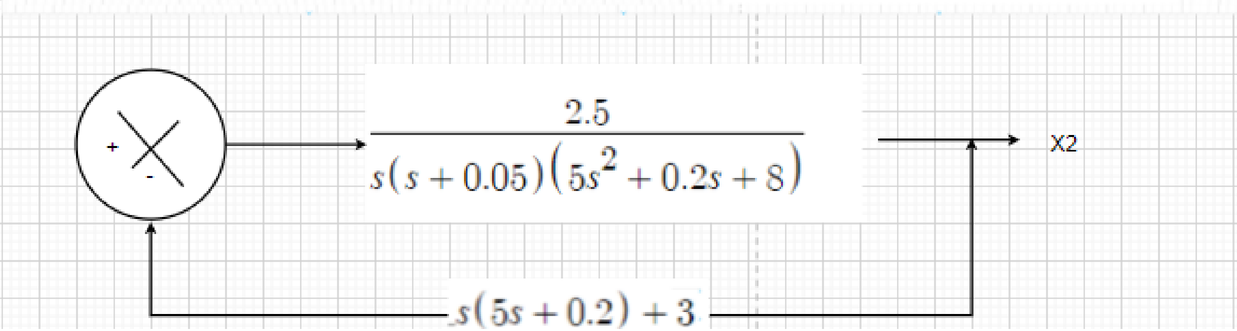


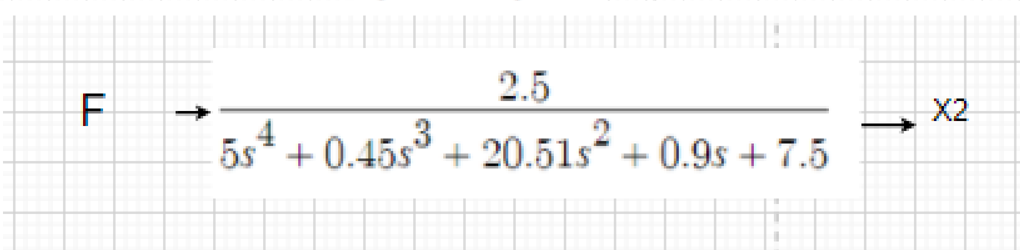
f
x_1
x_2
$\frac{1}{2s}$
$\frac{1}{s}$
5
$\frac{1}{5s}$
0.1
0.2
3
$\frac{1}{5s+0.2}$
$\frac{1}{s(5s+0.2)}$
$\frac{1}{s(5s+0.2)+3}$

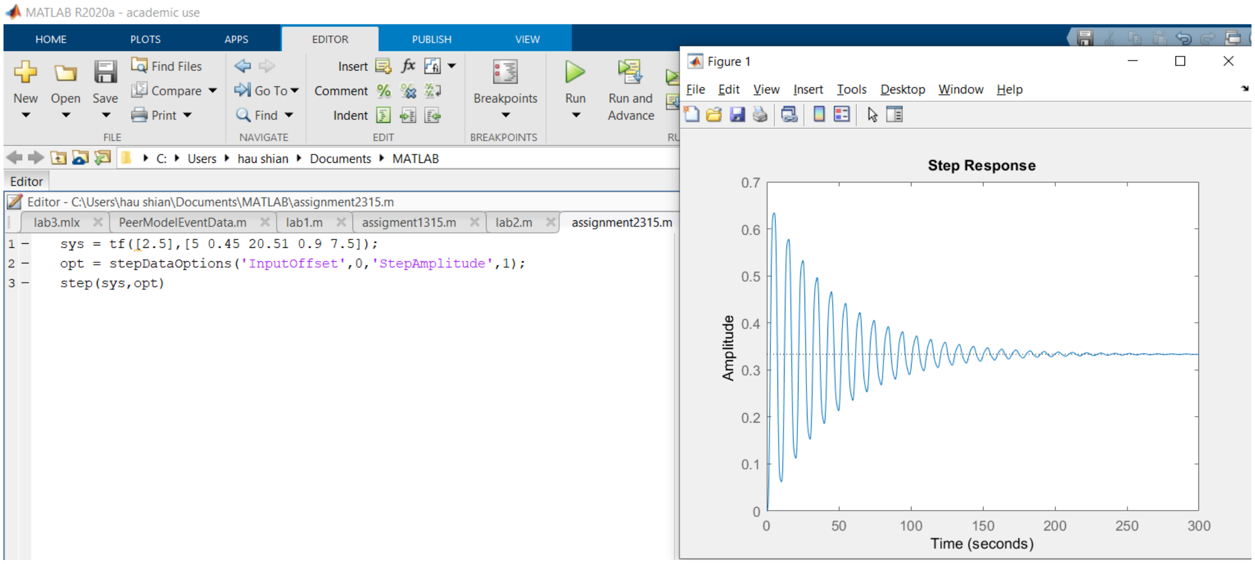

f
+
-
1/(2s + 0.1)
1/s
x1
5/(5s^2 + 0.2s + 8)
x2
s(5s + 0.2) + 3


f
+
-
0.5/(s(s + 0.05))
x1
5/(5s^2 + 0.2s + 8)
x2
s(5s + 0.2) + 3


f
+
-
0.5/(s(s + 0.05))
x1
5/(5s^2 + 0.2s + 8)
x2
s(5s + 0.2) + 3


+
-
2.5/(s(s + 0.05)(5s^2 + 0.2s + 8))
X2
s(5s + 0.2) + 3


F
2.5/(5s^4 + 0.45s^3 + 20.51s^2 + 0.9s + 7.5)
X2

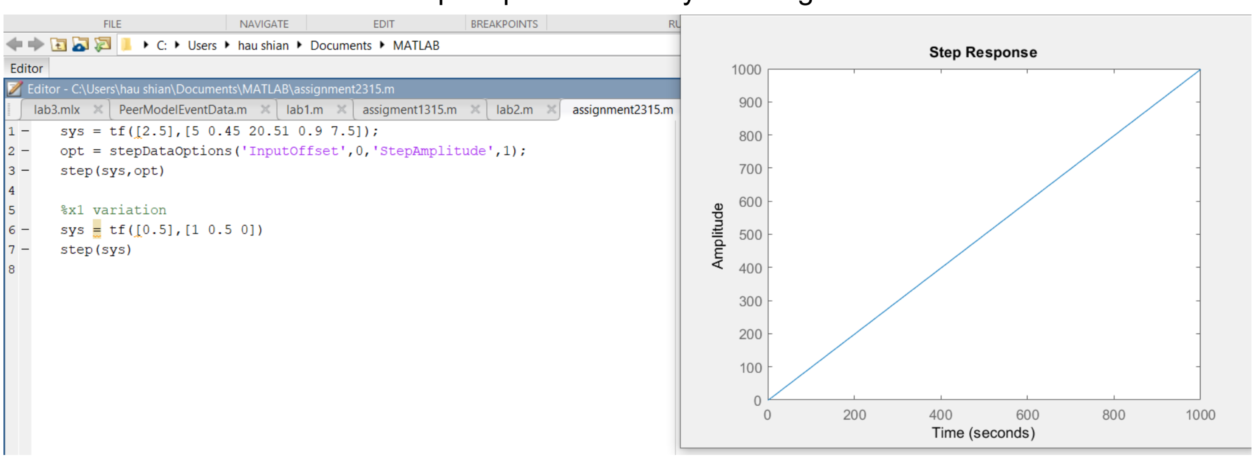


Step response of the 4th order system.

X1 variation is given as

$$\frac{0.5}{s(s+0.05)}$$

The step response of X1 system is given as



Question 5

```
for C = 0.1:0.001:10
    sys = feedback(series(C,tf(6,[1 7 6 0])),1);
    B = isstable(sys);
    if B == 0
        break
    end
end
disp(['gain > ', num2str(C)])
```

```
gain > 7
```

This means our controller value in series must be greater than 7