Control Systems HW5

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1. Simulations by script (use the function ode45)

From det|sI-A|, we know characteristic eqn. q(s) is

$$q(s) = M*L*s^3 – KD*S^2 – [(M+m)g + KP]S – KI.$$

Utilizing Routh-Hurwitz criterion, we have

S^3 |	M*L	– [(M+m)g + KP]
S^2 |	-KD	– KI
S^1 |	b	0
S^0 |	-KI	0

where

$$b = [KD*[(M+m)g + KP] – (M*L*(-KI))]/-KD.$$

For a stable system, we require that the coefficient of q(s) be positive and b > 0, which means that

$$-[(M+m)g + KP] – (M*L*(KI/KD)) >0, \quad -KD>0, \quad – KI>0.$$

Therefore, the range of PID parameters that stabilize this system are

$$KP < - (M+m)g - (M*L*(KI/KD)), \quad KD < 0, \quad KI < 0$$

For my PID controller I choose

```
KD =

  -100

KI =

   -30

KP =

  -1.1391e+03
```

PID controller system:

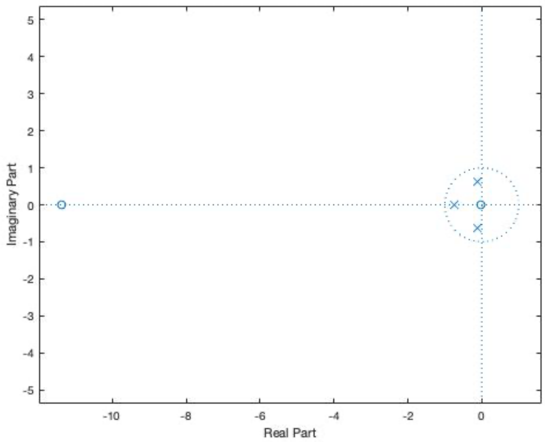
```
C =

             1
  Kp + Ki * --- + Kd * s
             s

  with Kp = -1.14e+03, Ki = -30, Kd = -100

Continuous-time PID controller in parallel form.
```

Closed-loop transfer function.

```
T_sys =

    s^2 + 11.39 s + 0.3
  ----------------------
  s^3 + s^2 + 0.6 s + 0.3

Continuous-time transfer function.
```

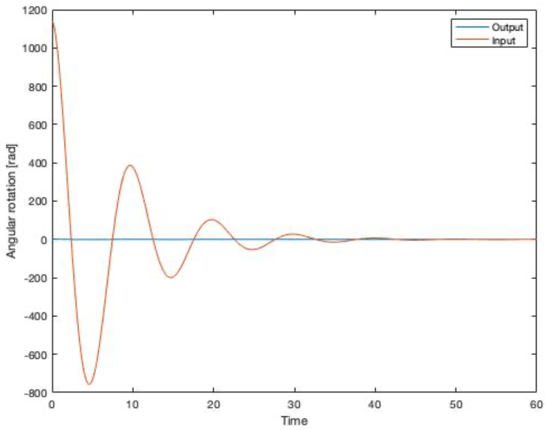
The roots of my characteristic eqn. q(s) are

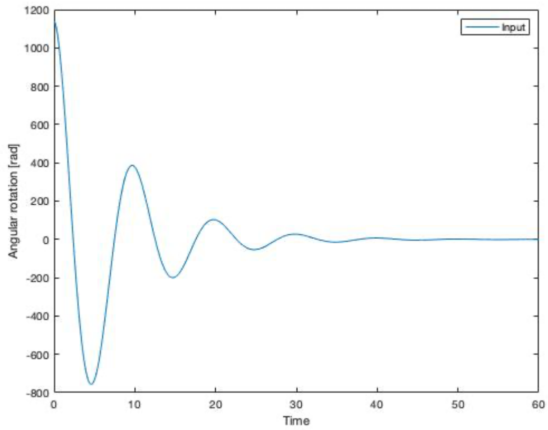
```
ans =

- 0.131068 - 0.624019i
- 0.131068 + 0.624019i
            -0.737864
```

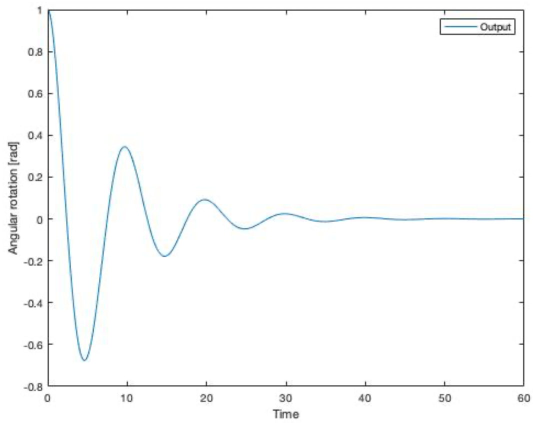


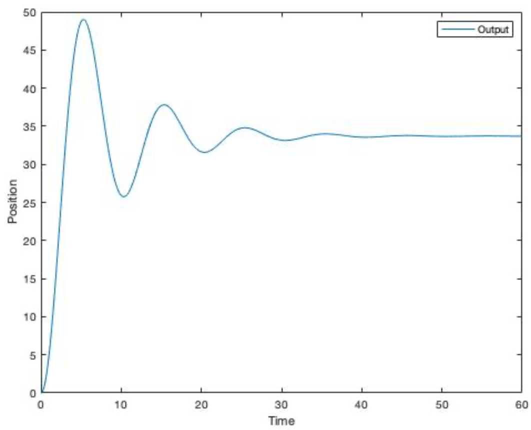
All roots are located in the left-half s-plane, means system is stable.

The waveforms using ode45:



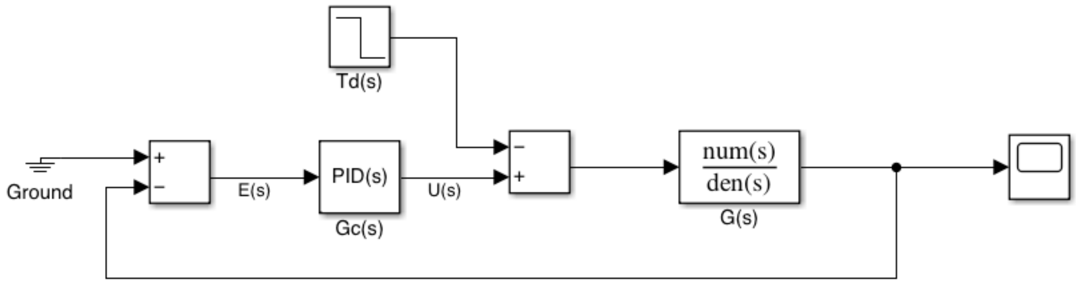




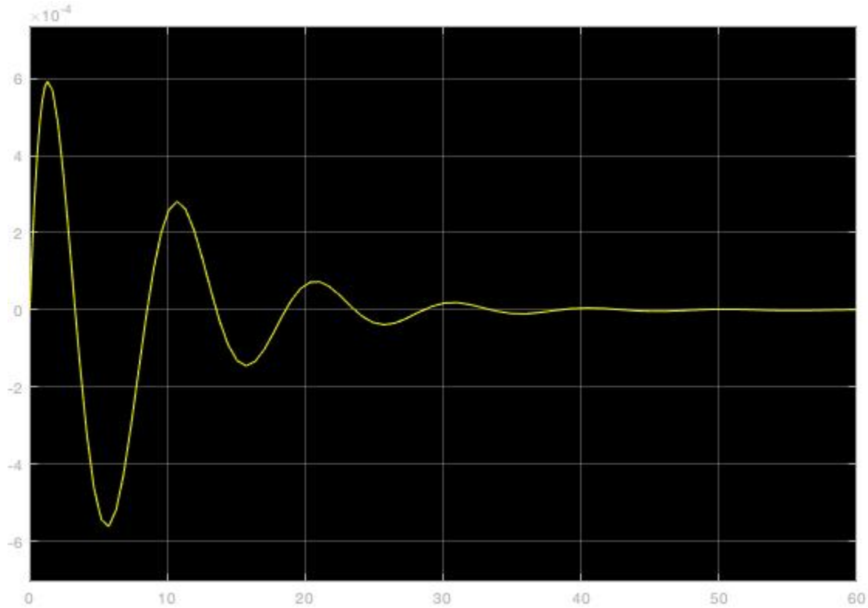


See the waveform of output angular rotation. The output response decays to zero as time approaches infinity, showing that system is stable.

2. Simulations by Simulink



The waveform using Simulink:



The output response also decays to zero as time approaches infinity, showing that system is stable.