Robotics II

Day 10: Control Systems II

The equation of motion of the given system is given as,

After Linearization and Laplace Transforming,

The Transfer function is given by the following equation,

By utilizing the control theory for PD control,

Taking R(s) as zero for out assumption,

The combing with the transfer function resulting system is shown as the following equation,

The poles of the system is given by the following equation,

1. “Stability Limit” behavior using PD control.

For a system operating at the stability limit, the Kv gain is zero, while the Kp­ gain is that satisfies the condition

Under this condition, the system behaves similarly to an un-damped mass spring system, which will oscillate about a given point.

The selected Kp gain values are:

* Kp = 15

The pole values are given as:

* s = 0.0 + 4.963j
* s = 0.0 - 4.963j
* Kp = 30

The pole values are given as:

* s = 0.0 + 8.073j
* s = 0.0 - 8.073j

The implemented python script is included under the filename [InvertedPendulum\_odeint\_Stability\_Limit\_1.py](Script/InvertedPendulum_odeint_Stability_Limit_1.py) and [InvertedPendulum\_odeint\_Stability\_Limit\_2.py](Script/InvertedPendulum_odeint_Stability_Limit_2.py).

The results are shown in figures 1.1 and 1.2.

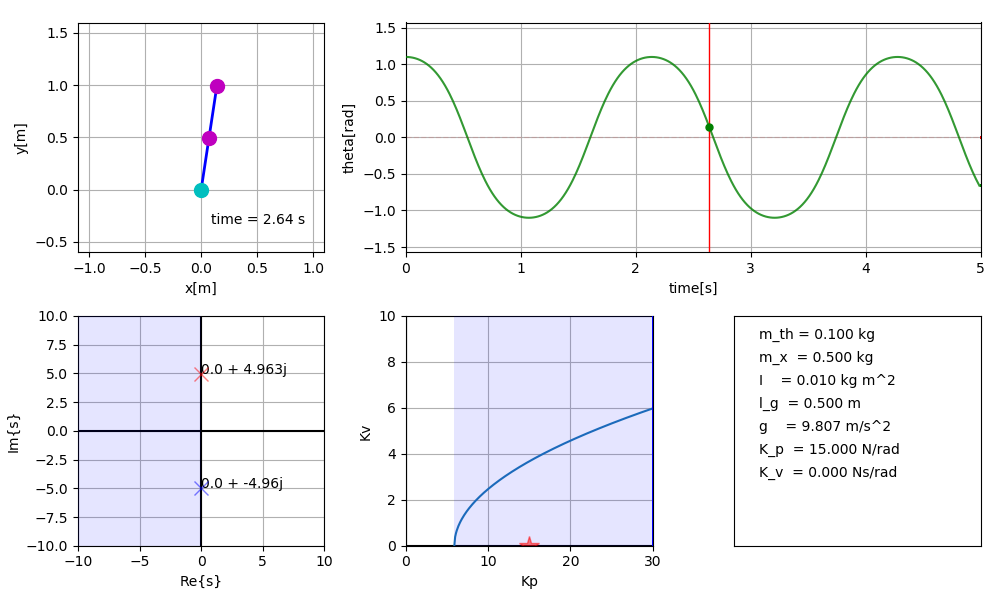


Figure 1.1 “Stability Limit” behavior with Kp­ gain of 15

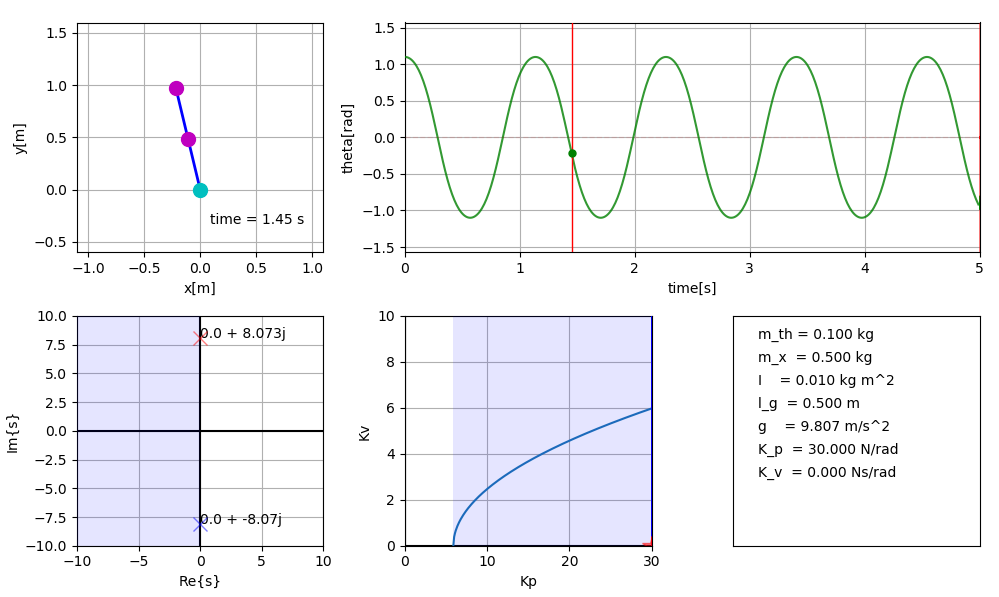


Figure 1.2 “Stability Limit” behavior with Kp­ gain of 30

1. “Critically Damped” behavior using PD control.

For a critically damped system, the Kv and Kp gain is selected to satisfy the following condition.

The selected Kp and Kv gain values are:

* Kp = 15, Kv = 3.673

The pole values are given as:

* s = -4.96 + 0.0j

The implemented python script is included under the filename [InvertedPendulum\_odeint\_Critically\_Damped.py](Script/InvertedPendulum_odeint_Critically_Damped.py).

The results are shown in figure 2.1.

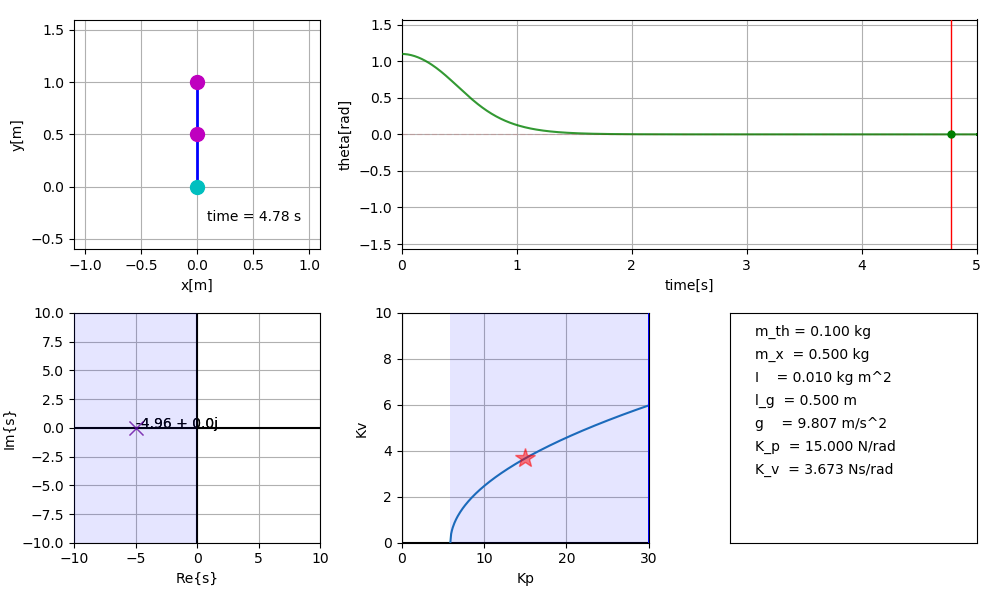


Figure 2.1 “Critically Damped” behavior with Kp­ gain of 15 and Kv­ gain of 3.673

1. “Over-damped” behavior using PD control.

An over-damped system realized when the Kp and Kv gains selected satisfies the following condition.

The selected Kp and Kv gain values are:

* Kp = 15, Kv = 9

The pole values are given as:

* s = -23.2 + 0.0j
* s = -1.05 + 0.0j

The implemented python script is included under the filename [InvertedPendulum\_odeint\_Overdamped.py](Script/InvertedPendulum_odeint_Overdamped.py).

The results are shown in figure 3.1.

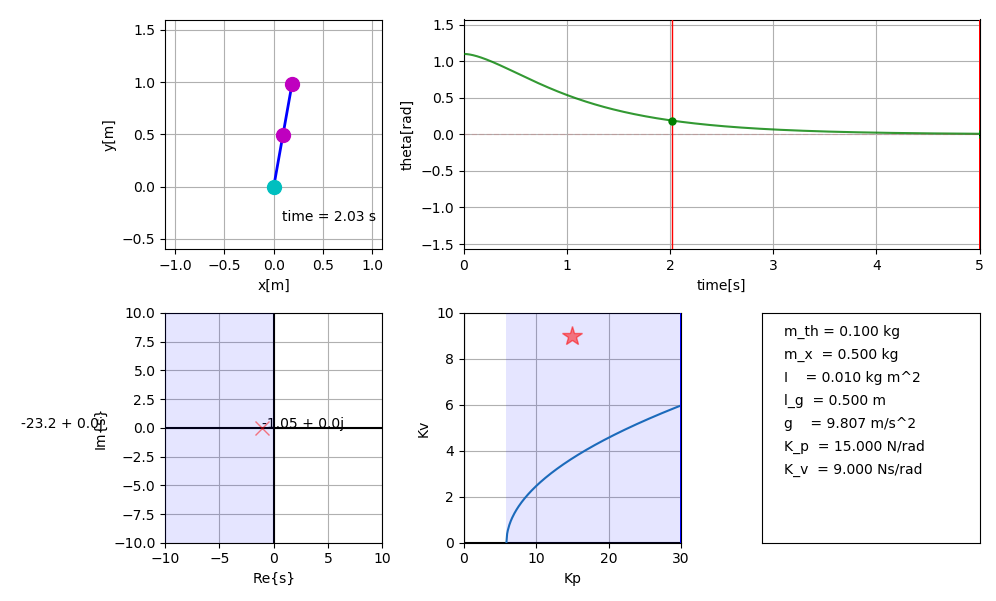


Figure 3.1 “Over-damped” behavior with Kp­ gain of 15 and Kv­ gain of 9

1. “Under-damped” behavior using PD control.

An over-damped system realized when the Kp and Kv gains selected satisfies the following condition.

The selected Kp and Kv gain values are:

* Kp = 15, Kv = 1

The pole values are given as:

* s = 1.35 + 4.776j
* s = 1.35 - 4.776j

The implemented python script is included under the filename [InvertedPendulum\_odeint\_Underdamped.py](Script/InvertedPendulum_odeint_Underdamped.py).

The results are shown in figure 4.1.

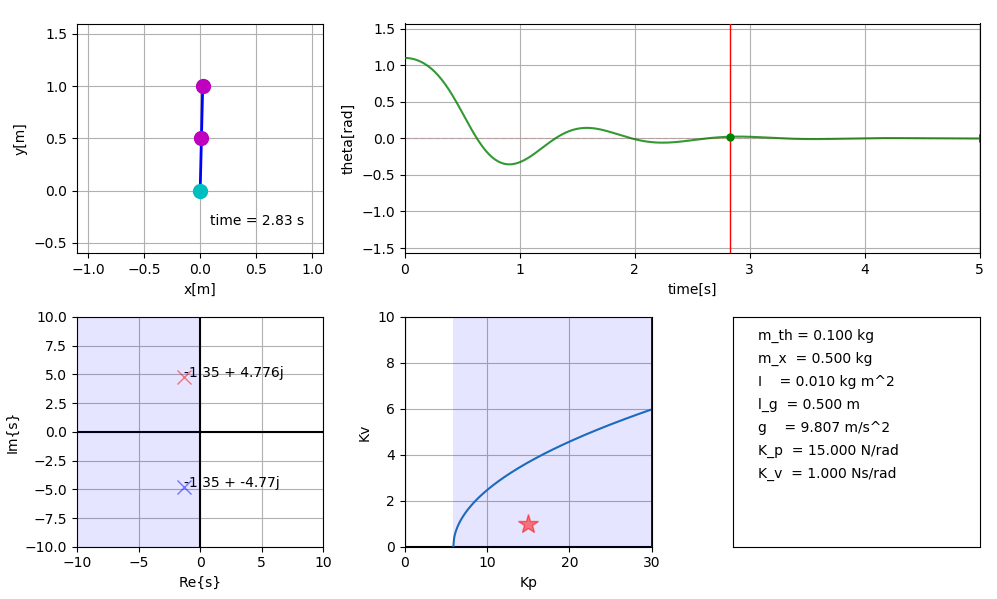


Figure 4.1 “Over-damped” behavior with Kp­ gain of 15 and Kv­ gain of 1