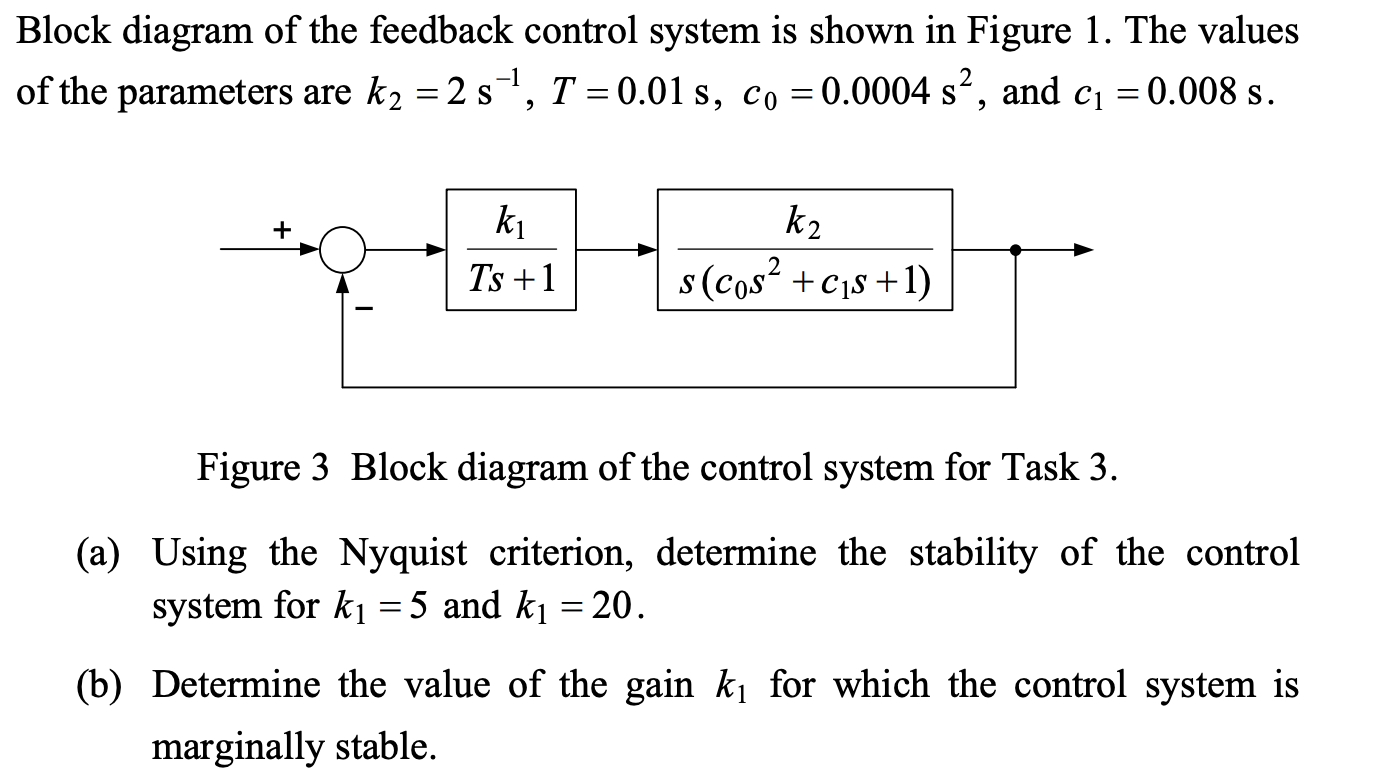
# Control Theory 1

# Report

# Lab 9

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## Task 3



## Solution

**Task A)**

The open-loop transfer function  G(s)H(s)  of the system is:

By substituting the given parameters:

• ,

• T = 0.01s1 ,

• c0 = 0.0004s2 ,

• c1 = 0.008s.

This becomes:

Steps:

1. Determine the Nyquist plot for  k1 = 5  and  k1 = 20 .

The transfer function for k1 = 5, k1 = 20 becomes:

Substitute :

After solving the equation we conclude that the system’s stability depends on k\_1. For k\_1 \leq 5, it is stable. For k\_1 > 20, it is unstable. The exact threshold for marginal stability (k\_1) lies between these values.

**Part (b): Marginal stability**

To find the **marginal stability** condition in part (b), we solve for the critical gain k1 when the magnitude of the open-loop transfer function equals 1, i.e., .

**Transfer Function:**

.

The magnitude of the denominator is:

.

For marginal stability:

.

Solve for k1:

.

Marginal stability occurs at a critical frequency . Numerically solve for by evaluating the phase and ensuring the Nyquist plot passes through -1 (where the phase is ).

So as the result, **the system is marginally stable at .**

# Task 4

The stability of the closed-loop system is analyzed using the Nyquist criterion by examining the Nyquist plot of the open-loop transfer function  L(s) :

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• Determine encirclements of the -1 point in the Nyquist plot.

• Use  N = Z - P , where  P = 1  (one pole in the right-half plane) to calculate  Z , the number of right-half-plane poles in the closed-loop system.

2. **Step Response Verification**:

The closed-loop transfer function is:

.

# Task 5

The open-loop transfer function includes a time delay , which affects stability. The Nyquist plot changes as \tau increases, causing potential encirclements of the -1 point.

1. **Transfer Function**:

2. **Nyquist Criterion**:

• Plot the Nyquist plot for each \tau value.

• Determine if the -1 point is encircled.

• Stability is determined using N = Z - P, where P = 0 (no open-loop right-half-plane poles).