Question 1

Consider the following systems, \( G(s) \):

1. \( \frac{10}{(s+1)(s+10)} \)
2. \( \frac{1}{(s+1)(s-2)} \)
3. \( \frac{1}{s^2+s+1} \)
4. \( \frac{1}{s(s+1)} \)

Find the suitable values for the parameters of a member of the PID family to control each of these models (Use direct synthesis or IMC with a closed-loop time-constant \( \tau_c = 1 \)).

Question 2

Consider the model

\[
G(s) = \frac{(-\alpha s + 1)}{(s + 1)(s + 2)}
\]  

(1)

Use IMC tuning to design a PID controller \( \tau_c = 0.5 \). Compute the complementary sensitivity function. Comment on the servo-response of the closed-loop system for \( \alpha \) in the interval \([0.1; 20]\).

Question 3

Consider a plant with nominal model

\[
G(s) = \frac{-s + 3}{(s + 3)(s + 5)}
\]  

(2)

- Using IMC, synthesize a PID controller for this system, with \( \tau_c = 0.1 \).
- Compute the complementary sensitivity function. Comment on the servo-response of the closed-loop system.
**Question 4**

The following nominal model is given:

\[ G_0(s) = \frac{(s - 2)}{(s + 4)(s + 2)} \]  

(3)

The following controller was designed for this process:

\[ C(s) = \frac{k(s + 4)(s + 2)}{s(s + 1)} \]  

(4)

where \( k \) is a positive constant.

You are asked to assess the stability of the resulting closed-loop system.

- Compute the characteristic equation \( (A_0(s)L(s) + B_0(s)P(s) = 0) \), compute the poles of the closed-loop system and determine whether this system can be stabilized using a positive gain \( k \). Determine a value of \( k \) such that the system is internally stable.

- Compute the nominal complementary sensitivity \( T_0(s) \).

- Will this closed-loop result in zero steady-state tracking error (i.e. \( \lim_{t \to \infty} (y(t) - r(t)) = 0 \)?)