International Master's Programs of Chemical Engineering in the Graduate School of Engineering, Kyushu University (Academic Year from October, 2026)

Subject: Process Control (1sheet)

1. (20 points)

Consider the following differential equation:

$$\frac{dy(t)}{dt} + 2y(t) = 3u(t)$$

where $u(t)$ is the input and $y(t)$ is the output. Assume the initial condition is $y(0) = 0$. Answer the following questions.

(1.1) Derive the transfer function $G(s) = \frac{Y(s)}{U(s)}$, from the differential equation.

(1.2) When the input is a unit step input, $u(t) = 1$, find the time response $y(t)$.

(1.3) Find the time required for the output to reach 50% of its steady-state value.

2. (30 points)

Answer the following questions with respect to the feedback control system. The loop transfer function of the feedback control system is given by

$$G_0(s) = \frac{K}{(s+1)^3}$$

where *K* is a positive constant.

(2.1) Find the *K* when the feedback control system reaches the stability limit.

(2.2) When *K* = 2, compute the gain margin in this feedback control system.

(2.3) When *K* = 2, compute the steady-state offset for a unit step change in the set point, using

$$\frac{E(s)}{R(s)} = \frac{1}{1 + G_0(s)}$$