NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

BACHELOR OF ENGINEERING (HONS) DEGREE

Part V Examination

2013

TCE 5102-IIA Process Dynamics, Modeling and Control (Supplementary)

Duration of Examination: 3 Hours

Instructions to candidates:

Answer **ALL** questions and each question carries **25marks**
Answer each question on a **FRESH PAGE**
Write CLEARLY

QUESTION 1

A. With the aid of labeled sketch diagrams explain the effects of gain (K_c) and reset time (τ_I) parameters on controlled processes. **[15].**

B. Explain the five (5) most quoted simple performance criteria characterizing closed-loop response of a system. **[10].**

QUESTION 2

A. If $G_p = 10/(s-1)$; $G_f = G_m = 1$ and $G_c = K_c$, formulate the corresponding characteristic equation and deduce conditions of stability. **[10].**

B. Check whether the following characteristic equation is stable or not using the Ruoth-Herwitz test: $s^5 + 4s^4 + 8s^3 + 8s^2 + 7s + 4 = 0$ **[15].**

QUESTION 3

A. Can a process with the following response: $y(s) = \frac{10}{s-1} m(s) + \frac{5}{s-1} d(s)$ be stabilized by a proportional controller? Assume that $G_m = G_f = 1$ **[10].**

B. A proportional controller which measures the concentration of C and manipulates the flowrate of reactant A is represented by the following transfer function for the process:#

$$G_p(s) = \frac{y(s)}{m(s)} = \frac{2.98(s + 2.25)}{(s + 1.45)(s + 2.85)^2(s + 4.35)}$$

If $G_m = G_f = 1$, formulate the characteristic equation and calculate the roots when $K_c = 0$ and $K_c = 1$. Comment on the results. **[15].**

QUESTION 4

A. Explain the Ziegler-Nichols tuning technique for closed-loop systems. **[10].**

B. The frequency response for a first order system input is sinusoidal in nature and has the following characteristic:

$$u(t) = M\sin(\omega t)$$

and the process is a linear 1st – order system with the following transfer function:

$$\frac{Y(s)}{U(s)} = \left(\frac{K_p}{1 + \tau s}\right)$$

The Laplace transform of the input signal given by:#

$$U(s) = L\{M\sin(\omega t)\} = \frac{M\omega}{s^2 + \omega^2}$$

and the output in the Laplace domain is given by: #

$$Y(s) = \left(\frac{K_p}{1 + \tau s}\right)\frac{M\omega}{s^2 + \omega^2}$$

Obtain the following ultimate frequency response for the linear system:

#

$$y(t) = \frac{(K_p M)}{(1+\omega^2\tau^2)}\left[\omega\tau \exp\left(-\frac{t}{\tau}\right) + \sqrt{1 + \omega^2\tau^2}\,\sin(\omega t + \emptyset)\right]$$

$x \sin\alpha + y\cos\alpha = z\sin(\alpha + \Phi)$; $\tan\Phi = y/x$; $z^2 = x^2 + y^2$ **[15].**