# UNIT 1

## Introduction and Overview

Welcome to *Tuning of Industrial Control Systems*. The first unit of this self-study program provides the information you will need to take the course.

**Learning Objectives — When you have completed this unit, you should be able to:**

**A. Understand the general organization of the course.**

**B. Know the course objectives.**

**C. Know how to proceed through the course.**

### 1-1. Course Coverage

This book focuses on the fundamental techniques for tuning industrial control systems. It covers the following topics:

A. The common techniques for representing and measuring the dynamic characteristics of the controlled process.

B. The selection and tuning of the various modes of feedback control, including those of computer- and microprocessor-based controllers.

C. The selection and tuning of advanced control techniques, such as cascade, feedforward, multivariable, and adaptive control.

When you finish this course you will understand how the methods for tuning industrial control systems relate to the dynamic characteristics of the controlled process. By approaching the subject in this way you will gain insight into the tuning procedures rather than simply memorizing a series of recipes.

Because microprocessor- and computer-based controllers are now widely used in industry, this book will extend the techniques originally developed for analog instruments to digital controllers. We will examine tuning techniques that have been specifically developed for digital controllers as well as those for adaptive and auto-tuning controllers.

No attempt is made in this book to provide an exhaustive presentation of tuning techniques. In fact, we have specifically omitted techniques based on frequency response, root locus, and state space analysis because they are more applicable to electrical and aerospace systems than to industrial

processes. Such techniques are unsuitable for tuning industrial control systems because of the nonlinear nature of industrial systems and the presence of transportation lag (dead time or time delay).

## 1-2. Purpose

The purpose of this book is to present, in easily understood terms, the principles and practice of industrial controller tuning. Although this course cannot replace actual field experience, it is designed to give you the insights into the tuning problem to speed up your learning process during field training.

## 1-3. Audience and Prerequisites

The material covered will be useful to engineers, first-line supervisors, and senior technicians who are concerned with the design, installation, and operation of process control systems. The course will also be helpful to students in technical schools, colleges, or universities who wish to gain some insight into the practical aspects of automatic controller tuning.

There are no specific prerequisites for taking this course. However, you will find it helpful to have some familiarity with the basic concepts of automatic process control, whether acquired through practical experience or academic study. In terms of mathematical skills, you do not need to be intimately familiar with some of the mathematics used in the text in order to understand the fundamentals of tuning. This book has been designed to minimize the barrier that mathematics usually presents to students' understanding of automatic control concepts.

## 1-4. Study Materials

This textbook is the only study material required in this course. It is an independent, stand-alone textbook that is uniquely and specifically designed for self-style.

Appendix A contains a list of suggested readings to provide you with additional reference and study materials.

## 1-5. Organization and Sequence

This book is organized into ten separate units. The next three units (Units 2-4) are designed to teach you the fundamental concepts of tuning, namely, the modes of feedback control, the characterization and measurement of process dynamic response, the selection of controller

performance, and the adjustment of the tuning parameters. Unit 5 tells you how to select controller modes and tuning parameters for some typical control loops. An entire unit, Unit 6, is devoted to the specific problem of tuning computer- and microprocessor-based controllers. The last four units, Units 7 through 10, demonstrate how to tune the more advanced industrial control strategies, namely, cascade, feedforward, multivariable, and adaptive control systems.

As mentioned, the method of instruction used is self-study: you select the pace at which you learn best. You may browse through or completely skip some units if you feel you are intimately familiar with their subject matter and devote more time to other units that contain material new to you.

Each unit is designed in a consistent format with a set of specific *learning objectives* stated at the very beginning of the unit. Note these learning objectives carefully; the material in the unit will teach to these objectives. Each unit also contains examples to illustrate specific concepts and exercises to test your understanding of these concepts. The solutions for all of these exercises are contained in Appendix B, so you can check your own solutions against them.

You are encouraged to make notes in this textbook. Ample white space has been provided on every page for this specific purpose.

## 1-6. Course Objectives

When you have completed this entire book, you should:

- Know how to characterize the dynamic response of an industrial process.
- Know how to measure the dynamic parameters of a process.
- Know how to select performance criteria and tune feedback controllers.
- Know how to pick the right controller modes and tuning parameters to match the objectives of the control system.
- Understand the effect of sampling frequency on the performance of computer-based controllers.
- Know when to apply and how to tune cascade, feedforward, ratio, and multivariable control systems.
- Know how to apply adaptive and auto-tuning control techniques to compensate for process nonlinearities.

Besides these overall course objectives, each individual unit contains its own set of learning objectives, which will help you direct your study.

## 1-7. Course Length

The basic premise of self-study is that students learn best when they proceed at their own pace. As a result, the amount of time individual students require for completion will vary substantially. Most students will complete this course in thirty to forty hours, but your actual time will depend on your experience and personal aptitude.