《控制原理》教学大纲

一、课程基本信息

课程名称/英文名称:	控制原理/Introduction to Control	课程代码:	EE160
课程层次:	本科生课程	学 分/学 时:	4/64
主要面向专业:	,	授课语言:	英语
先修课程:	无	建议先修课程说明:	建议先修线性代数，高等数学，信号与系统
开课单位:	信息科学与技术学院	课程负责人:	汪阳

二、课程简介

《自动控制原理》是自动化，电气工程，信息工程及机器人相关专业的一门重要的专业基础课。课程的主要任务是通过本课程的，使学生了解自动控制系统内的组成，特点及专业术语，学习并掌握经典控制理论的基本分析方法，设计方法，为后续的理论课程和工程应用的学习打下坚实的基础。通过课堂教学环节与实践教学环节相结合，强化学生对基本概念，基本理论，基本方法的理解和掌握：要求学生掌握控制系统的数学模型的建立方法，了解控制系统的基本校正方案，并掌握对各种控制系统的性能进行分析的基本方法。

三、课程教学目标

本课程目的是通过课堂讲授、课外作业和实验等教学环节使学生掌握自动控制的基本理论，熟悉工程分析与计算方法，为完成CS和EE专业各相关课程学习打下必要的基础。 本课程任务是通过本课程学习，要求学生掌握： 1. 闭环控制与开环控制，反馈控制系统的构成; 2. 控制系统数学模型(包括传递函数和状态空间模型等)的建立方法; 3. 系统稳态和动态性能分析，包括一阶系统与二阶系统的瞬态响应和稳态性能分析方法，以及高阶系统的性能分析，结合工程专业问题，对系统性能进行分析评价; 4. 根轨迹分析方法以及利用根轨迹分析方法设计和校正系统，主要包括超前、滞后和滞后-超前校正方法; 5. 频率响应分析方法及利用频率响应分析方法设计和校正系统，并结合工程专业问题进行应用分析; 6. 系统状态空间模型;可控性和可观性的概念及判断依据; 7. 应用状态空间分析方法进行控制系统的设计与补偿，并结合工程专业问题进行应用分析。 结合本课程的特点，培养学生抽象思维的能力，既要善于从个性中概括出共性，又要从共性出发深刻了解个性，学习用广义动力学的方法去抽象与解决实际问题，培养学生运用辩证唯物主义的方法论思考、分析与解决问题的基本能力，培养学生的学习和创造力。

四、课程教学方法

教学方法：课堂讲授基本概念和基本方法，采用启发式教学，培养学生提出问题，思考问题、分析问题和解决问题的能力；引导和鼓励学生通过实践和自学获取知识，培养学生的自学能力。增设有讨论和答疑课(由助教辅助完成)，调动学生学习的主观能动性。对重点难点章节安排习题课，通过例题讲解帮助学生消化和巩固所学的知识。 教学手段： 本课程属于专业选修课，在教学中采用电子教案，PPT课件和板书相结合的形式，并借助MATLAB、Simulink软件进行现场演示，同时课程匹配有四次实验课，包含机械系统和电路系统的典型性能分析和工程控制问题，确保在有限的学时内，全面、高质量地完成课程教学任务。

五、课程教学内容与安排

以章节名称方式安排教学内容

本课程共64学时，包含56学时的理论课和8学时的实验课（共4个实验），具体教学内容与安排如下：

章节名称	主要教学内容 （主要知识点）	教学周	学时安排	教学方法 （仅列名称）
控制系统导论	控制理论和实践的发展历史。其主要目的在于介绍设计和实现控制系统的一般流程和方法。	1	2	上课
系统数学模型	数学模型的基本概念、表达方式，建模方法；介绍了实际物理系统的输入输出模型，以传递函数形式为主，涵盖了机械系统，电气系统等。	1-2	4	上课+作业
系统数学模型	状态空间模型。介绍了采用状态变量的系统状态空间模型。运用矩阵工具，讨论了控制系统的瞬态时间响应以及性能。方框图的概念，方框图的化简，信号流图的基本概念，方框图与信号流图的关系。	2-3	4	上课+作业

反馈控制系统的特性	控制系统的典型输入信号，线性定常系统的时域响应及暂态响应的性能指标。一阶系统的暂态响应。二阶系统的暂态响应（暂态响应与极点之间的关系，暂态响应性能指标公式及计算，应用举例）。高阶系统的暂态响应（闭环主导极点、偶极子的概念）。	3-4	6	上课+作业
线性系统稳定性	线性系统的稳定性（稳定的概念，线性系统稳定的充要条件，Routh稳定判据及应用）。控制系统的稳态性能分析。	5	4	上课+作业
实验一	MATLAB、Simulink软件介绍，以及示波器使用指导	5-6	2	课上实验+课后报告（共6个实验课时）
根轨迹法	根轨迹的基本概念（根轨迹的概念，意义，举例），绘制常规负反馈系统根轨迹的基本条件和基本规则。增加开环零极点对根轨迹的影响，利用根轨迹分析系统的暂态响应。PID 控制及尼克尔斯整定法。	6-7	8	上课+作业
实验二	典型环节动态性能和稳定性分析	7-8	2	课上实验+课后报告（共6个实验课时）

控制系统的频域分析	频率响应概念。频率特性（频域响应、频率特性的概念），幅相频率特性图与对数频率特性图的建立。典型环节的频率特性，开环系统频率特性。线性系统稳定性的Nyquist稳定判据：利用幅相频率特性曲线；线性系统稳定性的Nyquist稳定判据：利用对数频率特性曲线。控制系统的相对稳定性（相角裕度、幅值裕度的概念及计算）；闭环频率特性及频域性能指标；频域指标与时域指标的关系。	8-10	12	上课+作业
实验三	典型环节的频域分析	9-10	2	课上实验+课后报告（共6个实验课时）
反馈控制系统设计	串联校正网络，根轨迹法设计超前、滞后补偿器，波特图设计超前、滞后补偿器。利用积分型校正网络设计反馈控制系统。	11-12	6	上课+作业
实验四	直流电机PID控制实验	11-12	2	课上实验+课后报告（共6个实验课时）
状态变量反馈系统设计	能控性和能观性，全状态观反馈设计，观测器设计，观测器和全状态的反馈控制的集成，最优控制系统，内模设计。	12-13	6	上课+作业

		14-15	0	无课堂教学，学生完成课程大作业
	大作业（新型倒立摆系统控制）展示与汇报	16	2	小组PPT展示
	答疑	16	2	

六、考核方式和成绩评定方法

平时考核（50%） 考核方式 平时作业40% 课程大作业10% 结业考核（50%） 考核方式 卷面考试（闭卷）50% 平时作业配合上课进度，内容多样化，要求学生必须在规定时限内独立完成。大作业将以解决实际问题为目的，以一个符合工程实际的自适应控制问题形式呈现，要求学生组队完成从系统建模到控制器设计再到系统性能分析的一系列工作，最后将工作以书面报告和口头汇报两种形式展现。期末考试将以半闭卷形式，要求学生在规定时限内独立完成卷面问题。

七、教材和参考书目

(一)、推荐教材

(二)、参考书目

书名	作者	译者	出版社	出版年月	ISBN	版次
Modern Control System	Richard Dorf; Robert Bishop				978-0-13-440762-3	13
Control Systems Engineering	Norman S. Nice				978-1118963579	5v 7
《自动控制						

原理基础教程》	胡寿松编	科学出版社	2013	9787030370587	
Modern Control Engineering	Katsuhiko Ogata			v	v5
《自动控制原理》	李友善编著	国防工业出版社	2010	9787118036923	

八、学术诚信教育

九、其他说明(可选)

《Introduction to Control》 Syllabus

1.Basic course information

course name	Introduction to Control	course code	EE160
Course Level	Undergraduate	Credit/Contact Hour:	4/64
Major:	,	Teaching Language	English
Prerequisite	NULL	Prerequisite suggestion	Mathematical Analysis II,Linear Algebra
School/Institute	School of Information Science and Technology	Instructor	wangyang

2.Course Introduction

The course “Introduction to Control” provides an overview of control systems. The first part of the course focuses on the basic intuition and model-free control learning. You will learn how to regulate basic single-input-single-output system with PID controllers. The second part of the course introduces all students to linear differential equations systems and modeling of basic electrical and mechanical control systems. The course covers both basic control theory including stability analysis of open-loop and closed-loop systems as well as state-space analysis method using the concepts of observability and controllability. Outdated frequency space analysis methods (such as Bode diagrams) will not be covered, but Fourier transforms will be introduced in order to understand the physics of noise and resonance and how to amplify or damp it. Moreover, all students will learn how to use Matlab to simulate and design control systems. Active participation in numerous smaller and bigger programming projects is required. The course is highly recommended for all students in the field of engineering, mathematics, physics, and computer science, who want to develop a basic understanding of control. The course is mandatory for everyone who wants to work in electrical or electronic engineering, circuit design, robotics, signal processing, network algorithms, and optimal control.

3.Learning Goal

Cognitive competence： §Learn the process of modeling linear time-invariant (LTI) dynamical syst ems for engineering applications. Be able to classify control systems by their configuration and basic features. §Learn to derive the mathematical model of common dynamic systems, obtain the transfer f unction and state space representation of a system from its mathematical model §Understand the char acteristics of plant model qualitatively and quantitatively, both in the transient and steady-state regim es, and appreciate how it impacts the performance behavior of real systems. §Evaluate stability, contr ollability of a dynamic system. Understand the relationship between closed loop poles and system pe rformance. §Learn how to design PID and LQR feedback controller systems meeting specific system performance requirements. Comprehensive qualities, §Improve the critical thinking ability in terms o f systematic design §Improve the individual and teamwork ability §Be able to communicate technica l issues with both control experts and laymen §Be able to contribute to creative process of controller design

4.Instructional Pedagogy

The course will be given via lectures along with Q&A sessions and experiments. Students will learn how to use the knowledge to solve practical problem via homework and a course project. Homework is required to be completed independently, TAs will organization a few tutorial after each homework. The course project is usually done in a teamwork form. Students are asked to submit a formal report and a 15-mins oral presentation to demonstrate how they solve a practical control design problem.

5. Course Content and Schedule

Course Structure by Chapter

This course has a total of 64 class hours, including 56 class hours of theoretical courses and 8 class hours of experimental courses (4 experiments in total). The specific teaching content and arrangement are listed as follows:

Chapter	Teaching Contents	Week	Contact Hours	Teaching Modes
Introduction to Control Systems	The brief history of classic control. Introduction of the general approach to design a control system.	1	2	Lecture
System Modeling	The basic concepts of mathematical modeling of physical systems, including transfer function and state-space model.	1-2	4	Lecture and homework

System Modeling	Signal-flow graph and block diagram models. the relationship between block diagram and signal-flow graph. Time response.	2-3	4	Lecture and homework
Experiment 1	Introduction to MATLAB and Simulink, guidance on oscilloscopes.	3-4	6	Classroom experiment
Feedback Control System Characteristics	Typical input signals of control systems, the performance indexes for time response and transient response of LTI systems. Transient response of the first order system and second order system (relationship between transient response and poles, equation and calculation of the performance indexes). Transient response of high order system (dominant poles and dipoles).	5	4	Lecture and homework
The Stability of Linear Feedback Systems	The stability of linear feedback systems (the concept of stability, the Routh-Hurwitz stability criterion, and its applications). The steady-state performance analysis of control systems.	5-6	2	Lecture and homework
Experiment 2	Dynamic performance and stability analysis of typical modes.	6-7	8	Classroom experiment

The Root Locus Method	The basic concepts of root locus. Parameter design by root locus method. PID control and Ziegler-Nichols tuning methods.	7-8	2	Lecture and homework
Frequency domain analysis	The concept of frequency response and frequency response measurement. Performance specifications in the frequency domain. Bode diagram. System bandwidth.	8-10	12	Lecture and homework
Experiment 3	Frequency domain analysis of typical modes.	9-10	2	Classroom experiment
The Design of Feedback Control Systems	Cascade compensation networks, phase-lead and -lag design using the root locus, bode diagram. System Design Using Integration Compensators.	11-12	6	Lecture and homework
Experiment 4	Control of an inverted pendulum system.	11-12	2	Classroom Experiment
The Design of State Variable Feedback Systems	Controllability and observability, full-state feedback control, observer design, integrated full-state feedback and observer, basic optimal control systems.	12-13	6	Lecture and homework

		14-15		No lecture, students doing course project homework
	Course project presentation,	16	2	Oral presentation
	review, Q&A.	16	2	

6.Grading Policy

Homework: 50 %, Final Exam: 50 %

7. Textbook & Recommended Reading

(1) Textbook

(2) Recommended Reading

book name	author	translator	press	publication time	ISBN	edition
Modern Control System	Richard Dorf; Robert Bishop				978-0-13-440762-3	13
Control Systems Engineering	Norman S. Nice				978-1118963579	5v 7
《自动控制原理基础教程》	胡寿松编		科学出版社	2013	9787030370587	
Modern Control Engineering	Katsuhiko Ogata				v	v5
《自动控制原理》	李友善编著		国防工业出版社	2010	9787118036923	

8.Academic Integrity

This course highly values academic integrity. Behaviors such as plagiarism and cheating are strictly prohibited. Please list more if you have more specific requirements.

9.Other Information (Optional)