

课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	课程名称 Course Title	测试与检测技术基础 Fundamentals of Measurement Technology
2.	授课院系 Originating Department	机械与能源工程系 Department of Mechanical and Energy Engineering
3.	课程编号 Course Code	ME310
4.	课程学分 Credit Value	3
5.	课程类别 Course Type	专业选修课 Major Elective Courses
6.	授课学期 Semester	春季 Spring
7.	授课语言 Teaching Language	中英双语 English & Chinese
8.	授课教师、所属学系、联系方式 (如属团队授课, 请列明其他授课教师) Instructor(s), Affiliation & Contact (For team teaching, please list all instructors)	融亦鸣、黄业绪 机械与能源工程系 Department of Mechanical and Energy Engineering rongym@sustc.edu.cn huangyx3@sustc.edu.cn
9.	实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact	无 NA
10.	选课人数限额(可不填) Maximum Enrolment (Optional)	

11. 授课方式 Delivery Method	讲授	习题/辅导/讨论	实验/实习	其它(请具体注明)	总学时
	Lectures	Tutorials	Lab/Practical	Other (Please specify)	Total
学时数 Credit Hours	48	0	0	0	48
12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	ME307 控制工程基础 Fundamentals of Control Engineering EE205 信号和系统 Signals and Systems				
13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite	无 NA				
14. 其它要求修读本课程的学系 Cross-listing Dept.	电子与电气工程系 Department of Electrical and Electronic Engineering				

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

本课程主要讲授测试技术的基本原理、方法与应用，包括测试数据处理与误差分析、测试系统特性分析、传感器的工作原理、传感器设计计算及制造流程、信号获取与处理方法；各种物理量的测试及实验系统设计。

The course is intended to provide the students with adequate knowledge on principles and methods of measurement technology, including signal theories and signal processing, test data processing and error analysis, characteristic analysis of measurement system, principles for various sensors and transducers design calculation and manufacturing process, signal acquisition and processing method, measuring techniques for various physical quantities and experimental system design.

16. 预达学习成果 Learning Outcomes

本课程为仪器仪表类和机械电子及控制类专业重要的专业基础课程。通过本课程的学习，将使學生掌握测试与检测系统的组成及基本原理；测试与检测中所获数据及信号的分析与处理方法。通过传感器工作原理的学习，使學生掌握传感器设计的计算方法，了解其制造过程，掌握部分传感器信号的处理方法，以期获得较为准确的信号。完成本课程的学习后，使學生掌握常见物理量的测试与检测方法及实验设计，了解并提高解决不同物理量的测试技能，最终会根据实际要求搭建一个真正的测试系统。

This course is an important professional basic course for instrumentation and mechanical and control professionals. After completing this course, the students should know well the basic concepts and principles of measurement and test system. Through the learning of the working principle of the sensor, students are able to grasp the calculation method of the sensor design, understand their manufacturing process, and grasp the processing method of the signal of the sensor in order to obtain a more accurate signal. After completion of this course, students will be able to understand the common physical quantity measurement and test methods and experimental design, understand and improve the test skills of different physical quantities, and build an actual test system according to the actual requirements.

17. 课程内容及教学日历（如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）

Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

课程内容 (Course Contents)	教学要求 (Teaching Demands)	学时分配 (Credit Hours)
第一章 绪论 <ul style="list-style-type: none"> 测试的基本概念 测试系统的基本组成 	掌握测试、测量、检测的基本概念和测试系统的基本组成，了解测试技术的发展和检测量的国际单位	2

<ul style="list-style-type: none"> 测试系统实例 检测技术的发展方向 标准及其单位 <p>Chapter 1 Introduction</p> <ul style="list-style-type: none"> The concept of test and measurement The basic form of the test system Examples of test system The development direction of measurement Standards and Units 	<p>Understand the basic concepts of testing, measurement and detection;</p> <p>Understand the basic form of the testing system;</p> <p>Understand the development direction of testing technology and the unit of measuring parameter;</p>	
<p>第二章 传感器的静态特性及测试数据处理</p> <ul style="list-style-type: none"> 传感器的定义、组成、分类 传感技术的发展方向、国内外研究现状 传感器的静态输出曲线拟合方法 <p>Chapter 2 Sensor Static characteristics and test data processing</p> <ul style="list-style-type: none"> Definition, composition and classification of sensors The development direction of sensing technology and the research status Sensor static output curve fitting method 	<p>掌握传感器的定义、组成、分类,了解传感技术的发展方向及研究现状,了解传感器的静态输出曲线拟合方法,重点掌握最小二乘法</p> <p>Understand the definition, composition and classification of sensors;</p> <p>Understand the development direction and research status of sensing technology;</p> <p>Understand the sensor static output curve fitting method;</p> <p>Emphasis understand the Least Squares Method;</p>	2
<p>传感器的静态特性指标</p> <ul style="list-style-type: none"> 线性度 灵敏度 分辨率 迟滞 漂移 重复性 稳定性 <p>Static performance indicators of sensors</p> <ul style="list-style-type: none"> linearity sensitivity resolution hysteresis drifting repeatability stability 	<p>掌握传感器的静态特性指标:线性度、灵敏度、分辨率、迟滞、漂移、重复性、稳定性等的定义、测试方法和数据处理方法</p> <p>Understand the definition, test method and data processing method of the sensor static characteristics:</p> <p>linearity, sensitivity, resolution, hysteresis, drifting, repeatability, stability.</p>	2
<p>测试数据处理</p> <ul style="list-style-type: none"> 测量误差分析与处理 测试仪器精度的选择原则 测量数据处理 <p>Measurement data processing</p> <ul style="list-style-type: none"> Measurement error analysis and processing The selection principle of the test instrument Measurement Data Handler 	<p>了解各种误差的定义、产生机理和消除办法</p> <p>了解测试仪器的选用原则</p> <p>掌握测量数据的处理办法</p> <p>Understand the definition, mechanism and elimination method of errors</p> <p>Understand the selection principle of test instrument</p> <p>Understand the processing method of measurement data</p>	2
<p>第三章 测试系统和传感器的动态特性分析</p> <p>测试系统和传感器的传递函数和时域响应特性</p> <ul style="list-style-type: none"> 系统的传递函数 一阶系统的时域响应特性 二阶系统的时域响应特性 <p>Chapter 3 Dynamic Characteristic Analysis of test systems and sensor</p> <p>The transfer function and time-domain response characteristics of the system and sensor</p>	<p>掌握传递函数的求法;</p> <p>掌握一阶系统时间常数的求法;</p> <p>掌握二阶系统上升时间、峰值时间、调节时间、超调量、阻尼比、固有频率的定义和计算方法</p> <p>Understand the definition and calculation of transfer function</p> <p>Understand the calculation method of time constant of first-order system</p> <p>Understand the definition and calculation</p>	2

<ul style="list-style-type: none"> The transfer function of the system The time-domain response characteristics of first-order systems The time-domain response characteristics of second-order systems 	<p>method of the rise time, peak time, settling time, overshoot, damping ratio and natural frequency of the second-order system</p>	
<p>测试系统和传感器的频域响应特性</p> <ul style="list-style-type: none"> 零阶系统的频域响应特性 一阶系统的频域响应特性 二阶系统的频域响应特性 二阶系统的频率响应特性指标 <p>The transfer function and frequency domain response characteristics of the system and sensor</p> <ul style="list-style-type: none"> Frequency response characteristics of zero - order systems The frequency -domain response characteristics of first-order systems The frequency -domain response characteristics of second-order systems <p>测试环节的串联、并联和反馈</p> <p>The Series, parallel and feedback of test systems</p>	<p>会求零阶系统、一阶系统、二阶系统的频率响应； 掌握零阶系统、一阶系统、二阶系统 Bode 图的画法； 会计算系统的转折频率； 掌握时间常数、系统带宽、阻尼比、固有频率的计算方法</p> <p>Understand the definition and calculation of frequency -domain response characteristics Understanding the Bode diagram drawing Understand the calculation method of the break frequency Understand the calculation method of the time constant, system bandwidth, damping ratio, natural frequency Understand how the test links are connected</p>	4
<p>传感器的标定和校准</p> <ul style="list-style-type: none"> 标定和校准的定义 标定的标准条件 标定仪器的选用原则 标定方法的设计 标定数据的处理方法 <p>Sensor testing and calibration</p> <ul style="list-style-type: none"> definitions of testing verification and calibration Standard conditions for testing Selection principle of test instrument Calibration method of design Test data processing method 	<p>理解标定和校准的含义和区别，熟悉标定的标准条件和仪器的选用原则，会设计标定方法，会熟练利用标定数据计算稳定性、重复性、综合误差、阻尼比、固有频率等指标</p> <p>Understand the meaning and difference of testing verification and calibration, Understanding the standard conditions of calibration and the selection principles of instruments, Understanding design the calibration method, and Understanding in using the test data to calculate such as stability, repeatability, comprehensive error, damping ratio and natural frequency</p>	2
<p>第 4 章 单参数的检测及获取-角度传感器 角度及角位移的测量和检测</p> <ul style="list-style-type: none"> 直接测量 间接测量 角度传感器的分类及特点 角度传感器的常用指标要求 微动同步器的工作原理 微动同步器的设计 <p>Chapter 4 One parameter measurement and Detection</p> <p>Angle and angular displacement Detection</p> <ul style="list-style-type: none"> Measurement Detection The category of Angle sensor The performance index for Angle sensors The operating principle of microsyn The design of microsyn 	<p>了解角度的直接测量方法，了解角度传感器的类型，熟悉微动同步器的工作原理，掌握微动同步器的设计计算方法</p> <p>Understand the direct measurement method of Angle, understand the type of Angle sensor, Understanding the operating principle of microsyn, Understanding the design and calculation method of microsyn</p>	2

<p>微动同步器的制造流程和测试</p> <ul style="list-style-type: none"> • 制造流程 • 测试大纲和规范的制定 • 测试和标定 <p>Manufacturing process and testing of microsyn</p> <ul style="list-style-type: none"> • Manufacturing process of microsyn • Testing and calibration of microsyn 	<p>了解同步器的制造流程，会编写测试大纲和测试规范</p> <p>Understand the manufacturing process of microsyn, can write test outline and test specification of microsyn</p>	2
<p>动圈式角度传感器</p> <ul style="list-style-type: none"> • 工作原理 • 设计计算 • 制造流程 • 测试和标定 <p>Moving coil Angle sensor</p> <ul style="list-style-type: none"> • The operating principle of moving coil Angle sensor • The design of moving coil Angle sensor • Manufacturing process of moving coil Angle sensor • Testing and calibration of moving coil Angle sensor 	<p>了解动圈式角度传感器的制造流程，熟悉其工作原理，掌握其设计计算，会编写测试大纲</p> <p>Understanding the operating principle of moving coil Angle sensor, Understanding the design and calculation method of moving coil Angle sensor, Understand the manufacturing process of moving coil Angle sensor, can write test outline of moving coil Angle sensor</p>	2
<ul style="list-style-type: none"> • 微动同步器与动圈式角度传感器的对比分析 • 其它类型角度传感器介绍 • 角度传感器零位信号分析 • 角度传感器输出信号对干扰的处理 • Comparison and analysis of microsyn and moving coil Angle sensor • Other types of Angle sensors are introduced • Analysis of zero signal of Angle sensor • Angle sensor output signal processing 	<p>了解各角度传感器的异同点，了解角度传感器零位信号的各分量。掌握角度传感器输出信号的处理方法。</p> <p>Understand the similarities and differences of the Angle sensor Understand the components of the zero signal of the Angle sensor. Understand the processing method of Angle sensor output signal.</p>	2
<p>第4章 单参数的检测及获取-力矩器</p> <ul style="list-style-type: none"> • 力矩器简介 • 力矩器的工作原理 • 磁路基本知识简介 • 力矩器的设计 • 力矩器的制造流程 <p>Chapter 4 One parameter measurement and Detection</p> <p>Torque Detection</p> <ul style="list-style-type: none"> • Introduction to torquer • The operating principle of torquer • Introduction to basic knowledge of magnetic circuit • The design of torquer • Manufacturing process of torquer 	<p>了解力矩器的概念和制造流程，掌握力矩器的工作原理和设计方法</p> <p>Understand the concept and manufacturing process of torquer Understand the working principle and design method of torquer</p>	2
<p>第4章 单参数的检测及获取-转速检测</p> <ul style="list-style-type: none"> • 电机转速检测原理 • 电机转速检测设计 • 转速检测信号处理 • 转速检测器制造流程 • 光电编码器工作原理 • 机床主轴转速检测 <p>Chapter 4 One parameter measurement and Detection</p>	<p>了解光电编码器的工作原理和机床主轴转速检测的原理，掌握电机转速检测的原理和设计方法及信号处理</p> <p>Understand the working principle of photoelectric encoder and the principle of machine spindle rotate speed detection Understand the principle and design method of motor rotate speed detection and signal processing</p>	2

<p>Rotate speed measurement and Detection</p> <ul style="list-style-type: none"> • Introduction to Rotate speed measurement of motor • The design of Rotate speed measurement • Rotate speed detection signal processing • Manufacturing process of Speed detector • Photoelectric encoder working principle • Machine spindle speed detection 		
<p>第4章 单参数的检测及获取-位移检测</p> <ul style="list-style-type: none"> • 电容传感器的类型 • 电容传感器的工作原理 • 电容传感器的信号处理 • 位移检测原理 <p>Chapter 4 One parameter measurement and Detection</p> <p>Displacement detection</p> <ul style="list-style-type: none"> • Introduction to type of capacitance sensor • The operating principle of capacitance sensors • Signal processing of capacitance sensors • Introduction to displacement detection method 	<p>了解电容传感器的类型, 掌握电容传感器的工作原理和信号处理, 掌握常用的位移检测方法</p> <p>Understand the types of capacitance sensors</p> <p>Understand the working principle and signal processing of capacitance sensor</p> <p>Understand common displacement detection methods</p>	2
<p>第5章 多参数的检测及获取 角速率检测系统</p> <ul style="list-style-type: none"> • 基于牛顿力学的角速度检测 • 速率传感器的种类及运动方程 • 速率传感器的工作原理 • 速率传感器的设计 • 速率测试系统的动态特性优化 <p>Chapter 5 Multi-parameter measurement and Detection</p> <p>Angular velocity detection system</p> <ul style="list-style-type: none"> • Angular velocity detection based on Newtonian mechanics • The category of Angular velocity sensor and Equations of motion • The operating principle of Angular velocity sensor • The design of Angular velocity sensor • The Dynamic performance optimization of Rate test system 	<p>了解各种速率传感器的运动方程, 掌握速率传感器的工作原理和信号处理及设计, 掌握速率测试系统的设计方法及性能优化</p> <p>Understand the motion equations of various rate sensors</p> <p>Understand the working principle, signal processing and design of rate sensor</p> <p>Understand the design method and performance optimization of rate test system</p>	4
<ul style="list-style-type: none"> • 基于萨格奈克效应的角速度检测 • 光纤速率传感器的工作原理 • 光纤速率传感器的设计和制造流程 • 速率传感器的评价指标 • 速率传感器的测试 • Angular velocity detection based on Sagnac effect • The operating principle of Optical fiber Angular velocity sensor • The Design and manufacturing processes of Optical fiber Angular 	<p>了解各种速率传感器的指标要求和制造流程, 掌握光纤速率传感器的工作原理和信号处理及设计, 掌握速率测试系统测试规范的制定</p> <p>Understand the performance index and manufacturing process of various rate sensors</p> <p>Understand the working principle, signal processing and design of Optical fiber Angular velocity sensor</p> <p>Understand the formulation of test specification for rate test system</p>	4

<ul style="list-style-type: none"> velocity sensor The Performance index of Angular velocity sensor Rate sensor testing 		
<p>第5章 多参数的检测及获取 加速度检测系统</p> <ul style="list-style-type: none"> 加速度计的工作原理 MEMS 加速度计的测试 <p>Chapter 5 Multi-parameter measurement and Detection Acceleration detection system</p> <ul style="list-style-type: none"> The operating principle of accelerometer MEMS accelerometer testing 	<p>了解加速度计的指标要求，掌握加速度计的工作原理和信号处理及设计，掌握加速度计测试规范的制定</p> <p>Understand the performance index of accelerometer Understand the working principle, signal processing and design of accelerometer Understand the formulation of test specification for accelerometer</p>	2
<p>第5章 多参数的检测及获取</p> <ul style="list-style-type: none"> 姿态组合测量系统 惯性测量单元(IMU)设计 IMU 冗余设计 IMU 中传感器的选用原则 <p>Chapter 5 Multi-parameter measurement and Detection</p> <ul style="list-style-type: none"> Attitude measurement system The Design of IMU(Inertial measurement unit) The Redundancy design of IMU Selection principles of sensors using IMU 	<p>了解姿态的测量，掌握 IMU 的设计，了解冗余的概念</p> <p>Understand the attitude measurement Understand the design of IMU Understand the concept of redundancy</p>	2
<p>第六章 自动测试系统设计</p> <ul style="list-style-type: none"> 陷波滤波器的运用 自动测试系统的组成 自动测试系统的接口 <p>Chapter 6 Automatic test system design</p> <ul style="list-style-type: none"> The application of notch filter The composition of automatic test system The interface of automatic test system 	<p>了解自动测试系统的组成和接口关系，掌握滤波器的使用</p> <p>Understand the composition and interface form of the automated test system Understand the techniques for using filters</p>	2
<p>第六章 自动测试系统设计</p> <ul style="list-style-type: none"> 模拟量自动测试系统设计实例 数字量自动测试系统设计实例 <p>Chapter 6 Automatic test system design</p> <ul style="list-style-type: none"> Automatic Test system design for analog quantity Automatic Test system design for digital quantity 	<p>能设计简单的自动测试系统</p> <p>Understand and design simple automatic test system</p>	4

18. 教材及其它参考资料 Textbook and Supplementary Readings

教材:
《传感器与检测技术》(第4版), 徐科军 等编, 电子工业出版社(2016)

参考资料:

1. 《传感器与检测技术》(Sensor and Detection Technology)(第3版), 胡向东 等编, 机械工业出版社(2018).
2. 《检测技术》(第4版), 施文康, 余晓芬 编, 机械工业出版社(2015).
3. 《干涉型光纤传感用光电子器件技术》, 王巍, 丁东发, 夏君磊著, 科学出版社(2014).

课程评估 ASSESSMENT

19. 评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance		10%		
课堂表现 Class Performance		10%		
小测验 Quiz				
课程项目 Projects				
平时作业 Assignments		20%		
期中考试 Mid-Term Test				
期末考试 Final Exam				
期末报告 Final Presentation		60%		
其它（可根据需要 改写以上评估方式） Others (The above may be modified as necessary)				

20. 记分方式 GRADING SYSTEM

- A. 十三级等级制 Letter Grading
 B. 二级记分制（通过/不通过） Pass/Fail Grading

课程审批 REVIEW AND APPROVAL

21. 本课程设置已经过以下责任人/委员会审议通过
 This Course has been approved by the following person or committee of authority