SDM271 系统建模与仿真课程大纲

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南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

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	系统建模与仿真 System Modeling and Simulation
2.	授课院系 Originating Department	系统设计与智能制造学院 School of System Design and Intelligent Manufacturing (SDIM)
3.	课程编号 Course Code	SDM271
4.	课程学分 Credit Value	3
5.	课程类别 Course Type	专业核心课 Major Core 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）	陈亮名　副教授 chenlm6@sustech.edu.cn 系统设计与智能制造学院 CHEN Liangming　Associate Professor chenlm6@sustech.edu.cn School of System Design and Intelligent Manufacturing (SDIM)
9.	实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact	待公布 To be announced
10.	选课人数限额(可不填) Maximum Enrolment （Optional）	

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11. 授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other（Please specify）	总学时 Total
学时数 Credit Hours	32		32		64

12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	EE207 工程数学 EE207 Engineering Mathematics
13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite	无
14. 其它要求修读本课程的学系 Cross-listing Dept.	无

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

系统建模与仿真是自动化专业的一门核心课程，可为学生提供强有力的理论与实践工具来研究系统问题，在培养学生系统性思维和建模仿真分析能力等方面具有重要作用。

本课程主要讲授系统建模、辨识与仿真的概念、方法及工具，使学生了解和掌握系统建模辨识方法与仿真方法，能够通过基于机理的建模、基于实验数据的建模、基于机理与实验数据相结合的建模等方法建立典型系统的模型，掌握基本的系统辨识方法，进一步了解并能运用系统建模与仿真的常用工具，进行系统仿真实验；通过课堂教学和上机实验等环节，培养学生的创新意识、分析问题的能力以及建模仿真知识的应用能力，培养学生运用数学模型和仿真软件工具模拟、分析和解决工程领域中实际问题的能力。

System Modeling and Simulation (M&S) is a core course of automation major, which can provide students with powerful theoretical and practical tools to study system and plays an important role in cultivating students' systematic thinking and M&S analysis ability.

This course will cover the concept of system modeling, identification and simulation, their methods, and tools. The objective is to make the students understand the system M&S methods, establish a typical system model based on the mechanism modeling, experimental data, or hybrid methods, and further be able to use the common tools of system M&S to conduct system simulation experiments. Through classroom teaching and computer experiments, the course will cultivate students' innovative consciousness, the application ability of M&S knowledge, and the ability to analyze and solve practical problems in the field of engineering by using mathematical models and simulation software tools.

16. 预达学习成果 Learning Outcomes

学生完成本课程的学习后，应能够获得如下学习成果：

1. 观念与思维方式：
   通过对系统建模与仿真课程的学习，使学生掌握系统的分类以及黑箱、白箱和灰箱系统建模方法的区别， 了解三类不同系统各自的方法论，包括白箱系统的还原论、黑箱系统辨识法和灰箱法。
2. 知识与过程：
   通过对案例的学习，掌握建模的基本过程，掌握连续系统和离散系统的概念和特点，掌握连续和离散两类系统建模各自的知识框架的特征，掌握简单连续系统的建模方法，掌握简单离散系统的建模特征。了解模型验 证的基本模式。理解物理仿真、数学仿真和混合仿真之间的区别与联系。
3. 技能与实践：
   掌握数学仿真工具 MATLAB 的基本使用方法，包括 MATLAB 矩阵定义与操作方法、多项式的操作方法、各类方程的解法、符号运算、二维与三维绘图、简单程序设计、简单图形界面设计、Simulink 仿真初步等，并学习对案例的

模型进行仿真。

After this course, students should be able to obtain:

1. Concept and way of thinking
   Through the study of system M&S, students can master the classification of systems and the difference of black-box, white-box and grey-box system modelling methods, and understand the methodology of three different systems, including the reductionism of white-box system, black-box system identification method and grey-box method.
2. Knowledge and procedure
   By studying the M&S cases, students can master the basic procedure of modelling, the concepts and characteristics of continuous system and discrete system, the characteristics of continuous and discrete system modelling, the modelling methods of simple continuous system and simple discrete system, understand the basic patterns of model verification, understand the differences and connections between physical simulation, mathematical simulation and hybrid simulation.
3. Skills and practices
   Master the basic usage of mathematical simulation tool MATLAB, including MATLAB matrix definition and operation, polynomial operation, solving various equations, symbolic operation, two-dimensional and three-dimensional drawing, simple program design, simple graphic interface design, Simulink simulation, and learn to simulate the case model, etc.

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.)

1. 绪论（2 学时）
   介绍控制系统建模与仿真的目的、意义以及最新的发展动态。系统概述，介绍系统的分类与各自建模的特点。
2. 仿真软件 Matlab/Simulink 介绍（4 学时）
   介绍 Matlab 矩阵、多项式、符号运算、绘图等操作以及 Simulink 使用要点.
3. 系统建模的过程与方法概述（6 课时）
   介绍系统建模的基本概念，介绍系统的分类与各自建模的特点，系统建模的一般过程概述，连续/离散系统的建模，同时结合实例讲述不同实际系统进行数学建模的基本方法及其优缺点，基于机理模型建模与实验建模法（频率特征法/系统辨识法）。
4. 基于系统辨识的建模方法（8 课时）
   介绍经典系统辨识方法（阶跃响应法、频率响应法、脉冲响应法）；介绍近代辨识方法（最小二乘辨识, 极大似然估计法）。
5. 经典的连续系统仿真建模方法学（4 课时）
   介绍连续系统离散化原理、龙格-库塔法、线性多步法等经典的连续系统建模和仿真方法。
6. 系统建模、仿真分析实例（4 课时）
   介绍综合建模法、模型验证步骤，并结合前面的建模和仿真技术的学习基础，结合实际控制系统几个实例（如基于 LQR 的一级倒立摆控制），在已知的控制器设计下，从数学建模、系统分析、控制系统仿真各个环节完整的给出控制系统建模与仿真流程，明晰一个完整的控制系统建模与仿真分析设计全过程。
7. 现代的系统建模方法：学习和进化模型，系统动力学模型（4 学时）
   简单介绍一些基于人工神经网络与遗传算法的系统建模方法，以及基于系统动力学模型与仿真技术。
8. 上机实验部分（32 学时）
   开设四个上机实验项目：Matlab/Simulink 基本操作，直流伺服系统，直线倒立摆，基于 Simulink 的半实物仿真。

1. Introduction (2 class hours)

This module intends to introduce the objective, the significance, and the latest development of control system M&S, as well as system overview, the concept of system classification and their modelling characteristics.

2. Introduction to simulation software Matlab/Simulink (4 class hours)
This module intends to provide the most basic concepts of high-performance computing used for modelling purposes. It also aims at teaching the basics of Matlab/Simulink which will be the programming language used for the quizzes in this course.

3. Overview of system modelling process and methods (6 class hours)
This module introduces the basic concepts of system modelling, the classification of systems and the properties of different modelling methods, general modelling of continuous/discrete systems, and uses some examples to introduce the basic methods of mathematical modelling (based on mechanism model modelling and experimental modelling, frequency response method/system identification method) for different practical systems.

4. Modelling method based on system identification (8 class hours)
This module introduces classical system identification methods (e.g., step response method, frequency response method, impulse response method), and some modern identification methods (e.g., least square identification, maximum likelihood estimation).

5. Classical continuous system simulation modelling methodology (4 class hours)
This module introduces the continuous system discretization principle, Runge-Kutta method, linear multi-step method and other classical continuous system modelling methods.

6. System modelling and simulation analysis examples (4 class hours)
This module introduces the integrated modelling method, model validation steps, and combined with the previous study of M&S technology and some practical control system case (single inverted pendulum based on LQR control), describe each step of control system M&S (from the mathematical modelling, system analysis, to control system simulation), and establish a complete picture of control system M&S analysis design process.

7. Modern systems modelling methods: Learning and Evolution Models, System Dynamics Models (4 class hours)
This module introduces some modern system modelling method (e.g., based on artificial neural network and genetic algorithm, based on system dynamics model).

8. Experimentation (32 class hours)
There are four experimental projects: Matlab/Simulink basic operation, DC servo system, linear inverted pendulum, and Simulink simulation with practical platforms

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

张晓华. 系统建模与仿真（第二版）. 清华大学出版社. 2015 年
刘思峰. 系统建模与仿真.科学出版社.2019 年
肖田元. 连续系统建模与仿真. 电子工业出版社. 2010 年.
李言俊、张科. 系统辨识理论及应用. 国防工业出版社. 2002 年.
薛定宇. 基于 MATLAB\Simulink 的系统仿真技术与应用. 清华大学出版社. 2011 年.
Richard C. Dorf.(谢红卫译).现代控制系统. 电子工业出版社. 2010.

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				
课堂表现				

Class Performance				
小测验 Quiz				
课程项目 Projects		30		
平时作业 Assignments		10		
期中考试 Mid-Term Test				
期末考试 Final Exam		60		
期末报告 Final Presentation				
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

SUSTech Southern University of Science and Technology

课程详述

COURSE SPECIFICATION

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1.	**课程名称 Course Title**	系统建模与仿真 System Modelling and Simulation
2.	**授课院系** **Originating Department**	系统设计与智能制造学院 School of System Design and Intelligent Manufacturing (SDIM)
3.	**课程编号** **Course Code**	SDM271
4.	**课程学分 Credit Value**	3
5.	**课程类别** **Course Type**	专业核心课 Major Core 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）**	陈亮名　副教授 chenlm6@sustech.edu.cn 系统设计与智能制造学院 CHEN Liangming　Associate Professor chenlm6@sustech.edu.cn School of System Design and Intelligent Manufacturing (SDIM)
9.	**实验员/助教、所属学系、联系方式** **Tutor/TA(s), Contact**	待公布　To be announced
10.	**选课人数限额(可不填)** **Maximum Enrolment（Optional）**	

SUSTech Southern University of Science and Technology

11.	授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other（Please specify）	总学时 Total
	学时数 Credit Hours	32		32		64

12.	先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	SDM246 信号与线性系统分析，PHY106 大学物理（下），EE104 电路基础 SDM246 Signals and Linear System Analysis, PHY106 College Physics II, EE104 Fundamentals of Electric Circuits
13.	后续课程、其它学习规划 Courses for which this course is a pre-requisite	无
14.	其它要求修读本课程的学系 Cross-listing Dept.	无

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

系统建模与仿真是自动化专业的一门核心课程，可为学生提供强有力的理论与实践工具来研究系统问题，在培养学生系统性思维和建模仿真分析能力等方面具有重要作用。

本课程主要讲授系统建模、辨识与仿真的概念、方法及工具，使学生了解和掌握系统建模辨识方法与仿真方法，能够通过基于机理的建模、基于实验数据的建模、基于机理与实验数据相结合的建模等方法建立典型系统的模型，掌握基本的系统辨识方法，进一步了解并能运用系统建模与仿真的常用工具，进行系统仿真实验；通过课堂教学和上机实验等环节，培养学生的创新意识、分析问题的能力以及建模仿真知识的应用能力，培养学生运用数学模型和仿真软件工具模拟、分析和解决工程领域中实际问题的能力。

System Modeling and Simulation (M&S) is a core course of automation major, which can provide students with powerful theoretical and practical tools to study system and plays an important role in cultivating students' systematic thinking and M&S analysis ability.

This course will cover the concept of system modeling, identification and simulation, their methods, and tools. The objective is to make the students understand the system M&S methods, establish a typical system model based on the mechanism modeling, experimental data, or hybrid methods, and further be able to use the common tools of system M&S to conduct system simulation experiments. Through classroom teaching and computer experiments, the course will cultivate students' innovative consciousness, the application ability of M&S knowledge, and the ability to analyze and solve practical problems in the field of engineering by using mathematical models and simulation software tools.

16. 预达学习成果 Learning Outcomes

学生完成本课程的学习后，应能够获得如下学习成果：

1. 观念与思维方式：
   通过对系统建模与仿真课程的学习，使学生掌握系统的分类以及黑箱、白箱和灰箱系统建模方法的区别， 了解三类不同系统各自的方法论，包括白箱系统的还原论、黑箱系统辨识法和灰箱法。
2. 知识与过程：
   通过对案例的学习，掌握建模的基本过程，掌握连续系统和离散系统的概念和特点，掌握连续和离散两类系统建模各自的知识框架的特征，掌握简单连续系统的建模方法，掌握简单离散系统的建模特征。了解模型验 证的基本模式。理解物理仿真、数学仿真和混合仿真之间的区别与联系。
3. 技能与实践：
   掌握数学仿真工具 MATLAB 的基本使用方法，包括 MATLAB 矩阵定义与操作方法、多项式的操作方法、各类方程的解法、符号运算、二维与三维绘图、简单程序设计、简单图形界面设计、Simulink 仿真初步等，并学习对案例的

模型进行仿真。

After this course, students should be able to obtain:

1. Concept and way of thinking
   Through the study of system M&S, students can master the classification of systems and the difference of black-box, white-box and grey-box system modelling methods, and understand the methodology of three different systems, including the reductionism of white-box system, black-box system identification method and grey-box method.
2. Knowledge and procedure
   By studying the M&S cases, students can master the basic procedure of modelling, the concepts and characteristics of continuous system and discrete system, the characteristics of continuous and discrete system modelling, the modelling methods of simple continuous system and simple discrete system, understand the basic patterns of model verification, understand the differences and connections between physical simulation, mathematical simulation and hybrid simulation.
3. Skills and practices
   Master the basic usage of mathematical simulation tool MATLAB, including MATLAB matrix definition and operation, polynomial operation, solving various equations, symbolic operation, two-dimensional and three-dimensional drawing, simple program design, simple graphic interface design, Simulink simulation, and learn to simulate the case model, etc.

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.)

1. 绪论（2 学时）
   介绍系统、建模、仿真三个部分的基本概念，系统建模与仿真的目的、意义以及发展历史。
2. 系统模型介绍（2 学时）
   介绍系统的基本数学模型表示方法、建模的重要性及原则.
3. 系统建模方法（8 课时）
   介绍机理建模、数据建模、机理和数据结合下的建模方法。
4. 现代的系统建模方法：机器学习及模型等（2 学时）
   简单介绍一些基于人工神经网络等的系统建模方法。
5. 系统建模实例分析（4 课时）
   结合具体工程实例进行系统建模分析。
6. 经典的连续系统仿真方法（6 课时）
   介绍连续系统离散化原理、龙格-库塔法、线性多步法等经典的连续系统建模和仿真方法。
7. 虚拟样机技术及实物仿真技术（4 课时）
   介绍虚拟样机建模、半实物仿真、实物仿真等方法。
8. 系统建模、仿真分析实例（4 课时）
   介绍综合建模法、模型验证步骤，并结合前面的建模和仿真技术的学习基础，结合实际控制系统几个实例，在已知的控制器设计下，从数学建模、系统分析、控制系统仿真各个环节完整的给出系统的建模与仿真流程，明晰一个完整的系统的建模与仿真分析设计全过程。
9. 上机实验部分（32 学时）
   拟开设四个上机实验项目：Matlab/Simulink 基本操作，电机伺服系统，倒立摆，基于 Simulink 的半实物仿真。

（以上安排可能会根据具体教学进度进行局部调整）

1. Introduction (2 class hours)
   This module intends to introduce the basic concepts of system, modelling and control. Also, the objective, the

significance, and the development history of system modelling and control will be introduced.

2. Introduction to system models(2 class hours)
This module intends to provide the representation of system models, the importance of system modelling and the principles of system modelling.

3. System modelling methods (8 class hours)
This module introduces mechanistic modeling, data-based modeling, and modeling methods based on the combination of mechanism and data.

4. Modelling method based on modern machine learning approach (2 class hours)
This module briefly introduces some system modeling methods based on artificial neural networks.

5. Case Study of System Modeling (4 hours)
This module introduces some specific engineering examples, where the system modeling and analysis are carried out.

6. Classical continuous system simulation modelling methodology (6 class hours)
This module introduces the continuous system discretization principle, Runge-Kutta method, linear multi-step method and other classical continuous system modelling methods.

7. Virtual Prototyping Technology and Physical Simulation Technology (4 class hours)
This module introduces virtual prototype modeling, hardware-in-the-loop simulation, and physical simulation.

8. Examples of system modeling, simulation and analysis (4 class hours)
This module introduces the comprehensive modeling method and model verification steps, and combines the previous modeling and simulation technology, and gives the complete system modeling and simulation process from the aspects of mathematical modeling, system analysis and control system simulation under the known controller design, and clarifies the whole process of modeling, simulation analysis and design of a complete system.

9. Experimentation (32 class hours)
There are four experimental projects: Matlab/Simulink basic operation, DC servo motor, linear inverted pendulum, and Simulink simulation with practical platforms.

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

教材：张晓华. 系统建模与仿真（第二版）. 清华大学出版社. 2015 年
其它参考资料：
刘思峰. 系统建模与仿真.科学出版社.2019 年
肖田元. 连续系统建模与仿真. 电子工业出版社. 2010 年.
李言俊、张科. 系统辨识理论及应用. 国防工业出版社. 2002 年.
薛定宇. 基于 MATLAB\Simulink 的系统仿真技术与应用. 清华大学出版社. 2011 年.
Richard C. Dorf.(谢红卫译).现代控制系统. 电子工业出版社. 2010.

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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		8		理论课出勤+实验课出勤

课堂表现 Class Performance		10		理论课课堂表现+实验课实验完成情况
小测验 Quiz				
课程项目 Projects		16		理论课项目+实验课项目
平时作业 Assignments		16		理论课作业+实验课实验报告
期中考试 Mid-Term Test				
期末考试 Final Exam		50		
期末报告 Final Presentation				
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

SUSTech Southern University of Science and Technology