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**	微型计算机处理器设计 Microprocessor Design
2.	**授课院系** **Originating Department**	微电子学院 School of Microelectronics
3.	**课程编号** **Course Code**	SME309
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**	秋季 Fall
7.	**授课语言** **Teaching Language**	英文 English
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）**	林龙扬，助理教授，深港微电子学院 Longyang Lin, Assistant Professor, School of Microelectronics
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）**	

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	0	32		64

12.	先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	SME202 集成电路基础 II 或 EE202-17 数字电路 SME202 Fundamentals of Integrated Circuit II or EE202-17 Digital circuits
13.	后续课程、其它学习规划 Courses for which this course is a pre-requisite	本课程为微电子科学与工程专业核心课，主要包含计算机体系结构及硬件实现与应用。其它专业学生如果想学习相关知识也可选修本课程。 This course is the major core course for undergraduate students in Microelectronics, and it includes the basic computer architecture theory, embedded hardware implementation and application in microprocessors. It should however also be suitable for non-specialists, i.e. for all those students who show interests in microprocessor design to gain a certain amount of relevant knowledge.
14.	其它要求修读本课程的学系 Cross-listing Dept.	无 None

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

本课程旨在培养本科生在微电子芯片设计的兴趣与能力。本课程分为三个部分：1. 近现代计算机架构理论的学习；2. 了解计算机内部运作机制以及指令集运算；3. 通过对指令集的学习将理论模型进行硬件实现。

After the completion of this course, students should know the following items: (1) fundamentals of computer architecture; (2) mechanisms of instruction set in microprocessors; (3) hands-on implementation of an instruction set on actual hardware platforms.

16. 预达学习成果 Learning Outcomes

本课程是微电子专业的核心专业课，致力于让学生们了解微处理器芯片设计的基本原理和关键技术。本课程将深入介绍微处理器的架构、指令集、内存与接口等核心理论，培养学生的理论水平与相关问题的分析能力。本课程通过开设实现 ARM 架构微型处理器的实验课和课程项目，进一步培养学生在微处理器芯片设计的实际动手能力，学习如何利用硬件描述语言进行数字芯片设计，为学生今后从事芯片设计科研及开发工作打下良好的专业基础。

This course is a core course for students in Microelectronics majors. It focuses on the fundamentals and the key technologies in microprocessor design. The theories such as computer architecture, instruction set, memory and I/O interface will be well covered to help students develop a comprehensive understanding on microprocessor design. This course also includes lab sessions to implement the ARMv3 architecture microprocessor, aiming to sharpen students' practical ability in microprocessor chip design with hands-on experience of hardware description language, which finally lays a good professional foundation for students to engage in research and development of microprocessor and integrated circuit design in the future.

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.)

一、授课内容包括：

Week 1-2: 微处理器概述（Microprocessor Overview: History, Technology, Performance）

此部分内容包含三大部分，第一部分介绍微处理器发展历史，以及现阶段微处理器发展中所面临的技术挑战；第二部分通过介绍用于 CMOS VLSI 工艺以及该工艺如何促进了微处理器的发展。第三部分介绍如何衡量微处理器的性能。

This part consists of three sections:1. Introduction to the history , research hotspots and challenges of microprocessor; 2. Introduction to CMOS VLSI circuit process; 3. Introduction to the performance metrics of microprocessor.

Week 3-4: 数字系统介绍 (Introduction to Digital System Design)

本部分内容将介绍数字系统，设计数字系统时所面临的挑战，以及数字系统的具体设计方法。

This part will introduce digital system, the related design challenges, and systematic design methodology to implement digital systems.

Week 5-6: 单周期微处理器 (The Single Cycle Processor)

本部分内容通过介绍单周期微处理器让学生们了解微处理器架构，包含 ARM 架构介绍、ARMv3 指令集、数据路径、控制设计和指令集扩展。

This part will introduce the computer architecture based on the single cycle processor design, including ARM architecture overview, ARMv3 instruction encoding, datapath design, controller design and extensions for other instructions.

Week 7-8: 微处理器算术 (Computer Arithmetic)

本部分内容介绍微处理器算术基础，包括加法器、减法器、算术模块、移位器、乘法器、除法器、浮点运算等。

This part will introduce arithmetic modules in microprocessor, including adder, subtractor, ALU, shifter, multiplier, divider and floating point arithmetic.

Week 9: 期中考试 (Mid-term exam)

Week 10-11: 内存 (Memory)

此部分将介绍微处理器中内存的基础，包含内存的种类及工作原理、缓存的工作原理和内存的性能。

This part will introduce the basic principles of memory, including cache design, performance metrics, mapping techniques, replacement algorithms, and virtual memory technology.

Week 12-13: 流水线微处理器设计(The Pipelined Processor)

此部分将介绍微处理器流水线工作原理，设计考虑，设计方法，优势与缺点等。

This part will introduce pipelining in processors, including basic principles, design considerations, detail implementation, advantages and drawbacks.

Week 14-16: 多核处理器、接口基础和异常处理 (Multiprocessor Systems, IO Basics and Exception Handling)

此部分将介绍多核处理器系统，微处理器系统 I/O 的理论基础及工作原理，以及异常处理。

This part will introduce multiprocessor systems, basic I/O concepts, and exception handling.

二．实验内容与课程项目 (Lab Session and Project)：

实验主要目的是让学生熟悉微型处理器开发流程，包括利用硬件描述语言（如 Verilog）进行微型处理器设计，熟悉相应处理器体系架构（如 ARMv3 架构）的汇编语言以及硬件仿真环境，并且对所设计的微型处理器进行功能验证。实验具体安排如下：

This lab project will help students get the hands-on experience of microprocessor design, including the use of hardware description languages (e.g. Verilog) for actual microprocessor hardware design, being familiar with the assembly language of the corresponding computer architecture (e.g. ARMv3) and the hardware simulation environment for the functional verification of the designed microprocessor. The detail plan is as followed.

Week 1-5: 熟悉硬件描述语言及汇编语言 (Familiarization with HDL and Assembly Language)

此部分内容包含三大部分，第一部分介绍 Verilog HDL；第二部分介绍仿真软件的安装和使用；第三部分介绍汇编语言及编译器的使用。

This part contains three parts: the first part introduces Verilog HDL; the second part introduces the installation and use of HDL simulation software; the third part introduces assembly language and compiler.

Week 6-12: 简单微型处理器设计 (Implementation of an ARMv3 Processor)

学生将实现他们在课堂上学到的基础版 ARMv3 处理器，它应该支持以下指令：LDR，STR，AND，OR，ADD，SUB，B。此外，学生还需编写相应测试和验证代码以展示所编写的处理器的准确性。

Students will implement the basic ARMv3 processor they had learnt in lectures. Essentially, it should support the following instructions: LDR, STR, AND, OR, ADD, SUB, B. Also, students need to write the corresponding test benches to demonstrate the correctness of all functions.

Week 13-16: 乘法器及除法器模块设计 (Multiplication / Division units)

学生将设计乘法器和除法器模块，并将其加入到以上所设计的基础版 ARMv3 处理器里。同样，学生还需编写相应测试和验证代码以展示所有功能的准确性。

Students will design multiplier and divider modules and incorporate them into their microprocessor. Similarly,

students need to write the corresponding test benches to demonstrate the correctness of all functions.

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

参考资料 Computer architecture a quantitative approach [John L. Hennessy, David A. Patterson]

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		0		
课程项目 Projects		10		
平时作业 Assignments		20		
期中考试 Mid-Term Test		20		
期末考试 Final Exam		30		
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
