第 3 章

“数学与统计”课程群

3.1 “工科数学分析”课程大纲

课程名称：工科数学分析

Course：Mathematical Analysis for Engineering

先修课程：无

Prerequisites：None

学分：12

Credits：12

3.1.1 课程目的和基本内容(Course Objectives and Basic Content)

本课程是人工智能学院本科专业基础必修课。

This course is a basic compulsory course for undergraduates in College of Artificial Intelligence.

本课程介绍了极限、微分、积分、级数等重要的数学工具，并将分析、代数和几何内容进行了有机结合。相关的知识对包括人工智能专业在内的众多工科专业提供了不可或缺的高等数学基础，也使学生在数学的抽象性、逻辑性和严谨性等方面受到必要的熏陶和训练。为学生今后增进数学知识、学习人工智能的方法奠定良好的基础，培养学生应用数学知识进行数据分析和建模，以及解决实际问题的意识、兴趣和能力。

本课程的教学，要求学生系统地掌握一元函数微积分学、无穷级数、多元函数微积分学、常微分方程组的基本概念、基本理论和基本方法，同时通过数学实验培养学生的综合素质，即实验动手能力、分析设计能力及团队合作精神，拓展学生思维，激发学生的创新意识。对数学分析的基本思维方法进行必要的训练，逐步提高数学素养以及运算能力、抽象思维能力、逻辑推理能力、空间想象能力、学习能力、分析问题和解决问题

的能力，并对现代数学的某些思想方法有所了解，以利于与今后学习现代数学接轨。

This course introduces some important mathematical tools, such as limit, differential, integral and series, and organically combines analysis, algebra and geometry. Relevant knowledge in this course provides an indispensable foundation of advanced mathematics for AI majors and lots of other engineering majors. It lets students take necessary trainings in abstraction, logic and rigor of mathematics, and also lays a good foundation to absorb more mathematics knowledge and learn artificial intelligence in the future, and cultivates readers' awareness, interest and ability to apply mathematics knowledge to solve practical problems.

This course requires students to systematically master the basic concepts, basic theories and basic methods of calculus of unary functions, infinite series, multivariate function calculus, and ordinary differential equations. Meanwhile, the comprehensive quality of students can be cultivated through mathematical experiments. It can be called experimental hands-on ability, analysis design ability and teamwork spirit, and it can also expand student thinking and stimulate students' sense of innovation. Simultaneously, let students have some understanding of thinking methods of modern mathematics, so as to facilitate the future study of modern mathematics.

3.1.2　课程基本情况(Course Arrangements)

<table>
<tr><td>课程名称</td><td colspan="8">工科数学分析
Mathematical Analysis for Engineering</td><td rowspan="3">数学与统计</td><td rowspan="2">必修
(学分)</td><td>工科数学分析(12)</td></tr>
<tr><td rowspan="2">开课时间</td><td colspan="2">一年级</td><td colspan="2">二年级</td><td colspan="2">三年级</td><td colspan="2">四年级</td><td>线性代数与解析几何(4)</td></tr>
<tr><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td><td></td><td></td><td>计算机科学与人工智能的数学基础(6)
概率统计与随机过程(4)
复变函数与积分变换(3)
博弈论(2)</td></tr>
<tr><td>课程定位</td><td colspan="8">本科生“数学与统计”课程群必修课</td><td></td><td>选修
(学分)</td><td>/</td></tr>
<tr><td>学　　分</td><td colspan="8">12 学分</td><td colspan="3"></td></tr>
<tr><td>总 学 时</td><td colspan="8">216 学时
(授课 192 学时、实验 24 学时)</td><td colspan="3"></td></tr>
<tr><td>授课学时分配</td><td colspan="8">课堂讲授(190 学时)，小组讨论(2 学时)</td><td colspan="3"></td></tr>
<tr><td>先修课程</td><td colspan="11">无</td></tr>
<tr><td>后续课程</td><td colspan="11"></td></tr>
<tr><td>教学方式</td><td colspan="11">课堂教学、上机教学、课外学习</td></tr>
<tr><td>考核方式</td><td colspan="11">闭卷考试成绩占 80%，平时作业占 10%，数学实验成绩占 10%</td></tr>
</table>

续表

参考教材	王绵森,马知恩.工科数学分析基础[M].3版.北京:高等教育出版社,2017.
参考资料	李继成.数学实验[M].北京:高等教育出版社,2014.
其他信息	

3.1.3 教学目的和基本要求(Teaching Objectives and Basic Requirements)

(1) 系统掌握一元函数微积分、无穷级数、多元函数微积分、常微分方程组的基本概念、基本理论和基本方法;

(2) 训练数学分析的基本思维方法,提高运算能力、抽象思维能力、逻辑推理能力、空间想象能力,逐步提高数学素养、学习能力、分析问题和解决问题的能力;

(3) 了解现代数学的思想方法,以利于与今后学习现代数学接轨。

3.1.4 教学内容及安排(Syllabus and Arrangements)

第一章 映射、极限、连续(Mapping, Limit and Continuity)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
1.1	集合、映射与函数 Set, mapping and function	4	(1) 了解实数集的完备性及确界概念 (2) 理解映射与函数的概念 (1) Understand the completeness and concepts of supremum and infimum (2) Comprehend the concepts of mapping and function
1.2	数列的极限 Limit of sequence	6	(1) 理解数列极限的概念与性质 (2) 了解数列极限收敛性的判别准则 (3) 掌握数列极限的求解方法 (1) Comprehend the concepts and properties of the limit of sequence (2) Understand some criteria for existence of the limit of sequence (3) Master the solution to the limit of sequence

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
1.3	函数的极限 Limit of a function	3	(1) 理解函数极限的概念与性质 (2) 掌握两个重要极限 (3) 了解函数极限的存在准则 (4) 掌握函数极限的求解方法 (1) Comprehend the concepts and properties of functional limit (2) Master two important limits of function (3) Understand the existence criteria of function limit (4) Master the solution to the limit of function
1.4	无穷小量和无穷大量 Infinitesimal and infinite quantities	2	(1) 理解无穷小量与无穷大量的概念 (1) Comprehend the concepts of infinitesimal and infinite quantities
1.5	连续函数 Continuous function	8	(1) 理解连续函数的概念与性质 (2) 了解闭区间上连续函数的性质 (3) 了解一致连续的概念 (4) 了解压缩映射原理 (1) Comprehend properties and concepts of continuous function (2) Understand properties of continuous function on a closed interval (3) Understand continuity of elementary functions (4) Understand the principle of compression mapping

第二章　一元函数微分学及其应用(Unary Function Differential Calculus and Its Applications)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
2.1	导数概念 Concept of derivative	2	(1) 理解导数的概念 (1) Comprehend concept of derivative

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
2.2	求导的基本法则 Fundamental derivatives rules	4	(1) 掌握求导的基本法则 (1) Master fundamental derivatives rules
2.3	函数的微分 The differential of function	6	(1) 理解微分的概念 (2) 了解高阶微分的概念及微分在近似计算中的应用 (1) Comprehend concept of differential (2) Understand applications of the high-order differential in approximate computation
2.4	微分中值定理及其应用 The mean value theorem and its applications	2	(1) 理解微分中值定理 (2) 掌握洛必达法则求不定式的极限 (1) Comprehend the mean value theorem (2) Master L'Hospital's rule to solve the limit of infinitive
2.5	泰勒公式 Taylor formula	2	(1) 了解泰勒定理 (1) Understand Taylor's theorem
2.6	函数性质研究 Function properties study	6	(1) 掌握用导数研究函数单调性及极值的方法 (2) 理解函数极值的概念 (3) 掌握求函数的最大值与最小值的方法 (4) 了解函数凸性的概念 (1) Master the method of using the derivative to study the monotonicity and extremum of the function (2) Comprehend the concept of function extremum (3) Master the method of solving the maximum and minimum values of a function (4) Understand the concept of function convexity

第三章　一元函数积分学及其应用(Unary Function Integrals Calculus and Its Applications)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
3.1	定积分的概念与性质 Concept and properties of definite integral	3	(1) 理解定积分的概念与性质 (2) 了解定积分存在的条件 (1) Comprehend concept and properties of definite integral (2) Understand the conditions for integral exist
3.2	微积分基本公式与基本定理 Basic formulas for indefinite integral and basic theorems	5	(1) 理解不定积分的概念与性质 (2) 掌握微积分基本公式与基本定理 (1) Comprehend concept and properties of indefinite integral (2) Master basic formulas for indefinite integral and basic theorems
3.3	换元积分法与分部积分法 Integration by substitution and by parts in definite integral	7	(1) 掌握换元积分法与分部积分法 (1) Master integration by substitution and by parts in definite integral methods
3.4	定积分的应用 Applications of definite integrals systems	6	(1) 掌握建立积分表达式的微元法及用定积分去计算一些几何量(如面积、体积等)和一些物理量(如功、压力、引力和函数的平均值等)的方法 (1) Master the method of establishing the integral expression of the micro-element method and definite integral to calculate some geometric quantities (such as area, volume, etc.) and some physical quantities (such as work, pressure, gravity and the average value of the function, etc.)

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
3.5	反常积分 Improper integral	5	(1) 理解反常积分的概念 (2) 了解反常积分的审敛准则 (3) 了解 Γ 函数的概念 (1) Comprehend concept of improper integral (2) Understand the criteria for improper integral (3) Understand the concept of function Γ

第四章 微分方程(Differential Equations)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
4.1	微分方程的基本概念与可分离变量的微分方程 Basic concept of differential equation and separable equations	7	(1) 理解常微分方程与常微分方程组的基本概念及其相互关系 (2) 掌握变量可分离微分方程和一阶线性微分方程的解法 (3) 了解可降阶微分方程的解法 (1) Comprehend the basic concepts of ordinary differential equation and systern ordinary differential equation and their relationship (2) Master the solution of variable separable differential equation and first-order linear differential equation (3) Understand the solution of reduced order differential equation

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
4.2	微分方程的解 Solution of differential equation	8	（1）理解线性微分方程组的解的性质及解的结构 （2）掌握常系数线性微分方程组的求解方法 （3）理解高阶线性微分方程解的结构 （4）掌握常系数齐次线性微分方程的求解方法 （5）掌握非齐次项 $f(x)$ 为一些常见类型的（如 $\varphi(t)e^{\gamma t}$、$\varphi(x)e^{\gamma t}\cos\nu t$、$\varphi(x)e^{\gamma t}\sin\nu t$，其中 $\varphi(t)$ 为多项式）的二阶常系数非齐次线性微分方程的特解求解方法 （6）了解欧拉微分方程的解法及微分方程的幂级数解法 （1）Comprehend properties and structure of solution of linear differential equation （2）Master the solution of linear differential equation with constant coefficients （3）Comprehend structure of solution of higher-order linear differential equation （4）Master solution methods of homogeneous linear differential equation with constant coefficients （5）Master the particular solution method of second-order nonhomogeneous linear differential equation with constant coefficients and the function $f(x)$ includes $\varphi(t)e^{\gamma t}$, $\varphi(x)e^{\gamma t}\cos\nu t$, $\varphi(x)e^{\gamma t}\sin\nu t$, where $\varphi(t)$ is a polynomial （6）Understand solution methods of Euler's differential equation and the power series solution of differential equation
4.3	微分方程的定性分析方法初步 Preliminary analysis of qualitative analysis methods for differential equation	6	（1）了解自治系统和稳定性的基本概念 （2）了解判定稳定的李雅普诺夫方法和线性近似系统方法 （1）Understand the basic concepts of autonomous systems and stability （2）Understand the Liapunov method and the linear approximation system method for determining stability

第五章 多元函数微分学及其应用(Multi-variable Function Differential Calculus and Its Applications)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
5.1	多元函数的基本概念 The basic concept of multi-variable functions	2	(1) 了解 R^n 中点列的极限的概念 (2) 了解 R^n 中的开集、闭集、紧集与区域等概念 (3) 了解多元连续函数的性质 (1) Understand concept of the limit of a point set sequence in R^n (2) Understand concepts of open set, closed set, tight set and region in R^n (3) Understand properties of multi-variable continuous function
5.2	偏导数 Partial derivative	5	(1) 理解多元函数的偏导数的概念 (2) 了解方向导数与梯度的概念 (3) 掌握多元复合函数的偏导数的求解方法 (4) 掌握高阶偏导数的求解方法 (5) 掌握由一个方程确定的隐函数的偏导数的计算方法 (6) 掌握由方程组所确定的隐函数的偏导数的计算方法 (1) Comprehend concept of partial derivatives of multi-variable function (2) Understand concepts of directional derivative and the gradient (3) Master the solution method of partial derivatives of multi-variable composite (4) Master the solution method of high-order partial derivative (5) Master the calculation method of partial derivative of implicit function determined by an equation (6) Master the calculation method of partial derivative of the implicit function determined by equation system

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
5.3	全微分 Total differential	9	(1) 理解多元函数的全微分的概念 (2) 掌握多元复合函数的全微分的求解方法 (3) 掌握求解高阶全微分的方法 (4) 掌握由一个方程确定的隐函数的全微分的计算方法 (5) 掌握由方程组确定的隐函数的全微分的计算方法 (1) Comprehend concept of total differential of multi-variable functions (2) Master the calculation method of total differential of multi-variable composite functions (3) Master the solution method of high-order total differential (4) Master the calculation method of total differential of implicit function determined by an equation (5) Master the calculation method of total differential of the implicit function determined by equation systems
5.4	多元函数的泰勒公式与极值问题 Taylor formula of multi-variable function and extreme value	3	(1) 了解多元函数的泰勒公式 (2) 理解无约束极值和有约束极值的概念 (3) 掌握多元函数的极值及一些最大最小值应用问题的求解方法 (1) Understand Taylor formula of multi-variable function (2) Comprehend concepts of unrestricted and constrained extreme value (3) Master the extreme values of multi-variable functions and applications about maximum and minimum values

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
5.5	多元向量值函数的导数与微分 Derivative and derivation of multivariate vector value function	5	(1) 理解向量值函数的导数与微分的概念 (2) 掌握向量值函数的导数与微分的求解方法 (1) Comprehend concepts of derivative and differential of vector value function (2) Master the solution method of derivative and differential of vector value function
5.6	多元函数微分学的几何应用 Applications in geometry of the differential for multi-variable function	6	(1) 掌握空间曲线的切线与法平面方程的计算方法 (2) 掌握曲线弧长的求解方法 (3) 掌握曲面的切平面与法线方程的法求解方法 (1) Master the calculation of tangent line and normal plane of a space curve (2) Master the solution method of curve arc length (3) Master the method of solving the tangent plane and the normal equation of the curved surface
5.7	空间曲线的曲率与挠率 Curvature and torsion of space curves	4	(1) 掌握空间曲线的切线与法平面方程的求解方法 (2) 了解空间曲线的弗莱纳坐标系 (3) 弗莱纳标架与弗莱纳公式 (4) 掌握求解曲线的曲率和挠率的方法 (1) Master the solution method of tangent and normal plane equation of the space curve (2) Understand the Frenet of the space curve (3) Frenet frame and Frenet formula (4) Master the methods of solving the curvature and torsion of the curve

第六章　多元函数积分学及其应用(Multi-variable Function Integrals Calculus and Its Applications)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
6.1	多元函数积分的概念与性质 Concept and properties of multi-variable functions' integral	3	(1) 理解多元函数积分的概念与性质 (1) Comprehend concept and properties of multi-variable functions' integral
6.2	二重积分 Double integral	7	(1) 理解二重积分的几何意义 (2) 掌握二重积分在直角坐标系及极坐标系下的计算方法 (3) 了解二重积分在曲线坐标系下的计算方法 (1) Comprehend geometric meaning of double integral (2) Master the calculation of double integral in rectangular and polar coordinates (3) Understand the calculation of double integral in curve coordinates
6.3	三重积分 Triple integral	6	(1) 掌握三重积分在直角坐标系、柱面坐标系及球面坐标系下的计算方法 (1) Master the calculation of triple integral in rectangular, cylindrical and spherical coordinates
6.4	重积分的应用 Applications of multiple integral	2	(1) 了解重积分的微元法及重积分在几何、物理中的一些应用(如求曲面面积、立体的体积、质量、引力、质心及转动惯量等) (1) Understand the micro-element methods of multiple integral and some applications of multiple integral in geometry and physics (such as surface area, three-dimensional volume, mass, gravity, the center of mass and moment of inertia)

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
6.5	含参变量的积分与反常重积分 Parametric integral and improper multiple integral	6	(1) 了解含参变量的积分与反常重积分的概念 (1) Understand concepts of parametric integral and improper multiple integral
6.6	第一型线积分与面积分 Line integral of a scalar field and surface integrals	6	(1) 理解第一型线积分与面积分的概念 (2) 掌握第一型线积分与面积分的计算方法 (1) Comprehend concepts of line integral of a scalar field and surface integrals (2) Master the calculation of line integral of a scalar field and surface integrals
6.7	第二型线积分与面积分 Line integral of a vector field and surface integrals	6	(1) 理解第二型线积分与面积分的概念 (2) 掌握第二型线积分与面积分的计算方法 (1) Comprehend concept of line integral of a vector field and surface integrals (2) Master the calculation of line integral of a vector field and surface integrals
6.8	各种积分的联系及其在场论中的应用 The connection of various integrals and its application in field theory	8	(1) 掌握格林公式 (2) 理解平面积分与路径无关的条件 (3) 了解斯托克斯公式与旋度的概念 (4) 了解高斯公式与散度的概念 (5) 了解几种重要的特殊向量场 (1) Master Green's formula (2) Comprehend the conditions for surface integrals and path independence (3) Understand concepts of Stokes' formula and curl (4) Understand concepts of Gauss' formula and divergence (5) Understand several important special vector fields

第七章　无穷级数(Infinite Series)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
7.1	常数项级数 Series with constant terms	6	(1) 理解无穷级数的基本概念 (2) 了解无穷级数的性质及柯西收敛原理 (1) Comprehend the basic concepts of infinite series with constant terms (2) Understand properties of infinite series and Cauchy principle of convergence
7.2	函数项级数 Series with function terms	4	(1) 理解函数项级数的处处收敛与和函数的概念 (2) 了解函数项级数一致收敛的概念、性质及判别方法 (3) 掌握正项级数的审敛准则 (4) 了解变号级数的审敛准则 (1) Comprehend the concepts of the convergence and sum function of the series with function terms (2) Understand the concepts, properties and discriminant method of uniform convergence of function series (3) Master the criteria for positive series (4) Understand the criteria for series of variable signs
7.3	幂级数 Power series	6	(1) 理解阿贝尔定理 (2) 掌握幂级数收敛区间的求解方法 (3) 了解幂级数的性质 (4) 掌握将函数展开成幂级数的方法 (5) 了解幂级数在近似计算等问题中的简单应用 (1) Comprehend Abel's theorem (2) Master the solution method of convergence interval of the power series (3) Understand properties of the power series (4) Master the solution method of expanding a function into the power series (5) Understand the simple application of the power series in approximate calculation problems

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
7.4	傅里叶级数 Fourier series	6	(1) 掌握欧拉-傅里叶公式及狄利克雷定理 (2) 掌握将函数展开为傅里叶级数的方法 (3) 了解傅里叶级数的复数形式 (1) Master the Euler-Fourier formula and Dirichlet theorem (2) Master the solution method of expanding a function into the Fourier series (3) Understand the plural form of the Fourier series

3.1.5 实验环节(Experiments)

序号 Num.	实验内容 Experiment Content	课时 Class Hour	知 识 点 Key Points
1	基于 MATLAB 软件的计算方法 MATLAB based numerical solution methods	24	(1) 迭代法 (2) 最优化方法 (3) 数据拟合 (4) 数据插值 (5) 数值积分 (6) 微分方程的数值解方法 (1) Iterative method (2) Optimization method (3) Data fitting (4) Data interpolation (5) Numerical integration (6) Numerical solution of differential equation

大纲制定者:西安交通大学数学与统计学院数学教学中心

大纲修订者:杜少毅教授(西安交通大学人工智能学院)、汪建基副教授(西安交通大学人工智能学院)

大纲审定:西安交通大学人工智能学院本科专业知识体系建设与课程设置第二版修订工作组

3.2　“线性代数与解析几何”课程大纲

课程名称：线性代数与解析几何

Course：Linear Algebra and Analytic Geometry

先修课程：无

Prerequisites：None

学分：4

Credits：4

3.2.1　课程目的和基本内容(Course Objectives and Basic Content)

本课程是人工智能学院本科专业基础必修课。

This course is a basic compulsory course for undergraduates in College of Artificial Intelligence.

本课程的内容对近些年计算机技术的快速发展和人工智能领域的技术进步都有着重要的理论支撑，如计算机视觉与图像处理本质上就可看作是一种向量、矩阵或几何的运算。同时，本课程在教学中精简了内容，淡化了繁杂的运算技巧。这样可以使学生在掌握必要理论知识的同时能有更充足的时间进行应用实践，为将来在计算机科学和人工智能等领域的学习奠定重要的理论基础。

本课程力求将线性代数与解析几何融为一体，与数学分析的内容相互渗透，并为数学分析的多元部分提供必要的代数与几何基础。通过本课程的教学，使学生系统地获取线性代数与空间解析几何的基本知识、基本理论与基本方法，提高运用所学知识分析和解决问题的能力，并为学习相关课程及进一步学习现代数学奠定必要的数学基础。课堂教学中，注重将数学建模思想融入理论课教学，培养学生应用线性代数知识解决实际问题的能力和创新意识。

本课程的内容主要包括：行列式、矩阵、几何向量及其应用、n 维向量与线性方程组、线性空间与欧氏空间、特征值与特征向量、二次曲面与二次型、线性变换等。课程的第一章引入行列式并讨论了其基本性质和计算方法。第二章主要介绍了矩阵的基本概念及其运算。第三章首先介绍了向量的概念及它的线性运算和乘法运算，并引入

向量坐标的概念将向量运算转化为代数运算,然后利用向量研究平面和空间直线问题。第四章不仅讨论了向量相关的基本理论,还利用矩阵和向量等工具完整地解决线性方程组的求解问题。第五章介绍了线性空间与欧氏空间的基本概念,并讨论了它们的基本性质和基本结构。第六章介绍了特征值与特征向量的概念、性质与计算,然后讨论了矩阵对角化的问题和特征值的典型应用实例。第七章主要讨论了二次型相关理论。第八章介绍了线性变换的基本知识,包括线性变化的基本概念、线性变换的矩阵表示等。

This course has supported various important theoretical progresses to the rapid development of computer and artificial intelligence technologies in recent years. For example, computer vision and image processing can essentially be viewed as vector, matrix or geometric operation. At the same time, this course simplifies the content and weakens the complicated operation skills in teaching, so that students master the necessary theoretical knowledge and take more time to practice, which would lay an important theoretical foundation for the future study of computer science and artificial intelligence.

This course seeks to integrate linear algebra and analytic geometry together, infiltrate the contents of mathematical analysis, and provide the necessary algebraic and geometric basis for the multivariate part of mathematical analysis. By studying this course, students should systematically acquire the basic knowledge, theory and methods of linear algebra and spatial analytic geometry, improve their ability to analyze and solve problems with the knowledge they have learned, and lay the necessary mathematical foundation for learning related courses and further studying modern mathematics. In classroom teaching, this course takes the thinking of mathematical modelling into theoretical teaching to cultivate students' ability of innovative consciousness and the ability to solve practical problems with linear algebra knowledge.

The content of this course mainly includes determinant, matrix, geometric vector with applications, n-dimensional vector and system of linear equations, linear space and Euclidean space, eigenvalue and eigenvector, quadratic surface and quadratic form, and linear transformation, etc. Chapter 1 introduces the determinant and discusses its basic properties and calculation methods. The basic concepts and operations of matrix are introduced in Chapter 2. In Chapter 3, the concept of vector

and its linear and multiplication operations are firstly introduced. Moreover, the concept of vector coordinates helps to transform vector operations into algebraic operations, and then the planar and spatial straight line problems can be studied by vectors. In Chapter 4, the basic theories of vector correlation are discussed, and the methods to solve the system of linear equations by using tools such as matrix and vector are also introduced. Chapter 5 introduces the concepts of linear space and Euclidean space, and discusses their basic properties and basic structure. Chapter 6 introduces the concept, properties and calculations of eigenvalues and eigenvectors, and then discusses the problems of matrix diagonalization and typical application examples of eigenvalues. Chapter 7 focuses on the theory of quadratic correlation. Chapter 8 introduces the basics of linear transformation, including the basic concepts of linear variation, matrix representations of linear transformations.

3.2.2　课程基本情况(Course Arrangements)

<table>
<tr><td>课程名称</td><td colspan="8">线性代数与解析几何
Linear Algebra and Analytic Geometry</td></tr>
<tr><td rowspan="2">开课时间</td><td colspan="2">一年级</td><td colspan="2">二年级</td><td colspan="2">三年级</td><td colspan="2">四年级</td></tr>
<tr><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td></tr>
<tr><td>课程定位</td><td colspan="8">本科生“数学与统计”课程群必修课</td></tr>
<tr><td>学　　分</td><td colspan="8">4 学分</td></tr>
<tr><td>总 学 时</td><td colspan="8">64 学时
(授课 64 学时、实验 0 学时)</td></tr>
<tr><td>授课学时分配</td><td colspan="8">课堂讲授(62 学时),
小组讨论(2 学时)</td></tr>
<tr><td>先修课程</td><td colspan="8">无</td></tr>
<tr><td>后续课程</td><td colspan="8"></td></tr>
<tr><td>教学方式</td><td colspan="8">课堂教学、作业、自学</td></tr>
<tr><td>考核方式</td><td colspan="8">期中闭卷考试成绩占 30%,平时作业占 10%,期终闭卷考试成绩占 60%</td></tr>
<tr><td>参考教材</td><td colspan="8">魏战线,李继成. 线性代数与解析几何[M]. 北京：高等教育出版社,2015.</td></tr>
<tr><td>参考资料</td><td colspan="8">魏战线. 线性代数辅导与典型题解析[M]. 北京：高等教育出版社,2018.</td></tr>
<tr><td>其他信息</td><td colspan="8"></td></tr>
</table>

数学与统计	
必修(学分)	工科数学分析(12)
	线性代数与解析几何(4)
	计算机科学与人工智能的数学基础(6)
	概率统计与随机过程(4)
	复变函数与积分变换(3)
	博弈论(2)
选修(学分)	/

3.2.3 教学目的和基本要求(Teaching Objectives and Basic Requirements)

(1) 系统地掌握行列式、矩阵、几何向量及其应用、n 维向量与线性方程组、线性空间与欧氏空间(初步)、特征值与特征向量、二次曲面与二次型、线性变换(初步)的基本知识、基本理论与基本方法;

(2) 提高学生的运算能力;

(3) 训练学生的逻辑推理能力、抽象思维能力和空间想象能力;

(4) 能够运用所获取的知识去分析和解决问题。

3.2.4 教学内容及安排(Syllabus and Arrangements)

第一章 行列式(Determinant)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
1.1	行列式的定义与性质 Definition and properties of determinant	2	(1) 2 阶行列式与一类二元线性方程组的解 (2) n 阶行列式的定义 (3) 行列式的基本性质 (1) Solution of the 2nd order determinant and a kind of bivariate linear equations (2) Definition of nth-order determinant (3) Main properties of determinant
1.2	行列式的计算 The calculation of determinant	2	(1) 上三角行列式的转换与计算 (2) 降阶法的应用 (1) Conversion and calculation of the upper triangular determinant (2) Application of the reduced order method
1.3	克莱姆法则 Cramer's law	1	(1) 克莱姆法则的定理、推论以及应用 (1) Theorem, inference and applications of Cramer's law

第二章　矩阵(Matrix)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
2.1	矩阵及其运算 Matrix with operations	2	(1) 矩阵的概念 (2) 矩阵的代数运算 (3) 矩阵的转置 (4) 方阵的行列式 (1) Concept of matrix (2) Algebraic operation of matrix (3) Transpose of matrix (4) Determinant of square matrix
2.2	逆矩阵 Inverse matrix		(1) 逆矩阵 (2) 伴随矩阵的定义、定理和推论 (1) Inverse matrix (2) Definition of adjoint matrix with its theorem and inference
2.3	分块矩阵及其运算 Partitioned matrix and operations	1	(1) 子矩阵 (2) 分块矩阵 (1) Submatrix (2) Partitioned matrix
2.4	初等变换与初等矩阵 Elementary transformation and elementary matrix	1	(1) 初等变换与初等矩阵 (2) 阶梯形矩阵 (3) 再论可逆矩阵 (1) Elementary transformation and elementary matrix (2) Echelon form (3) Re-discussion on reversible matrix
2.5	矩阵的秩 Rank of matrix	1	(1) 矩阵的秩的定义和相关推论 (1) The definition and related inferences of rank of matrix

第三章　几何向量及其应用(Geometric Vector with Applications)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
3.1	向量及其线性运算 Vector and linear operations	3	(1) 向量的基本概念 (2) 向量的线性运算 (3) 向量共线、共面的充要条件 (4) 空间坐标系与向量的坐标 (1) Basic concept of vector (2) Linear operation of vector (3) Necessary and sufficient conditions for vector collinearity and coplanarity (4) Spatial coordinate system and coordinate of vector
3.2	数量积、向量积、混合积 Quantitative product, vector product, and triple product	2	(1) 两个向量的数量积(内积、外积) (2) 两个向量的向量积(内积、外积) (3) 混合积 (1) Quantitative product of two vectors (inner product, outer product) (2) Vector product of two vectors (inner product, outer product) (3) Triple product
3.3	平面和空间直线 Plane and space line	3	(1) 平面的方程 (2) 两个平面的位置关系 (3) 空间直线的方程 (4) 两条直线的位置关系 (5) 直线与平面的位置关系 (6) 距离 (1) Plane equation (2) Positional relationship between two planes (3) Equation of space line (4) Positional relationship between two straight lines (5) Positional relationship between line and plane (6) Distance

第四章　n 维向量与线性方程组(n-Dimensional Vectors and Systems of Linear Equations)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
4.1	消元法 Elimination method	2	(1) n 元线性方程组 (2) 消元法 (3) 线性方程组的解 (4) 数域 (1) System of linear equations with n variables (2) Elimination method (3) Solution of system of linear equations (4) Number field
4.2	向量组的线性相关性 Linear correlation of vector groups	3	(1) n 维向量及其线性运算 (2) 线性表示与等价向量 (3) 线性相关与线性无关 (1) n-dimensional vector and linear operation (2) Linear representation and equivalent vector (3) Linear correlation and independence
4.3	向量组的秩 Rank of vector group	2	(1) 向量组的极大无关组与向量组的秩 (2) 向量组的秩与矩阵的秩的关系 (1) Maximum independent group of vector group and rank of vector group (2) The relationship between rank of vector group and rank of matrix
4.4	线性方程组的解的结构 The structure of solutions of linear equations	3	(1) 齐次线性方程组 (2) 非齐次线性方程组 (1) Homogeneous linear equations (2) Nonhomogeneous linear equations

第五章　线性空间与欧氏空间(Linear Space and Euclidean Space)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
5.1	线性空间的基本概念 Basic concept of linear space	5	(1) 线性空间的定义 (2) 线性空间的基本性质 (3) 线性子空间的定义 (4) 基、维数和向量的坐标 (5) 基变换与坐标变换 (6) 线性空间的同构 (7) 子空间的交与和 (1) Definition of linear space (2) Basic properties of linear space (3) Definition of linear subspace (4) Coordinates of bases, dimensions and vectors (5) Base transformation and coordinate transformation (6) Isomorphism of linear spaces (7) Intersection and sum of subspaces
5.2	欧氏空间的基本概念 Basic concept of Euclidean space	5	(1) 内积及其基本性质 (2) 范数和夹角 (3) 标准正交基及其基本性质 (4) 格拉姆-施密特正交化方法 (5) 正交矩阵 (6) 矩阵的 QR 分解 (7) 正交分解和最小二乘法 (1) Inner product and its basic properties (2) Norm and angle (3) Standard orthogonal basis and its basic properties (4) Gram-Schmidt orthogonalization method (5) Orthogonal matrix (6) QR decomposition of the matrix (7) Orthogonal decomposition and least squares

第六章　特征值与特征向量(Eigenvalues and Eigenvectors)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
6.1	矩阵的特征值与特征向量 Eigenvalues and eigenvectors of matrix	2	(1) 特征值与特征向量的定义 (2) 特征方程、特征多项式与特征子空间的定义 (1) Definition of eigenvalues and eigenvectors (2) Definition of characteristic equations, characteristic polynomials and feature subspaces
6.2	相似矩阵与矩阵的相似对角化 Similar matrix and similar diagonalization of matrix	4	(1) 相似矩阵 (2) 矩阵可对角化的条件 (3) 实对称矩阵的对角化 (1) Similar matrix (2) Condition of matrix diagonalization (3) Diagonalization of real symmetric matrix
6.3	应用举例 Application examples	2	(1) 一类常系数线性微分方程组的求解 (2) 斐波那契数列与递推关系式的矩阵解法 (1) Solving a class of linear differential equations with constant coefficients (2) Matrix solutions of Fibonacci sequence and recursion relation

第七章　二次曲面与二次型(Quadric Surface and Quadric Form)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
7.1	曲面与空间曲线 Surface and space curve	3	(1) 曲面与空间曲线的方程 (2) 柱面、锥面、旋转面 (3) 5 种典型的二次曲面 (4) 4 种曲面在坐标面上的投影 (5) 空间区域的简图 (1) Equations of surface and space curve (2) Cylinder, tapered surface, rotating surface (3) Five quadric surfaces typically (4) Projections of four kinds of surfaces on the coordinate plane (5) Sketch of the space area

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
7.2	实二次型 Real quadratic form	5	(1) 二次型及其矩阵表示 (2) 二次型的标准型 (3) 合同变换与惯性定理 (4) 正定二次型 (5) 二次曲面的标准方程 (1) Quadratic form and its matrix representation (2) Standard Quadratic form (3) Congruent transformation and inertia theorem (4) Positive definite quadratic form (5) Standard equation of quadric

第八章 线性变换(Linear Transformation)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
8.1	线性变换及其运算 Linear transformation and its operations	4	(1) 线性变换的定义及其基本性质 (2) 核与值域 (3) 线性变换的运算 (1) Definition and basic properties of linear transformation (2) Core and range (3) Operations of linear transformation
8.2	线性变换的矩阵表示 Matrix representation of linear transformation	4	(1) 线性变换的矩阵 (2) 线性算子在不同基下的矩阵之间的关系 (1) Matrix of linear transformation (2) The relationship between matrices of linear operators with different bases

大纲制定者：西安交通大学数学与统计学院数学教学中心

大纲修订者：杜少毅教授(西安交通大学人工智能学院)、汪建基副教授(西安交通大学人工智能学院)

大纲审定：西安交通大学人工智能学院本科专业知识体系建设与课程设置第二版修订工作组

3.3　“计算机科学与人工智能的数学基础”课程大纲

课程名称：计算机科学与人工智能的数学基础

Course：Math Foundation of Computer Science and Artificial Intelligence

先修课程：工科数学分析、线性代数与解析几何

Prerequisites：Mathematical Analysis for Engineering, Linear Algebra and Analytic Geometry

学分：6

Credits：6

3.3.1　课程目的和基本内容(Course Objectives and Basic Content)

本课程是人工智能学院本科专业基础必修课。

This course is a basic compulsory course for undergraduates in College of Artificial Intelligence.

为了加强学生关于计算机和人工智能学科的数学基础，特开设本课程，其主要目的有：

(1) 人工智能相关的研究与实践需要诸多数学知识作为基础，而已开设的其他数学类课程：工科数学分析、线性代数与解析几何、概率统计与随机过程、复变函数与积分变换及博弈论，虽已为相关领域的学习打下良好基础，但仍有部分内容尚未涉及(如数值计算与优化理论等)，这些内容将在本课程中进行介绍；

(2) 部分内容(例如矩阵分析等)，虽在其他开设课程中已有涉及，但人工智能方向的研究与应用需要更加深入地了解这些内容，本课程将对这部分内容进行更深入和更有针对性的介绍。

“计算机科学和人工智能的数学基础”课程所包含的内容主要分为以下 6 部分：数理逻辑、集合论与组合分析、图论初步、矩阵与刚体运动、数值计算和优化理论初步。我们将其中部分内容命名为“初步”是因为对它们单独进行系统介绍都可能超过 4 学时，而本课程也并非仅仅对它们进行概念的介绍、浅尝辄止，而是对这些部分与人工智能学习非常密切的内容进行深入的介绍。其中，数理逻辑包含命题逻辑和谓词逻辑；

集合论与组合分析包含了集合的基本概念与运算、组合分析初步以及可数集 & 不可数集 & 康托集等内容；图论初步包括图的基本概念、特殊的图及树等内容；矩阵与刚体运动包含了矩阵基础、应用回归分析及三维刚体运动等内容；数值计算包括数值计算的数学基础、非线性方程的数值解法、线性方程组的数值解法、函数插值与逼近方法等内容；优化理论初步则包含了优化基础、无约束优化及约束优化等内容。

通过对上述内容的学习，为人工智能学院本科生进一步学习和实践打下扎实的数学基础。其中，数理逻辑不仅是人工智能三大学派之一的符号主义学派的理论基石，也是逻辑电路设计等课程的基础；集合论与组合分析初步可以帮助学生更好地用集合进行表达与分析，并为学习概率论奠定基础；图论初步部分为学生的编程学习以及学习数据结构等课程都有重要的帮助；矩阵与刚体理论的学习可以帮助学生更好地利用矩阵这一重要工具分析和解决在学习和实践中碰到的具体问题；数值计算为学生在实际中利用计算机解决各种数学问题打下基础；而优化理论初步所介绍的方法可以使学生在遇到实际问题时学会如何对问题更好地进行建模与优化求解。

课程采用集中授课与小组学习相结合的模式，并辅之以小组讨论、日常作业等教学手段，加强学生对数学基础的认识，为日后更好地利用数学知识解决在计算机及人工智能学科中遇到的问题奠定基础。课程还将通过大作业和算法编程实现等实践环节进一步加强学生独立分析问题、解决问题的能力，培养综合设计及创新能力，培养实事求是、严肃认真的科学作风和良好的实验习惯，为今后的学习和工作打下良好的基础。

To further strengthen the students' mathematical foundation on computer science and artificial intelligence, the course is offered specially. Its main purposes include the following two points.

(1) Although other mathematics courses, including Mathematical Analysis for Engineering, Linear Algebra and Analytic Geometry, Probability Statistics and Stochastic Processes, Complex Variable Function and Integral Transform, Game Theory, have laid a good foundation for students on the study of related fields, there are still some contents that have not been covered, such as numerical computation and optimization theory. These contents will be included in the course "Math Foundation of CS and AI".

(2) Some contents, such as matrix analysis, have already been introduced in other courses, but research and application in the field of artificial intelligence require a deeper understanding of these contents. This cource will provide move in-depth and

targeted introduction to this part.

The main contents of this course include the following six parts: Mathematical Logic, Set Theory and Combination Analysis, Graph Theory, Matrix and Rigid Body Motion, Numerical Computation, Optimization Theory. The part of Mathematical Logic includes two chapters: propositional logic and predicate logic; The part of Set Theory and Combination Analysis includes basic concepts and operations of sets, combination analysis, and countable set & uncountable set & Cantor Set; The part of Graph Theory includes basic concepts of graphs, special graphs, and trees; The part of Matrix and Rigid Body Motion includes Matrix foundation, applied regression analysis, and rigid body motion in three-dimensional space; The part of Numerical Computation includes four chapters: mathematics basis of numerical computation, numerical solutions of nonlinear equations, numerical solutions of linear equations, and function interpolation and approximation methods; The part of Optimization Theory includes basis of optimization, unconstrained optimization, and constrained optimization.

By studying the above contents, it lays a solid mathematical foundation for the further study and practice of undergraduates in AI College. Mathematical Logic is not only the basis of the follow-up contents in this course, but also is the basis for the study of proposition representation and reasoning, logic circuit design, etc. The study of Set Theory and Combination Analysis can help students better use sets for expression and analysis, and lay the foundation of probability theory. The knowledge in Graph Theory provides some good ideas in programming, and it also is a basis to learn the course "Data Structures and Algorithms". Matrix is an important tool which can help students to analyze and solve practical problems well. Numerical Computation lays a foundation for students to solve various mathematical problems by computers. The methods introduced in Optimization Theory can help students think about how to solve problems arising in practice.

The course adopts the group learning supplemented by group discussion, daily homework and other teaching methods, to strengthen the students' understanding of the mathematical knowledge and methods, which is the mathematical foundation for better use of mathematics knowledge to solve problems of computer science and artificial intelligence in the future. The course also further strengthen students'

ability to analyze problems and solve problems independently via large course assignments and algorithm programming, which can train comprehensive design and innovation ability. Moreover, this course will cultivate realistic, serious scientific style and good experimental habits, which can lay a good foundation for future work.

3.3.2 课程基本情况(Course Arrangements)

<table>
<tr><td>课程名称</td><td colspan="8">计算机科学与人工智能的数学基础
Math Foundation of Computer Science and Artificial Intelligence</td></tr>
<tr><td rowspan="2">开课时间</td><td colspan="2">一年级</td><td colspan="2">二年级</td><td colspan="2">三年级</td><td colspan="2">四年级</td></tr>
<tr><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td></tr>
<tr><td>课程定位</td><td colspan="8">本科生“数学与统计”课程群必修课</td></tr>
<tr><td>学　　分</td><td colspan="8">6 学分</td></tr>
<tr><td>总 学 时</td><td colspan="8">96 学时
(授课 96 学时,实验 0 学时)</td></tr>
<tr><td>授课学时分配</td><td colspan="8">课堂讲授(96 学时)</td></tr>
<tr><td>先修课程</td><td colspan="8">工科数学分析、线性代数与解析几何</td></tr>
<tr><td>后续课程</td><td colspan="8">人工智能概论、机器学习</td></tr>
<tr><td>教学方式</td><td colspan="8">课堂教学、课后作业</td></tr>
<tr><td>考核方式</td><td colspan="8">笔试成绩占 70%,平时成绩(作业、大作业、上机实验等)占 20%,考勤占 10%</td></tr>
<tr><td>参考教材</td><td colspan="8">1. 耿素云. 离散数学[M]. 北京: 清华大学出版社,2013.
2. 李桂成. 计算方法[M]. 北京: 电子工业出版社,2018.
3. 孙文瑜,徐成贤,朱德通. 最优化方法[M]. 北京: 高等教育出版社,2010.
4. 钱颂迪,等. 运筹学[M]. 北京: 清华大学出版社,2018.</td></tr>
<tr><td>参考资料</td><td colspan="8">1. Lehman E, Leighton F T, Meyer A R. Mathematics for Computer Science[M]. Cambridge: MIT Press,2016.
2. 张贤达. 矩阵分析与应用[M]. 北京: 清华大学出版社,2016.
3. 何晓群,刘文卿. 应用回归分析[M]. 北京: 中国人民大学出版社,2015.
4. 高立. 数值最优化方法[M]. 北京: 北京大学出版社,2018.
5. Boyd S, Vandenberghe L. 凸优化[M]. 王书宁,许鋆,黄晓霖,译. 北京: 清华大学出版社,2018.
6. 高翔,张涛,等. 视觉 SLAM 十四讲: 从理论到实践[M]. 北京: 电子工业出版社,2019.</td></tr>
<tr><td>其他信息</td><td colspan="8"></td></tr>
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数学与统计	
必修(学分)	工科数学分析(12)
	线性代数与解析几何(4)
	计算机科学与人工智能的数学基础(6)
	概率统计与随机过程(4)
	复变函数与积分变换(3)
	博弈论(2)
选修(学分)	/

3.3.3　教学目的和基本要求(Teaching Objectives and Basic Requirements)

(1) 掌握命题逻辑中的命题符号化、命题公式及分类、等值验算、范式与基本的逻辑推理方法,了解全功能集;

(2) 深入理解谓词逻辑中的合式公式及解释,并学会利用谓词逻辑等值式求前束范式;

(3) 熟悉集合的基本概念、基本运算与集合元素的计数方法,学会利用组合分析方法对集合或多重集中的元素进行计数,了解基于递推方程的算法复杂度分析方法;

(4) 理解无限集的势和可数集,了解不可数集和常见集合的势,了解康托集;

(5) 了解图的基本概念并学会图的矩阵表示方法,掌握一些常见的特殊图并了解其重要的应用实例,掌握树的概念与基本分析方法;

(6) 熟练掌握主成分分析方法,掌握矩阵的奇异分解与 K-SVD 算法,掌握稀疏矩阵方程求解的常用方法;

(7) 熟悉矩阵与向量的求导法则,并学会利用求导法则解决实际问题,掌握基于帽子矩阵的多元线性回归方法;

(8) 熟练掌握群、旋转矩阵、变换矩阵、特殊正交群和特殊欧氏群等概念,学会应用旋转向量与四元数;了解李群和李代数的基本概念及作用在其上的映射变换关系;

(9) 掌握二分法、牛顿迭代法、弦截法和迭代法等非线性方程的数值解法,理解高斯消元法、矩阵分解法和迭代法等线性方程组的数值解法;

(10) 熟悉拉格朗日插值、牛顿插值、埃尔米特插值和样条插值等多项式插值和分段插值的方法,掌握最佳一致逼近和最佳平方逼近理论;

(11) 理解最优化问题,掌握凸集、凸函数和凸优化的概念,学会使用黄金分割法和二分法等最优化方法;

(12) 掌握最速下降法、牛顿法和共轭梯度法等无约束优化方法;了解等式约束优化、不等式约束优化和二次规划的基本理论;

(13) 熟悉使用 C 语言和 MATLAB 进行数值计算和优化方法的实现。

3.3.4　教学内容及安排(Syllabus and Arrangements)

第一部分　数理逻辑(Mathematical Logic)

第一章　命题逻辑(Propositional Logic)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
1.1	命题符号化及联结词 Symbolization of propositions & connectives	2	(1) 命题及其真值 (2) 联结词(否定联结词、合取联结词、析取联结词、蕴涵联结词、等价联结词) (1) Propositions and their real values (2) Connectives (negation connectives, conjunction connectives, disjunction connectives, conditional connectives, biconditional connectives)
1.2	命题公式及分类 Propositional formula & classification	2	(1) 命题公式及其赋值 (2) 真值表 (3) 重言式、矛盾式、可满足式 (1) Propositional formula & assignment (2) Truth table (3) Tautology, contradiction, satisfactable formula
1.3	等值验算 Equivalent deduction		(1) 置换规则 (1) Replacement rule
1.4	范式 Normal form	2	(1) 析取范式、合取范式 (2) 主析取范式、主合取范式 (1) Disjunctive normal form and conjunctive normal form (2) Principal disjunctive normal form and principal conjunctive normal form
1.5	联结词全功能集 Set of fully capable connectives	2	(1) 联结词全功能集 (1) Set of fully capable connectives
1.6	推理理论 Reasoning theory		(1) 前提、推理、结论 (1) Premise, logical deduction, conclusion

第二章　谓词逻辑(Predicate Logic)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
2.1	谓词逻辑基本概念 Basic concept of predicate logic	2	(1) 个体词、谓词 (2) 存在量词、全称量词 (3) 特性谓词 (1) Individual term, predicate (2) Existential quantifier, universal quantifier (3) Characteristic predicate
2.2	谓词逻辑合式公式及解释 Well-formed formula in predicate logic and its interpretation	2	(1) 合式公式 (2) 逻辑有效式、矛盾式、可满足式 (1) Well-formed formula (2) Tautology, contradiction, satisfactable formula
2.3	谓词逻辑等值式与前束范式 Logical equivalence and prenex normal in predicate logic	2	(1) 等值式 (2) 前束范式 (1) Logical equivalence (2) Prenex normal

第二部分　集合论与组合分析(Set Theory and Combination Analysis)

第三章　集合的基本概念和运算(Basic Concepts and Operations of Set)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
3.1	集合的基本概念 Basic concepts of set	2	(1) 子集、空集、幂集 (1) Subset, empty set, power set
3.2	集合的基本运算 Basic operations of set		(1) 并集、交集、补集 (2) 对称差 (3) 文氏图 (1) Union set, intersection set, complementary set (2) Symmetric difference (3) Venn diagram

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
3.3	集合中元素的计数 Cardinality of set	2	(1) 包含排斥原理 (1) Principle of inclusion and exclusion

第四章 组合分析初步(Combinatorial Analysis)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
4.1	加法法则和乘法法则 Sum rule and product rule	2	(1) 加法法则 (2) 乘法法则 (1) Sum rule (2) Product rule
4.2	基本排列组合的计数方法 Counting method of permutation and combination		(1) 排列、组合 (2) 多重集 (1) Permutation, combination (2) Multiple set
4.3	递推方程的求解与应用 Solution and application of recursive equation	2	(1) 迭代 (2) 递推方程 (1) Iteration (2) Recursive equation

第五章 可数集、不可数集、康托集(Countable Set, Uncountable Set, Cantor Set)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
5.1	映射、对等与可数集 Mapping, counter and countable set	2	(1) 映射、满射、单射、双射 (2) 可数集 (1) Mapping, surjection, injection, bijection (2) Countable set

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
5.2	不可数集、集合的势 Uncountable set, cardinality of set,	2	(1) 康托闭集定理，不可数集、集合的势、伯恩斯坦定理 (1) Cantor's intersection theorem, uncountable set, cardinality of set, Bernstein's theorem
5.3	康托集 Cantor set		(1) 康托集 (1) Cantor set

第三部分 图论初步(Graph Theory)

第六章 图的基本概念(Basis Concepts of Graph)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
6.1	无向图和有向图 Undirected graph and digraph	2	(1) 无向图、有向图 (2) 顶点、边、握手定理、图的同构 (1) Undirected graph, digraph (2) Vertex, edge, handshake theorem, graph isomorphism
6.2	通路、回路和图的连通性 Pathway, cycle and connectivity of graph	2	(1) 通路、回路、简单通路、简单回路、初级通路、初级回路 (2) 连通、可达、点割集、边割集 (1) Path, cycle, simple path, simple cycle, primary path, primary cycle (2) Connectivity, reachability, vertex cut set, edge cut set
6.3	图的矩阵表示 Matrix representation of graph	2	(1) 关联矩阵、邻接矩阵、可达矩阵 (1) Incidence matrix, adjacency matrix, reachability matrix
6.4	最短路径、关键路径和着色 Shortest path, critical path and coloring	2	(1) 最短路径、关键路径 (2) 着色 (1) Shortest path, critical path (2) Coloring

第七章　特殊的图(Special Graphs)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
7.1	二部图 Bipartite graph	2	(1) 二部图 (1) Bipartite graph
7.2	欧拉图 Euler graph		(1) 欧拉图 (1) Euler graph
7.3	哈密顿图 Hamilton graph	2	(1) 哈密顿图 (1) Hamilton graph
7.4	平面图 Plane graph		(1) 平面图,欧拉公式 (1) Plane graph,Euler's formula

第八章　树(Tree)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
8.1	无向树及生成树 Undirected tree and spanning tree	2	(1) 无向树、生成树 (1) Undirected tree,spanning tree
8.2	根树及其应用 Root tree and its applications	2	(1) 根数、二叉树 (2) 最佳前缀码 (1) Root tree,binary tree (2) Best prefix code

第四部分　矩阵与刚体运动(Matrix and Rigid Body Motion)

第九章　矩阵基础(Matrix Foundation)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
9.1	特征分析 Eigen analysis	3	(1) 特征值与特征向量、特征多项式 (2) 主成分分析 (1) Eigenvalues and eigenvectors,eigen polynomial (2) Principal component analysis

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
9.2	矩阵的求导 Derivation of matrix	2	(1) 函数矩阵的求导 (2) 雅可比矩阵与梯度矩阵 (1) Derivation of function matrix (2) Jacobian matrix and gradient matrix
9.3	矩阵的奇异分解 Singular decomposition of matrix	1	(1) 奇异分解 (1) Singular decomposition
9.4	广义逆矩阵与最小二乘法 Least square method	2	(1) 广义逆矩阵 (2) 最小二乘法 (1) Generalized inverse matrix (2) Least square method
9.5	稀疏矩阵 Sparse matrix	3	(1) 稀疏表征 (2) 稀疏矩阵方程的求解 (3) K-SVD 算法 (1) Sparse representation (2) Solution of equations with sparse matrix (3) K-SVD algorithm

第十章　应用回归分析初步(Applied Regression Analysis)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
10.1	回归问题概述与线性回归 Overview of regression problems	2	(1) 变量间的统计关系、回归分析 (2) Statistical relations among variables, regression analysis
10.2	线性回归 Linear regression		(1) 一元线性回归 (2) 多元线性回归 (3) 帽子矩阵求解法 (1) Simple regression (2) Multivariate linear regression (3) Hat-matrix method for linear regression

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
10.3	多元相关性与条件不相关性 Multivariate correlation and conditional uncorrelation	2	(1) 无符号相关系数与无符号不相关系数 (2) 条件不相关系数 (1) Unsigned correlation coefficient and unsigned uncorrelation coefficient (2) Conditional uncorrelation coefficient
10.4	非线性回归 Nonlinear regression	1	(1) 多项式回归 (2) 其他非线性回归模型 (1) Polynomial regression (2) Other nonlinear regression models

第十一章 三维空间刚体运动(Rigid Body Motion in Three-Dimensional Space)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
11.1	代数系统 Algebraic system	4	(1) 群、环、域 (1) Group, ring, field
11.2	刚体运动 Rigid body motion		(1) 旋转矩阵与特殊正交群 SO(3) (2) 变换矩阵与特殊欧式群 SE(3) (3) 旋转向量与四元数 (1) Rotation matrix and special orthogonal group SO(3) (2) Transformation matrix and special euclidean group SE(3) (3) Rotation vector and quaternion
11.3	李群与李代数 Lie group and Lie algebra	3	(1) 李群、李代数 (2) SO(3)上的指数映射 (3) SE(3)上的指数映射 (1) Lie group, Lie algebra (2) Exponential map of SO(3) (3) Exponential map of SE(3)

第五部分　数值计算(Numerical Computation)

第十二章　数值计算的数学基础(Mathematics Basis of Numerical Computation)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
12.1	数值算法概论 Introduction to numerical algorithm	4	(1) 数值解与逼近解的概念 (1) Concepts of numerical solution and approximate solution
12.2	向量和矩阵范数 Norms of vector and matrix		(1) 范数的定义 (1) Norm definition
12.3	误差 Error		(1) 误差的定义 (1) Definition of error

第十三章　非线性方程的数值解法(Numerical Solutions of Nonlinear Equations)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
13.1	非线性方程问题 Nonlinear equation problem	2	(1) 非线性方程问题 (1) Nonlinear equation problem
13.2	二分法 Dichotomy method		(1) 二分法 (1) Dichotomy method
13.3	牛顿迭代法 Newton's iterative method		(1) 牛顿迭代法 (1) Newton's iterative method
13.4	弦截法 Chord section methods	2	(1) 单点弦截法、双点弦截法 (1) Single-point chord section method, double-point chord section method
13.5	迭代法 Iterative methods		(1) 不动点迭代方法 (2) 收敛性质、收敛阶 (1) Fixed point iteration method (2) Convergence property, order of convergence

第十四章　线性方程组的数值解法(Numerical Solutions of Linear Equations)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
14.1	线性方程组问题 Linear equations problem	3	(1) 线性方程问题 (1) Linear equations problem
14.2	高斯消元法 Gauss elimination methods		(1) 高斯消元法 (2) 主元素高斯消元法 (3) 高斯-约当消元法 (1) Gauss elimination method (2) Principal element Gauss elimination method (3) Gauss-Jordan elimination method
14.3	矩阵分解法 Matrix decomposition methods		(1) 矩阵三角分解法 (2) 乔列斯基分解法 (1) Matrix triangular decomposition method (2) Cholesky decomposition method
14.4	误差分析 Error analysis	3	(1) 不适定问题、病态问题 (2) 病态方程组、条件数 (1) Ill-posed problem, ill-conditioned problem (2) Ill-conditioned equation system, condition number
14.5	迭代法 Iterative methods		(1) 雅可比迭代法、高斯-赛德尔迭代法 (2) 迭代法的收敛性 (1) Jacobi iterative method, Gauss-Seidel iterative method (2) Convergence of iterative method

第十五章　函数插值与逼近方法(Function Interpolation and Approximation Methods)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
15.1	函数插值与逼近 Function interpolation and approximation	1	(1) 插值的基本概念 (2) 逼近的基本概念 (1) Concepts of interpolation (2) Concepts of approximation

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
15.2	插值方法 Interpolation methods	4	(1) 拉格朗日插值、分段线性插值、牛顿插值、埃尔米特插值、样条插值 (1) Lagrange interpolation, piecewise linear interpolation, Newton interpolation, Hermite interpolation, spline interpolation
15.3	函数的内积与正交多项式 Innerproduct of functions and orthogonal polynomials	3	(1) 函数的内积 (2) 正交多项式 (1) Innerproduct of functions (2) Orthogonal polynomials
15.4	函数最佳逼近 Optimal approximation of functions		(1) 最佳一致逼近 (2) 最佳平方逼近 (1) Optimal consistent approximation (2) Optimal square approximation

第六部分　优化理论初步(Optimization Theory)

第十六章　优化基础(Basis of Optimization)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
16.1	最优化问题 Optimization problem	1	(1) 最优化问题 (2) 约束优化、无约束优化 (3) 线性规划、二次规划 (1) Optimization problem (2) Constrained optimization, unconstrained optimization (3) Linear programming, quadratic programming
16.2	凸集、凸函数和凸优化 Convex set, convex function and convex optimization	2	(1) 凸集、凸函数 (2) 凸优化 (1) Convex set, convex function (2) Convex optimization
16.3	最优化方法 Optimal method		(1) 最优化算法和收敛性 (2) 黄金分割法、二分法 (1) Optimization algorithm and convergence (2) Golden section method, dichotomy method

第十七章　无约束优化(Unconstrained Optimization)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
17.1	无约束优化问题 Unconstrained optimization problem	1	(1) 无约束优化问题 (2) 最小二乘法 (1) Unconstrained optimization problem (2) Least square method
17.2	最速下降法 Steepest descent method	2	(1) 无约束优化方法 (2) 最速下降法 (1) Unconstrained optimization method (2) Steepest descent method
17.3	牛顿法 Newton method		(1) 牛顿法 (2) Newton method
17.4	共轭梯度法 Conjugate gradient method		(1) 共轭梯度法 (2) Conjugate gradient method

第十八章　有约束优化(Constrained Optimization)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
18.1	有约束优化 Constrained optimization	2	(1) 等式约束优化 (2) 不等式约束优化 (1) Equality constrained optimization (2) Inequality constrained optimization
18.2	点集配准实例 Examples of point set registration	2	(1) 点集配准问题 (2) 几何变换及其代数表达式 (3) 迭代最近点算法 (4) 场景重建与定位 (1) Point set registration problem (2) Geometric transformation and its algebraic expression (3) Iterative closest point algorithm (4) Scene reconstruction and localization

大纲指导者：郑南宁教授（西安交通大学人工智能学院）

大纲制定者：杜少毅教授（西安交通大学人工智能学院）、汪建基副教授（西安交通大学人工智能学院）

大纲审定：西安交通大学人工智能学院本科专业知识体系建设与课程设置第二版修订工作组

3.4　“概率统计与随机过程”课程大纲

课程名称：概率统计与随机过程

Course：Probability Theory and Stochastic Process

先修课程：工科数学分析、线性代数与解析几何

Prerequisites：Mathematical Analysis for Engineering, Linear Algebra and Analytic Geometry

学分：4

Credits：4

3.4.1　课程目的和基本内容（Course Objectives and Basic Content）

本课程是人工智能学院本科专业基础必修课。

This course is a basic compulsory course for undergraduates in College of Artificial Intelligence.

本课程为计算机科学与人工智能提供了重要的数理统计基础。人工智能的相关方法大多涉及数据分析问题，其中不确定性几乎是不可避免的。因此，引入随机变量并建立相关的理论、模型和方法是人工智能的一个重要理论基础。本课程包含概率论、数理统计和随机过程三部分内容。其中第一章到第四章介绍了概率论中的基本概念及基本原理：随机事件与概率、随机变量及其概率分布、随机变量的数字特征、极限定理等；第五章到第七章介绍了数理统计的基本概念及经典方法：参数估计、假设检验等；第八章和第九章介绍了随机过程的基本知识以及平稳过程等。

课程通过对概率论和数理统计基本知识的学习，要求学生理解并掌握随机事件与概率的基本概念和基本计算方法，理解并掌握随机变量及概率分布的概念及基本性质，掌握随机变量的数学特征的基本概念和计算方法，了解大数定律的基本原理，会用

中心极限定理求近似概率,了解数理统计的基本概念,掌握参数估计及假设检验的基本理论和方法,熟悉随机过程(包括复的)的概论,理解平稳过程的概念、相关函数的性质,了解各态历经性的判定,掌握谱密度的概念、性质和计算方法,了解平稳时间序列的概念、线性模型及模型识别,会进行有关的参数估计并会用这些方法解决一些工程和经济管理中遇到的实际问题。

概率统计与随机过程是从数量方面研究随机现象统计规律性的一门学科,它在人工智能、模式识别、计算机视觉、经济管理、金融投资、保险精算、企业管理等众多领域都有广泛的应用。学习和正确运用概率统计方法已成为对工科类大学生的基本要求。使学生掌握处理随机现象的基本思想和方法,培养他们运用概率统计知识分析和解决实际问题的能力,并为学习后继课程和继续深造打好基础。

This course provides an important mathematical statistics foundation for computer science and artificial intelligence. Most artificial intelligence methods involve data analysis, where uncertainty is almost inevitable. Therefore, the introduction of random variables and the establishment of related theories, models and methods are important theoretical basis of artificial intelligence. This course consists of three parts: Probability Theory, Mathematical Statistics, and Stochastic Process. Chapter 1 to Chapter 4 introduce the basic concepts and principles of probability theory, such as random events and probability, random variables and their probability distribution, digital characteristics of random variables, limit theorem, etc. Chapter 5 to Chapter 7 introduce the basic concepts and classical methods of mathematical statistics, such as parameter estimation, hypothesis test, etc. Chapter 8 to Chapter 9 introduce the basic knowledge of stochastic process and stationary process.

Through studying the basic knowledge of probability theory and mathematical statistics, this course requires students to understand and master the basic concepts and calculation methods of random events and probability. Understand and master the concepts and basic properties of random variables and probability distribution. Grasp the basic concepts and calculation methods of the mathematical characteristics of random variables. Understand the basic principles of the law of large numbers. The approximate probability can be obtained by using the central limit theorem. Understand the basic concepts of mathematical statistics. Grasp the basic theory and method of parameter estimation and hypothesis test. Be familiar with general knowledge of stochastic process, including complex ones. Understand the concept of stationary process and the properties of correlation function. Understand the determination of ergodicity of states. Grasp the concept, properties and calculation

methods of spectral density. Understand the concept of stationary time series, linear model and model recognition. The relevant parameters can be estimated and these methods can be used to solve some practical problems encountered in engineering and economic management.

Probabilistic statistics and stochastic process are disciplines that study the statistical regularity of stochastic phenomena in quantity. It is widely used in many fields, such as artificial intelligence, pattern recognition, computer vision, economic management, financial investment, insurance actuarial, enterprise management. Learning and correctly using probability and statistics methods have become the basic requirements for students major in engineering. It is a basic theoretical course for students to master the basic ideas and methods of dealing with random phenomena, to train their abilities to analyze and solve practical problems by using probability and statistics knowledge, and to lay a good foundation for subsequent courses and further studies.

3.4.2　课程基本情况(Course Arrangements)

<table>
<tr><td>课程名称</td><td colspan="8">概率统计与随机过程
Probability Theory and Stochastic Process</td></tr>
<tr><td rowspan="2">开课时间</td><td colspan="2">一年级</td><td colspan="2">二年级</td><td colspan="2">三年级</td><td colspan="2">四年级</td></tr>
<tr><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td></tr>
<tr><td>课程定位</td><td colspan="8">本科生“数学与统计”课程群必修课</td></tr>
<tr><td>学　　分</td><td colspan="8">4 学分</td></tr>
<tr><td>总 学 时</td><td colspan="8">64 学时
(授课 64 学时、实验 0 学时)</td></tr>
<tr><td>授课学时分配</td><td colspan="8">课堂讲授(62 学时)，
大作业讨论(2 学时)</td></tr>
<tr><td>先修课程</td><td colspan="8">工科数学分析、线性代数与解析几何</td></tr>
<tr><td>后续课程</td><td colspan="8"></td></tr>
<tr><td>教学方式</td><td colspan="8">课堂教学、综合大作业</td></tr>
<tr><td>考核方式</td><td colspan="8">期中考试成绩占 30%，期末考试成绩占 50%，平时作业占 10%，实验成绩占 10%</td></tr>
<tr><td>参考教材</td><td colspan="8">1. 施雨，李耀武. 概率论与数理统计应用[M]. 西安：西安交通大学出版社，2015.
2. 魏平，王宁，符世斌. 概率论与数理统计教程[M]. 西安：西安交通大学出版社，2007.</td></tr>
<tr><td>参考资料</td><td colspan="8">魏平. 概率论与数理统计综合辅导[M]. 西安：西安交通大学出版社，2007.</td></tr>
<tr><td>其他信息</td><td colspan="8"></td></tr>
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<table>
<tr><th colspan="2">数学与统计</th></tr>
<tr><td rowspan="7">必修
(学分)</td><td>工科数学分析(12)</td></tr>
<tr><td>线性代数与解析几何(4)</td></tr>
<tr><td>计算机科学与人工智能的数学基础(6)</td></tr>
<tr><td>概率统计与随机过程(4)</td></tr>
<tr><td>复变函数与积分变换(3)</td></tr>
<tr><td>博弈论(2)</td></tr>
<tr><td>选修
(学分)</td><td>/</td></tr>
</table>

3.4.3 教学目的和基本要求(Teaching Objectives and Basic Requirements)

(1) 理解随机事件与概率的基本概念,掌握其基本计算方法;
(2) 掌握随机变量及概率分布的概念及基本性质;
(3) 熟悉随机变量的数学特征的基本概念,掌握其计算方法;
(4) 了解大数定律的基本原理,会用中心极限定理求近似概率;
(5) 理解数理统计的基本概念,掌握参数估计及假设检验的基本理论和方法;
(6) 熟悉随机过程的概论,理解平稳过程的概念、相关函数的性质;
(7) 了解各态历经性的判定,掌握谱密度的概念、性质和计算方法;
(8) 掌握平稳时间序列的概念、线性模型及模型识别;
(9) 会进行有关的参数估计并会用这些方法解决一些工程和经济管理中的实际问题。

3.4.4 教学内容及安排(Syllabus and Arrangements)

第一章 随机事件与概率(Random Events and Probability)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
1.1	随机事件 Random events	1	(1) 随机现象与随机试验 (2) 样本空间与随机事件 (3) 事件的关系与运算 (1) Random phenomena and random experiments (2) Sample space and random events (3) The relation and operation of events
1.2	概率 Probability	1	(1) 概率的古典定义 (2) 概率的统计定义 (3) 概率的公理化定义 (4) 概率的性质 (1) Classical definition of probability (2) Statistical definition of probability (3) Axiomatic definition of probability (4) The properties of probability

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
1.3	古典概率的计算 The calculation of classical probability	2	(1) 古典概率的计算方法 (1) The calculating method of classical probability
1.4	条件概率，事件的独立性 Conditional probability, event independence	4	(1) 条件概率与乘法定理 (2) 全概率公式与贝叶斯公式 (3) 事件的独立性 (1) Conditional probability and multiplication theorem (2) Total probability formula and Bayesian formula (3) Independence of events

第二章　随机变量及概率分布(Random Variables and Probability Distribution)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
2.1	一维随机变量 One-dimensional random variable	4	(1) 随机变量与分布函数 (2) 离散型随机变量 (3) 连续型随机变量 (1) Random variables and distribution functions (2) Discrete random variables (3) Continuous random variables
2.2	二维随机变量 Two-dimensional random variable	4	(1) 二维随机变量与联合分布函数 (2) 二维离散型随机变量 (3) 二维连续型随机变量 (1) Two-dimensional random variables and joint distribution function (2) Two-dimensional discrete random variables (3) Two-dimensional continuous random variables

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
2.3	条件分布 Conditional distribution	1	(1) 条件分布律 (2) 条件概率密度 (1) Conditional distribution law (2) Conditional probability density
2.4	随机变量的相互独立性 Interdependence of random variables	1	(1) 随机变量的相互独立性 (1) Interdependence of random variables
2.5	随机变量函数的概率分布 Probability distribution of functions of random variables	2	(1) 一维随机变量的函数的概率分布 (2) 二维随机变量的函数的概率分布 (1) Probability distribution of functions of one-dimensional random variables (2) Probability distribution of functions of two-dimensional random variables

第三章 随机变量的数字特征(Digital Characteristics of Random Variables)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
3.1	数学期望 Mathematical expectation	2	(1) 数学期望的定义 (2) 随机变量函数的数学期望 (3) 数学期望的性质 (1) Definition of mathematical expectation (2) Mathematical expectations of functions of random variables (3) The properties of mathematical expectation

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
3.2	方差 Variance	2	(1) 方差和标准差 (2) 方差的性质 (1) Variance and standard deviation (2) The properties of variance
3.3	协方差与相关系数，矩 Covariance and correlation coefficient, moment	2	(1) 协方差与相关系数 (2) 矩 (3) 协方差矩阵 (1) Covariance and correlation coefficient (2) Moment (3) Covariance matrix

第四章　大数定律及中心极限定理(Law of Large Numbers and Central Limit Theorem)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
4.1	大数定律 Law of large number	1.5	(1) 切比雪夫不等式 (2) 切比雪夫大数定律 (3) 贝努利大数定律 (1) Chebyshev inequality (2) Chebyshev's law of large number (3) Bernoulli law of large number
4.2	中心极限定理 Central limit theorem	1.5	(1) 独立同分布的中心极限定理 (2) 不同分布的中心极限定理 (1) Central limit theorem of independent and identical distribution (2) Central limit theorem of different distributions

第五章　数理统计的基本概念(Basic Concept of Mathematical Statistics)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
5.1	总体与样本 Population and sample	1	(1) 总体及分布 (2) 样本 (1) Population and distribution (2) Sample
5.2	样本分布 Sample distribution	1	(1) 样本频数分布与频率分布 (2) 频率直方图 (3) 经验分布函数 (1) Sample frequency distribution and frequency distribution (2) Frequency histograms (3) Empirical distribution function
5.3	统计量 Statistic	1	(1) 统计量概念 (2) 几个常用的统计量 (1) Concept of statistics (2) Several commonly used statistics
5.4	抽样分布 Sampling distribution	2	(1) 几个常用的重要分布 (2) 分位数 (3) 正态总体的抽样分布 (1) Several commonly used important distributions (2) Quantiles (3) Sampling distribution of normal population

第六章　参数估计(Parameter Estimation)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
6.1	点估计 Point estimation	2	(1) 矩估计法 (2) 极大似然估计法 (1) Moment estimation method (2) Maximum likelihood estimation

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
6.2	估计量的评选标准 Criteria for selection of estimators	1	(1) 无偏性 (2) 有效性 (3) 相合性 (1) Unbiased (2) Effectiveness (3) Consistency
6.3	区间估计 Interval estimation	2	(1) 双侧区间估计 (2) 单侧区间估计 (1) Bilateral interval estimation (2) Unilateral interval estimation
6.4	正态总体参数的区间估计 Interval estimation of normal population parameters	1	(1) 单个总体 $N(\mu,\sigma^2)$ 的情形 (2) 两个总体 $N(\mu_1,\sigma_1^2)$ 和 $N(\mu_2,\sigma_2^2)$ 的情形 (1) The case of a single population (2) The case of two populations

第七章　假设检验(Hypothesis Test)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
7.1	假设检验的基本概念 Basic concepts of hypothesis test	1	(1) 假设检验的基本原理 (2) 假设检验的一般步骤 (1) Basic principles of hypothesis test (2) General steps of hypothesis test
7.2	正态总体参数的假设检验 Hypothesis test of normal population parameters	2	(1) 单个总体 $N(\mu,\sigma^2)$ 的情形 (2) 两个总体 $N(\mu_1,\sigma_1^2)$ 和 $N(\mu_2,\sigma_2^2)$ 的情形 (1) The case of a single population (2) The case of two populations

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
7.3	单边假设检验 Unilateral hypothesis test	1	(1) 单边假设 (1) Unilateral hypothesis
7.4	参数假设的大样本检验 Large sample Test of parametric hypothesis	1	(1) 参数假设的大样本检验方法 (1) Large sample test method for parametric hypothesis
7.5	总体分布的假设检验 Hypothesis test of population distribution	1	(1) 分布拟合检验 (2) 皮尔逊定理 (3) χ^2 拟合检验法 (1) Distribution fitting test (2) Pearson theorem (3) χ^2 fitting test method

第八章　随机过程的基本知识(Basic Knowledge of Stochastic Process)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
8.1	随机过程的概念 The concept of stochastic process	2	(1) 随机过程的概念和记号 (1) Concept and notation of stochastic process
8.2	随机过程的概率特征 Probabilistic characteristics of stochastic process	2	(1) 有限维分布函数族 (2) 随机过程的数字特征 (3) 两个随机过程的不相关与相互独立 (1) Finite dimensional distribution function family (2) Digital characteristics of stochastic process (3) Uncorrelated and independent of two random processes

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
8.3	随机过程的基本类型 Basic types of stochastic process	2	(1) 按参数集与状态空间分类 (2) 按过程的性质特点分类 (1) Classification by parameter set and state space (2) Classification according to the nature and characteristics of the process
8.4	泊松过程与布朗运动 Poisson process and Brownian motion	2	(1) 泊松过程的定义与性质 (2) 布朗运动 (1) Definition and properties of Poisson process (2) Brownian motion

第九章　平稳过程(Stationary Process)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
9.1	平稳过程概念 The concept of stationary process	2	(1) 平稳过程的概念 (1) The concept of stationary process
9.2	相关函数的性质 Properties of correlation function	2	(1) 自相关函数的性质 (2) 互相关函数的性质 (1) Properties of auto-correlation function (2) Properties of cross-correlation function
9.3	平稳过程的谱密度 Spectral density of stationary process	2	(1) 相关过程的谱分解 (2) 谱密度的物理意义 (3) 谱密度与互谱密度的性质 (4) 相关函数与谱密度之间的变换 (1) Spectral decomposition of related process (2) Physical significance of spectral density (3) Properties of spectral density and cross-spectral density (4) Transform between correlation function and spectral density

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
9.4	各态的历经性 Ergodicity of states	2	(1) 各态历经性概念 (2) 各态历经定理 (3) 各态历经的应用 (1) The concept of ergodicity of states (2) Ergodic theorems of states (3) Applications of ergodic states

大纲制定者:西安交通大学数学与统计学院数学教学中心

大纲修订者:杜少毅教授(西安交通大学人工智能学院)、汪建基副教授(西安交通大学人工智能学院)

大纲审定:西安交通大学人工智能学院本科专业知识体系建设与课程设置第二版修订工作组

3.5 “复变函数与积分变换”课程大纲

课程名称:复变函数与积分变换

Course: Complex Analysis and Integral Transformation

先修课程:工科数学分析、线性代数与解析几何

Prerequisites: Mathematical Analysis for Engineering, Linear Algebra and Analytic Geometry

学分:3

Credits: 3

3.5.1 课程目的和基本内容(Course Objectives and Basic Content)

本课程是人工智能学院本科专业基础必修课。

This course is a basic compulsory course for undergraduates in College of Artificial Intelligence.

本课程为数字信号处理等专业课打好基础,培养学生的数学素质,提高其应用数学知识解决实际问题的能力,也为计算机科学与人工智能的学习提供了重要的理论基

础。本课程旨在使学生初步掌握复变函数与积分变换的基本理论和方法，为学习有关后继课程和进一步扩大数学知识面奠定必要的基础。本课程的内容包括：复数与复变函数、复变函数的导数及其性质，复变函数的积分及其性质，解析函数的性质（包括高阶导数公式）、幂级数和罗伦级数的展开，孤立奇点的分类（包括无穷远点），留数及其应用，共形映射的概念及性质（特别要掌握双线性映射以及几个初等函数定义的映射所具有的性质），傅里叶变换及其性质，拉普拉斯变换及其应用。

This course lays a foundation for major courses such as digital signal processing and etc.，which cultivates students' mathematical quality and improves the students' ability to apply mathematics knowledge to solve practical problems. It also provides an important theoretical foundation for the study of computer science and artificial intelligence. The course is offered to make students grasp the basic theories and methods of complex analysis and integral transformation, and lay a necessary foundation for learning the subsequent courses and further expanding mathematical knowledge. The content of this course includes: complex and complex function, derivative of complex function and its properties，integral of complex function and its properties，properties of analytic functions (including higher derivative formulas), expansion of power series and Loren series, classification of isolated singularities (including infinite points), residual number and its applications, the concept and properties of conformal mapping (in particular，students should master the properties of bilinear mappings and mappings defined by several elementary functions)，Fourier transform and its properties，Laplace transform and its applications.

3.5.2　课程基本情况（Course Arrangements）

<table>
<tr><td>课程名称</td><td colspan="8">复变函数与积分变换
Complex Analysis and Integral Transformation</td></tr>
<tr><td rowspan="2">开课时间</td><td colspan="2">一年级</td><td colspan="2">二年级</td><td colspan="2">三年级</td><td colspan="2">四年级</td></tr>
<tr><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td></tr>
<tr><td>课程定位</td><td colspan="8">本科生“数学与统计”课程群必修课</td></tr>
<tr><td>学　　分</td><td colspan="8">3 学分</td></tr>
<tr><td>总 学 时</td><td colspan="8">48 学时
（授课 48 学时、实验 0 学时）</td></tr>
<tr><td>授课学时分配</td><td colspan="8">课堂讲授（40 学时），
小组讨论（8 学时）</td></tr>
</table>

数学与统计	
必修（学分）	工科数学分析（12）
	线性代数与解析几何（4）
	计算机科学与人工智能的数学基础（6）
	概率统计与随机过程（4）
	复变函数与积分变换（3）
	博弈论（2）
选修（学分）	/

续表

先修课程	工科数学分析、线性代数与解析几何
后续课程	数字信号处理
教学方式	课堂教学、大作业、小组讨论
考核方式	闭卷考试成绩占80%,平时成绩占20%
参考教材	1. 王绵森.复变函数[M].北京:高等教育出版社,2008. 2. 张元林.积分变换[M].北京:高等教育出版社,2004.
参考资料	王绵森.复变函数学习辅导与习题选解[M].北京:高等教育出版社,2004.
其他信息	

3.5.3 教学目的和基本要求(Teaching Objectives and Basic Requirements)

(1) 掌握复数的各种表示方法及其运算,了解区域的概念,了解复球面与无穷远点的概念,理解复变函数的基本概念,了解复变函数的极限和连续性的概念;

(2) 理解复变函数的导数及复变函数解析的概念,掌握复变函数解析的充要条件,了解调和函数与解析函数的关系,会从解析函数的实(虚)部求其虚(实)部,了解指数函数、三角函数、双曲函数、对数函数及幂函数的定义及它们的主要性质(包括在单值域中的解析性);

(3) 了解复变函数积分的定义及性质,会求复变函数的积分,理解柯西积分定理,掌握柯西积分公式和解析函数的高阶导数公式,了解解析函数无限次可导的性质;

(4) 理解复数项级数收敛、发散及绝对收敛等概念,了解幂级数收敛的概念,会求幂级数的收敛半径,了解幂级数在收敛圆内的一些基本性质,理解泰勒定理,了解 e^z,$\sin z$,$\cos z$,$\ln(1+z)$,$(1+z)^\mu$ 的马克劳林展开式,并会利用它们将一些简单的解析函数展开为幂级数,理解洛朗定理及孤立奇点的分类(包括无穷远点),会用间接方法将简单的函数在其孤立奇点附近展开为洛朗级数;

(5) 熟悉留数概念,掌握极点处留数的求法(包括无穷远点),掌握留数定理,掌握用留数求围道积分的方法,会用留数求一些实变函数的积分;

(6) 掌握解析函数导数的几何意义及共形映射的概念,掌握线性映射的性质和分式性映射的保圆性及保对称性,了解函数 $w=z^\alpha$(α 为正有理数)、$w=e^z$ 和有关映射的性质,会求一些简单区域(例如平面、半平面、角形域、圆、带形域等)之间的共形映射;

（7）理解傅里叶变换的概念，掌握傅里叶变换的性质，了解傅里叶变换的基本应用；

（8）熟悉拉普拉斯变换的概念，掌握拉普拉斯变换的性质，了解拉普拉斯变换的基本应用。

3.5.4　教学内容及安排（Syllabus and Arrangements）

第一章　复数与复变函数（Complex Number and Complex Function）

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
1.1	复数的表示与运算 Representation and operation of complex number	3	（1）区域的概念 （2）复球面与无穷远点的概念 （1）The concept of region （2）The concept of complex sphere and infinite point
1.2	复变函数的基本概念 Basic concept of complex function		（1）复变函数的极限 （2）复变函数的连续性 （1）Limit of complex function （2）Continuity of complex function

第二章　解析函数及其在平面场中的应用（Analytic Function and Its Application in Plane Field）

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
2.1	解析函数的概念 The concept of analytic function	4	（1）复变函数的导数 （2）复变函数解析的概念 （3）复变函数解析的充要条件 （1）Derivative of complex function （2）The concept of analysis of complex function （3）Necessary and sufficient condition of analysis of complex function

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
2.2	解析函数的性质 Properties of analytic function		(1) 调和函数与解析函数的关系 (2) 从解析函数的实(虚)部求其虚(实)部 (3) 指数函数、三角函数、双曲函数、对数函数及幂函数的定义及它们的主要性质(包括在单值域中的解析性) (1) The relation between harmonic function and analytic function (2) Finding the real (virtual) part of analytic function from the real(virtual) part (3) Definitions of exponential function, trigonometric function, hyperbolic function, logarithmic function and power function and their main properties (including analyticity in single value domain)

第三章 复变函数的积分(Integral of Complex Function)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
3.1	复变函数积分的定义 Definition of complex function integral	1	(1) 复变函数积分的概念 (2) 复变函数积分的性质 (1) The concept of complex function integral (2) Properties of complex function integral
3.2	复变函数积分的公式 Formula for integral of complex function	1	(1) 复变函数积分的求解 (1) Solving the integral of complex function
3.3	柯西积分定理 Cauchy integral theorem	1	(1) 柯西积分定理的定义 (2) 柯西积分定理的性质 (1) Definition of Cauchy integral theorem (2) Properties of Cauchy integral theorem

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
3.4	柯西积分公式 Cauchy integral formula	1	(1) 柯西积分的求解 (1) Solution of Cauchy integral
3.5	解析函数的高阶导数公式 The formula of higher order derivative of analytic function	1	(1) 解析函数的高阶导数求解 (1) Solution of higher order derivative of analytic function

第四章　复变函数项级数(Term Series of Complex Function)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
4.1	复变函数项级数 Term series of complex function	1	(1) 复数项级数收敛 (2) 复数项级数发散 (3) 复数项级数绝对收敛 (1) Convergence of complex series (2) Divergence of complex series (3) Absolute convergence of complex series
4.2	幂级数收敛 Convergence of power series	1	(1) 幂级数的收敛半径 (2) 幂级数在收敛圆内的基本性质 (1) Convergence radius of power series (2) Basic properties of power series in convergent circle
4.3	泰勒定理 Taylor theorem	1	(1) 泰勒展开式 (2) 马克劳林展开式 (3) 解析函数展开为幂级数 (1) Taylor expansion (2) Marklaurin expansion (3) Analytic function expands to power series

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
4.4	洛朗定理 Laurent theorem	2	(1) 洛朗定理 (2) 孤立奇点的分类 (3) 用间接方法将简单的函数在其孤立奇点附近展开为洛朗级数 (1) Laurent theorem (2) Classification of isolated singularities (3) Simple functions are expanded to Laurent series near their isolated singularities via indirect method

第五章 留数及其应用(Residue and Its Application)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
5.1	留数的概念 The concept of residue	1	(1) 留数的定义 (2) 极点处留数的求法 (1) Definition of residue (2) Solution of residual number at pole
5.2	留数定理 Residue theorem	2	(1) 留数定理 (2) 留数求围道积分的方法 (1) Residue theorem (2) The method of finding contour integral by residual number
5.3	留数的应用 Applications of residue	2	(1) 用留数求一些实变函数的积分 (1) Solving integrals of some real analysis by residual number

第六章　共形映射(Conformal Mapping)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
6.1	共形映射的概念 The concept of conformal mapping	1	(1) 解析函数导数的几何意义 (2) 共形映射的概念 (1) The geometric meaning of derivative of analytic function (2) The concept of conformal mapping
6.2	线性映射和分式性映射的性质 Properties of linear mapping and fractional mapping	2	(1) 线性映射的性质 (2) 分式性映射的保圆性 (3) 分式性映射的保对称性 (4) 函数 $w=z^{\alpha}$(α 为正有理数)、$w=e^{z}$ 和有关映射的性质 (1) Properties of linear mapping (2) Roundness preservation of fractional mapping (3) Symmetry preservation of fractional mapping (4) Properties of mappings of $w=z^{\alpha}$ (α is a positive rational number), $w=e^{z}$ and other functions
6.3	共形映射的求解 Solution of conformal mapping	1	(1) 求解简单区域(例如平面、半平面、角形域、圆、带形域等)之间的共形映射 (1) Solving conformal mappings between simple domains (e. g. plane, half plane, angular domain, circle, band domain, etc.)

第七章　傅里叶变换(Fourier Transform)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
7.1	傅里叶变换的概念 The concept of Fourier transform	1	(1) 傅里叶变换的定义 (1) Definition of Fourier transform

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
7.2	傅里叶变换的性质(一) Properties of Fourier transform(1)	2	(1) 傅里叶变换的性质(一) (1) Properties of Fourier transform(1)
7.3	傅里叶变换的性质(二) Properties of Fourier transform(2)	2	(1) 傅里叶变换的性质(二) (1) Properties of Fourier transform(2)
7.4	傅里叶变换的应用(一) Applications of Fourier transform(1)	1	(1) 傅里叶变换的应用(一) (1) Applications of Fourier transform(1)
7.5	傅里叶变换的应用(二) Applications of Fourier transform(2)	1	(1) 傅里叶变换的应用(二) (1) Applications of Fourier transform(2)

第八章 拉普拉斯变换(Laplace Transform)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
8.1	拉普拉斯变换的概念 Concept of Laplace transform	1	(1) 拉普拉斯变换的概念 (1) The concept of Laplace transform
8.2	拉普拉斯变换的性质(一) Properties of Laplace transform(1)	2	(1) 拉普拉斯变换的性质(一) (1) Properties of Laplace transform(1)
8.3	拉普拉斯变换的性质(二) Properties of Laplace transform(2)	1	(1) 拉普拉斯变换的性质(二) (1) Properties of Laplace transform(2)
8.4	拉普拉斯变换的应用(一) Applications of Laplace transform(1)	1	(1) 拉普拉斯变换的应用(一) (1) Applications of Laplace transform(1)

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
8.5	拉普拉斯变换的应用(二) Applications of Laplace transform(2)	2	(1) 拉普拉斯变换的应用(二) (1) Applications of Laplace transform(2)

大纲制定者：西安交通大学数学与统计学院数学教学中心

大纲修订者：杜少毅教授(西安交通大学人工智能学院)、汪建基副教授(西安交通大学人工智能学院)

大纲审定：西安交通大学人工智能学院本科专业知识体系建设与课程设置第二版修订工作组

3.6　“博弈论”课程大纲

课程名称：博弈论

Course：Game Theory

先修课程：工科数学分析、概率统计与随机过程

Prerequisites：Mathematical Analysis for Engineering, Probability Theory and Stochastic Process

学分：2

Credits：2

3.6.1　课程目的和基本内容(Course Objectives and Basic Content)

本课程是人工智能学院本科专业基础必修课。

This course is a basic compulsory course for undergraduates in College of Artificial Intelligence.

该课程介绍有关决策主体的行为产生相互作用时，各决策主体之间的最优策略

选择以及策略均衡的知识体系。博弈论不仅是现代经济学的一个标准分析工具,而且在管理学、政治学、国际关系学、军事战略等学科有着广泛的应用。随着博弈论的不断发展和完善,该理论逐渐被应用到电力系统、人工智能等工程设计领域。近几年,算法博弈论迅速发展,并与多智能系统研究融合,其普及程度已逐渐追赶上人工智能的发展。博弈论的思维模式和分析方法将会对人工智能领域的研究起到重要的推动作用。

该课程以博弈的信息结构、博弈过程和博弈方式为主线,按照博弈的类型,用8章的内容系统介绍以下7种博弈的基本原理和分析方法:完全信息静态博弈、完全且完美信息动态博弈、重复博弈、完全但不完美信息动态博弈、不完全信息静态博弈、不完全信息动态博弈、博弈学习和进化博弈。第一章是该课程的导论,主要通过与日常生活密切相关的博弈游戏介绍博弈的基本特征和博弈的分类。第二章到第八章分别介绍上述7种博弈。

该课程主要采用课堂授课模式,并辅之以小组讨论、行为经济学实验等教学手段。在课堂授课中,将始终以博弈实例或博弈模型分析为基本手段,帮助学生通过实例分析掌握博弈论的基本概念、基本原理和分析方法,最终使得学生在自己的知识体系中构建起博弈论的理论框架,在思维习惯上培养学生用博弈思想分析决策问题的思维模式,在掌握的分析工具中学会应用博弈分析方法。在小组讨论中,将训练学生用博弈论的基本理论和方法分析解决实际决策问题的能力,并引导学生逐渐将博弈论的思想融入人工智能领域的学习和研究中。

This course introduces the knowledge system about optimal strategy choice and strategic equilibrium among players when the behavior of players interacts. Game Theory is not only a standard analytical tool for modern economics, but also has a wide range of applications in Management Science, Politics, International Relations, Military Strategy, and other disciplines. With the continuous development and improvement of Game Theory, this theory has been used in engineering design fields such as power systems and artificial intelligence. In recent years, algorithm game theory has developed rapidly and merged with multi-intelligent systems, and its popularity has gradually caught up with the development of AI. The thinking mode and analysis method of game theory will play an important role in promoting the research in the field of AI.

Based on the main logical line of information structures, game processes and game modes, according to the types of game, the basic principles and analysis methods of seven kinds of games are introduced in eight chapters. The theories of seven games are as follows: games with complete information, dynamic games with complete and

perfect information, repeated games, dynamic games with complete but imperfect information, static games with incomplete information, dynamic games with incomplete information, game learning and evolutionary games. Chapter 1 is an introduction to this course, which introduces the basic characteristics of the game and the classification of games mainly through games closely related to daily life. The seven types of games are introduced in Chapter 2 to Chapter 8 respectively.

The course mainly adopts classroom teaching mode, supplemented by group discussion, behavioral economics experiment, and other teaching methods. In classroom teaching, we will use game examples or game models analysis as the basic means to help students obtain the basic concepts, basic principles and analysis methods of Game Theory. By teaching this course, we expect to enable students to construct a theoretical framework of Game Theory in their own knowledge system, to train students' thinking mode of using Game Theory to analyze decision-making problems in their thinking habits, and to teach students can use game analysis tool in their tool boxes. In group discussions and behavioral economics experiments, students will be trained to use the basic theory and methods of Game Theory to analyze and solve practical decision-making problems, and guide students to gradually incorporate the idea of game theory into the study and research of AI.

3.6.2　课程基本情况(Course Arrangements)

<table>
<tr><td>课程名称</td><td colspan="8">博弈论
Game Theory</td></tr>
<tr><td rowspan="2">开课时间</td><td colspan="2">一年级</td><td colspan="2">二年级</td><td colspan="2">三年级</td><td colspan="2">四年级</td></tr>
<tr><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td><td>秋</td><td>春</td></tr>
<tr><td>课程定位</td><td colspan="8">本科生“数学与统计”课程群必修课</td></tr>
<tr><td>学　　分</td><td colspan="8">2 学分</td></tr>
<tr><td>总 学 时</td><td colspan="8">32 学时
(授课 32 学时、实验 0 学时)</td></tr>
<tr><td>授课学时分配</td><td colspan="8">课堂讲授(32 学时)</td></tr>
</table>

数学与统计	
必修(学分)	工科数学分析(12)
	线性代数与解析几何(4)
	计算机科学与人工智能的数学基础(6)
	概率统计与随机过程(4)
	复变函数与积分变换(3)
	博弈论(2)
选修(学分)	/

续表

先修课程	工科数学分析、概率统计与随机过程
后续课程	
教学方式	课堂教学、小组讨论
考核方式	闭卷考试成绩占 70%,小组讨论占 5%,平时成绩占 25%
参考教材	谢识予. 经济博弈论[M]. 上海: 复旦大学出版社,2018.
参考资料	1. 葛泽慧,于艾琳,赵瑞,等. 博弈论入门[M]. 北京: 清华大学出版社,2018. 2. Gibbons M. 博弈论基础[M]. 高峰,译. 北京: 中国社会科学出版社,1999. 3. Maschler M,Solan E,Zamir S. 博弈论[M]. 赵世永,译. 北京: 格致出版社,2018.
其他信息	

3.6.3 教学目的和基本要求(Teaching Objectives and Basic Requirements)

(1) 理解博弈论的基本概念、博弈的特征和博弈的分类;

(2) 熟练掌握完全信息静态博弈的基本分析思路和方法、纳什均衡、混合策略和混合策略纳什均衡;

(3) 熟悉完全且完美信息动态博弈的表示法和特点、子博弈和子博弈完美纳什均衡、逆推归纳法;

(4) 了解有限次重复博弈和无限次重复博弈;

(5) 理解完全但不完美信息动态博弈以及完美贝叶斯均衡;

(6) 熟练掌握不完全信息静态博弈和贝叶斯纳什均衡;

(7) 了解不完全信息动态博弈、声明博弈和信号博弈;

(8) 掌握有限理性博弈、博弈学习模型和演化博弈论。

3.6.4 教学内容及安排(Syllabus and Arrangements)

第一章 导论(Introduction)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
1.1	从游戏到决策理论 From game to decision theory	1	(1) 博弈论的学习目的及学习内容 (1) Learning purpose and contents of game theory

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
1.2	典型的博弈例子 Typical game examples	1	(1) 囚徒困境 (2) 双寡头竞价博弈 (3) 田忌赛马 (4) 古诺模型 (5) 空城计中的博弈 (1) Prisoners' dilemma (2) Duopoly bidding game (3) Tianji horse racing (4) Cournot model (5) Game in empty city planning
1.3	博弈的特征和博弈的分类 Characteristics and classification of game	1	(1) 博弈方 (2) 博弈策略 (3) 博弈过程 (4) 博弈得益 (5) 博弈信息结构 (6) 博弈决策方式 (7) 博弈方式 (8) 博弈理论结构 (1) Game players (2) Game strategy (3) Game process (4) Game payoff (5) Information structure of game (6) Decision-making mode of game (7) Game mode (8) Structure of game theory

第二章　完全信息静态博弈(Game with Complete Information)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
2.1	博弈的基本分析思路和方法 Basic analytical thinking and methods of game	1	(1) 上策均衡 (2) 严格下策反复消去法 (3) 划线法 (4) 箭头法 (1) Dominant strategy equilibrium (2) Iterated elimination of weakly dominated strategies (3) Line-drawing method (4) Arrow method
2.2	纳什均衡 Nash equilibrium		(1) 纳什均衡的定义 (2) 纳什均衡与严格下策反复消去法 (3) 纳什均衡的一致预测性质 (1) Definition of Nash equilibrium (2) Nash equilibrium and iterated elimination of weakly dominated strategies (3) Uniform prediction of Nash equilibrium
2.3	无限策略博弈分析和反应函数 Infinite strategy game analysis and response function	1	(1) 古诺模型 (2) 反应函数 (3) 伯特兰德寡头模型 (4) 公共资源问题 (5) 反应函数的问题 (1) Cournot model (2) Response function (3) Bertrand oligopoly model (4) Public resources problem (5) Problem of response function

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
2.4	混合策略和混合策略纳什均衡 Mixed strategy and mixed strategy Nash equilibrium	2	（1）严格竞争博弈和混合策略的引进 （2）多重均衡博弈和混合策略 （3）混合策略和严格下策反复消去法 （4）混合策略反应函数 （1）Strict competition game and introduction of mixed strategy （2）Multiple equilibrium game and mixed strategy （3）Mixed strategy and iterated elimination of weakly dominated strategies （4）Mixed strategy response function
2.5	纳什均衡的存在性 The existence of Nash equilibrium	1	（1）纳什定理 （2）纳什定理的意义和扩展 （1）Nash theorem （2）Significance and extension of Nash theorem
2.6	纳什均衡的选择和分析方法扩展 Selection and analysis method extension of Nash equilibrium		（1）帕累托和风险上策均衡 （2）聚点和相关均衡 （3）共谋和防共谋均衡 （1）Pareto dominant strategy equilibrium and risk dominant strategy equilibrium （2）Focus equilibrium and relevance equilibrium （3）Collusion and anti-collusion equilibrium

第三章　完全且完美信息动态博弈（Dynamic Game with Complete and Perfect Information）

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
3.1	动态博弈的表示法和特点 Representation and characteristics of dynamic game	2	（1）动态博弈的阶段和扩展形表示 （2）动态博弈的基本特点 （1）Stage and extensive-form of dynamic game （2）Basic characteristics of dynamic game

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
3.2	策略的可信性和纳什均衡的问题 The credibility of strategy and problem of a Nash equilibrium		(1) 选择和策略的可信性问题 (2) 纳什均衡的问题 (3) 逆推归纳法 (1) Selection and credibility of a strategy (2) Problem of Nash equilibrium (3) Reverse induction
3.3	子博弈和子博弈完美纳什均衡 Subgame and subgame perfect Nash equilibrium		(1) 子博弈与子博弈完美纳什均衡 (1) Subgame and subgame perfect Nash equilibrium
3.4	经典的动态博弈模型 Classical dynamic game model	1	(1) 斯塔克博格模型 (2) 劳资博弈 (3) 议价博弈 (4) 委托人-代理人理论 (1) Stackelberg model (2) The game between labor unions and firms (3) Bargaining game (4) Principal-agent theory
3.5	有同时选择的动态博弈模型 Dynamic game model with simultaneous selection	1	(1) 标准模型 (2) 间接融资和挤兑风险 (3) 国际竞争和最优关税 (4) 有同时选择的委托人-代理人关系 (1) Standard model (2) Indirect financing and risk of bank run (3) International competition and optimal tariff (4) Principal-agent relationship with simultaneous choice

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
3.6	动态博弈分析的问题和扩展讨论 Problems and extended discussion of dynamic game analysis	1	(1) 逆推归纳法的问题 (2) 颤抖手均衡和顺推归纳法 (3) 蜈蚣博弈 (1) Problems of inverse induction (2) Trembling hand equilibrium and progressive induction (3) Centipede game

第四章　重复博弈(Repeated Game)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
4.1	重复博弈引论 Introduction to repeated game	2	(1) 重复博弈的定义和意义 (2) 重复博弈的基本概念 (1) Definition and significance of repeated game (2) Basic concepts of repeated game
4.2	有限次重复博弈 Finite repeated game		(1) 两人零和博弈的有限次重复博弈 (2) 唯一纯策略纳什均衡博弈的有限次重复博弈 (3) 多个纯策略纳什均衡博弈的有限次重复博弈 (4) 有限次重复博弈的民间定理 (1) Finite repeated game of two-person zero-sum game (2) Finite repeated game with unique pure strategy Nash equilibrium (3) Finite repeated game with multiple pure strategy Nash equilibriums (4) The folk theorems of finite repeated game

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
4.3	无限次重复博弈 Infinite repeated game	2	(1) 两人零和博弈的无限次重复博弈 (2) 唯一纯策略纳什均衡博弈的无限次重复博弈 (3) 无限次重复古诺模型 (4) 有效工资率 (1) Infinite repeated game of two-person zero-sum game (2) Infinite repeated game with unique pure strategy Nash equilibrium (3) Infinite repeated Cournot model (4) Effective wage rate

第五章 完全但不完美信息动态博弈(Dynamic Game with Complete but Imperfect Information)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
5.1	不完美信息动态博弈 Dynamic game with imperfect information	2	(1) 概念和例子 (2) 不完美信息动态博弈的表示 (3) 不完美信息动态博弈的子博弈 (1) Concepts and examples (2) Representation of dynamic game with imperfect information (3) Subgame of dynamic game with imperfect information
5.2	完美贝叶斯均衡 Perfect Bayesian equilibrium		(1) 完美贝叶斯均衡的定义 (2) 关于判断形成的进一步理解 (1) Definition of perfect Bayesian equilibrium (2) Further understanding of judgment formation

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
5.3	单一价格二手车交易的博弈 The game of used vehicle trading with single price	2	(1) 单一价格二手车交易的博弈模型 (2) 均衡的类型 (3) 博弈模型的纯策略完美贝叶斯均衡 (4) 博弈模型的混合策略完美贝叶斯均衡 (1) The game model of used vehicle trading with single price (2) Types of equilibriums (3) Perfect Bayesian equilibrium with pure strategy of the game model (4) Perfect Bayesian equilibrium with mixed strategy of the game model
5.4	双价二手车交易的博弈 The game of two-price used car trading		(1) 双价二手车交易博弈模型 (2) 博弈模型的均衡 (1) The game model of two-price used car trading (2) Equilibrium of game model
5.5	有退款保证的双价二手车交易 Two-price used car trading with refund guarantee		(1) 有退款保证的双价二手车交易 (1) Two-price used car trading with refund guarantee

第六章　不完全信息静态博弈(Static Game with Incomplete Information)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
6.1	不完全信息静态博弈和贝叶斯纳什均衡 Incomplete information static game and Bayesian Nash equilibrium	2	(1) 问题和例子 (2) 不完全信息静态博弈的一般表示 (3) 海萨尼转换 (4) 贝叶斯纳什均衡 (1) Problems and examples (2) General representation of incomplete information static game (3) Harsanyi conversion (4) Bayesian Nash equilibrium

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
6.2	暗标拍卖 Sealed-bid auction		(1) 暗标拍卖 (1) Sealed-bid auction
6.3	双方报价拍卖 Bid auction	2	(1) 双方报价拍卖的贝叶斯纳什均衡条件 (2) 线性策略均衡 (1) Conditions of Bayesian Nash equilibrium of bid auction (2) Linear strategic equilibrium

第七章 不完全信息动态博弈(Dynamic Game with Incomplete Information)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
7.1	不完全信息动态博弈及其转换 Dynamic game with incomplete information and its conversion	2	(1) 不完全信息动态博弈问题 (2) 类型和海萨尼转换 (1) Problems of dynamic game with incomplete information (2) Types and Harsanyi conversion
7.2	声明博弈 Declarations game		(1) 声明和信息传递 (2) 离散型声明博弈 (3) 连续型声明博弈 (1) Declarations and information transfer (2) Discrete declarations game (3) Continuous declarations games

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
7.3	信号博弈 Signaling game	2	(1) 行为传递的信息和信号机制 (2) 信号博弈模型和完美贝叶斯均衡 (3) 股权换投资博弈 (4) 劳动市场信号博弈 (1) Information transmitted by behaviors and signal mechanism (2) Signaling game model and perfect Bayesian equilibrium (3) Game of exchanging stock right for investment (4) Signaling game in labor market
7.4	不完全信息工会厂商谈判 Negotiation between labor union and firms under the condition of incomplete information		(1) 不完全信息工会厂商谈判 (1) Negotiation between labor and firms under the condition of incomplete information

第八章　博弈学习和进化博弈论(Game Learning and Evolutionary Game)

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知　识　点 Key Points
8.1	有限理性和博弈分析 Limited rationality and game analysis	1	(1) 有限理性问题 (2) 有限理性博弈分析方法 (1) The problem of limited rationality (2) Analysis methods of game with limited rationality
8.2	博弈学习模型 Game learning model	1	(1) 最优反应动态 (2) 虚拟行动 (3) 博弈学习模型小结 (1) Optimal response dynamics (2) Virtual action (3) Summary of game learning model

续表

章节序号 Chapter Number	章节名称 Chapters	课时 Class Hour	知 识 点 Key Points
8.3	进化博弈论 Evolutionary game theory	1	(1) 生物进化博弈论 (2) 经济中的进化博弈论 (1) Game theory of biology evolutionary (2) Evolutionary game theory in economy

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