北 京 化 工 大 学

《离散数学》教学大纲

一、课程基本信息

<table>
<tr><td colspan="2">课程代码</td><td colspan="8">MAT21601T</td></tr>
<tr><td colspan="2">课程信息</td><td>所属学科</td><td colspan="3">数学学科</td><td>知识领域</td><td colspan="3">离散结构</td></tr>
<tr><td>总学时</td><td>64</td><td>学分</td><td>4</td><td>理论学时</td><td>64</td><td>实验/实践学时</td><td>0</td><td>上机学时</td><td>0</td></tr>
<tr><td colspan="2">课程中文名称</td><td colspan="8">离散数学</td></tr>
<tr><td colspan="2">课程英文名称</td><td colspan="8">Discrete Mathematics</td></tr>
<tr><td colspan="2">适用专业</td><td colspan="8">计算机类</td></tr>
<tr><td colspan="2">开课学期</td><td colspan="8">第 3 学期</td></tr>
<tr><td colspan="2">预修课程（名称）</td><td colspan="8">高等数学，线性代数</td></tr>
<tr><td colspan="2">并修课程（名称）</td><td colspan="8">数据结构</td></tr>
<tr><td colspan="2">课程简介（中文）</td><td colspan="8">离散数学是一门研究离散对象的数量关系、以及离散结构数学模型的专业基础课程。它充分描述了计算机科学离散性的特点，是学习计算机科学与技术理论必不可少的数学工具。
本课程以经典逻辑和朴素集合论的知识为基础，主要介绍命题逻辑、谓词逻辑的推理演算和形式化方法，以及集合、关系和函数的性质及运算。
本课程的任务是培养学生利用离散数学知识分析问题和解决问题的能力，以及良好的抽象思维和缜密概括能力。使学生能够应用离散数学知识建立复杂离散结构问题的描述模型与方法，为学生处理离散信息、解决复杂工程问题提供必备的数学基础，为后续的计算机课程学习奠定理论基础。</td></tr>
<tr><td colspan="2">课程简介（英文）</td><td colspan="8">Discrete mathematics is a professional foundation course for studying the quantitative relationship of discrete objects and the mathematical model of discrete structures. It fully describes the characteristics of the discreteness of computer science and is an indispensable mathematical tool for learning computer science and technology theory.
Based on the knowledge of classical logic and naive set theory, this course mainly introduces propositional logic, inferential calculus and formal methods of predicate logic, and the properties and operations of sets, relations and functions.</td></tr>
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	The task of this course is to develop students' ability to use discrete mathematics to analyze and solve problems, as well as good abstract thinking and meticulous generalization. It enables students to apply discrete mathematics knowledge to construct description models and methods for complex discrete structure problems, provide students with the necessary mathematical basis for dealing with discrete information and solve complex engineering problems, and lay a theoretical foundation for the subsequent computer course learning.

二、课程性质及课程目标

2.1 课程性质

本课程属于计算机科学与技术专业及其相关专业的专业基础课，是计算机科学与技术及相关专业学生的必修课程。

2.2 课程目标

通过本课程的理论学习，培养学生抽象思维和逻辑思维能力，为后续的专业课以及将来的科学研究提供必要的相关数学知识，为建立离散系统的数学模型提供数学描述工具，为分析和解决计算机类复杂工程问题提供推理理论和方法。**通过中国邮递员问题等中国元素增强同学们的民族自豪感和信心、提高数学基础与文化素养，树立不断追求国家富强、民主、文明、和谐的远大理想。**

G1. 掌握离散数学的基础知识和解决问题的基本方法，培养学生形式化、模型化的抽象思维能力。

G2：掌握离散对象的基本研究方法，能够运用离散数学知识对复杂工程问题进行识别、判断、分析、描述和建立数学模型，并选择恰当方法求解问题。

G3：更好地理解开展终身学习的重要性，培养自主学习和终身学习的能力，促进终生学习习惯的养成，为后续课程的学习和今后的工作打下良好基础。

三、课程目标与毕业要求指标点对应关系

表 1 课程目标与毕业要求的对应表

毕业要求	观测点	课程目标	达成途径	评价依据	支撑程度（H、M、L）
1 工程知识	观测点 1.1	G1	课堂讲授、课堂讨论、课堂练习	平时表现、期末考试	H
2 问题分析	观测点 2.1	G2	课堂讲授、课堂讨论、课堂练习	平时表现、期末考试	H
12 终身学习	观测点 12.1	G3	课堂讲授、课堂讨论、课堂练习	平时表现、期末考试	M

H---代表“高” M---代表“中等” L---代表“低”

支撑程度：选修课至少要有一个 H 或 M。专业必修课和核心课至少要有一个 H。

观测点 1.1：能够针对计算机领域复杂工程问题建立数学模型并求解。

观测点 2.1：具备基本的问题分析能力，能够分析计算机领域复杂工程问题，识别和判断其中的关键环节。

观测点 12.1：理解自主学习和终身学习的重要性与必要性，具有自主学习和终身学习的意识，掌握一定的自主学习和终身学习方法。

四、理论教学内容与要求

4.1 命题逻辑（8 学时）

4.1.1 教学目标

对应课程目标 G1、G2、G3。

4.1.2 教学内容

（1）命题和联结词；

（2）命题公式和真值表；

（3）命题的翻译；

（4）等价式和蕴含式；

（5）联结词的完备集；

（6）对偶式；

（7）范式；

（8）命题逻辑推理。

4.1.3 教学要求

理解命题公式的概念；掌握命题公式的等价演算；理解析取范式与合取范式的概念；掌握主析取范式与主合取范式的求解方法；理解析取范式与合取范式的概念；掌握主析取范式与主合取范式的求解方法；掌握命题翻译的方法。

4.2 谓词逻辑（8 学时）

4.2.1 教学目标

对应课程目标 G1、G2、G3。

4.2.2 教学内容

（1）谓词逻辑的基本概念；

（2）谓词公式与命题翻译；

（3）谓词逻辑的等价式和蕴涵式；

（4）前束范式；

（5）谓词逻辑推理。

4.2.3 教学要求

理解谓词、量词、变元等概念；掌握构造谓词逻辑公式的方法；掌握命题翻译的方法；理解谓词逻辑的等价式和蕴涵式；理解前束范式的概念。

4.3 集合（4 学时）

4.3.1 教学目标

对应课程目标 G1、G2、G3。

4.3.2 教学内容

（1）集合的基本概念；

（2）集合的运算与维恩图；

（3）集合恒等式；

（4）基本计数原理；

（5）集合的基数。

4.3.3 教学要求

了解集合的概念；理解集合的性质；掌握集合的运算和集合恒等式；掌握基本计数原理；了解集合基数的概念。

4.4 关系（8 学时）

4.4.1 教学目标

对应课程目标 G1、G2、G3。

4.4.2 教学内容

（1）序偶与笛卡尔积；

（2）关系及其表示；

（3）关系的运算；

（4）关系的性质；

（5）等价关系与集合的划分；

（6）相容关系与集合的覆盖；

（7）偏序关系。

4.4.3 教学要求

理解笛卡儿积与关系的概念；掌握关系的表示、运算与性质；掌握等价关系与集合划分；掌握相容关系与集合覆盖；理解偏序关系。

4.5 函数（4 学时）

4.5.1 教学目标

对应课程目标 G1、G2、G3。

4.5.2 教学内容

（1）函数的基本概念；

（2）函数的运算；

（3）置换与轮换；

（4）递归。

4.5.3 教学要求

理解函数的概念；掌握函数的性质；掌握函数的运算；理解置换和轮换的概念。

4.6 代数系统（10 学时）

4.6.1 教学目标

对应课程目标 G1、G2、G3。

4.6.2 教学内容

（1）代数系统的基本概念；

（2）代数运算及其性质。

（3）特殊元；

（4）群与子群；

（5）交换群与循环群；

（6）同态与同构；

（7）环与子环；

（8）域。

4.6.3 教学要求

了解代数系统的基本概念；掌握代数运算的性质；理解代数系统之间的同态关系和同构关系；理解群、子群的性质；理解交换群和循环群的性质；了解环和域的概念及其性质。

4.7 格和布尔代数（4 学时）

4.7.1 教学目标

对应课程目标 G1、G2、G3。

4.7.2 教学内容

（1）格的定义和性质；

（2）保序映射；

（3）分配格和有补格。

4.7.3 教学要求

理解格的定义；掌握格的性质；理解保序映射；掌握分配格、布尔格的判别方法。

4.8 图（6 学时）

4.8.1 教学目标

对应课程目标 G1、G2、G3。

4.8.2 教学内容

（1）图的基本概念；

（2）子图；

（3）图的连通性；

（4）图的矩阵表示。

4.8.3 教学要求

理解图、子图的基本概念；理解图的连通性的概念；掌握图的表示方法、图的可达性与连通性等性质的判断。

4.9 欧拉图和哈密尔顿图（4 学时）

4.9.1 教学目标

对应课程目标 G1、G2、G3。并通过中国邮递员问题等中国元素增强同学们的民族自豪感和信心，树立不断追求国家富强、民主、文明、和谐的远大理想。

4.9.2 教学内容

（1）欧拉图与欧拉路径；

（2）哈密尔顿图与哈密尔顿路径；

（3）图的应用与算法。

4.9.3 教学要求

了解欧拉图与汉密尔顿图的概念；掌握欧拉图与汉密尔顿图的判定方法；掌握图的典型应用与算法。

4.10 特殊图（8 学时）

4.10.1 教学目标

对应课程目标 G1、G2、G3。

4.10.2 教学内容

（1）二分图与匹配；

（2）平面图与欧拉公式；

（3）对偶图；
（4）四色定理；
（5）树与子树；
（6）二叉树及其应用。

4.10.3 教学要求

了解二分图的概念；理解匹配；理解平面图和欧拉公式；理解对偶图的概念；掌握平面图的着色；掌握树、子树和二叉树的定义和性质；掌握树的几种经典算法。

五、实践教学内容与要求（标注每一个实践或者实验支撑哪些课程目标，参照第四部分的内容进行细化，定稿请删除此注意事项）

无

六、考核方式和评分标准

6.1 考核方式和内容（仅供参考，具体的评价内容和比例是依具体课程的要求来定）

本课程的考核方式包括过程考核和期末考试。其中过程考核包括课堂表现（包括出勤和参与）和习题作业等；期末考试为闭卷笔试，考试题型包括填空、判断、选择、计算和证明等。

课程最终考核的评定是过程考核与期末考试的综合评定，并以此为依据进行课程目标达成情况的评价，具体如下表所示。

表 2 课程考核方式和内容及其对课程目标的支撑关系

课程目标	分值	考核方式	考核方式所占比例	主要考核内容
G1	40	课堂参与	10%	课堂参与程度
		平时作业	20%	平时作业情况
		期末考试	70%	知识与能力
G2	40	课堂参与	10%	课堂参与程度
		平时作业	20%	平时作业情况
		期末考试	70%	知识与能力
G3	20	课堂参与	10%	课堂参与程度
		平时作业	20%	平时作业情况
		期末考试	70%	知识与能力

6.2 评分标准

课堂表现（包括出勤和参与）、习题作业两部分的评分标准具体如表 3-4 所示。期末考试按照当次期末考试试卷的评分标准进行评分。

表 3 课堂表现的评分标准

考核指标	权重	100-90	89-80	79-70	69-60	59-0
出勤	70%	全勤	缺课 1 次	缺课 2 次	缺课 4 次	缺课>4 次
课堂参与	30%	主动	积极配合	配合	比较配合	不配合

表 4 习题作业的评分标准

考核指标	权重	100-90	89-80	79-70	69-60	59-0
作业完成情况	80%	全交	少交 1 次	少交 2 次	少交 4 次	少交>4 次
作业正确率	20%	>90%	>80%	>70%	>60%	<60%

七、教材和参考书（标明教材的类型，比如国家精品教材、自编教材等）

[1] 邓辉文. 离散数学，第 4 版，清华大学出版社，北京，2019 (国家级规划教材)
[2] 古天龙，常亮. 离散数学，清华大学出版社，北京，2012

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Syllabus for Discrete Mathematics

Ⅰ. General Information

Course Code			MAT21601T						
Course Information			Academic Discipline	Mathematics		Knowledge Domain	Discrete Structure		
Total Class Hours	64	Credits	4	Lecture Hours	64	Laboratory Hours	0	Computer Lab Hours	0
Course Title (in Chinese)			离散数学						
Course Title (in English)			Discrete Mathematics						
Applicable Majors			Computer Science and Technology						
Semester Available			No. 3						
Prerequisites (Course Title)			Advanced Maths, Linear Algebra						
Corequisites (Course Title)			Data Structure						
Brief Course Description			Discrete mathematics is a professional foundation course for studying the quantitative relationship of discrete objects and the mathematical model of discrete structures. It fully describes the characteristics of the discreteness of computer science and is an indispensable mathematical tool for learning computer science and technology theory. Based on the knowledge of classical logic and naive set theory, this course mainly introduces propositional logic, inferential calculus and formal methods of predicate logic, and the properties and operations of sets, relations and functions. The task of this course is to develop students' ability to use discrete mathematics to analyze and solve problems, as well as good abstract thinking and meticulous generalization. It enables students to apply discrete mathematics knowledge to construct description models and methods for complex discrete structure problems, provide students with the necessary mathematical basis for dealing with discrete information and solve complex engineering problems, and lay a theoretical foundation for the subsequent computer course learning.							

Ⅱ. Curriculum Nature and Course Objectives

Through the theoretical study of this course, students' ability of abstract thinking and logical thinking is cultivated, which provides the necessary relevant mathematical knowledge for follow-up professional courses and future scientific research, mathematical description tools for the establishment of mathematical models of discrete systems, and reasoning theories and methods for analyzing and solving complex engineering problems of computer classes. Through the Chinese postman problem and other Chinese elements to enhance the students' national pride and confidence, improve the mathematical foundation and cultural literacy, establish the constant pursuit of national prosperity, democracy, civilization, harmony of the lofty ideal.

G1. Master the basic knowledge of discrete mathematics and the basic methods of solving

problems, and cultivate students' formal and modeled abstract thinking ability.

G2: Master the basic research methods of discrete objects, and be able to use discrete mathematical knowledge to identify, judge, analyze, describe and establish mathematical models of complex engineering problems, and choose appropriate methods to solve problems.

G3: Better understand the importance of lifelong learning, develop the ability of self-learning and lifelong learning, promote the formation of lifelong learning habits, and lay a good foundation for follow-up courses and future work.

Ⅲ. The Corresponding Relationship between Course Objectives and Graduation Requirements

Table 1 Correspondence between Course Objectives and Graduation Requirements

Graduation requirements	Indicator point	Course objectives	Implement Methods	Evaluation Criteria	Support Level （H、M、L）
1 Engineering knowledge	1.1	G1	lectures, discussions, exercises	Class behavior, final exam	M
2 Problem analysis	2.1	G2	lectures, discussions, exercises	Class behavior, final exam	M
12 Lifelong learning	12.1	G3	lectures, discussions, exercises	Class behavior, final exam	M

1.1: With mathematical, natural science and engineering basic knowledge, it can be used for the description of computer complex engineering problems, mathematical model construction and model solution.

2.1: With basic problem analysis ability, the student can analyze the complex engineering problems in the field of computer, identify the mathematical problems, establish mathematical models, choose the calculation method to solve.

12.1: Understand the importance and necessity of self-learning and lifelong learning, the student have the consciousness of self-learning and lifelong learning, master certain methods of self-learning and lifelong learning.

Ⅳ. Teaching Contents and Requirements for the Lecturing Part

4.1 Proposition Logic (8 hours)

4.1.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.1.2 Teaching content

(1) Propositions and operator;

(2) Proposition formula and truth table;

(3) Interpretation of propositions;

(4) Equivalent and implication;

(5) Operator Completeness;

(6) Dual formula;

(7) Normal Form;

(8) Logical reasoning of propositions.

4.1.3 Teaching requirements

Understand the concept of proposition formula, master the equivalent relations of proposition formula, analyze the concept of paradigm and common-choice paradigm, master the solution method of the CNF and the DNF, analyze the concept of the paradigm and the paradigm of the solution, master the solution method of the CNF and the DNF, and master the method of proposition interpretation.

4.2 Predicate Logic (8 hours)

4.2.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.2.2 Teaching content

(1) The basic concept of predicate logic;

(2) Predicate formula and interpretation;

(3) The equivalence and implications of predicate logic;

(4) Prenex normal form;

(5) Predicate logical reasoning.

4.2.3 Teaching requirements

Understand the concepts of predicates, quantity words, variables, etc., master the method of constructing the logical formula of predicates, master the method of interpretation, understand the equivalence and implication of predicate logic, and understand the concept of the PNF.

4.3 Set theory (4 hours)

4.3.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.3.2 Teaching content

(1) The basic concept of set;

(2) The operation of the set and the Venn diagram;

(3) equations of sett;

(4) The basic counting principle;

(5) The cardinality of the collection.

4.3.3 Teaching requirements

Understand the concept of a set, understand the nature of a set, master the operation of a set, master the basic principles of counting, and understand the concept of a set cardinality.

4.4 Relations (8 hours)

4.4.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.4.2 Teaching content

(1) Pair and Cartesian product;

(2) Relation and its representation;

(3) Operation of the relations;

(4) Property of the relations;

(5) Equivalent relations and set partition;

(6) Tolerance relation and covering

(7) Partial order relation.

4.4.3 Teaching requirements

Understand the concept of Descartes product and relations, master the representation, operation and property of relationship, master the equivalent relation and set partition, master the tolerance relation and set covering, and understand the partial order relations.

4.5 Function (4 hours)

4.5.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.5.2 Teaching content

(1) The basic concept of function;

(2) Operation of the function;

(3) Displacement and transposition;

(4) Recursion.

4.5.3 Teaching requirements

Understand the concept of functions, master the properties of functions, master the operation of functions, understand the concepts of displacement and transposition.

4.6 Algebra System (10 hours)

4.6.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.6.2 Teaching content

(1) The basic concept of algebraic system;

(2) Algebraic operations and their properties.

(3) Special elements;

(4) Groups and subgroups;

(5) Abelian group and Cyclic group;

(6) Homomorphism and isomorphism;

(7) Rings and sub-rings;

(8) Field.

4.6.3 Teaching requirements

Understand the basic concepts of algebraic systems, master the nature of algebraic operations, understand the homomorphic and homogenous relationships between algebraic systems, understand the nature of groups and subgroups, understand the nature of Abelian groups and cyclic groups, and understand the concepts and properties of rings and fields.

4.7 Lattice and Boolean Algebra (4 hours)

4.7.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.7.2 Teaching content

(1) Definition and properties of the Lattice;

(2) Order-preserving mapping;

(3) Distributive and complemented lattice.

4.7.3 Teaching requirements

Understand the definition of grid, master the nature of grid, understand the order-preserving mapping, master the classification method of distributive and complemented lattice..

4.8 Graph (6 hours)

4.8.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.8.2 Teaching content

(1) The basic concept of the graph;

(2) sub-graph;

(3) the connectivity of the graph;

(4) The matrix representation of the graph.

4.8.3 Teaching requirements

Understand the basic concepts of graph and subgraph, understand the concept of connectivity of graphs, and master the matrix representation method of graph, the accessibility and connectivity of graphs.

4.9 Euler graph and Hamilton graph (4 hours)

4.9.1 Teaching objectives

Corresponding to course objectives G1, G2, G3. And through the Chinese postman problem and other Chinese elements to enhance the students' national pride and confidence, establish the pursuit of national prosperity, democracy, civilization, harmony of the lofty ideals.

4.9.2 Teaching content

(1) Euler graph and Euler paths;

(2) Hamilton graph and Hamilton Path;

(3) The application and algorithm of the graph.

4.9.3 Teaching requirements

Understand the concept of Euler graph and Hamilton graph, master the method of determining Euler graph and Hamilton graph, master the typical application and algorithm of graph.

4.10 Special Graph (8 hours)

4.10.1 Teaching objectives

Corresponding to course objectives G1, G2, G3.

4.10.2 Teaching content

(1) Bipartite graph and matching;

(2) Planar graph and Euler formula;

(3) Dual graphs;

(4) Four-color theorem;

(5) Trees and subtrees;

(6) Binary tree and its application.

4.10.3 Teaching requirements

Understand the concept of bipartite graph, understand matching, understand planar graph and Euler formulas, understand the concept of dual graph, master the coloring of plans, master the definition and properties of trees, subtrees and binary trees, master several classical algorithms for trees.

Ⅴ. Teaching Contents and Requirements for the Practical Part

Null

Ⅵ. Evaluation Standards

6.1 Assessment methods and content

This course is evaluated in a way that includes a process assessment and a final exam. The process assessment includes classroom performance (including attendance and participation) and

exercise homework, etc.

The assessment of the final assessment of the course is the comprehensive assessment of the process assessment and the final examination, and based on this evaluation of the achievement of the course objectives, as shown in the table below.

Table 2 The way and content of curriculum assessment and its supporting relationship to curriculum objectives

Course objectives	value	Assessment method	Proportion	Assessment Contents
G1	40	Participation	10%	Participation
		Assignment	20%	Assignment
		Final Test	70%	Knowledge and ability
G2	40	Participation	10%	Participation
		Assignment	20%	Assignment
		Final Test	70%	Knowledge and ability
G3	20	Participation	10%	Participation
		Assignment	20%	Assignment
		Final Test	70%	Knowledge and ability

6.2 Rating criteria

Class performance (including attendance and participation), exercise assignments, two parts of the scoring criteria as shown in Table 3-4. The final exam is graded according to the scoring criteria of the final exam paper.

Table 3 The criteria of rating for class performance

Assessment metrics	Weight	100-90	89-80	79-70	69-60	59-0
Attendance	70%	Full attendance	Absences=1	absences =2	absences <=4	absences >4
Participation	30%	excellent	better	good	fair	does not participate

Table 4 The criteria of rating for assignment

Assessment metrics	Weig ht	100-90	89-80	79-70	69-60	59-0
assignment completion	80%	Full	incompletion =1	incompletio n =2	incompletio n <=4	incompletion > 4
assignment correctness rate	20%	>90 %	>80%	>70%	>60%	<60%

Ⅶ. Textbooks and Recommended References

1. Deng Huiwen. Discrete Mathematics, 4th Edition, Tsinghua University Press, Beijing, 2019 (National Planning Textbook)
2. Gu Tianlong. Discrete Mathematics, Tsinghua University Press, Beijing, 2012

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