

# Discrete Mathematics

Adopted 2013

## Mathematical process standards

- 1. The student uses mathematical processes to acquire and demonstrate mathematical understanding** DMPS.9-12.1

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  - (A) apply mathematics to problems arising in everyday life, society, and the workplace** DMPS.9-12.1.A

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  - (B) use a problem-solving model that incorporates analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution** DMPS.9-12.1.B

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  - (C) select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems** DMPS.9-12.1.C

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  - (D) communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate** DMPS.9-12.1.D

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  - (E) create and use representations to organize, record, and communicate mathematical ideas** DMPS.9-12.1.E

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  - (F) analyze mathematical relationships to connect and communicate mathematical ideas** DMPS.9-12.1.F

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  - (G) display, explain, and justify mathematical ideas and arguments using precise mathematical language in written or oral communication** DMPS.9-12.1.G

## Graph theory

- 2. The student applies the concept of graphs to determine possible solutions to real-world problems** DMPS.9-12.2

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  - (A) explain the concept of graphs** DMPS.9-12.2.A

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  - (B) use graph models for simple problems in management science** DMPS.9-12.2.B

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  - (C) determine the valences of the vertices of a graph** DMPS.9-12.2.C

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  - (D) identify Euler circuits in a graph** DMPS.9-12.2.D

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  - (E) solve route inspection problems by Eulerizing a graph** DMPS.9-12.2.E

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- (F)** determine solutions modeled by edge traversal in a graph DMPS.9-12.2.F

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  - (G)** compare the results of solving the traveling salesman problem (TSP) using the nearest neighbor algorithm and using a greedy algorithm DMPS.9-12.2.G

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  - (H)** distinguish between real-world problems modeled by Euler circuits and those modeled by Hamiltonian circuits DMPS.9-12.2.H

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  - (I)** distinguish between algorithms that yield optimal solutions and those that give nearly optimal solutions DMPS.9-12.2.I

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  - (J)** find minimum-cost spanning trees using Kruskal's algorithm DMPS.9-12.2.J

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  - (K)** use the critical path method to determine the earliest possible completion time for a collection of tasks DMPS.9-12.2.K

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  - (L)** explain the difference between a graph and a directed graph DMPS.9-12.2.L
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### Planning and scheduling

- 3.** The student uses heuristic algorithms to solve real-world problems DMPS.9-12.3

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  - (A)** use the list processing algorithm to schedule tasks on identical processors DMPS.9-12.3.A

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  - (B)** recognize situations appropriate for modeling or scheduling problems DMPS.9-12.3.B

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  - (C)** determine whether a schedule is optimal using the critical path method together with the list processing algorithm DMPS.9-12.3.C

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  - (D)** identify situations appropriate for modeling by bin packing DMPS.9-12.3.D

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  - (E)** use any of six heuristic algorithms to solve bin packing problems DMPS.9-12.3.E

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  - (F)** solve independent task scheduling problems using the list processing algorithm DMPS.9-12.3.F

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  - (G)** explain the relationship between scheduling problems and bin packing problems DMPS.9-12.3.G
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### Group decision making

- 4.** The student uses mathematical processes to apply decision-making schemes. The student analyzes the effects of multiple types of weighted voting and applies multiple voting concepts to real-world situations DMPS.9-12.4

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- (A)** describe the concept of a preference schedule and how to use it DMPS.9-12.4.A

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- (B)** explain how particular decision-making schemes work DMPS.9-12.4.B

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- (C)** determine the outcome for various voting methods, given the voters' preferences DMPS.9-12.4.C

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- (D)** explain how different voting schemes or the order of voting can lead to different results DMPS.9-12.4.D
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- (E)** describe the impact of various strategies on the results of the decision-making process DMPS.9-12.4.E
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- (F)** explain the impact of Arrow's Impossibility Theorem DMPS.9-12.4.F
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- (G)** relate the meaning of approval voting DMPS.9-12.4.G
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- (H)** explain the need for weighted voting and how it works DMPS.9-12.4.H
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- (I)** identify voting concepts such as Borda count, Condorcet winner, dummy voter, and coalition DMPS.9-12.4.I
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- (J)** compute the Banzhaf power index and explain its significance DMPS.9-12.4.J
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## Fair division

- 5.** The student applies the adjusted winner procedure and Knaster inheritance procedure to real-world situations DMPS.9-12.5
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- (A)** use the adjusted winner procedure to determine a fair allocation of property DMPS.9-12.5.A
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- (B)** use the adjusted winner procedure to resolve a dispute DMPS.9-12.5.B
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- (C)** explain how to reach a fair division using the Knaster inheritance procedure DMPS.9-12.5.C
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- (D)** solve fair division problems with three or more players using the Knaster inheritance procedure DMPS.9-12.5.D
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- (E)** explain the conditions under which the trimming procedure can be applied to indivisible goods DMPS.9-12.5.E
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- (F)** identify situations appropriate for the techniques of fair division DMPS.9-12.5.F
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- (G)** compare the advantages of the divider and the chooser in the divider-chooser method DMPS.9-12.5.G
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- (H)** discuss the rules and strategies of the divider-chooser method DMPS.9-12.5.H
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- (I)** resolve cake-division problems for three players using the last-diminisher method DMPS.9-12.5.I
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- (J)** analyze the relative importance of the three desirable properties of fair division: equitability, envy-freeness, and Pareto optimality DMPS.9-12.5.J
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- (K)** identify fair division procedures that exhibit envy-freeness DMPS.9-12.5.K
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**Game (or competition) theory**

**6. The student uses knowledge of basic game theory concepts to calculate optimal strategies. The student analyzes situations and identifies the use of gaming strategies** DMPS.9-12.6

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**(A) recognize competitive game situations** DMPS.9-12.6.A

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**(B) represent a game with a matrix** DMPS.9-12.6.B

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**(C) identify basic game theory concepts and vocabulary** DMPS.9-12.6.C

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**(D) determine the optimal pure strategies and value of a game with a saddle point by means of the minimax technique** DMPS.9-12.6.D

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**(E) explain the concept of and need for a mixed strategy** DMPS.9-12.6.E

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**(F) compute the optimal mixed strategy and the expected value for a player in a game who has only two pure strategies** DMPS.9-12.6.F

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**(G) model simple two-by-two, bimatrix games of partial conflict** DMPS.9-12.6.G

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**(H) identify the nature and implications of the game called "Prisoners' Dilemma"** DMPS.9-12.6.H

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**(I) explain the game known as "chicken"** DMPS.9-12.6.I

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**(J) identify examples that illustrate the prevalence of Prisoners' Dilemma and chicken in our society** DMPS.9-12.6.J

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**(K) determine when a pair of strategies for two players is in equilibrium** DMPS.9-12.6.K

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**Theory of moves**

**7. The student analyzes the theory of moves (TOM). The student uses the TOM and game theory to analyze conflicts** DMPS.9-12.7

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**(A) compare and contrast TOM and game theory** DMPS.9-12.7.A

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**(B) explain the rules of TOM** DMPS.9-12.7.B

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**(C) describe what is meant by a cyclic game** DMPS.9-12.7.C

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**(D) use a game tree to analyze a two-person game** DMPS.9-12.7.D

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**(E) determine the effect of approaching Prisoners' Dilemma and chicken from the standpoint of TOM and contrast that to the effect of approaching them from the standpoint of game theory** DMPS.9-12.7.E

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**(F) describe the use of TOM in a larger, more complicated game** DMPS.9-12.7.F

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**(G)** model a conflict from literature or from a real-life situation as a two-by-two strict ordinal game and compare the results predicted by game theory and by TOM DMPS.9-12.7.G