3 - Graph Theory

Content Area: **Mathematics**
Course(s):
Time Period: **Marking Period 1**
Length: **2 weeks**
Status: **Published**

Summary of Graph Theory

Graph Theory is the study of graphs – which are mathematical structures used to model pairwise relations between objects. A graph is a collection of vertices and edges. An edge connects one vertex to another vertex, and each vertex represents a person, place, or thing. The edge indicates the relationship between the vertices. The academic field of graph theory includes a surprising number of applications and may be used in a variety of contexts. In this unit of study, graph theory will be developed and applied within the realm of conflict resolution. With special emphasis on the four-color map theorem, this course will relate key concepts in graph theory to the management of conflict among multiple parties – simultaneously indicating compatible and incompatible relationships. In that respect, this approach to graph theory extends upon the previous unit of social choice math in which the optimal solution recognizes antagonizing forces and demands a stasis that accommodates both competing and cooperative positions of all participants.

Revision Date: July 2026

Essential Questions for Graph Theory

- How may discrete graphs be used to model real-life situations?
- What do vertices and edges symbolize in the field of graph theory, and how do corresponding graphs provide insight into to the relationships among them?
- How can groups be formed amongst a set of elements that are in conflict?
- What is the Four Color Math Theorem, and what are its applications?
- How may the principles of graph theory be used to optimize complex scheduling matters?

Enduring Understandings for Graph Theory

- Real-life situations may be modeled by graphs, where vertices represent nouns and edges represent a singular well-defined relationship between them.
- Vertex coloring can provide a way to solve problems involving conflict resolution.
- Graph theory may be used to determine optimal scheduling arrangements, as well as the transportation and storage of incompatible elements.

Objectives for Graph Theory

Students Will Know:

- How to interpret and construct a graph that uses edges to represent clearly-defined relationships among nouns.

- How to interpret and construct graphs that demonstrate relationships of influence and directional flow.

Objectives for Graph Theory

Students Will Be Skilled At:

- Utilizing the four-color map theorem for situations requiring conflict resolution.
- Constructing graphs with vertices and edges; identifying and interpreting relationships among the elements contained with the graph.
- Creating a scheduling arrangement that recognizes and resolves inherent conflicts among multiple parties.
- Achieving and presenting solutions within complex settings of restraints and conflicts.
- Identifying connectivity among elements in vertex-edge graphs.

Learning Plan for Graph Theory

Cooperative small-group activities will be the focal point of this unit. Class time will alternate between brief teacher lectures and group tasks, with greater emphasis being given to the time devoted towards completing hands-on tasks. Students will work with their peers to create models and determine solutions for real-life situations containing matters of conflict. The four-color map theorem will drive the content and context for this unit of study. It is important for the instructor to initially introduce key concepts, yet provide students with frequent opportunities to thoughtfully engage in modeling exercises with graph theory. Students will have many opportunities to learn and practice the application of graph theory to solve problems, and they will be expected to present their findings to their classmates – both verbally and with the use of digital audiovisual aids.

Evidence/Performance Tasks for Graph Theory

The graph theory unit consists of several formative assessments in which the students will work together on achieving original solutions to a variety of real-life problems. Students will be placed into small groups for cooperative problem-solving activities and they will be evaluated upon the strength of their solutions and the thoughtfulness of their efforts. The instructor will design and assign tasks that require the application of the four-color map theorem, and students will be expected to work together and communicate their solutions with their classmates. Peer presentations will follow each group activity, and students will immediately receive constructive feedback from each other and the instructor. At the conclusion of the unit, a summative written assessment will be administered, and will have the opportunity to verbally elaborate on their written responses to demonstrate their understanding of key concepts.

Materials for Graph Theory

Core instructional materials: Core Book List including district approved textbook: *Mathematical*

Ideas, 14th ed. Miller, Heeran, Hornsby, and Heeran. Pearson (2020).

Supplemental instructional materials: Lecture notes and classroom activities designed by instructor. Internet resources, including instructional videos on YouTube, Khan Academy, and teacher-recommended math education websites.

Standards for Graph Theory

Through collaborative learning about various discrete mathematics applications, students will embrace each other's differing points of view and logical reasoning. Through group and class discussions, students will reinforce their comfort with critiquing each other's thought process which incorporates elements of the following:

NJ Diversity and Inclusion Law:
In accordance with New Jersey's Chapter 32 Diversity and Inclusion Law, this unit includes instructional materials that highlight and promote diversity learning, including: economic diversity, equity, inclusion, tolerance, and belonging in connection with gender and sexual orientation, race and ethnicity, disabilities, and religious tolerance.

	Modeling Standards:
P.4	Demonstrate creativity and innovation.
P.5	Utilize critical thinking to make sense of problems and persevere in solving them.
9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).
9.4.12.CT	Critical Thinking and Problem-solving
P.8	Use technology to enhance productivity increase collaboration and communicate effectively.
P.9	Work productively in teams while using cultural/global competence.
MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
MA.F-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

Suggested Accommodations and Modifications

Link to Google Doc with list of accommodations and modifications:

https://docs.google.com/spreadsheets/d/1pRh--nhM8IFIomBxghCfN1PrwPPFT7n_y6BvOpAt6nQ/edit#gid=1426178898