"Graph theory"
for the master degree program "Geographic Information Systems"

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Main topics

- What graph theory is?
- How is it applied in geographic information systems?
- What problems are considered in the course?
- What are the planning results of education?

What graph theory is?

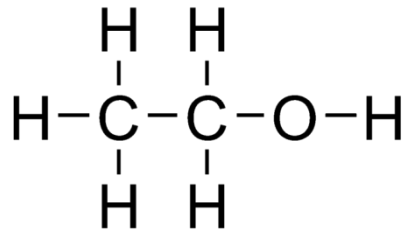**Graphs** are mathematical structures used to model pairwise relations between objects.

Graph G(V,E):

- V – the set of "vertices" or "nodes";
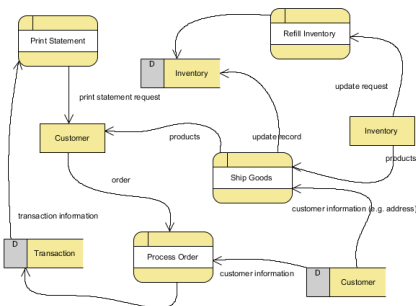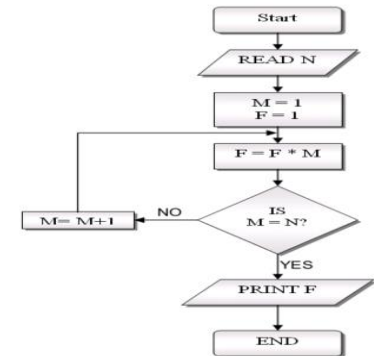- E – the set of "edges" that connect pairs of nodes.
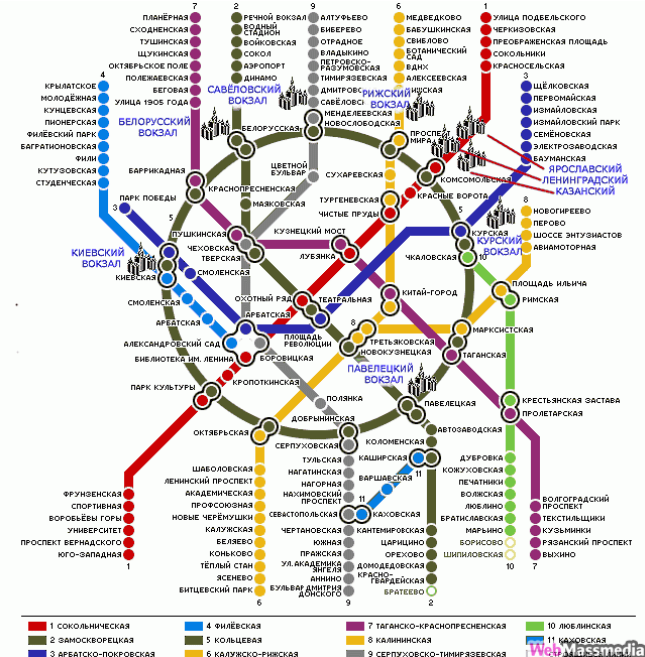
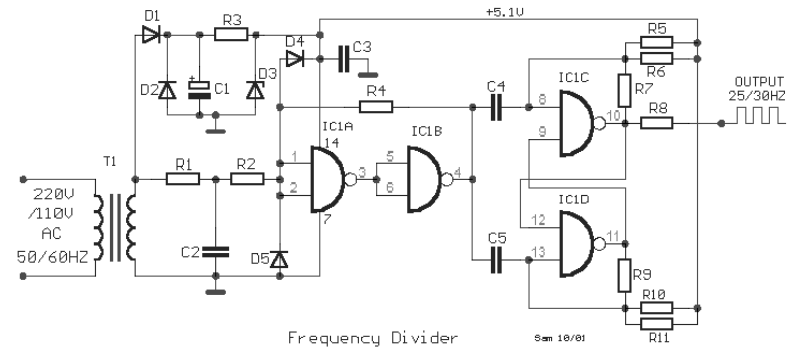# Applications

Chemistry (molecular graph)

Programming
(flow chart)

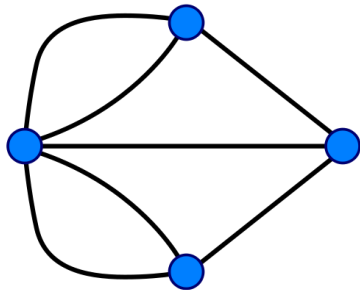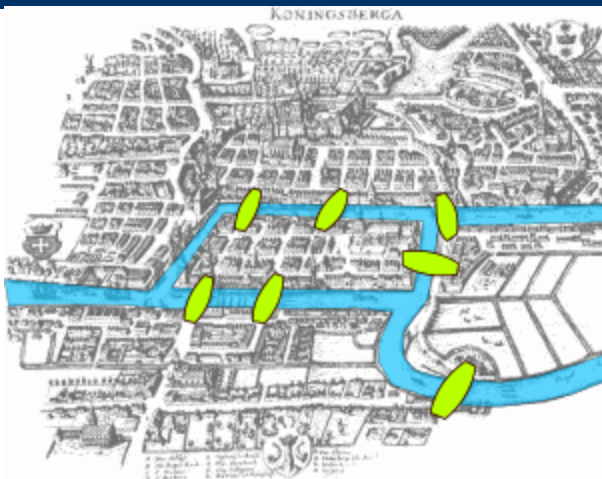Business (data flow diagram)

Engineering (digital circuit)

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Seven Bridges of Königsberg

- The problem was to find a walk through the city that would cross each bridge once and only once.

- Its negative resolution by Leonhard Euler in 1735 laid the foundations of graph theory.

- The first problem of graph theory is connected with GIS!

Graphs in GIS

- **Transportation networks**

Transportation involves the movement of people and the shipment of goods from one location to another.

- **River networks**

A hydrologic network usually models a river as a connected set of stream reaches and their confluences.

- **Utility networks**

Utility networks are the built environment that supplies energy, water, and communications and removes effluent and storm water.

Example: ArcGIS («Network Analyst»)

Main possibilities

- Finds shortest routes.

- Produces the most efficient routes for a fleet of vehicles that must visit many locations.

- Uses time windows to limit when vehicles can arrive at locations.

- Locates closest facilities.

- Etc.
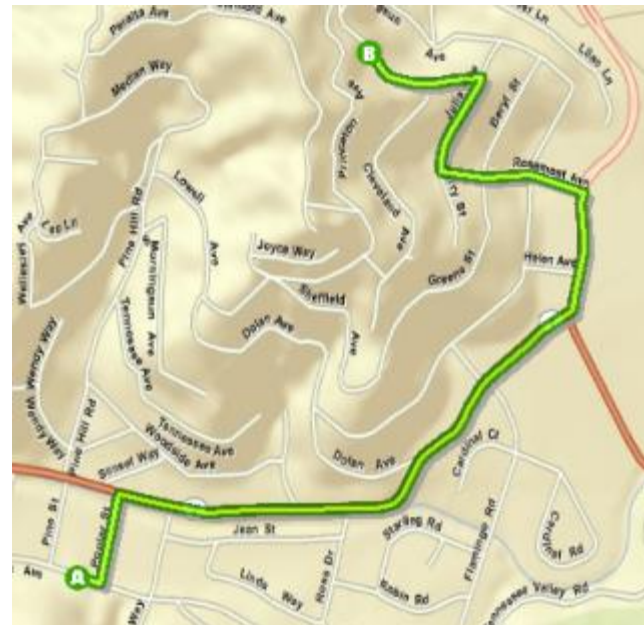
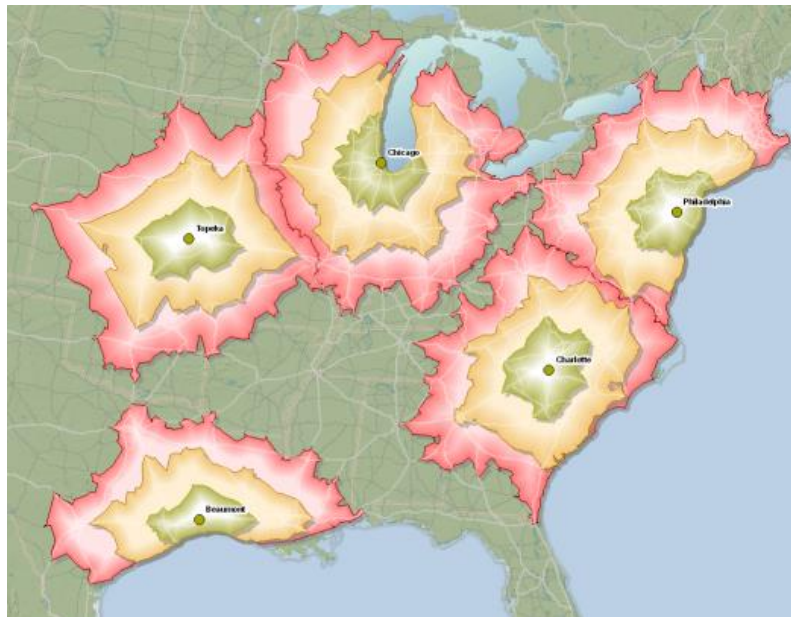# Example: Q GIS («Road Graph»)

Main possibilities

- Calculates path, as well as length and travel time.

- Optimizes by length or by travel time.

- Exports path to a vector layer.

- Highlights roads directions.
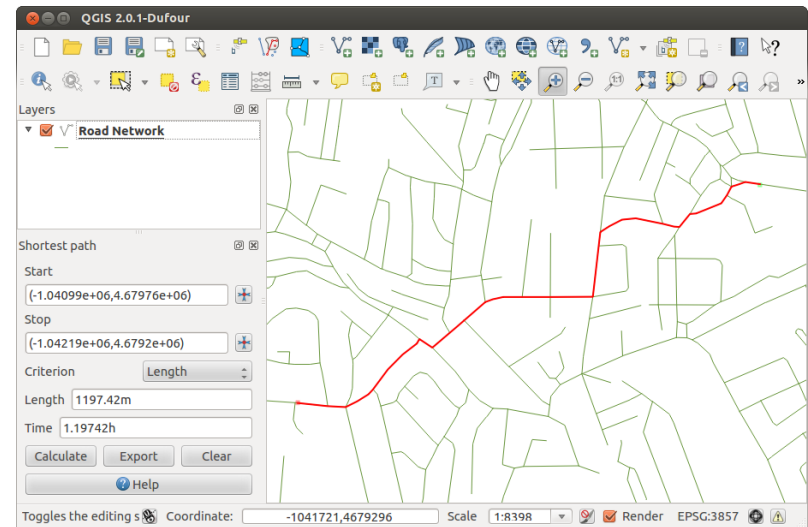
Problems

- p-centre and p-median
- Maximum flow and minimum-cost flow
- Matching
- Chinese postman and traveling salesman

# p-centre and p-median problems (NP-hard)

- Which ambulances or patrol cars can respond quickest to an incident?

- What market areas does a business cover?

- Where can a business open a store to maximize market share?

# Maximum flow and minimum-cost flow problems
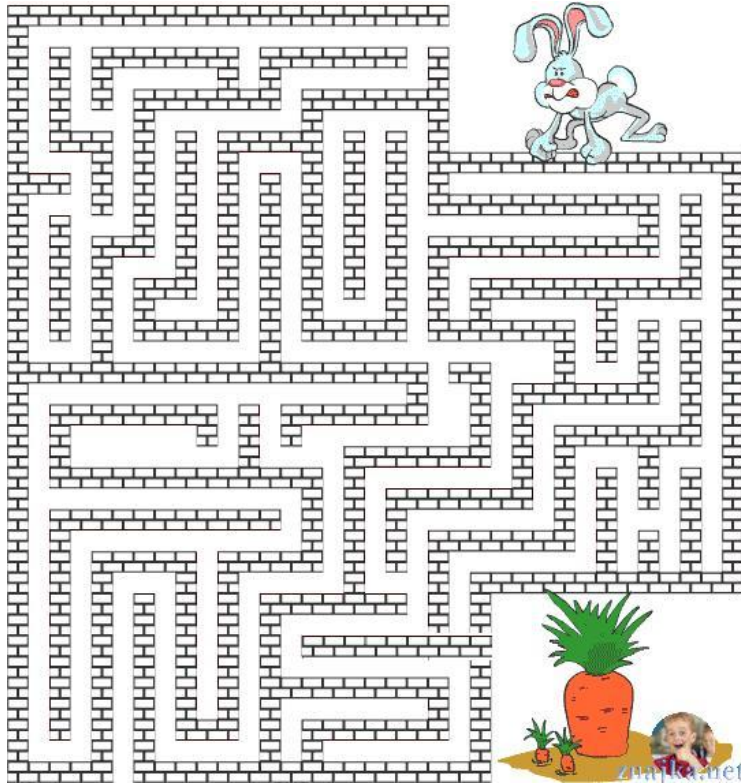
- How to find a feasible flow through a flow network that is maximum?

- How to find the cheapest possible way of sending a certain amount of flow through a flow network?

Matching problems
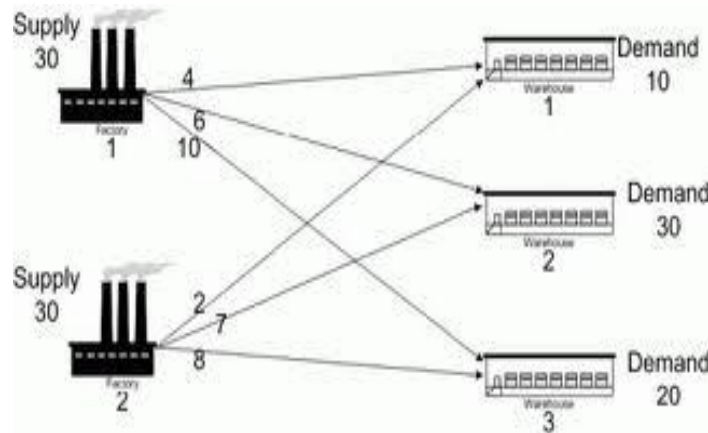
- How to assign customers to a warehouse so as to meet their demands?

- How to distribute a commodity from a group of supply centers to a group of receiving centers to minimize total cost?

Chinese Postman and Traveling Salesman problems (NP-hard)
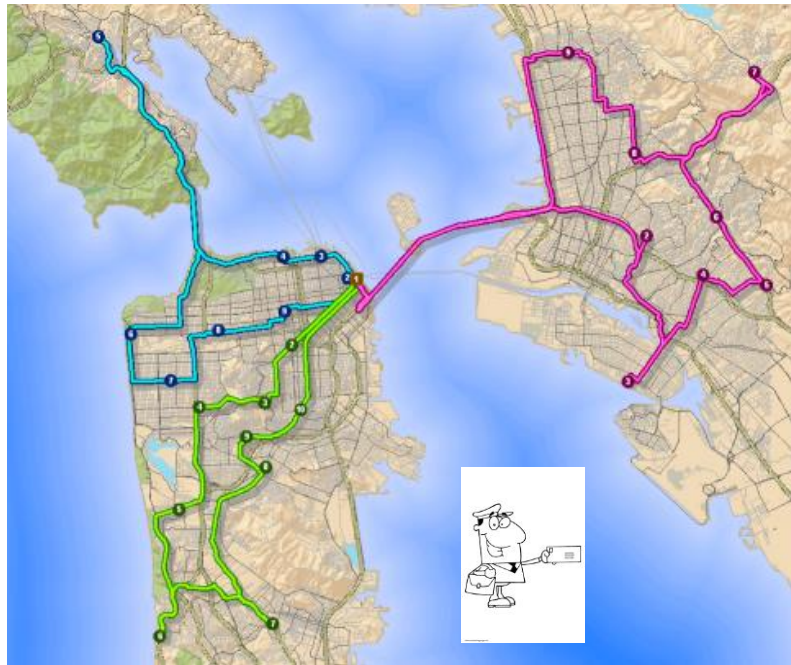
- What is the best path and sequence to visit customers?

- How to find an efficient rout for a garbage truck?

Results of education

- Notion of graph theory applications in GIS
- Knowledge of graph theory problems and basic algorithms
- Skills in algorithm developing and estimation of their quality for NP-hard problems
- Skills in reading of technical literature in English

Thank you!

Happy to answer your questions.