Graphs

\[ G = (V, E) \]

Use parentheses to denote ordered set

- \( V = \text{set of vertices} \)
  - ex: \( V = \{a_1, b_1, c_1, d_1, e_1\} \)

- \( E = \text{set of edges} \)
  - \( E \subseteq V \times V \)
  - ex: \( E = \{\{a_1, b_1\}, \{a_1, c_1\}, \{a_1, d_1\}, \{b_1, c_1\}, \{d_1, e_1\}, \{b_1, e_1\}, \{c_1, e_1\}\} \)

Each edge is a set consisting of 2 vertex elements.

Draw this Graph:

- \( \text{a} \)
- \( \text{b} \)
- \( \text{c} \)
- \( \text{d} \)
- \( \text{e} \)
Graphs:

```
Raccoon       Hawk       Owl
    Anne      Bob        Lard
Squirrel     Crow
Dave
Eve
```

- "Niche overlap graph"
  - Connection if share a food source
  - Connection if friends on Facebook

Natural questions:
- Which vertex has the largest degree (# of neighbors)? *Most omnivorous*
- Are two nodes connected? *Linked in*
- What is the shortest path from one node to another?
- What are the fewest edges one would need to remove to separate two nodes? *Cyber attack 
  railway attack*

The question that started it all:

Is there a path through the graph (starting anywhere) that takes you on each edge once?

Königsberg Bridge Problem:

Euler solved for any graph
Directed Graph
\[ G = (V, E) \]

- \( V \) = set of vertices
- \( E \) = set of edges

An edge \( e = (a, b) \) is an ordered pair of vertices.

\[ a \quad \rightarrow \quad b \]
Q. What types of websites are on the left of the bow?

- Personal websites (left)
- Company websites (right)
- Gov't websites (right)
- Facebook

If time: discuss goals, solve generalized bridge problem