Force-Directed Layout

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Graphs
Force-Directed Layout

“springs” (edges) pull nodes together

“particles” (nodes) repel each other
Springs: Hooke’s Law

these forces bring nodes together

depends upon:
spring constant \( (k) \)
and
difference between
distance between nodes (length of spring)
equilibrium, or “natural” length of the spring

\[ f = -k (\text{length} - \text{equilibriumLength}) \]

the force vector is:
\[ \mathbf{f}_{\text{edge}} = \left[ f*\text{length}_x/\text{length}, f*\text{length}_y/\text{length} \right] \]

apply equal but opposite forces to each node attached to the spring

\[ \mathbf{f}_A = \mathbf{f}_A + \mathbf{f}_{\text{edge}} \]
\[ \mathbf{f}_B = \mathbf{f}_B - \mathbf{f}_{\text{edge}} \]
Nodes: Coulomb’s Law

these forces repel all nodes in the graph from each other

repulsion between nodes A and B depends upon:
  a constant $c$ (usually Coulomb’s constant in physics)
  mass of A and B
  distance between A and B

$$f = c \times \text{mass}_A \times \text{mass}_B / \text{distance}^2$$

$$\mathbf{f}_{A\text{from}B} = [f \times -\text{dist}_X, f \times -\text{dist}_Y]$$

$$\mathbf{f}_A = \mathbf{f}_A + \mathbf{f}_{A\text{from}B}$$

calculate this force for all nodes in the graph from all other nodes in the graph (whether they are linked or not)
Move nodes

To apply a force $\mathbf{f}$ on a node with position $\mathbf{p}$

$$\mathbf{p} = \mathbf{p} + \mathbf{f}$$

Tweak the layout

You can play with the values of the spring constant, the equilibrium length, and Coulomb’s constant to see how they affect the layout.
Exercises

Fill in the methods inside Spring.java to calculate Hooke’s law and normalized vectors.

\[ f = k \times (\text{length} - \text{equilibriumLength}) \]

Fill in the method inside FDLayoutDriver.java to calculate Coulomb’s law.

\[ f = 100 \times \text{mass1} \times \text{mass2} / \text{length}^2 \]

Fill in the section inside FDLayoutDriver.java that applies Forces.

--> See your graph layout!

Add Interaction
- hover
- drag nodes and see them re-layout

Play with the parameters (spring constant, equilibrium)

Try the random graph and the planar graph.