Reminders

- Assignment 10 is due Monday, April 3rd at 9:00pm.
- There will be a review session, the time and location will be posted on Piazza.
- Do not forget to participate in the poll on Piazza to choose suitable time for a review session.

Review: Graph Terminology

An edge is an ordered pair of nodes, which we can represent by an arrow from one node to another.

Given an edge \((v, w)\), we say that \(w\) is an out-neighbor of \(v\), and \(v\) is an in-neighbor of \(w\).

A sequence of nodes \(v_1, v_2, \ldots, v_k\) is a route or path of length \(k - 1\) if \((v_1, v_2), (v_2, v_3), \ldots, (v_{k-1}, v_k)\) are all edges. If \(v_1 = v_k\), this is called a cycle.

Directed graphs without cycles are called DAGs (directed acyclic graphs).
Review: Adjacency List Representation

We can represent a graph as a list of pairs, each pair consisting of a symbol (the node's name) and a list of symbols (the names of the node's out-neighbours).

This is called the adjacency list representation.

Example:

```
((A (B C D))
 (B (E F))
 (C (E))
 (D (F H G))
 (E ())
 (F (H))
 (H ())
 (G ()))
```

Clicker Question - count-edges

How many edges are there in the following graph?

```
((A (C F))
 (B ())
 (C (B))
 (D (A B E))
 (E ())
 (F (B C G))
 (G (D)))
```

A 5
B 7
C 10
D 17
Clicker Question - Cycles in Explicit Graphs

Is there a cycle in this adjacency list representation of a graph?

```
((A (C F))
(B ())
(C (B))
(D (A B E))
(E ())
(F (B C G))
(G (D)))
```

A  Yes
B  No

Group Problem - count-edges

Write a function `count-edges` that consumes a `(listof (list Sym (listof Sym)))` representing a graph, and produces the number of edges in the graph. Include a contract.

```
(check-expect (count-edges
  '((A (C F))
    (B ())
    (C (B))
    (D (A B E))
    (E ())
    (F (B C G))
    (G (D)))) 10)
```

Network Union

Given the following data definition of a SocialNetwork, write a function `network-union` that consumes two SocialNetworks, twitter and instagram, and produces a SocialNetwork with all the users and following connections of twitter and instagram. The produced SocialNetwork should not have any duplicate users or following connections.

```
;; A SocialNetwork is a (listof (list User Following))
;; A User is a Sym
;; A Following is a (listof User)
```
Network Union-Example

```scheme
(define tweet '((IronMan (Batman))
  (Spiderman (IronMan Batman))
  (Batman ()))
  (Don (Vlad))
  (Vlad (Don))))

(define inst '((IronMan (BlackWidow))
  (Spiderman (Ironman BlackWidow))
  (BlackWidow ())
  (Don (Vlad))
  (Vlad (Don))))

(check-expect (network-union twitter instagram)
  '((IronMan (Batman BlackWidow))
    (Spiderman (IronMan Batman BlackWidow))
    (Batman ()))
    (BlackWidow ())
    (Don (Vlad))
    (Vlad (Don))))
```

Group Problem - cyclic?

Write a function cyclic? which consumes a Graph and produces true if a cycle exists in the graph and false otherwise. You may assume the function neighbours from module 12 slide 13 has been defined.

Challenge problem: Use abstract list functions in your code.