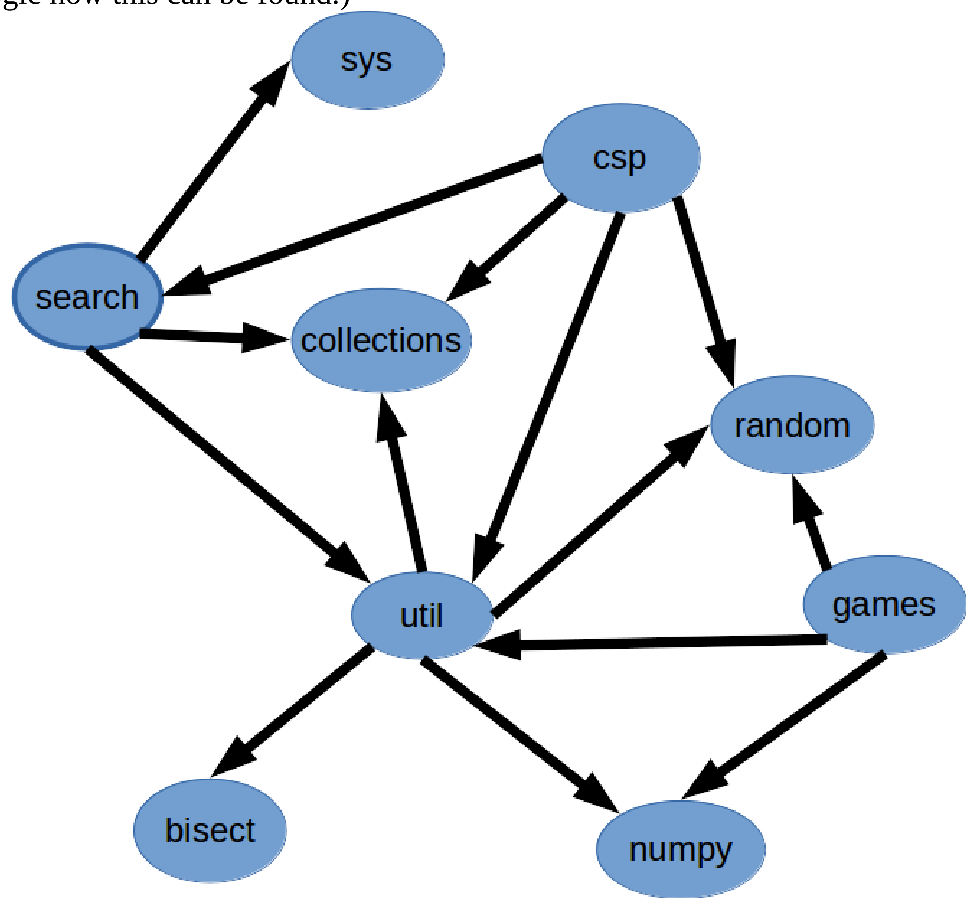
4511W, Fall-2021
ASSIGNMENT 5:
Assigned: 11/23/21 Due: 11/30/21 at 11:55 PM (submit on gradescope, mark the page(s) associated for each problem when submitting). Show work for full credit.

Problem 1. (20 points)
In CSCI quite often you import a library to use another person's code (no reason to "re-invent the wheel"). However, these libraries can themselves import from another library and so in in a recursive fashion. For example, our search.py in the AIMA code imports from: sys, collections, and utils. utils.py (also in the AIMA folder) then recursively imports from bisect, collections (again), ... and quite a few others.

Suppose we had a dependency/import structure as given in the picture below (simplified).
(1) Suppose you were going to import "search" and "csp" in your original program. How would you represent this import/dependency problem in propositional logic (for the whole picture shown).

(2) How can you tell whether or not you will import (recursively or directly) any given library? Give an example of how you would tell if "numpy" was imported. (Note: you do not need to solve this, rather just state in logic how this can be found.)



Problem 2. (10 points)
Convert the following propositional logic sentences into conjunctive normal form (CNF):

(1) $A \vee ((B \wedge C) \Rightarrow D) \equiv A \vee (B \wedge C \Rightarrow D)$

(2) $A \Rightarrow (B \Rightarrow (C \wedge D)) \equiv A \Rightarrow (B \Rightarrow C \wedge D)$

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Problem 3. (30 points)
Suppose you had a KB with the following sentences:
$A \vee \neg B \vee \neg C$
$B \vee C$
$\neg A \vee B \vee \neg C$
$C \vee D$
$\neg A \vee \neg B \vee \neg D$

Use resolution to find whether or not the following sentences (α) are entailed by KB or not:
(1) $\alpha = \neg A \wedge B$
(2) $\alpha = \neg A \vee \neg D$
(3) $\alpha = \neg A \vee \neg B \vee \neg C$

Problem 4. (20 points)
Convert the following English sentences into first order logic. Use only the following relations:
Believes(x,y), Favorite(x), Good(x), Person(x), Present(x), Santa(x)

(1) “Someone in the world believes in Santa”
(2) “Santa brings presents to all good people”
(3) “Santa brings coal (not a present) to all bad people”
(4) “Everyone has a favorite present”
(5) “There are at least two good people in the world”

Problem 5. (20 points)
Use backward chaining to determine if (KB on next page):
$KB \models \exists x\ P(x)$?

KB = {
$\forall x\ A(x) \land B(x) \Rightarrow C(x)$
$\forall x\ A(x) \land D(x) \Rightarrow E(x)$
$\forall x\ A(x) \Rightarrow D(x)$
$\forall x\ B(x) \land D(x) \Rightarrow F(x)$
$\forall x\ B(x) \land C(x) \Rightarrow D(x)$
$\forall x\ B(x) \land C(x) \land E(x) \Rightarrow G(x)$
$\forall x\ C(x) \Rightarrow F(x)$
$\forall x\ C(x) \land D(x) \land E(x) \Rightarrow G(x)$
$\forall x\ E(x) \land F(x) \Rightarrow G(x)$
$\exists x\ A(x)$
$\forall x\ J(x) \land K(x) \Rightarrow L(x)$
$\forall x\ J(x) \Rightarrow M(x)$
$\forall x\ J(x) \land M(x) \Rightarrow N(x)$
$\forall x\ K(x) \land L(x) \land O(x) \Rightarrow P(x)$
$\forall x\ K(x) \land L(x) \land M(x) \land O(x) \Rightarrow P(x)$
$\forall x\ K(x) \land O(x) \Rightarrow N(x)$
$\forall x\ L(x) \Rightarrow O(x)$
$\forall x\ L(x) \land O(x) \Rightarrow M(x)$
$\forall x\ M(x) \land O(x) \land N(x) \Rightarrow P(x)$
$J(Rabbit)$
$K(Rabbit)$
$\forall x\ R(x) \Rightarrow T(x)$
$\forall x\ R(x) \land T(x) \Rightarrow S(x)$
$\forall x\ R(x) \land U(x) \Rightarrow V(x)$
$\forall x\ T(x) \land S(x) \land U(x) \Rightarrow V(x)$
$\forall x\ U(x) \land V(x) \Rightarrow W(x)$
$\forall x\ U(x) \land W(x) \Rightarrow V(x)$
$\exists x\ R(x)$
$\forall x\ B(x) \land U(x) \land X(x) \Rightarrow Z(x)$
$\forall x\ C(x) \land K(x)(x) \Rightarrow Z(x)$
$\forall x\ D(x) \land K(x) \Rightarrow Z(x)$
$\forall x\ G(x) \land P(x) \land W(x) \Rightarrow X(x)$
$\forall x\ G(x) \land P(x) \land R(x) \Rightarrow Y(x)$
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