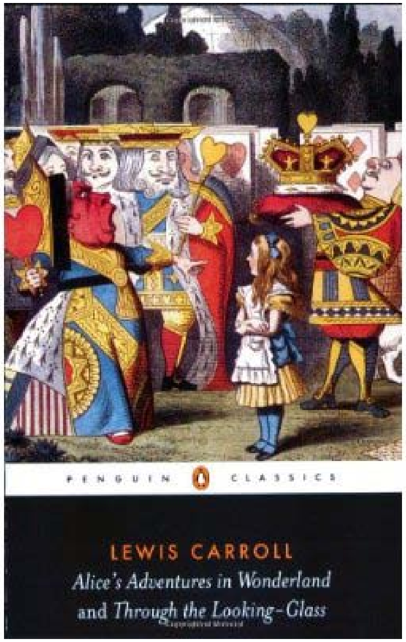
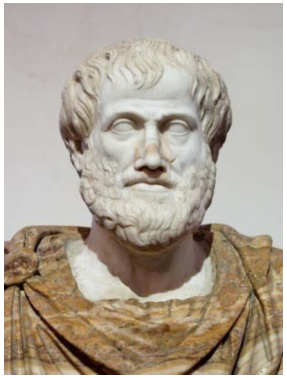
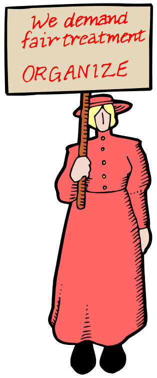




COMP2000

Lecture 5 (last)

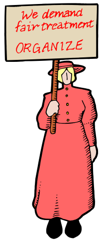


Logic: All, None, Some, and NOT

Admin stuff

- Quiz next Thursday, study guide to be posted by Monday.
- No lecture Tuesday: midterm break
- Lab questions?

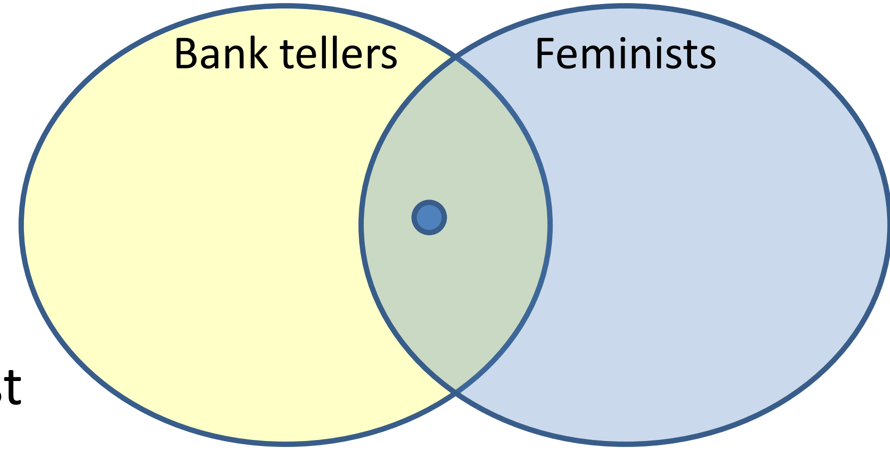
Probabilities and logic



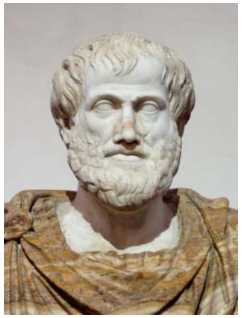
- Susan is 28 years old, single, outspoken, and very bright. She majored in philosophy. As a student she was deeply concerned with issues of discrimination and social justice and also participated in anti-nuke demonstrations.

  Please rank the following possibilities by how likely they are. List them from least likely to most likely.

1. a kindergarden teacher
2. works in a bookstore and takes yoga classes
3. an active feminist
4. a psychiatric social worker
5. a member of the Sierra club
6. a bank teller
7. an insurance salesperson
8. a bank teller and an active feminist



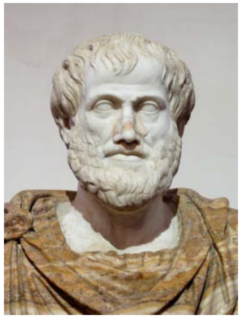
Universal Modus Ponens



- All men are mortal
- Socrates is a man
- Therefore, Socrates is mortal

- All cats like fish
- Molly likes fish
- Therefore, Molly is a cat

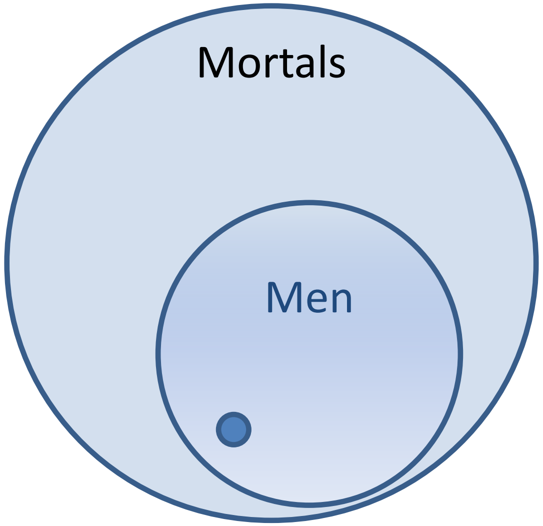
Universal Modus Ponens



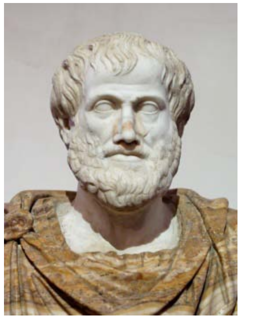
- All men are mortal
- Socrates is a man
- Therefore, Socrates is mortal

- All numbers are either odd or even
- 2 is a number
- Therefore, 2 is either odd or even.

- All trees drop leaves
- Pine does not drop leaves
- Therefore, pine is not a tree

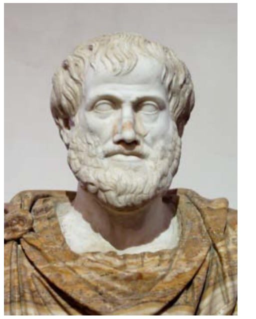


Negating the universal



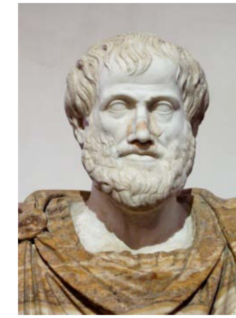
- What is the opposite of “All”?
  - All girls hate math.
  - No!
    - All girls love math?
    - Some girls do not hate math!
  - Everybody in O’Brian family is tall
    - No, Jenny is O’Brian and she is quite short.
  - It is foggy all the time, every day in St. John’s
    - No, sometimes it is not foggy (like today).

Negating the universal

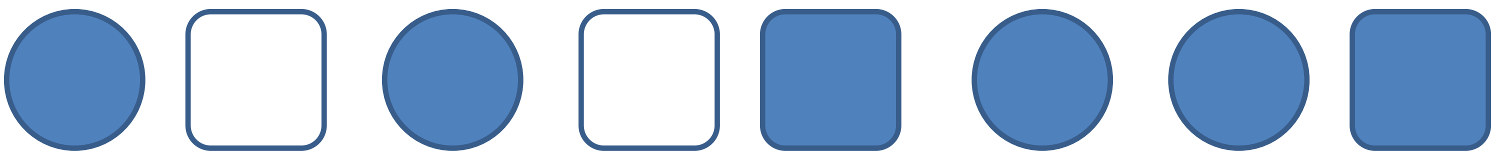


- What is the opposite of “All”? $\forall$
- The negation of “All” is “Some” $\exists$
- “Some” may include all, but not necessarily.
- “Nobody” is not a negation of “All”
  - You wouldn’t say “it is never foggy in St. John’s” when somebody tells you it is always foggy. Sometimes it is, sometimes it isn’t.
  - $\forall$ x (if x is a number, then x is even or odd.)
  - $\exists$ x (x is a number and x is prime)
- Negation of $\forall$ is $\exists$, and negation of $\exists$ is $\forall$
  - Also, negation of -> is /\

Tricky universals

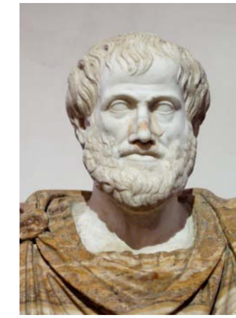


- Which statements are true?
  - All squares are white. All white shapes are squares
  - All circles are blue. All blue shapes are circles.



  - All lemurs live in the trees. All animals living in the trees are lemurs.

“NOT” makes life harder



- It is easy to visualize a tree, or a person
- It is harder to visualize a “not tree” or “not person”
- So “NOT (ALL trees have leaves)” is harder to understand than “some trees have something other than leaves (e.g., needles).
- Multiple negatives make it even harder
  – I vote against repealing the ban on smoking in public.
    - Do I like smoking in public?

Mixing quantifiers

- We can make statements of predicate logic mixing existential and universal quantifiers.
  - Predicate: X loves Y
  - Everybody loves somebody: $\forall$ X $\exists$ Y (X loves Y)
    - Normal people
  - Somebody loves everybody: $\exists$ X $\forall$ Y (X loves Y)
    - Mother Teresa
  - Everybody is loved by somebody $\forall$ X $\exists$ Y (Y loves X)
    - Their mother
  - Somebody is loved by everybody $\exists$ X $\forall$ Y (Y loves X)
    - Elvis Presley

Negating mixed quantifiers

- Now, a "not" in front of such a sentence means all $\forall$ and $\exists$ are interchanged, and the inner part becomes negated.
  - Predicate: X loves Y
  - Everybody loves somebody: $\forall$ X $\exists$ Y (X loves Y)
    - Somebody does not love anybody $\exists$ X $\forall$ Y NOT(X loves Y)
  - Somebody loves everybody: $\exists$ X $\forall$ Y (X loves Y)
    - Everyone doesn't like somebody $\forall$ X $\exists$ Y NOT(X loves Y)
  - Everybody is loved by somebody $\forall$ X $\exists$ Y (Y loves X)
    - Somebody is not loved by anybody $\exists$ X $\forall$ Y NOT(Y loves X)
  - Somebody is loved by everybody $\exists$ X $\forall$ Y (Y loves X)
    - Everyone is not loved by somebody $\forall$ X $\exists$ Y NOT(Y loves X)

Logic summary

- Propositional logic: A, B are either true or false
  - A and B: true if both are true
  - A or B: true if at least one is true
  - Not A: true if A is false
  - If A then B: true if either A is false, or both are true (equivalent to (not A or B).
- Predicate logic: Predicates are propositions with parameters: e.g., Odd(x) means number x is odd.
  - Universal quantifier: $\forall$ x Odd(x) – all x are odd.
  - Existential quantifier: $\exists$ x Odd(x) – some x is odd.

How do computers reason?

- They use logic (like one that we just studied)
  - For example, for relationships between concepts: if it is an animal, then it is alive.
- They use probabilities (which scenarios are more likely than other?)
- Fancy machine learning algorithms
- Example: IBM's "Watson" winning Jeopardy game.
- More to come...