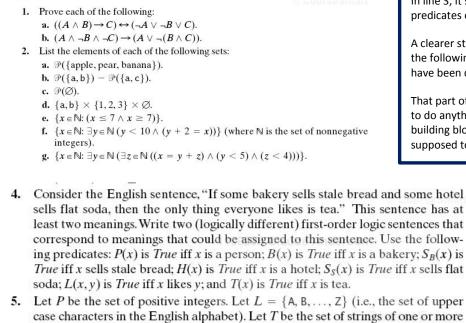
## Former 474 HW 1 problems, now optional HW0 (highlighted problems were the ones to turn in)



- upper case English characters. Define the following predicates over those sets. • For  $x \in L$ , V(x) is *True* iff x is a vowel. (The vowels are A, E, I, O, and U.)
- For  $x \in L$  and  $n \in P$ , S(x, n) is *True* iff x can be written in n strokes.

## <mark>A.4, A.5</mark>

A.1 A.2

- For  $x \in L$  and  $s \in T$ , O(x, s) is *True* iff x occurs in the string s.
- For  $x, y \in L$ , B(x, y) is *True* iff x occurs before y in the English alphabet.
- For  $x, y \in L$ , E(x, y) is True iff x = y.

Using these predicates, write each of the following statements as a sentence in first-order logic:

- **a.** A is the only upper case English character that is a vowel and that can be written in three strokes but does not occur in the string STUPID.
- **b.** There is an upper case English character strictly between K and R that can be written in one stroke
- 6. Choose a set A and predicate P and then express the set {1, 4, 9, 16, 25, 36, ... } in the form:

 $\{x \in A : P(x)\}.$ 

- 7. Find a set that has a subset but no proper subset.
- 8. Give an example, other than one of the ones in the book, of a reflexive, symmetric, intransitive relation on the set of people.
- 9. Not equal (defined on the integers) is (circle all that apply): reflexive, symmetric, transitive.
- A.6-A.9
  - 11. Using the definition of  $\equiv_p$  (equivalence modulo p) that is given in Example A.4, let  $R_p$  be a binary relation on  $\mathbb{N}$ , defined as follows, for any  $p \ge 1$ :

## $R_p = \{(a, b): a \equiv_p b\}.$

So, for example  $R_3$  contains (0, 0), (6, 9), (1, 4), etc., but does not contain (0, 1), (3, 4), etc.

- **a.** Is  $R_p$  an equivalence relation for every  $p \ge 1$ ? Prove your answer.
- **b.** If  $R_p$  is an equivalence relation, how many equivalence classes does it induce for a given value of p? What are they? (Any concise description is fine.)
- **c.** Is  $R_p$  a partial order? A total order? Prove your answer.

## Note on problem A.5:

In line 3, it says, "Define the following predicates over those sets."

A clearer statement would be "Assume that the following predicates over those sets have been defined."

That part of the problem is not asking you to do anything; instead it is giving you the building blocks to use for what you are supposed to do, which is parts a and b.

<mark>A.11</mark>

A 12-13a. Choose a small subset of Subsympt A.5. b. Is Subsympt A.5. b. Is Subsympt A.5. b. Is Subsympt A.5. p. Is Subsympt A.5. <th></th> <th>12. Let <math>S = \{w \in \{a, b\}^*\}</math>. Define the relation Substring of <math>t\}</math>.</th> <th></th>		12. Let $S = \{w \in \{a, b\}^*\}$ . Define the relation Substring of $t\}$ .		
13. Let P be the set of people. Define the function:Claude Andersonfather-of: $P \rightarrow P$ . father-of: $P \rightarrow P$ . father-of: $P \rightarrow P$ . father-of: $P \rightarrow P$ . 	A 12-13	<ul> <li>we drew the graph of Example A.5).</li> <li>b. Is Substr a partial order?</li> <li>13. Let P be the set of people. Define the function:</li> <li>father-of: P → P.</li> <li>father-of(x) = the person who is x's father</li> </ul>		
father-of: $P \rightarrow P$ . father-of (x) = the person who is x's fathera. Is father-of one-to-one? b. Is it onto?b. Is it onto?b. Is it onto?a. The negative integers under subtraction. b. The negative integers under division. c. The positive integers under exponentiation. d. The finite sets under cartesian product. The odd integers under andider.A 14.Part d for turnina. The negative integers under exponentiation. d. The finite sets under cartesian product. The odd integers under remainder, mod 3. f. The rational numbers under addition.A 15A 15A 15A 16A 16b. The intersection of two countably infinite sets can be finite. b. The intersection of two countable sets can be countably infinite. c. The intersection of two ouncountable sets can be uncountable.A 17A 17A 18A 18, A19A 18, A19A 18, A19A 18, A19A 192 for turnin20. Prove that the set of rational numbers is countably infinite. c. $\eta \in N: n = _30$ $) \subset (n \in N: n is prime).c. \eta \in N: n = _30 ) \subseteq (n \in N: n is prime).c. \eta \in N: n = _30 ) \subseteq (n \in N: n is prime).c. \eta \in N: n = _30 ) \subseteq (n \in N: n is prime).c. \eta \in N: n = _30 ) \subseteq (n \in N: n is prime).c. \eta \in N: n is prime).A 19A 19A 19A 10A 10A 110A 111A 111A 112A 112A 113A 113A 114A 115A 115A 115A 116<$				
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A 14.Is it onto?A 14.If Are the following sets closed under the following operations? If not, give an example that proves that they are not and then specify what the closure is a. The negative integers under division. b. The negative integers under Cartesian product. d. The finite sets under Cartesian product. Here at our and the sets and the set of finite sets under" I.e., is the Cartesian product of two finite sets always a finite set?A 15.A 15.A 15.Give examples to show that: a. The intersection of two countably infinite sets can be finite. b. The intersection of two ouncountable sets can be countably infinite. c. The intersection of two uncountable sets can be countably infinite. c. The intersection of two uncountable sets can be countably infinite. c. The intersection of two uncountable sets can be countably infinite. c. The intersection of two uncountable sets can be countably infinite. c. The intersection of two uncountable sets can be uncountable.A 15.If Let R = {(1, 2), (2, 3), (3, 5), (5, 7), (7, 11), (11, 13), (4, 6), (6, 8), (8, 9), (9, 10), (10, 12). Draw a directed graph representing R*, the reflexive, transitive closure of R.A17.If Let N be the set of nonnegative integers. For each of the following sentences in first-order logic, state whether the sentence is valid, is not valid but is satifiable, or is unsatifiable. Assume the standard interpretation for < and >. Assume that fould be any function on the integers. Prove your answer. a. $\forall x \in \mathbb{N} (\exists y \in \mathbb{N} (y < x))$ b. $\forall x \in \mathbb{N} (\exists y \in \mathbb{N} (y < x))$ b. $\forall x \in \mathbb{N} (\exists y \in \mathbb{N} (y < x))$ c. $\forall x \in \mathbb{N} (\exists y \in \mathbb{N} (x) = y)$ A18, A19IN that is the cardinality of each of the following sets? Prove your answer. a. $\{n \in \mathbb{N} : n = _30\}$ h. $\{n \in \mathbb{N} : n = _30\} \cap \{n \in $				
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A1716. Let $R = \{(1, 2), (2, 3), (3, 5), (5, 7), (7, 11), (11, 13), (4, 6), (6, 8), (8, 9), (9, 10), (10, 12)\}$ . Draw a directed graph representing $R^*$ , the reflexive, transitive closure of $R$ .A1717. Let N be the set of nonnegative integers. For each of the following sentences in first-order logic, state whether the sentence is valid, is not valid but is satisfiable, or is unsatisfiable. Assume the standard interpretation for $<$ and $>$ . Assume that $f$ could be any function on the integers. Prove your answer.a. $\forall x \in \mathbb{N} (\exists y \in \mathbb{N} (y < x))$ b. $\forall x \in \mathbb{N} (\exists y \in \mathbb{N} (y > x))$ b. $\forall x \in \mathbb{N} (\exists y \in \mathbb{N} f(x) = y)$ 18. Let N be the set of nonnegative integers. Let $A$ be the set of nonnegative integers $x$ such that $x =_3 0$ . Show that $ \mathbb{N}  =  A $ .A18, A1919. What is the cardinality of each of the following sets? Prove your answer.a. $\{n \in \mathbb{N} : n =_3 0\}$ b. $\{n \in \mathbb{N} : n \equiv_3 0\} \cap \{n \in \mathbb{N} : n \text{ is prime}\}$ c. $\{n \in \mathbb{N} : n =_3 0\} \cup \{n \in \mathbb{N} : n \text{ is prime}\}$ 20. Prove that the set of rational numbers is countably infinite.				
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