General

Read through the “Background” section below, then copy and paste the questions out of the “Assignment” section into your word processor and answer the questions. Turn in the questions using the instructions posted on the class web site.

At the top of the every document that you create (word processing or source files) include:

# **// Your name**

**// CS-160, Lab #X** (replace the X with the Lab #)

**// xxxx Term, 20xx** (i.e. Winter Term, 2007)

For ALL Word processing documents, you must submit your documents in one of the following formats: MS-Word (NOT Works), RTF (most word processors can save in this format), or Open Document (used by the freely available Open Office suite). They will be returned ungraded if submitted in any other format.

**Concepts**

This lab will help you review the concepts presented in the algorithms and programming modules. These modules introduce you to several concepts important for understanding and expressing algorithms. You will start with an introduction to a basic problem solving technique (“enumeration” or sometimes known as “brute force”). Then you will gain some experience with reading and writing ***psuedocode*** which is one method of expressing an algorithm. Finally you will use the “Scratch” programming environment and tutorials to give you some experience with implementing algorithms as programs.

**Background**

*Note: Original source of the background contained below is from the “CS160 Worksheets” by Daniel Balls of the CS department at Oregon State University; updated and revised by Mitch Fry (CS, Chemeketa Community College).*

**Problem-Solving By Enumeration**

(aka “brute force” techniques)

The ability to solve problems is important in many disciplines, including computer programming. Computer programmers seek to obtain effective and efficient to perform desired tasks. Let’s elaborate on three important terms in the previous sentence: algorithm, effective, and efficient. “An algorithm is an ordered set of unambiguous, executable steps that defines a terminating process” (Brookshear, *Computer Science: An Overview*, 2007). An algorithm is effective if it finds the solution (or a close enough approximation). An algorithm is efficient if the number of steps it performs is reasonable.

In this worksheet and the ones to follow, we will explore several important problem-solving strategies. It should be noted that there is no single set of rules that, if followed, always leads to an effective and efficient algorithm. In fact, problem solving relies so much on creativity and ingenuity that some people regard computer programming as an art form! Looking for better algorithms can be a lot of fun. With this in mind, think of the following worksheets as an opportunity to develop your own creative problem-solving techniques.

The first technique we are going to explore is called *enumeration*. Some types of problems have many possible solutions that are partially correct, but only one that satisfies all the criteria outlined. Enumeration means listing each of the possibilities and then systematically eliminating those that don’t fit the requirements set out in the statement of the problem.

To illustrate problem-solving by enumeration , let’s look at an example. Boronoff, Pavlow, Revistsky, and Sukarek are individuals who work in different fields of the arts and humanities: one is a painter, one is a writer, one a dancer, and one is a singer. Using the information below, determine the profession of each of these four people.

1. *Boronoff and Revitsky were both in the audience the night the singer made his debut on the concert stage.*
2. *The writer’s biography of Sukarek was a best seller. He also wants to write Boronoff’s biography, but hasn’t met him yet.*
3. *Both Pavlow and the writer have sat for portraits by the painter.*
4. *Boronoff has never heard of Revitsky.*

To solve this problem by the enumeration technique, we will begin by listing all possible combinations of the individuals and their professions:

|  |  |  |  |
| --- | --- | --- | --- |
| **Dancer** | **Singer** | **Painter** | **Writer** |
| Revitsky | Pavlow | Boronoff | Sukarek |
| Revitsky | Pavlow | Sukarek | Boronoff |
| Revitsky | Sukarek | Boronoff | Pavlow |
| Revitsky | Sukarek | Pavlow | Boronoff |
| Revitsky | Boronoff | Pavlow | Sukarek |
| Revitsky | Boronoff | Sukarek | Pavlow |
| Sukarek | Pavlow | Boronoff | Revitsky |
| Sukarek | Pavlow | Revitsky | Boronoff |
| Sukarek | Revitsky | Boronoff | Pavlow |
| Sukarek | Revitsky | Pavlow | Boronoff |
| Sukarek | Boronoff | Pavlow | Revitsky |
| Sukarek | Boronoff | Revitsky | Pavlow |

|  |  |  |  |
| --- | --- | --- | --- |
| **Dancer** | **Singer** | **Painter** | **Writer** |
| Boronoff | Pavlow | Revitsky | Sukarek |
| Boronoff | Pavlow | Sukarek | Revitsky |
| Boronoff | Sukarek | Revitsky | Pavlow |
| Boronoff | Sukarek | Pavlow | Revitsky |
| Boronoff | Revitsky | Pavlow | Sukarek |
| Boronoff | Revitsky | Sukarek | Pavlow |
| Pavlow | Boronoff | Revitsky | Sukarek |
| Pavlow | Boronoff | Sukarek | Revitsky |
| Pavlow | Sukarek | Revitsky | Boronoff |
| Pavlow | Sukarek | Boronoff | Revitsky |
| Pavlow | Revitsky | Boronoff | Sukarek |
| Pavlow | Revitsky | Sukarek | Boronoff |

Now we’ll use the clues to eliminate those possibilities that do not meet the first criterion. Since Boronoff and Revitsky were both in the audience when the singer was on stage, neither of them can be the singer. Therefore we will cross out (i.e. eliminate) each row in which either Boronoff or Revitsky is the singer, as shown below.



The second piece of information lets us know that the writer must be someone other than Boronoff or Sukarek. Therefore we will eliminate any row in which Boronoff or Sukarek is the writer, as shown below.



The third sentence informs us that Pavlow is neither the writer nor the painter and we will eliminate the rows in which Pavlow is the writer or the painter, as shown below.



After these three rows have been eliminated, we are left with only two rows: one in which Boronoff is the dancer and Revitsky is the writer (option A), and one in which Boronoff is the painter and Revitsky is the writer (option B). It is clear that Revitsky is the writer, and, according to the third piece of information, Revitsky sat for a portrait by the painter (who is Boronoff if option B is true). The last clue, however, states that Boronoff has never heard of Revitsky, which means option B cannot be true. Thus Boronoff must be the dancer, Pavlow is the singer, Revitsky is the writer, and Sukarek is the painter.

**PSEUDOCODE STANDARD**(Adopted from Dr. John Dalbey, Cal Poly Computer Science Department)

Pseudocode is a kind of structured english for describing algorithms. It allows the designer to focus on the logic of the algorithm without being distracted by details of language syntax.  At the same time, the pseudocode needs to be complete.  It describe the entire logic of the algorithm so that implementation becomes a rote mechanical task of translating line by line into source code.

In general the vocabulary used in the pseudocode should be the vocabulary of the problem domain, not of the implementation domain.  The pseudocode is a narrative for someone who knows the requirements (problem domain) and is trying to learn how the solution is organized.

Extract the next word from the line (good)   
set word to get next token (poor)

Append the file extension to the name (good)   
name = name + extension (poor)

FOR all the characters in the name (good)   
FOR character = first to last (ok)

Note that the logic must be decomposed to the level of a single loop or decision. Thus "Search the list and find the customer with highest balance" is too vague because it takes a loop AND a nested decision to implement it. It's okay to use "Find" or "Lookup" if there's a predefined function for it such as String.indexOf().

Each textbook and each individual designer may have their own personal style of pseudocode. Pseudocode is not a rigorous notation, since it is read by other people, not by the computer. There is no universal "standard" for the industry, but for instructional purposes it is helpful if we all follow a similar style. However, in ALL pseudocode styles, ***INDENTATION is VITAL*** in communicating the blocks of operations that are nested within each of the structures described in the following sections.

The "structured" part of pseudocode is a notation for representing six specific structured programming constructs: SEQUENCE, WHILE, IF-THEN-ELSE, REPEAT-UNTIL, FOR, and CASE. Each of these constructs can be embedded inside any other construct. These constructs represent the logic, or flow of control in an algorithm.

It has been proven that three basic constructs for flow of control are sufficient to implement any "proper" algorithm.

1. **SEQUENCE** is a linear progression where one task is performed sequentially after another.
2. **WHILE** is a loop (repetition) with a simple conditional test at its beginning.
3. **IF-THEN-ELSE** is a decision (selection) in which a choice is made between two alternative courses of action.

Although these constructs are sufficient, it is often useful to include three more constructs:

1. **REPEAT-UNTIL** is a loop with a simple conditional test at the bottom.
2. **CASE** is a multiway branch (decision) based on the value of an expression. CASE is a generalization of IF-THEN-ELSE.
3. **FOR** is a "counting" loop.

**SEQUENCE**

Sequential control is indicated by writing one action after another, each action on a line by itself, and all actions aligned with the same indent. The actions are performed in the sequence (top to bottom) that they are written.

Example

Example (non-computer)   
Brush teeth   
Wash face   
Comb hair   
Smile in mirror

Example

READ height of rectangle   
READ width of rectangle   
COMPUTE area as height times width

Common Action Keywords

Several keywords are often used to indicate common input, output, and processing operations.

Input: READ, OBTAIN, GET   
Output: PRINT, DISPLAY, SHOW   
Compute: COMPUTE, CALCULATE, DETERMINE   
Initialize: SET, INIT   
Add one: INCREMENT, BUMP

**WHILE**

The WHILE construct is used to specify a loop with a test at the top. The beginning and ending of the loop are indicated by two keywords WHILE and ENDWHILE. The general form is:

WHILE condition

sequence

ENDWHILE

The loop is entered only if the condition is true. The "sequence" is performed for each iteration. At the conclusion of each iteration, the condition is evaluated and the loop continues as long as the condition is true.

Example

WHILE Population < Limit

Compute Population as Population + Births - Deaths

ENDWHILE

Example

WHILE employee.type NOT EQUAL manager AND personCount < numEmployees

INCREMENT personCount  
CALL employeeList.getPerson with personCount RETURNING employee

ENDWHILE

**IF-THEN-ELSE**

Binary choice on a given Boolean condition is indicated by the use of four keywords: IF, THEN, ELSE, and ENDIF. The general form is:

IF condition THEN

sequence 1

ELSE

sequence 2

ENDIF

The ELSE keyword and "sequence 2" are optional. If the condition is true, sequence 1 is performed, otherwise sequence 2 is performed.

Example

IF HoursWorked > NormalMax THEN

Display overtime message

ELSE

Display regular time message

ENDIF

**REPEAT-UNTIL**

This loop is similar to the WHILE loop except that the test is performed at the bottom of the loop instead of at the top. Two keywords, REPEAT and UNTIL are used. The general form is:

REPEAT

sequence

UNTIL condition

The "sequence" in this type of loop is always performed at least once, because the test is peformed after the sequence is executed. At the conclusion of each iteration, the condition is evaluated, and the loop repeats if the condition is false. The loop terminates when the condition becomes true.

**CASE**

A CASE construct indicates a multiway branch based on conditions that are mutually exclusive. Four keywords, CASE, OF, OTHERS, and ENDCASE, and conditions are used to indicate the various alternatives. The general form is:

CASE expression OF

condition 1 : sequence 1   
condition 2 : sequence 2   
...   
condition n : sequence n   
OTHERS: default sequence

ENDCASE

The OTHERS clause with its default sequence is optional. Conditions are normally numbers or characters indicating the value of "expression", but they can be English statements or some other notation that specifies the condition under which the given sequence is to be performed. A certain sequence may be associated with more than one condition.

Example

        CASE  Title  OF  
                Mr      : Print "Mister"  
                Mrs     : Print "Missus"  
                Miss    : Print "Miss"  
                Ms      : Print "Mizz"  
                Dr      : Print "Doctor"  
        ENDCASE

Example

        CASE  grade  OF  
                A       : points = 4  
                B       : points = 3  
                C       : points = 2  
                D       : points = 1  
                F       : points = 0  
        ENDCASE

**FOR**

This loop is a specialized construct for iterating a specific number of times, often called a "counting" loop.  Two keywords, FOR and ENDFOR are used. The general form is:

FOR iteration bounds

sequence

ENDFOR

In cases where the loop constraints can be obviously inferred it is best to describe the loop using problem domain vocabulary.

Example

FOR each month of the year (good)   
FOR month = 1 to 12 (ok)

FOR each employee in the list (good)   
FOR empno = 1 to listsize (ok)

**NESTED CONSTRUCTS**

The constructs can be embedded within each other, and this is made clear by use of indenting. Nested constructs should be clearly indented from their surrounding constructs.

Example

SET total to zero   
REPEAT

READ Temperature   
IF Temperature > Freezing THEN   
    INCREMENT total   
END IF

UNTIL Temperature < zero   
Print total

In the above example, the IF construct is nested within the REPEAT construct, and therefore is indented.

**INVOKING SUBPROCEDURES**

Use the CALL keyword. For example:

CALL AvgAge with StudentAges   
CALL Swap with CurrentItem and TargetItem   
CALL Account.debit with CheckAmount   
CALL getBalance RETURNING aBalance   
CALL SquareRoot with orbitHeight RETURNING nominalOrbit

**Assignment Instructions**

***Answer the following questions. Please copy and paste the questions below into your editor (use the I-bar tool in Acrobat Reader to do this) and TYPE your answers below each question.***

**Part 1: Problem Solving**

***Use Solve by Enumeration for each of these questions; list all possibilities and then do elimination as shown in the background section of this document. IMPORTANT NOTE: 2/3rds of the grade on these questions will be for showing that you understand the problem solving technique, only 1/3 of the grade is for correctness of you answer. So you MUST show your work in order to get most of the points on these questions; just listing the correct answer is only worth 1/3 of the points.***

**Hint:**

1) First step is designing your representation for the specific problem,

2) Then generate all of the possible enumerations for the problem,

3) Finally, using one fact at a time, eliminate those elements that are inconsistent with the fact. Repeat this for each stated fact.

***Q1***: In a certain bank three employees—Sonya, Kirk, and Dakota—work as a teller, branch manager, and loan officer (not necessarily in that order). Use the information below to determine who fills what position at the bank.

1. The teller, who is an only child, earns the least amount of money.
2. Dakota, who married Sonya’s brother, earns more than the branch manager does.

***Q2***: One weekend a reporter from a campus newspaper came by to do a feature on four college roommates—Keon, Randall, Yoshio, and Fernando, but each was out of town. The reporter asked a neighbor if he knew anything about the roommates. After thinking for a while, the neighbor replied, “One of them is a computer science major, another is an avid golfer and mows the lawn at the country club, a third has had a mohawk since 5th grade, and the last one is allergic to kiwi.” (continued on next page)

The reporter then rudely reminded the neighbor that he *was* writing a feature and needed a little more information than that. The annoyed neighbor replied by giving the following intentionally veiled facts: “Fernando, who is bald, usually waits for the golfer to finish his putting practice before they walk to campus together. Unlike Keon, who prefers a traditionally conservative hairstyle, Yoshio is thinking about getting a mohawk after the term. The roommate with a kiwi allergy always cooks enough food for Keon who is deathly allergic to grass pollen.” With that the neighbor bid the reporter good day and went back into his home.

Based on the neighbor’s information, match up each roommate with his unique characteristic.

***Optional Challenge Question*:** Five sisters all have their birthday in a different month—February, March, June, July, and December. Using the information below, determine each of the sister's birthday months. (Adapted from Puzzlers Paradise Website, <http://www.puzzlersparadise.com/article1021.html>.)

1. Paula and the sister born in June have their birthdays earlier in the year than Brenda.
2. Abigail and Brenda have their birthdays in consecutive months.
3. Within a calendar year, Paula’s birthday is between Mary’s and that of the sister born in February.

**Part 2: Algorithms and Pseudocode**

***Q3:* Reading Algorithms**: The following algorithm (expressed in pseudocode) takes as input a list of numbers (e.g. {4, 5, 99, -4, 0} and {-2, 4} would both be valid inputs):

//==========Start============

Let N be the number of items in the list.

Do the following N times:

Let I = 1

While (I < N) repeat the following:

If the Ith number in the list is greater than the (I+1)th number then:

Swap the Ith and (I+1)th numbers in the list.

EndIf.

Add 1 to I.

EndWhile.

EndDo.

Print out the list.

//==========END===============

ANSWER THE FOLLOWING:

1. Explain what this algorithm does.
2. What output does the algorithm give on input 4, 3, 2, 1?
3. What output does the algorithm give on input 9, 10, -4, 9?

***Q4:* Writing Algorithms**: Write an algorithm (expressed in pseudo-code) which when given a set of N positive numbers, finds the number with the ***largest*** value. (Hint: Let “Max” be initialized to 0 and then loop through the numbers looking for anything bigger that the current value of “Max”. Let “Max” have the newly found larger value and continue looking at each number in the list until there are no more numbers).

**Part 3: Introduction to Programming (using Scratch)**

***Q5:*** Do the first 9 steps (through Explore) in the Scratch “Getting Started Guide”. The guide is available from a link on my web site under the week 6 outline (under the offline tutorials section). At the end of this tutorial, do a couple of print screens (alt+PrintScrn) showing what you did and paste it into the end of your assignment document that you will turn in.