Programming Basics – Part 1

- Creating Algorithms
- HIPO Charts
- Pseudocode
- Variables
- Flowcharts
- DeskChecks

Solving problems using the Computer as a Tool

- Much like the microscope does not define biology or the test tube does not define chemistry, the computer doesn't define Computer Science.
- The computer is a tool by which Computer Scientists accomplish their goals – to solve problems.

Computer Science

- Is NOT just about coding or hardware or software!
- Computer Science is about PROBLEM SOLVING
- Computer Science is about ***developing algorithms*** to solve complex problems

Control / Logic Structures

All modern programming languages are based on 3 basic control structures

- Sequence
  - Instructions are executed one after another in the order they appear in the program
  - Until another control structure takes precedence
- Selection
  - Based on some condition, either one part of the program is executed or another part is executed
  - The program chooses which part to execute based on the condition
- Repetition
  - Part of the code is executed over and over (repeated)
  - This can be for a set number of times or until a condition is met

Control / Logic Structures

- Tools we use to create Algorithms

WHAT IS AN ALGORITHM?

- An algorithm is a step-by- step definition of a process.
  - It should also be a well-developed, organized approach to solving a complex problem.
- Computer Scientists ask themselves ***four critical questions*** when they evaluate algorithms …

Algorithm Questions

1. Does the algorithm solve the stated problem?
2. Is the algorithm well-defined?
3. Is it efficient?

Developing an Algorithm

1. Identify the Input
2. Identify the Output
3. Identify the Processes
4. Develop a HIPO Chart
5. Develop Pseudocode or a Flowchart
6. Test our algorithm with a Desk Check

1. Identify the INPUT

- What data do I need to generate the output?
- How will I get the data?
  - From the user?
- What is the format of the data?

2. Identify the OUTPUT

- What output do I need to return to the user?
- How should it be displayed?
- How can I display the data to produce meaningful results?
  - Data vs. Information

3. Identify the Processing

- What do we need to do to produce the output with the given input

HIPO Charts, PseudoCode, & Flowcharts

- We use these tools for 2 reasons
  - 1 - they help us to develop our algorithms
  - 2 - they help us communicate our ideas with others
- HIPO Charts (Hierarchical, Input, Processing, Output)
  - This is where we begin - Divide & Conquer!
  - Describes the system from a high level
- Pseudocode - A terse-English description of our algorithm
  - This is where we define the specific flow of our algorithm
- Flowcharts - A symbolic representation of our algorithm
  - Describes our algorithm similarly to pseudocode, but creates a diagrammatic representation of our algorithm

A Simple Sequence Problem

Problem Statement:

- Develop an algorithm that calculates the sum and average of two numbers entered by the user

1. Create a HIPO chart
2. Write the Pseudocode
3. Create a Flowchart
4. Perform a Desk Check to test our algorithm

All of these techniques help us develop our algorithm without dealing with the complexities of a programming language

Creating our HIPO Chart

Hierarchical and Input, Processing Output Chart

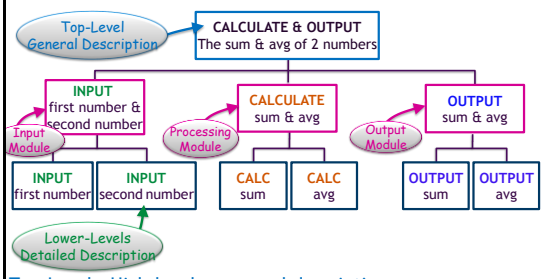
- Shows the overall structure of the program
- Shows the relationship between different components/modules in the system
- Top-level is general
- 2nd level breaks it down into
  → Input, Processing & Output
- Each successive level is more detailed

First we need to ask a few questions:

- What is the specified input?
- What is the specified output?
- What processing do we need to do to go from the input to t output?

- How can we break out problem into more manageab sub problems

HIPO CHART



Top-Level : High-level or general description

2nd-Level : Breaks it down into Input, Processing and Output Modules

Bottom-Level: Detailed Solution → for now detail to 1 instruction

Exercise #1

Design the algorithm for a program that calculates the total of a retail sale.

The program should ask the user for the following:
- the retail price of the item being purchased and
- the sales tax rate.

Once the information has been entered the program should calculate and display the following:
- The sales tax for the purchase and
- the total sale.

First, we need to ask ourselves a few questions.

Some things to think about

- What is our input?
- What are our output?
- What do we need to calculate (processing)?

HIPO CHART

INPUT OUTPUT PROCESSING

Writing Pseudocode

- Terse English description of a algorithm
  - Can be easily converted into any programming language
  - Each sentence starts with a command
  - Uses keywords such as:
  - PROMPT, READ, INPUT, ASSIGN, CALCULATE, OUTPUT

Example:

Calculate sum and average of two numbers

Should Be Capitalized

```
BEGIN PROGRAM
   PROMPT the user for the first input
   READ the first input
   PROMPT the user for the second input
   READ the second input

   CALCULATE the sum
   CALCULATE the average

   OUTPUT the sum
   OUTPUT the average
END PROGRAM
```

} these can be combined into just **INPUT**→

} It is implied that the user input will be read after a prompt

Exercise #1

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- the sales tax rate.

Once the information has been entered the program should calculate and display the following:
- The sales tax for the purchase and
- the total sale.

Write the Pseudocode for this problem.

Pseudocode

Calculate the sales tax and total purchase price:

Before we move on…

- We need to think about the values that we want the computer to store as the program executes
- For our example program…
  - We need to store into memory the two numbers we are using as input (num1 & num2)
  - We also will want to store the sum and the avg of these numbers
  - … those memory locations are called variables

Variable:
A place in memory we use to store data. Variables store data that can change during program execution

Variables

- We don't know exactly where the data is stored
  - But we don't need to…
  - We reference the memory locations with names that we determine
    - The OS keeps track of the actual address (like file names)
  - Naming memory locations is called symbolic addressing
- Variables are essential to programming because we want to be able to use data that we store to do calculations

Variable Naming Rules

We can't just name them anything…

- Required rules → what the compiler cares about
  - Can only have letters, numbers, and underscore (_)
  - Variables must begin with a letter
  - They are case-sensitive
    - 'A' ≠ 'a'
  - Can't have spaces
  - Can't have special characters

Can't be keywords

Keywords
→ Words that have special meaning in C++

Variables – Naming Rules

- Stylistic rules → what we care about
  - Use meaningful names
  - For 1 word → Keep it lowercase
  - For 2 or more words → 1st word is lowercase
  - Capitalize the 1st char of each subsequent word

Variables - Examples

GOOD
sum
total
countGrades
payRate

BAD
SUM
Total grades
3num
%payrate
pay rate
Payrate
PAYRATE

Assignment Statements

An assignment statement is one way that put data into the memory location referenced by a variable

Syntax
variable = *expression*;

sum = num1 + num2;

Assignment Operator

This assigns the value of num1 + num2
to the memory location referenced by sum

Assignment Statement Examples

GOOD

```
ageOne = 15
ageTwo = 23
averageAge = (ageOne + ageTwo) / 2.0
answer = 'y'
sum = num1 + num2
```

BAD

```
10 + sum = sum
23 = sum + 5
sum + 5 = sum
```


Types of Calculations

We can use basic math calculations in programming

Name	Symbol	Example
addition	+	sum = 4 + 7
subtraction	-	difference = 18.55 - 14.21
multiplication	*	product = 5 * 3.5
division	/	quotient = 14 / 3
modulo ("mod")	%	remainder = 10 % 6

Back to flowcharts

Flowcharts

- A detailed picture (or description) of an algorithm
- Represents the flow of the program
  - The sequence in which instructions are executed
- Drawn from Top to Bottom → shows the exact order that the instructions will execute
  - The top symbol represents the first instruction executed
  - The bottom symbol represents the last instruction executed
- Uses special symbols to represent different program statements

Using Variables in a Flowchart

- Names of the variables in a flowchart must match exactly the actual names of variables use in a program
- Thus… we must use appropriate names
- For the sum & average problem we will name ou variables as follows:
  - num1, num2, sum and avg

Note:
C++ is CASE SENSITIVE!
In other words it does not consider 'A' to be the same as 'a'

Flowcharting Symbols

We will start with the 3 flowcharting symbols

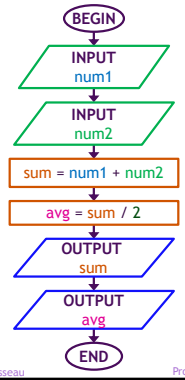
Begin/End of Block

Process

Input/Output

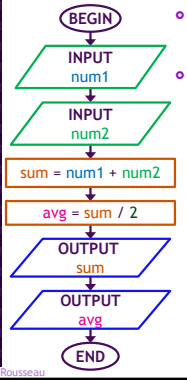
I will introduce more symbols as we go along

Sum & Average Flowchart



- **Note**: The flowchart begins with the process outlined on the bottom left of the HIPO chart
- i.e. the lowest level where the specific steps have been outlined

Variable List



- The Variable List should contain a complete list of Variables The necessary for this algorithm.
- We don't need duplicates - just a complete list.

VARIABLE LIST

INPUT
retailPrice
salesTaxRate

OUTPUT
salesTax
totalSale

PROCESSING
<nothing additional>

All Flowcharts & Pseudocode should include a Variable List!

Exercise

Design the algorithm for a program that calculates the total of a retail sale.

The program should ask the user for the following:
- the retail price of the item being purchased and
- the sales tax rate.

Once the information has been entered the program should calculate and display the following:
- The sales tax for the purchase and
- the total sale.

Draw the flowchart for this algorithm.

Some things to think about

- What is our input?
- What are our output?
- What do we need to calculate (processing)?
- What should we name our variables?

SOMETHING THAT MAKES SENSE!

Flowchart Exercise

VARIABLE LIST
INPUT

OUTPUT

PROCESSING

Exercise #2

Draw a flowchart to match the following pseudocode.

```
BEGIN PROGRAM
    ASSIGN  num1 = 5
    ASSIGN  num2 = 10
    CALC    num2 = num2 + 10
    CALC    num3 = num1 * 2
    CALC    num2 = num2 - num1
    OUTPUT num1
    OUTPUT num2
    OUTPUT num3
END PROGRAM
```

- What is our input?
- What is our output?
- What are our variables?

Exercise #2

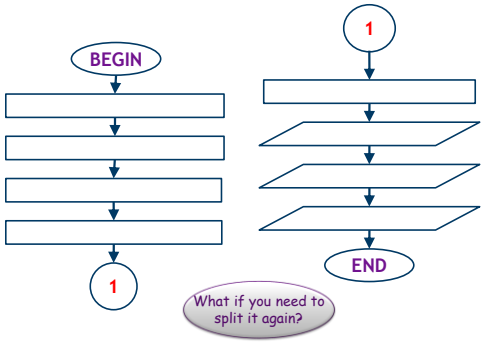
VARIABLE LIST

INPUT

OUTPUT

PROCESSING

What if you run out of space?



Desk Checks

We perform Desk checks for 2 reasons

1 - to test our algorithm

2 - to understand someone else's algorithm

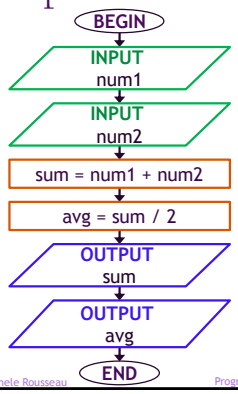
The idea is to *mimic the computer* and track

- the values that are stored in memory &
- the output

We do this by writing down all the variables and tracing through the program

Example Desk Check

Let's perform a desk check on the sum and avg algorithm Using the values 3 & 7



INPUT: 3 (num1)
7 (num2)

EXPECTED OUTPUT:

num1 num2 sum avg OUTPUT

Exercise #2: Desk Check

- Trace the steps in your flowchart from the previous exercise and show the output produced by this program.

Exercise #2 Desk Check

num1 num2 num3 OUTPUT

Exercise #1: Desk Check

Trace the steps in your flowchart from the sales tax and retail price problem.

INPUT: $300.00 & 10%

EXPECTED OUTPUT:

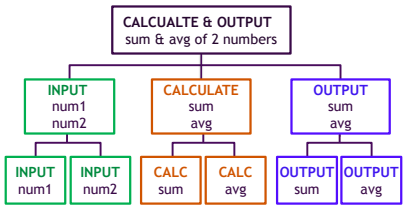
Exercise Desk Check

Let's perform a desk check on the sum and avg algorithm Using the values 300.00 & 0.10

EXAMPLE UPDATED

- The 3 slides demonstrate the final versions of the topic example for the HIPO chart, pseudocode and flowchart
- The 4th slide provides a detailed explanation of how to conduct a desk check
- The 5th slide will show the final desk check
- Notice that all the diagrams and the pseudocode use proper variable names

Example HIPO Chart



INPUT	OUTPUT	PROCESSING
num1	sum	sum = num1 + num2
num2	avg	avg = sum / 2

Example Pseudocode

```
BEGIN PROGRAM
   INPUT num1
   INPUT num2

   CALCULATE  sum = num1 + num2
   CALCULATE  avg  = sum / 2

   OUTPUT sum
   OUTPUT average
END PROGRAM
```

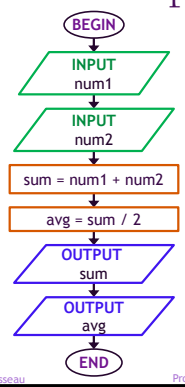
VARIABLE LIST

INPUT
num1
num2

OUTPUT
sum
avg

PROCESSING
<no additional>

Example Flowchart



VARIABLE LIST

INPUT
num1
num2

OUTPUT
sum
avg

PROCESSING
<no additional>

Example Desk Check

Desk checks are how we are test our algorithm

- we start by selecting test data - for this example we will test 2 sets of data. Now every time we execute a PROMPT in pseudocode or an INPUT in a flowchart we store one of our input values into the variable specified. We start read our input values in from left to right.
  - Test set #1: 3 & 7
  - Test set #2: 9 & 5
- Next, we want to do is figure out what the output should be and then walk through our algorithm (flowchart or pseudocode) one step at a time and see if it produces the same results.
  - Test set #1:

INPUT VALUES	EXPECTED OUTPUT
3 (num1)	10 (sum)
7 (num2)	5 (avg)

  - Test set #2:

INPUT VALUES	EXPECTED OUTPUT
9 (num1)	14 (sum)
5 (num2)	7 (avg)

- Now we step through our algorithm and trace what will be stored in each of our variables AND we track what will be output
- Finally, we confirm that our output from our desk check matches our EXPECTED OUTPUT

Example Desk Check

TEST CASE #1:

INPUT: 3 (num1)
7 (num2)

EXPECTED OUTPUT: 10 (sum)
5 (avg)

num1	num2	sum	avg	OUTPUT
3	7	10	5	10 (sum) 5 (avg)

TEST CASE #2:

INPUT: 9 (num1)
5 (num2)

EXPECTED OUTPUT: 14 (sum)
7 (avg)

num1	num2	sum	avg	OUTPUT
9	5	14	7	14 (sum) 7 (avg)