CPE 112 - Computer Methods in Engineering

Chapter 1

Course Basics

- **Assignment:**
  - Read Chapter 1,
  - Read pages 161-167 on Functional Decomposition ← **Important**
- **At the end of each chapter, study Exam Preparation, Quick Check and programming warm-up Exercises and Case study follow up questions.**

- **All Class communications will be handled via ANGEL**

ANGEL Course Management System

- **ANGEL**
  - Account username MAY be different from your engineering account username. Password will be different as well.

  - Your ANGEL username is the same as your uah email username (username@uah.edu or username@email.uah.edu). Password is the same as for accessing your UAH email account.

    https://angel.uah.edu/default.asp

  - Example login and program submission

Remote Access

- **Remote access of the Linux servers (eagle or blackhawk) is possible. See the handout best suited for your machine type**

- **To edit a file type the command: gedit filename**

- **Editors to use are gedit, vim (vi) or emacs. However, there are limitations on these editors when accessing the Linux servers remotely.**

INTRODUCTION to C++

- **Programming styles are very individualistic**
- **Need to develop your own style (within reason) and stay with it**
- **Debugging is an art form of sorts. Several tools are available to help with finding where errors occur.**

- **Comment Statements**
  - // at the beginning of a line means the entire line is a comment
  - **//** in the middle of a line means the rest of a line is a comment
  - **/* text */** all text between the two markers is a comment. The text can be multiple lines

```
// this is a comment line
and this is not
/* this is a comment
and so is this
*/
```

Overview of Computer Programming

- **Computer Programming is telling computers what to do in a language that they understand (instructions/coding)**
- **Writing and maintaining a program consists of 3(4) phases**
  0. **Problem Definition** - Purpose for writing the program
  1. **Problem Solving** (All done by hand) – most important step
     - ***Analysis and specification*** - Understand the problem and solution
     - ***General Solution*** - An Algorithm. Logical steps solving a problem
     - ***Verify*** - Determine if the solution solves the problem.
  2. **Implementation**
     - ***Concrete solution*** - convert algorithm into a programming language
     - ***Test*** - verify that the computer results are those expected. Fix all syntax and logic errors that are discovered
  3. **Maintenance**
     - ***Use*** (execute/run) the program
     - ***Maintain*** - Modify the program to meet changing requirements

Overview of Computer Programming

- ***Algorithm*** **- A step by step procedure for solving a problem in a finite amount of time.**
- **Car Starting and Weekly Wage algorithms - page 4 of book**
- **Algorithm example (Baking a cake)**

  Obtain all ingredients -SubAlgorithm
  Pre-heat oven to 350 degrees
  Mix cake batter components together - SubAlgorithm
  Pour mix into pan
  Cook mix for a fixed amount of time
  Cool cake for 2 hours
  Make frosting - SubAlgorithm
  Frost Cake
  Eat

What is Computer Programming?

- **Algorithms are translated (coded)**
  - Into different programming languages (C++,Pascal,Fortran,…)
  - by different people in different ways
- **A *Programming Language* is a simplified version of English that adheres to a strict set of rules**
- **Documentation is a very important part of programming**
  - External - Specifications, development history, design document
  - Internal – Comments ← Very important part
- **Implementation - coding and testing of an algorithm. Do not jump immediately to the implementation phase by avoiding the Problem-solving phase**
- **Think first and code later**

Computer Terms and Definitions

- **Machine Language - binary coded (1's and 0's) instructions used by the computer**
- **Assembly Language - Low-level programming language using mnemonics to represent machine language instructions (ADD, SUB)**
- **Assembler - Program to translate assembly language to machine language**
- **High Level Language - Highly structured language close to English that can be translated to many different machine languages by compilers**
- **Compiler - Program that translates a high-level language to machine language**
  - Source Program - Program written in a high-level language
  - Object Program - Machine language (executable) version of the source program.

Control Structures

- **Four ways of structuring statements (instructions) in most programming languages. These control structures allow for the expression of algorithms as programs. Most programs will contain 2 or more of these structures**
  - ***Sequentially*** - instructions executed one after the other
  - ***Selection*** (if, switch) - conditional control - pick one of multiple choices
  - ***Loop*** (while, for, etc)- perform same instructions repetitively until a condition is met
  - ***Subprogram*** (function)- pass control over to another set of instructions/code. Allows for breaking up a large program into smaller units/programs

Ethics and Responsibilities in the Computing Profession

- **Software Piracy - Copying of software without permission of its creator**
- **Privacy of Data - Do not take advantage of special access to confidential data**
- **Use of computer resources - Do not use computer resources without permission (i.e. hacking, viruses)**
- **Software Engineering - Programmers have a responsibility for developing software that is free from errors**

Problem Solving Techniques

- **Ask Questions** - Make sure you understand the problem
- **Look for things that are familiar** - re-use functions
- **Solve by analogy** - Solving a similar problem may help with the current problem
- **Means-Ends Analysis** - Define the ends and then analyze the way(s) (means) of getting from one end to the other
- **Divide and Conquer** - Break large problems up into smaller ones
- **Building-Block Approach** - Combine solutions of smaller problems to solve larger problems. Combination of look for things that are familiar and divide and conquer approaches
- **Merge Solutions** – Combine existing solutions on a step-by-step basis.
- **Mental Blocks** - Avoid by writing down the problem and start looking at individual parts to the problem.

Problem-Solving a Case Study

- **Problem: Need to write a program that can be used to determine whether a year is a leap year**
  - Need clear instructions
  - Leap years are divisible by 4, but not by 100
  - Leap years are divisible by 400
- **Use divide and conquer to solve - three obvious first steps:**
  - Obtain the data
  - Compute the results
  - Output the results

Case Study (continued)

Algorithm for Program

- Obtain a four-digit year – Sub-Algorithm
- Test the year to see if it is a leap year – Sub-Algorithm
- Write out if it is a leap year or not

Sub-Algorithms

- **Obtain Data**
  - Prompt for a year
  - Read in the value entered

- **Determine if year is a leap year – This algorithm is implemented as a function in the example**
  - Is the year divisible by 4?
    - No – then not a leap year
    - Yes – is the year divisible by 100
      - No – then it is a leap year
      - Yes – is the year divisible by 400
        - No – then it is not a leap year
        - Yes – then it is a leap year

Sub-Algorithms (continued)

- **Output data**
  - Output if the year is a leap year or not

- **Actual C++ code is listed in the book pages 33-36.**

Sample Header Format

```
// ************************************
// ProgramTitle: Sample.cpp
// Name: Ron Bowman
// Course Section: CPE-112-01 (section 1 of the course)
// Lab Section: 4
// Due Date: 01/12/05
// program description: What does the program do?
// Inputs: four-digit year
// Outputs: if year is a leap year
// Assumptions: four-digit year is entered
// Functions called: IsLeapYear
// ****************************************
```

Chapter Summary

- **Computers are dumb, they must be told what to do. And they do exactly what they are told - even if it is incorrect!**
- **Computers are tools used to solve problems**
- **Think about strategies for solving problems before you start writing algorithms and before writing code (repeat)**

- **Study Quick check and Exam preparation Exercises in Ch. 1**
- **Read Chapter 2**

Algorithm Example

- **Page 41 – programming warm up exercise #1**
- **Write an Algorithm for driving from engineering building parking lot to the nearest airport.**

  Leave school grounds
  - go south in parking lot and exit to the west
  - turn left onto road (Lakeside).
  - turn right at Y in road
  - go to stop light and turn left onto Sparkman Drive

  Drive to airport
  - From Sparkman Drive, turn right onto 565 West
  - Take airport exit #7
  - Follow signs to departing flight drop-off

Functional Decomposition – Pages 161-167

- **Work from the abstract – A list of the major steps in a solution, to the particular – algorithmic steps that can be translated directly into C++ code.**
- **Take major steps and break them down into smaller size pieces which become sub-problems.**
  - Sub-problems may be reduced further into smaller sub-problems
  - Creates a hierarchical or tree structure to the problem
- **See figure 4-4 on page 167**
- **Concrete Step – a step that has enough implementation details that can be coded directly into C++**
- **Abstract Step – a step for which some implementation details remain unspecified – further sub-dividing is necessary**
- **Module – A self contained collection of steps that solves a problem or subproblem**

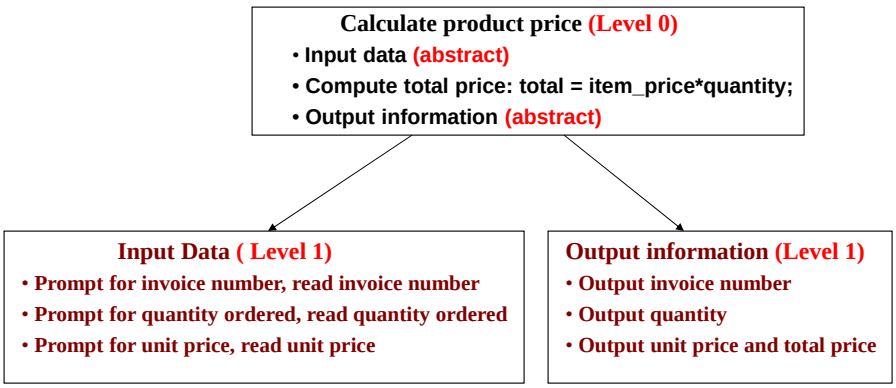
Functional Decomposition Continued

- **Properly written final modules contain concrete steps only**
- **If a module contains concrete and abstract steps, the abstract steps require additional sub-problem analysis in a new module**
  - Modules may contain concrete and abstract steps
  - Final modules along a tree branch contain only concrete steps
- **Look at figure 4-3 on page 162 for an example of a top module with 3 abstract steps.**

Functional Decomposition Example

- **Write a F.D. to read an invoice number, quantity ordered and unit price. Use this information to compute the total price. The following information should be output with identifying phrases: the invoice number, quantity, unit price and total price**
- **Calculate product price (Program name – top module - Level 0)**
  - Input data ← **abstract** (step in top module - Level 0)
    Prompt for invoice number, read invoice number ← concrete(Level 1)
    Prompt for quantity ordered, read quantity ordered ← concrete(Level 1)
    Prompt for unit price, read unit price ← concrete(Level 1)
  - Compute total price: total = item_price*quantity; ← **concrete**(Level 0)
  - Output information ← **abstract** (step in top module - Level 0)
    Output invoice number ← concrete(Level 1)
    Output quantity ← concrete(Level 1)
    Output unit price and total price ← concrete(Level 1)

Functional Decomposition Example



Sample Program

```
#include <iostream>
using namespace std;
int Square( int );
int Cube( int );
int main()
{
    cout << "The square of 27 is " << Square(27) << endl;
    cout << "and the cube of 27 is " << Cube(27) << endl;
    return 0;
}
int Square( int n )
{
    return n * n;
}
int Cube( int n)
{
    return n * n * n;
}
```


Sample Program Analysis – Part 1

Statements: **#include <iostream>**
using namespace std;

Output: <no visible output>

Comments: Statements tell the preprocessor and compiler where to find required information on the built-in functions used by the program

Sample Program Analysis – Part 2

Statement: `int Square( int );`
`int Cube( int );`

Output: <no visible output>

Comments: Tell the compiler that two user defined functions
Square and **Cube** will be used that each take one
integer argument and return an integer value upon
completion

Sample Program Analysis – Part 3

Statement:
`cout << "The square of 27 is "<< Square(27) << endl;`

Output: The square of 27 is 729

Comments: During execution, the function **Square** is invoked.
-**Square** returns the integer value 729
-**cout** prints the string "The square of 27 is ", followed by the integer 729, followed by the new line character.

Sample Program Analysis – Part 4

Statement:

```
cout << "and the cube of 27 is " << Cube(27) << endl;
```

Output: and the cube of 27 is 19683

Comments: During execution, the function **Cube** is invoked
- **Cube** returns the integer value 19683
- **cout** prints the string "and the cube of 27 is ",
  followed by the integer 19683,
  followed by the newline character.

Sample Program Analysis – Part 5

Statement: **return** 0;

Output: <no visible output>

Comments: **return** sends the integer value 0 back to the calling function, in this case the operating system, telling it that this function (main) executed successfully

Sample Program Analysis – Part 6

Statement:
```
int Square( int n )
{
    return n * n;
}
```

Output: <no visible output>

Comments: **Function definition for Square. This definition shows that the function has one integer parameter and returns an integer value that is the square of the integer parameter**

Sample Program Analysis – Part 7

Statement:
```
int Cube( int n)
{
    return n * n * n;
}
```

Output: <no visible output>

Comments: **Function definition for Cube. This definition shows that the function has one integer parameter and returns an integer value that is the cube of the integer parameter**

Examples of Defective Software

- **Ariane 5** (June 4, 1996)
  - **Loss of attitude/guidance information after liftoff**
  - **Software specification and design errors**
  - **Defect: Untrapped Numeric Overflow**
    - **Conversion of a 64-bit floating point value to a 16-bit signed integer value**
  - **Result:**

    Loss of rocket and cargo valued at $500 million

    Source: //www.ima.umn.edu/~arnold/disasters/ariane.html

Examples of Defective Software

- **Mars Climate Observer** (September 23, 1999)
  - **Erroneous steering commands lead to loss of spacecraft and failure of mission costing $125 million (Mixing English and metric units)**
- **Mars Polar Lander** (December 7, 1999)
  - **Defective software shuts off engines prematurely leading to loss of spacecraft**
- **Common Defects**:
  - **Software specification/design errors**
  - **Project Management: "Faster, Cheaper, Better"**

[Sources: James Oberk, IEEE Spectrum, December 1999 and *Winning with Software: An Executive Strategy* (2002) Watts S. Humphrey]

Examples of Defective Software

- **Therac-25** (June 1985 - January 1987)
  - **Computerized radiation therapy machine**
  - **Defective control software**
  - **Relied on software, not hardware safety interlocks**
  - **Six known massive radiation overdoses**
  - **Results: radiation burns and patient deaths**

Source: Nancy Leveson and Clark S. Turner,
IEEE Computer, vol. 26, no. 7, July 1993, pp.18-41.