MET 107
Problem Solving With A Computer

We are concerned with solving problems using a computer. This class of problems are generally well stated – they provide enough information so that the problem can be solved. Sometimes, assumptions have to be made by the problem solver.

A well-stated problem describes the current or initial state that is to be transformed into some other state, which is the solution or results.

Given and Results
- Information is usually pretty straightforward.
- Normally descriptive – nouns and adjectives

Transformations:
- The process involved in going from the given to the results.
- Obvious information or things that can be reasonably assumed are often not given.
- May not be straightforward
- May be left up to the inventiveness and ingenuity of the problem solver
- Usually stated in verbs and adverbs

Concept:
"What must be done to change (action, verb) what is given (descriptive, noun) into what is required (descriptive, noun)?"

Example: Express the temperature 85 degrees Fahrenheit (F) in degrees centigrade (C).

Initial Situation: the temperature is 85°F

Final Situation: want the temperature in degrees centigrade

Transformations: The only verb is express – doesn’t give a clue to how to make the transformation. Upon reflection, we see that the action is really “convert” though the how is unspecified and left up to the solver. We need to determine a tool to use:

Conversion chart
Algebraic equation

Assume we find the formula $^\circ{}C = \frac{5(F - 32)}{9}$. If we further assume that the operation of this tool is known – we have the necessary skills to evaluate the expression, we can create this diagram of our problem solution:

<table>
<thead>
<tr>
<th>INPUT</th>
<th>TRANSFORMATION</th>
<th>OUTPUT</th>
</tr>
</thead>
</table>
| Ti = 85°F  | 1. Get initial temperature, Ti  
             | 2. Compute degrees centigrade:  
             | $C = \frac{5}{9} (Ti - 32)$  
             | 3. Output the solution         | Temp. in Degrees Centigrade, C |

When developing transformations, it is important to work from a very broad and general statement of the transformations to a detailed and very specific statement of the PROCESS. Testing for correctness by hand can occur at any time that seems appropriate, but it must certainly be done with the “final” process. If an
error is found, the process must, of course, be corrected. If a process appears to be without error, it may be accepted as final, though, it may still contain errors.

The flowchart for the preceding example could be:

```
Start
Get Temp, Ti
C = 5 * (Ti - 32) / 9
Display Temp, C
End
```

The process, or Algorithm, is the set of detailed, unambiguous, and ordered instructions developed to describe the transformations necessary to go from the initial (given) situation to the final (required) situation.

The following are required properties of an algorithm:
1. It must be sufficiently detailed to describe the transformations necessary to solve the problem.
2. It must be unambiguous, so that anyone can perform the transformations correctly every time.
3. It must always give the same results for the same initial conditions.
4. It must give correct results in all cases.

A process must meet these criteria to be considered an algorithm. In computer programming, the process used to solve the problem must be an algorithm. An algorithm can be thought of as a series of one or more well-known operations. In order for an operation to be well known, it must meet the requirements of an algorithm.

**Example:** The problem is to find the sum of two numbers.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>TRANSFORMATION</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two numbers</td>
<td>Get the numbers</td>
<td>Sum</td>
</tr>
<tr>
<td></td>
<td>ADD the first to the second</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Display the results</td>
<td></td>
</tr>
</tbody>
</table>

Our operation is ADD. Is ADD a well-known operation?

1. Is ADD sufficiently detailed to describe the necessary transformations? Yes. We know how to add.
2. Is it unambiguous? Yes.
3. Does it always give the same results? Yes.
4. Does it give the correct result? Yes. (we assume that the addition is done correctly.)

Add can be considered to be a well-known operation. The distinction between an algorithm and an well-known operation depends on the user's knowledge. To a child, ADD must be described in simpler operations, such as counting.
5 Things a Computer Can Do:
Algorithms that are to be performed by a computer must be stated in terms well known to computers. One must, therefore, become familiar with the few operations that computers can perform. Five of these operations are:

1. Perform arithmetic: add, subtract, multiply, and divide numbers.
2. Compare two pieces of information and select one of two alternative actions, depending on the outcome of the comparison.
3. Receive and put out information.
4. Repeat any group of operations.
5. Save any piece of information for later use.

Any algorithm to be used on a computer must be stated in terms of the five well-known computer operations.


Excel Example:
Convert the temperature example from earlier to Excel:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>This worksheet converts temperatures given in °F</td>
<td>to temperatures in °C.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Given:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Temperature =</td>
<td><strong>85.00</strong> °F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Results:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Temperature =</td>
<td><strong>29.44</strong> °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The degree symbol is obtained by:
1. Press and hold down the Alt key.
2. Using the keypad, type the number 248.
3. Release the Alt key to display the symbol.

Or
On the Insert Tab, select Symbol from the Text group. Select the “Symbol” font to find the degree symbol.

1. Worksheets should have a description of what they do at the top.
2. You may want to organize your worksheet by identifying what is given, what is to be found, what the computations are, and what the results are.
3. Often, the contents of a cell are identified by text in adjacent cells which we call labels. Examples are in A5 and A8.
4. Note that the typical units are included in C5 and C8 to guide the user to input the proper values.
5. The final solution is usually highlighted in some way. In this case, the solution is bold.
6. All worksheets should be checked using hand-calculations on engineering calculation paper.

\[ ^\circ\text{C} = \frac{5(\text{°F} - 32)}{9} = \frac{5(85 - 32)}{9} = 29.44^\circ\text{C} \Rightarrow \text{CHECKS} \]

7. Does our worksheet work for all temperatures given in degrees Fahrenheit?
8. Expand the solution of this problem to also convert the temperature to degrees Kelvin and degrees Rankine. These are temperatures measured on the absolute scales (defined by the absolute minimum possible temperature) with respect to °C and °F respectively.

For general information:

Degrees Kelvin = degrees C + 273.2
Degrees Rankin = Degrees F + 459.7
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Triangle Example:

A triangle in space is defined by three vertices A, B, and C, having coordinates \((X_A, Y_A, Z_A)\), \((X_B, Y_B, Z_B)\), and \((X_C, Y_C, Z_C)\) respectively. Create an ITO diagram to define the process of computing the area of the triangle.

\[
\textbf{Distance Formula:} \\
d = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2 + (Z_2 - Z_1)^2}
\]

\[
\textbf{Area of a Triangle:} \\
A = \sqrt{S(S-a)(S-b)(S-c)} \text{ where } S = \frac{1}{2}(a + b + c)
\]

<table>
<thead>
<tr>
<th>INPUT</th>
<th>TRANSFORMATION</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>((X_A, Y_A, Z_A)), ((X_B, Y_B, Z_B)), and ((X_C, Y_C, Z_C))</td>
<td>1. Get the coordinates, (X_A, Y_A, Z_A, X_B, Y_B, Z_B, X_C, Y_C, Z_C)</td>
<td>The area, (A), of the triangle.</td>
</tr>
<tr>
<td>(a = ((X_C - X_B)^2 + (Y_C - Y_B)^2 + (Z_C - Z_B)^2)^{.5})</td>
<td>2. Determine the length of side ‘(a)’:</td>
<td></td>
</tr>
<tr>
<td>(b = ((X_C - X_A)^2 + (Y_C - Y_A)^2 + (Z_C - Z_A)^2)^{.5})</td>
<td>3. Compute the length of side ‘(b)’:</td>
<td></td>
</tr>
<tr>
<td>(c = ((X_B - X_A)^2 + (Y_B - Y_A)^2 + (Z_B - Z_A)^2)^{.5})</td>
<td>4. Determine the length of side ‘(c)’:</td>
<td></td>
</tr>
<tr>
<td>(S = \frac{1}{2}(a + b + c))</td>
<td>5. Find (S):</td>
<td></td>
</tr>
<tr>
<td>(\text{Area} = (S \times (S - a) \times (S - b) \times (S - c))^{.5})</td>
<td>6. Calculate the Area:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Display the Area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. End</td>
<td></td>
</tr>
</tbody>
</table>