Designing a Program and Subroutines

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Note: Subroutines are commonly called, depending on the programming language, modules, subprograms, methods, and functions.

Top-down design (sometimes called stepwise refinement) is used to break down an algorithm into subroutines.

Top-Down Design Process:

- The overall task of the program is broken down into a series of subtasks.
- Each of the subtasks is examined to determine whether it can be further broken down into more subtasks. This step is repeated until no more subtasks can be identified.
- Once all of the subtasks have been identified, they are written in code.

Three main tools for designing a program and its subroutines:

1. **Hierarchy Chart** – or a structure chart, a top-level visual representation of the main program and the relationships between subroutines.
2. **Flowcharts** – a diagram that graphically depicts the steps that take place in a program.
3. **Pseudocode** – or "fake code" is an informal language that has no syntax rules, it is a "mock-up" program. Each statement in the pseudocode represents an operation that can be performed in any high-level language.

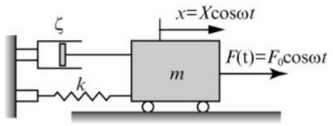
Source: Gaddis, T., *Programming Logic and Design* (New Jersey: Pearson, 2013) pp. 79 – 112.

Top-Down Design

Program: 3D Surface Plot of Amplitude Ratio of a Steady-State Vibration of a Friction-Free Spring-Mass-Damper System

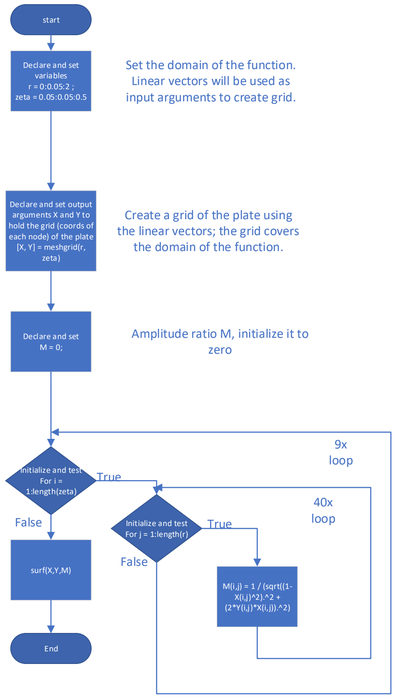
Overall Task:
Create a 3D surface plot of the normalized amplitude as a function of the frequency ratio and the damping ratio.

Steps that must be taken to perform the task:
1. Calculate the normalized amplitude (Xk/Fo shown in the equation below) for the domain of the function.
2. Plot the results.



$$\frac{Xk}{F_o} = \frac{1}{\sqrt{(1-r^2)^2 + (2\zeta r)^2}}$$

2. Flowchart



Set the domain of the function. Linear vectors will be used as input arguments to create grid.

nzeta = 9
nr = 40

Create a grid of the plate using the linear vectors; the grid covers the domain of the function.

Amplitude ratio M, initialize it to zero

There are two nested for loop shown here. Why have nested loops in the first place? Think of a clock display – the program has three for loops nested together, because each 'outer' loop is dependent on the 'inner' loop. Refer to Gaddis, p. 215.
The loop with the greatest iterations should be the innermost loop, then in a descending fashion outward.

The surf function creates a three-dimensional surface plot. The function plots the values in matrix Z as heights above a grid in the x-y plane defined by X and Y. The function also uses Z for the color data, so color is proportional to height.

3. Pseudocode