CMSC201
Computer Science I for Majors

Lecture 15 – Program Design

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Last Class We Covered

- Functions
  - Returning values
  - Returning multiple values at once
- Modifying parameters
  - Mutable
  - Immutable
- Modular programming

Any Questions from Last Time?

Today's Objectives

- To discuss the details of "good code"
- To learn how to design a program
- How to break it down into smaller pieces
  - Top Down Design
- To introduce two methods of implementation
- To learn more about Modular Development

“Good Code” – Readability

Motivation

- We've talked a lot about certain 'good habits' we'd like you all to get in while writing code
  - What are some of them?

- There are two main reasons for this
  - Readability
  - Adaptability

Readability

- Having your code be readable is important, both for your sanity and someone else's
- Having highly readable code makes it easier to:
  - Figure out what you're doing while writing the code
  - Figure out what the code is doing when you come back to look at it a year later
  - Have other people read and understand your code

Improving Readability

- Improving readability of your code can be accomplished in a number of ways
  - Comments
  - Meaningful variable names
  - Breaking code down into functions
  - Following consistent naming conventions
  - Language choice
  - File organization

Readability Example

- What does the following code snippet do?

```
def nS(p, c):
    l = len(p)
    if (l >= 4):
        c += 1
        print(p)
        if (l >= 9):
            return p, c
    # FUNCTION CONTINUES...
```

- There isn't much information to go on, is there?

Readability Example

- What if I added meaningful variable names?

```
def nS(p, c):
    l = len(p)
    if (l >= 4):
        c += 1
        print(p)
        if (l >= 9):
            return p, c
    # FUNCTION CONTINUES...
```

Readability Example

- What if I added meaningful variable names?

```
def nextState(password, count):
    length = len(password)
    if (length >= 4):
        count += 1
        print(password)
        if (length >= 9):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- And replaced the magic numbers with constants?

```
def nextState(password, count):
    length = len(password)
    if (length >= 4):
        count += 1
        print(password)
        if (length >= 9):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- And replaced the magic numbers with constants?

```
def nextState(password, count):
    length = len(password)
    if (length >= MIN_LENGTH):
        count += 1
        print(password)
        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- And added vertical space?

```
def nextState(password, count):
    length = len(password)
    if (length >= MIN_LENGTH):
        count += 1
        print(password)
        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- And added vertical space?

```
def nextState(password, count):
    length = len(password)


    if (length >= MIN_LENGTH):
        count += 1
        print(password)


        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- Maybe even some comments?

```
def nextState(password, count):
    length = len(password)


    if (length >= MIN_LENGTH):
        count += 1
        print(password)


        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- Maybe even some comments?

```
def nextState(password, count):
    length = len(password)

    # if long enough, count as a password
    if (length >= MIN_LENGTH):
        count += 1
        print(password)

        # if max length, don't do any more
        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- Now the purpose of the code is a bit clearer!
  - (It's actually part of some code that generates a complete list of the possible passwords for a swipe-based login system on a smart phone)

- You can see how small, simple changes increase the readability of a piece of code

Commenting is an "Art"

- Though it may sound pretentious, it's true

- There are NO hard and fast rules for when to a piece of code should be commented
  - Only guidelines
  - (This doesn't apply to required comments like file headers, though!)

General Guidelines

- If you have a complex conditional, give a brief overview of what it accomplishes

```
# check if car fits customer criteria
if color == "black" and int(numDoors) > 2 \
                    and int(price) < 27000:
```

- If you did something you think was clever, comment that piece of code
  - So that “future you” will understand it!

General Guidelines

- **Don't** write obvious comments

```
# iterate over the list
for item in myList:
```

- **Don't** comment every line

```
# initialize the loop variable
choice = 1
# loop until user chooses 0
while choice != 0
```

“Good Code” – Adaptability

Adaptability

- Often, what a program is supposed to do evolves and changes as time goes on
  - Well-written flexible programs can be easily altered to do something new
  - Rigid, poorly written programs often take a lot of work to modify
- When coding, keep in mind that you might want to change or extend something later

Adaptability: Example

- Remember how we talked about not using "magic numbers" in our code?

Bad:

```
def makeGrid():
    temp = []
    for i in range(0, 10):
        temp.append([0] * 10)
    return temp
```

Good:

```
def makeGrid():
    temp = []
    for i in range(0, GRID_SIZE):
        temp.append([0] * GRID_SIZE)
    return temp
```

Adaptability: Example

- In the whole of this program we use **`GRID_SIZE`** a dozen times or more
  - What if we suddenly want a bigger or smaller grid? Or a variable sized grid?
  - If we've left it as 10, it's very hard to change
- But **`GRID_SIZE`** is very easy to change
  - Our program is more adaptable

Solving Problems

Simple Algorithms

- Input
  - What information we will be given, or will ask for
- Process
  - The steps we will take to reach our specific goal
- Output
  - The final product that we will produce

More Complicated Algorithms

- We can apply the same principles to more complicated algorithms and programs

- There may be multiple sets of input/output, and we may perform more than one process

Complex Problems

- If we only take a problem in one piece, it may seem too complicated to even begin to solve
  - Creating your own word processor
  - Making a video game from scratch
  - A program that recommends classes based on availability, how often the class is offered, and the professor's rating

Top Down Design

Top Down Design

- Computer programmers use a divide and conquer approach to problem solving:
  - Break the problem into parts
  - Solve each part individually
  - Assemble into the larger solution
- These techniques are known as *top down design* and *modular development*

Top Down Design

- Breaking the problem down into pieces makes it more manageable to solve

- *Top-down design* is a process in which a big problem is broken down into small sub-problems, which can themselves be broken down into even smaller sub-problems

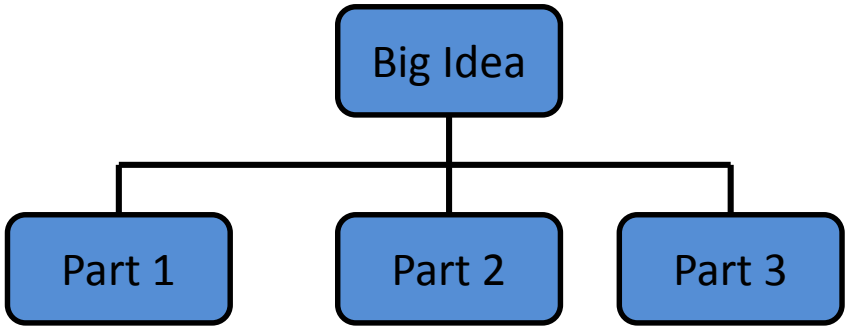
Top Down Design: Illustration

- First, start with a clear statement of the problem or concept

- A single big idea

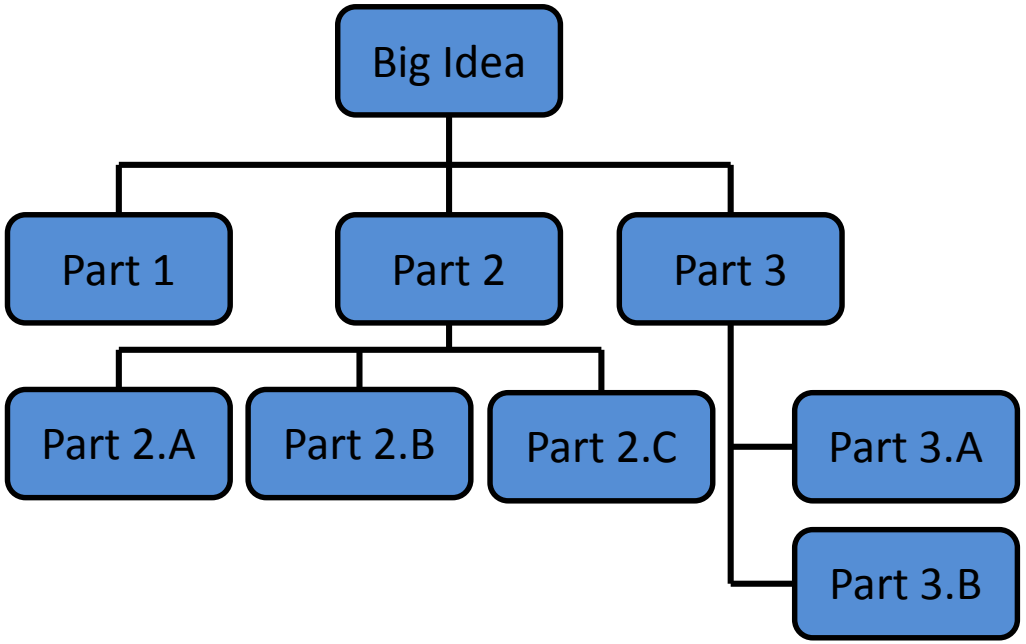
Top Down Design: Illustration

- Next, break it down into several parts



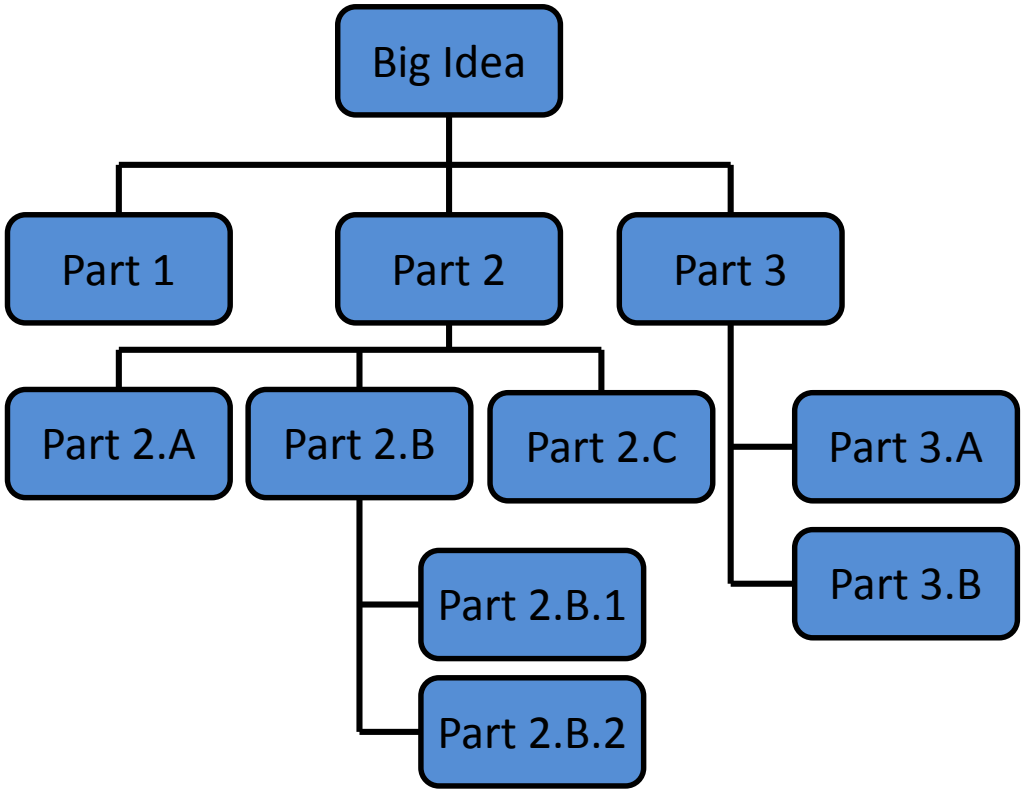
Top Down Design: Illustration

- Next, break it down into several parts
- If any of those parts can be further broken down, then the process continues…



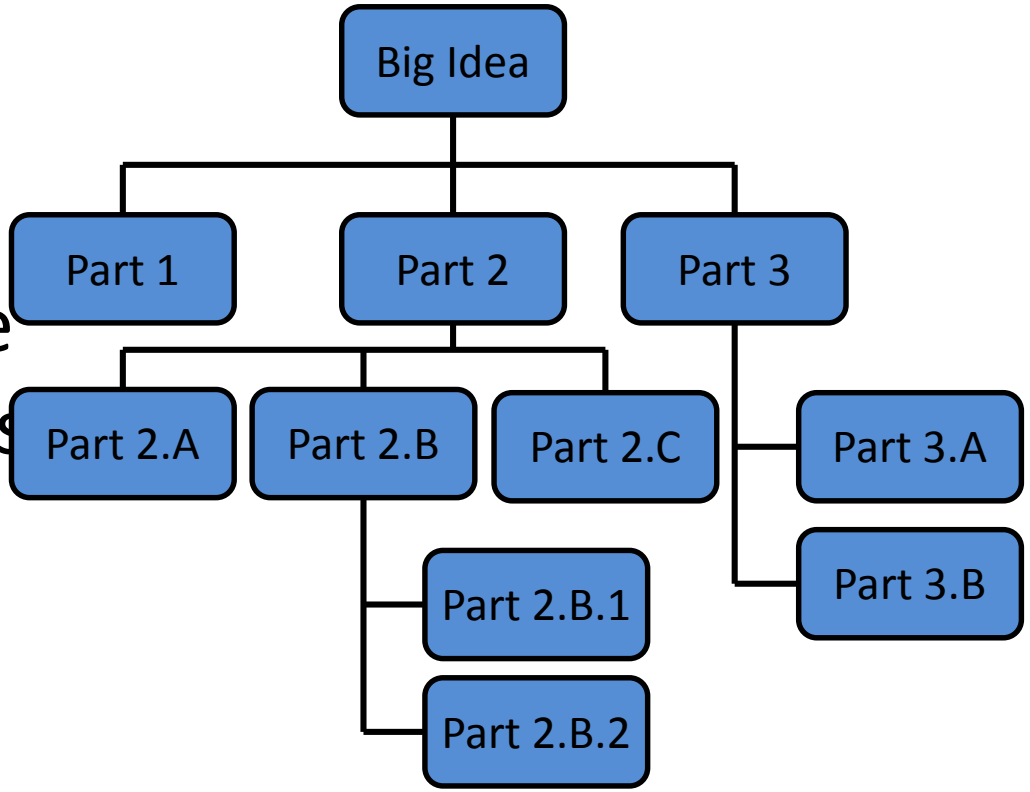
Top Down Design: Illustration

- And so on…



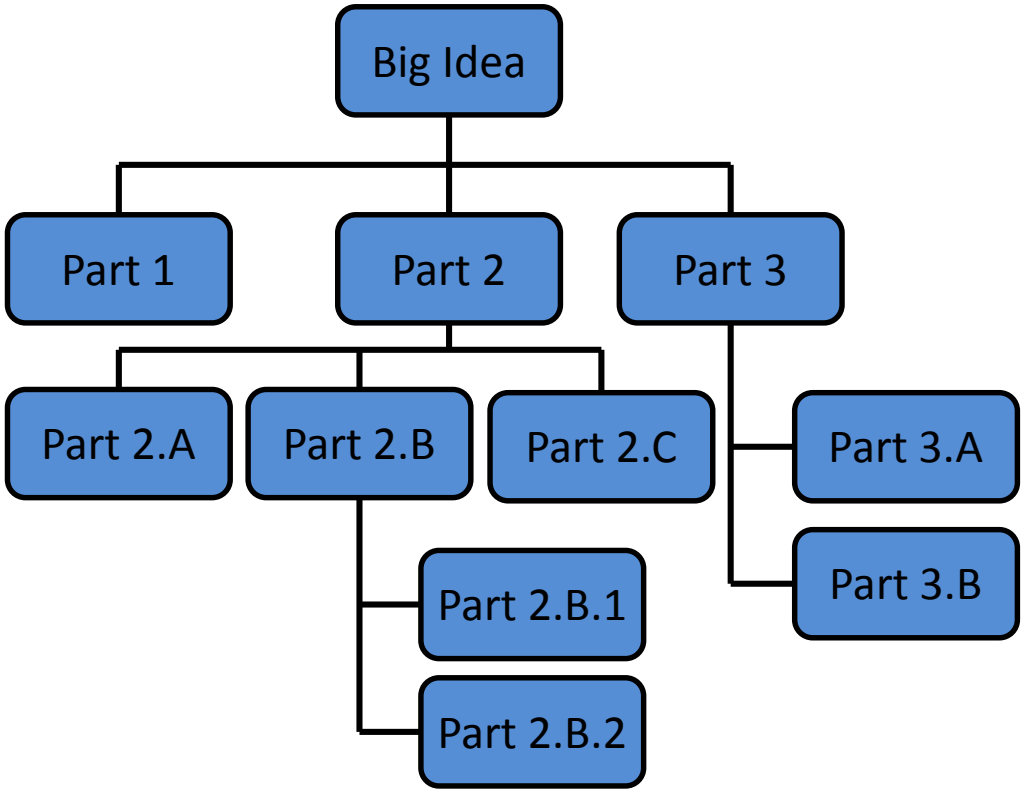
Top Down Design: Illustration

- Your final design might look like this chart, which shows the overall structure of the smaller pieces that together make up the "big idea" of the program



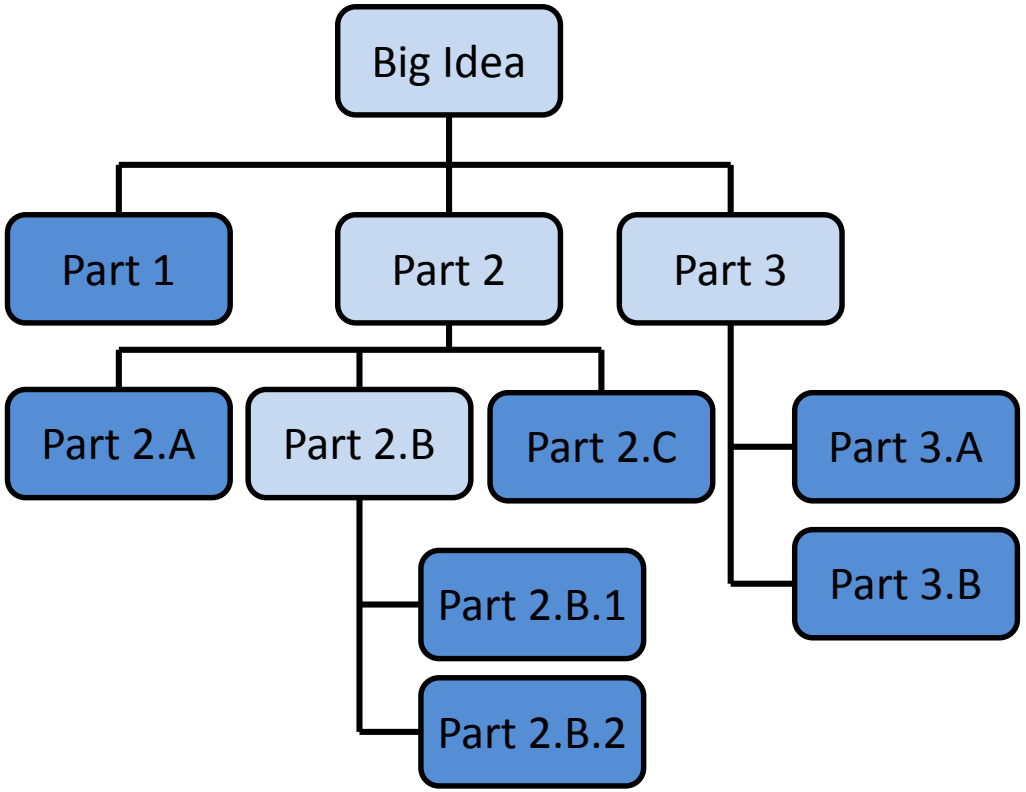
Top Down Design: Illustration

- This is like an upside-down tree, where each of the nodes represents a process



Top Down Design: Illustration

- The bottom nodes represent pieces that need to be developed and then recombined to create the overall solution to the original problem.



Analogy: Paper Outline

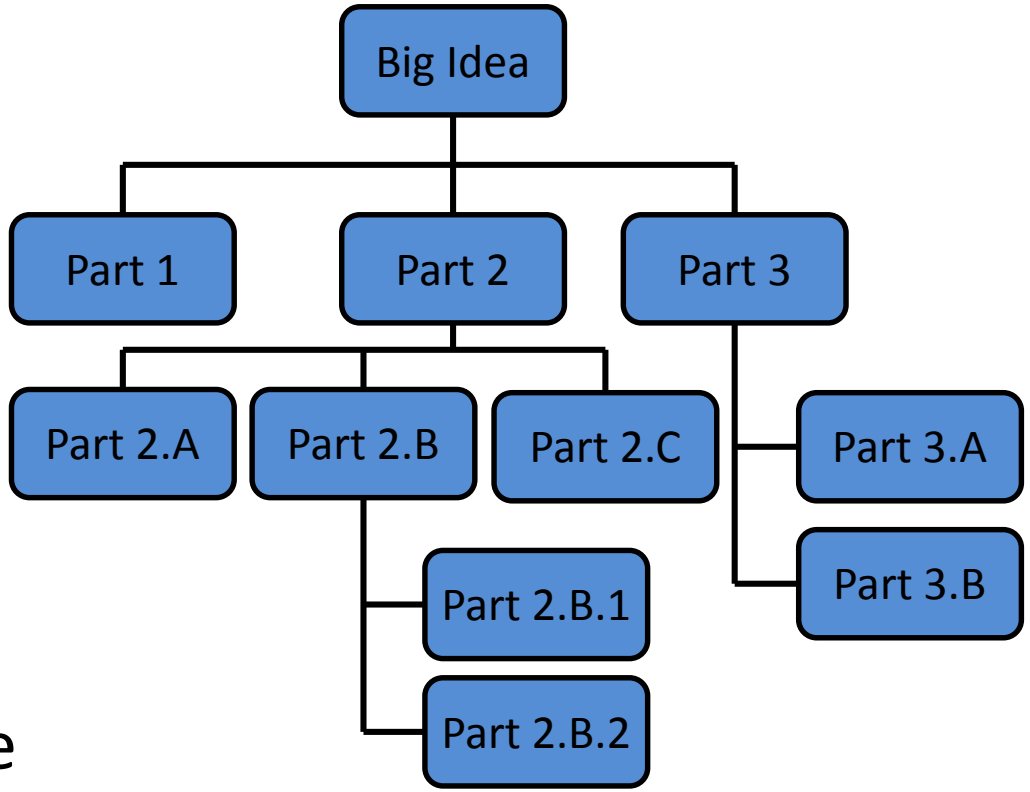
- Think of it as an outline for a paper you're writing for a class assignment

- You don't just start writing things down
  - You come up with a plan of the important points you'll cover, and in what order
  - This helps you to formulate your thoughts as well

Implementing from a Top Down Design

Bottom Up Implementation

- Develop each of the modules separately
  - Test that each one works as expected
- Then combine into their larger parts
  - Continue until the program is complete



Bottom Up Implementation

- To test your functions, you will probably use **`main()`** as a (temporary) testing bed

- Calling functions with different test inputs
  - Ensuring that functions “play nicely” together

Top Down Implementation

- Create "dummy" functions that fulfill the requirements, but don't perform their job
  - For example, a function that is supposed to take in a file name and return the weighted grades simply returns a 1
- Write up a "functional" **`main()`** that calls these dummy functions
  - Help pinpoint other functions you may need

How To Implement?

- Top down? Or bottom up?
- It's up to you!
  - As you do more programming, you will develop your own preference and style
- For now, just use something – don't code up everything at once without testing anything!

In-Class Example

In-Class Example

- (Expanding on the “Used Car Lot” from Lab 8)
- You run a Used Car Lot franchise, with multiple locations in the area
  - Every morning you get a list of available cars from each location as a separate file
  - Customers may come in and request any combination of features (color, price, etc.)
  - You have to handle your stock for the day, and handle customers who ask for impossible things

In-Class Example

- What is the “big picture” problem?
- What sort of tasks do you need to handle?
  - What functions would you make?
  - How would they interact?
  - What does each function take in and return?
- What will your **`main()`** look like?

In-Class Example

- Specifics:
  - Keep track of what cars are available at each location, and which have already been sold
    - Read in stock at beginning of program (“morning”)
    - Write down stock at end of the program (“closing shop”)
  - Don’t accept requests for things like 8 door cars
  - Customers don’t need a preference for everything
    - *e.g.*, a 4 door under $35,000 – but don’t care what color
  - Offer the option to buy from another location

Modular Development

Why Use Modular Development?

- Modular development of computer software:
  - makes a large project more manageable
  - is faster for large projects
  - leads to a higher quality product
  - makes it easier to find and correct errors
  - increases the reusability of solutions

Managing Large Projects

- Makes a large project more manageable...

- Easier to understand tasks that are smaller and less complex
- Smaller tasks are less demanding of resources

Faster Project Development

- Is faster for large projects…

- Different people work on different modules
- Then put their work together

- Different modules developed at the same time
  - Speeds up the overall project

Higher Quality Product

- Leads to a higher quality product...

- Assign people to use their strengths
- Programmers with knowledge and skills in a specific area, such as graphics, accounting, or data communications, can be assigned to the parts of the project that require those skills

Correcting Errors

- Makes it easier to find and correct errors...
- Sometimes the hardest part of debugging is finding out *where* the error is coming from
  - And solving it is the easy part
  - (Sometimes!)
- Modular development makes it easier to isolate the part of the software that is causing trouble

Reuse of Code (Solutions)

- Increases the reusability of solutions…
- Solutions to small, targeted problems are more likely to be useful elsewhere than solutions to bigger problems
  - *e.g.*, getting valid user input (returns one int) vs. getting and calculating quiz grades
- They are more likely to be reusable code

Libraries

- Over time, you may develop your own "library" of useful functions

- Just like Python has libraries for doing things with strings, opening and writing to files, and other common tasks you might want to do

Final In-Class Exercise

- What functions would you need to write a tic-tac-toe program that plays from the terminal?

- How would they interact?
- Draw a diagram if you need to!

Any Other Questions?

Announcements

- We'll go over the exam in class next time
  - Bring your exam with you!
- Homework 7 is out
  - Due by Thursday (Oct 29nd) at 8:59:59 PM
- Project 1 will be out Oct 29th