Program Development

Lecture 8
Section 1.6

Robb T. Koether

Hampden-Sydney College

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Outline

Program Development: Step 1

- Step 1:
  - Decide what the input and the output will be.
  - The input tells you what information you have to work with.
  - The output tells you what the goal is.

Program Development: Step 2

- Step 2:
  - Work an example by hand.
  - Choose simple values.
  - Avoid special cases.

Program Development: Step 3

- Step 3:
  - Sketch the algorithm based on the example.
  - Use any convenient mixture of English syntax and C++ syntax.
  - Avoid technical issues that can be addressed later (e.g., **`float`** vs. **`int`**).

Program Development: Step 4

- Step 4:
  - Fill in details until it is clear how each step will be written in C++.

Program Development: Step 5

- Step 5:
  - Write the program in C++.
  - Once Step 4 is complete, it should be clear how to write the program statements.

Outline

Example – Making Change

Example (Example)

- Write a program that will read an amount of money representing change and then output the number of dollar bills, quarters, dimes, nickels, and pennies that represent that amount.
- Assumptions
  - The dollars is given in dollars.
  - We give as many dollar bills as possible, then as many quarters as possible, and so on.

Step 1 - Input and Output

Example (Input and Output)

- The input will be
  - The amount of change

Step 1 - Input and Output

Example (Input and Output)

- The input will be
  - The amount of change
- The output will be
  - The number of dollar bills.
  - The number of quarters.
  - The number of dimes.
  - The number of nickels.
  - The number of pennies.

Step 2 - Work an Example

Example (Work an Example)

- Let the change be $2.87.

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- Let the change be \$2.87.
- The number of dollar bills is 2, leaving \$0.87, or 87¢.
- Remove 3 quarters (75¢) from 87¢, leaving 12¢.

Step 2 - Work an Example

Example (Work an Example)

- Let the change be $2.87.
- The number of dollar bills is 2, leaving $0.87, or 87¢.
- Remove 3 quarters (75¢) from 87¢, leaving 12¢.
- Remove 1 dime (10¢) from 12¢, leaving 2¢.

Step 2 - Work an Example

Example (Work an Example)

- Let the change be $2.87.
- The number of dollar bills is 2, leaving $0.87, or 87¢.
- Remove 3 quarters (75¢) from 87¢, leaving 12¢.
- Remove 1 dime (10¢) from 12¢, leaving 2¢.
- Remove 0 nickels.

Step 2 - Work an Example

Example (Work an Example)

- Let the change be $2.87.
- The number of dollar bills is 2, leaving $0.87, or 87¢.
- Remove 3 quarters (75¢) from 87¢, leaving 12¢.
- Remove 1 dime (10¢) from 12¢, leaving 2¢.
- Remove 0 nickels.
- The remaining amount is 2 pennies.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

1. Get the integer part of the input value. That represents the number of dollar bills.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

1. Get the integer part of the input value. That represents the number of dollar bills.
2. Subtract the number of dollars from the amount and then multiply by 100.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

1. Get the integer part of the input value. That represents the number of dollar bills.
2. Subtract the number of dollars from the amount and then multiply by 100.
3. Get the whole number quotient of the amount divided by 25. That represents the number of quarters.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

1. Get the integer part of the input value. That represents the number of dollar bills.
2. Subtract the number of dollars from the amount and then multiply by 100.
3. Get the whole number quotient of the amount divided by 25. That represents the number of quarters.
4. Get the remainder of that same quotient. That is the remaining change.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

1. Get the integer part of the input value. That represents the number of dollar bills.
2. Subtract the number of dollars from the amount and then multiply by 100.
3. Get the whole number quotient of the amount divided by 25. That represents the number of quarters.
4. Get the remainder of that same quotient. That is the remaining change.
5. Repeat steps 3 and 4, using divisors 10 and then 5.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

1. Get the integer part of the input value. That represents the number of dollar bills.
2. Subtract the number of dollars from the amount and then multiply by 100.
3. Get the whole number quotient of the amount divided by 25. That represents the number of quarters.
4. Get the remainder of that same quotient. That is the remaining change.
5. Repeat steps 3 and 4, using divisors 10 and then 5.
6. After getting the nickels, whatever is left is the pennies.

Step 4 - Fill in the Details

Example (Fill in the Details)

- No further details are necessary in this example.

Step 5 - Write the Program

Example (Write the Program – Input)

```
cout << "Enter the change, in dollars: ";
float amt;
cin >> amt;
```

Step 5 Continued

Example (Write the Program – Calculations)

```
int dollars = amt;
int change = 100*(amt - dollars);
int quarters = change/25;
change = change % 25;
int dimes = change/10;
change = change % 10;
int nickels = change/5;
change = change % 5;
int pennies = change;
```

Step 5 Continued

Example (Write the Program – Output)

```
cout << "Number of dollar bills = " << dollars << endl
cout << "Number of quarters = " << quarters << endl;
cout << "Number of dimes = " << dimes << endl;
cout << "Number of nickels = " << nickels << endl;
cout << "Number of pennies = " << pennies << endl;
```

Example of Program Development

Example (Test the Program)

- Enter the program, run it, and test it.

Outline

Example – Savings Account

Example (Example)

- Write a program that will compute the amount of interest earned on a pension plan, given the amount of each monthly deposit, the interest rate, and the number of years.
- Assumptions
  - The deposits are equal and made monthly.
  - The first deposit is made at the *end* of the first month.
  - Interest is applied at the end of each month.
  - The duration of the loan will be a whole number of years.

Step 1 - Input and Output

Example (Input and Output)

- The input will be
  - The monthly deposit.
  - The interest rate as an annual percent.
  - The number of years.

Step 1 - Input and Output

Example (Input and Output)

- The input will be
  - The monthly deposit.
  - The interest rate as an annual percent.
  - The number of years.
- The output will be
  - The total amount of the account.
  - The total amount invested.
  - The total interest earned.

Step 2 - Work an Example

Example (Work an Example)

- The formula for the account balance is

$$A = \frac{P[(1+r)^n - 1]}{r},$$

where

- P is the monthly deposit.
- A is the amount of the account.
- r is the *monthly* interest rate.
- n is the number of *months*.

Step 2 - Work an Example

Example (Work an Example)

- The formula for the account balance is

$$A = \frac{P[(1+r)^n - 1]}{r},$$

where

  - P is the monthly deposit.
  - A is the amount of the account.
  - r is the *monthly* interest rate.
  - n is the number of *months*.

- Let the monthly deposit be \$300.00, the interest rate be 12% per annum, and the duration be 20 years.

Step 2 Continued

Example (Work an Example)

- The monthly interest rate is $0.12/12 = 0.01$ and the number of months is $20 \times 12 = 240$.

Step 2 Continued

Example (Work an Example)

- The monthly interest rate is $0.12/12 = 0.01$ and the number of months is $20 \times 12 = 240$.
- Compute the amount of the account

$$A = \frac{300[(1 + 0.01)^{240} - 1]}{0.01}$$
$$= \$296776.61.$$

Step 2 Continued

Example (Work an Example)

- The monthly interest rate is $0.12/12 = 0.01$ and the number of months is $20 \times 12 = 240$.
- Compute the amount of the account

$$A = \frac{300[(1 + 0.01)^{240} - 1]}{0.01}$$
$$= \$296776.61.$$

- Total amount invested $= 240 \times \$300 = \$72,000$.

Step 2 Continued

Example (Work an Example)

- The monthly interest rate is $0.12/12 = 0.01$ and the number of months is $20 \times 12 = 240$.
- Compute the amount of the account

$$A = \frac{300[(1 + 0.01)^{240} - 1]}{0.01}$$
$$= \$296776.61.$$

- Total amount invested $= 240 \times \$300 = \$72,000$.
- Total interest earned $= \$296,776.61 - \$72,000 = \$224,776.61$.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

- Divide the annual rate by 12 to get the monthly rate r.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

- Divide the annual rate by 12 to get the monthly rate r.
- Multiply the number of years by 12 to get the number of months n.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

- Divide the annual rate by 12 to get the monthly rate r.
- Multiply the number of years by 12 to get the number of months n.
- Substitute P, r, and n into the formula to get A.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

- Divide the annual rate by 12 to get the monthly rate r.
- Multiply the number of years by 12 to get the number of months n.
- Substitute P, r, and n into the formula to get A.
- Total amount invested is $T = P \times n$.

Step 3 - Write the Algorithm

Example (Write the Algorithm)

- Divide the annual rate by 12 to get the monthly rate r.
- Multiply the number of years by 12 to get the number of months n.
- Substitute P, r, and n into the formula to get A.
- Total amount invested is $T = P \times n$.
- Total interest earned is $I = A - T$.

Step 4 - Fill in the Details

Example (Fill in the Details)

- No further details are necessary in this example.

Step 5 - Write the Program

Example (Write the Program – Input)

```
cout << "Enter the monthly deposit: ";
float amt;
cin >> amt;

cout << "Enter the annual interest rate (as %): ";
float ann_rate;
cin >> ann_rate;

cout << "Enter the number of years: ";
float yrs;
cin >> yrs;
```

Step 5 Continued

Example (The Power Function)

- How do we calculate $(1 + r)^n$?

Step 5 Continued

Example (The Power Function)

- How do we calculate $(1 + r)^n$?
- That is, how do we raise a number to a power in C++?

Step 5 Continued

Example (The Power Function)

- How do we calculate $(1 + r)^n$?
- That is, how do we raise a number to a power in C++?
- There is a "power" function named `pow()`.

`pow(x, y)` computes x^y.

Step 5 Continued

Example (Write the Program – Calculations)

```
float mon_rate = ann_rate/12.0;
float num_mons = 12.0 * yrs;
float amt = dep*(pow(1.0 + mon_rate, num_mons) - 1.0)
                              /mon_rate;
float amt_inv = num_mons * dep;
float tot_int = amt - amt_inv;
```

Step 5 Continued

Example (Write the Program – Output)

```
cout << "Account balance = $" << amt << endl;
cout << "Total invested = $" << amt_inv << endl;
cout << "Interest earned = $" << tot_int << endl;
```

Example of Program Development

Example (Test the Program)

- Enter the program, run it, and test it.

Outline

Program Debugging

- To debug a program is to correct its errors.
- First we must correct all syntax (compile-time) errors.
- Do not use trial and error. That only makes matters worse.
- Understand each error.

Program Debugging

- Then we must correct the logical (run-time) errors.
- Insert output statements to display values of key variables.
- Comment out segments of code.
- Use a debugger.

The Visual Studio Debugger

- The Visual Studio debugger allows the programmer to
  - Execute the program one statement at a time.
  - Check the values of variables during execution.
  - By comparing the actual values to the correct values, the programmer can pinpoint the statement where his program is going wrong.

Outline

Program Testing

- To test a program is to demonstrate that it is error-free.
- Use the worked example as test data.
- Check the output for correctness.
- Test special cases.
- Be sure that every possible path in the program is executed.

Outline

Assignment

Assignment

- Read Section 1.6.