Week 2

Branching & Looping

Gaddis: Chapters 4 & 5

CS 5301
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Relational Operators

- relational operators (result is bool):

  == Equal to (do not use =)
  != Not equal to
  > Greater than
  < Less than
  >= Greater than or equal to
  <= Less than or equal to

```
int x=90;
int n=6;
7 < 25
89 == x
x % 2 != 0
8 + 5 * 10 <=10 * n
```

- operator precedence:

```
* / %
+ -
< > <= >=
== !=
=
```

Which operation happens first? next? …

```
int x, y;

...  x < y -10 ...
...  x * 5 >= y + 10 …


bool t1 = x > 7;
bool t2 = x * 5 >= y + 10;
```


if/else

- if and else

```
if (expression)
   statement1
else
   statement2
```

  - if expression is true, statement1 is executed
  - if expression is false, statement2 is executed

```
double rate, monthlySales;
. . .
if (monthlySales > 3000)
   rate = .025;
else
   rate = .029;
```

- the else is optional:

```
if (expression)
   statement
```

  - if expression is true, statement is executed, otherwise statement is skipped

Block or compound statement

- a set of statements inside braces:

```
{
   int x;
   cout << "Enter a value for x: " << endl;
   cin >> x;
}
```

- This allows us to use multiple statements when by rule only one is allowed.

```
int number;
cout << "Enter a number" << endl;
cin >> number;
if (number % 2 == 0)
{
   number = number / 2;
   cout << "0";
}
else
{
   number = (number + 1) / 2;
   cout << "1";
}
```

Nested if/else

- if-else is a statement. It can occur as a statement inside of another if-else statement.

```
if (score >= 90)
   grade = 'A';
else {
      if (score >= 80)
         grade = 'B';
      else {
            if (score >= 70)
               grade = 'C';
            else {
                  if (score >= 60)
                     grade = 'D';
                  else
                     grade = 'F';
               }
         }
   }
```

This is equivalent to the code on the left. It is just formatted differently

```
if (score >= 90)
   grade = 'A';
else if (score >= 80)
   grade = 'B';
else if (score >= 70)
   grade = 'C';
else if (score >= 60)
   grade = 'D';
else
   grade = 'F';
```

- The braces are optional on this side

Nested if/else

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```
if (score >= 90)
   grade = 'A';
else {
      if (score >= 80)
         grade = 'B';
      else {
            if (score >= 70)
               grade = 'C';
            else {
                  if (score >= 60)
                     grade = 'D';
                  else
                     grade = 'F';
               }
         }
   }
```

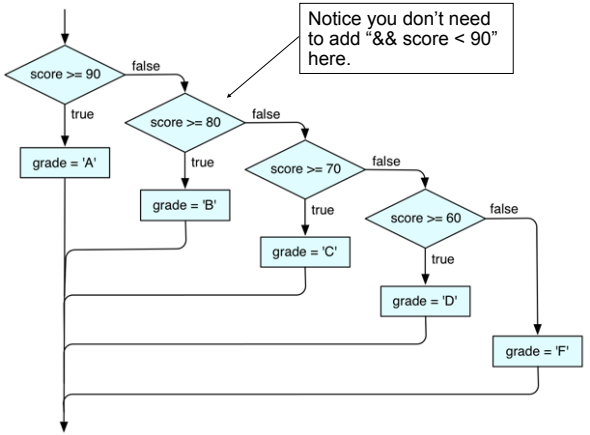
If we are in this else branch, what do we know about the value of score?

This is equivalent to the code on the left. It is just formatted differently

```
if (score >= 90)
   grade = 'A';
else if (score >= 80)
   grade = 'B';
else if (score >= 70)
   grade = 'C';
else if (score >= 60)
   grade = 'D';
else
   grade = 'F';
```


Nested if/else

- Here is a flowchart indicating the flow of control during execution of the nested if on the previous slide:



Logical Operators

- logical operators (values and results are bool):

! not
&& and
|| or

!a	is true when a is false
a && b	is true when **both** a and b are true
a || b	is true when **either** a or b is true

- operator precedence:

```
!
* / %
+ -
< > <= >=
== !=
&&
||
```

- examples T/F?:

```
int x=6;
int y=10;
a. x == 5 && y <= 3
b. x > 0 && x < 10
c. x == 10 || y == 10
d. x == 10 || x == 11
e. !(x > 0)
f. !(x > 6 || y == 10)
```

switch statement

- switch stmt:

```
switch (expression) {
   case constant: statements
   ...
   case constant: statements
   default: statements
}
```

  - execution *starts* at the case labeled with the value of the expression.
  - if no match, *start* at default
  - use break to exit switch (usually at end of statements)
- example:

```
switch (ch) {
   case 'a':
   case 'A': cout << "Option A";
             break;
   case 'b':
   case 'B': cout << "Option B";
             break;
   default: cout << "Invalid choice";
}
```


Input Validation

- Input validation: inspecting input data to determine whether it is acceptable
- Invalid input is an error that should be treated as an exceptional case.
  - The program can ask the user to re-enter the data
  - The program can exit with an error message

```
cout << "Enter a score between 0 and 100: ";
cin >> score;
if (score < 0 || score > 100) {
   cout << "That is an invalid score." << endl;
} else {
  //do something with score here
}
```


More assignment statements

- Compound assignment

operator	usage	equivalent syntax:
+=	x += e;	x = x + e;
-=	x -= e;	x = x - e;
*=	x *= e;	x = x * e;
/=	x /= e;	x = x / e;

- increment, decrement

operator	usage	equivalent syntax:
++	x++; ++x;	x = x + 1;
--	x--; --x;	x = x - 1;

while loops

- while

```
while (expression)
   statement
```

statement may be a compound statement (a block: {statements})

  - if expression is true, statement is executed, repeat
- Example:

```
int number;
cout << "Enter a number, 0 when finished: ";
cin << number;
while (number != 0)
{
   cout << "You entered " << number << endl;
   cout << "Enter the next number: ";
   cin >> number;
}
cout << "Done" << endl;
```

- output:

```
Enter a number, 0 when finished: 22
You entered 22
Enter the next number: 5
You entered 5
Enter the next number: 0
Done
```

two kinds of loops

- conditional loop
  - execute as long as a certain condition is true
- count-controlled loop:
  - executes a specific number of times
    - initialize counter to zero (or other start value).
    - test counter to make sure it is less than count.
    - update counter during each iteration.

```
int number = 1;
while (number <= 3)
{
   cout << "Student" << number << endl;
   number = number + 1; // or use number++
}
cout << "Done" << endl;
```

number is a "counter", it keeps track of the number of times the loop has executed.

for loops

- for:

```
for (expr1; expr2; expr3)
   statement
```

statement may be a compound statement (a block: {statements})

  - equivalent to:

```
expr1;
while (expr2) {
   statement
   expr3;
}
```

- Good for implementing count-controlled loops:

pattern: for (initialize; test; update)

```
for (int number = 1; number <= 3; number++)
{
   cout << "Student" << number << endl;
}
cout << "Done" << endl;
```


do-while loops

- do while:

```
do
   statement
while (expression);
```

statement may be a compound statement (a block: {statements})

statement is executed.
if expression is true, then repeat

- The test is at the end, statement ALWAYS executes at least once.

```
int number;
do {
  cout << "Enter a number, 0 when finished: ";
  cin << number;
  cout << "You entered " << number << endl;
} while (number != 0);
```


Keeping a running total (summing)

- Example:

```
int days;
float total = 0.0;  //Accumulator

cout << "How many days did you ride your bike? ";
cin >> days;

for (int i = 1; i <= days; i++)
{
   float miles;
   cout << "Enter the miles for day " << i << ": ";
   cin >> miles;
   total = total + miles;
}

cout << "Total miles ridden: " << total << endl;
```

Sentinel controlled loop

- A sentinel controlled loop continues to process data until reaching a special value (called the sentinel) that signals the end.

```
get the first data item
while item is not the sentinel
   process the item
   get the next data item
```

- The first item is retrieved before the loop starts. This is called the priming read, since it gets the process started.
- If the first item is the sentinel, the loop terminates and no data is processed.

Sentinel controlled loop

- Example: summing using a sentinel

```
float total = 0.0;  //Accumulator
float miles;

cout << "Enter the miles you rode (-1 to quit): ";
cin >> miles;

while (miles != -1)
{
    total = total + miles;
    cout << "Enter the miles you rode (-1 to quit): ";
    cin >> miles;
}

cout << "Total miles ridden: " << total << endl;
```


Nested loops

- When one loop appears in the body of another
- For every iteration of the outer loop, we do all the iterations of the inner loop

```
for (row=1; row<=3; row++)  //outer
{
   for (col=1; col<=3; col++) //inner
     cout << row * col << " ";
   cout << endl;
}
```

Output:

```
1 2 3
2 4 6
3 6 9
```


continue and break Statements

- Use `break` to terminate execution of a loop
- When used in a nested loop, terminates the inner loop only.

- Use `continue` to go to end of **current** loop and prepare for next repetition
- while, do-while loops: go immediately to the test, repeat loop if test passes
- for loop: immediately perform update step, then test, then repeat loop if test passes

Example problem: Future Value

- Money deposited in a bank account earns interest annually. How much will the account be worth 10 years from now?
- Inputs: the principal and the annual interest rate
- Output: value of the investment in 10 years
- Relationship between Inputs and Outputs:

  Value after one year is given by this formula:

  ```
  principal * (1 + apr)
  ```

  This needs to be done 10 times.

Example problem: Future Value

- Design:

```
Print an introduction
Input the amount of the principal (principal)
Input the annual percentage rate (apr)
Repeat 10 times:
   principal = principal * (1 + apr)
Output the value of principal
```


Example problem: Future Value

- Code:

```
int main() {
    cout << fixed << setprecision(2);
    double principal, apr;

    //Print an introduction
    cout <<"This program calculates the future ";
    cout <<"value of a 10-year investment." << endl;

    //Input the amount of the principal and interest
    cout << "Enter the initial principal: ";
    cin >> principal;
    cout << "Enter the annual interest rate: ";
    cin >> apr;

    //Repeat 10 times:
    for (int i=1; i<=10; i++)
       principal = principal * (1 + apr);

    //Output the value of principal
    cout << "The value in 10 years is: " << principal << endl;
}
```