Topic 3

1. The `if` statement
2. Comparing numbers and strings
3. Multiple alternatives
4. Nested branches
5. Problem solving: flowcharts
6. Problem solving: test cases
7. Boolean variables and operators
8. Application: input validation
9. Chapter summary

Multiple Alternatives Need Multiple Nested if() Statements

Table 3 Richter Scale	
Value	Effect
8	Most structures fall
7	Many buildings destroyed
6	Many buildings considerably damaged, some collapse
4.5	Damage to poorly constructed buildings

In the case of the Richter Scale for earthquake magnitude, there are five branches:

one each for the four descriptions of damage, and a "default" fifth one for no destruction (not shown).

Flowchart for the Richter Scale Code

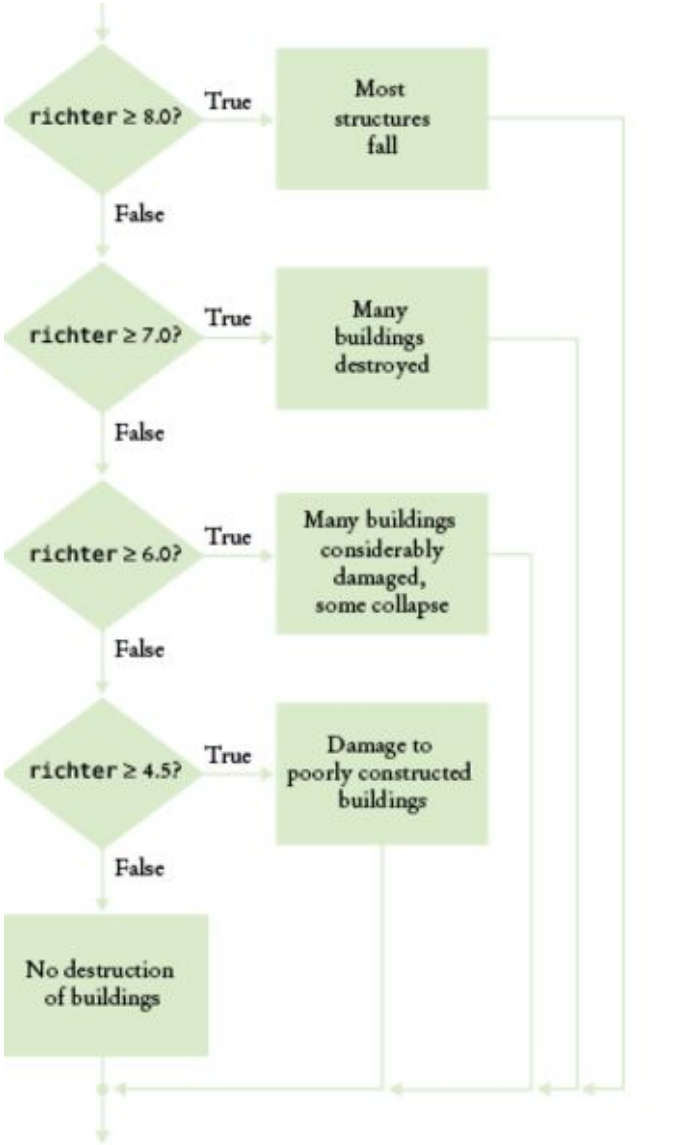

Figure 3 Multiple Alternatives

Multiple Alternatives (Richter Scale Code)

```
if (richter >= 8.0)
{
   cout << "Most structures fall";
}
else if (richter >= 7.0)
{
   cout << "Many buildings destroyed";
}
else if (richter >= 6.0)
{
   cout << "Many buildings considerably damaged, some collapse";
}
else if (richter >= 4.5)
{
   cout << "Damage to poorly constructed buildings";
}
else
{
   cout << "No destruction of buildings";
}
. . .
```

Multiple Alternatives – Order of Tests

Because of this execution order,
when using multiple `if` statements,
pay attention to the order of the conditions.

Multiple Alternatives – Wrong Order of Tests

```
if (richter >= 4.5)    // Tests in wrong order
{
   cout << "Damage to poorly constructed buildings";
}
else if (richter >= 6.0)
{
   cout << "Many buildings considerably damaged, some collapse";
}
else if (richter >= 7.0)
{
   cout << "Many buildings destroyed";
}
else if (richter >= 8.0)
{
   cout << "Most structures fall";
}
```

Suppose the value of richter is 7.1. Because we tested small first with a >=, the first statement is (wrongly) printed.

The `switch` Statement vs. the `if` statement

- Below is a complicated `if()` statement to choose a text `string` to assign based on the value of an `int` variable:

```
int digit;
…  //digit variable gets set here by some code
if (digit == 1) { digit_name = "one"; }
else if (digit == 2) { digit_name = "two"; }
else if (digit == 3) { digit_name = "three"; }
else if (digit == 4) { digit_name = "four"; }
else if (digit == 5) { digit_name = "five"; }
else if (digit == 6) { digit_name = "six"; }
else if (digit == 7) { digit_name = "seven"; }
else if (digit == 8) { digit_name = "eight"; }
else if (digit == 9) { digit_name = "nine"; }
else { digit_name = ""; }
```

The `switch` Statement

- The `switch` statement is an alternative to nested `if() else` statements. But `switch` is at least as awkward to code as nested `if() else`:

```
int digit; //switch can only test int and char types
…  //digit variable gets set here by some code
switch(digit)
{
   case 1: digit_name = "one"; break;
   case 2: digit_name = "two"; break;
   case 3: digit_name = "three"; break;
   case 4: digit_name = "four"; break;
   case 5: digit_name = "five"; break;
   case 6: digit_name = "six"; break;
   case 7: digit_name = "seven"; break;
   case 8: digit_name = "eight"; break;
   case 9: digit_name = "nine"; break;
   default: digit_name = ""; break; //taken if none of the
  above
}
```

`break` statements in the `switch` statement

- Every branch of the switch must be terminated by a **`break`** statement. And each branch must terminate with a semicolon.

- **`break`** tells the machine to skip down to the end of the `switch` statement, because a match was found.

- If the **`break`** is missing, execution falls through to the next branch, and so on, until finally a **`break`** or the end of the switch is reached.

- In practice, this fall-through behavior is rarely useful, and

  it is a common cause of errors.

- If you accidentally forget the **`break`** statement, your program compiles but executes unwanted code. Try it and see!

Topic 4

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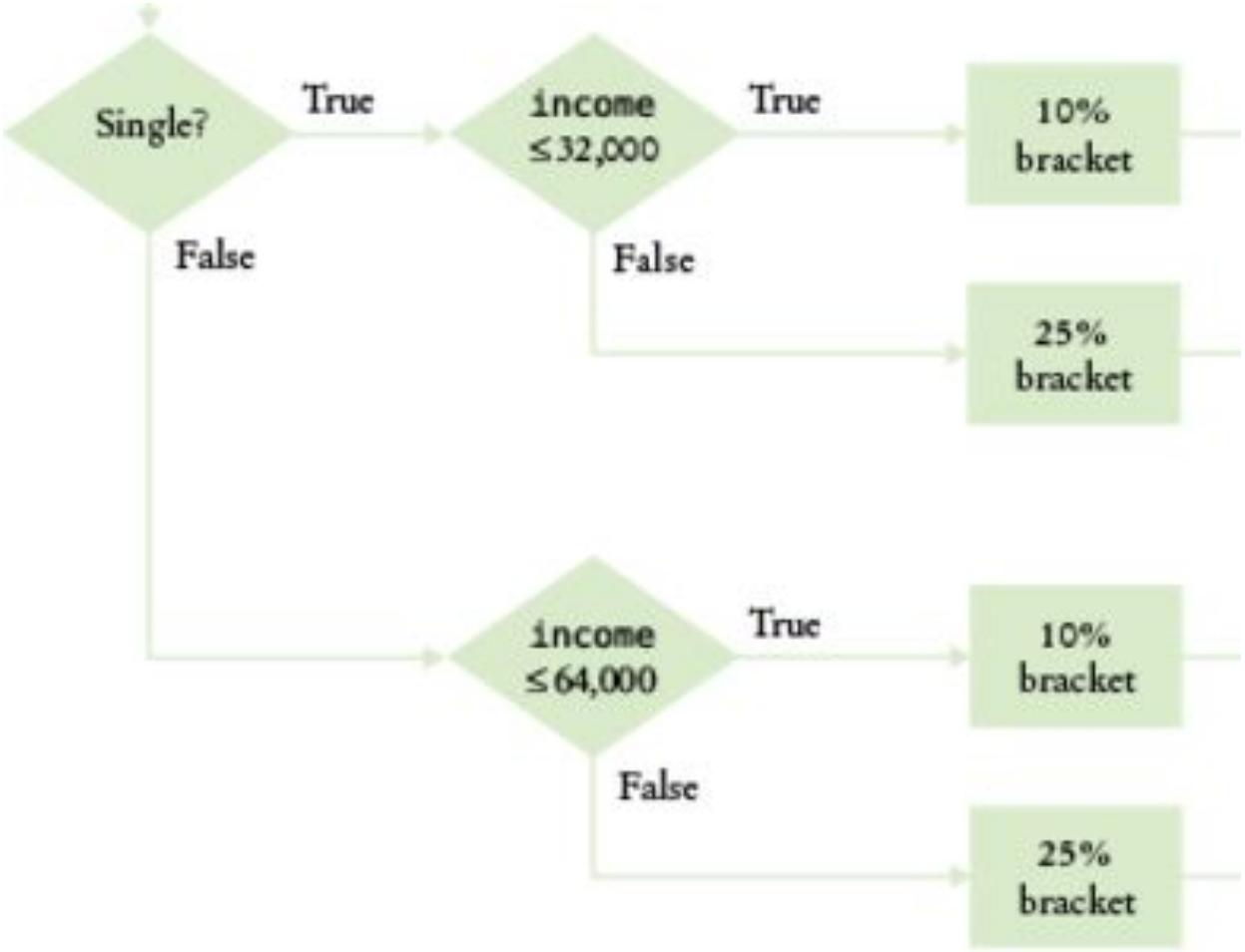
Nested Branches – Taxes

- In the United States different tax rates are used depending on the taxpayer's marital status – single rates are higher.
- Married taxpayers add their income together and pay taxes on the total. See the IRS table below from a recent year:

Table 4 Federal Tax Rate Schedule		
If your status is Single and if the taxable income is	the tax is	of the amount over
at most $32,000	10%	$0
over $32,000	$3,200 + 25%	$32,000
If your status is Married and if the taxable income is	the tax is	of the amount over
at most $64,000	10%	$0
over $64,000	$6,400 + 25%	$64,000

Flowchart for Tax Table Decisions



Nested Branches – Taxes – Complete Code part 1

```
#include <iostream>
#include <string>
using namespace std;
int main()
{
   const double RATE1 = 0.10;
   const double RATE2 = 0.25;
   const double RATE1_SINGLE_LIMIT = 32000;
   const double RATE1_MARRIED_LIMIT = 64000;

   double tax1 = 0;
   double tax2 = 0;

   double income;
   cout << "Please enter your income: ";
   cin >> income;

   cout << "Please enter s for single, m for married: ";
   string marital_status;
   cin >> marital_status;
```

Nested Branches – Taxes (Code part 2)

```
if (marital_status == "s")
   {
      if (income <= RATE1_SINGLE_LIMIT)
      {
         tax1 = RATE1 * income;
      }
      else
      {
         tax1 = RATE1 * RATE1_SINGLE_LIMIT;
         tax2 = RATE2 * (income -
  RATE1_SINGLE_LIMIT);
      }
   }
else
```

Nested Branches – Taxes (Code part 3)

```
   {
      if (income <= RATE1_MARRIED_LIMIT)
      {
         tax1 = RATE1 * income;
      }
      else
      {
         tax1 = RATE1 * RATE1_MARRIED_LIMIT;
         tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT);
      }
   }

   double total_tax = tax1 + tax2;

   cout << "The tax is $" << total_tax << endl;
   return 0;
}
```

Hand-Tracing

- A very useful technique for understanding whether a program works correctly is called *hand-tracing*.
- You simulate the program's activity on a sheet of paper.
- You can use this method with pseudocode or C++ code.

Hand-Tracing, How to

- Looking at your pseudocode or C++ code,
  - Use a marker, such as a paper clip,
    (or toothpick from an olive)
    to mark the current statement.
  - "Execute" the statements one at a time.
  - Every time the value of a variable changes,
    cross out the old value, and
    write the new value below the old one.

Hand-Tracing the Tax Program

```
int main()
{
   const double RATE1 = 0.10;
   const double RATE2 = 0.25;
   const double RATE1_SINGLE_LIMIT = 32000;
   const double RATE1_MARRIED_LIMIT = 64000;

   double tax1 = 0;
   double tax2 = 0;
```

tax1	tax2	income	marital status
0	0		

Hand-Tracing, Filling in the Trace Table

```
double income;
cout << "Please enter your income: ";
cin >> income;
```

Assume user typed 80000.

```
cout << "Please enter s for single, m for married: ";
string marital_status;
cin >> marital_status;
```

The user typed `m`

tax1	tax2	income	marital status
0	0	80000	m

Hand-Tracing #2

```
 if (marital_status == "s")
{
   if (income <= RATE1_SINGLE_LIMIT)
   {
      tax1 = RATE1 * income;
   }
   else
   {
      tax1 = RATE1 * RATE1_SINGLE_LIMIT;
      tax2 = RATE2 * (income - RATE1_SINGLE_LIMIT);
   }
}
else  //this branch is taken because marital_status != "s"
```

Hand-Tracing #3

tax1	tax2	income	marital status
0	0	80000	m

```
 else
{
   if (income <= RATE1_MARRIED_LIMIT)
   {
      tax1 = RATE1 * income;
   }
   else
   {
      tax1 = RATE1 * RATE1_MARRIED_LIMIT;
      tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT);
   }
}
double total_tax = tax1 + tax2;
```

Hand-Tracing #4

```
 else
{
   if (income <=  64000) //this branch is skipped, false
   {
      tax1 = RATE1 * income;
   }
   else //this branch is taken
   {
      tax1 = RATE1 * RATE1_MARRIED_LIMIT;
      tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT);
   }
}
double total_tax = tax1 + tax2;
```

Hand-Tracing #5

tax1	tax2	income	marital status	total tax
~~0~~	~~0~~	80000	m	
6400	4000			10400

```
 else
{
   if (income <= RATE1_MARRIED_LIMIT)
   {
      tax1 = RATE1 * income;
   }
   else //executed
   {
      tax1 = RATE1 * RATE1_MARRIED_LIMIT;
      tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT);
   }
}
double total_tax = tax1 + tax2; //always executed
```