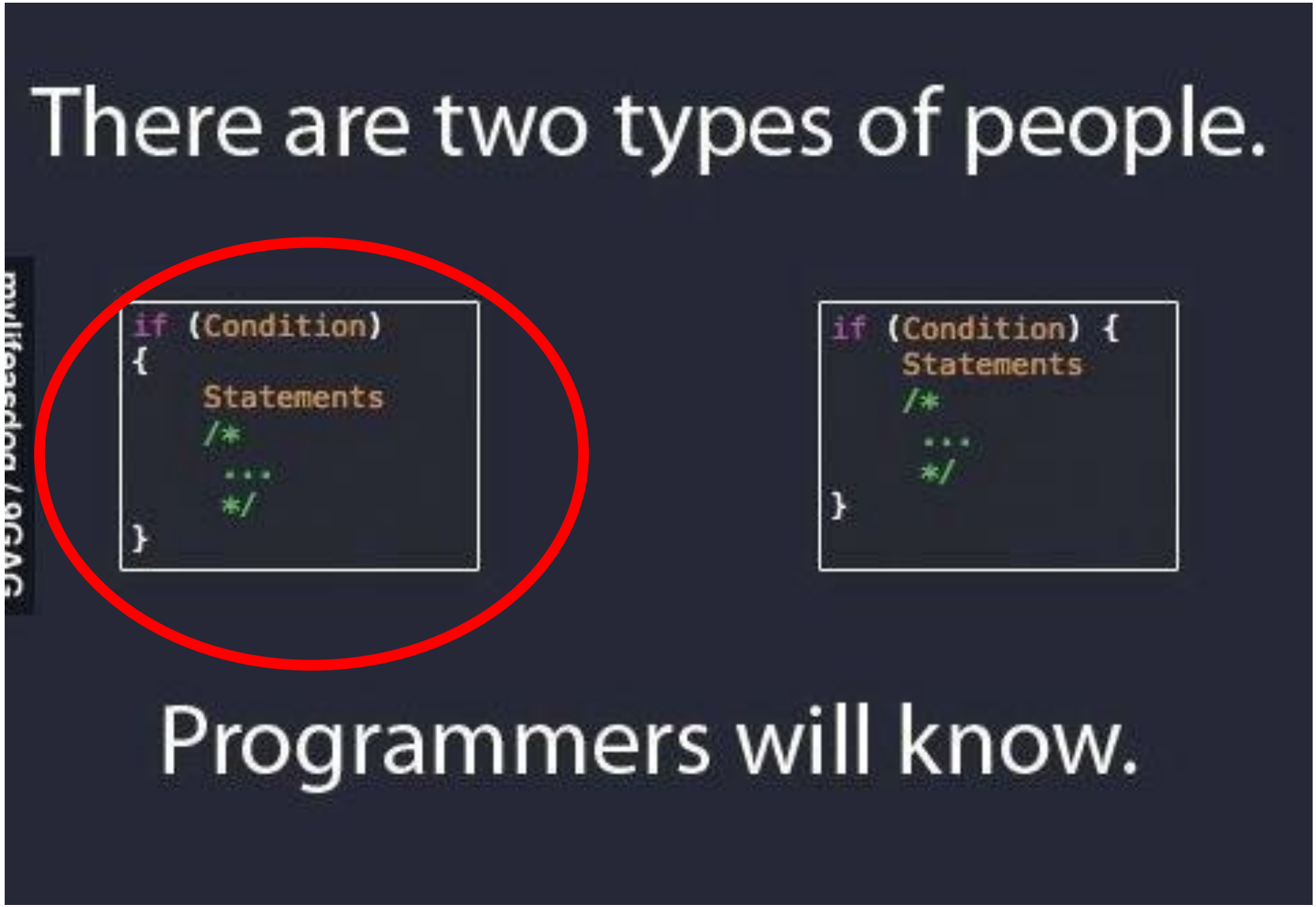
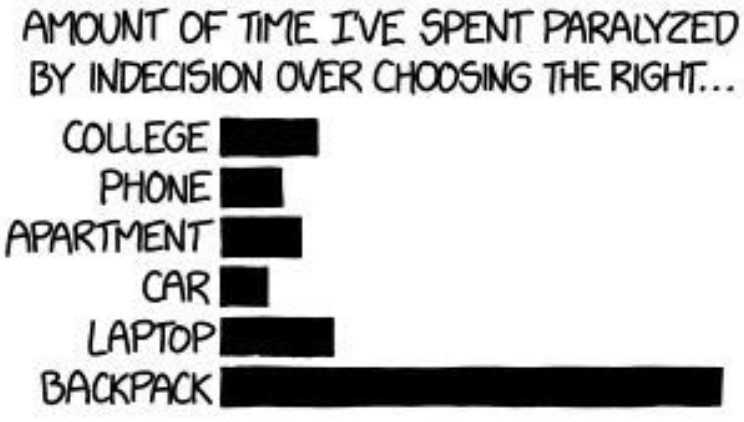

There are two types of people.
if (Condition)
{
Statements
/*
...
*/
}
if (Condition) {
Statements
/*
...
*/
}
Programmers will know.

# Multiple Alternatives

# Due this week

- **Homework 2**
  - Write solutions in VSCode and paste in Autograder, **Homework 2 CodeRunner**.
  - Zip your .cpp files and submit on canvas **Homework 2**.
- Start going through the textbook readings and watch the videos
  - Take **Quiz 3**.
- Participation: 3-2-1
- Check the due date! **No late submissions!!**

# Practicum 1

- Coming up in week 5: Sep 19th during lecture
- Covers material from weeks 1 – 3 and H3
  - .cpp programs
  - Variables, arithmetic, cin, cout
  - If-else, nested if-else, switch statements
- Chapters 1, 2 and 3 from the textbook (everything!)
- Paper exam – bring writing utensils

# Practicum – Format and Rules

**Logistics:**

- You may bring 1 sheet of handwritten notes
- Bring an ID to class
  - Student ID: BuffOne Card, Government ID
- You have **30 minutes** to complete it (tentative)
  - Focus on your own solution
  - This is an individual assessment!
  - There is not enough time to help others

# Practicum - Practice, practice, practice!

- Review all previous assignments – quizzes, recitations and homeworks
- Review examples we did in class
- Practice Questions will be released on Monday, September 12th
- Time is short; prepare accordingly
  - Time yourself on practice problems

# Tips for Timed Exam

- Read the Questions
  - read them not once, but **TWICE** before starting to code
- Create or Modify Code
  - know your C++ syntax
  - Know your data types, operators (arithmetic, relational, logical)
  - know how to create a condition
  - know how and when to use SWITCH and “break;”
- Spot and fix errors!

# Today

- Nested if, nested if else
- `switch` statement

# Comparing numbers and strings

# Common Error – Exact Comparison of Floating-Point Numbers

***Roundoff errors***

- Floating-point numbers have only a limited precision.
- Calculations can introduce roundoff errors.
- *Given r=2,*

$$\text{Does } \left(\sqrt{r}\right)^2 == 2 \text{ ?}$$

Let's see (by writing code, of course) …

# Exact Comparison of Floating-Point Yields Unexpected Value

```
double r = sqrt(2.0);
if (r * r == 2)
{
   cout << "sqrt(2) squared is 2" << endl;
}
else
{
   cout << "sqrt(2) squared is not 2 but "
      << fixed << setprecision(18) << r * r << endl;
}
```

**This program displays:**

```
sqrt(2) squared is not 2 but 2.000000000000000044
```

# How to Compare Floating-Point Numbers

*Roundoff errors – a solution*

Close enough will do. $\left|x - y\right| < \varepsilon$

$\varepsilon$ is the Greek letter epsilon, a letter used to denote a very small quantity

# Comparison of Floating-Point Numbers: Tolerance

- It is common to set ε to $10^{-14}$ when comparing double numbers:

```
const double EPSILON = 1E-14;
double r = sqrt(2.0);
if (fabs(r * r - 2) < EPSILON)
{
   cout << "sqrt(2) squared is approximately ";
}
```

- Include the `<cmath>` header to use sqrt and the fabs function which gives the absolute value.

# Let’s implement it!


Ben Porter
@eigenbom
I'll sometimes leave a dangling else just as a threat to the compiler that it better run that if statement or else.
if (condition) {
// ...
}
else;


Ben Porter
@eigenbom
I'll sometimes leave a dangling else just as a threat to the compiler that it better run that if statement or else.
if (condition) {
// ...
}
else;

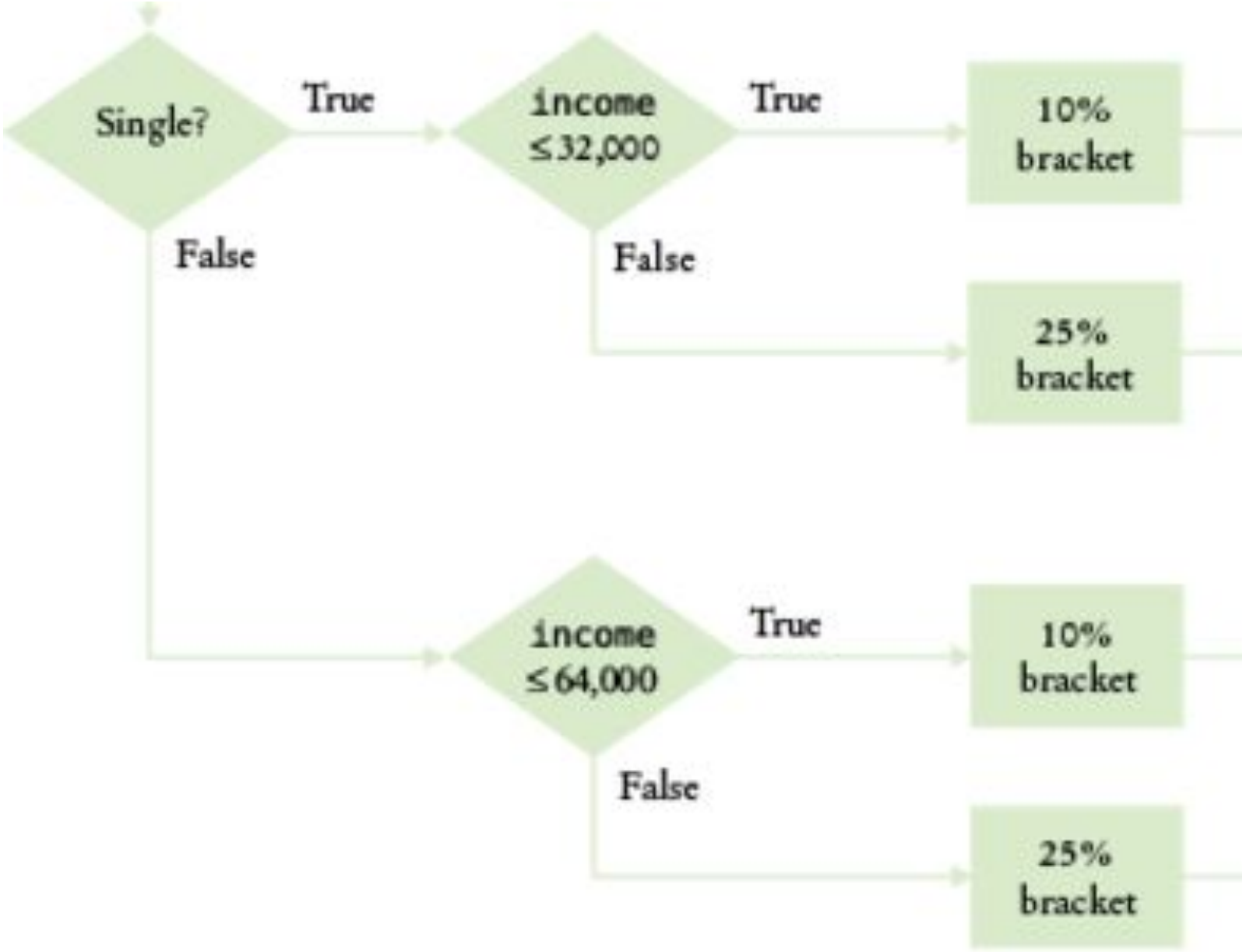
# Nested Branches

# Nested Branches – Taxes

| 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 |

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:


YO DOG, I HEARD YOU LIKED IF ELSE STATEMENTS
SO I PUT IF ELSE STATEMENTS IN YOUR IF ELSE STATEMENTS
memegenerator.net




# 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 – Complete 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 – Complete Code part 2

```
   {
      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;
}
```

# Multiple Alternatives

# Multiple Alternatives Need Multiple Nested `if()` Statements

- 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).

**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 |

# Flowchart for Richter Scale Code

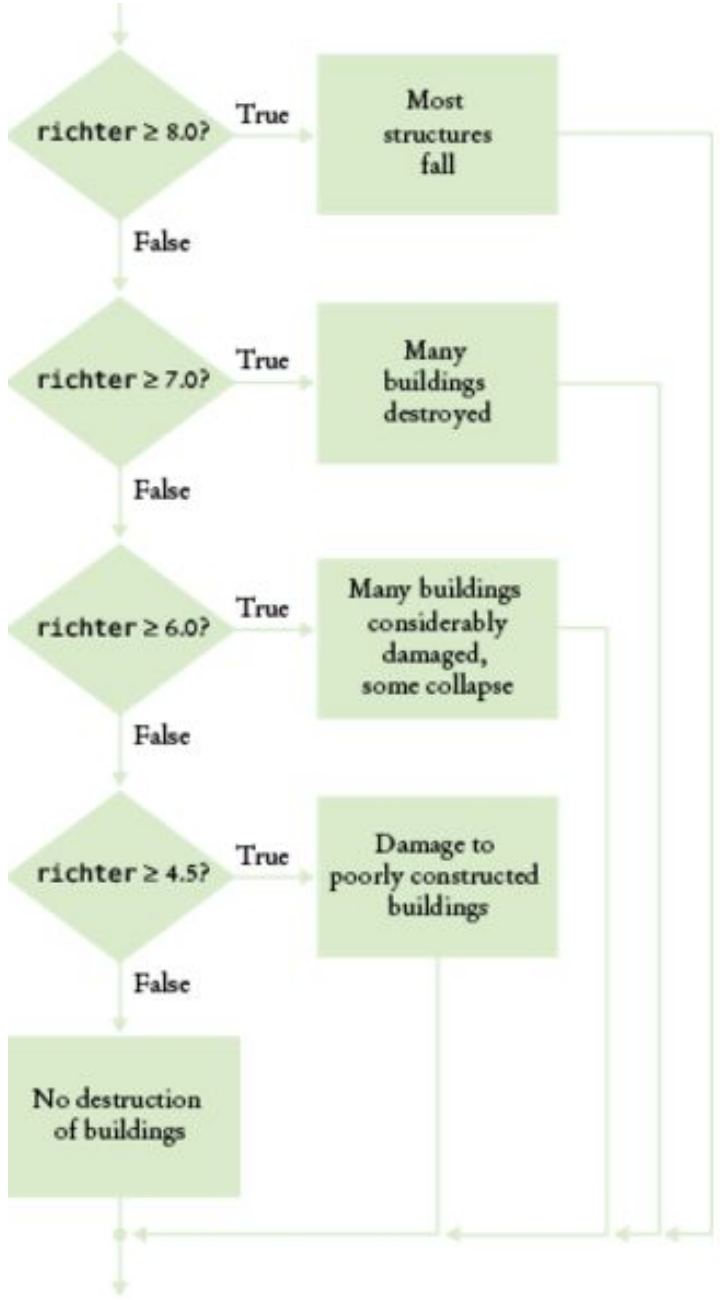



**Figure 3** Multiple Alternatives

# 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!


If
/ else
Switch
Corporate needs you to find the differences
between this picture and this picture.
Compilers
They're the same picture.

| What it is | | What people think it is |
| --- | --- | --- |
| IF ...<br>THEN |  | Computational Breakthrough |
| IF ...<br>THEN ...<br>ELSE ... |  | Artificial Intelligence |
| IF ...<br>THEN ...<br>ELSE IF ...<br>ELSE ... |  | *Real*<br>Artificial Intelligence |
| SWITCH ... |  | SINGULARITY |