Week 4: *Conditionals & Testing*

EMSE 4574: Intro to Programming for Analytics

John Paul Helveston

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1. Conditionals
2. Testing
3. Tips

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"Flow Control"

Code that alters the otherwise linear flow of operations in a program.

This week:

- `if` statements
- `else` statements

Next week:

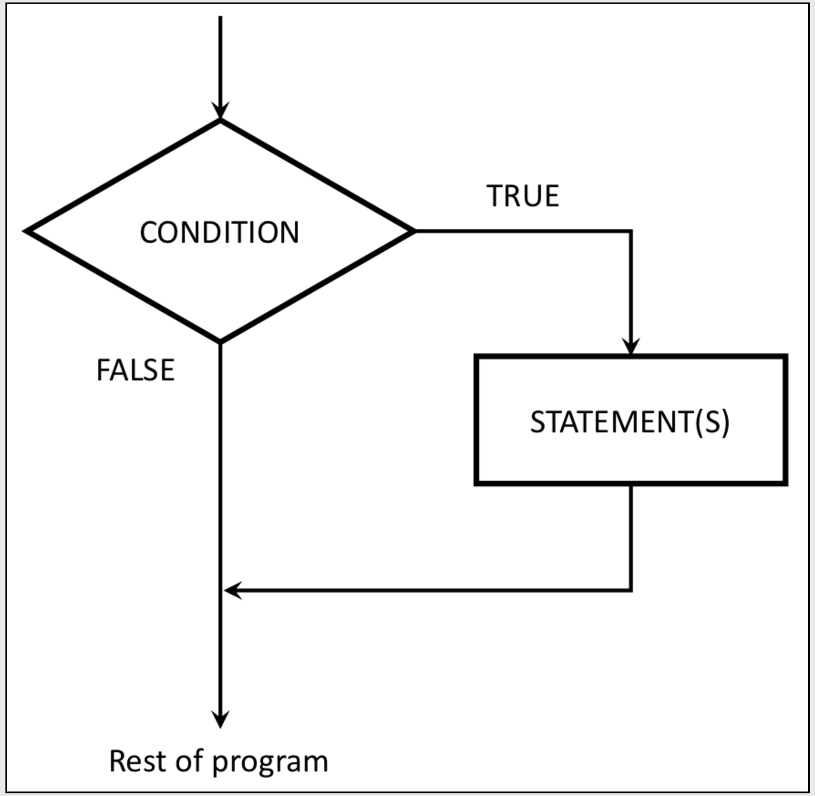
- `for` loops
- `while` loops
- `break` statements
- `next` statements

The `if` statement

Basic format

```
if ( CONDITION ) {
    # Do stuff here
}
```

Flow chart:



Quick code tracing

Cosider this function:

```r
f <- function(x) {
    cat("A")
    if (x == 0) {
        cat("B")
        cat("C")
    }
    cat("D")
}
```

What will this print?

```r
f(1)
f(0)
```

Quick practice

03:00

Write the function `absValue(n)` that returns the absolute value of a number (and no cheating - you can't use the built-in `abs()` function!)

Tests:

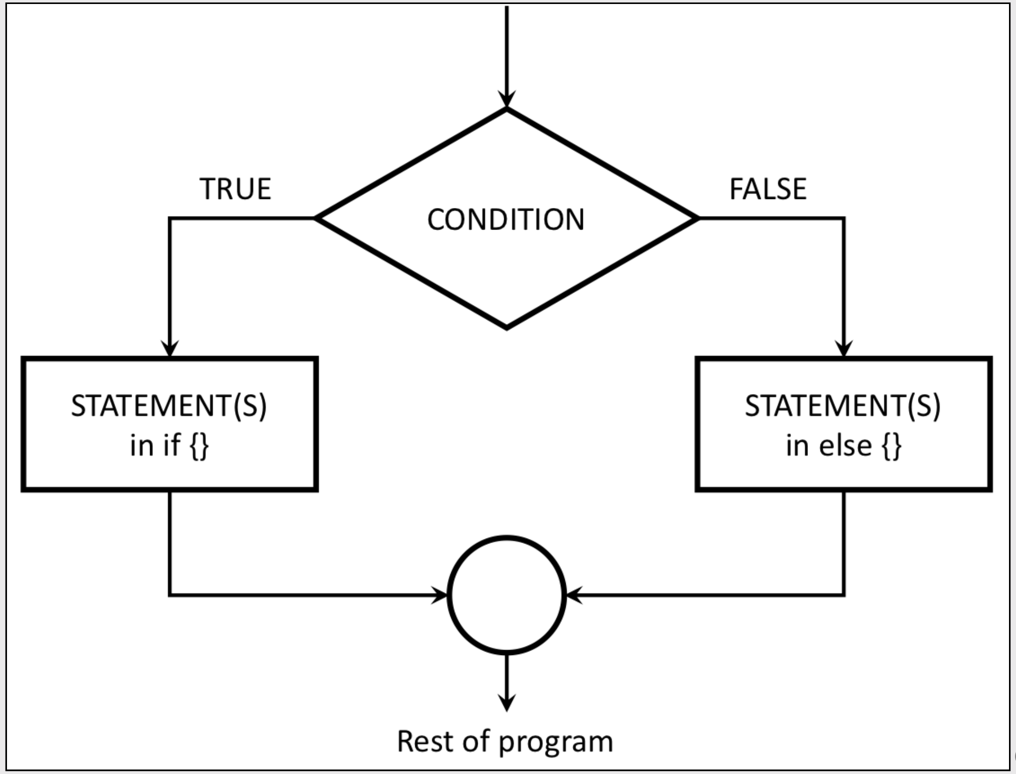
- `absValue(7) == 7`
- `absValue(-7) == 7`
- `absValue(0) == 0`

Adding an `else` to an `if`

Basic format:

```
if ( CONDITION ) {
  # Do stuff here
} else {
  # Do other stuff here
}
```

Flow chart:



Quick code tracing

Consider this code:

```
f <- function(x) {
    cat("A")
    if (x == 0) {
        cat("B")
        cat("C")
    } else {
        cat("D")
        if (x == 1) {
            cat("E")
        } else {
            cat("F")
        }
    }
    cat("G")
}
```

What will this print?

```
f(0)
f(1)
f(2)
```

`else if` chains

Example - "bracketing" problems:

```
getLetterGrade <- function(score) {
    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"
    }
    return(grade)
}
```

Check function output:

```
getLetterGrade(99)
```

```
## [1] "A"
```

```
getLetterGrade(88)
```

```
## [1] "B"
```

```
getLetterGrade(70)
```

```
## [1] "C"
```

```
getLetterGrade(61)
```

```
## [1] "D"
```

```
getLetterGrade(22)
```

```
## [1] "F"
```

Think-Pair-Share

08:00

Write the function `getType(x)` that returns the type of the data (either `integer`, `double`, `character`, or `logical`). Basically, it does the same thing as the `typeof()` function (but you can't use `typeof()` in your solution).

Tests:

- `getType(3) == "double"`
- `getType(3L) == "integer"`
- `getType("foo") == "character"`
- `getType(TRUE) == "logical"`

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Why write test functions?

1. They help you understand the problem
2. They verify that a function is working as expected

Test function "syntax"

Function:

```r
functionName <- function(arguments) {
    # Do stuff here
    return(something)
}
```

Test function:

```r
test_functionName <- function() {
    cat("Testing functionName()...")
    # Put test cases here
    cat("Passed!\n")
}
```

Writing test cases with `stopifnot()`

`stopifnot()` stops the function if whatever is inside the `()` is not `TRUE`.

Function:

```
isEven <- function(n) {
    return((n %% 2) == 0)
}
```

- `isEven(1)` should be `FALSE`
- `isEven(2)` should be `TRUE`
- `isEven(-7)` should be `FALSE`

Test function:

```
test_isEven <- function() {
    cat("Testing isEven()...")
    stopifnot(isEven(1) == FALSE)
    stopifnot(isEven(2) == TRUE)
    stopifnot(isEven(-7) == FALSE)
    cat("Passed!\n")
}
```

Writing test cases with `stopifnot()`

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Function:

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isEven <- function(n) {
    return((n %% 2) == 0)
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- `isEven(1)` should be `FALSE`
- `isEven(2)` should be `TRUE`
- `isEven(-7)` should be `FALSE`

Test function:

```r
test_isEven <- function() {
    cat("Testing isEven()...")
    stopifnot(isEven(1) == FALSE)
    stopifnot(isEven(2) == TRUE)
    stopifnot(isEven(-7) == FALSE)
    cat("Passed!\n")
}
```

```r
test_isEven()
```

```
## Testing isEven()...Passed!
```

Write the test function *first*!

Step 1: Write the test function

```r
test_isEven <- function() {
    cat("Testing isEven()...")
    stopifnot(isEven(1) == FALSE)
    stopifnot(isEven(2) == TRUE)
    stopifnot(isEven(-7) == FALSE)
    cat("Passed!\n")
}
```

Step 2: Write the function

```r
isEven <- function(n) {
    return((n %% 2) == 0)
}
```

Step 3: Test the function

```r
test_isEven()
```

```
## Testing isEven()...Passed!
```

Test cases to consider: NOLES

- **N**ormal cases
- **O**pposites
- **L**arge & small cases
- **E**dge cases
- **S**pecial cases

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Example:

```
isEven <- function(n) {
    return((n %% 2) == 0)
}
```

- `isEven(1) == FALSE`
- `isEven(2) == TRUE`
- `isEven(-7) == FALSE`

Test cases to consider: NOLES

- **N**ormal cases
- **O**pposites
- **L**arge & small cases
- **E**dge cases
- **S**pecial cases

Example:

```
isEven <- function(n) {
    return((n %% 2) == 0)
}
```

Need cases that return both TRUE and FALSE

- `isEven(52) == TRUE`
- `isEven(53) == FALSE`

Test cases to consider: NOLES

- **N**ormal cases
- **O**pposites
- **L**arge & small cases
- **E**dge cases
- **S**pecial cases

Example:

```r
isEven <- function(n) {
    return((n %% 2) == 0)
}
```

- `isEven(8675309) == FALSE`
- `isEven(-8675309) == FALSE`

Test cases to consider: NOLES

- **N**ormal cases
- **O**pposites
- **L**arge & small cases
- **E**dge cases
- **S**pecial cases

Example:

```
isPositive <- function(n) {
    return(n > 0)
}
```

- `isPositive(0.000001) == TRUE`
- `isPositive(0) == FALSE`
- `isPositive(-0.000001) == FALSE`

Test cases to consider: NOLES

- **N**ormal cases
- **O**pposites
- **L**arge & small cases
- **E**dge cases
- **S**pecial cases

- Negative numbers
- `0` and `1` for integers
- The empty string, `""`
- Strange input *types*, e.g. `"2"` instead of `2`.

Testing function inputs

What if we gave `isEven()` the wrong input type?

```r
isEven <- function(n) {
    return((n %% 2) == 0)
}
```

```r
isEven('42')
```

```
## Error in n%%2: non-numeric
argument to binary operator
```

An improved function that checks inputs:

```r
isEven <- function(n) {
    if (! is.numeric(n)) {
        return(NaN)
    }
    return((n %% 2) == 0)
}
```

Testing function inputs

What if we gave `isEven()` the wrong input type?

```r
isEven <- function(n) {
    return((n %% 2) == 0)
}
```

```r
isEven('42')
```

```
## Error in n%%2: non-numeric
argument to binary operator
```

An improved function that checks inputs:

```r
isEven <- function(n) {
    if (! is.numeric(n)) {
        return(NaN)
    }
    return((n %% 2) == 0)
}
```

```r
isEven('42')
```

```
## [1] NaN
```

```r
isEven(TRUE)
```

```
## [1] NaN
```

Think-Pair-Share

15:00

For each of the following functions, start by writing a test function that tests the function for a variety of values of inputs. Consider cases that you might not expect!

1. Write the function `isFactor(f, n)` that takes two integer values and returns `TRUE` if `f` is a factor of `n`, and `FALSE` otherwise. Note that every integer is a factor of `0`. Assume `f` and `n` will only be numeric values, e.g. `2` is a factor of `6`.

1. Write the function `isMultiple(m, n)` that takes two integer values and returns `TRUE` if `m` is a multiple of `n` and `FALSE` otherwise. Note that `0` is a multiple of every integer other than itself. Hint: You may want to use the `isFactor(f, n)` function you just wrote above. Assume `m` and `n` will only be numeric values.

Break

05:00

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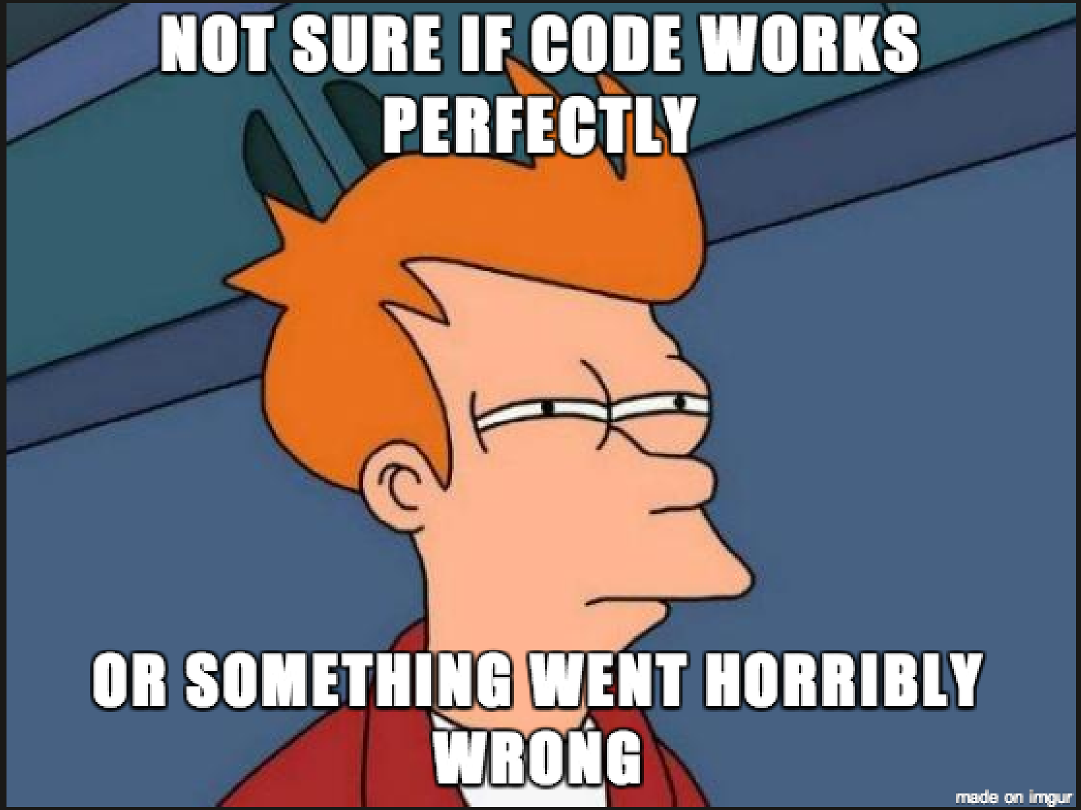

Debugging your code

Use `traceback()` to find the steps that led to an error (the "call stack")

```
f <- function(x) {
    return(x + 1)
}
g <- function(x) {
    return(f(x) - 1)
}
```

```
g('a')
```

```
## Error in x + 1: non-numeric argument to binary operator
```

```
traceback()
```

```
2: f(x) at #2
1: g("a")
```

When testing *numbers*, use `almostEqual()`

Rounding errors can cause headaches:

```
x <- 0.1 + 0.2
x
```

```
## [1] 0.3
```

```
x == 0.3
```

When testing *numbers*, use `almostEqual()`

Rounding errors can cause headaches:

```r
x <- 0.1 + 0.2
x
```

```
## [1] 0.3
```

```r
x == 0.3
```

```
## [1] FALSE
```

```r
print(x, digits = 20)
```

```
## [1] 0.30000000000000004441
```

When testing *numbers*, use `almostEqual()`

Rounding errors can cause headaches:

```r
x <- 0.1 + 0.2
x
```

```
## [1] 0.3
```

```r
x == 0.3
```

```
## [1] FALSE
```

```r
print(x, digits = 20)
```

```
## [1] 0.30000000000000004441
```

Define a function that checks if two values are *almost* the same:

```r
almostEqual <- function(n1, n2,
threshold = 0.00001) {
    return(abs(n1 - n2) <= threshold)
}
```

```r
x <- 0.1 + 0.2
almostEqual(x, 0.3)
```

```
## [1] TRUE
```

Checking for integer values

Since numbers are doubles by default, the `is.integer(x)` function can be confusing:

```r
is.integer(7)
```

```
## [1] FALSE
```

Define a new function that returns TRUE if the *value* is an integer:

```r
is.integer.val <- function(x) {
    y <- round(x)
    return(almostEqual(x, y))
}
is.integer.val(7)
```

```
## [1] TRUE
```

Checking for special data types

Not available: NA

value is "missing"

```
x <- NA
x == NA
```

```
## [1] NA
```

No value: NULL

no value whatsoever

```
x <- NULL
x == NULL
```

```
## logical(0)
```

Checking for special data types

Not available: NA

value is "missing"

```
x <- NA
x == NA
```

```
## [1] NA
```

Have to use special function:

```
is.na(x)
```

```
## [1] TRUE
```

No value: NULL

no value whatsoever

```
x <- NULL
x == NULL
```

```
## logical(0)
```

Have to use special function:

```
is.null(x)
```

```
## [1] TRUE
```

Think-Pair-Share

15:00

Write the function `getInRange(x, bound1, bound2)` which takes 3 numeric values: `x`, `bound1`, and `bound2` (`bound1` is not necessarily less than `bound2`). If `x` is between the two bounds, just return `x`, but if `x` is less than the lower bound, return the lower bound, or if `x` is greater than the upper bound, return the upper bound. For example:

- `getInRange(1, 3, 5)` returns `3` (the lower bound, since 1 is below [3,5])
- `getInRange(4, 3, 5)` returns `4` (the original value, since 4 is between [3,5])
- `getInRange(6, 3, 5)` returns `5` (the upper bound, since 6 is above [3,5])
- `getInRange(6, 5, 3)` returns `5` (the upper bound, since 6 is above [3,5])

Bonus: Re-write `getInRange(x, bound1, bound2)` without using conditionals

HW 4

You'll need to write a *test function* for each function!