Programming Basics ICA
Overview

- It’s coding time!
  - We'll identify a problem, design a solution, and code it up in R!
  - We'll solve it using functions, conditionals, and loops.
The Problem

Your electricity bills have been very high lately. You're worried about your environmental impact (not to mention the financial burden!).

To find the root cause, you’ve collected a year of electricity data. A snippet looks like this:

<table>
<thead>
<tr>
<th>Month</th>
<th>Day</th>
<th>Hour</th>
<th>Kitchen</th>
<th>Laundry</th>
<th>Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>26</td>
<td>18</td>
<td>12</td>
<td>27</td>
<td>1046</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>19</td>
<td>534</td>
<td>41</td>
<td>1058</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>20</td>
<td>534</td>
<td>0</td>
<td>1060</td>
</tr>
</tbody>
</table>

Each row represents an hour, specified by month, day, hour, and three types of energy usage. Measurements are reported in watt-hours (Wh).
The Problem

Your goal is: for each month of your annual electricity data, find the day and hour during which the maximum electricity was used.

<table>
<thead>
<tr>
<th>Month</th>
<th>Day</th>
<th>Hour</th>
<th>Kitchen</th>
<th>Laundry</th>
<th>Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>26</td>
<td>18</td>
<td>12</td>
<td>27</td>
<td>1046</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>19</td>
<td>534</td>
<td>41</td>
<td>1058</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>20</td>
<td>534</td>
<td>0</td>
<td>1060</td>
</tr>
</tbody>
</table>

Solution Steps:
1. Algorithm
2. Pseudocode
3. Code
Step 1: Algorithm

Perhaps you've heard of the word algorithm before, but what does it mean?

An **algorithm** is defined as a step-by-step procedure for converting inputs to outputs, often to solve a problem.

A canonical example of an algorithm is a recipe. It is a step-by-step process for converting raw ingredients into a food product.

What would be a good sequence of steps to find the solution to our problem?
Hint: Split-Apply-Combine

As discussed in lecture, the **split-apply-combine** paradigm is very common in data science.

Indeed, to solve this problem, we must:

1. **Split** the data by month
2. For each month
   a. **Apply** a function to find day and hour during which consumption was maximum
3. **Combine** and display the results
Step 2: Pseudocode

A written description of the sequence of steps necessary to solve a problem is pseudocode. Here is a first attempt at pseudocode for our algorithm:

1. for each month, read through all the days and hours
2. find the one that has the maximum consumption
3. return the day and hour at that moment
Step 2: Pseudocode

But you can also write pseudocode that looks more like real code.

For example, here is pseudocode for the function `printSign(x):`

```
print_sign function(x):
    if x is positive:
        print "x is positive."
    else:
        print "x is negative."
```
Step 2: Pseudocode

Here is pseudocode for our problem that looks (a bit) more like real code:

```python
def find_max_consumption(monthly_bill):
    for each month in monthly bill:
        total_column = sum of the columns for kitchen, laundry, and heating
        index = the index of the element in total_column that has the maximum value
        concatenate and print month, day, and hour at this index
```
Step 3: Coding Time!

Let's try to implement this function!

We'll go through the solution with you step-by-step, so no need to rush!

Download the .csv file, and create a new Rmd or R file in the same folder as the download.

At the start of your new file, enter (or copy and paste) this code snippet:

```r
raw_data <- read.csv(file = 'http://cs.brown.edu/courses/cs100/lectures/scripts/section4/electricity_consumption.csv')
monthly_bill <- split(raw_data, factor(raw_data$Month))
```

These two lines mean: import the data into `raw_data`, and then split `raw_data` into a vector of 12 separate data frames for each month. Store the split data in `monthly_bill`. The `monthly_bill` data type is something new: a list.
A sequence can only hold numerics.
A vector can only hold one type of data.

A list is a collection of components of any type.

```r
> lst <- list("Fred", "Wilma", -1, c(1,3,5,7,9))
> lst

[[1]]
[1] "Fred"
[[2]]
[1] "Wilma"
...
Aside: Lists

As you can see list components are indexed with double brackets:

```r
> lst[[1]]
[1] "Fred"

> lst[[4]]
[1] 1 3 5 7 9

> lst[[4]][1]
[1] 1
```
Aside: Lists

You can loop through a list, just like you might loop through a sequence or a vector.

```r
lst <- list("Fred", "Wilma", -1, c(1,3,5,7,9))
for (i in lst) {
    print(i)
}

Fred
Wilma
-1
1 3 5 7 9
Step 3: Coding Time!

Now, enter (or copy and paste) this code snippet:

```r
find_max_consumption <- function(monthly_bill) {
  # TODO: insert your code here
}

find_max_consumption(monthly_bill)
```

Your task is to implement the `find_max_consumption` function. So pair with a neighbor, and start coding! Feel free to refer back to the lectures notes on loops.
Solution

```r
find_max_consumption <- function(monthly_bill) {
  # loop over all months
  for (i in 1:length(monthly_bill)) {
    
  }
}
```
Solution

```r
find_max_consumption <- function(monthly_bill) {
  # loop over all months
  for (i in 1:length(monthly_bill)) {
    # save current month
    month <- monthly_bill[[i]]
  }
}
```
Solution

```r
find_max_consumption <- function(monthly_bill) {
  # loop over all months
  for (i in 1:length(monthly_bill)) {

    # save current month
    month <- monthly_bill[[i]]

    # total is a new vector that adds up Kitchen, Laundry, and Heating
    total <- month$Kitchen + month$Laundry + month$Heating

  }
}
```
find_max_consumption <- function(monthly_bill) {
  # loop over all months
  for (i in 1:length(monthly_bill)) {

    # save current month
    month <- monthly_bill[[i]]

    # total is a new vector that adds up Kitchen, Laundry, and Heating
    total <- month$Kitchen + month$Laundry + month$Heating

    # for each month, we want to find the index of the maximum consumption
    # instead of the max function, we use which.max
    index <- which.max(total)

  }
}
find_max_consumption <- function(monthly_bill) {
  # loop over all months
  for (i in 1:length(monthly_bill)) {

    # save current month
    month <- monthly_bill[[i]]

    # total is a new vector that adds up Kitchen, Laundry, and Heating
    total <- month$Kitchen + month$Laundry + month$Heating

    # for each month, we want to find the index of the maximum consumption
    # instead of the max function, we use which.max
    index <- which.max(total)

    # display the result in month-day-hour format
    cat(i, "-", month$Day[index], "-", month$Hour[index], "\n", sep = " ")
  }
}
More than just the basics
What's going under the hood?

In the code we just wrote, we used a built-in function to find the index of the maximum value.

index <- which.max(total)

How would you write the `which.max` function from scratch?

First, let’s write a `max` function from scratch.

Solution Steps:
1. Algorithm
2. Pseudocode
3. Code

Discuss a possible algorithm, and then write pseudocode, with your neighbors.
max

max function()
    max = 0
    for each item in vector:
        if item > max:
            then max = item
    return max
But we really want to find the index of the maximum element, not the maximum value. So now, let’s write the `which.max` function from scratch.

Discuss an algorithm and pseudocode with your neighbors.

Here's the pseudocode for `max` for your reference:

```plaintext
max function()
  max = 0
  for each item in vector:
    if item > max:
      then max = item
  return max
```
max and which.max

max function()
  max = 0
  for each item in vector:
    if item > max:
      then max = item
  return index

argmax function()
  max = 0
  index = 0
  for each item in vector:
    if item > max:
      then max = item
      and index = the index of this item
  return index
Wrapping up

That's it for programming basics! Good work.

Next week we'll start delving into data cleaning.

Have a good weekend!