# WORKSHEET 7: RECURSION

Version 2.0
Computing
COMP110

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## Introduction

**Factorio** is a game in which players build factories to mine resources, assemble complex products from simpler ones, and ultimately build and launch a rocket into space. In this worksheet, you will implement a tool which calculates the amount of raw resources required to assemble a given product.

Many products in Factorio can be crafted within the player's inventory according to a **recipe**. The recipe specifies the materials it uses[1] and the time it takes. The exception is **raw materials**, which cannot be crafted by the player and instead have to be obtained from the world[2].

For example, the *automation-science-pack* requires 1 *copper-plate* and 1 *iron-gear-wheel*, and takes 5 seconds. In turn, one *iron-gear-wheel* requires 2 *iron-plate* and takes 0.5 seconds. This means, in total, the *automation-science-pack* takes 1 *copper-plate*, 2 *iron-plate* and 5.5 seconds. Note that *copper-plate* and *iron-plate* are raw materials.

Recipes encountered later in the game are much more complex, requiring many more intermediate products. For example *spidertron* (a vehicle that becomes available late in the game) requires 7 different types of raw materials, and up to 6 stages of intermediate products between raw materials and the final product.

Note that this worksheet is using Factorio as an example, but you are **not** required to purchase or play the game. Indeed, for time management reasons, you are actively discouraged from playing Factorio when assignment deadlines are present.

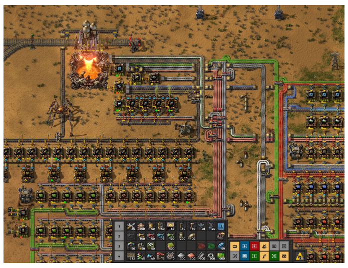
To complete this worksheet, **fork** the skeleton project and **open** the solution file in Visual Studio. **Implement** the following methods of the `Calculator` class:

### `GetTotalAssemblyTimeForProduct()`

This method should return the total time (in seconds) to craft the given product from raw materials. For example,

```
GetTotalAssemblyTimeForProduct("automation-science-pack")
```

should return `5.5` as explained above. If the given product is itself a raw material, this function should return `0`.


A screenshot from Factorio, showing a successful rocket launch.

[1] Note for experienced Factorio players: in this worksheet we assume that every recipe crafts 1 product. Recipes which usually craft multiple products are divided accordingly. For example, rather than 2 copper cable requiring 1 copper plate and 0.5 seconds, we say that 1 copper cable requires 0.5 copper plates and 0.25 seconds.

[2] Note for experienced Factorio players: I consider "raw materials" to be anything which cannot be crafted in the player's inventory. For example mined resources, smelting, recipes involving fluids, and certain products such as engine units.

`GetRawMaterialsForProduct()`

This method should return the names and quantities of the raw materials required to craft the given product. These are returned as a dictionary mapping strings to quantities. For example,

```
GetRawMaterialsForProduct("automation-science-pack")
```

should return

```
{
        ["copper-plate"] = 1,
        ["iron-plate"] = 2
}
```

If the given product is itself a raw material, this function should return a dictionary with a single entry for that product with a quantity of 1. For example,

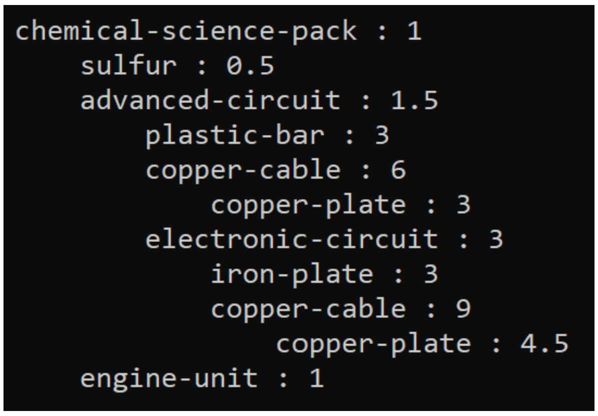
```
GetRawMaterialsForProduct("iron-plate")
```

should return

```
        {
                ["iron-plate"] = 1
        }
```

## Stretch goal

For extra credit, implement a function which displays a breakdown of the intermediate products and raw materials for a given product. It should output the information as an indented list, like so:



```
chemical-science-pack : 1
    sulfur : 0.5
    advanced-circuit : 1.5
        plastic-bar : 3
        copper-cable : 6
            copper-plate : 3
        electronic-circuit : 3
            iron-plate : 3
            copper-cable : 9
                copper-plate : 4.5
    engine-unit : 1
```

For *extra* extra credit, implement a function to display this information in a graphical format. You may use external general-purpose libraries or tools (or even Unity) to display the information, however you may **not** use any code from existing tools developed by the Factorio player community.

## Navigating the skeleton project

The skeleton project contains a file Program.cs, which you may find useful when testing your code. There is also a unit test project which defines a series of tests using the MSTest framework; these can be run locally within Visual Studio.

The provided `Recipes` class loads a database of Factorio recipes, and provides the following useful methods:

- `IsRawMaterial()` determines whether the given product is considered a raw material.
- `FindIngredientsForProduct()` returns the ingredients for a given product, as a dictionary whose keys are product names and whose values are quantities. If the product is a raw material, an error will be raised.
- `FindAssemblyTimeForProduct()` returns the time in seconds to craft a given product. If the product is a raw material, an error will be raised.

## Submission instructions

Begin by **forking** the GitHub repository at the following URL:

https://gamesgit.falmouth.ac.uk/projects/COMP110/repos/comp110-ws-recursion/brow

Edit Calculator.cs, implementing the required functions. When you have finished, open a **pull request**.

**Do not move or rename Calculator.cs, and do not edit or delete any of the other files in the repository except for Program.cs.** Doing so will interfere with the automated testing scripts used to check your submission for correctness, and as a result may lead to you losing marks.

Upload all material to the git server and open a pull request by the deadline listed on LearningSpace.

## Additional information

A video is provided on LearningSpace which explains the worksheet in more detail and provides useful additional information.

## Marking criteria

Remember that **it is better to submit incomplete work than to submit nothing at all**.

Your work will be marked according to the following criteria:

- **Functional coherence**. Is your implementation correct? Your code will be run through TravisCI to verify that it gives the correct results for a sample of input values.
- **Sophistication**. Have you made use of appropriate code structures and data structures? Note the emphasis is on **appropriate**; extra credit will **not** be given for unnecessarily complex solutions. However extra credit **will** be given for solutions that allow for efficient code reuse between functions, for example using iterator functions and/or LINQ.
- **Maintainability**. Is your code well commented? Are your identifier names appropriate and descriptive? Have you adhered to appropriate coding standards?
- **Stretch goal**. Have the stretch goals been completed? Partial credit will be given for partial attempts, and extra credit for particularly high-quality work.