

# E-MOD321 Project in Basic Python

## coding for subsurface applications

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Jan 15, 2024

### Learning objectives.

- Create simple plots using `matplotlib`.
- Loop over, group and filter data.
- Use vanilla Python, Numpy and Pandas to achieve similar results.
- Wrap code in functions to reuse code.
- Wrap data and functions into classes to create good interfaces.

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## 1 Exercise 1: Matplotlib visualization

In `jotun_data.py` in the data folder "official production data": <https://factpages.sodir.no/en/field/PageView/All/43604> are available as lists. You can import them as

```
import sys
sys.path.append('../data/')# alternatively put jotun_data.py in your folder
from jotun_data import years, months, oil_gross, gas_gross, oe_gross, wat_prod
```

### Question:

- Use matplotlib to plot oil equivalents, `oe_gross` vs the `years` data. Try to make the plot as similar as possible to figure 1.

```
#answer
```

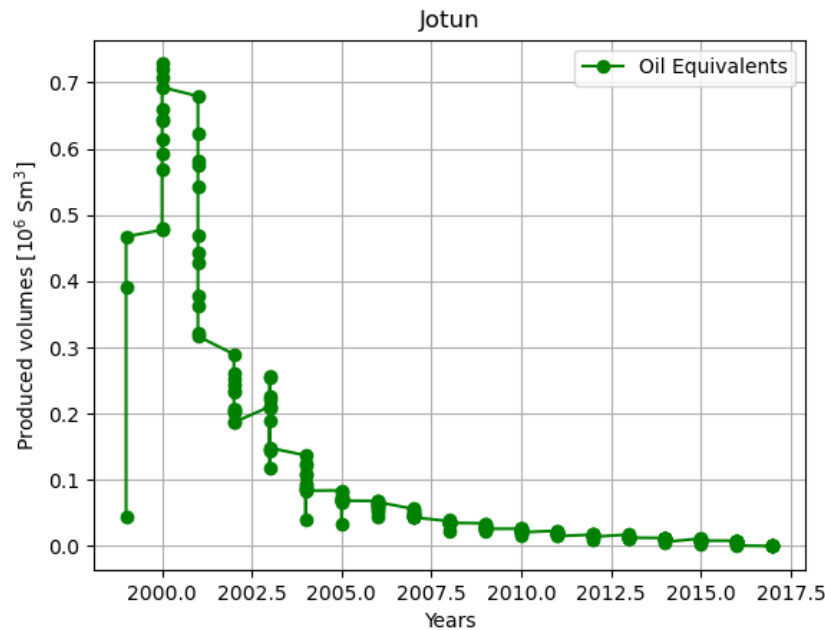


Figure 1: Jotun production data.

## 2 Exercise 2: Loop over data

Oil equivalents are simply the sum of oil volumes and gas volumes. (Or to be more specific: The convention used when comparing gas volumes with oil volumes is to divide the gas volumes by 1000, see [conversion factors](#). However, we do not need to do anything here because the unit of the gas volumes in `jotun_data.py` is  $10^9 \text{ Sm}^3$  and the oil volumes in  $10^6 \text{ Sm}^3$ .)

Thus, to calculate oil equivalents from our lists that contain oil and gas volumes you just have to add them together.

**Question 1:** Use vanilla Python to loop over `oil_gross` and `gas_gross`, create a new *list*, which holds your calculated oil equivalents volumes. Note: You can compare with `oe_gross` to check if your calculations are correct.

**Question 2:** Convert your lists to `numpy.arrays`, by doing e.g. `np.array(oil_gross)`. Perform the same calculation as in Question 1, but this time using Numpy (and no loop).

```
#answer
```

### 3 Exercise 3: Boolean masking

**Question 1:** Use vanilla Python to create a loop and sum up all oil equivalents that was produced for the year 2000. (If you did everything correct you should get  $7.529206 \cdot 10^6 \text{Sm}^3$  for the year 2000.)

**Question 2:** Create to new `numpy`.arrays, by

```
years_np=np.array(years)
oe_np=np.array(oe_gross)
```

Show how you can use Boolean masking to pick out only produced oil equivalents for the year 2000, without using a loop. Use `np.sum()` to sum all the volumes.

**Question 3:** Use `np.unique()` to create a unique `np.array()` of years. Loop over this array and use Boolean masking to create a new list (or `np.array()`) that holds the total produced oil equivalents for that year.

**Question 4:** Use the results in the previous question to create a bar plot and compare with figure [2](#)

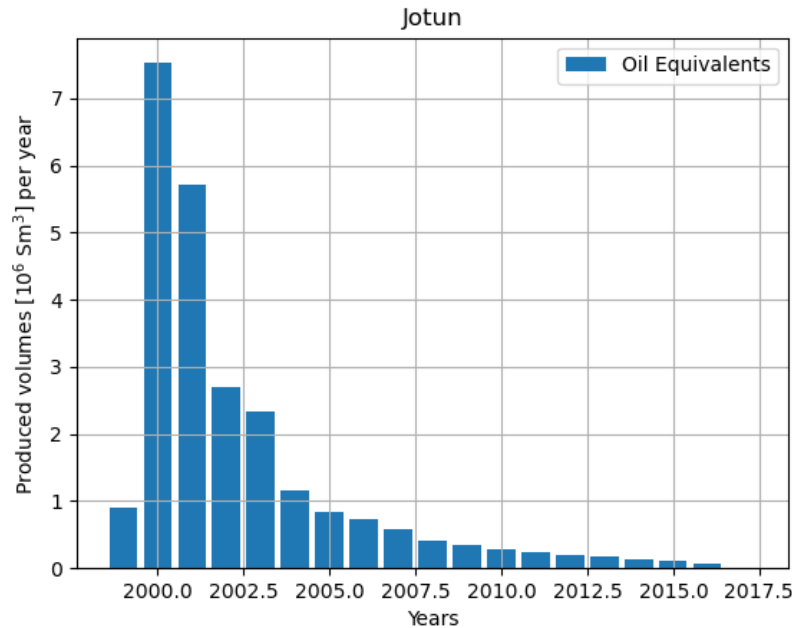


Figure 2: Jotun production data.

## 4 Exercise 4: Dictionaries and Pandas DataFrame

**Question 1:** Create a dictionary that holds all the Jotun data (i.e. `years`, `months`, `oil_gross`, `gas_gross`, you imported in Exercise 1. Choose suitable key names to use in the dictionary.

```
data_dict={# fill inn}
```

**Question 2:** Create a loop over all the keys in `data_dict` and show how you can print out the keys and the values in the dictionary.

**Question 3:** Create a DataFrame from your dictionary. Show how we can use `DataFrame.groupby().sum()` to find production of oil, gas, water, and oil equivalents per year.

## 5 Exercise 5: Extract data using a function

**Question:** Create a function from the following code. The function should take as argument the field name and return a DataFrame with field data. Include a docstring in the function.

```
df_prod=pd.read_excel('../data/field_production_gross_monthly.xlsx')
df=df_prod[df_prod['Field (Discovery)'] == 'JOTUN']
```

```
def get_data(field):
    # write code here ..
    return #...
```

**Optional:** Make the function more robust, by allowing for case insensitive names and/or give a warning if no data was extracted for the field.

```
#answer
```

## 6 Exercise 6: Create a function for plotting data

**Question 1:** Create a function that takes as argument the name of a field, and plots oil equivalent production vs time. (Hint: you should use the function you wrote in the previous exercise to extract the data.)

```
def plot_field(field):
    # create plot ...
```

**Question 2:** Extend the function such that if no data is extracted from the field, write a warning and do not make the plot. (Note: you can use `DataFrame.empty()` to check if the DataFrame contains data.)

**Optional:** Extend the function such that it can take in a list of values (e.g. gas, oil, etc.) that should be plotted in the same plot.

```
#answer
```

## 7 Exercise 7: Write data to files

**Question 1:** Explain what the following code does. By adding comment lines to each line of the following code.

```

field='JOTUN' # com1
#----- start -----
df=get_data(field) # com2
data_folder=pt.Path('tmp_data') # com3
data_folder.mkdir(exist_ok=True)# etc.
new_name=str.replace(field,'/','')
new_path=data_folder / new_name
new_path.mkdir(exist_ok=True)
df2=df[df.columns[0]==field]
df2.to_excel(new_path/'production_data.xlsx',index=False)
#----- stop -----

```

**Question 2:** Create a function from the code between - start - and - stop -. It should take as argument the field name.

```

def write_data(field):
    # ....
    return #optional

```

**Question 3:** If your Excel file is open in another program, the command `df2.to_excel(new_path/'production_data.xlsx',index=False)`, will fail. Use the `try:` and `except:` commands to try and write the Excel file, and if this fails, give the user a warning.

**Optional:** Extend the previous function and introduce a default argument, representing `tmp_data` so that the user can specify the directory name.

```
#answer
```

## 8 Exercise 8: Loop over all fields

The following code writes all field data to separate Excel files.

```

df=pd.read_excel('../data/field_production_gross_monthly.xlsx')
fields=df[df.columns[0]].unique() #skip duplicates
data_folder=pt.Path('tmp_data')
data_folder.mkdir(exist_ok=True)
for field in fields:
    new_name=str.replace(field,'/','')
    new_path=data_folder / new_name
    new_path.mkdir(exist_ok=True)
    df2=df[df.columns[0]==field]
    df2.to_excel(new_path/'production_data.xlsx',index=False)

```

**Question:** Use one or several functions to achieve the same as the block of code above does. Comment on your choice.

```
#answer
```

## 9 Exercise 9: lambda functions

Rewrite the following functions, using Python's `lambda` function

```
def remove_space(x):  
    return x.strip()
```

```
def upper_case(x):  
    return x.upper()
```

```
#answer
```

## 10 Exercise 10: Assert your code

Create two assert tests for `remove_space` and `upper_case` defined in the previous exercise.

```
#answer
```

## 11 Exercise 11: A simple class

**Question1:** Take a look at the following class, and explain what each line does, by adding comments behind each line.

```
class DeclineCurve:  
    def __init__(self,q,tau):  
        self.q=q  
        self.tau=tau  
  
    def f(self,t):  
        return self.q*np.exp(-t/self.tau)
```



**Question2:** Add a function to the class, named `plot()`, such that the following code produce the output in figure 3. (To create a suitable list of `t` values you can do `t=np.linspace(0,10,1000)`, or more general `t=np.linspace(0,10*self.tau,1000)`)

```
A=DeclineCurve(1,1)
A.plot()
```

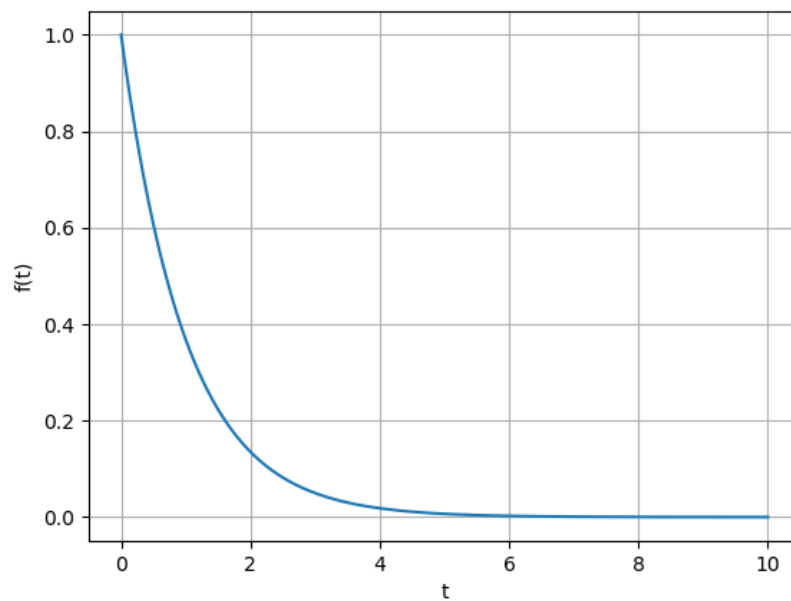


Figure 3: An exponential decline curve.

## 12 Exercise 12: A more comprehensive class

Inspect the following class

```
class ProdData:
    """
    A class to extract production data from FactPages
    """
    def __init__(self):
        self.df_prod=pd.read_excel('../data/field_production_gross_monthly.xlsx')

    def get_data(self,field):
        """
        Extracts data for a specific field
        """
```

```
df= self.df_prod[(self.df_prod['Field (Discovery)'] == field)]
return df
```

Add the following functions to the class:

1. `write_data(field)` write data for a single field to an Excel file
2. `write_all_data()` write an Excel file for each field
3. A function to plot production data for a field

**The following is optional:**

1. Add some checking to the functions, this could be a sensible error message if e.g. the file `../data/field_production_gross_monthly.xlsx` does not exist or that it is not possible to write data to file.
2. Add some unit tests using `assert`, this could be to check that the oil produced for a certain year (and month) for a specific field is equal to a specific value.

## 13 (OPTIONAL) Exercise 13: The Dash library

The [Dash library](#) is one of the most popular libraries. Install it by doing

---

Terminal

```
conda install dash
```

---

(If this fails, run `pip install dash`). Run the following code, which is copied from [a minimal dash app](#).

```
from dash import Dash, html, dcc, callback, Output, Input
import plotly.express as px
import pandas as pd

df = pd.read_csv('https://raw.githubusercontent.com/plotly/datasets/master/gapminder_unfiltered.csv')

app = Dash(__name__)

app.layout = html.Div([
    html.H1(children='Title of Dash App', style={'textAlign': 'center'}),
    dcc.Dropdown(df.country.unique(), 'Canada', id='dropdown-selection'),
    dcc.Graph(id='graph-content')
])

@callback(
    Output('graph-content', 'figure'),
    Input('dropdown-selection', 'value')
)
```

```
def update_graph(value):  
    dff = df[df.country==value]  
    return px.line(dff, x='year', y='pop')  
  
if __name__ == '__main__':  
    app.run(debug=True)
```

**Question:** Can you modify the code above to read and plot our data in `../data/field_production_gross_monthly.xlsx`? (Note: you can also download the production data directly by copying the correct address, by right-clicking on the Excel (or csv) tab [here](#).)