

## Numerical Method

National Cheng Kung University

Department of Engineering Science

Instructor: Chi-Hua Yu

### HW 7

Programming, Due 09:00, Wednesday, April 27<sup>th</sup>, 2022

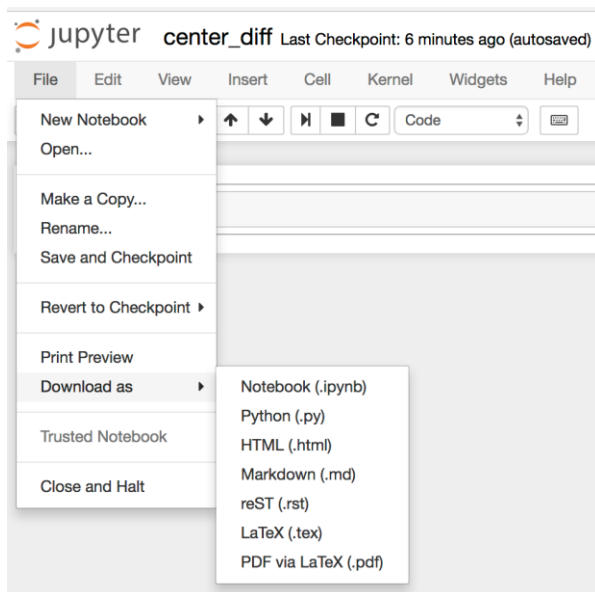
注意事項：

1. Homework 的時間為公布題目後至下次上課前結束(上課當天 09:00)。
2. 請在規定的時段內完成作業，並用你的學號與 HW number 做一個檔案夾 (e.g., N96091350\_HW3), 將你的全部 ipynb 檔放入檔案夾，壓縮後上傳至課程網站 (e.g., N96091350\_HW3.zip)，超過期限後不予補交。

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#### Homework Submission Procedure (請仔細閱讀)

1. You should submit your Jupyter notebook and Python script (\*.py, in Jupyter, click File, Download as, Python (\*.py)).



2. Name a folder using your student id and lab number (e.g., n96081494\_HW1), put all the pdf and all the Jupyter notebooks and python scripts into the folder and zip the folder (e.g., n96081494\_HW1.zip).
3. Submit your lab directly through the course website.

1. (100%) Name your Jupyter notebook `second_difference.ipynb` and Python script `second_difference.py`. Consider the function  $f(x) = \frac{1}{4}x^4 + \frac{1}{3}x^3 + 5x$ . Write a function to complete the second order derivative of  $f(x)$  without using the function `np.diff`.

- (1) Use the **forward-difference formula** to calculate the first derivative. Then the result of the first differential is substituted into the **backward-difference formula** to approximate the second order derivative. (Name your forward-difference function as `my_forward_diff` and backward-difference function as `my_backward_diff`.)

**forward difference:** 
$$f'(x_j) = \frac{f(x_{j+1}) - f(x_j)}{x_{j+1} - x_j}$$

**backward-difference:** 
$$f'(x_j) = \frac{f(x_j) - f(x_{j-1})}{x_j - x_{j-1}}$$

- (2) Please write a function which name `sec_order_diff` to complete the second order derivative. The equation is as follows:

$$f''(x_j) \approx \frac{f(x_{j+1}) - 2f(x_j) + f(x_{j-1}))}{h^2}.$$

Plot the difference and print the value of maximum error between the aforementioned numerical differentiation methods and their accuracy.

Below is the running example:

```
# step size
h = 0.1

# define grid
x = np.arange(-2, 4, h)

# compute function
y = (1/4)*(x**4) + (1/3)*(x**3) + 5*x

# compute corresponding grid
x_diff = x[1:-1:]

# compute exact solution
exact_solution = 3*(x_diff**2) + 2*x_diff
```

The wide of the Exact solution is 12 and color is 'darkblue'.

The wide of Finite difference is 5, linestyle is "--" and color is 'orange'.

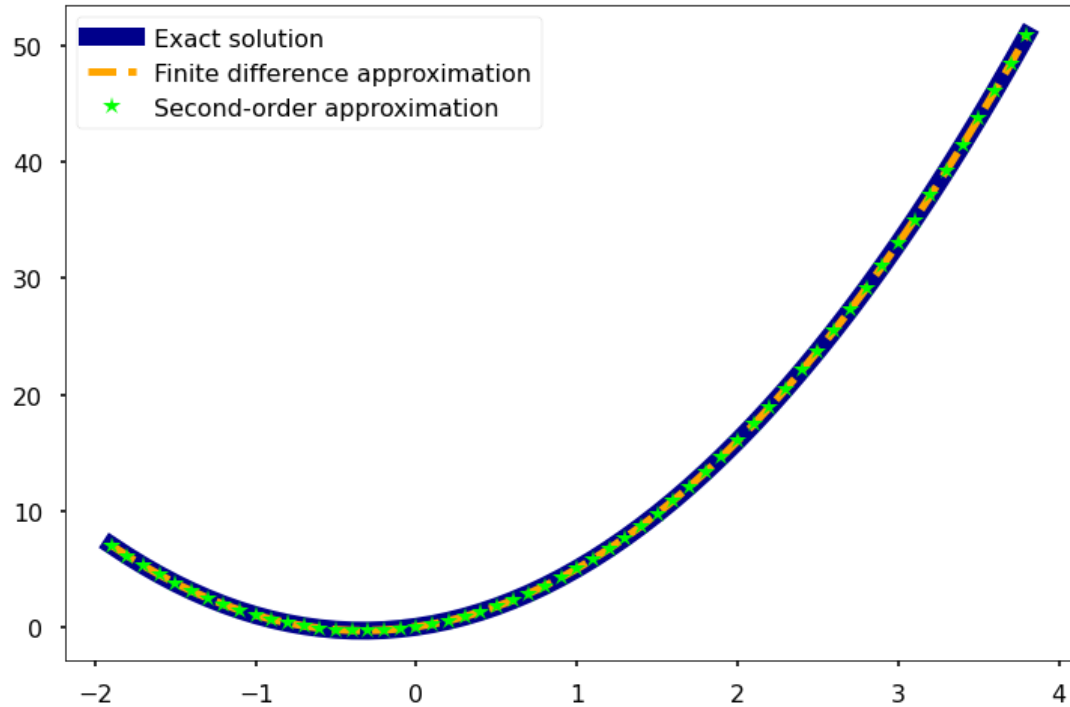
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The marker size of Second-order is 13, markerstyle is "\*", linestyle = " " and color is 'lime'.



error of finite difference: 0.0050000000075272055

error of second-order: 0.0050000000075201