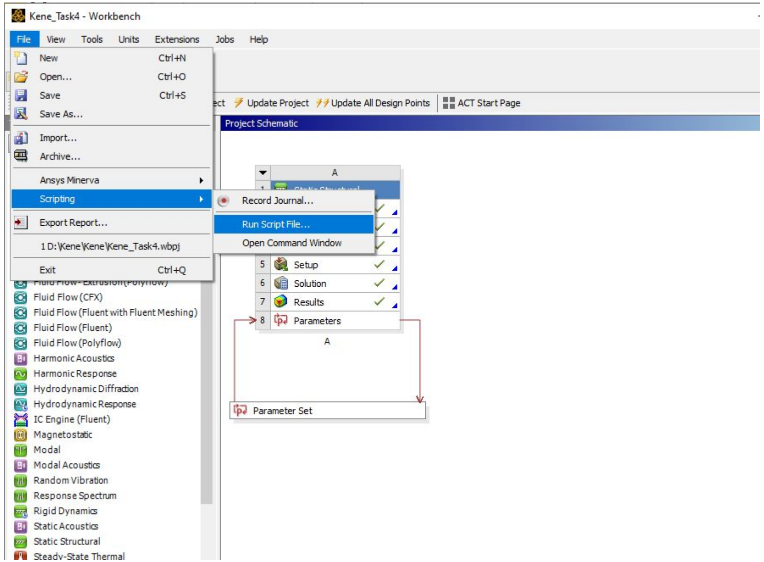
Python Scipy Optimization

Running Python Script on Ansys Interface

https://www.youtube.com/watch?v=61DQdMMUuH4&t=1059s



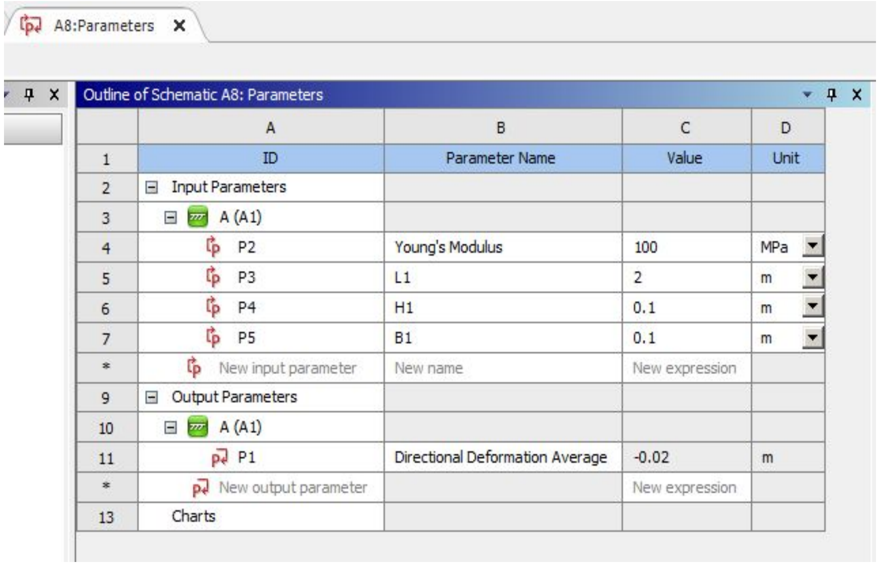
Disadvantages

Opens ANSYS Interface (Therefore, defeats the whole purpose of the code)

Opening ANSYS Workbench File as A Text File

I was able to open the workbench file as a text file. However, I was not able to interpret the entries of this text file:

- P1 => Displacement
- P2 => Young's Modulus
- P3 => L1 (Length of Column)
- P4 => H1 (Cross-Sectional Height)
- P5 => B1 (Cross-Section Width)

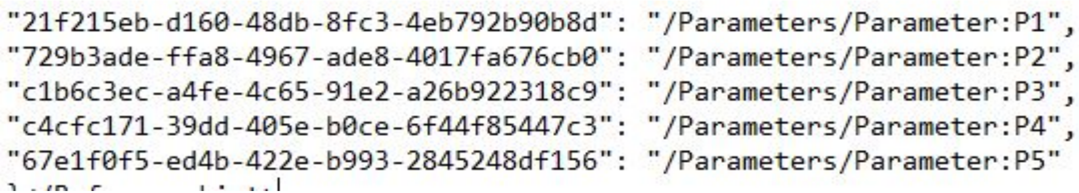


Outline of Schematic A8: Parameters

	A	B	C	D
1	ID	Parameter Name	Value	Unit
2	⊟ Input Parameters			
3	⊟ A (A1)			
4	P2	Young's Modulus	100	MPa
5	P3	L1	2	m
6	P4	H1	0.1	m
7	P5	B1	0.1	m
*	New input parameter	New name	New expression	
9	⊟ Output Parameters			
10	⊟ A (A1)			
11	P1	Directional Deformation Average	-0.02	m
*	New output parameter		New expression	
13	Charts			

From Generated Text-File:

(Text File in Task4_Trial1 zipped folder)



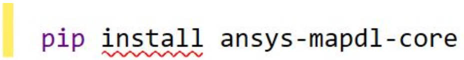
```
"21f215eb-d160-48db-8fc3-4eb792b90b8d": "/Parameters/Parameter:P1",
"729b3ade-ffa8-4967-ade8-4017fa676cb0": "/Parameters/Parameter:P2",
"c1b6c3ec-a4fe-4c65-91e2-a26b922318c9": "/Parameters/Parameter:P3",
"c4cfc171-39dd-405e-b0ce-6f44f85447c3": "/Parameters/Parameter:P4",
"67e1f0f5-ed4b-422e-b993-2845248df156": "/Parameters/Parameter:P5"
```

PyAnsys Attempt

https://www.ansys.com/resource-center/video/what-is-pyansys-and-how-can-it-help-with-simulation

https://docs.pyansys.com/

Error with pip install command:



```
pip install ansys-mapdl-core
```

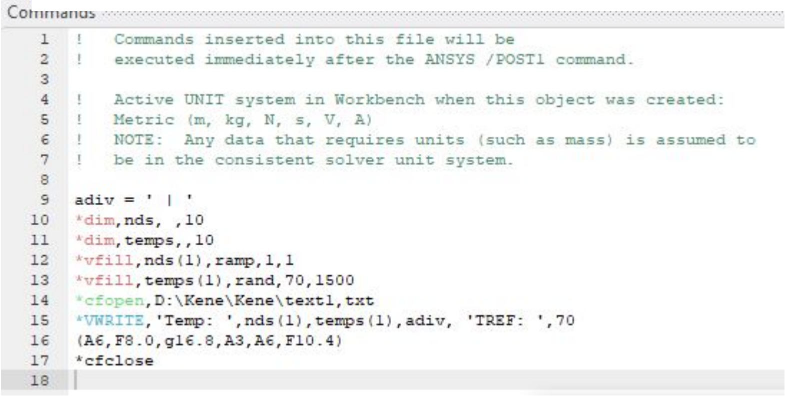
Troubleshooting attempts:

1. How to fix: ‘pip’ is not recognized as an internal or external command https://www.troubleshootingcentral.com/how-to-fix-pip-is-not-recognized-as-an-internal-or-external-command/
2. How To Install Pip On Windows https://www.activestate.com/resources/quick-reads/how-to-install-pip-on-windows/
3. How To Install PIP to Manage Python Packages On Windows https://phoenixnap.com/kb/install-pip-windows
4. Python PIP https://www.w3schools.com/python/python_pip.asp
5. PyAnsys Attempt with CORBA: https://www.youtube.com/watch?v=bSP9pi-4QW0

Remark: Could not get *pip install ansys-mapdl-core* to work.

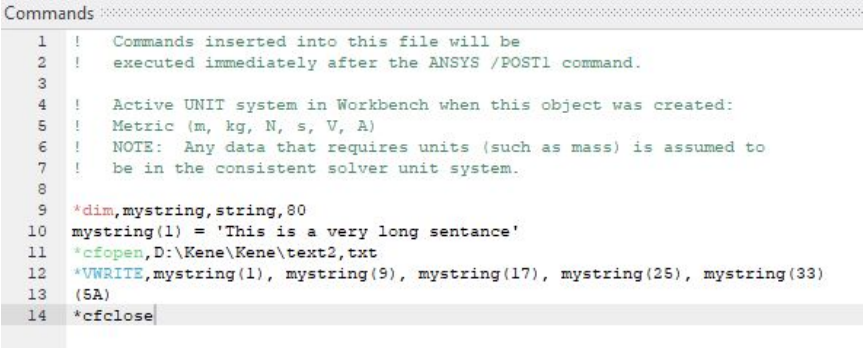
Exploring VWrite: Tutorials

CODE



Commands

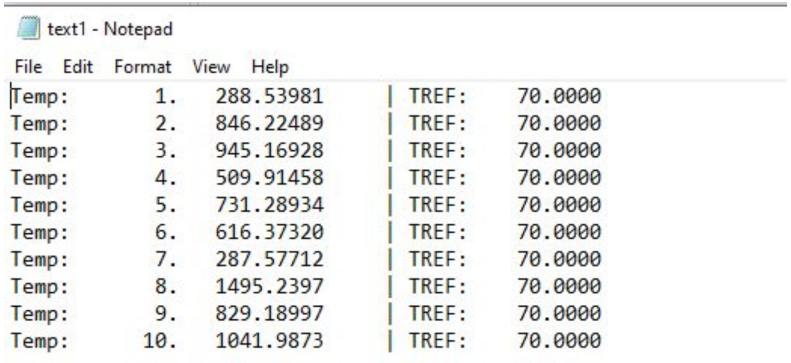
```
!   Commands inserted into this file will be
!   executed immediately after the ANSYS /POST1 command.

!   Active UNIT system in Workbench when this object was created:
!   Metric (m, kg, N, s, V, A)
!   NOTE:  Any data that requires units (such as mass) is assumed to
!   be in the consistent solver unit system.

adiv = ' | '
*dim,nds, ,10
*dim,temps,,10
*vfill,nds(1),ramp,1,1
*vfill,temps(1),rand,70,1500
*cfopen,D:\Kene\Kene\text1,txt
*VWRITE,'Temp: ',nds(1),temps(1),adiv, 'TREF: ',70
(A6,F8.0,g16.8,A3,A6,F10.4)
*cfclose

```



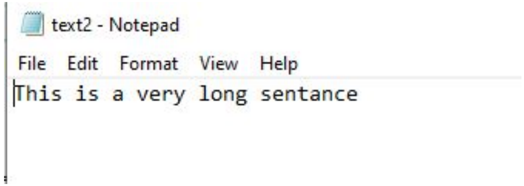
Commands

```
!   Commands inserted into this file will be
!   executed immediately after the ANSYS /POST1 command.

!   Active UNIT system in Workbench when this object was created:
!   Metric (m, kg, N, s, V, A)
!   NOTE:  Any data that requires units (such as mass) is assumed to
!   be in the consistent solver unit system.

*dim,mystring,string,80
mystring(1) = 'This is a very long sentance'
*cfopen,D:\Kene\Kene\text2,txt
*VWRITE,mystring(1), mystring(9), mystring(17), mystring(25), mystring(33)
(5A)
*cfclose
```

OUTPUT



```
Temp:       1.   288.53981      | TREF:    70.0000
Temp:       2.   846.22489      | TREF:    70.0000
Temp:       3.   945.16928      | TREF:    70.0000
Temp:       4.   509.91458      | TREF:    70.0000
Temp:       5.   731.28934      | TREF:    70.0000
Temp:       6.   616.37320      | TREF:    70.0000
Temp:       7.   287.57712      | TREF:    70.0000
Temp:       8.   1495.2397      | TREF:    70.0000
Temp:       9.   829.18997      | TREF:    70.0000
Temp:      10.   1041.9873      | TREF:    70.0000
```



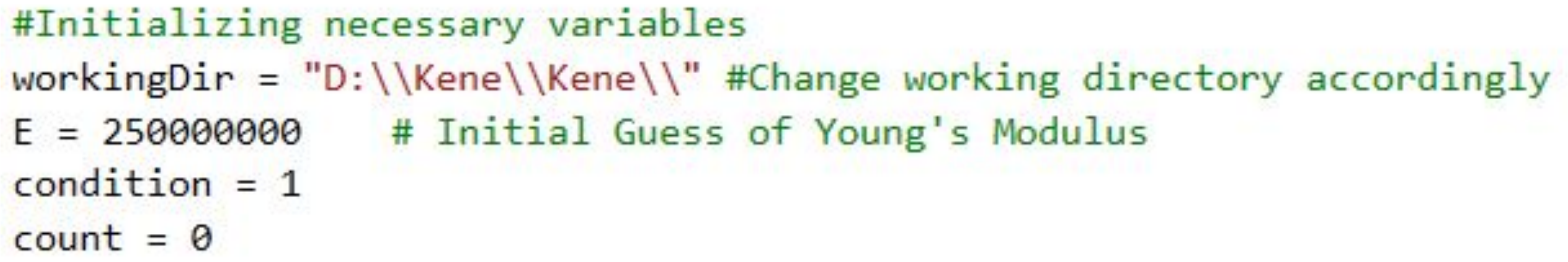
```
This is a very long sentance
```

Python Scipy Optimization

Current Update

Python File Breakdown

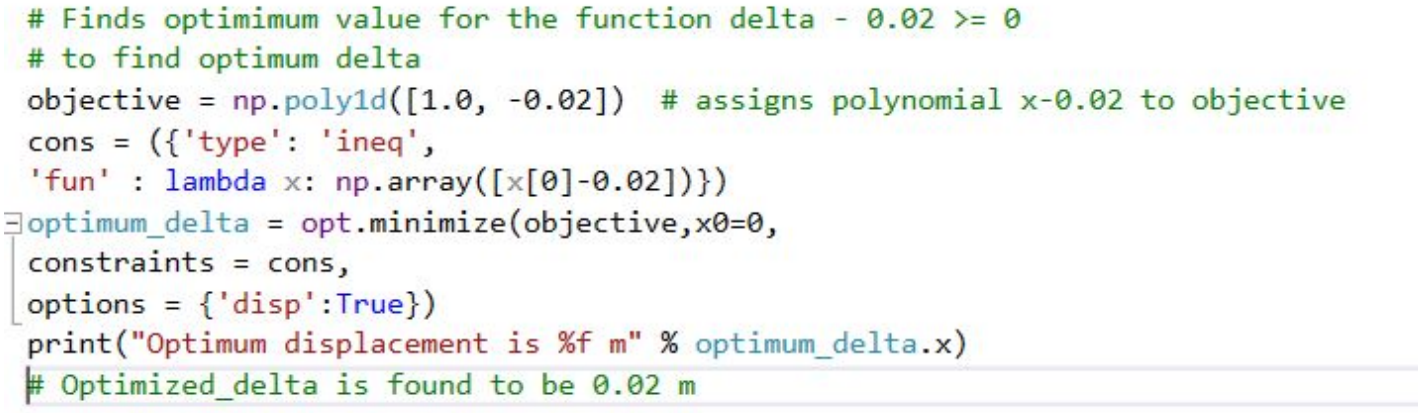
- Set a working directory
- Gave an initial guess of Young’s Modulus = 250 MPa
- In ANSYS input file, P = 10 KN, L = 2m, A = 0.01 square metres



```
#Initializing necessary variables
workingDir = "D:\\Kene\\Kene\\" #Change working directory accordingly
E = 250000000     # Initial Guess of Young's Modulus
condition = 1
count = 0
```

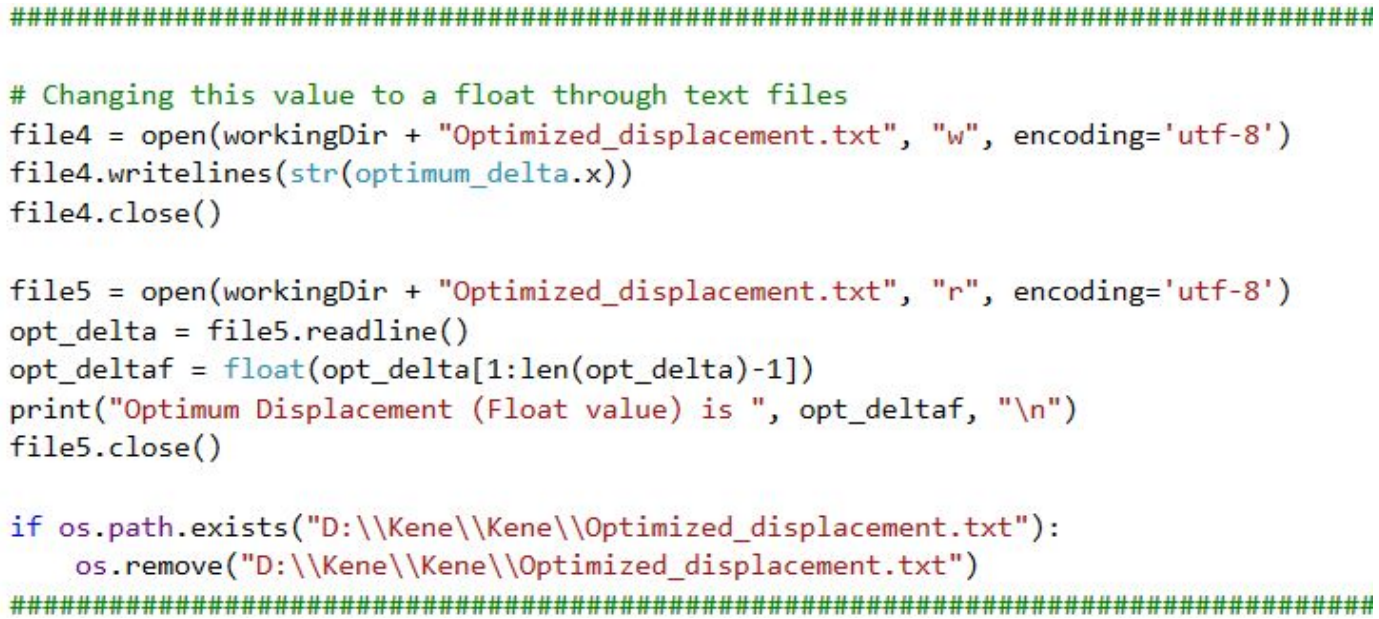
Used scipy.optimize to find optimum displacement at which Young’s Modulus is minimum

- ΔL given to be optimized is 0.02m
- Thus, the optimizer function was set to be : ΔL - 0.02 m >= 0
- Derived value of optimized displacement

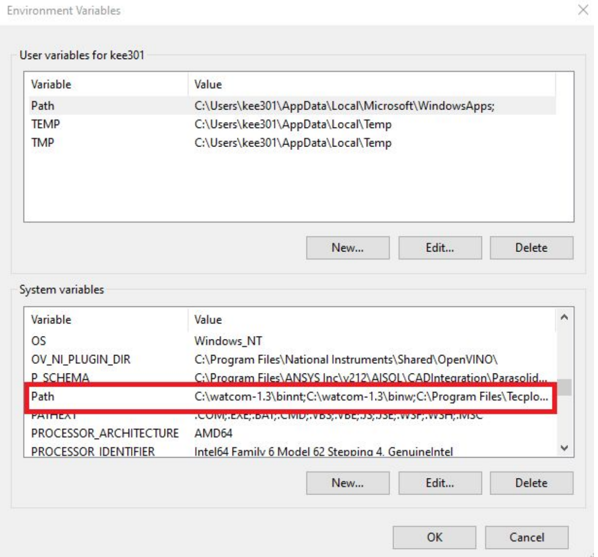


```
# Finds optimimum value for the function delta - 0.02 >= 0
# to find optimum delta
objective = np.poly1d([1.0, -0.02])  # assigns polynomial x-0.02 to objective
cons = ({'type': 'ineq',
'fun' : lambda x: np.array([x[0]-0.02])})
optimum_delta = opt.minimize(objective,x0=0,
constraints = cons,
options = {'disp':True})
print("Optimum displacement is %f m" % optimum_delta.x)
# Optimized_delta is found to be 0.02 m
```

- Converted value of optimized displacement to a float type for arithmetic manipulation
- Used text files for conversion



```
###################################################################################

# Changing this value to a float through text files
file4 = open(workingDir + "Optimized_displacement.txt", "w", encoding='utf-8')
file4.writelines(str(optimum_delta.x))
file4.close()

file5 = open(workingDir + "Optimized_displacement.txt", "r", encoding='utf-8')
opt_delta = file5.readline()
opt_deltaf = float(opt_delta[1:len(opt_delta)-1])
print("Optimum Displacement (Float value) is ", opt_deltaf, "\n")
file5.close()

if os.path.exists("D:\\Kene\\Kene\\Optimized_displacement.txt"):
    os.remove("D:\\Kene\\Kene\\Optimized_displacement.txt")
###################################################################################
```



Environment Variables

User variables for kee301

Variable	Value
Path	C:\Users\kee301\AppData\Local\Microsoft\WindowsApps;
TEMP	C:\Users\kee301\AppData\Local\Temp
TMP	C:\Users\kee301\AppData\Local\Temp

System variables

Variable	Value
OS	Windows_NT
OV_NI_PLUGIN_DIR	C:\Program Files\National Instruments\Shared\OpenVINO\
P_SCHEMA	C:\Program Files\ANSYS Inc\v212\AISOL\CADIntegration\Parasolid...
Path	C:\watcom-1.3\binnt;C:\watcom-1.3\binw;C:\Program Files\Tecplo...
PATHEXT	.COM;.EXE;.BAT;.CMD;.VBS;.VBE;.JS;.JSE;.WSF;.WSH;.MSC
PROCESSOR_ARCHITECTURE	AMD64
PROCESSOR_IDENTIFIER	Intel64 Family 6 Model 62 Stepping 4, GenuineIntel

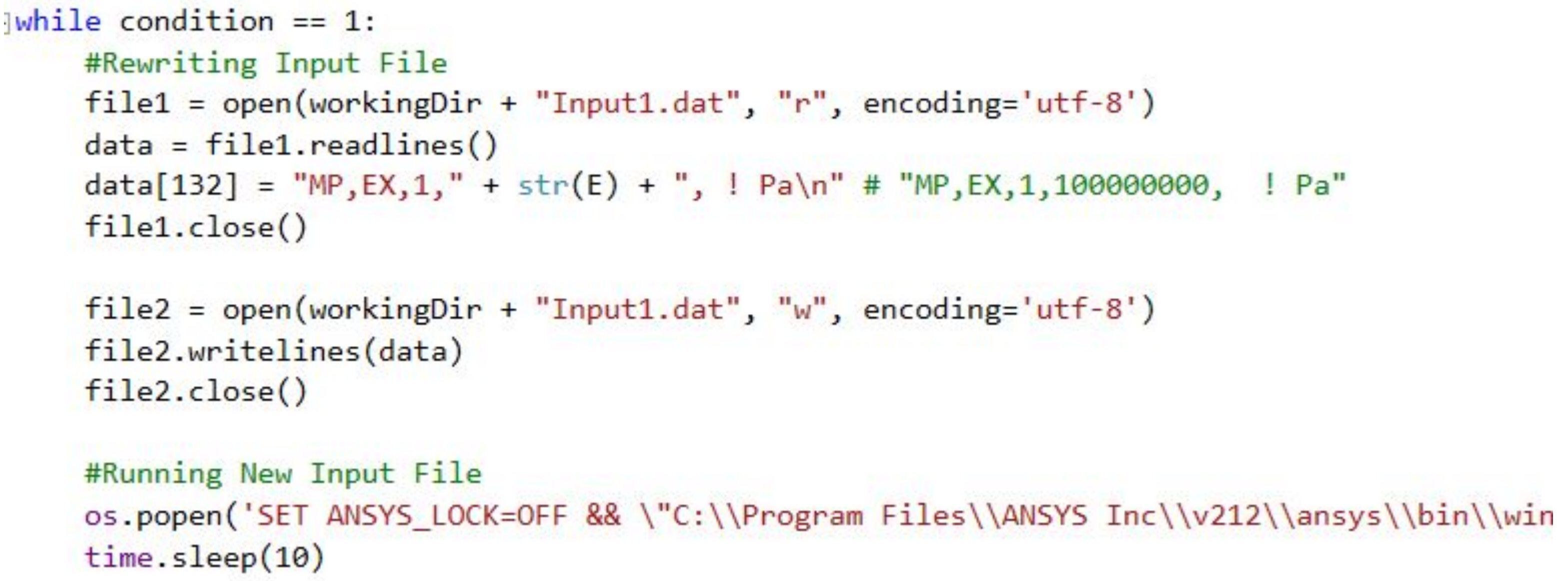
To enable python to use shell commands

Control Panel>System>Advanced System Settings>Environment Variables>System Variables>Path>New

Added: C:\Program Files\ANSYS Inc\v212\ansys\bin\winx64\ansys2021R2.exe

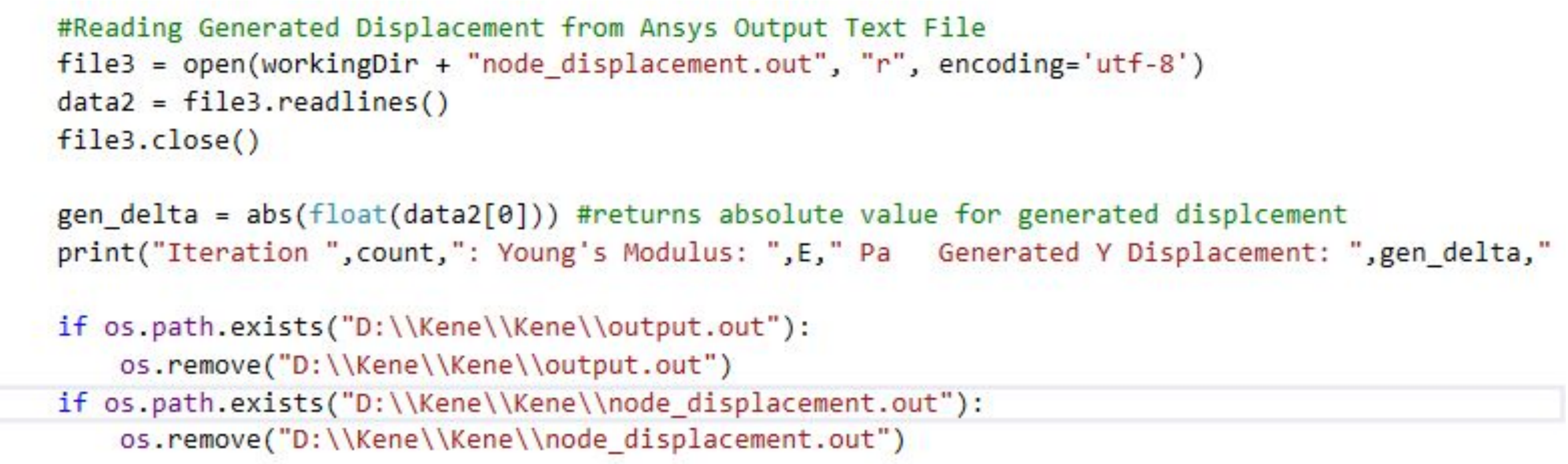
Clicked OK

- Rewriting input file with a guess of Young Modulus
- Running input file on ANSYS interface without opening the application:
    - os.popen('SET ANSYS_LOCK=OFF && \"C:\\Program Files\\ANSYS Inc\\v212\\ansys\\bin\\winx64\\ansys2021R2.exe\" -b -i \"D:\\Kene\\Kene\\Input1.dat\" -o \"D:\\Kene\\Kene\\output.out\"')



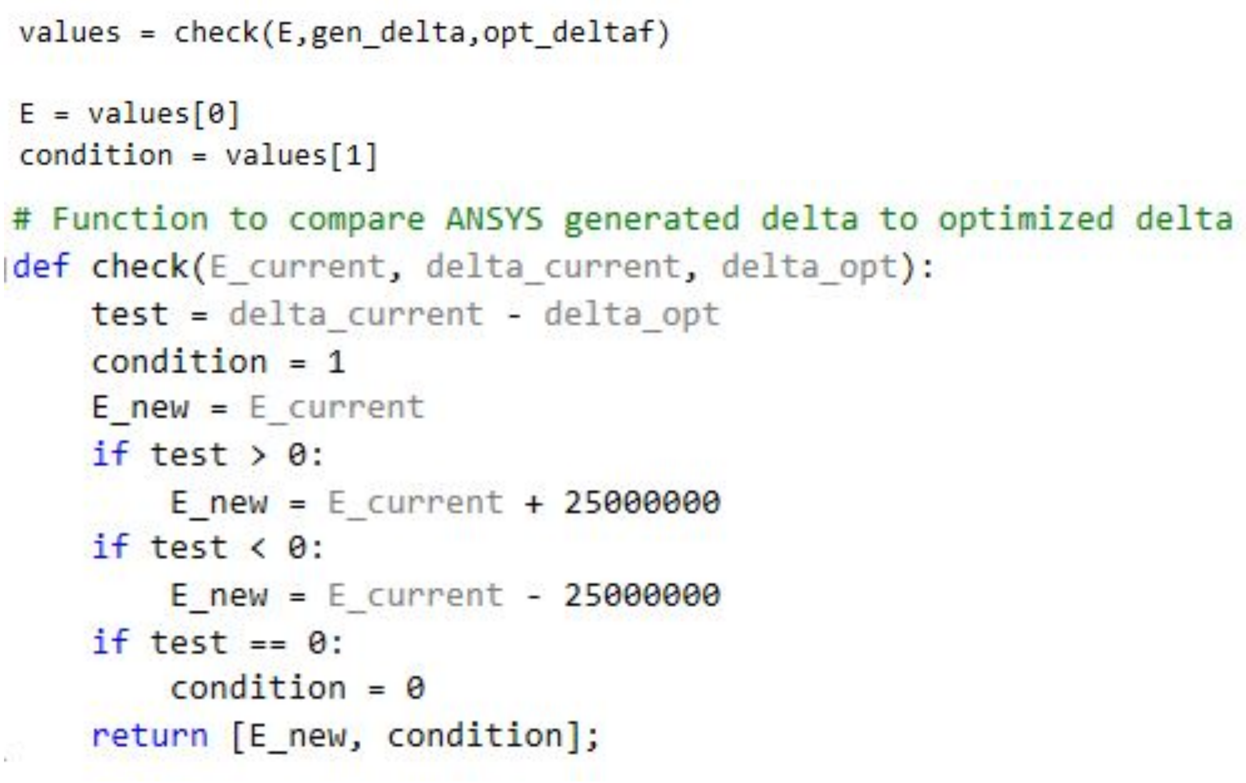
```python
while condition == 1:
    #Rewriting Input File
    file1 = open(workingDir + "Input1.dat", "r", encoding='utf-8')
    data = file1.readlines()
    data[132] = "MP,EX,1," + str(E) + ", ! Pa\n" # "MP,EX,1,100000000,  ! Pa"
    file1.close()

    file2 = open(workingDir + "Input1.dat", "w", encoding='utf-8')
    file2.writelines(data)
    file2.close()

    #Running New Input File
    os.popen('SET ANSYS_LOCK=OFF && \"C:\\Program Files\\ANSYS Inc\\v212\\ansys\\bin\\win
    time.sleep(10)
```

- Extracting Generated Displacement from Ansys Output Text File.



```
#Reading Generated Displacement from Ansys Output Text File
file3 = open(workingDir + "node_displacement.out", "r", encoding='utf-8')
data2 = file3.readlines()
file3.close()

gen_delta = abs(float(data2[0])) #returns absolute value for generated displcement
print("Iteration ",count,": Young's Modulus: ",E," Pa   Generated Y Displacement: ",gen_delta,"

if os.path.exists("D:\\Kene\\Kene\\output.out"):
    os.remove("D:\\Kene\\Kene\\output.out")
if os.path.exists("D:\\Kene\\Kene\\node_displacement.out"):
    os.remove("D:\\Kene\\Kene\\node_displacement.out")
```

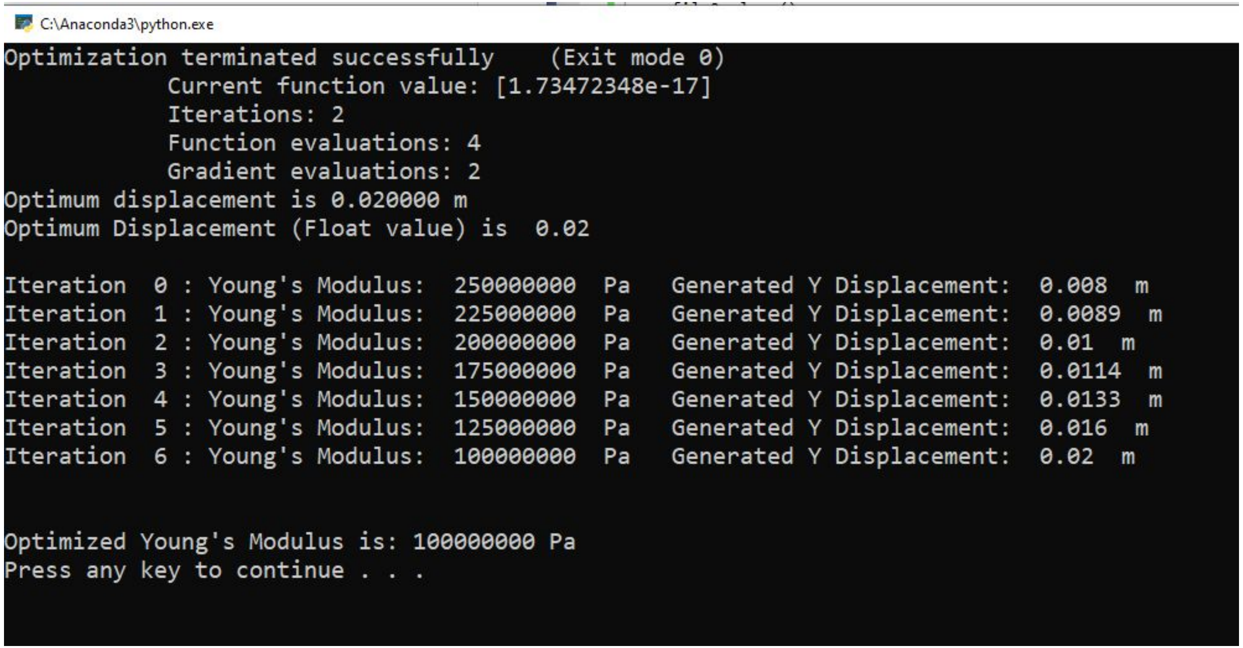
- Compares generated ΔL to optimized ΔL.
- Increments and decrements Young’s Modulus guess appropriately.
- Sends new condition to terminate while loop if generated ΔL = optimized ΔL



```
values = check(E,gen_delta,opt_deltaf)

E = values[0]
condition = values[1]

# Function to compare ANSYS generated delta to optimized delta
def check(E_current, delta_current, delta_opt):
    test = delta_current - delta_opt
    condition = 1
    E_new = E_current
    if test > 0:
        E_new = E_current + 25000000
    if test < 0:
        E_new = E_current - 25000000
    if test == 0:
        condition = 0
    return [E_new, condition];
```

Sample of Output Page

Initial Guess of Young’s Modulus = 250 MPa



```
Optimization terminated successfully    (Exit mode 0)
            Current function value: [1.73472348e-17]
            Iterations: 2
            Function evaluations: 4
            Gradient evaluations: 2
Optimum displacement is 0.020000 m
Optimum Displacement (Float value) is  0.02

Iteration  0 : Young's Modulus:  250000000  Pa   Generated Y Displacement:  0.008  m
Iteration  1 : Young's Modulus:  225000000  Pa   Generated Y Displacement:  0.0089  m
Iteration  2 : Young's Modulus:  200000000  Pa   Generated Y Displacement:  0.01  m
Iteration  3 : Young's Modulus:  175000000  Pa   Generated Y Displacement:  0.0114  m
Iteration  4 : Young's Modulus:  150000000  Pa   Generated Y Displacement:  0.0133  m
Iteration  5 : Young's Modulus:  125000000  Pa   Generated Y Displacement:  0.016  m
Iteration  6 : Young's Modulus:  100000000  Pa   Generated Y Displacement:  0.02  m


Optimized Young's Modulus is: 100000000 Pa
Press any key to continue . . .
```

Helpful Resources

https://www.researchgate.net/post/Is_it_possible_to_get_ANSYS_APDL_command_line_from_a_topology_optimisation_process_I_did_using_Ansys_Mechanical_through_Workbench

https://stackabuse.com/executing-shell-commands-with-python/

https://www.padtinc.com/blog/writing-text-files-with-vwrite/

https://www.mm.bme.hu/~gyebro/files/ans_help_v182/ans_cmd/Hlp_C_CmdTOC.html

Task 4 Current Updates

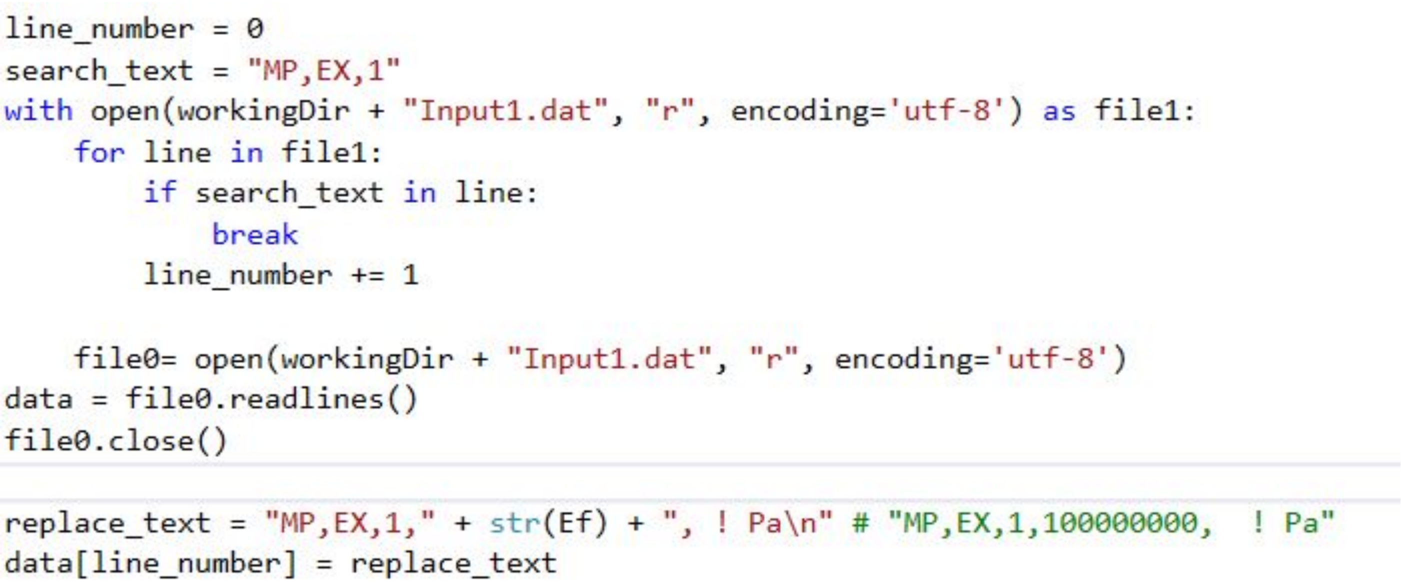
8/12/2021

Updates

- Removed “check” function. Scipy returns optimized E (Young’s Modulus).
- Removed time.sleep() function needed with **os.popen** by using **os.system**
- Code now searches for line with young modulus on the input file before changing that line.
- Used Nelder-Mead Method and 2 Global Optimization methods (SHGO and Differential-Evolution).
- Calculated and compared errors from results from the three methods.
- Calculated and compared time taken for each of the three methods .

Update 3

Code now searches for line with young modulus on the input file before changing that line



```
line_number = 0
search_text = "MP,EX,1"
with open(workingDir + "Input1.dat", "r", encoding='utf-8') as file1:
    for line in file1:
        if search_text in line:
            break
        line_number += 1

    file0= open(workingDir + "Input1.dat", "r", encoding='utf-8')
data = file0.readlines()
file0.close()
```

```
replace_text = "MP,EX,1," + str(Ef) + ", ! Pa\n" # "MP,EX,1,100000000,  ! Pa"
data[line_number] = replace_text
```

Associated Python Files on Drive

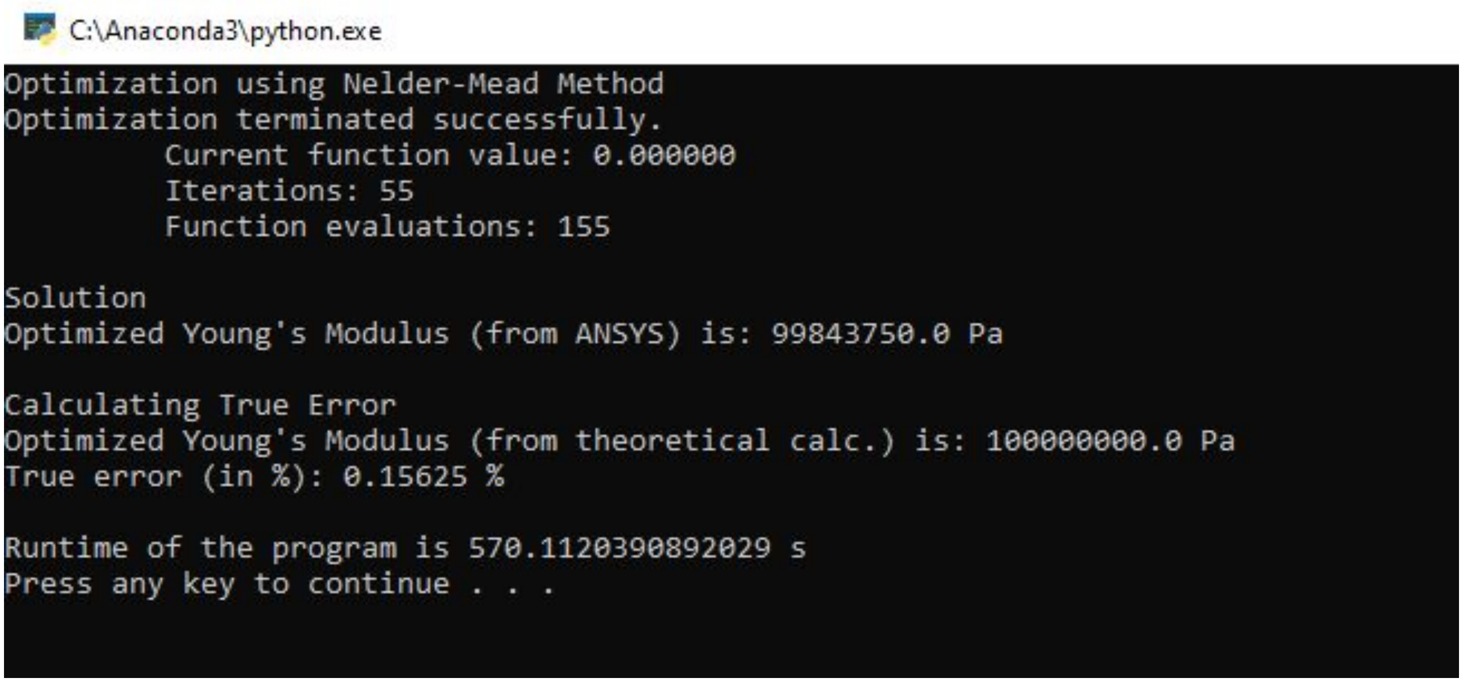
Tasks in Task_4_PythonFiles

Task4_9 => Nelder-Mead Method

Task4_10 => Global Optimization Method (Differential_evolution)

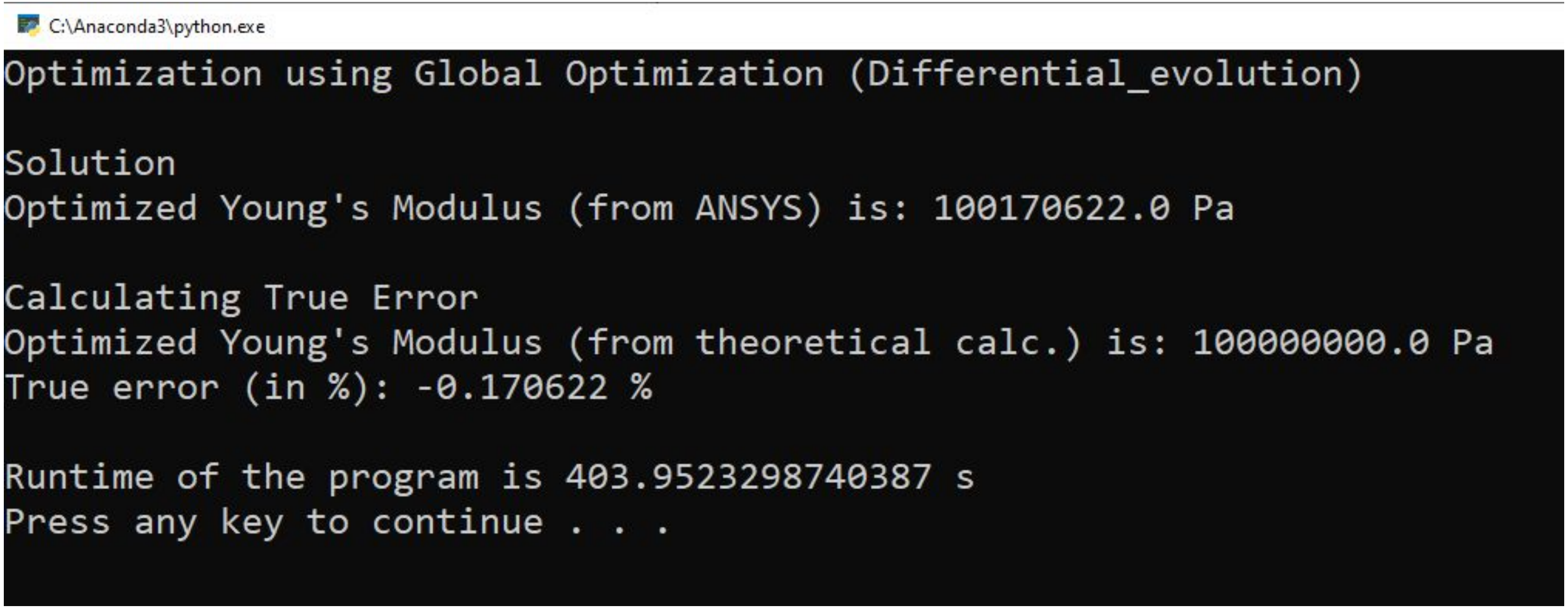
Task4_12 => Global Optimization (SHGO)

Nelder-Mead Method Results



```
Optimization using Nelder-Mead Method
Optimization terminated successfully.
         Current function value: 0.000000
         Iterations: 55
         Function evaluations: 155

Solution
Optimized Young's Modulus (from ANSYS) is: 99843750.0 Pa

Calculating True Error
Optimized Young's Modulus (from theoretical calc.) is: 100000000.0 Pa
True error (in %): 0.15625 %

Runtime of the program is 570.1120390892029 s
Press any key to continue . . .
```

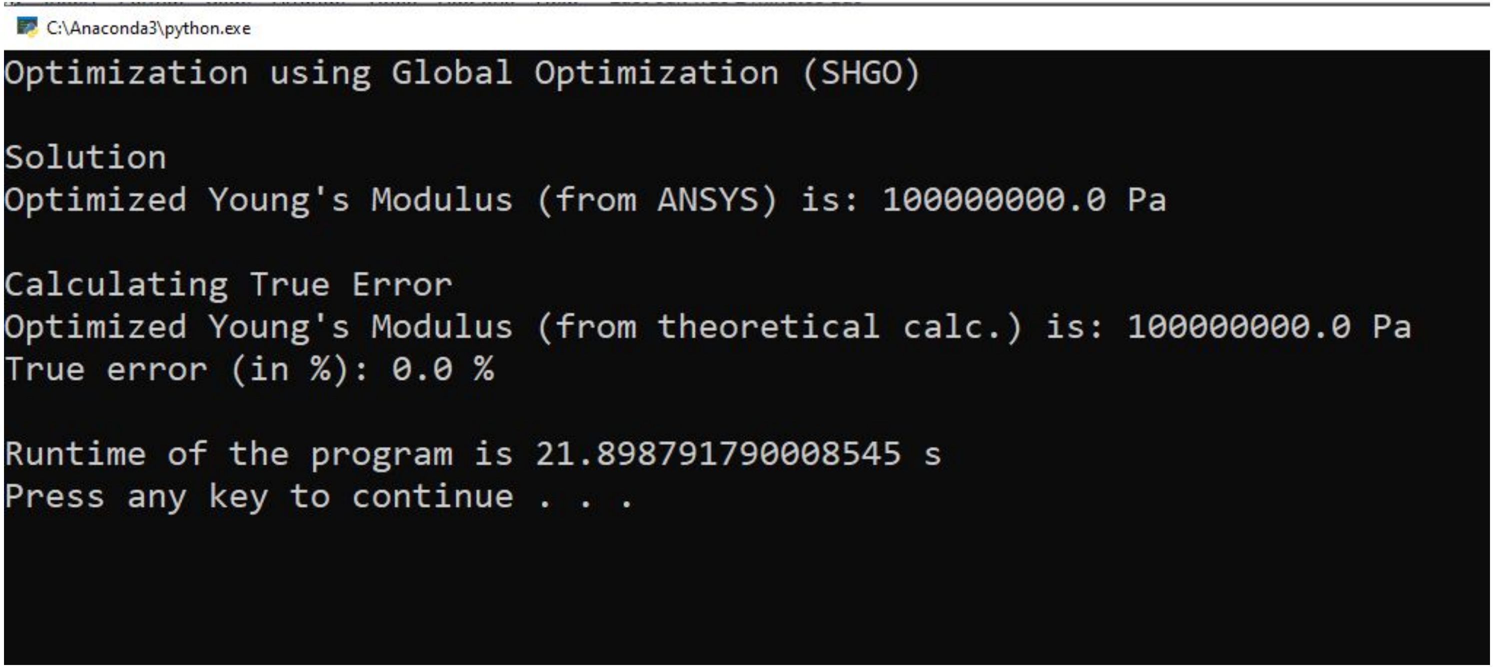
Global Optimization (Differential_evolution) Results



C:\Anaconda3\python.exe

```
Optimization using Global Optimization (Differential_evolution)

Solution
Optimized Young's Modulus (from ANSYS) is: 100170622.0 Pa

Calculating True Error
Optimized Young's Modulus (from theoretical calc.) is: 100000000.0 Pa
True error (in %): -0.170622 %

Runtime of the program is 403.9523298740387 s
Press any key to continue . . .
```

Global Optimization (SHGO) Results



```
Optimization using Global Optimization (SHGO)

Solution
Optimized Young's Modulus (from ANSYS) is: 100000000.0 Pa

Calculating True Error
Optimized Young's Modulus (from theoretical calc.) is: 100000000.0 Pa
True error (in %): 0.0 %

Runtime of the program is 21.898791790008545 s
Press any key to continue . . .
```

Comparison

Fastest Method: Global Optimization (SHGO)

Most accurate Method: Global Optimization (SHGO)