

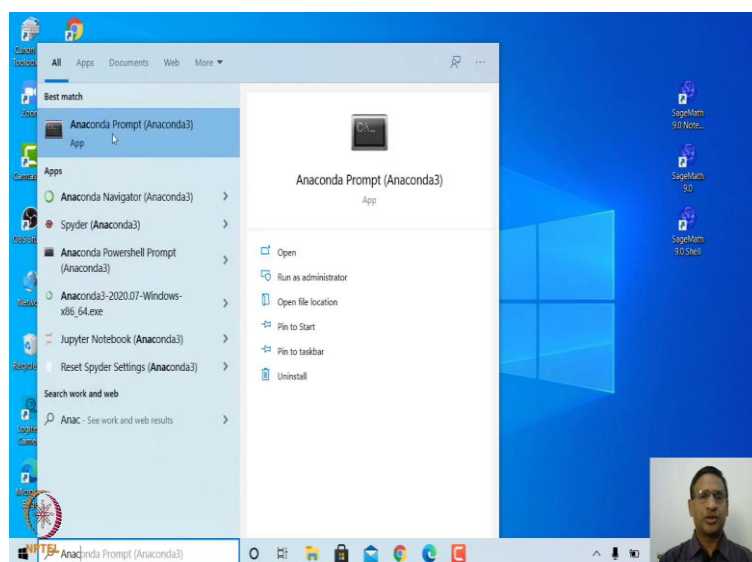
**Computational Mathematics with Sagemath**  
**Prof. Ajit Kumar**  
**Department of Mathematics**  
**Institute of Chemical Technology, Mumbai**

**Lecture – 02**  
**Getting Started with Python**

Good morning to all of you. First of all, I welcome all of you to this 1st lecture on Computational Mathematics with Sagemath. In this lecture, we will start exploring basics of Python. A basic knowledge in Python will help us to use SageMath more effectively and we can create our own programs in SageMath. I hope all of you have managed to install Anaconda environment in your system or at least you have figured it out how to use it online.

So, let us get started. First of all, let us start Jupyter Notebook. As I said, we will be using Jupyter Notebook to write Python programs and execute. Not only that, Sagemath will also be used through Jupyter Notebook. How do we start Jupyter Notebook? There are different ways of starting Jupyter Notebook. One way is to open Anaconda Navigator and then, launch Jupyter Notebook from there.

(Refer Slide Time: 01:43)

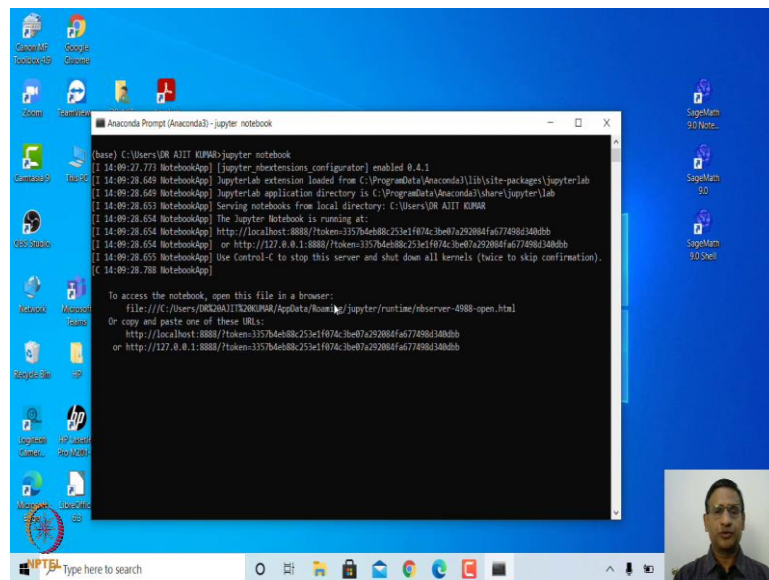


Another way is to open Anaconda Prompt. So, let us go to search window and type Anaconda Prompt. This is Anaconda Prompt. Let us click on this and then, type

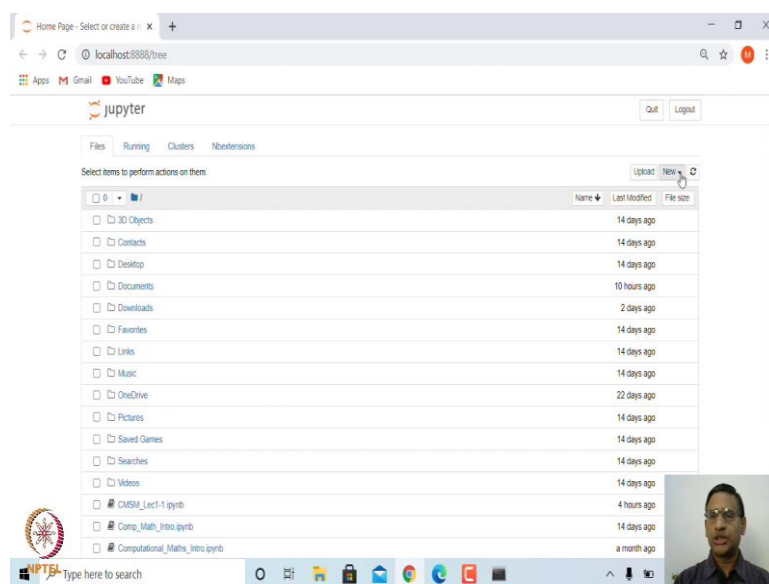
**jupyter notebook**

and hit enter.

(Refer Slide Time: 01:52)

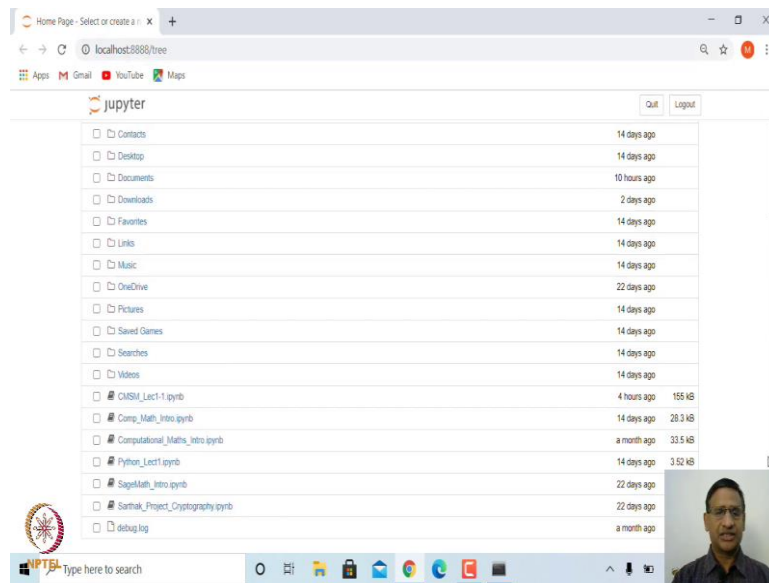


(Refer Slide Time: 02:13)



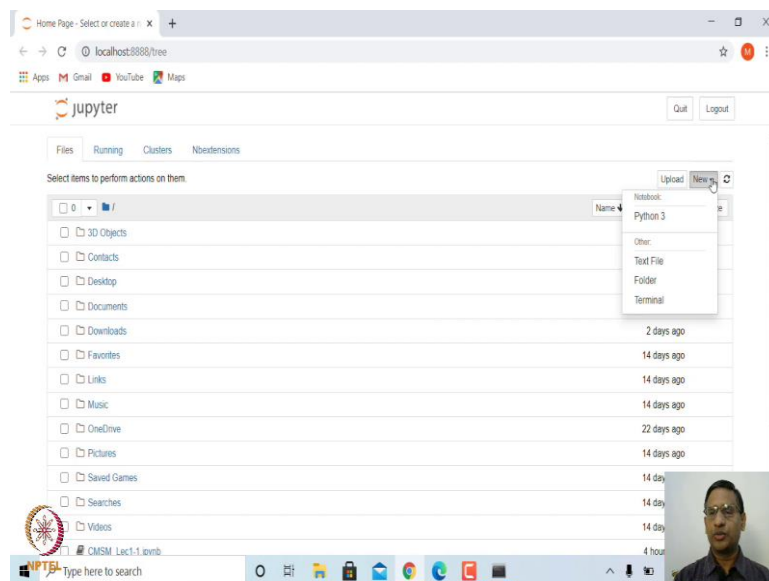
Once you enter, it may take few seconds to start the notebook. The Jupyter server will start in a browser and this is what you see here. So, it has created a local host and these are the folders and files.

(Refer Slide Time: 02:32)



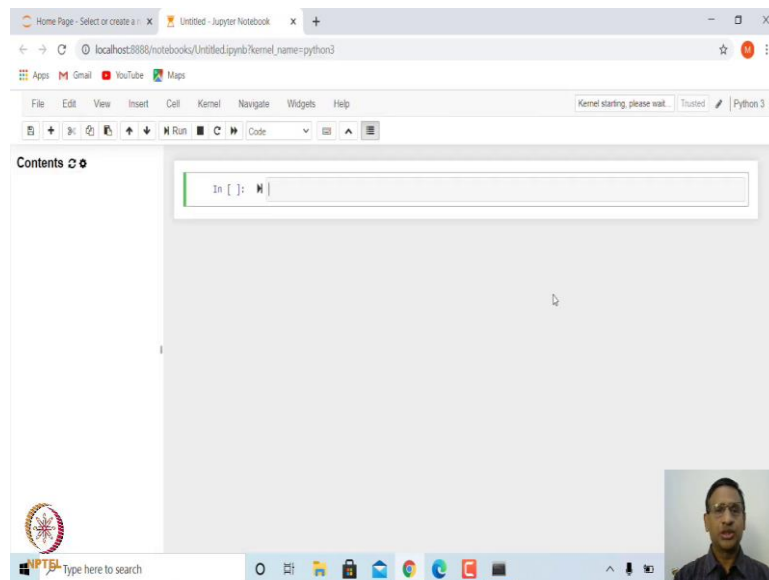
In case you have some files here, it will be coming at the bottom.

(Refer Slide Time: 02:45)



Now, in order to start Jupyter notebook, click on new and then click on Python 3.

(Refer Slide Time: 03:01)



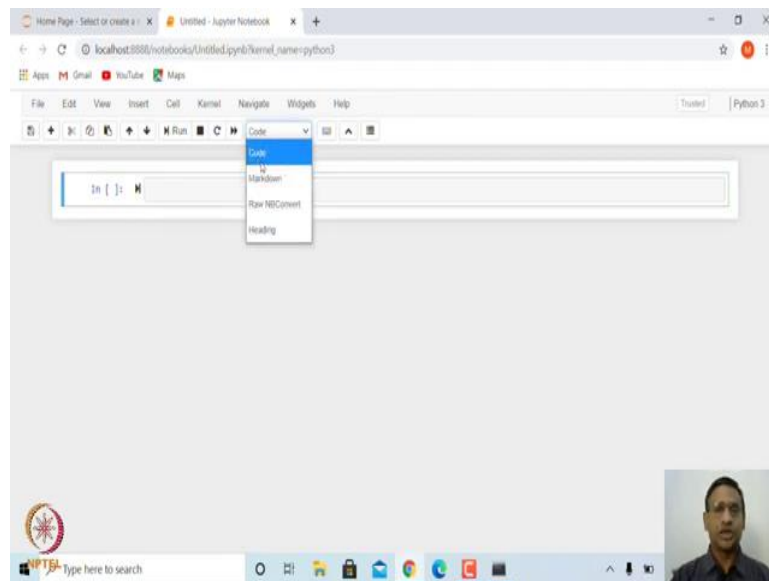
Then, Jupyter Notebook will start in a new tab. Let me disable this table of contents for the time being. This is what you see as a Jupyter Notebook and this particular cell which you see here that is a input cell. This is where all the inputs syntax, comments etc will be given. Now, if you look at this Jupyter Notebook, you have file menus and you also have toolbars.

We will be using some of these things. Of course, there are shortcuts for each of these things. For example, when you want to type anything in this Jupyter Notebook, there are two modes in this; one is edit mode and other one is command mode.

We at present we are in edit mode. This notebook, as I said, can contain Python codes, Python syntax and it can also contain some text comments, it could be result, it could be proof of some result, anything we can type here and it can also have the figures and things like that. Advantage of using Jupyter notebook is that you can have everything in this notebook itself. The statement of a result, a case you want to prove, you can insert here and also a Python codes along with its output. I am sure many of you might have already seen several blogs in which they have used Jupyter Notebook in order to do some computations along with the explanations.

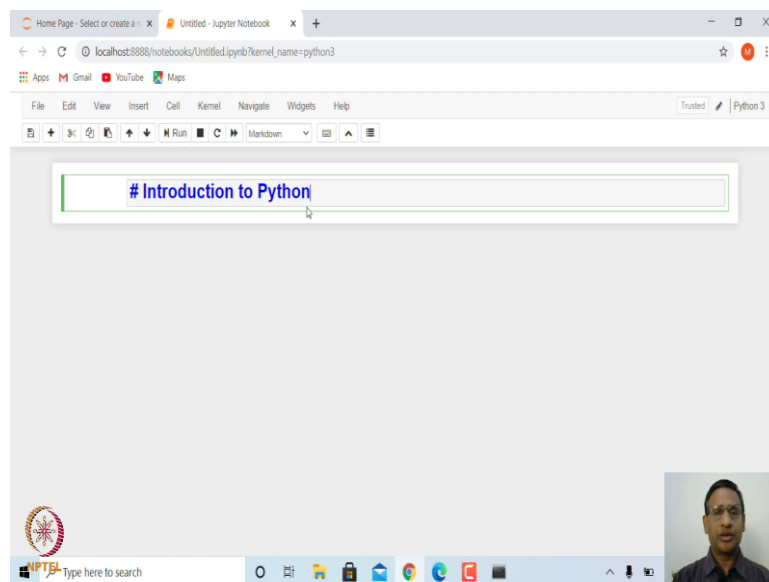
Ok, now, let us get started. Suppose we want to type anything in this cell. So, we can convert this cell into command mode or code mode, and you can convert this into what is called Markdown mode.

(Refer Slide Time: 05:17)



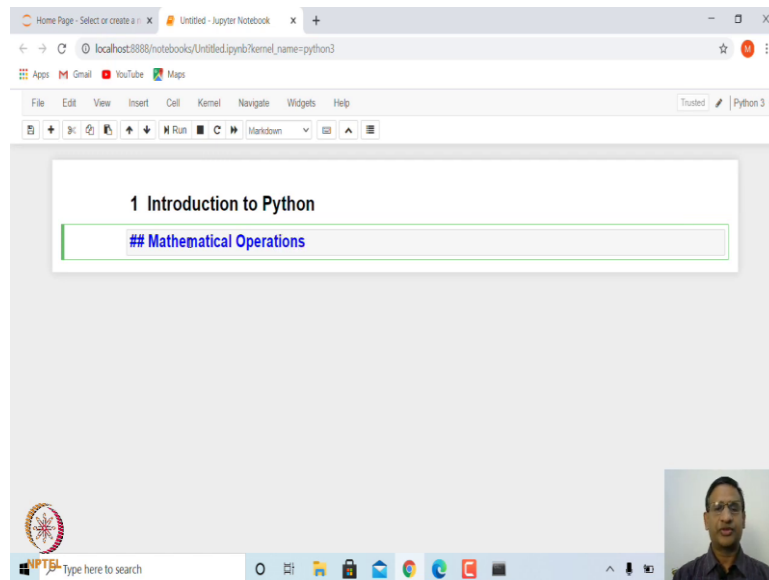
So, for example, if you click on this, you can select code mode or you can select Markdown. Suppose we want to let us say type a heading for this particular notebook.

(Refer Slide Time: 05:36)



Type one hash tag and then space and let us say we will call Introduction to Python. And then, in order to execute this, you can click on this run tool bar or you can press shift and enter both together.

(Refer Slide Time: 06:16)



Suppose, we want to create another. So, this is as heading, we want to create a sub heading. In that case again, we will select markdown and this time instead of one hash, we will put two hash tags and then, space and then, let us say we want to explore Mathematical Operations in Python. So, let us say mathematical operations like how to add, how to multiply, how to divide, how to raise powers etc. So, we will say “Mathematical Operations”.

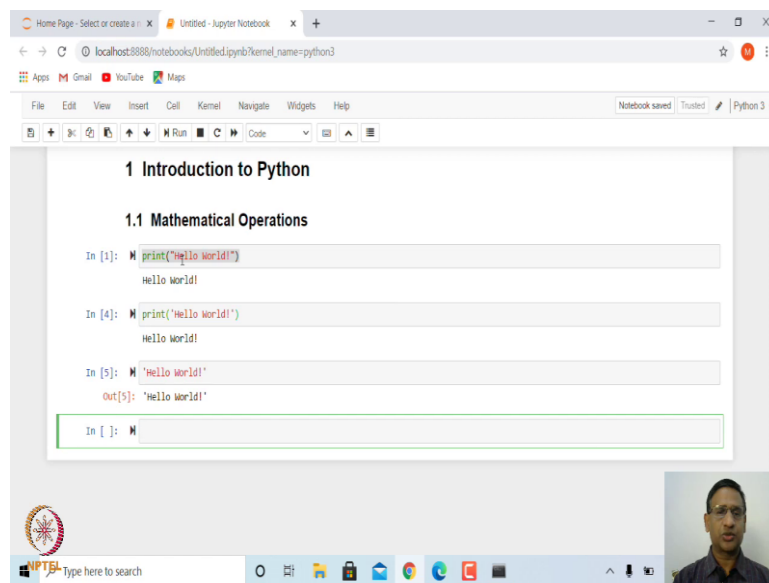
You can see here by default it converts into 1.1. So, the heading is 1 and then, this is sub heading you can think of as section, subsections and things like that. Off course, you might not see these number 1, 1.1 that I am able to see, this because I have enabled, what is called table of contents option. At some point, I will also tell you how to do this.

Now, let us see. Suppose we want to say print hello world! How do I do that? You can simply say `print('Hello World!')` and then, execute this. In order to execute this, we will use shift and enter.

Instead of using double quote, you can also use single quote. So, you can just highlight this particular code, copy that is, control c and paste that is control v or you could use this is to cut the cell selected cells, this is to copy, this is to paste. So, these menu toolbars can also be used.

Now instead of double quote, if I use single quote, then let us see what do we get? Yes, this is the same thing.

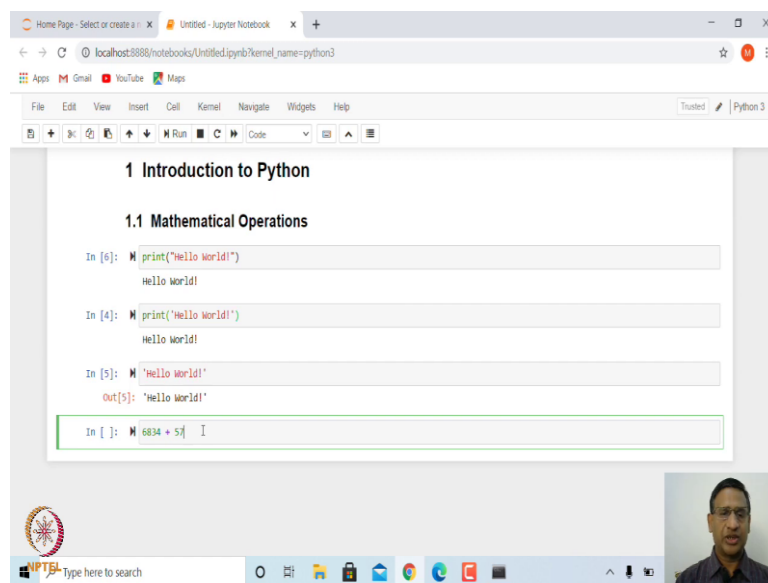
(Refer Slide Time: 08:36)



Of course, here you need not even type print, if you simply type, let us say 'Hello World!', then also you will get the output. Output is shown here.

You can see here each cell has got input and output. It also has a number and this number depends upon the order in which you execute. For example, if I go to the first one and execute, then it will have cell number 6. Yeah, that's correct. This is how you can print any sentence, any word, any string etc.

(Refer Slide Time: 08:59)



```
1 Introduction to Python

1.1 Mathematical Operations

In [6]: print("Hello World!")
Hello World!

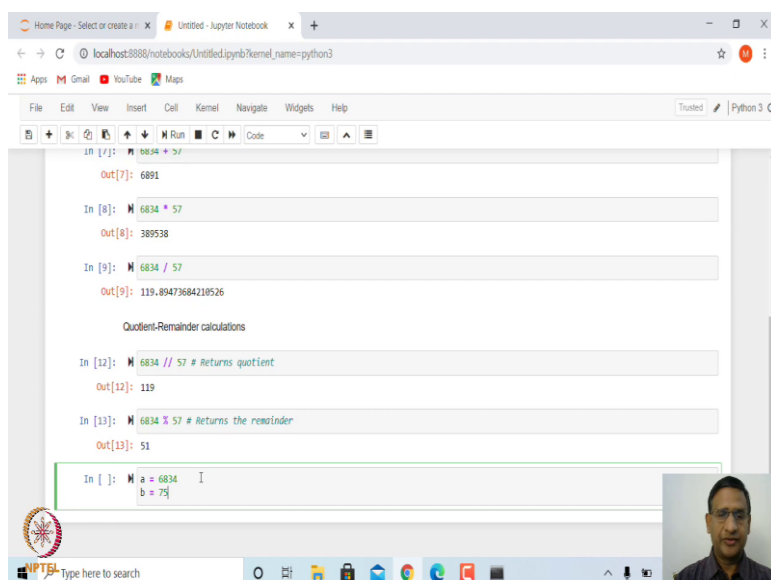
In [4]: print('Hello World!')
Hello World!

In [5]: print('Hello World!')
Out[5]: 'Hello World!'

In [ ]: 6834 + 57
```

Now, let us say we want to add two numbers. Let us take one number, say, 6834 and another number, say 57. So, if you have to add these two number, we can put plus in between and then, execute, that is, shift enter, you get the output 6891.

(Refer Slide Time: 09:31)



```
In [7]: 6834 + 57
Out[7]: 6891

In [8]: 6834 * 57
Out[8]: 389538

In [9]: 6834 / 57
Out[9]: 119.89473684210526

Quotient-Remainder calculations

In [12]: 6834 // 57 # Returns quotient
Out[12]: 119

In [13]: 6834 % 57 # Returns the remainder
Out[13]: 51

In [ ]: a = 6834
        b = 57
```

Suppose you want to multiply these two numbers, you can simply say 6834 into that is, \* and 57, you get this number, 389538.



(Refer Slide Time: 9.56)

Next suppose, you want to divide 6834 by 57, you put forward slash, then you get the decimal number. So 6834 divided by 57 is 119.894736 and so on.

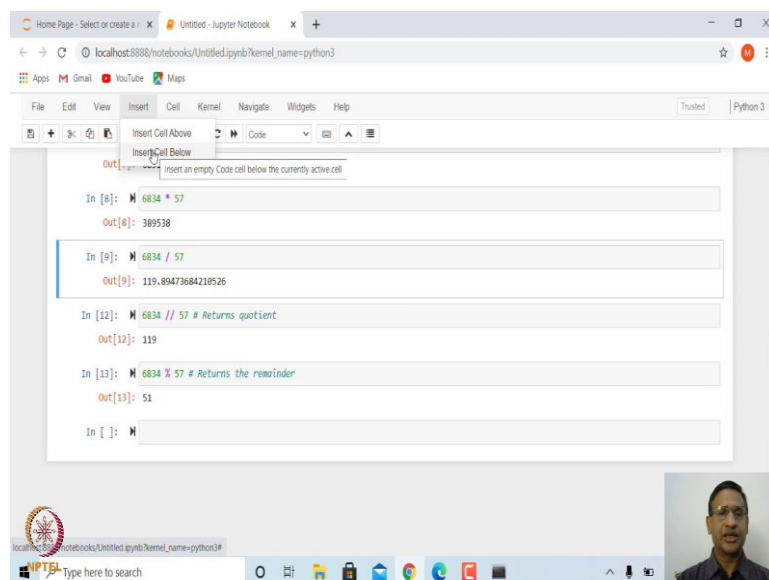
(Refer Slide Time: 10.13)

Now, suppose you want to find out quotient and remainder. See in this case, we have integer divided by integer; the output, we are getting is a decimal number, a floating-point number or a real number. But suppose, we want the quotient and the remainder for this. How do I do that? Instead of one forward slash, if you put double forward slashes; then, you get quotient. So, let me execute this. How do I execute? Shift and enter. So, this is the quotient, 119 and in order to find the remainder, you can use percentage in between. So, if I say percentage, it will give me remainder.

(Refer Slide Time: 11.02)

Now, suppose I wanted to write some comment along with this cell, we can simply write here # and then, we can say that this returns quotient. Similarly it returns the remainder.

(Refer Slide Time: 11:44)



```
In [8]: 6834 * 57
Out[8]: 389538

In [9]: 6834 / 57
Out[9]: 119.89473684210526

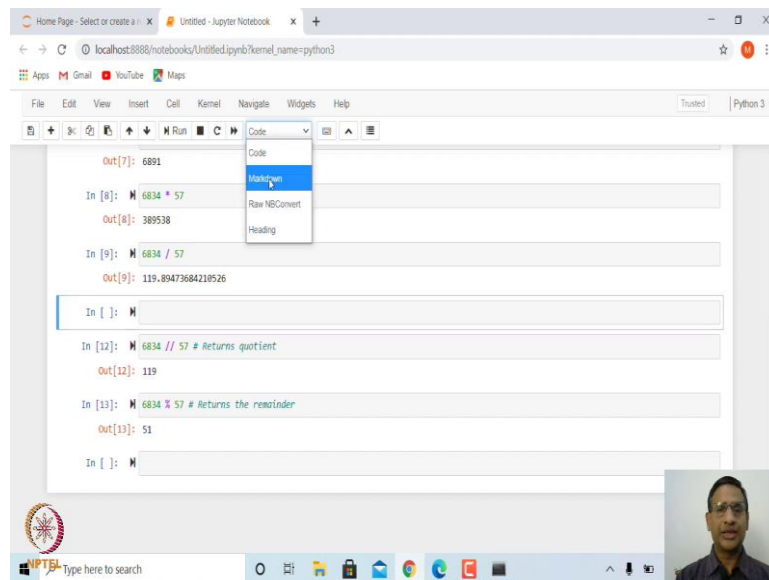
In [12]: 6834 // 57 # Returns quotient
Out[12]: 119

In [13]: 6834 % 57 # Returns the remainder
Out[13]: 51

In [ ]: 
```

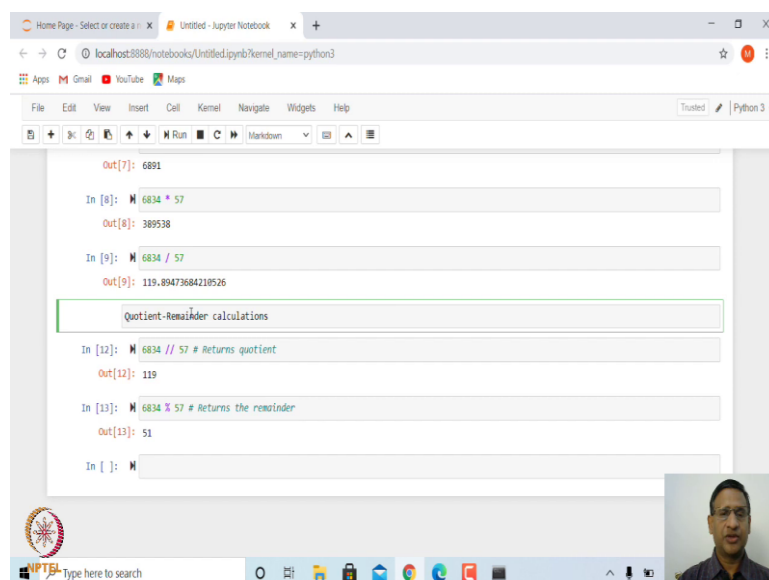
In between, if you want to add comments, let us say between input cell 9 and input cell 12, what you can do is, you can insert a new cell anywhere.

(Refer Slide Time: 12:09)



For example, if you go to insert, you have an option of insert cell above that is, above this input cell 9, or you can have insert cell below. So, let us take a insert a cell below this. Now, in between let us say we want to convert this into a comment box.

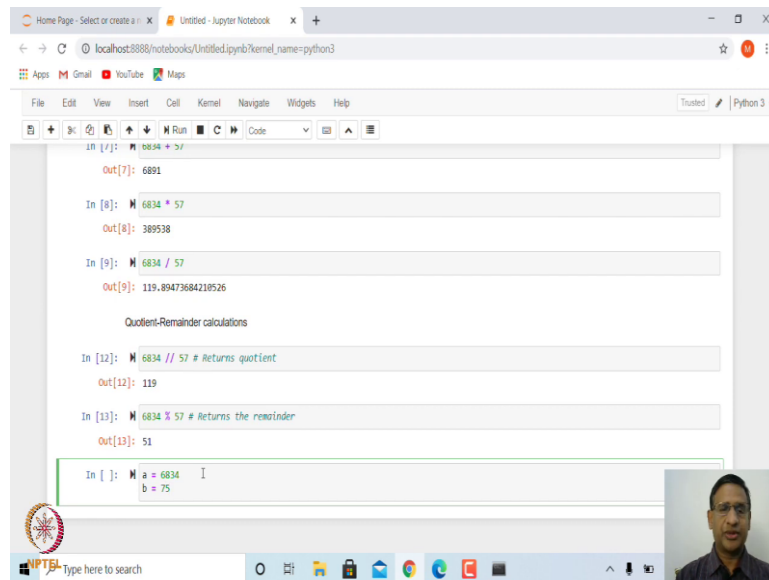
(Refer Slide Time: 12:13)



So, then we will go to Code and select Markdown and let us say, we can say here Quotient Remainder Calculations.

So, you can see here we can add comment between the two cells or we can add comment inside a Python code that is inside input cell and that is using this comment syntax hash.

(Refer Slide Time: 12:27)



The screenshot shows a Jupyter Notebook interface with the following code cells:

```
In [7]: 6834 * 57
Out[7]: 6891

In [8]: 6834 * 57
Out[8]: 389538

In [9]: 6834 / 57
Out[9]: 119.89473684210526

Quotient-Remainder calculations

In [12]: 6834 // 57 # Returns quotient
Out[12]: 119

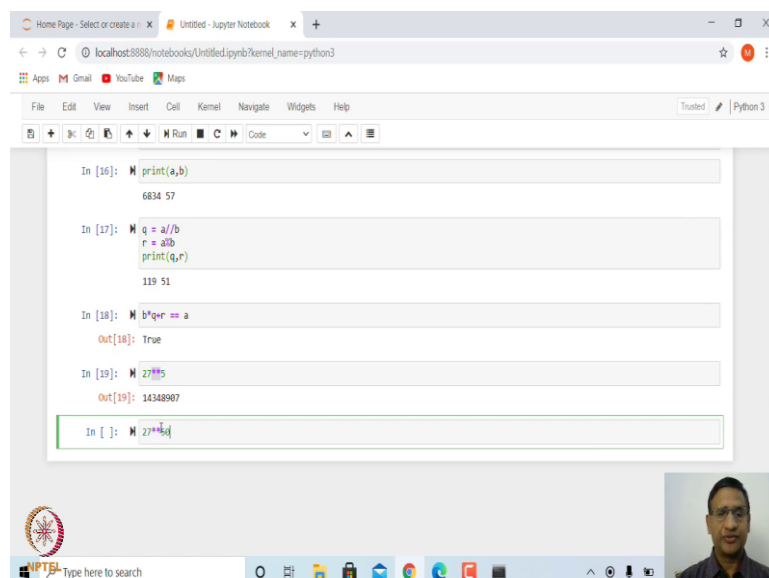
In [13]: 6834 % 57 # Returns the remainder
Out[13]: 51

In [ ]: a = 6834
        b = 57
```

The last cell is currently selected and highlighted with a green border.

Now, actually the better way to do these calculations, especially when you want to do the computations repeatedly, it is better to define these numbers in variables and do this computation. So, let us say I will define a is equal to 6834 and b is equal to 57. So, now, we have defined a which is equal to 6834 and b which is equal to 57.

(Refer Slide Time: 13:34)



The screenshot shows a Jupyter Notebook interface with the following code cells:

```
In [16]: print(a,b)
6834 57

In [17]: q = a//b
         r = a%b
         print(q,r)
119 51

In [18]: b*q+r == a
Out[18]: True

In [19]: 27**5
Out[19]: 14348907

In [ ]: 27**5d
```

The last cell is currently selected and highlighted with a green border.

(Refer Slide Time: 13.36)

And if I ask it to print what are a and b? You will see a and b are 6834 and 57 right.

(Refer Slide Time: 13.45)

Now, let us say we want to define what is q is equal to a divided by b, that is, the quotient and r is equal to a % b. Please notice that, in case you want to have more than one lines of commands in a single input cell, you should press enter not shift enter and then, let us say we want to print what are q and r. Then, we will get the q as 119 and r is 51.

Let us verify this division algorithm which says that in case a is divided by b and which gives you the quotient q and r, then  $b*q + r$ , this should be equal to a.

I am using here double equal to, this is logical equality. In this case, we are checking whether  $a == b*q + r$  and the answer is true. In case when we write  $b*q + r == a$ , this means value of a is assigned to  $b*q + r$  which is not proper in this case. We want to check whether  $a == b*q + r$ . So, this is how we can find quotient and remainder.

(Refer Slide Time: 15.10)

Now, suppose, we want to raise power of a number. How do I do that? In case we want to find power of a number, then we can say we. Let us say that we want to find out 27 to the power 5. How do I write? So, you can say  $27**5$ , this will give you 27 to the power 5. So, power is given as  $**$ .

(Refer Slide Time: 15:46)

```
Out[18]: True

In [19]: 27**5
Out[19]: 14348907

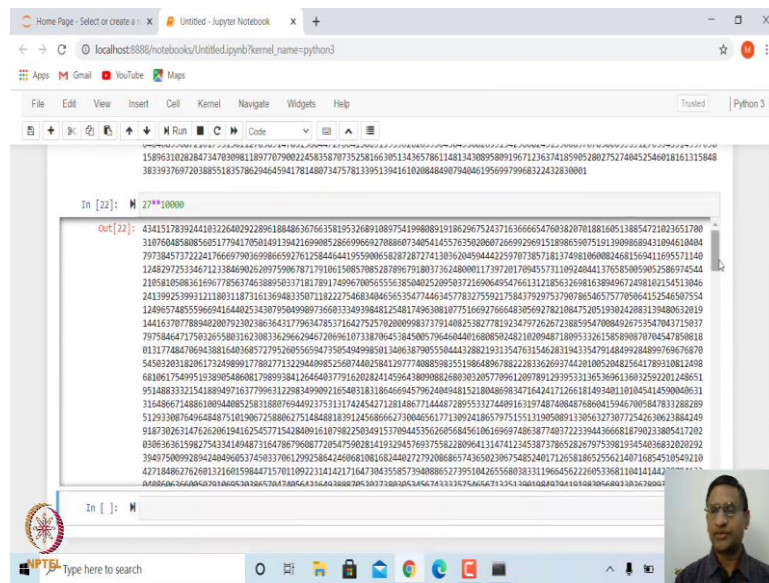
In [20]: 27**50
Out[20]: 369988485035126972924700782451696644186473100389722973015184405301748249

In [21]: 27**500
Out[21]: 4807088077112701783341840006386042489324244724492451489593450371750114329692179535869917626581847711672278437594757859060697
9154024171864166329574817483293881028710535973176979596219731991520830514694374771774636807890694422882343405923800484901643
617730596619404008970261599869155013404931429752342726180705520458979112259712386721798394528829489512924153249937054916029
6404689968721617931501127858914783136844727664158691595962620395045849308263915425608241139008970783006393912709943914957698
158963102828473470309611897707900224583587073525816630513436578611481343089508919671236374185052802752748452540618161315848
383937697203855183570294645941781480734757813395139416102084849079408619569579968312432830801

In [ ]: 27**10000
```

If I want to find 27 to the power, let us say instead of 5, suppose we want to find 50; again, it will give you in no time. Suppose, we want to find 27 to the power let us say 500, still you will get very easily.

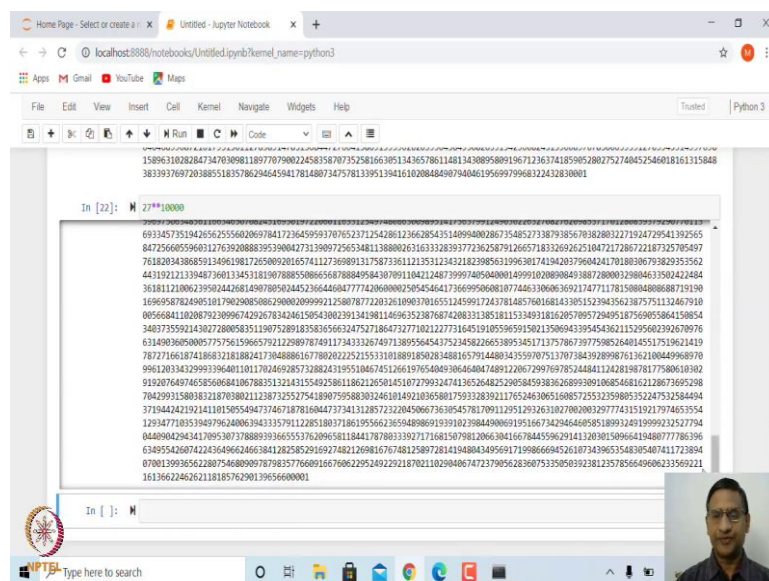
(Refer Slide Time: 16:05)



The screenshot shows a Jupyter Notebook interface with a code cell containing the expression `27**10000`. The output cell displays a long string of digits, representing the 10000th power of 27. The interface includes a top bar with file and kernel management options, a left sidebar with file explorer, and a bottom status bar with a search bar and system icons. A small video feed of a person is visible in the bottom right corner.

Suppose, we want to find 27 to the power instead of 500, let us say 10000. Again, you can see here. It gives you the 10000 power of 27 and this has several digits.

(Refer Slide Time: 16:15)



This screenshot is similar to the one above, showing a Jupyter Notebook with the same code `27**10000` and its output. The output is a long string of digits. The interface elements are consistent with the previous screenshot, including the top bar, sidebar, and bottom status bar. A small video feed of a person is visible in the bottom right corner.

So, you can see here Python is quite powerful, when it comes to handling a large digit ok.

(Refer Slide Time: 16:26)

The screenshot shows a Jupyter Notebook window with a URL bar indicating it's running on localhost:8888. The notebook contains a large list of numbers, likely generated by a script. Below this list, there is a code cell with the input `27**100000`. The output of this cell is `2700000`. The interface includes standard Jupyter Notebook controls like 'File', 'Edit', 'View', 'Insert', 'Cell', 'Kernel', 'Navigate', 'Widgets', and 'Help' menus, as well as a 'Run' button and a 'Python 3' interpreter selection.

(Refer Slide Time: 16:40)

This screenshot is similar to the previous one, showing the same Jupyter Notebook interface. It displays a large list of numbers and a code cell with the input `27**100000`. The output of this cell is `2700000`. The interface includes standard Jupyter Notebook controls like 'File', 'Edit', 'View', 'Insert', 'Cell', 'Kernel', 'Navigate', 'Widgets', and 'Help' menus, as well as a 'Run' button and a 'Python 3' interpreter selection.

You can even find 27 to the power let us say one lakh, 100000. So  $27^{100000}$ , this will take little longer; but you will get the answer. So, again you can see that it is able to find 27 to the power 100000.

(Refer Slide Time: 16:46)



So, again you can see that it is able to find 27 to the power 100000.

Of course, you can increase the power; but of course, it has got limitations. So, do not try to find very large power, it may be able to compute; but it may take lot of time, you may have to wait quite some time. So, this is how you can find to the power.

Now, let us see whatever computations which we have done, we have done; how to add two numbers, how to multiply two numbers, how to divide one number by another number, how to find quotient, how to find remainder and how to find power of a number.

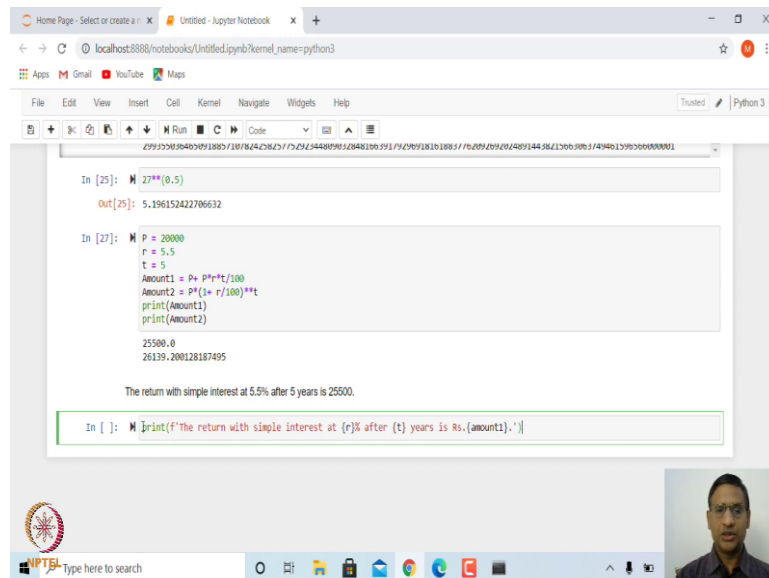
(Refer Slide Time: 17.50)

Now, suppose you if suppose you want to find let us say not integer power, but a power of any number. So, for example, if I say 27 to the power let us say 0.5 that is, 27 square root, that also it will give you. So, you can find not only the integer power, but you can also find any real power.

Now let us look at we want to do very basic computations involving all these operations. So, for example, let us say suppose you are investing some amount in a bank and bank gives you interest, let us say 5.5 percent and the interest can be simple interest or it can be compound interest. In both these cases, we want to find out what will be the return, let us say after 5 years.



(Refer Slide Time: 17:41)



The screenshot shows a Jupyter Notebook window with the following content:

```
In [25]: 27**(0.5)
Out[25]: 5.196152422706632

In [27]: P = 20000
         r = 5.5
         t = 5
         Amount1 = P + P*r*t/100
         Amount2 = P*(1 + r/100)**t
         print(Amount1)
         print(Amount2)

25500.0
26139.20012817495

The return with simple interest at 5.5% after 5 years is 25500.

In [ ]: print(f'The return with simple interest at {r}% after {t} years is Rs.{amount1}.')
```

So, let us define variables. So, for example, variable the principal, I will call this as P which is a principal. So, that is let us say you have invested 20000 rupees and the rate, I will call this as r, that is let us say 5.5 percent and let us say you have invested this for t is which is equal to let us say 4 years or 5 years. And so, let us say what is the amount that you are going to get, when the bank is giving is return with simple interest. So, let me call that as amount is Amount1 first we will calculate the interest.

So, that is,  $p * r * t / 100$ , this is the interest and you add this to principal, you will get the amount and let us print what is the amount. Amount1, that is the 25500 is the return. Suppose, the now instead of simple interest, the bank gives you return with compound interest. Then what is the formula? The formula is let me call this as Amount2 and it will be  $P * (1 + r/100)$  to the power t, that is, the formula for compound interest. Let us print, what happens when we print Amount2. So, in this case the amount that you get when the interest is calculated using compound interest is 26139.200 and so on.

Suppose, the interest is calculated 3 times in a year; then you can use the appropriate formula and compute the return.

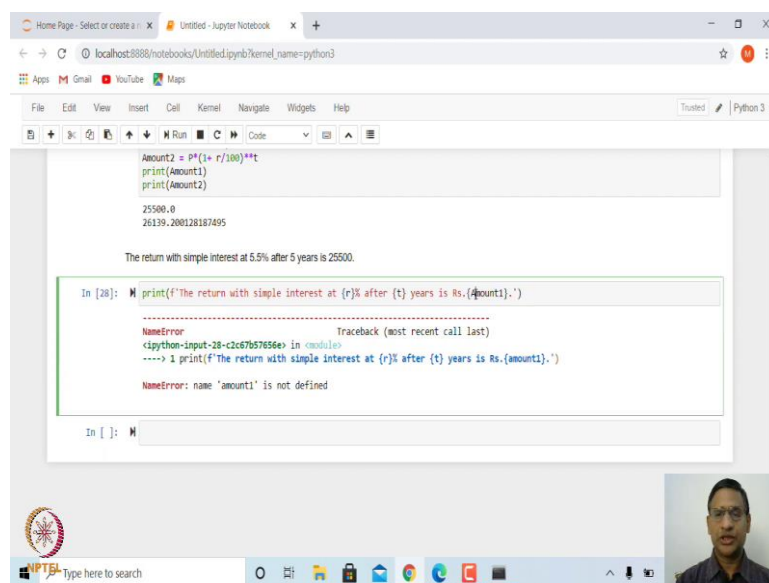
Now, suppose, we want to get the output which says that the amount after so many years and with so much interest rate is so much.

We want to say print something like this,

**The return with simple interest at 5.5% after 5 years is 25,500.**

This is what we want to print. So, how do I write that? This can be achieved by print statement. But we have to use what is called f string formatted print we will use, which was introduced recently in Python.

(Refer Slide Time: 23:07)



The screenshot shows a Jupyter Notebook interface. The top bar indicates the file is 'Untitled - Jupyter Notebook' and the kernel is 'python3'. The notebook contains a code cell with the following Python code:

```
Amount2 = P*(1+r/100)**t
print(Amount1)
print(Amount2)
```

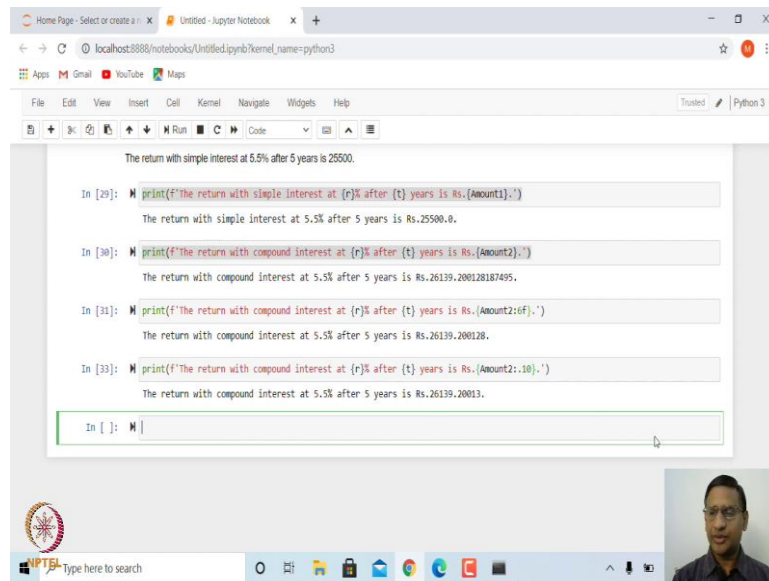
The output of the code cell shows the values 25500.0 and 26139.200128187495. Below the output, the text 'The return with simple interest at 5.5% after 5 years is 25500.' is displayed. The code cell is then executed again, resulting in a NameError:

```
In [28]: print(f'The return with simple interest at {r}% after {t} years is Rs.{Amount1}.')
```

Traceback (most recent call last):  
NameError: name 'Amount1' is not defined

So, we will put single quote or double quote, with simple interest at 5.5 percent. So, this is the rate. So, you write here r and after 5 years. So, this is the number of year t and this is you replace this by amount. So, inside the curly bracket, you write Amount 1. If you want, you can put here rupees this. I think A is capital. So, this is what you get. So, I think A is capital. So, this is A right. So, this is what you get.

(Refer Slide Time: 23:21)



```
The return with simple interest at 5.5% after 5 years is 25500.0.

In [29]: print(f'The return with simple interest at {r}% after {t} years is Rs.{Amount1}.')
The return with simple interest at 5.5% after 5 years is Rs.25500.0.

In [30]: print(f'The return with compound interest at {r}% after {t} years is Rs.{Amount2}.')
The return with compound interest at 5.5% after 5 years is Rs.26139.200128187495.

In [31]: print(f'The return with compound interest at {r}% after {t} years is Rs.{Amount2:6f}.')
The return with compound interest at 5.5% after 5 years is Rs.26139.200128.

In [33]: print(f'The return with compound interest at {r}% after {t} years is Rs.{Amount2:10}.')
The return with compound interest at 5.5% after 5 years is Rs.26139.20013.

In [ ]: 
```

Similarly, if I want to print the compound interest, I will simply say this compound interest compound interest. This will be Amount2. So, you get this number.

If you want to print say 4 digits or 5 digits or 6 digits, that option is also there in formatted print statement. So, if you put colon and then, put 6f, you will get only 6 decimal places.

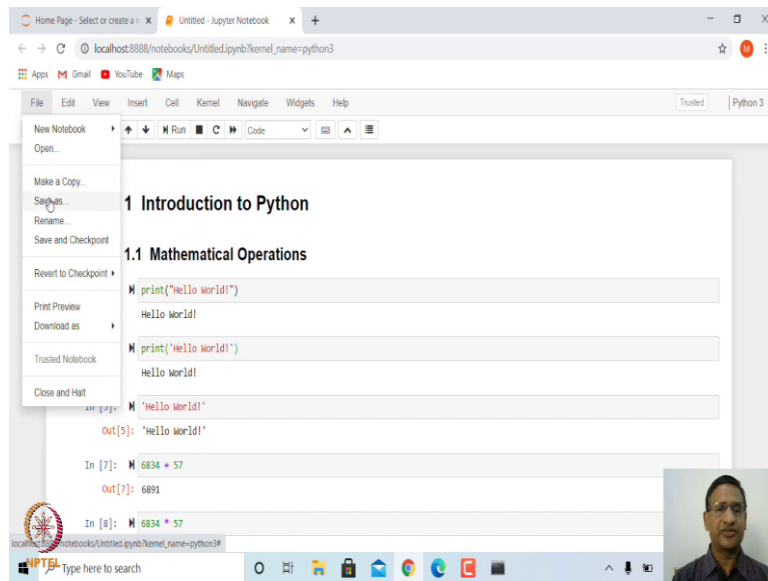
If you put colon dot, say, 8, then then it will print only the 8 significant digits.

If you want, 10 significant digits, you put here 10. So, this formatted print statement is quite useful. Using this you can print texts along with values of variables.

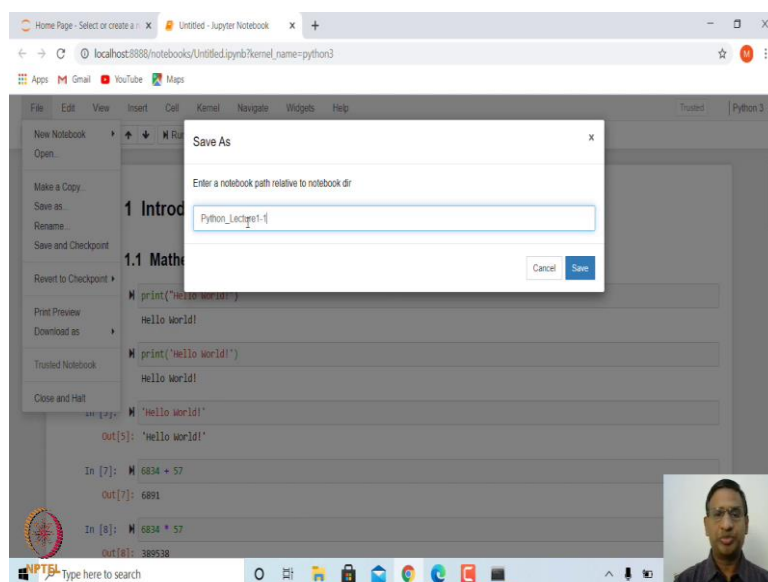
Let us see, if I want to do other calculations, like, you want to use Python as an advanced scientific calculator, we may have to square root, trigonometrical functions, logarithmic functions etc. This we will explore in the next class.

For the time being, now let us look at whatever we have done, we want to save this in a file.

(Refer Slide Time: 25:08)

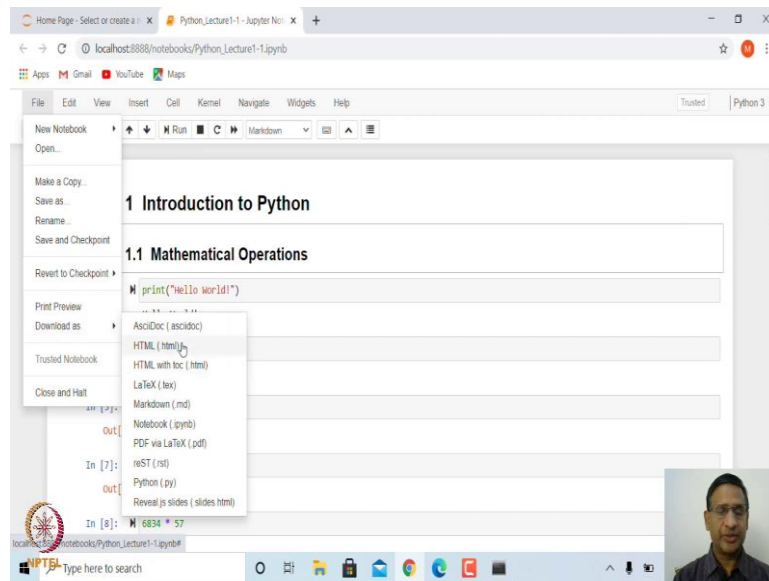


(Refer Slide Time: 25:10)



For the time being, now let us look at whatever we have done, we want to save this in a file. So, we can go to File menu and then, we can say save as and give the file name. Let me give file name as Python\_Lecture1-1. By default, you can see here, it has put an extension dot i p y n b. This is interactive Python notebook format. But you can also save this in various other formats, you can download this in html format, you can download this in standard Python extension, that is, .py format.

(Refer Slide Time: 25:40)



So, all these options are there. If you download this in html format, you can open this in a web browser and that you can put it online or put it in git hub ok. So, thank you very much.

In the next lecture, we will see how to make use of other scientific functions and do scientific calculations with Python. Thank you.