**Computational Mathematics with Sagemath**
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**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 Annaconda Navigator and then, launch Jupyter Notebook from there.

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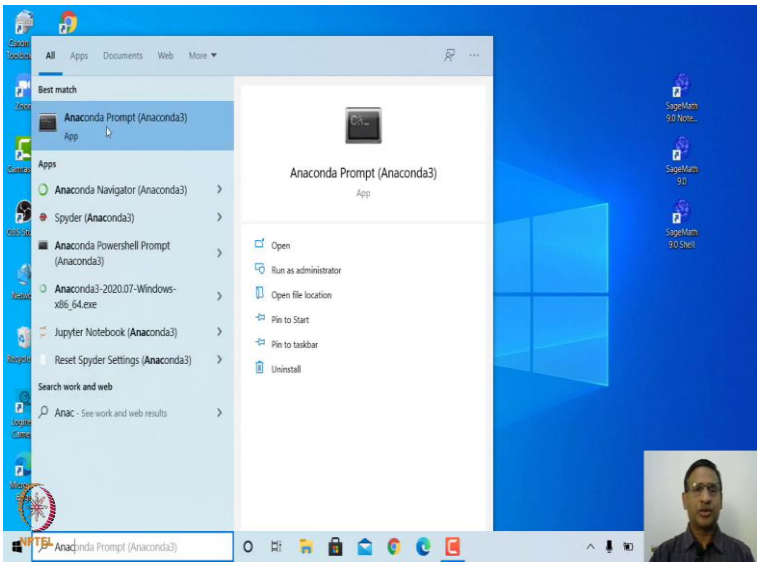


Another way is to open Anaconda Prompt. So, let us go to search window and type Anaconda Prompt. This is Anaconda Prompt. Let us click on this and then, type

**jupyter notebook**

and hit enter.

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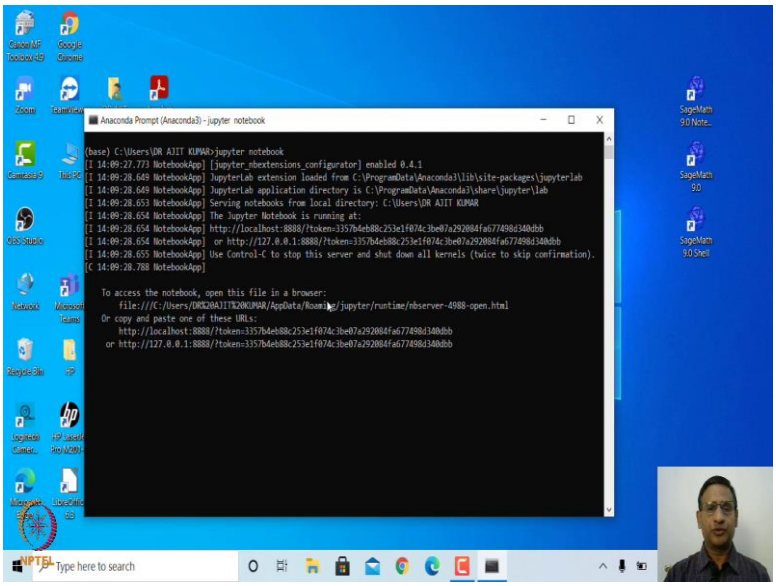


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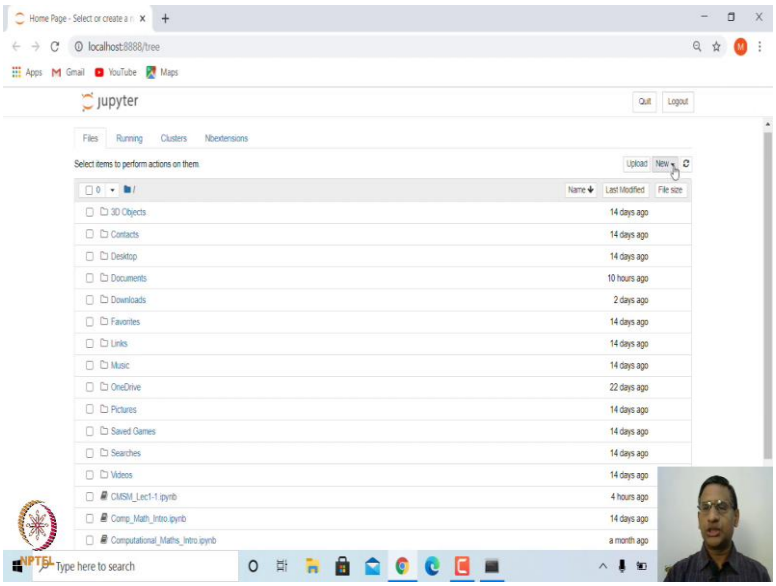


Once you enter, it may take few seconds to start the notebook. The Jupyter server will start in a browser and this is what you see here. So, it has created a local host and these are the folders and files.

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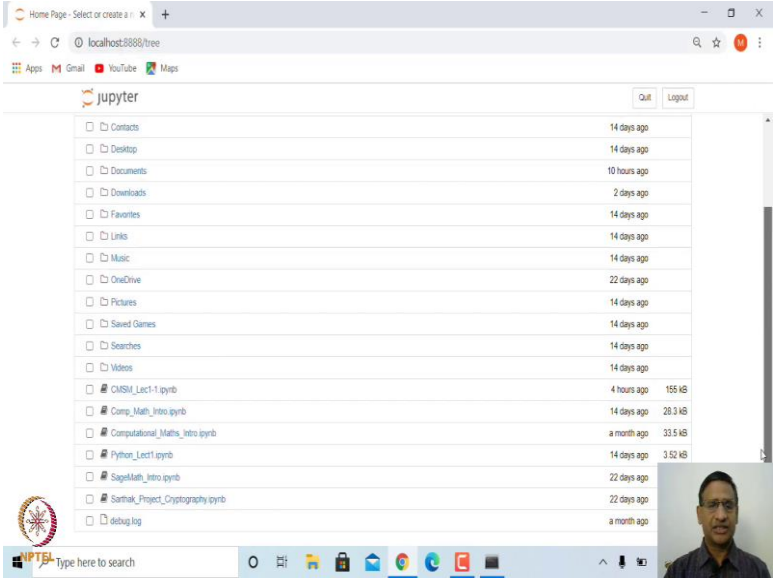


In case you have some files here, it will be coming at the bottom.

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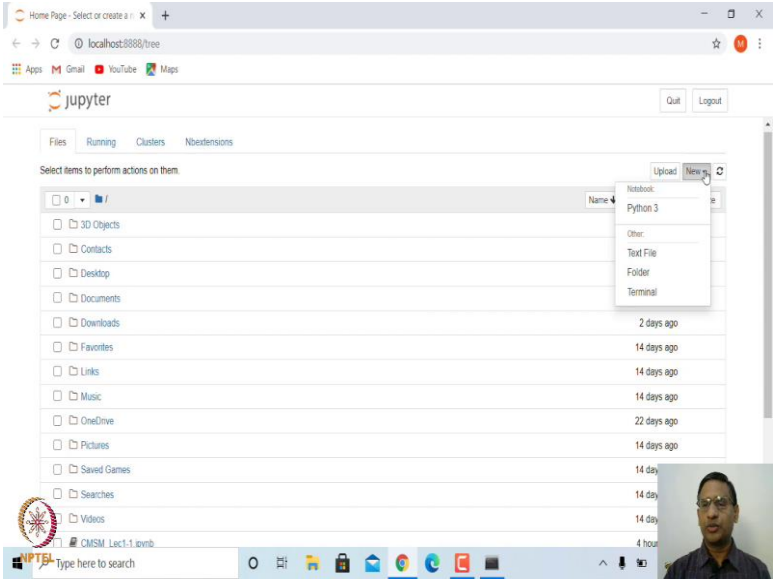


Now, in order to start Jupyter notebook, click on new and then click on Python 3.

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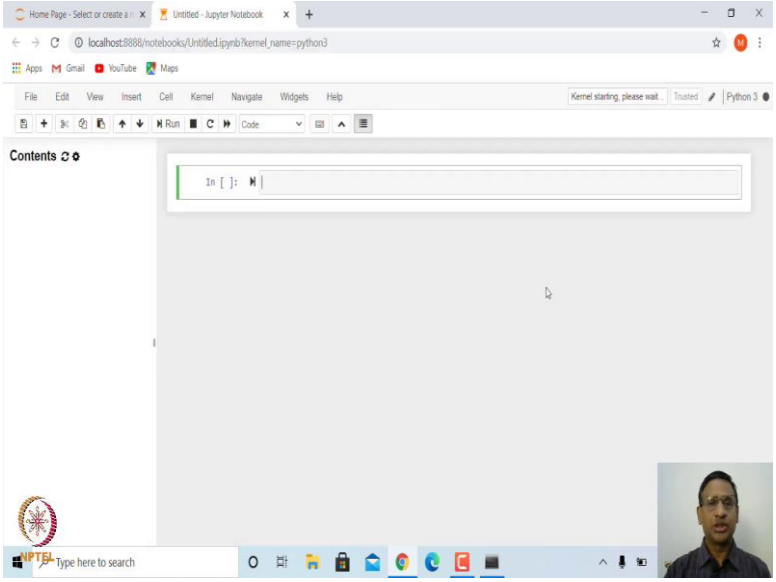


Then, Jupyter Notebook will start in a new tab. Let me disable this table of contents for the time being. This is what you see as a Jupyter Notebook and this particular cell which you see here that is a input cell. This is where all the inputs syntax, comments etc will be given. Now, if you look at this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

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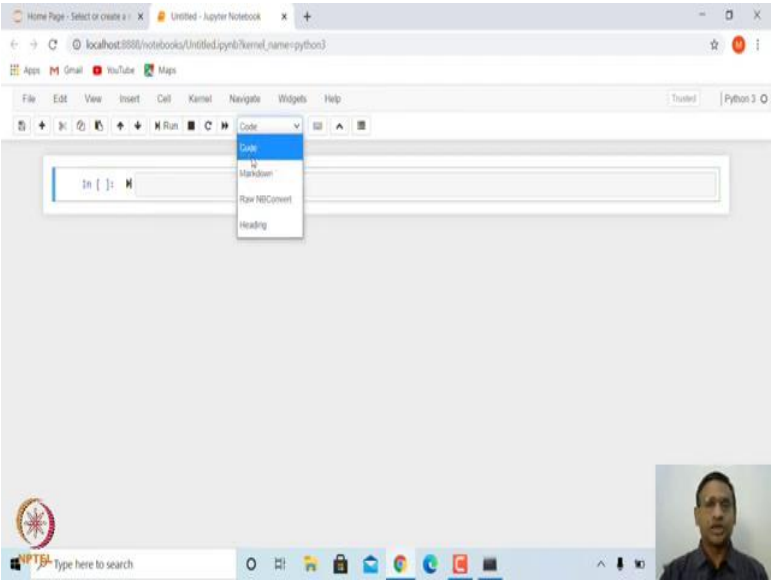


So, for example, if you click on this, you can select code mode or you can select Markdown. Suppose we want to let us say type a heading for this particular notebook.

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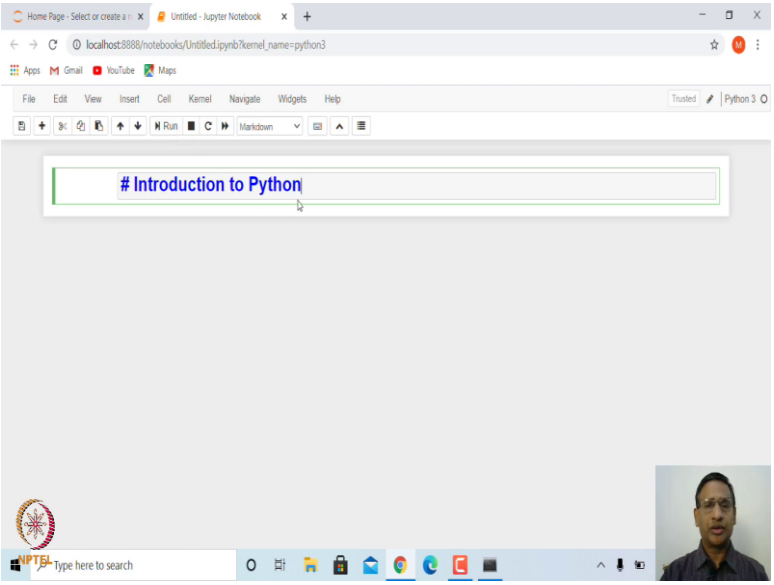

Type one hash tag and then space and let us say we will call Introduction to Python. And then, in order to execute this, you can click on this run tool bar or you can press shift and enter both together.

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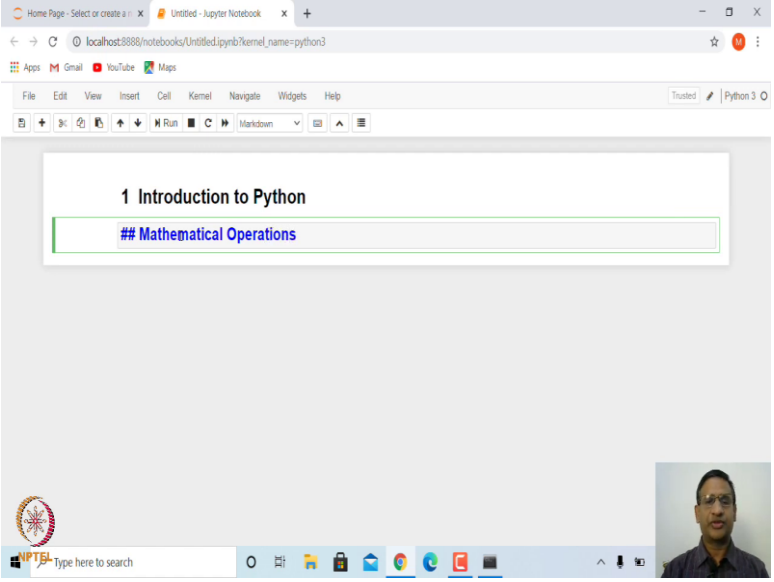


Suppose, we want to create another. So, this is as heading, we want to create a sub heading. In that case again, we will select markdown and this time instead of one hash, we will put two hash tags and then, space and then, let us say we want to explore Mathematical Operations in Python. So, let us say 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.

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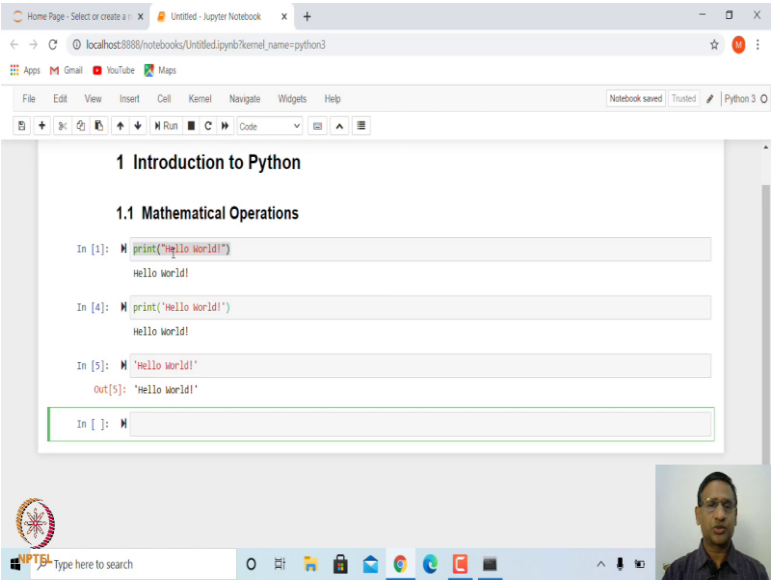


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Of course, here you need not even type print, if you simply type, let us say ‘Hello World!’, then also you will get the output. Output is shown here.

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.

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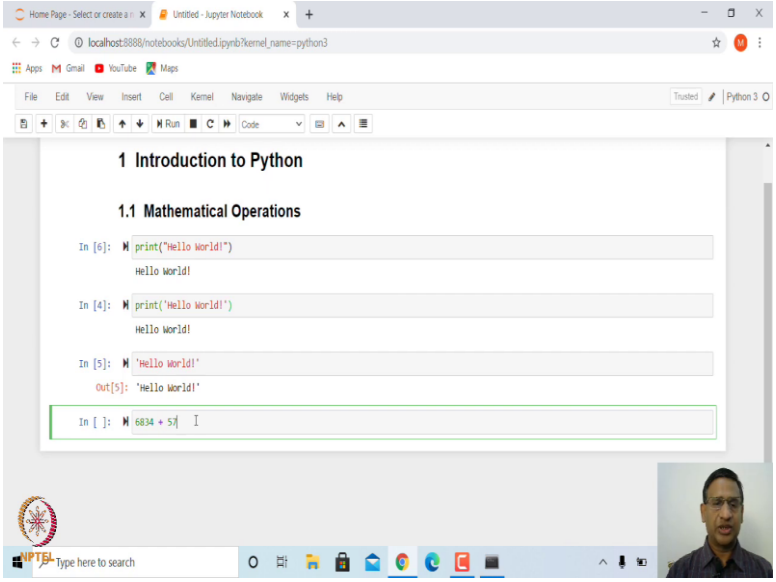


Now, let us say we want to add two numbers. Let us take one number, say, 6834 and another number, say 57. So, if you have to add these two number, we can put plus in between and then, execute, that is, shift enter, you get the output 6891.

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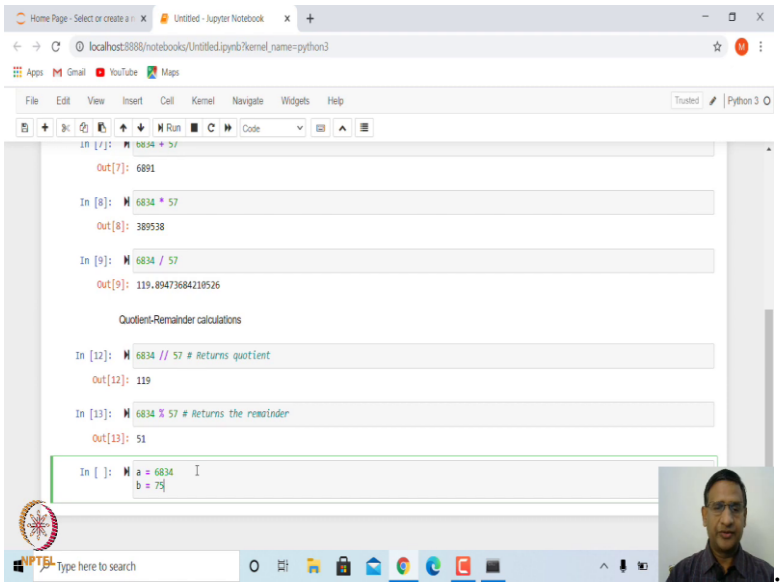


Suppose you want to multiply these two numbers, you can simply say 6834 into that is, * and 57, you get this number, 389538.

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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.

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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.

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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.

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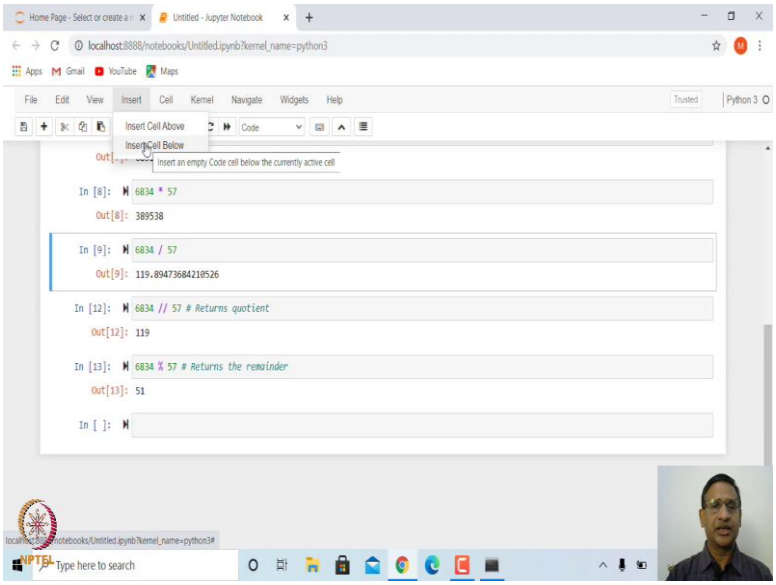


In between, if you want to add comments, let us say between input cell 9 and input cell 12, what you can do is, you can insert a new cell anywhere.

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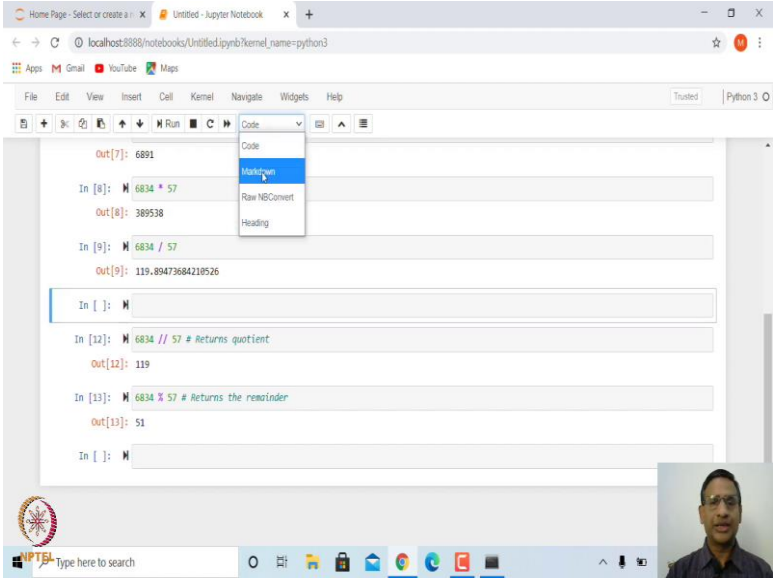


For example, if you go to insert, you have an option of insert cell above that is, above this input cell 9, or you can have insert cell below. So, let us take a insert a cell below this. Now, in between let us say we want to convert this into a comment box.

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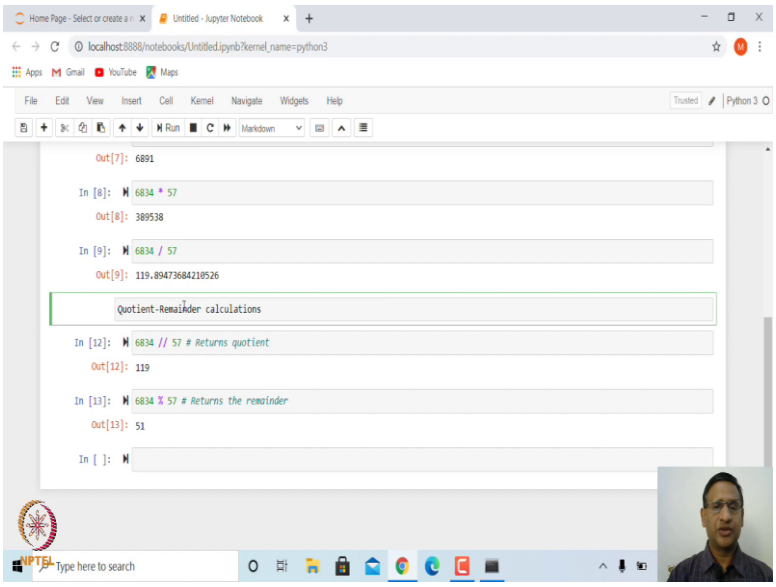


So, then we will go to Code and select Markdown and let us say, we can say here Quotient Remainder Calculations.

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.

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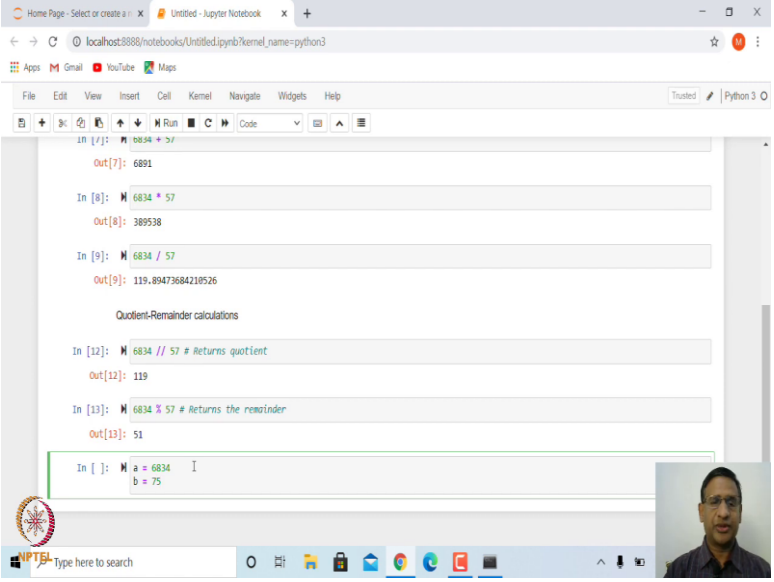


Now, actually the better way to do these calculations, especially when you want to to do the computations repeatedly, it is better to define these numbers in variables and do this computation. So, let us say I will define a is equal to 6834 and b is equal to 57. So, now, we have defined a which is equal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

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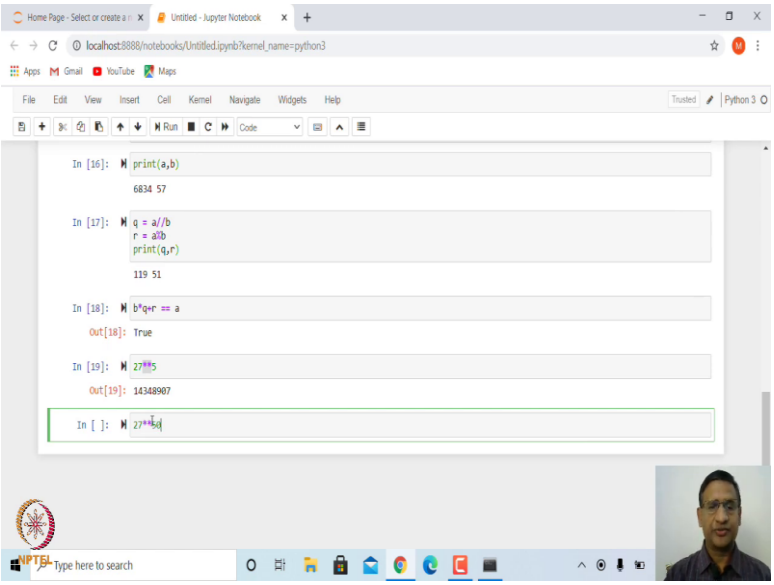

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And if I ask it to print what are a and b? You will see a and b are 6834 and 57 right.

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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.

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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 **.

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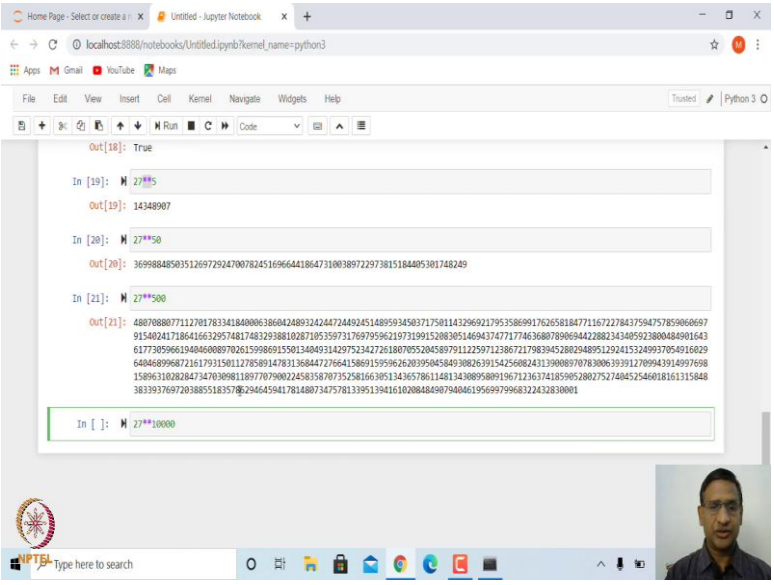


If I want to find 27 to the power, let us say instead of 5, suppose we want to find 50; again, it will give you in no time. Suppose, we want to find 27 to the power let us say 500, still you will get very easily.

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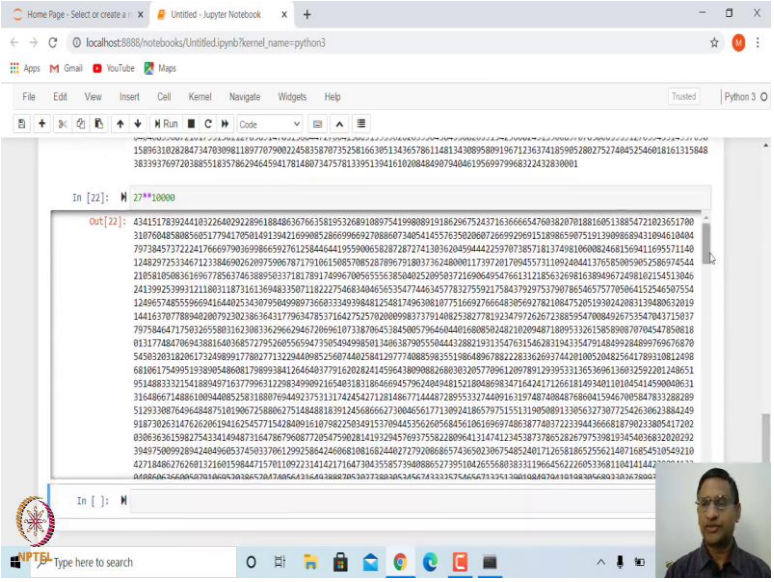


Suppose, we want to find 27 to the power instead of 500, let us say 10000. Again, you can see here. It gives you the 10000 power of 27 and this has several digits.

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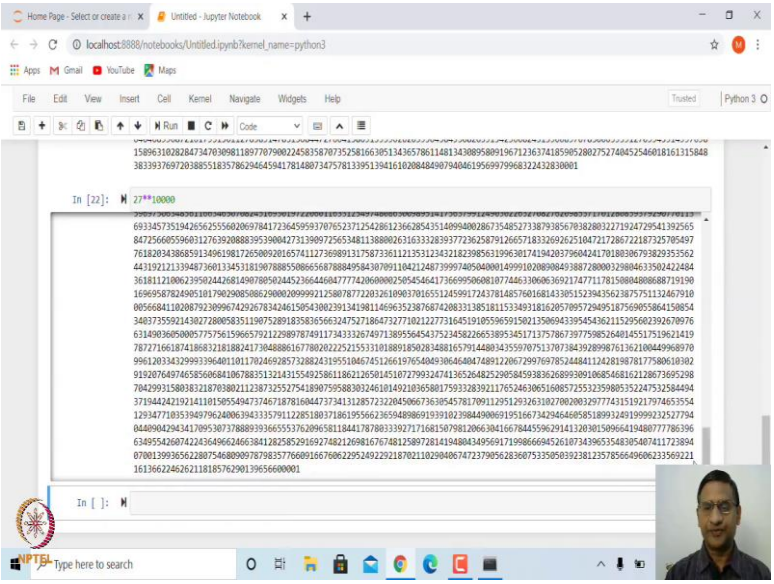


So, you can see here Python is quite powerful, when it comes to handling a large digit ok.

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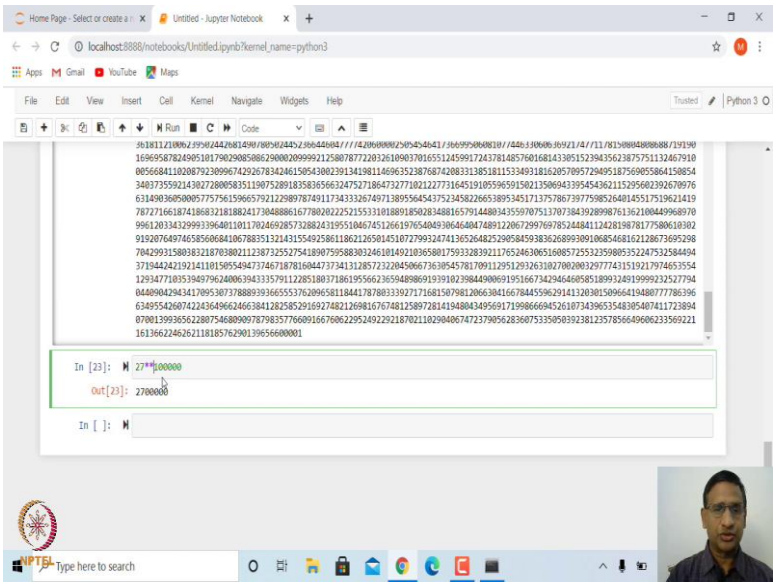


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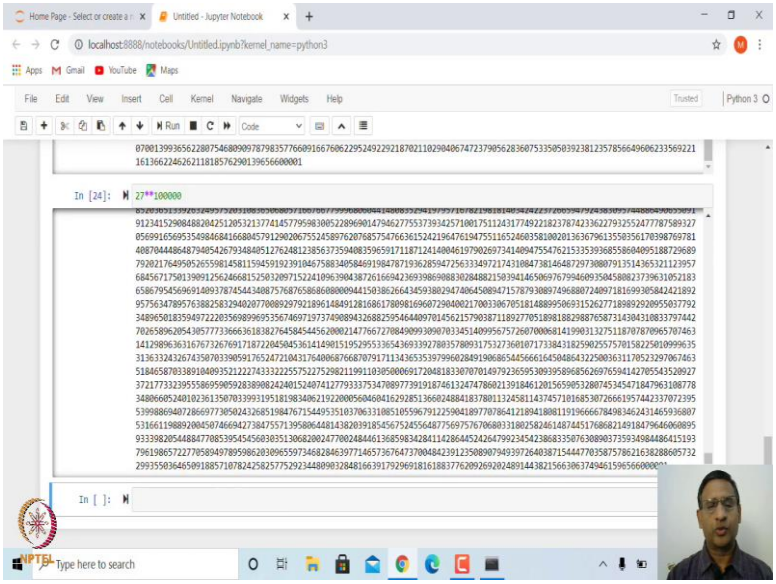


You can even find 27 to the power let us say one lakh, 100000. So 27 **100000, this will take little longer; but you will get the answer. So, again you can see that it is able to find 27 to the power 100000.

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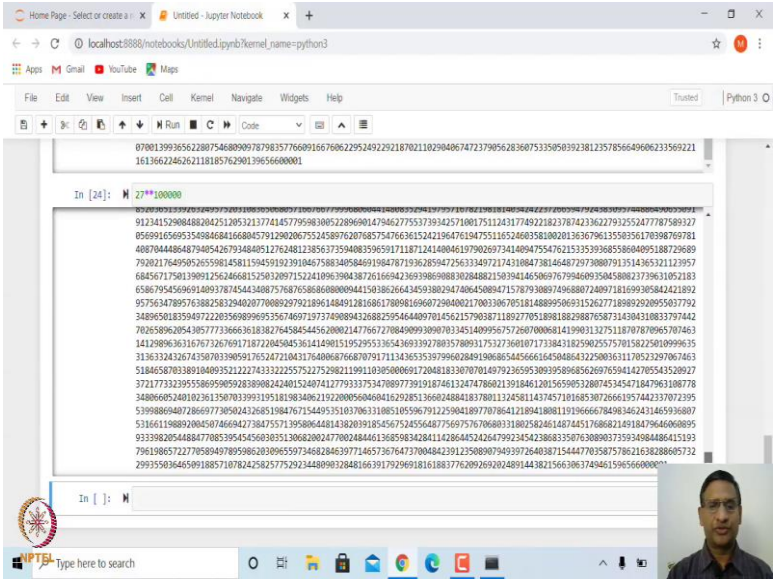


So, again you can see that it is able to find 27 to the power 100000.

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.

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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.

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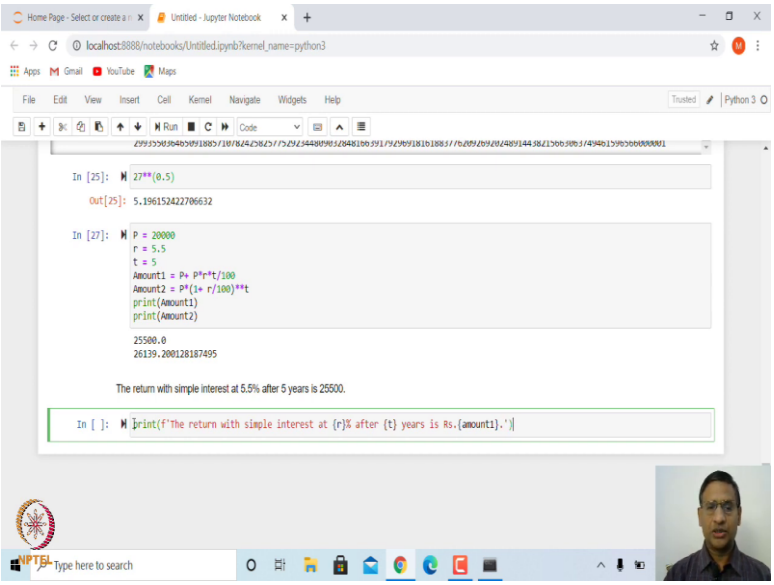


So, let us define variables. So, for example, variable the principal, I will call this as P which is a principal. So, that is let us say you have invested 20000 rupees and the rate, I will call this as r, that is let us say 5.5 percent and let us say you have invested this for t is which is equal to 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.

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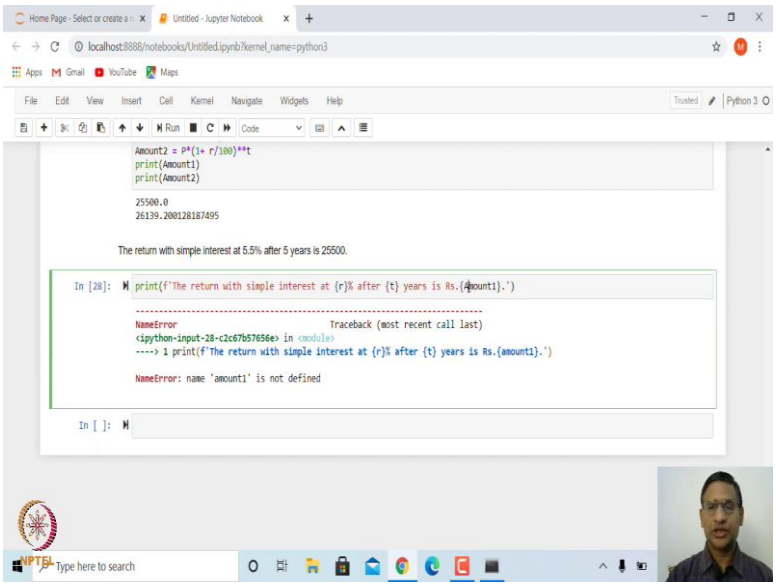


So, we will put single quote or double quote, with simple interest at 5.5 percent.

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.

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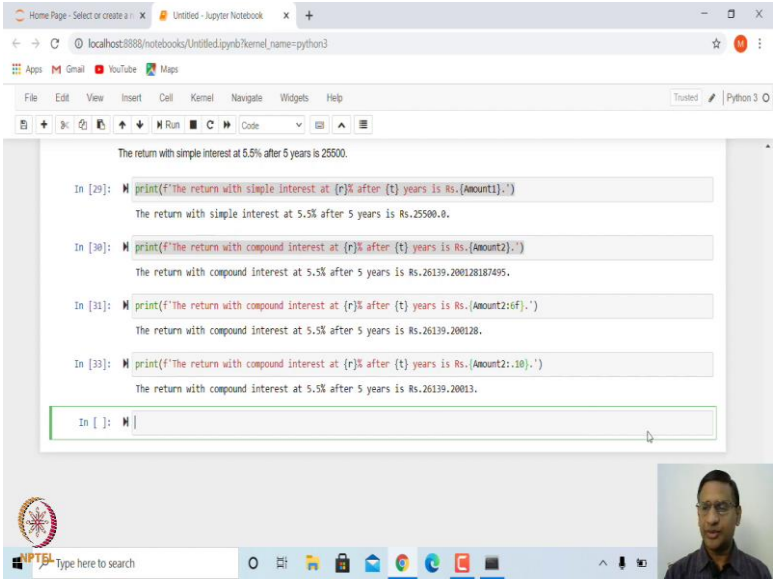


Similarly, if I want to print the compound interest, I will simply say this compound interest compound interest. This will be Amount2. So, you get this number.

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.
I 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.

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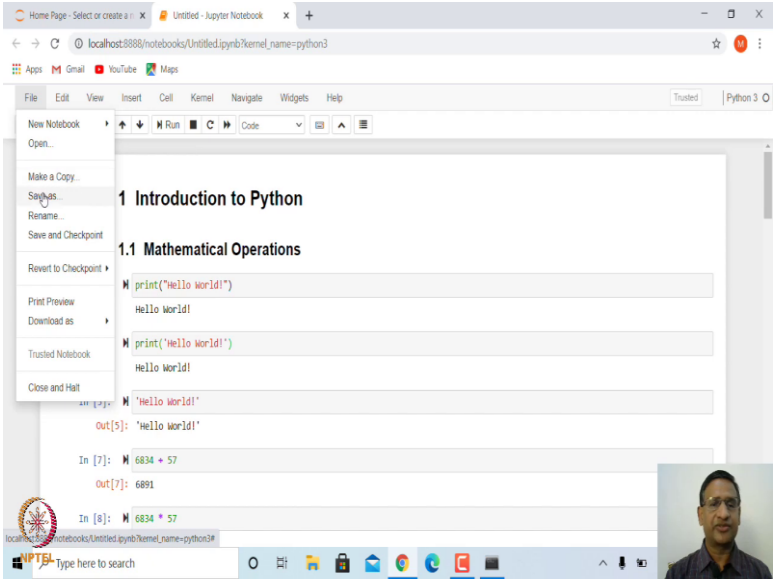


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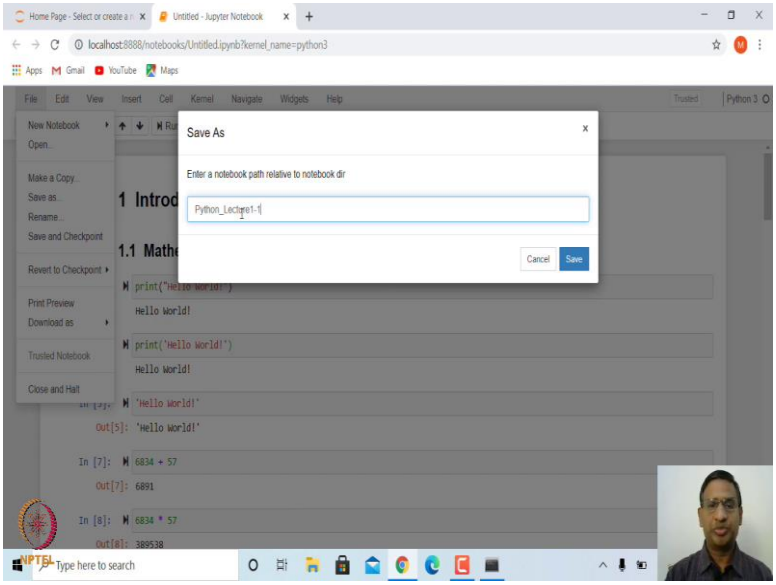


For the time being, now let us look at whatever we have done, we want to save this in a file. So, we can go to File menu and then, we can say save as and give the file name. Let me give file name as Python_Lecture1-1. By default, you can see here, it has put an extension dot i p y n b. This is interactive 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.

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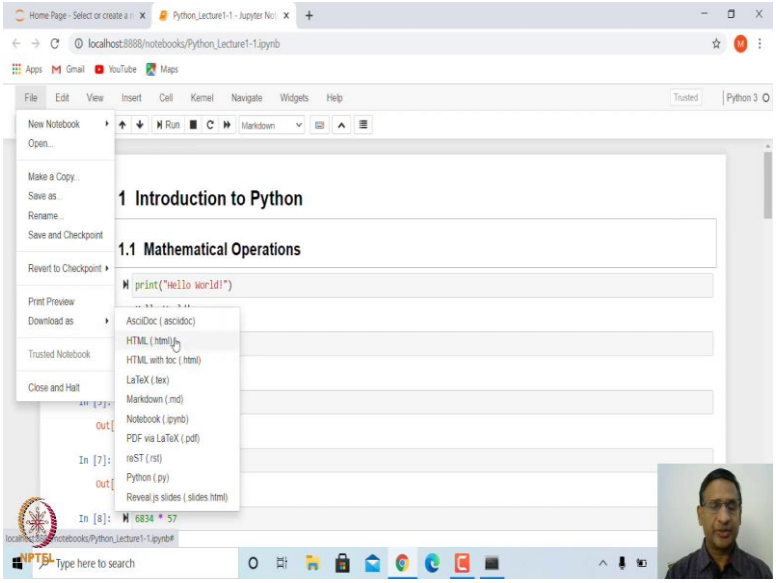


So, all these options are there. If you download this in html format, you can open this in a web browser and that you can put it online or put it in git hub ok. So, thank you very much.

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