
Lab: 6

Getting started with Sage



Go to <https://sagecell.sagemath.org/>.

You can enter basic Sage commands into the textbox on the page and click “Evaluate” to get the output. To get started let’s use sage like a fancy calculator. The operands for sum, difference, multiplication, and division are $+$, $-$, $*$, $/$.

Try the following operations:

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(a) $1 + 2 + 3$

(b) $42 - 23$

(c) $1331 * 11$

(d) $144 / 9$

2. That’s pretty standard stuff, you could more easily do those on your phone... But, can your phone calculate 200 digits of π in the blink of an eye? Try this:

```
n(pi, digits=200)
```

3. You may have noticed that the previous question’s answers were all whole numbers, but this last one was a decimal. We’ve been holding out on you a bit – sage does exact computations. Unless you ask it for a numerical approximation (which is what the `n()` function was all about) it will give answers that are 100% precise – but sometimes that doesn’t seem very helpful!

Try evaluating these:

(a) `pi`

(b) `sqrt(2)`

(c) `7/3`

4. Sage and its brethren are Symbolic Computer Algebra Systems. The reason it just parrots back the question to you has to do with the “Symbolic” part of that. For

example, the `sqrt(2)` thing above is regarded by Sage as a symbolic entity. It is a full and precise representation of the number we write as $\sqrt{2}$. It isn't some lame 4 or 10 or 100 digit approximation of $\sqrt{2}$. It is the real deal. Let's see what happens when we raise `sqrt(2)` to various powers (you can use either `^` or `**` for exponentiation in sage).

Try evaluating these:

- (a) `sqrt(2) ^ 2`
- (b) `sqrt(2) ^ 4`
- (c) `sqrt(2) ^ 7`

Was the answer to that last one suprising? Or does it make sense in retrospect?

5. Much of the power of Computer Algebra comes from the same feature that makes regular Algebra useful – variables.

There are two kinds that we need to distinguish: computer variables and mathematical variables. Computer variables are pretty easy, you can just make up whatever name you want and then start using it. For example:

```
myvar = sqrt(2) ^ 7
n(myvar)
```

BTW, notice how the default version of the `n()` function only gives about 13 decimal places? Try this too: `n(myvar, 100)` (that's what 100 bytes of accuracy looks like – if you want a specific number of decimal places, see the example involving π up above.)

6. Mathematical variables are handled a little differently. First (other than x which is there automatically) you have to declare them to the system. The syntax looks like this: `y = var('y')`. What's happening there is that we're telling the system that `y` is a variable, but also that we want the system to print 'y' when referring to it. I think you'll get the point if you figure out what happens when you evaluate `y = var('w') ; 6*y`.
7. Let's try a little mathy with a couple of variables. Remember how the equation of a line is usually written as $y = mx + b$? Put the following into the sage cell:

```

y=var('y')
m = 2 ; b = 1
y=mx+b

```

The error message you get when evaluating this should look like:

```

-----
NameError                                Traceback (most recent call last)
Cell In [1], line 3
      1 y=var('y')
      2 m = Integer(2) ; b = Integer(1)
----> 3 y=mx+b

NameError: name 'mx' is not defined

```

8. Calculate 2^0 , $2^0 + 2^1$, $2^0 + 2^1 + 2^2$, and $2^0 + 2^1 + 2^2 + 2^3$. Continue adding the next largest power of 2 until you notice a pattern in the result. What is the pattern?
9. Use Sage to determine all of the proper divisors of 28. Then verify that the sum of all of the proper divisors of 28 is 28.

m=2; b=1; y=mx+b

Signing up for CoCalc

For more advanced calculations that require multiple steps, it will be beneficial to signup for CoCalc. Follow the following steps to signup and load a Sage notebook for calculations.

1. Go to <https://cocalc.com/> in a web browser.
2. At the top right of the screen, click on the “Sign Up” link.
3. Follow the sign up instructions and complete sign up.
4. You should now see a page that says “Signed in as XXXX XXXX” at the top of the page.
5. Click on the “Projects” link at the top left of the page.
6. In the textbox that says, “Project title – you can easily change this at any time!” enter a name for your new project, then click on the “Create New Project” button.
7. On the next page, click the “New” link near the top of the page.

8. Pick a name for your file, select “Sage worksheet,” then click on the “Start project” button at the top of the page.
9. You will now see a blank file with line numbers on the left. By clicking on text area, you will see a blinking cursor where you can enter a calculation you would like for Sage to compute. After you type in your desired command, click the “Run” button at the top of the page or type SHIFT+ENTER to execute that line.
10. CoCalc will run the calculation on the CoCalc server, so give it a few seconds to respond. Once it does, you can continue entering new calculations in the lines below the output. Unlike in an embedded SageMathCell on a webpage, CoCalc will provide output for multiple calculations at once, and it will allow you to keep previous calculations on the webpage so that you can change them or refer back to them.