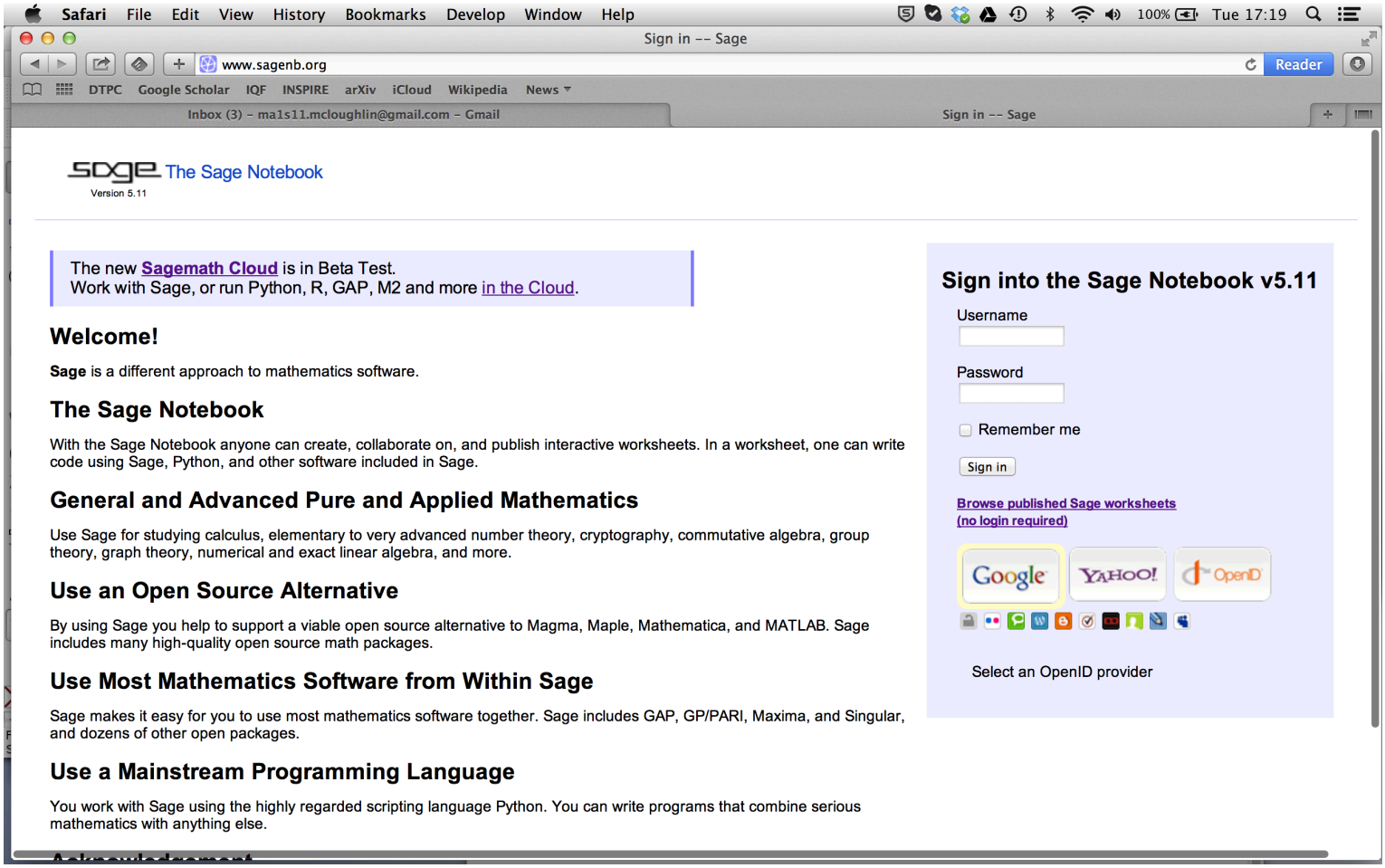
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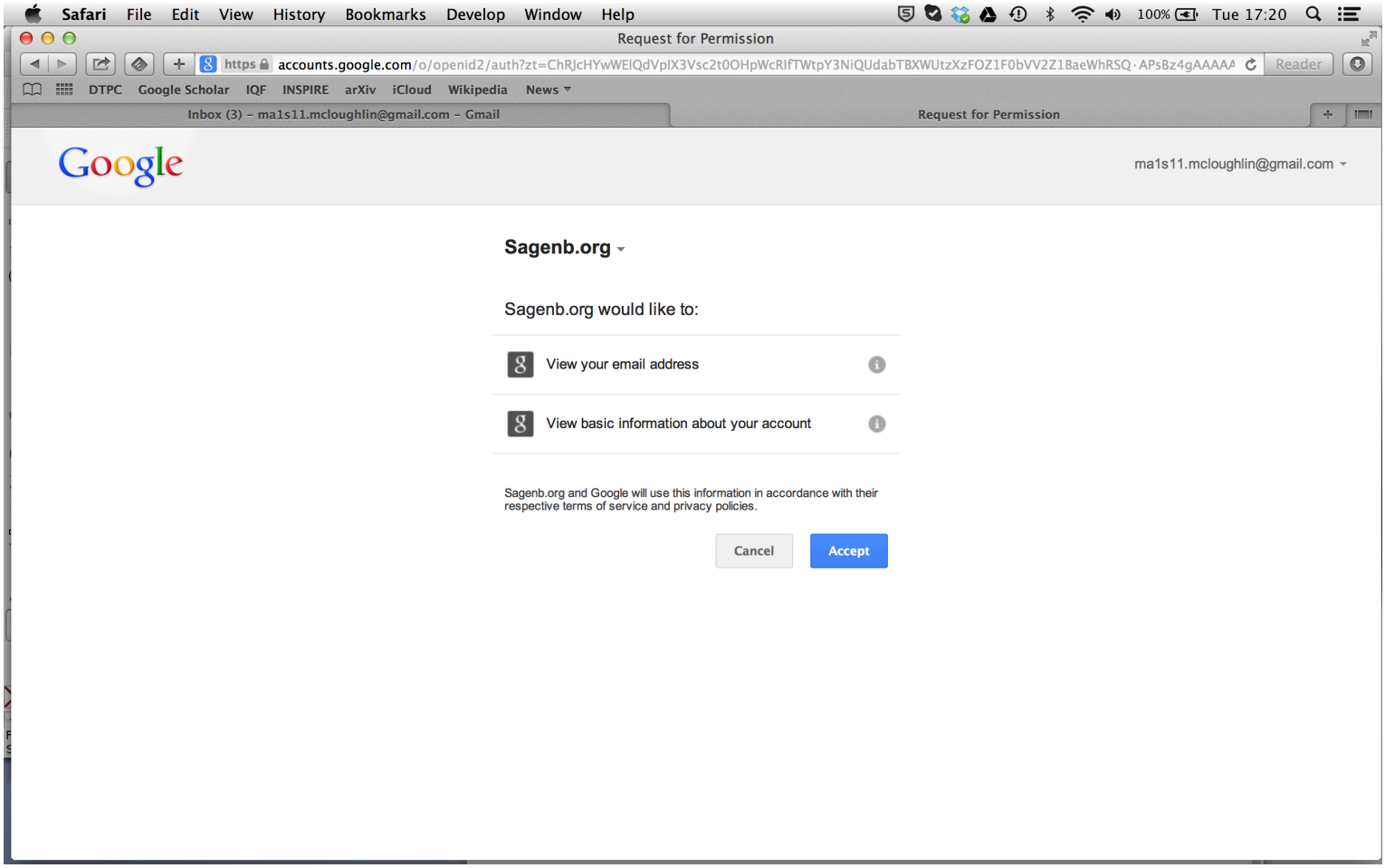
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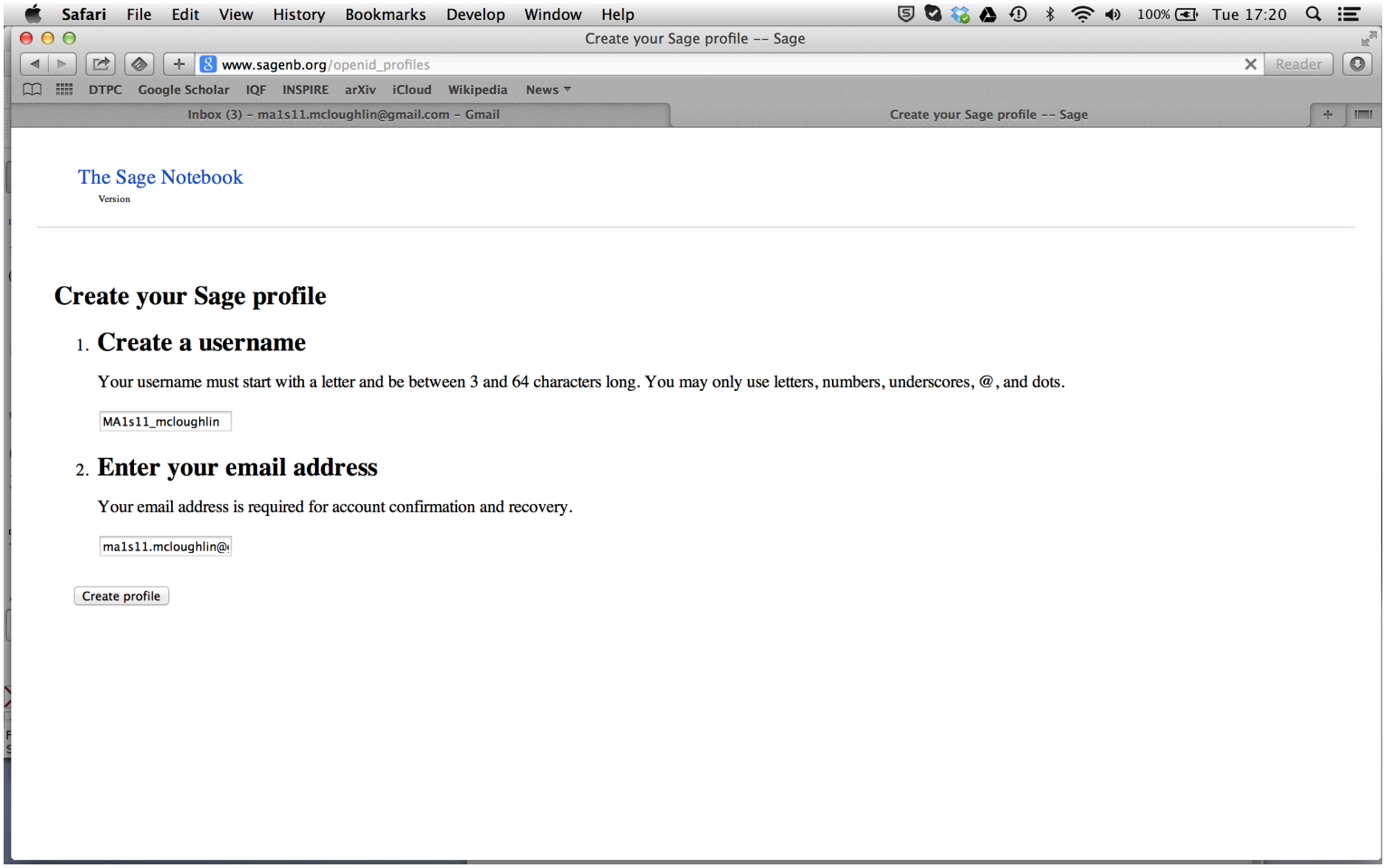
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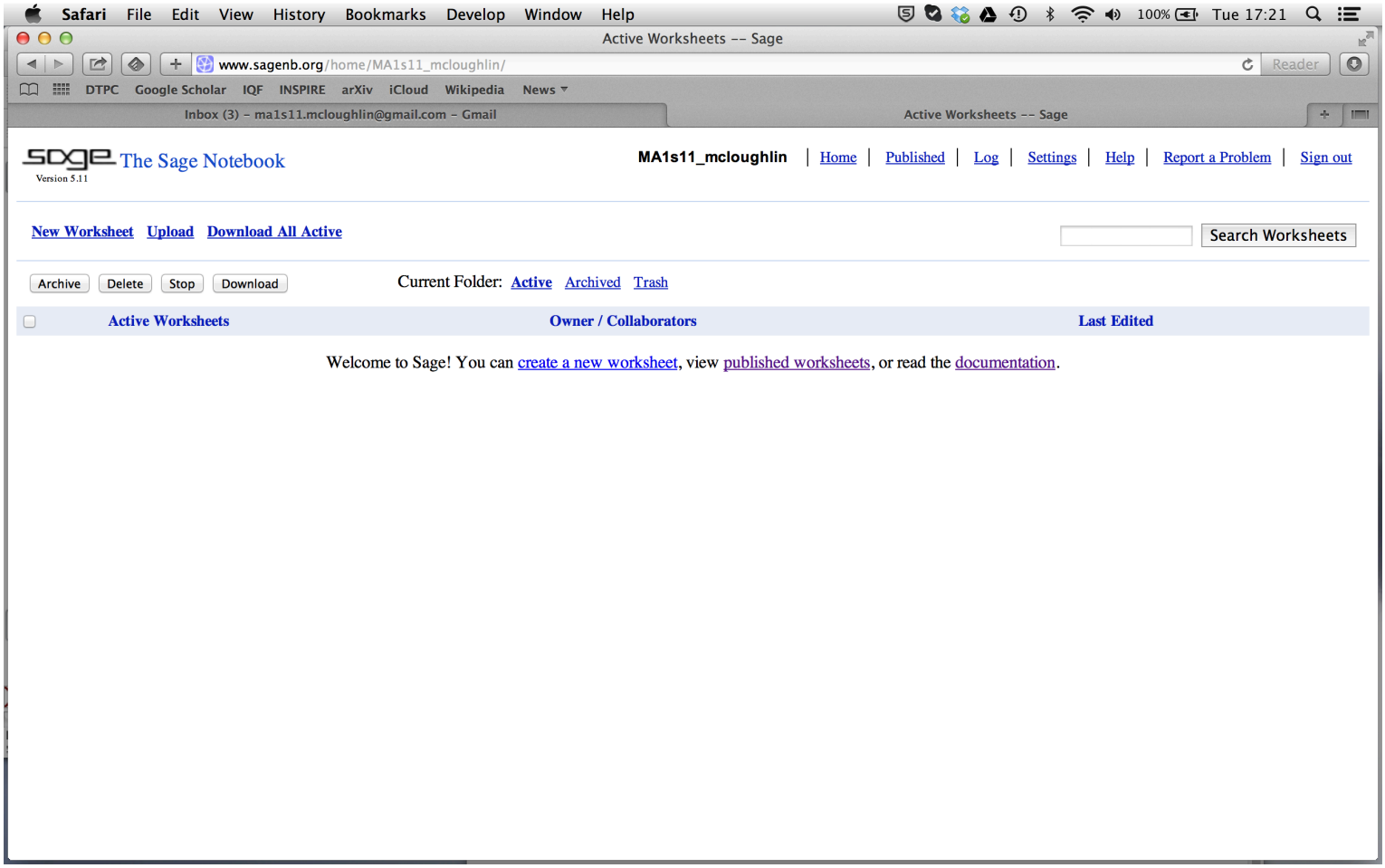
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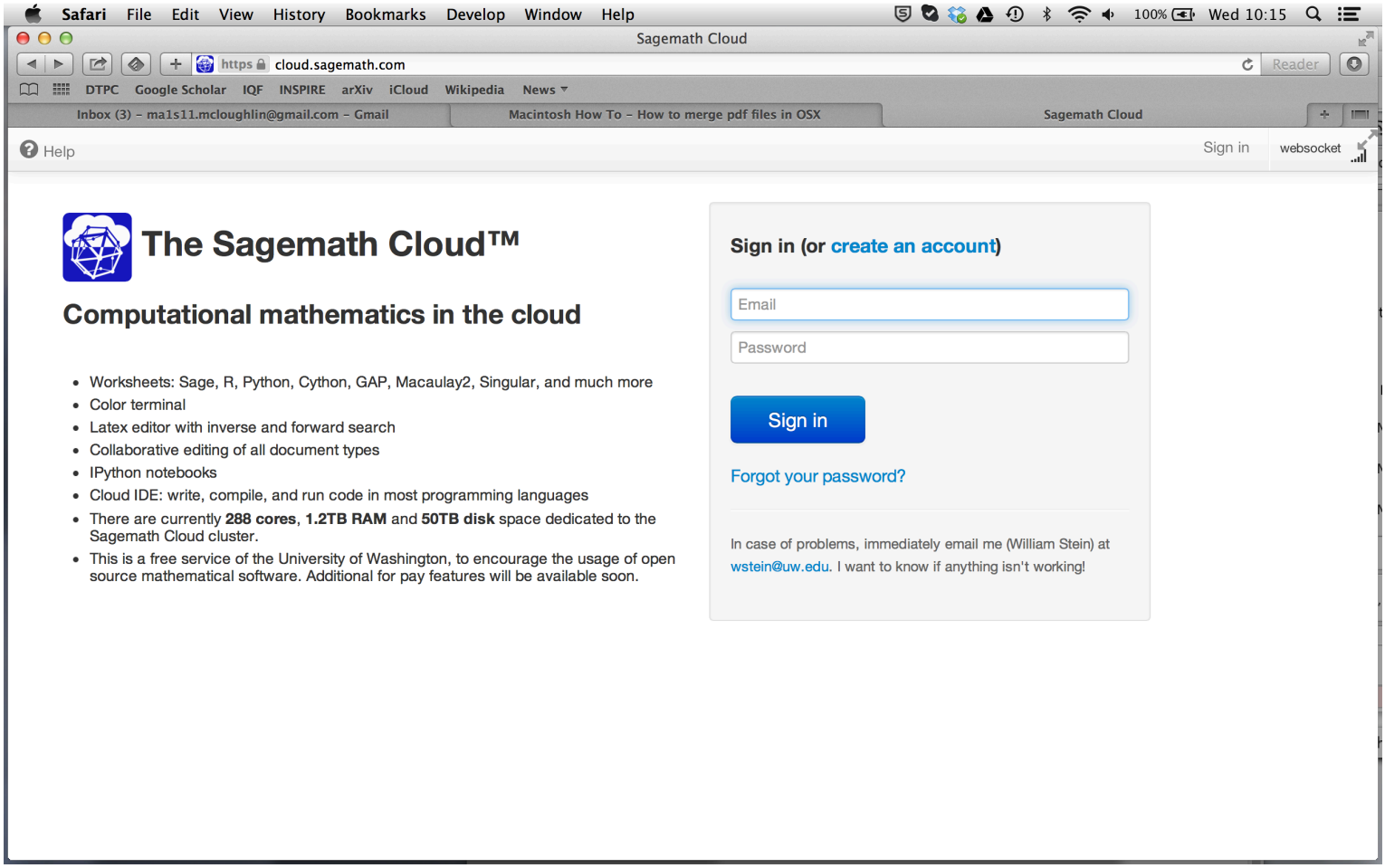
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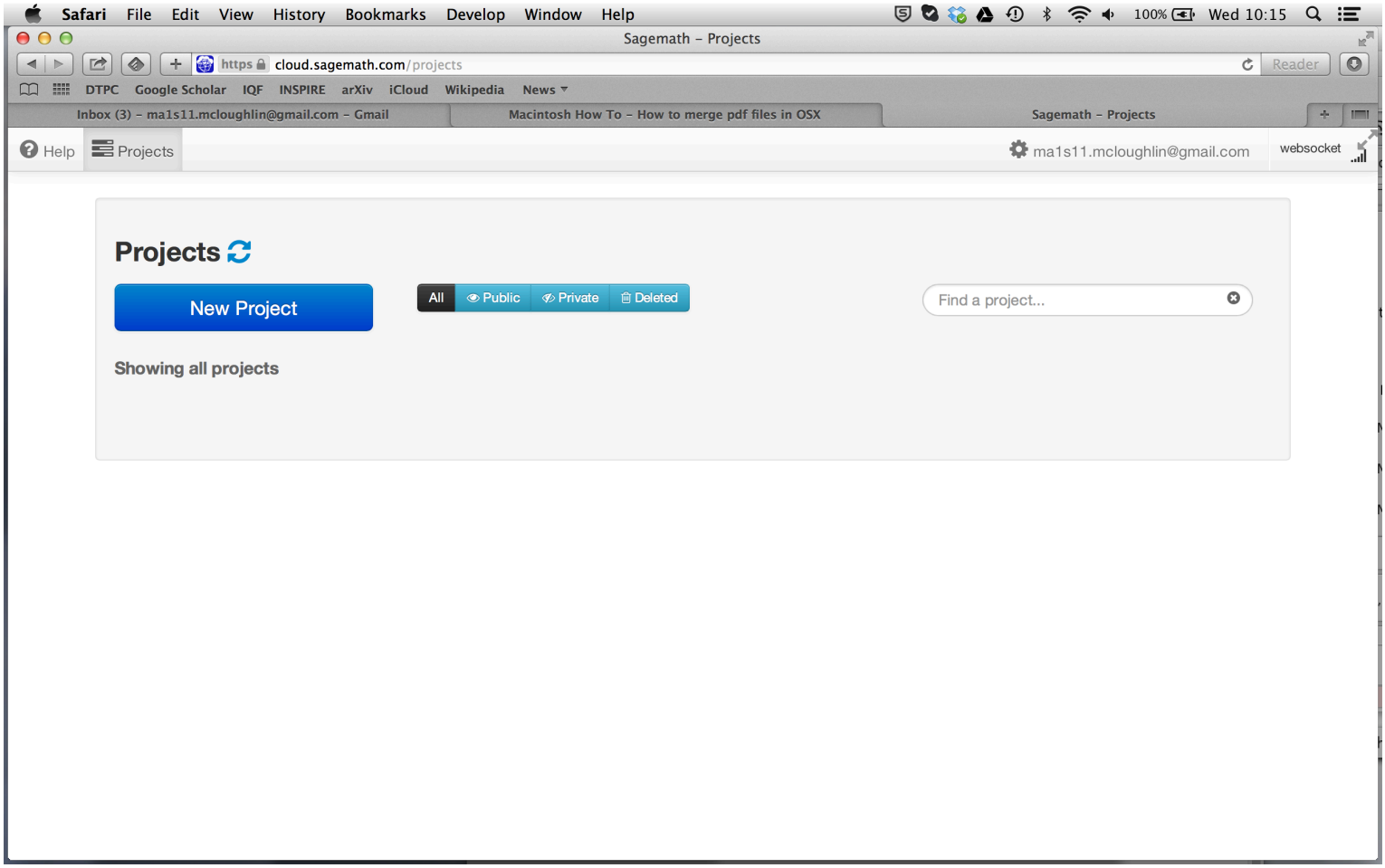
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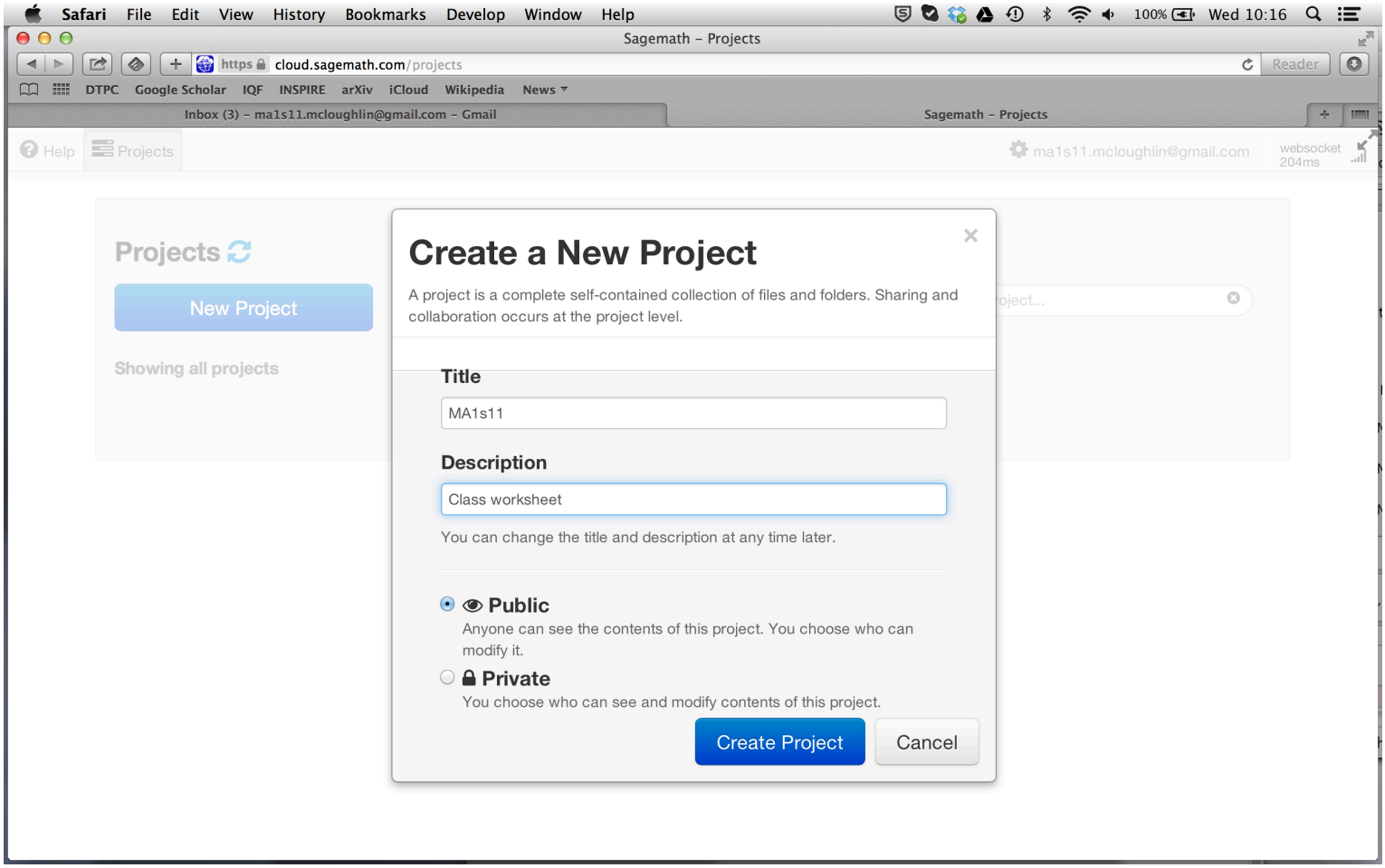
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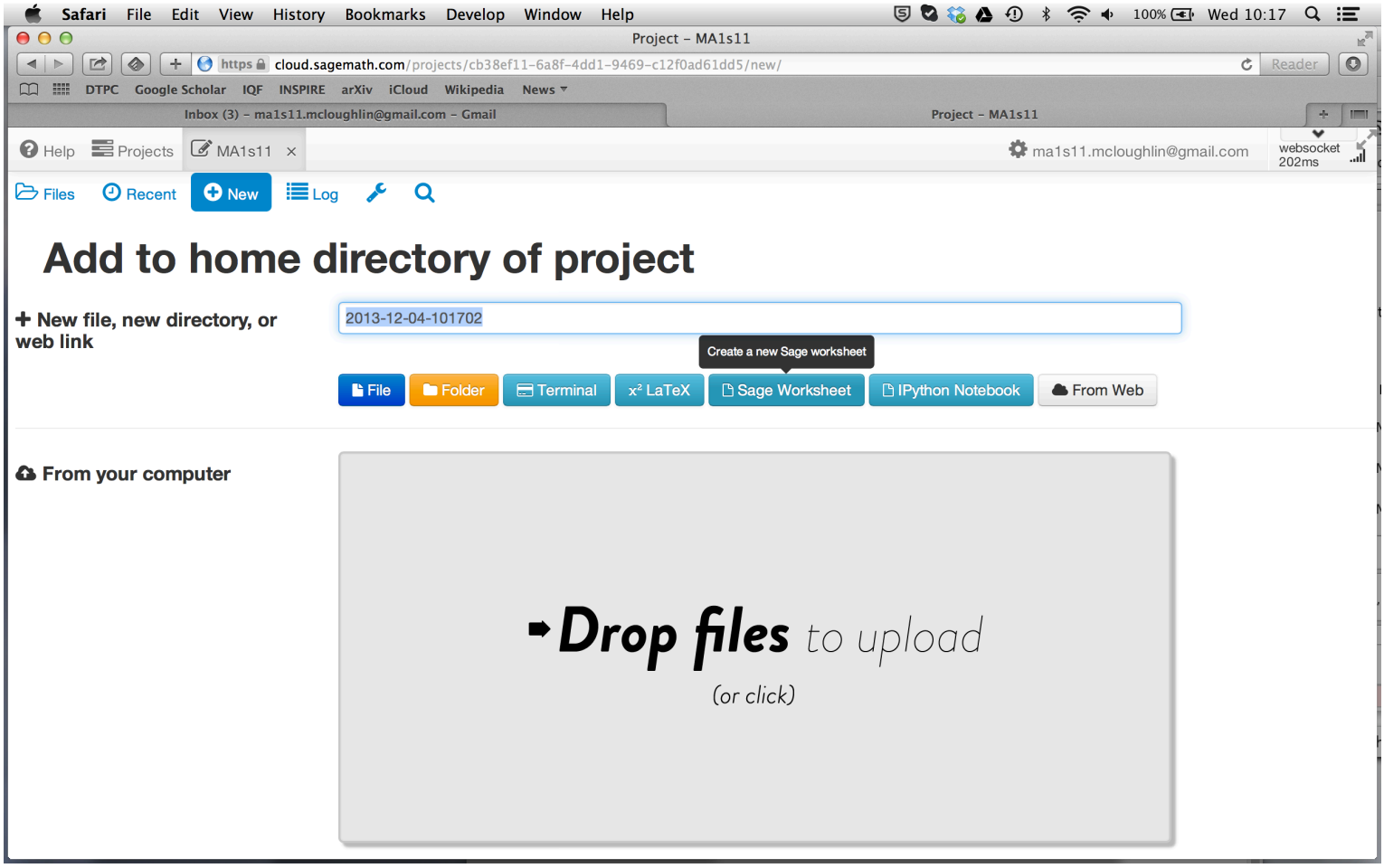
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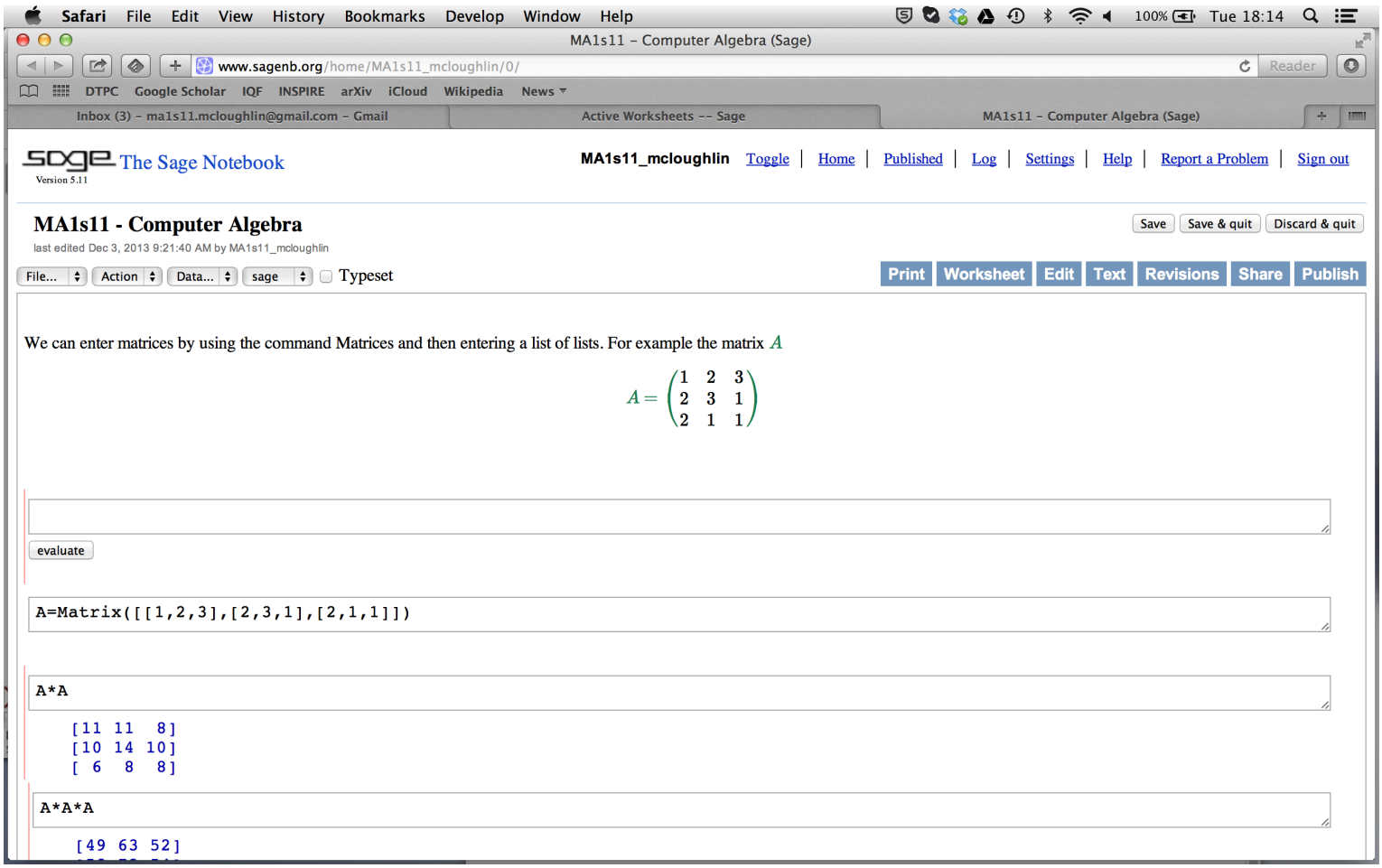
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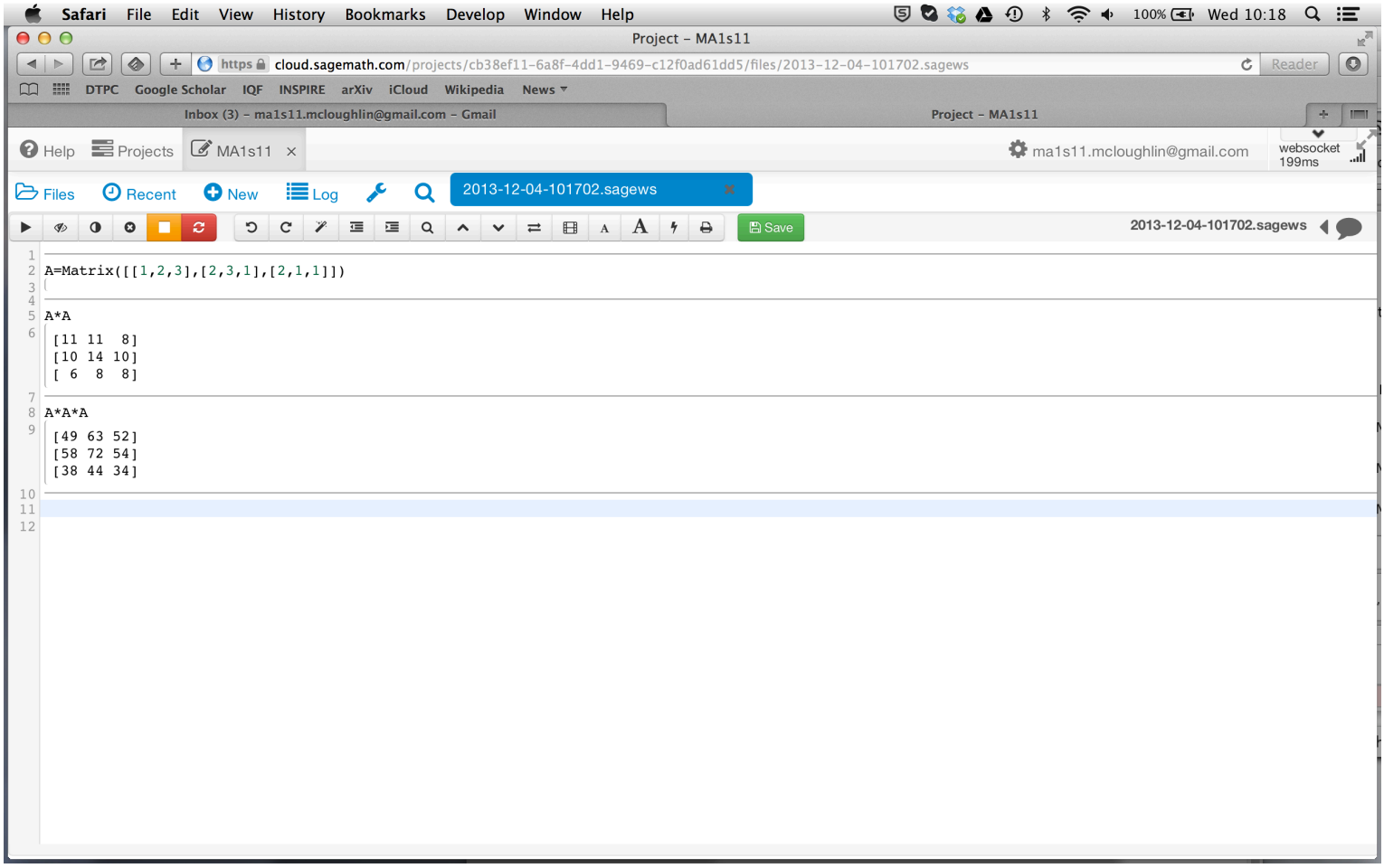
We can enter matrices by using the command Matrices and then entering a list of lists. For example the matrix A
$$A = \begin{pmatrix} 1 & 2 & 3 \\ 2 & 3 & 1 \\ 2 & 1 & 1 \end{pmatrix}$$
evaluate
A=Matrix([[1,2,3],[2,3,1],[2,1,1]])
A*A
[11 11 8]
[10 14 10]
[ 6 8 8]
A*A*A
[49 63 52]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A=Matrix([[1,2,3],[2,3,1],[2,1,1]])
A*A
[11 11 8]
[10 14 10]
[ 6 8 8]
A*A*A
[49 63 52]
[58 72 54]
[38 44 34]

$$A=\begin{pmatrix}1 & 2 & 3\\ 2 & 3 & 1\\ 2 & 1 & 1\end{pmatrix}$$

```
A=Matrix([[1,2,3],[2,3,1],[2,1,1]])
```

We can also define undetermined variables.

```
var('x1 x2 x3')
```

```
(x1, x2, x3)
```

and make a vector out of them

```
x=vector([x1,x2,x3]);x
```

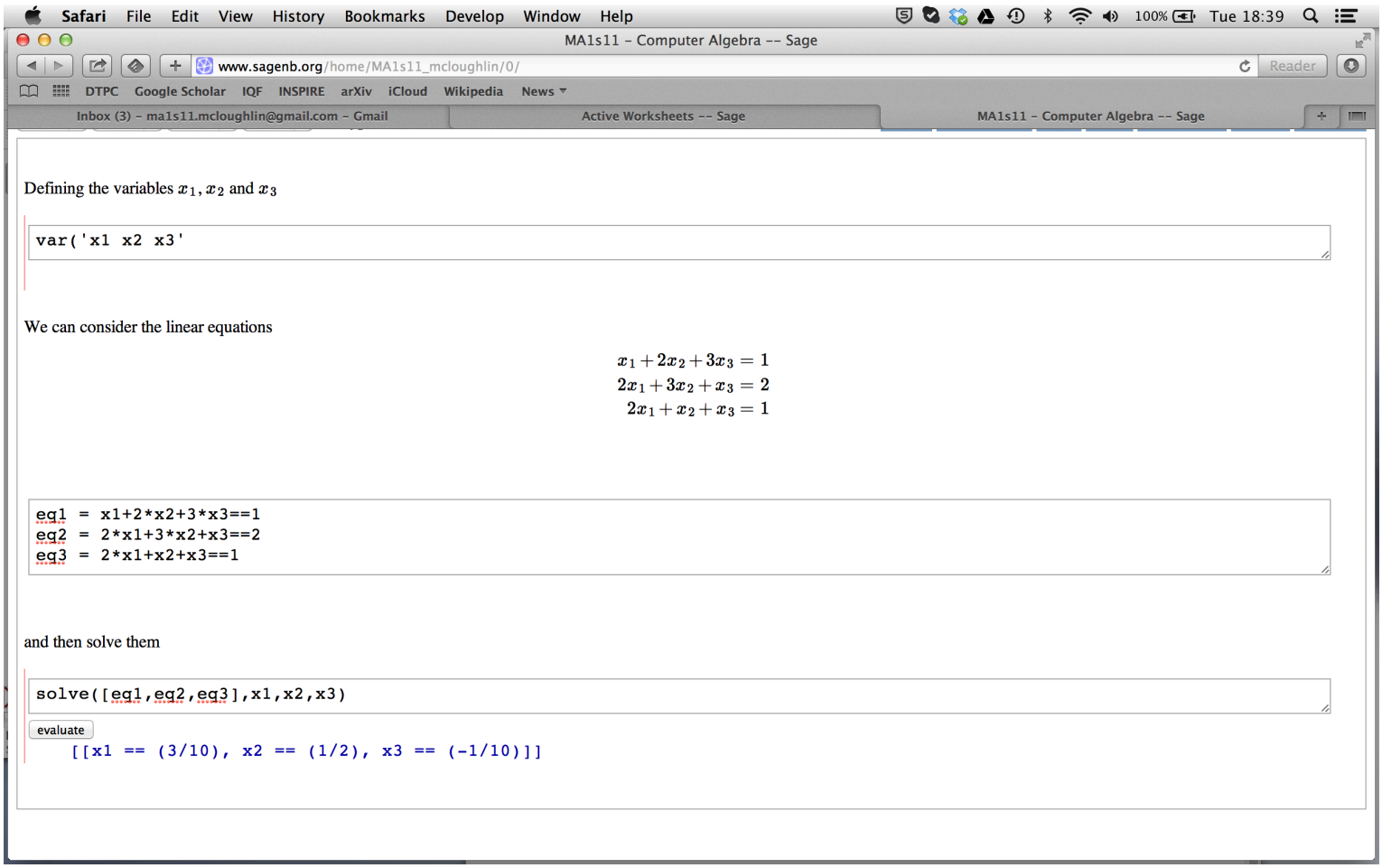
```
(x1, x2, x3)
```

We can multiply our vector by the matrix to get a new vector

```
A*x
```

evaluate

```
(x1 + 2*x2 + 3*x3, 2*x1 + 3*x2 + x3, 2*x1 + x2 + x3)
```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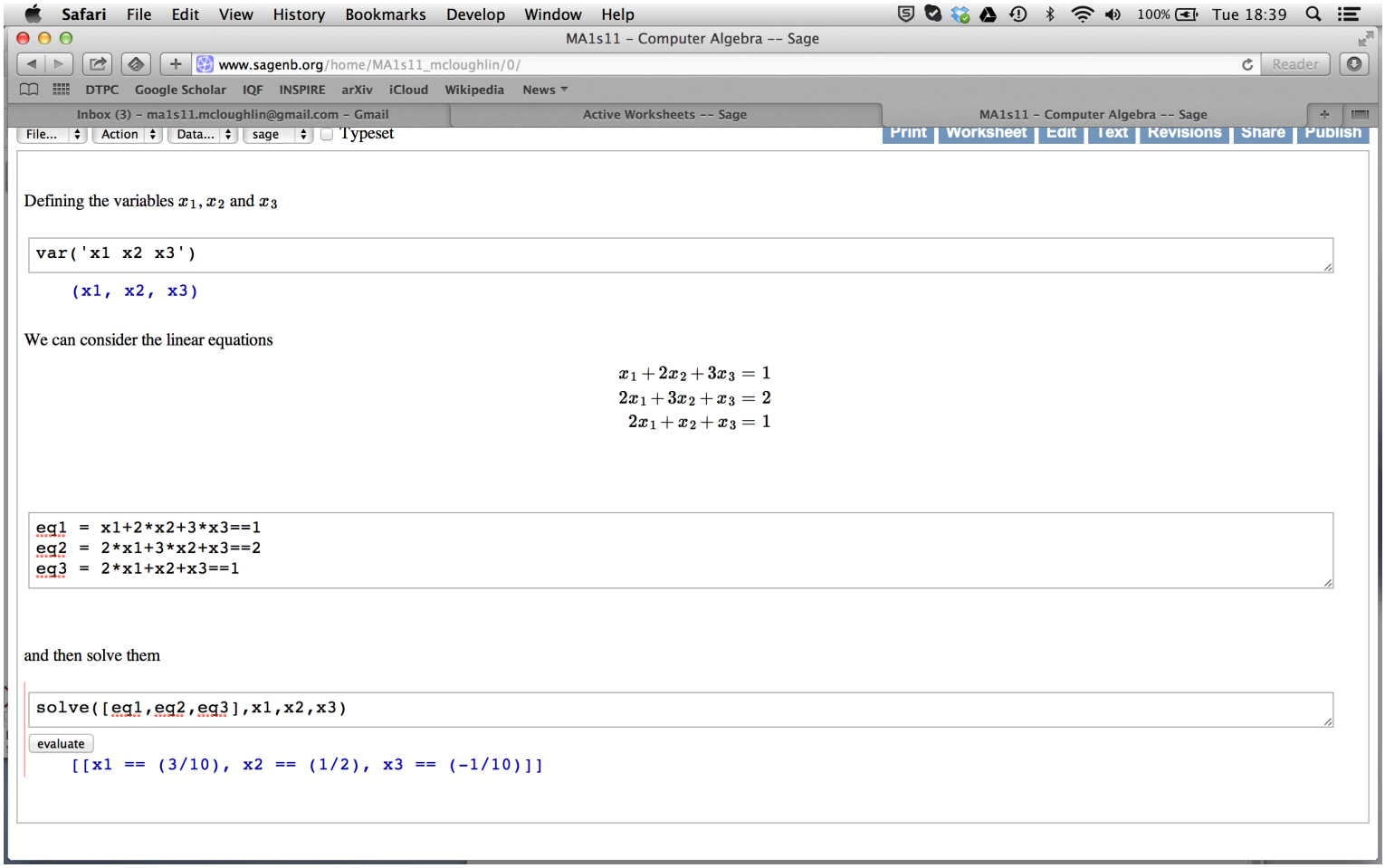
Defining the variables $x_1, x_2$ and $x_3$
var('x1 x2 x3'
We can consider the linear equations
$x_1 + 2x_2 + 3x_3 = 1$
$2x_1 + 3x_2 + x_3 = 2$
$2x_1 + x_2 + x_3 = 1$
eq1 = x1+2*x2+3*x3==1
eq2 = 2*x1+3*x2+x3==2
eq3 = 2*x1+x2+x3==1
and then solve them
solve([eq1,eq2,eq3],x1,x2,x3)
evaluate
[[x1 == (3/10), x2 == (1/2), x3 == (-1/10)]]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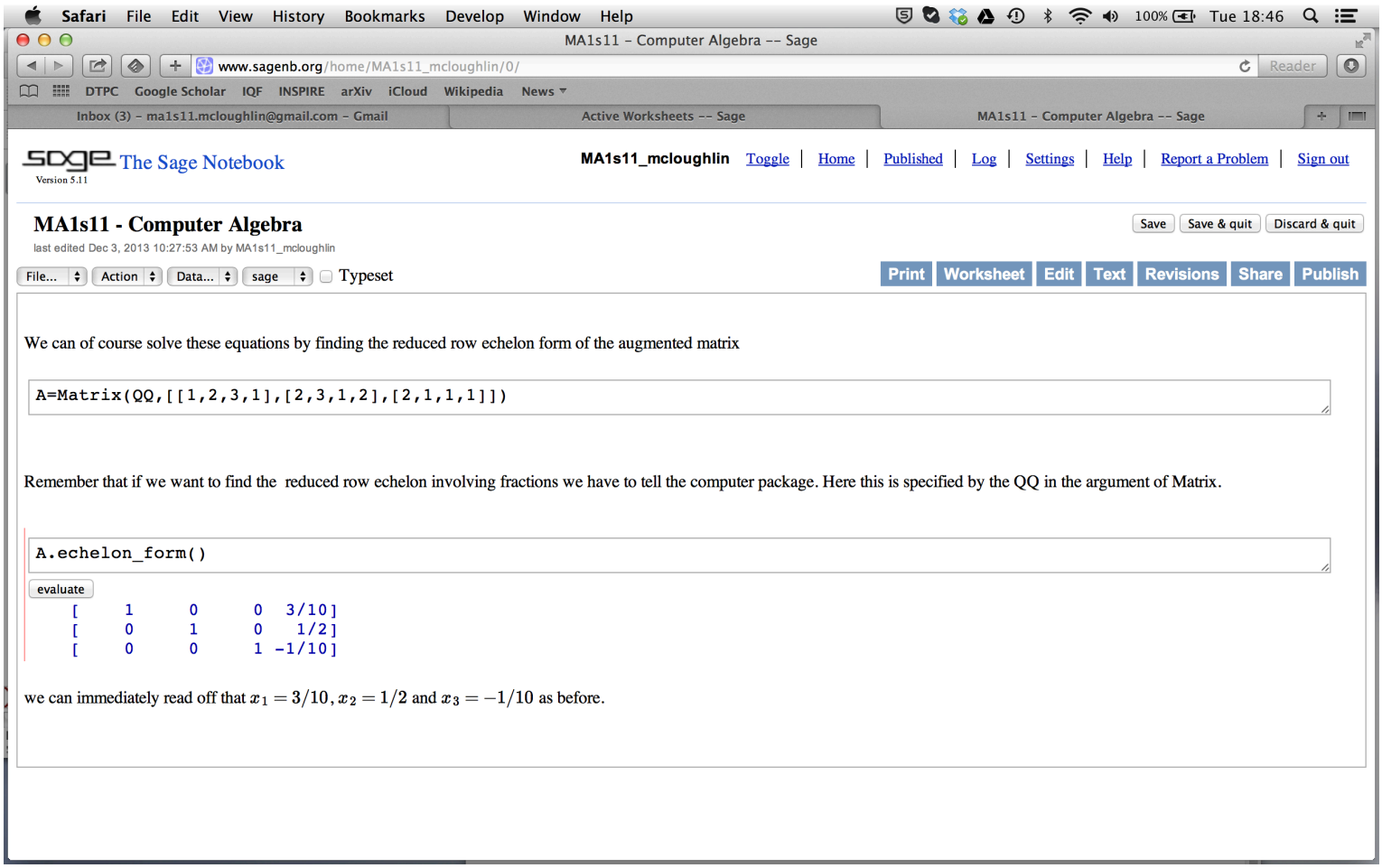
Defining the variables $x_1, x_2$ and $x_3$
var('x1 x2 x3')
(x1, x2, x3)
We can consider the linear equations
$$x_1 + 2x_2 + 3x_3 = 1$$
$$2x_1 + 3x_2 + x_3 = 2$$
$$2x_1 + x_2 + x_3 = 1$$
eq1 = x1+2*x2+3*x3==1
eq2 = 2*x1+3*x2+x3==2
eq3 = 2*x1+x2+x3==1
and then solve them
solve([eq1,eq2,eq3],x1,x2,x3)
evaluate
[[x1 == (3/10), x2 == (1/2), x3 == (-1/10)]]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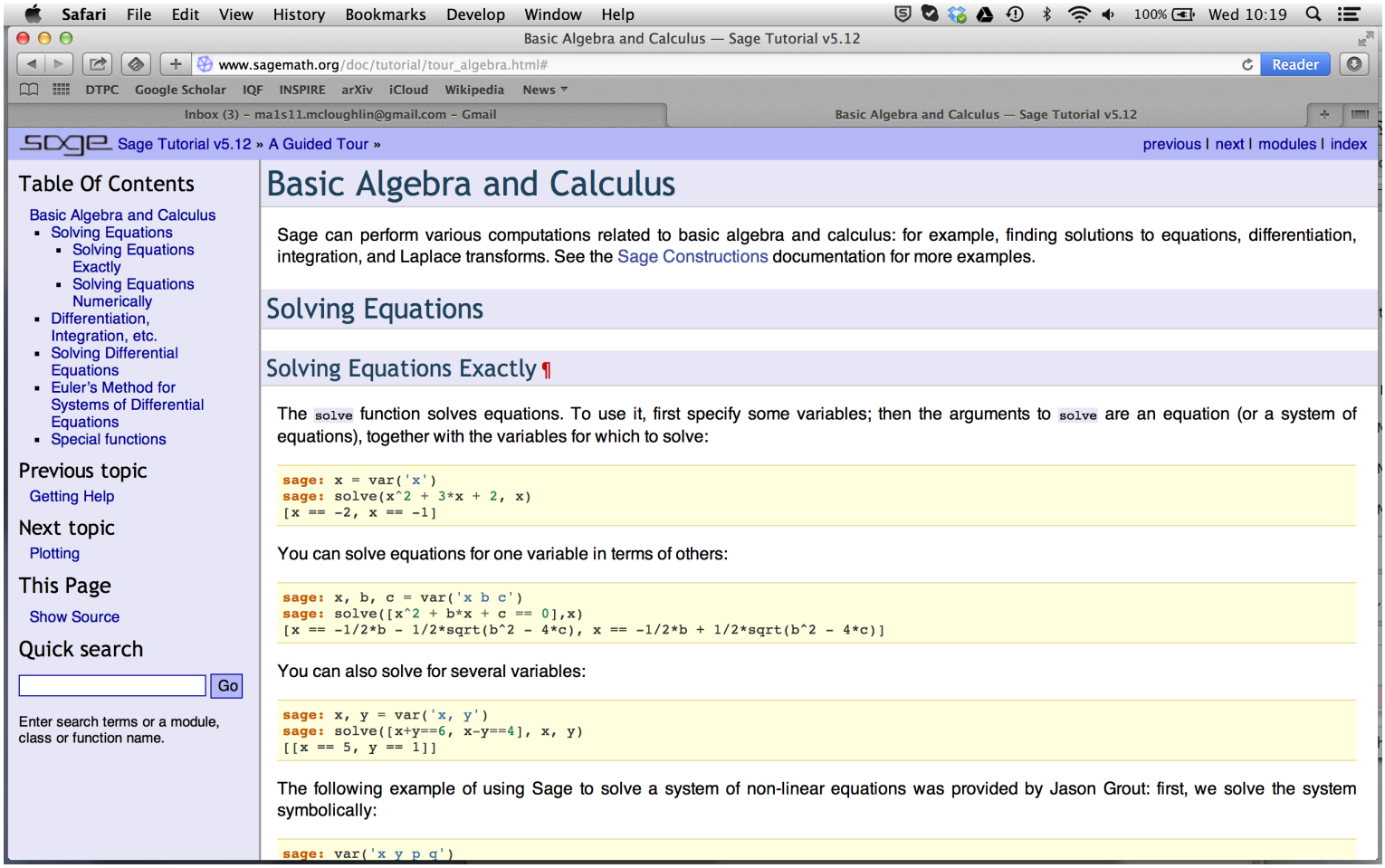
We can of course solve these equations by finding the reduced row echelon form of the augmented matrix
A=Matrix(QQ,[[1,2,3,1],[2,3,1,2],[2,1,1,1]])
Remember that if we want to find the reduced row echelon involving fractions we have to tell the computer package. Here this is specified by the QQ in the argument of Matrix.
A.echelon_form()
evaluate
[ 1 0 0 3/10]
[ 0 1 0 1/2]
[ 0 0 1 -1/10]
we can immediately read off that $x_1 = 3/10, x_2 = 1/2$ and $x_3 = -1/10$ as before.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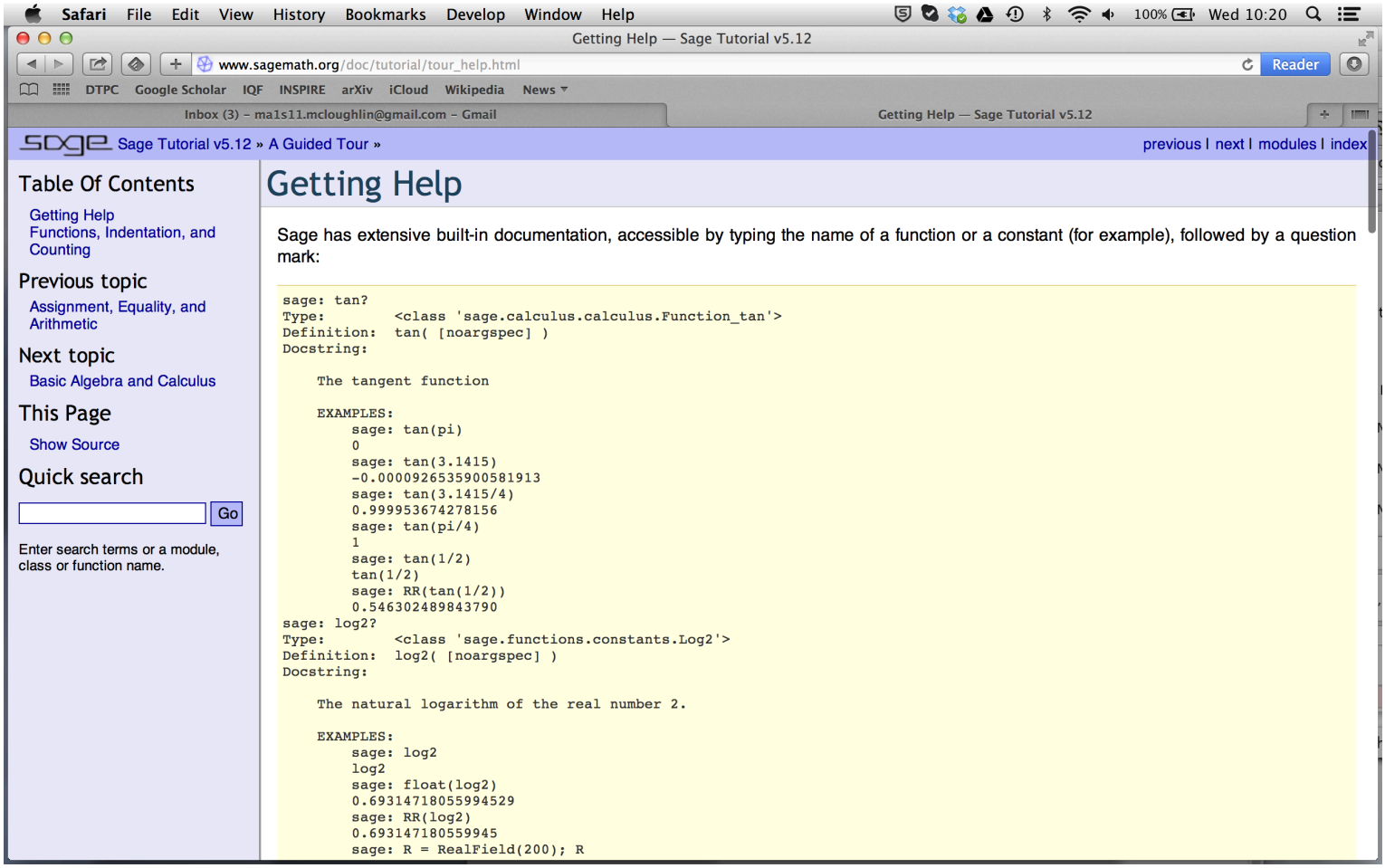
Basic Algebra and Calculus
Sage can perform various computations related to basic algebra and calculus: for example, finding solutions to equations, differentiation, integration, and Laplace transforms. See the Sage Constructions documentation for more examples.
Solving Equations
Solving Equations Exactly ¶
The solve function solves equations. To use it, first specify some variables; then the arguments to solve are an equation (or a system of equations), together with the variables for which to solve:
sage: x = var('x')
sage: solve(x^2 + 3*x + 2, x)
[x == -2, x == -1]
You can solve equations for one variable in terms of others:
sage: x, b, c = var('x b c')
sage: solve([x^2 + b*x + c == 0],x)
[x == -1/2*b - 1/2*sqrt(b^2 - 4*c), x == -1/2*b + 1/2*sqrt(b^2 - 4*c)]
You can also solve for several variables:
sage: x, y = var('x, y')
sage: solve([x+y==6, x-y==4], x, y)
[[x == 5, y == 1]]
The following example of using Sage to solve a system of non-linear equations was provided by Jason Grout: first, we solve the system symbolically:
sage: var('x y p q')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Docstring:
The tangent function
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sage: tan(3.1415)
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sage: tan(3.1415/4)
0.999953674278156
sage: tan(pi/4)
1
sage: tan(1/2)
tan(1/2)
sage: RR(tan(1/2))
0.546302489843790
sage: log2?
Type: <class 'sage.functions.constants.Log2'>
Definition: log2( [noargspec] )
Docstring:
The natural logarithm of the real number 2.
EXAMPLES:
sage: log2
log2
sage: float(log2)
0.69314718055994529
sage: RR(log2)
0.693147180559945
sage: R = RealField(200); R