In [1]:
```
from __future__ import print_function
%matplotlib inline
#import ganymede
#ganymede.configure('uav.beaver.works')
import matplotlib.pyplot as plt
import numpy as np
import sympy as sym
from sympy.plotting import plot
from IPython.display import YouTubeVideo, HTML
sym.init_printing(use_latex = "mathjax")
```

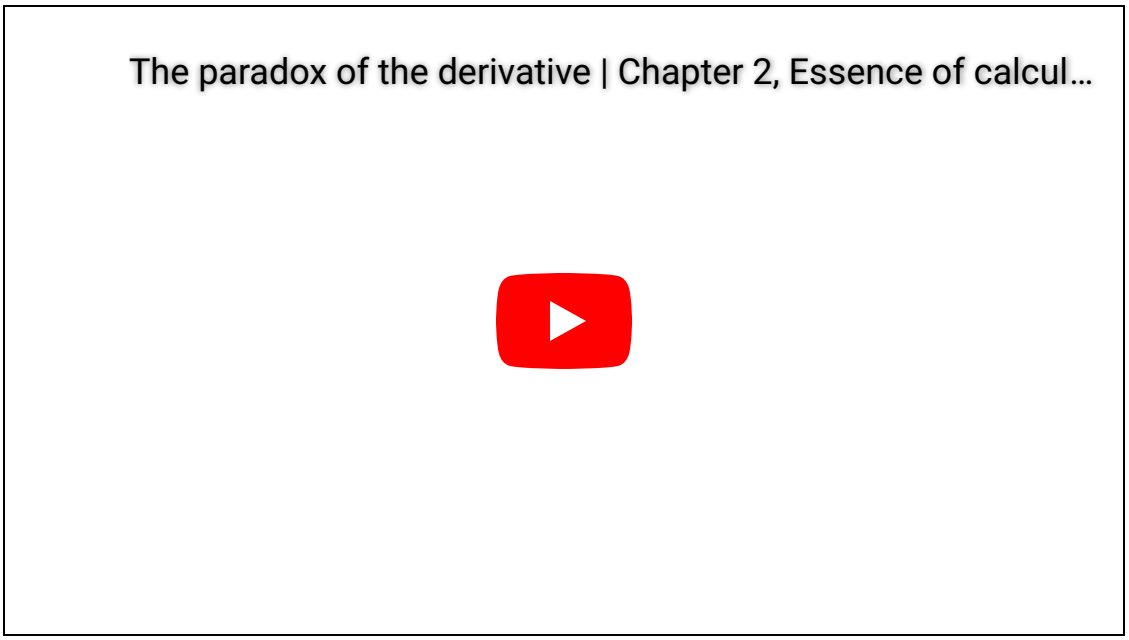
Enter your name below and run the cell:

Joy Deng Individual cells can be run with `Ctrl + Enter`

In [2]:
```
#ganymede.name('YOUR NAME HERE')
#def check(p):
    #ganymede.update(p,True)
#check(0)
```

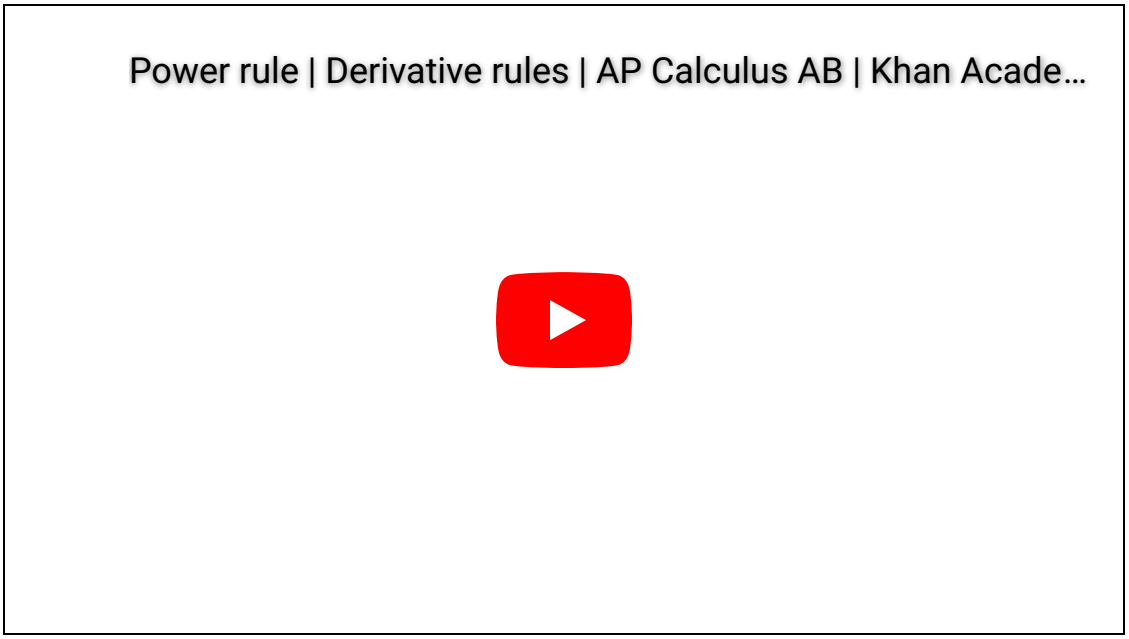
In [3]:
```
YouTubeVideo('9vKqVkMQHKk', width=560, height=315) # Video by http://www.
```

Out[3]:



In [4]:
```
YouTubeVideo('bRZmfc1YFsQ', width=560, height=315) #Note: All Khan Academ
```

Out[4]:



Power Rule

The derivative of x^n is nx^{n-1}

Read more

Other derivative rules

In [5]:
```
# Creating algebraic symbols
x = sym.symbols('x')
x
```

Out[5]: x

In [6]:
```
x = sym.symbols('x')
expr = x ** 2
expr
```

Out[6]: x^2

In [7]:
```
sym.Derivative(expr) # does not actually compute the derivative
```

Out[7]: $\frac{d}{dx}x^2$

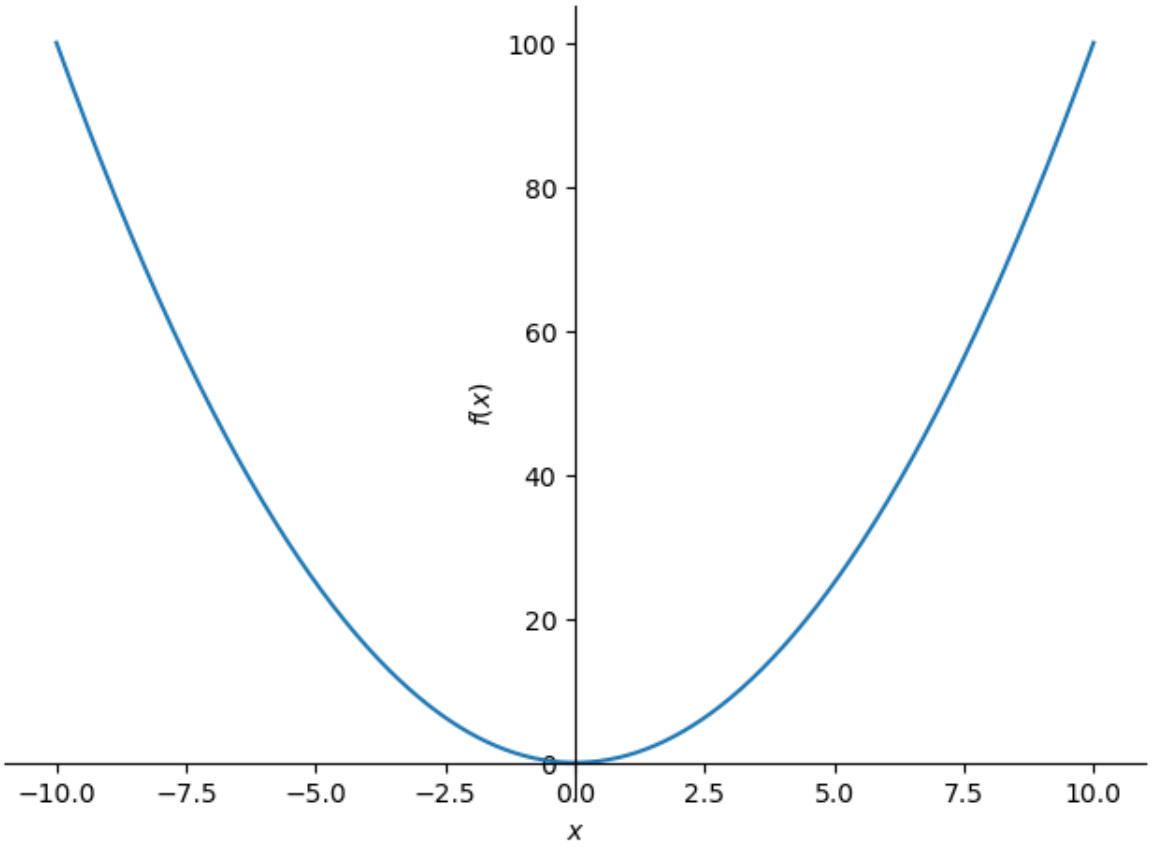
In [8]:
```
sym.Derivative(expr).doit()
```

Out[8]: $2x$

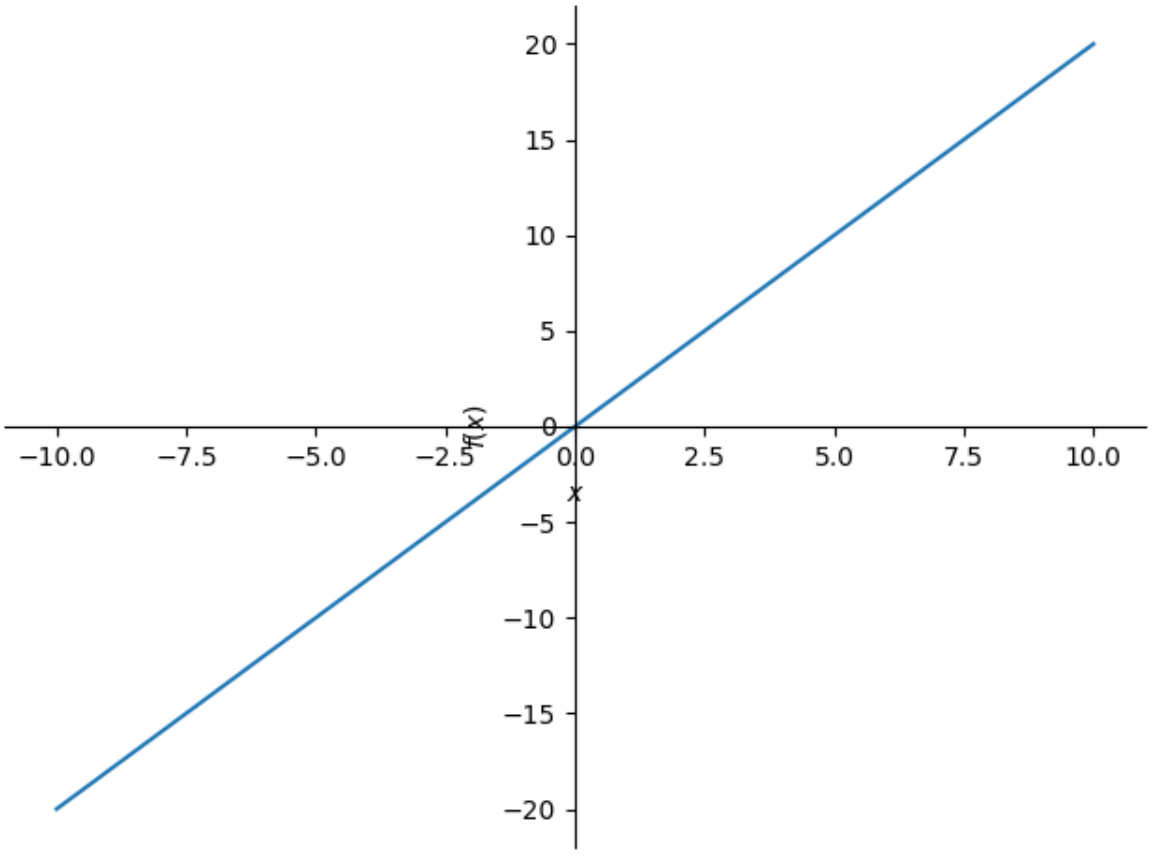
In [9]:
```
sym.diff(expr) #equivalent to doit()
```

Out[9]: $2x$

In [10]:
```
sym.plot(expr);
```

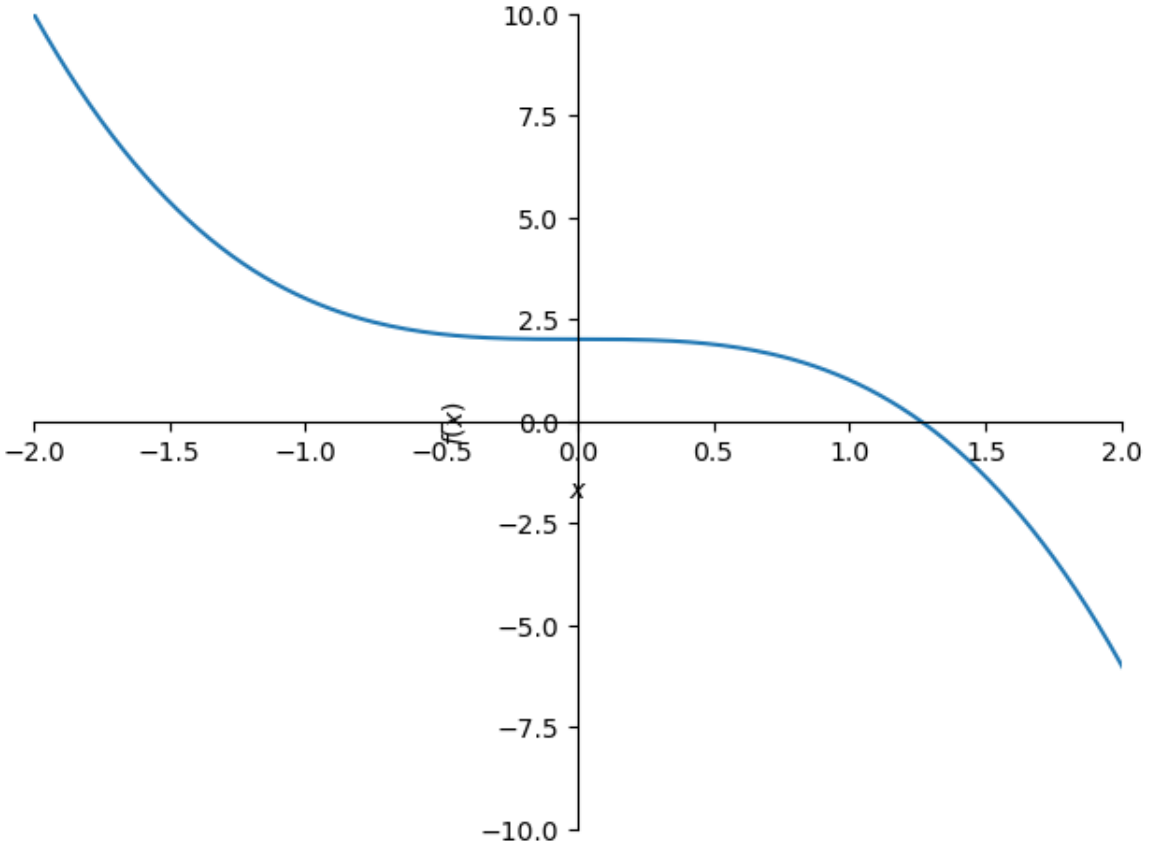


In [11]:
```
sym.plot(sym.diff(expr));
```



In [12]:
```
x = sym.symbols('x')
expr = -x ** 3 + 2

sym.plot(expr, xlim=(-2, 2), ylim=(-10, 10));
```



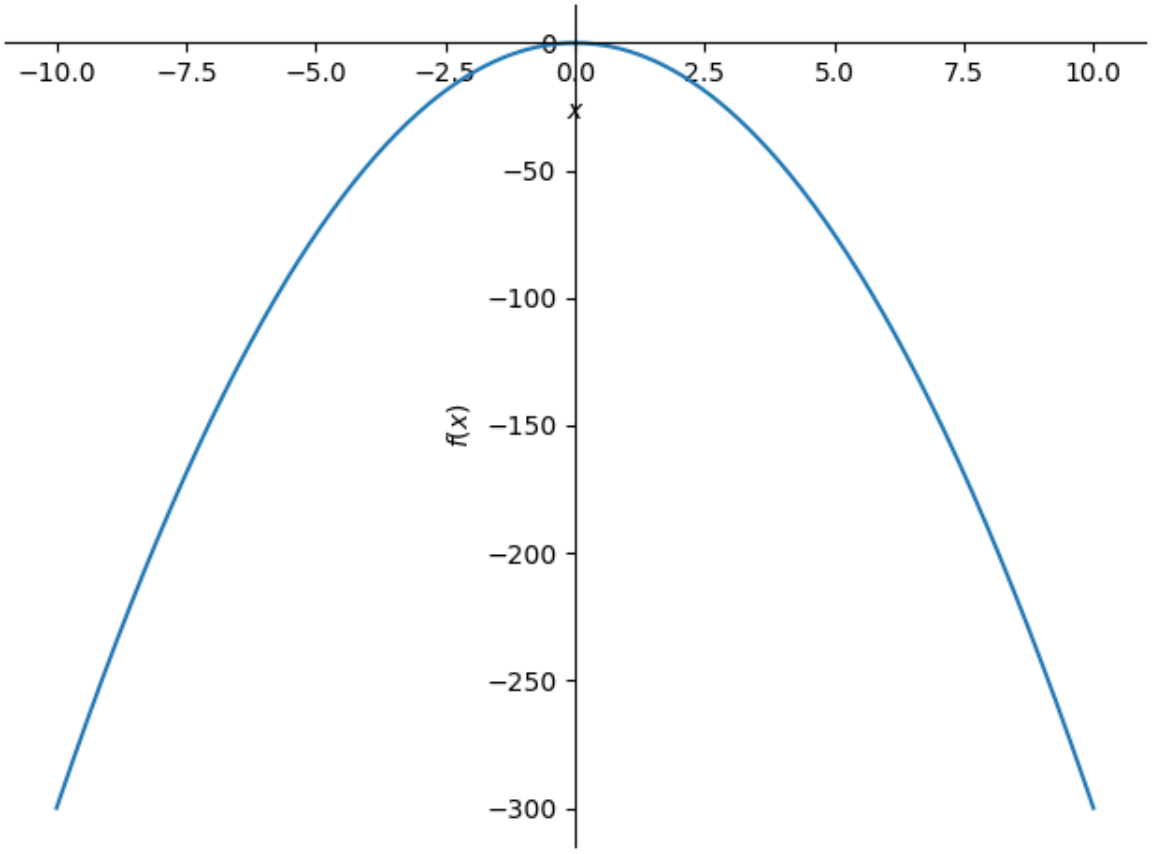
In [13]:
```
sym.Derivative(expr)
```

Out[13]: $\frac{d}{dx}\left(2 - x^{3}\right)$

In [14]:
```
sym.Derivative(expr).doit()
```

Out[14]: $-3x^{2}$

In [15]:
```
sym.plot(sym.diff(expr));
```



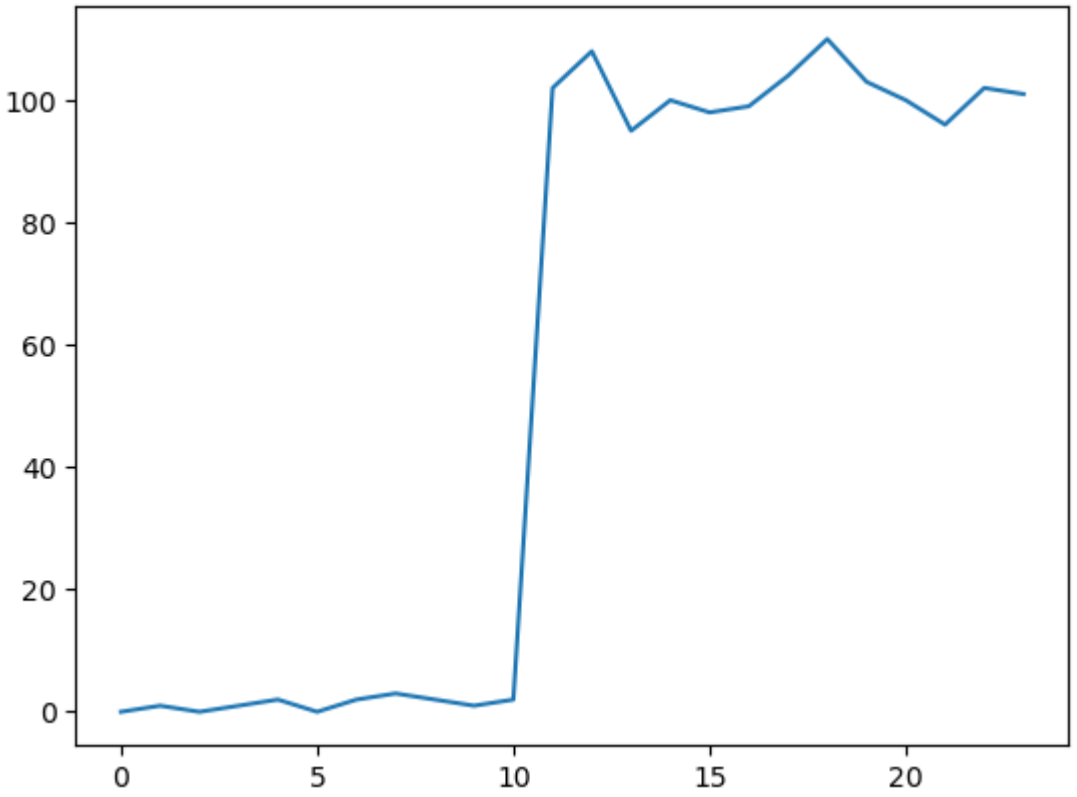
Now, let's generate a fake one-dimensional signal:

In [16]:
```
ys = np.array([0, 1, 0, 1, 2, 0, 2, 3, 2, 1, 2, 102, 108,  95, 100,  98,

fig,ax = plt.subplots()
ax.plot([i for i in range(len(ys))], ys);
check(1)
```

```
---------------------------------------------------------------------------
-
NameError                                 Traceback (most recent call las
t)
Cell In[16], line 5
      3 fig,ax = plt.subplots()
      4 ax.plot([i for i in range(len(ys))], ys);
----> 5 check(1)

NameError: name 'check' is not defined
```



Next, let's look at small chunks of our fake signal:

In [18]:
```
chunks = np.split(ys, len(ys)//2)
print(chunks)
check(2)
```

```
[array([0, 1]), array([0, 1]), array([2, 0]), array([2, 3]), array([2,
1]), array([  2, 102]), array([108,  95]), array([100,  98]), array([ 99,
104]), array([110, 103]), array([100,  96]), array([102, 101])]
---------------------------------------------------------------------------
-
NameError                                 Traceback (most recent call las
t)
Cell In[18], line 3
      1 chunks = np.split(ys, len(ys)//2)
      2 print(chunks)
----> 3 check(2)

NameError: name 'check' is not defined
```

Question: Which one of these chunks would you say is the most "interesting"? array([2,102]) **Question** If we always divide up the signal as we did above, will we always find something "interesting"?

Convolutions

Derivatives and convolutions are one technique to help us tackle the above problem.

First, you'll need to generate windows into the signal. Write a function that can generate windows with a user-supplied windowsize, and print them out.

An example signal with 3 window sizes is shown below. Your output does not need to replicate the formatting shown, but they should produce the same windows. E.g., given an input signal of `[10,20,30]` and a `windowsize=2`, your function should return `[[10,20], [20,30]]`.

A windowsize of 1:

```
signal:
        0   1   0   2   1   0   1 101 100  98 102 101
 0:     0
 1: ____    1
 2: _________   0
 3: _____________   2
 4: _________________   1
 5: _____________________   0
 6: _________________________   1
 7: _____________________________ 101
 8: _________________________________ 100
 9: _____________________________________  98
10: _________________________________________ 102
11: _____________________________________________ 101


::::::::::::::::::::::::::::::::::::::::::::::::

i:    0 |  i + windowsize:     1  |  window:  [   0]
i:    1 |  i + windowsize:     2  |  window:  [   1]
i:    2 |  i + windowsize:     3  |  window:  [   0]
i:    3 |  i + windowsize:     4  |  window:  [   2]
i:    4 |  i + windowsize:     5  |  window:  [   1]
i:    5 |  i + windowsize:     6  |  window:  [   0]
i:    6 |  i + windowsize:     7  |  window:  [   1]
i:    7 |  i + windowsize:     8  |  window:  [ 101]
i:    8 |  i + windowsize:     9  |  window:  [ 100]
i:    9 |  i + windowsize:    10  |  window:  [  98]
i:   10 |  i + windowsize:    11  |  window:  [ 102]
i:   11 |  i + windowsize:    12  |  window:  [ 101]
```

A windowsize of 2:

```
signal:
        0   1   0   2   1   0   1 101 100  98 102 101
 0:     0   1
 1: ____    1   0
 2: _________   0   2
 3: _____________   2   1
 4: _________________   1   0
 5: _____________________   0   1
 6: _________________________   1 101
 7: _____________________________ 101 100
 8: _________________________________ 100  98
 9: _____________________________________  98 102
10: _________________________________________ 102 101
```

```
::::::::::::::::::::::::::::::::::::::::::::::::

i:    0 |  i + windowsize:     2  |  window:  [   0,   1]
i:    1 |  i + windowsize:     3  |  window:  [   1,   0]
i:    2 |  i + windowsize:     4  |  window:  [   0,   2]
i:    3 |  i + windowsize:     5  |  window:  [   2,   1]
i:    4 |  i + windowsize:     6  |  window:  [   1,   0]
i:    5 |  i + windowsize:     7  |  window:  [   0,   1]
i:    6 |  i + windowsize:     8  |  window:  [   1, 101]
i:    7 |  i + windowsize:     9  |  window:  [ 101, 100]
i:    8 |  i + windowsize:    10  |  window:  [ 100,  98]
i:    9 |  i + windowsize:    11  |  window:  [  98, 102]
i:   10 |  i + windowsize:    12  |  window:  [ 102, 101]
```

A windowsize of 3

```
signal:
        0   1   0   2   1   0   1 101 100  98 102 101
 0:     0   1   0
 1: _____    1   0   2
 2: _________    0   2   1
 3: _____________    2   1   0
 4: _________________    1   0   1
 5: _____________________    0   1 101
 6: _________________________    1 101 100
 7: _____________________________  101 100  98
 8: _________________________________  100  98 102
 9: _____________________________________   98 102 101


::::::::::::::::::::::::::::::::::::::::::::::::

i:    0 |  i + windowsize:     3  |  window:  [   0,   1,
0]
i:    1 |  i + windowsize:     4  |  window:  [   1,   0,
2]
i:    2 |  i + windowsize:     5  |  window:  [   0,   2,
1]
i:    3 |  i + windowsize:     6  |  window:  [   2,   1,
0]
i:    4 |  i + windowsize:     7  |  window:  [   1,   0,
1]
i:    5 |  i + windowsize:     8  |  window:  [   0,   1,
101]
i:    6 |  i + windowsize:     9  |  window:  [   1, 101,
100]
i:    7 |  i + windowsize:    10  |  window:  [ 101, 100,
98]
i:    8 |  i + windowsize:    11  |  window:  [ 100,  98,
102]
i:    9 |  i + windowsize:    12  |  window:  [  98, 102,
101]
```

The below resources may be helpful::

List Comprehensions

https://www.pythonlikeyoumeanit.com/Module2_EssentialsOfPython/Generators_and_Comprehensions.html#List-&-Tuple-Comprehensions

Numpy indexing with slices

http://www.pythonlikeyoumeanit.com/Module3_IntroducingNumpy/AccessingDataAlongMultipleDimensions.html#Slice-Indexing

Formatting numbers in python

https://pyformat.info/#number

input: `'{:4d}'.format(42)`

output: `_ _ 4 2`

input: `'{:06.2f}'.format(3.141592653589793)`

output: `003.14`

String concatenation

```
>>> print('a' + 'b' + 'c')
abc
>>> print(''.join(['a', 'b', 'c']))
abc
>>> print(''.join(['a', 'b', 'c']))
a,b,c
```

In [23]:
```
def make_windows(sequence, windowsize):
    positions = len(sequence) - windowsize + 1
    final = []
    for i in range(positions):
        final.append(sequence[i:i+windowsize])
    return final
```

In [22]:
```
series = [0, 1, 0, 2, 1, 0, 1, 101, 100, 98, 102, 101]


make_windows(sequence=series, windowsize=1)
make_windows(sequence=series, windowsize=2)
make_windows(sequence=series, windowsize=3)

check(3)
```

```
---------------------------------------------------------------------------
-
NameError                                 Traceback (most recent call las
t)
Cell In[22], line 8
      5 make_windows(sequence=series, windowsize=2)
      6 make windows(sequence=series, windowsize=3)
----> 8 check(3)

NameError: name 'check' is not defined
```

When you are done:

Generate some example outputs in this notebook.

1. Double-check that you filled in your name at the top of the notebook!
2. Click `File -> Export Notebook As -> PDF`
3. Email the PDF to `YOURTEAMNAME@beaver.works`