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 IPython.display import YouTubeVideo, HTML
sym.init_printing(use_latex = "mathjax")
```

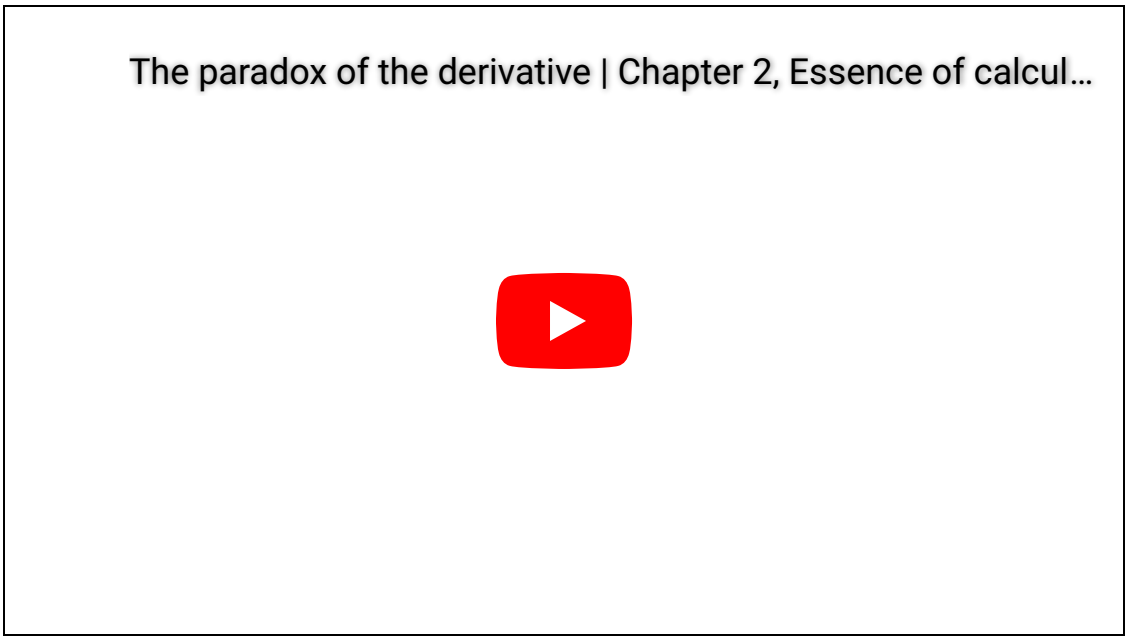
Enter your name below and run the cell:

Individual cells can be run with `Ctrl + Enter`

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

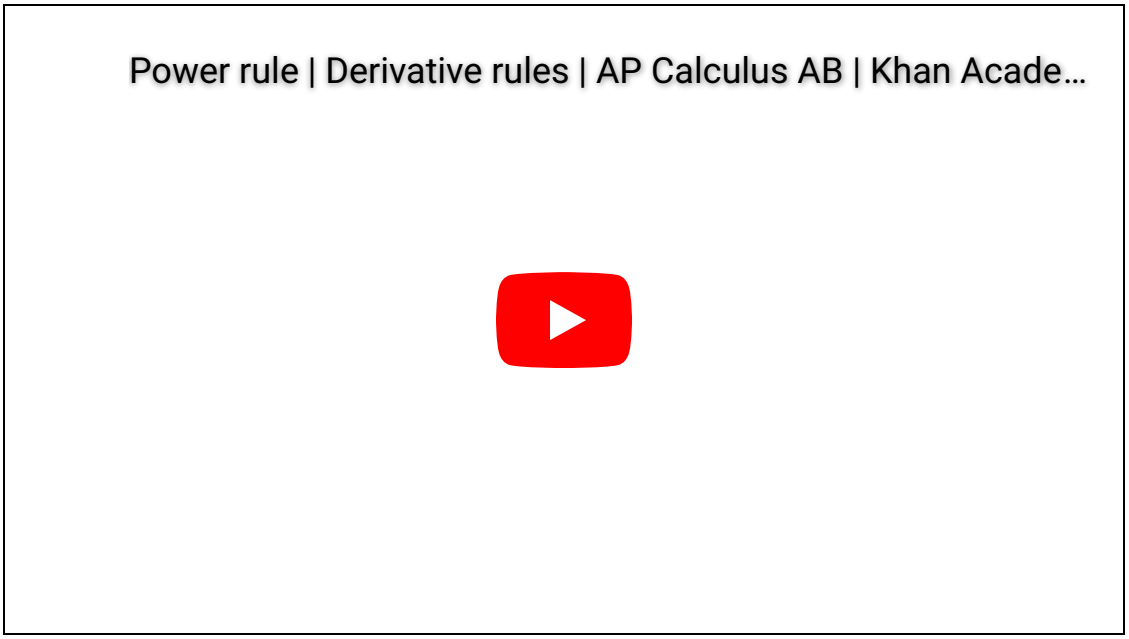
In [3]:
```
YouTubeVideo('9vKqVkMQHKk', width=560, height=315) # Video by http://www.
```

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

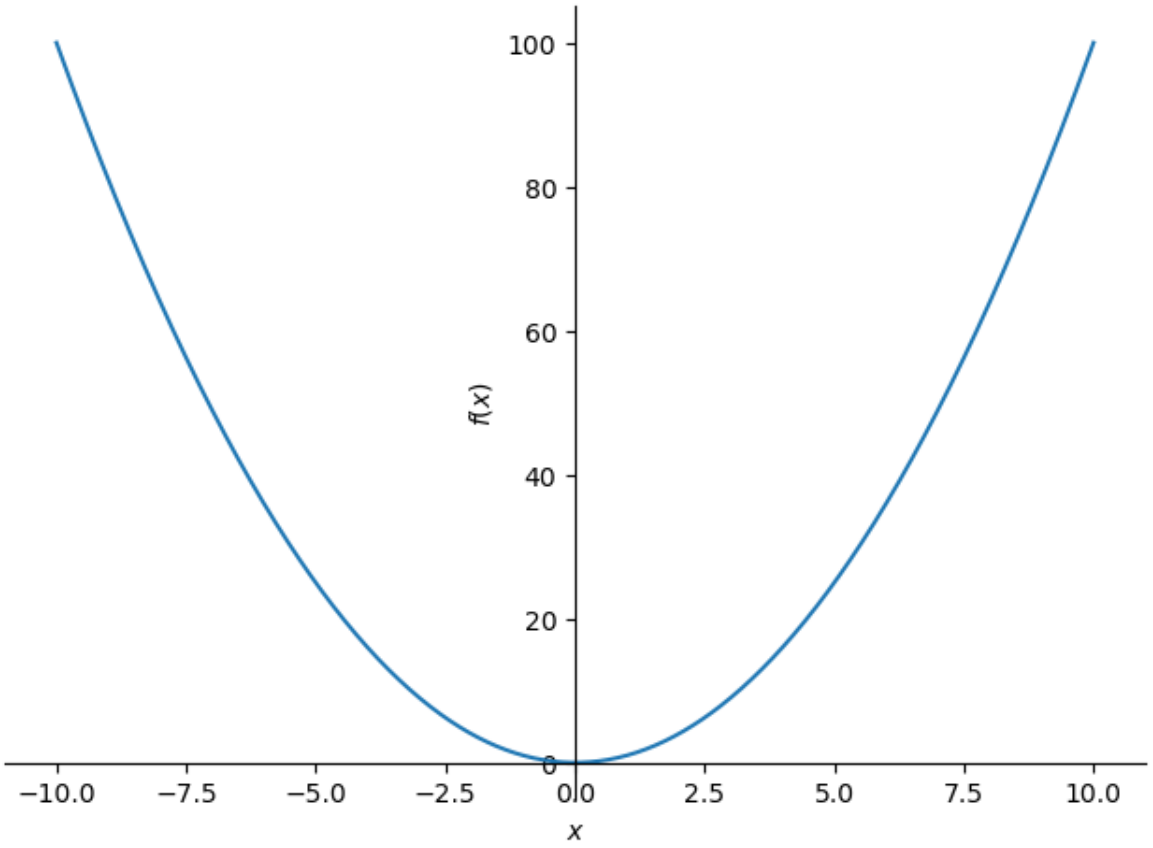
In [8]:
```
sym.Derivative(expr).doit()
```

Out[8]: $2x$

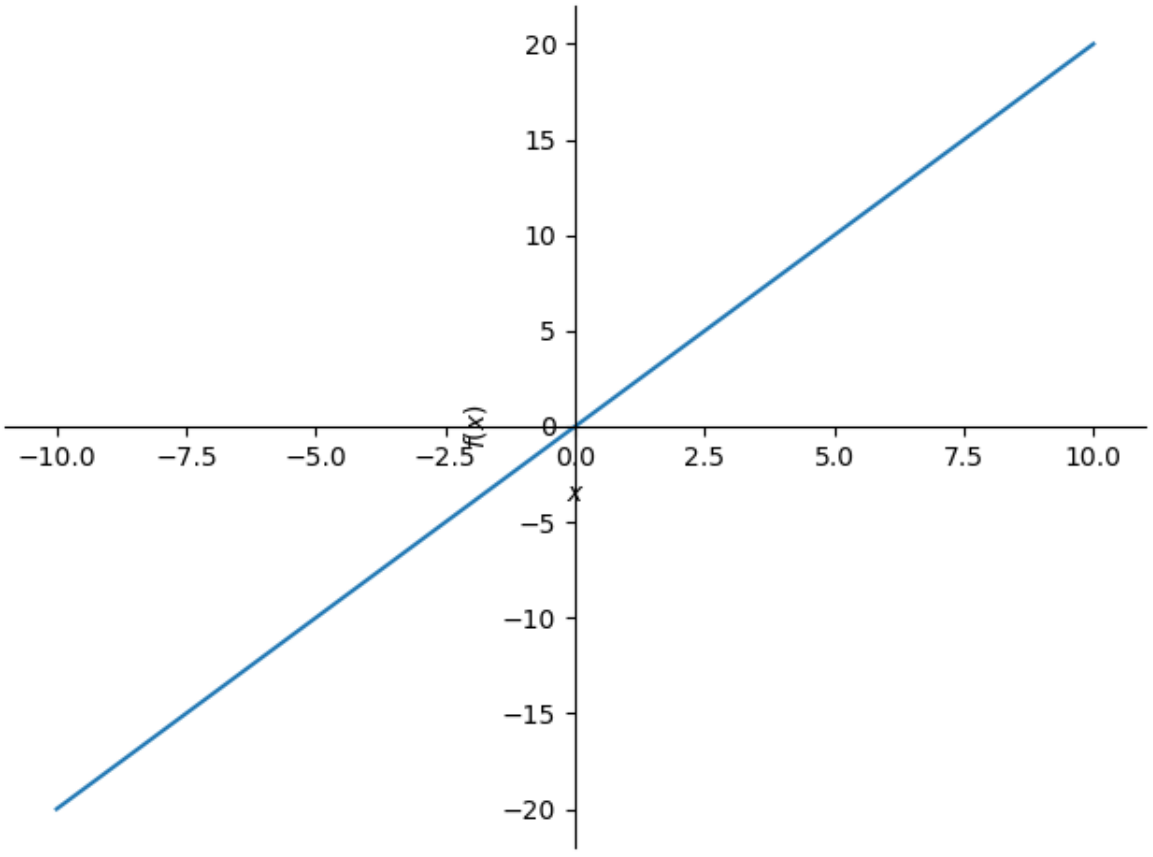
In [9]:
```
sym.diff(expr) #equivalent to doit()
```

Out[9]: $2x$

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

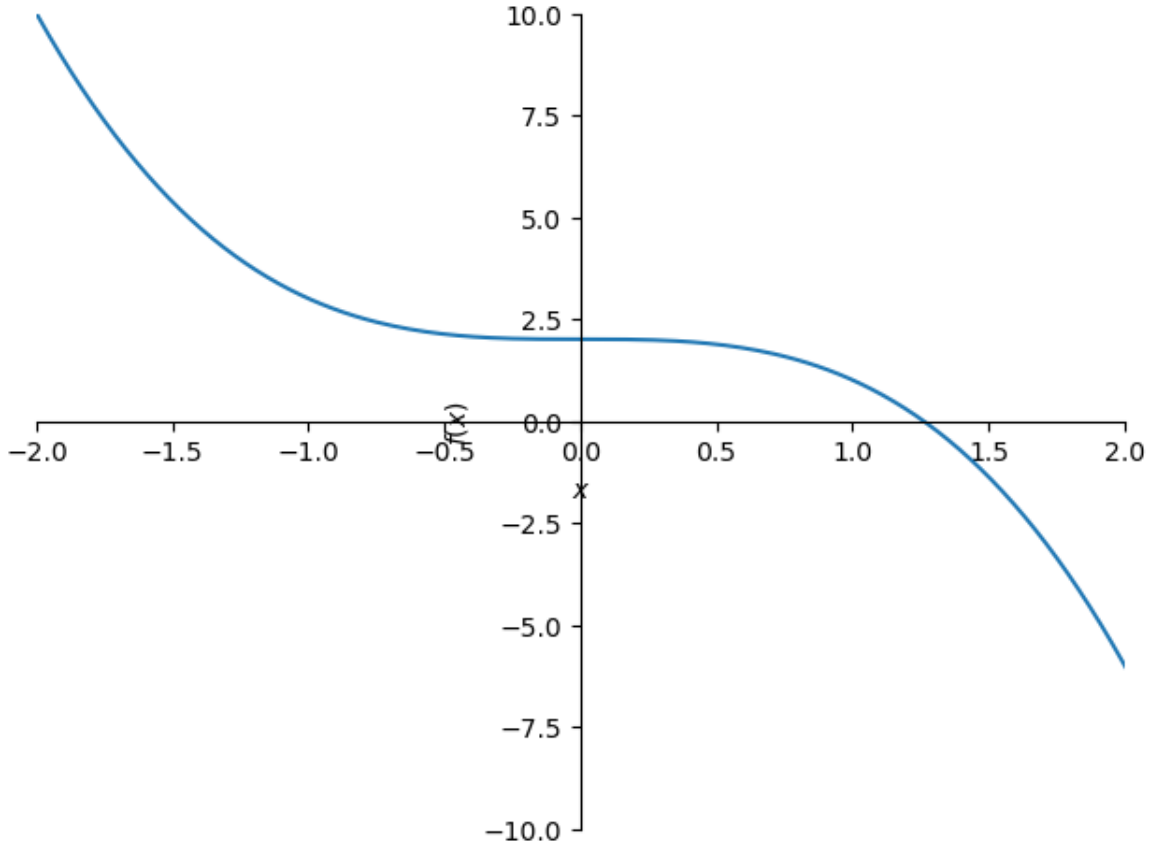


In [11]:
```
sym.plot(sym.diff(expr));
```



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

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



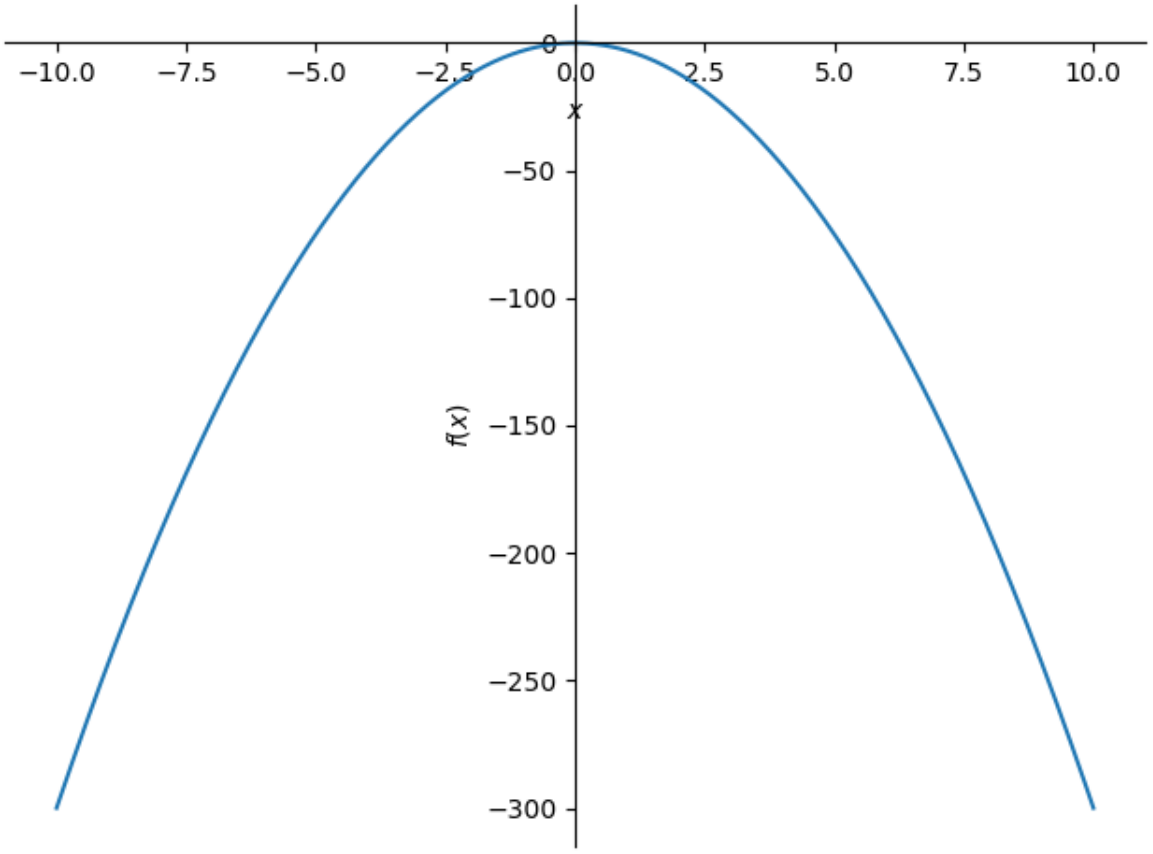
In [13]:
```
sym.Derivative(expr)
```

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

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

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

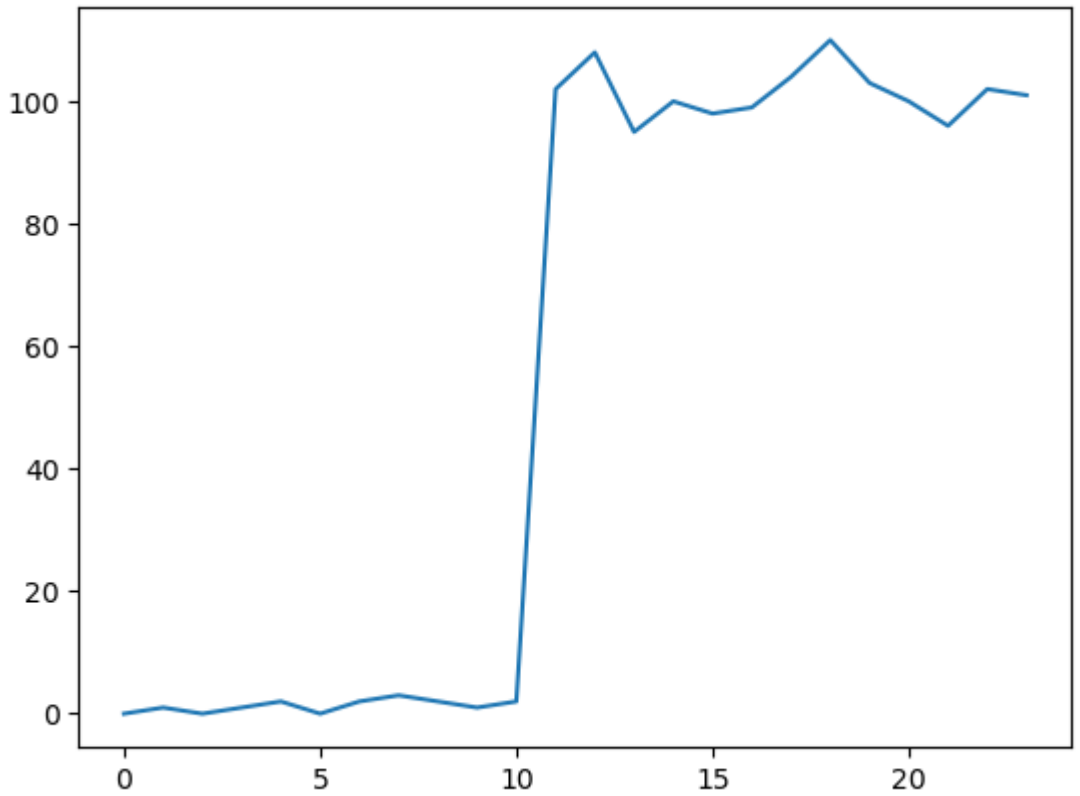
In [15]:
```
sym.plot(sym.diff(expr));
```



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)
```



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

In [17]:
```
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])]
```

Question: Which one of these chunks would you say is the most "interesting"?

The chunk around x = 10 because the y value suddenly increased by around 100.

Question If we always divide up the signal as we did above, will we always find something "interesting"?

Yes, because we can compare the numbers to find some outliers.

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 [36]:
```
def make_windows(sequence, windowsize):
    # raise NotImplementedError # TODO
    my_list = []
    # new_seq = enumerate(sequence)
    # for s in new_seq:
    #     for w in range(windowsize):
    #         seq = s[0]
    #         x = []
    #         if not (seq + w) >= len(sequence):
    #             x.append(sequence[seq + w])
    #             my_list.append(x)

    # return my_list

    place = len(sequence) - windowsize + 1
    for i in range(place):
        my_list.append(sequence[i:i + windowsize])

    return my_list
```

In [37]:
```
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)
```

Out[37]: $[[0, 1, 0], [1, 0, 2], [0, 2, 1], [2, 1, 0], [1, 0, 1], [0, 1, 101], [1, 101, 100], [101$

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`