Numpy-I Notes

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Installation Using `%pip`

In [ ]:

```
!pip install numpy
```

Importing Numpy

In [3]:

```
import numpy as np
```

Use case Introduction: Fitbit

#date	step_count	mood	calories_burned	hours_of_sleep	bool_of_active	weight_kg
06-10-2017	5464	200	181	5	0	66
07-10-2017	6041	100	197	8	0	66
08-10-2017	25	100	0	5	0	66
09-10-2017	5461	100	174	4	0	66
10-10-2017	6915	200	223	5	500	66
11-10-2017	4545	100	149	6	0	66
12-10-2017	4340	100	140	6	0	66
13-10-2017	1230	100	38	7	0	66
14-10-2017	61	100	1	5	0	66
15-10-2017	1258	100	40	6	0	65
16-10-2017	3148	100	101	8	0	65
17-10-2017	4687	100	152	5	0	65
18-10-2017	4732	300	150	6	500	65
19-10-2017	3519	100	113	7	0	65
20-10-2017	1580	100	49	5	0	65
21-10-2017	2822	100	86	6	0	65
22-10-2017	181	100	6	8	0	65
23-10-2017	3158	200	99	5	0	65

Every row is called a record or data point and every column is a feature

What kind of questions can we answer using this data?

- How many records and features are there in the dataset?
- What is the **average step count**?
- On which day the **step count was highest/lowest?**
- What's the **most frequent mood**?

We will try finding

- How daily activity affects mood?

Why use Numpy?

In [2]:

```
a = [1,2,3,4,5]
```

In [3]:

```
a = [i**2 for i in a]
print(a)
```

```
[1, 4, 9, 16, 25]
```

Lets try the same operation with NumPy

In [4]:

```
a = np.array([1,2,3,4,5])
print(a**2)
```

```
[ 1  4  9 16 25]
```

But is the clean syntax and ease in writing the only benefit we are getting here?

In [1]:

```
l = range(1000000)
```

In [2]:

```
%timeit [i**3 for i in l]
```

```
305 ms ± 8.66 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

In [4]:

```
l = np.arange(1000000)
```

In [5]:

```
%timeit l**3
```

```
2.24 ms ± 77.2 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

In [6]:

```
# Want more examples
l1 = range(10000)
l2 = [i**2 for i in range(10000)]
```

In [7]:

```
%timeit list(map(lambda x, y: x*y, l1, l2))
```

```
1.32 ms ± 45.3 µs per loop (mean ± std. dev. of 7 runs, 1000 loops each)
```

In [8]:

```
a1 = np.array(l1)
b1 = np.array(l2)
```

In [9]:

```
%timeit a1*b1
```

```
9.36 µs ± 568 ns per loop (mean ± std. dev. of 7 runs, 100000 loops each)
```

Takeaway ?

- NumPy provides clean syntax for providing element-wise operations
- Per loop time for numpy to perform operation is much lesser than list

In [ ]:

```

```

Basic arrays in NumPy

array()

In [6]:

```
# Let's create a 1-D array
arr1 = np.array([1, 2, 3])
print(arr1)
print(arr1 * 2)
```

```
[1 2 3]
[2 4 6]
```

What will be the dimension of this array?

In [7]:

```
arr1.ndim
```

Out[7]:

```
1
```

Shape of array

In [9]:

```
arr1.shape

```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
C:\Users\SHELEN~1\AppData\Local\Temp/ipykernel_14276/3738189820.py in <module>
----> 1 arr1.shape

NameError: name 'arr1' is not defined
```

Sequences in Numpy

From a range and stepsize - `arange()`

- `arange(start, end, step)`

In [2]:

```
import numpy as np
```

In [4]:

```
arr2 = np.arange(1, 5)
arr2
```

Out[4]:

```
array([1, 2, 3, 4])
```

In [7]:

```
arr2_stepsize = np.arange(1, 5, 2)
arr2_stepsize
```

Out[7]:

```
array([1, 3])
```

- In `np.arange()` , we can pass a **floating point number** as **step-size**

In [18]:

```
arr3 = np.arange(1, 5, 0.5)
arr3
```

Out[18]:

```
array([1. , 1.5, 2. , 2.5, 3. , 3.5, 4. , 4.5])
```

What if we want to generate equally spaced points?

`=> linspace()`

In [14]:

```
np.linspace(0, 10, 11)
```

Out[14]:

```
array([ 0.,  1.,  2.,  3.,  4.,  5.,  6.,  7.,  8.,  9., 10.])
```

Note: The `end` value is included in the array.

In [16]:

```
start, end, flag_count = 0, 100, 25
np.linspace(start, end, flag_count)
```

Out[16]:

```
array([  0.        ,   4.16666667,   8.33333333,  12.5       ,
        16.66666667,  20.83333333,  25.        ,  29.16666667,
        33.33333333,  37.5       ,  41.66666667,  45.83333333,
        50.        ,  54.16666667,  58.33333333,  62.5       ,
        66.66666667,  70.83333333,  75.        ,  79.16666667,
        83.33333333,  87.5       ,  91.66666667,  95.83333333,
       100.        ])
```

Lets check the type of a Numpy array

In [17]:

```
1 type(arr1)
```

Out[17]:

```
numpy.ndarray
```

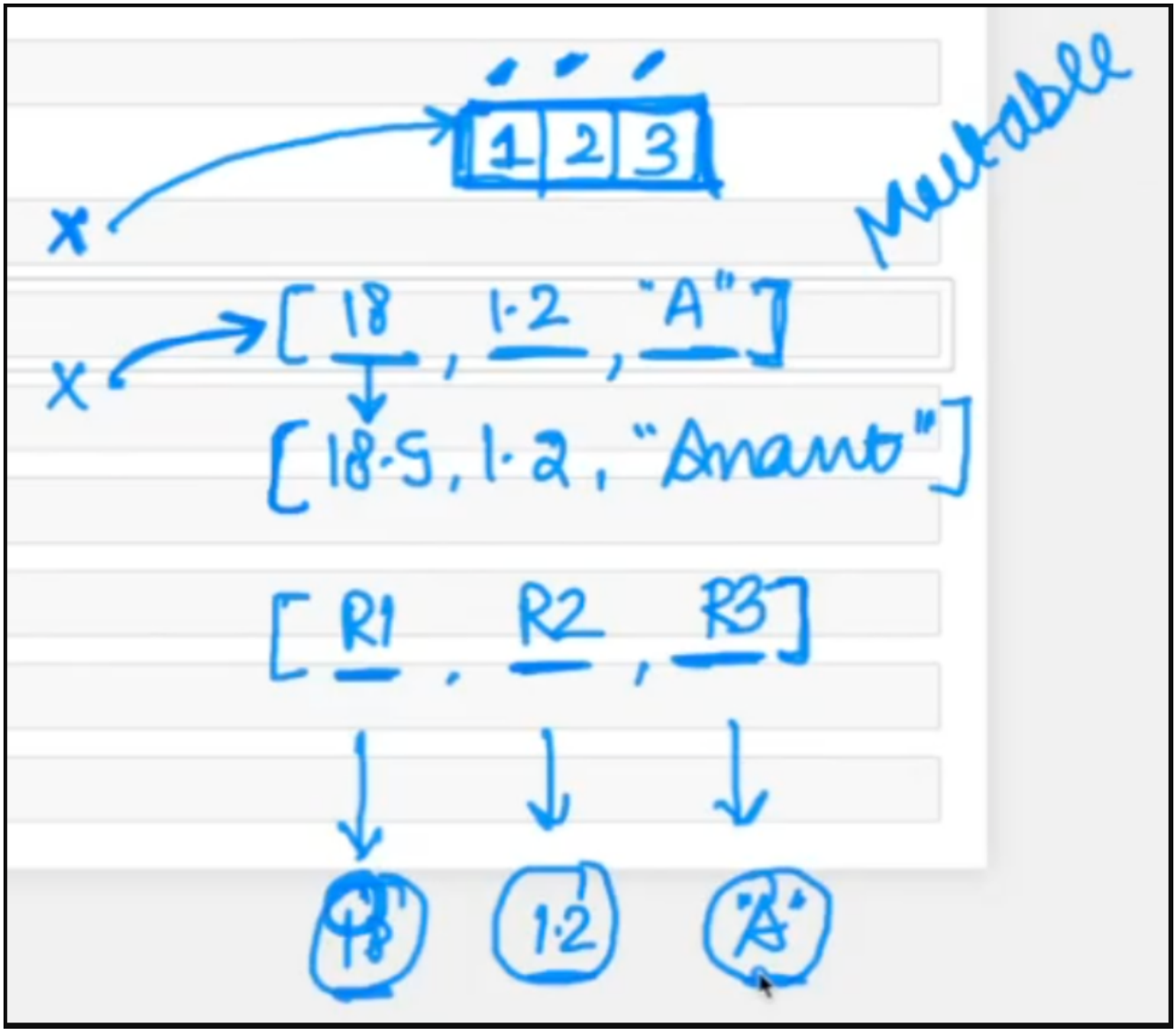
How numpy works under the hood?

- It's a **Python Library**, we will **write code in Python** to use numpy

However, numpy itself is written in C

Allows numpy to **manage memory very efficiently**

But why is C arrays more efficient or faster than Python Lists?



- In **Python List**, we can **store objects of different types together** - int, float, string, etc.
- The **actual values** of objects are **stored somewhere else in the memory**
- Only **References to those objects** (R1, R2, R3, ...) are stored in the Python List.
- So, when we have to access an element in Python List, we **first access the reference** to that element and then that **reference allows us to access the value** of element stored in memory

C array does all this in one step

- **C array stores objects of same data type together**
- **Actual values** are **stored in same contiguous memory**
- So, when we have to access an element in C array, we **access it directly using indices**.

This makes NumPy array lose the flexibility to store heterogenous data

==> Unlike Python lists, NumPy array can only hold contigous data

- So numpy arrays are **NOT** really **Python lists**
- They are basically **C arrays**

C type behaviour of Numpy

In [18]:

```
arr4 = np.array([1, 2, 3, 4])
arr4
```

Out[18]:

```
array([1, 2, 3, 4])
```

In [19]:

```
arr4 = np.array([1, 2, 3, 4.0])
arr4
```

Out[19]:

```
array([1., 2., 3., 4.])
```

- Because **one single C array** can store values of **only one data type** i.e. homogenous data

- We can specify the datatype of array at time of initialization using `dtype` parameter
  - ** by default set to `None` **

In [20]:

```
arr5 = np.array([1, 2, 3, 4])
arr5
```

Out[20]:

```
array([1, 2, 3, 4])
```

In [21]:

```
arr5 = np.array([1, 2, 3, 4], dtype="float")
arr5
```

Out[21]:

```
array([1., 2., 3., 4.])
```

Another way np array behaves like C arrays and not Python lists

- In Python lists, number values can be **arbitrarily large or small**
- There's **usually no overflow of number values**

However, in C, C++ and Java, there's overflow of values

- As soon as a **number crosses the max possible** value for a data-type,the number gets **wrapped around to a smaller value**

In [22]:

```
100**10 # no overflow
```

Out[22]:

```
10000000000000000000
```

In [28]:

```
arr6 = np.array([0, 100])
arr6 ** 10 # 100^10 will overflow
```

Out[28]:

```
array([         0, 1661992960], dtype=int32)
```

Working with 2-D arrays (Matrices)

In [29]:

```
m1 = np.array([[1,2,3],[4,5,6]])
m1
# Nicely printing out in a Matrix form
```

Out[29]:

```
array([[1, 2, 3],
       [4, 5, 6]])
```

How can we check shape of a numpy array?

In [30]:

```
m1.shape # arr1 has 3 elements
```

Out[30]:

```
(2, 3)
```

What is the type of this result of `arr1.shape` ? Which data structure is this?

Tuple

Now, What is the dimension of this array?

In [31]:

```
m1.ndim
```

Out[31]:

```
2
```

How can we create high dimensional arrays using `reshape()` ?

In [32]:

```
m2 = np.arange(1, 13)
m2
```

Out[32]:

```
array([ 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12])
```

Can we make `m2` a 4×4 array?

In [33]:

```
m2 = np.arange(1, 13)
m2.reshape(4, 4)
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-33-fc70b006b379> in <module>
      1 m2 = np.arange(1, 13)
----> 2 m2.reshape(4, 4)

ValueError: cannot reshape array of size 12 into shape (4,4)
```

So, What are the ways in which we can reshape it?

- 4×3
- 3×4
- 6×2
- 2×6
- 1×12
- 12×1

In [34]:

```
m2 = np.arange(1, 13)
m2.reshape(4, 3)
```

Out[34]:

```
array([[ 1,  2,  3],
       [ 4,  5,  6],
       [ 7,  8,  9],
       [10, 11, 12]])
```

In [42]:

```
m2 = np.arange(1, 13)
m2
```

Out[42]:

```
array([ 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12])
```

In [43]:

```
m2.shape
```

Out[43]:

```
(12,)
```

In [44]:

```
m2.reshape(12, 1)
```

Out[44]:

```
array([[ 1],
       [ 2],
       [ 3],
       [ 4],
       [ 5],
       [ 6],
       [ 7],
       [ 8],
       [ 9],
       [10],
       [11],
       [12]])
```

In [45]:

```
# no change in original array
m2
```

Out[45]:

```
array([ 1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12])
```

- `(12,)` means its a **1D array**
- `(12, 1)` means its a **2D array** with 12 rows and 1 column

Resize

In [48]:

```
c = np.arange(4)
c.resize((2,2))
c
```

Out[48]:

```
array([[0, 1],
       [2, 3]])
```

In [49]:

```
a = np.arange(4)
a.resize((2,4))
a
```

Out[49]:

```
array([[0, 1, 2, 3],
       [0, 0, 0, 0]])
```

difference between resize and reshape?

The difference is that it'll add extra zeros to it if shape exceeds number of elements. However, there is a catch: it'll throw an error if array is referenced somewhere and you try resizing it

In [50]:

```
b = a
a.resize((10,))
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-50-6e04a2659d2b> in <module>
      1 b = a
----> 2 a.resize((10,))

ValueError: cannot resize an array that references or is referenced
by another array in this way.
Use the np.resize function or refcheck=False
```

In [13]:

```
a = np.array([2,4,5,6])
a.resize((10,2))
a
```

Out[13]:

```
array([[2, 4],
       [5, 6],
       [0, 0],
       [0, 0],
       [0, 0],
       [0, 0],
       [0, 0],
       [0, 0],
       [0, 0],
       [0, 0]])
```

Transpose

- **Change rows into columns and columns into rows**

In [51]:

```
a = np.arange(3)
a
```

Out[51]:

```
array([0, 1, 2])
```

In [52]:

```
a.T
```

Out[52]:

```
array([0, 1, 2])
```

Why did Transpose did not work?

- **numpy sees a as a vector (3,), NOT a matrix**.

In [53]:

```
a = np.arange(3).reshape(1, 3) #reshape vector to a matrix
a
# Now a has dimensions (1, 3) instead of just (3,)
# It has 1 row and 3 columns
```

Out[53]:

```
array([[0, 1, 2]])
```

In [54]:

```
a.T
# It has 3 rows and 1 column
```

Out[54]:

```
array([[0],
       [1],
       [2]])
```

Flattening of an array

In [55]:

```
A = np.arange(12).reshape(3, 4)
A
```

Out[55]:

```
array([[ 0,  1,  2,  3],
       [ 4,  5,  6,  7],
       [ 8,  9, 10, 11]])
```

In [56]:

```
A.flatten()
```

Out[56]:

```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11])
```

In [57]:

```
A
```

Out[57]:

```
array([[ 0,  1,  2,  3],
       [ 4,  5,  6,  7],
       [ 8,  9, 10, 11]])
```

convert a matrix to 1D array using `reshape()`

What should I pass in `A.reshape()` if I want to use it to convert `A` to 1D vector?

- **(1, 1)?**

In [58]:

```
A.reshape(1, 1)
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-58-902e5c35e0d3> in <module>
----> 1 A.reshape(1, 1)

ValueError: cannot reshape array of size 12 into shape (1,1)
```

- So, **(1, 12)?**

In [59]:

```
A.reshape(1, 12)
```

Out[59]:

```
array([[ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11]])
```

- We need a vector of dimension (12,). So, we need to pass only 1 dimension.

In [60]:

```
A.reshape(12)
```

Out[60]:

```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11])
```

What will happen if we pass a negative integer in `reshape()` ?

In [61]:

```
A.reshape(6, -1)
```

Out[61]:

```
array([[ 0,  1],
       [ 2,  3],
       [ 4,  5],
       [ 6,  7],
       [ 8,  9],
       [10, 11]])
```

- Since **no. of elements in our matrix is 12** and **we passed 6 as no. of rows**, it is **able to figure out** that **no. of columns should be 2**

In [62]:

```
A.reshape(-1, 6)
```

Out[62]:

```
array([[ 0,  1,  2,  3,  4,  5],
       [ 6,  7,  8,  9, 10, 11]])
```

Special arrays using Numpy

numpy array with all zeros

In [63]:

```
np.zeros(3)
# Pass in how many values you need in array
# All values will be zeroes
```

Out[63]:

```
array([0., 0., 0.])
```

In [64]:

```
np.zeros((2, 3))
```

Out[64]:

```
array([[0., 0., 0.],
       [0., 0., 0.]])
```

numpy array with all ones

In [65]:

```
# Just like np.zeroes, but initialize all values to 1
np.ones(3)
```

Out[65]:

```
array([1., 1., 1.])
```

In [66]:

```
# 2D
np.ones((2,3))
```

Out[66]:

```
array([[1., 1., 1.],
       [1., 1., 1.]])
```

Now, do we need `np.twos()`, `np.threes()`, `np.fours()`, ... `np.hundreds()` ?

- We can just create array using `np.ones()` and multiply with required value

In [67]:

```
np.ones((2, 3)) * 5
```

Out[67]:

```
array([[5., 5., 5.],
       [5., 5., 5.]])
```

Datatype of special arrays

In [68]:

```
a = np.zeros((2,2))
a
```

Out[68]:

```
array([[0., 0.],
       [0., 0.]])
```

In [69]:

```
a.dtype
```

Out[69]:

```
dtype('float64')
```

It by defaults creates array with dtype float

Diagional matrices

In [70]:

```
np.diag([1, 2, 3])
# We pass values for diagonal elements as a list
# All other elements are zero
```

Out[70]:

```
array([[1, 0, 0],
       [0, 2, 0],
       [0, 0, 3]])
```

Identity matrix

square matrix where **all diagonal values are 1** and **All non-diagonal values are 0**

In [71]:

```
np.identity(3)
# Pass in the single dimension of required square identity matrix
```

Out[71]:

```
array([[1., 0., 0.],
       [0., 1., 0.],
       [0., 0., 1.]])
```

Indexing and Slicing upon Numpy arrays

In [72]:

```
m1 = np.arange(12)
m1
```

Out[72]:

```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11])
```

Indexing in np arrays

In [73]:

```
m1[0] # gives first element of array
```

Out[73]:

```
0
```

In [74]:

```
m1[12] # out of index Error
```

```
---------------------------------------------------------------------------
IndexError                                Traceback (most recent call last)
<ipython-input-74-24d969f9df5e> in <module>
----> 1 m1[12] # out of index Error

IndexError: index 12 is out of bounds for axis 0 with size 12
```

In [75]:

```
m1 = np.arange(1,10).reshape((3,3))
```

In [76]:

```
m1
```

Out[76]:

```
array([[1, 2, 3],
       [4, 5, 6],
       [7, 8, 9]])
```

In [77]:

```
m1[1][2]
```

Out[77]:

```
6
```

In [78]:

```
m1[1, 2] #m1[row, column] (another way of indexing using comma)
```

Out[78]:

```
6
```

list of indexes in numpy

In [79]:

```
m1 = np.array([100,200,300,400,500,600])
```

In [81]:

```
m1[[2,3,4,1,2,2]]
```

Out[81]:

```
array([300, 400, 500, 200, 300, 300])
```

List of indexes in 2D array

In [82]:

```
import numpy as np
```

In [83]:

```
m1 = np.arange(9).reshape((3,3))
```

In [84]:

```
m1
```

Out[84]:

```
array([[0, 1, 2],
       [3, 4, 5],
       [6, 7, 8]])
```

In [85]:

```
m1[[0,1,2],[0,1,2]] # picking up element (0,0), (1,1) and (2,2)
```

Out[85]:

```
array([0, 4, 8])
```

Slicing

In [86]:

```
m1 = np.arange(12)
m1
```

Out[86]:

```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11])
```

In [87]:

```
m1[:5]
```

Out[87]:

```
array([0, 1, 2, 3, 4])
```

Can we just get this much of our array `m1` ?

```
[[5, 6],
 [9, 10]]
```

Remember our `m1` is:

```
m1 = [[0, 1, 2, 3],
      [4, 5, 6, 7],
      [8, 9, 10, 11]]
```

In [88]:

```
m1 = np.arange(12).reshape(3,4)
```

In [89]:

```
# First get rows 1 to all
# Then get columns 1 to 3 (not included)
m1[1:, 1:3]
```

Out[89]:

```
array([[ 5,  6],
       [ 9, 10]])
```

What if I want this much part?

```
[[2, 3],
 [6, 7],
 [10,11]]
```

In [90]:

```
# First get all rows
# Then get columns 2 to all

m1[:, 2:]
```

Out[90]:

```
array([[ 2,  3],
       [ 6,  7],
       [10, 11]])
```

What if I need 1st and 3rd column?

```
[[1, 3],
 [5, 7],
 [9,11]]
```

In [91]:

```
# Get all rows
# Then get columns from 1 to all with step of 2

m1[:, 1::2]
```

Out[91]:

```
array([[ 1,  3],
       [ 5,  7],
       [ 9, 11]])
```

In [92]:

```
# Get all rows
# Then get columns 1 and 3

m1[:, (1,3)] #can also pass indices of required columns as a tuple to get the sam result
```

Out[92]:

```
array([[ 1,  3],
       [ 5,  7],
       [ 9, 11]])
```

Fancy indexing (Masking)

- Numpy arrays can be indexed with boolean arrays (masks).
- It creates copies not views.

In [93]:

```
m1 = np.arange(12).reshape(3, 4)
m1 < 6
```

Out[93]:

```
array([[ True,  True,  True,  True],
       [ True,  True, False, False],
       [False, False, False, False]])
```

In [94]:

```
m1[m1 < 6]
# Value corresponding to True is retained
# Value corresponding to False is filtered out
```

Out[94]:

```
array([0, 1, 2, 3, 4, 5])
```

In [95]:

```
m1
```

Out[95]:

```
array([[ 0,  1,  2,  3],
       [ 4,  5,  6,  7],
       [ 8,  9, 10, 11]])
```

In [96]:

```
m1[m1%2 == 0]
```

Out[96]:

```
array([ 0,  2,  4,  6,  8, 10])
```

Takeaway?

Matrix gets converted into a 1D array after masking because the filtering operation **implicitly converts high-dimensional array into 1D array** as it **cannot retain its 3×4 with lesser number of elements**

Multiple filter conditions

In [97]:

```
a = np.arange(11)
```

In [98]:

```
a[(a %2 == 0) | (a%5 == 0)] # filter elements which are multiple of 2 or 3
```

Out[98]:

```
array([ 0,  2,  4,  5,  6,  8, 10])
```

Aggregate / Universal Functions (`ufunc`)

Numpy universal functions are objects that belongs to `numpy.ufunc` class.

- Some ufuncs are **called automatically when the corresponding "arithmetic operator" is used on arrays**.

For example:

- When **addition of two array** is performed **element-wise** using + operator, then **np.add() is called internally.**

In [99]:

```
a = np.array([1,2,3,4])
b = np.array([5,6,7,8])
a+b  # ufunc `np.add()` called automatically
```

Out[99]:

```
array([ 6,  8, 10, 12])
```

In [100]:

```
np.add(a,b)
```

Out[100]:

```
array([ 6,  8, 10, 12])
```

Aggregate Functions/ Reduction functions

`np.sum()`

In [101]:

```
a = np.arange(12).reshape(3, 4)
a
```

Out[101]:

```
array([[ 0,  1,  2,  3],
       [ 4,  5,  6,  7],
       [ 8,  9, 10, 11]])
```

In [102]:

```
np.sum(a)  # sums all the values present in array
```

Out[102]:

```
66
```

We can do row-wise and column-wise sum by setting `axis` parameter

- **`axis = 0` ---> Changes will happen along the vertical axis**
- Summing of values happen **in the vertical direction**

In [103]:

```
np.sum(a, axis=0)
```

Out[103]:

```
array([12, 15, 18, 21])
```

- **`axis = 1` ---> Changes will happen along the horizontal axis**
- Summing of values happen **in the horizontal direction**

In [104]:

```
np.sum(a, axis=1)
```

Out[104]:

```
array([ 6, 22, 38])
```

`np.mean()`

In [105]:

```
1 np.mean(a)
```

Out[105]:

```
5.5
```

In [106]:

```
1 np.mean(a, axis=0)
```

Out[106]:

```
array([4., 5., 6., 7.])
```

In [107]:

```
1 np.mean(a, axis=1)
```

Out[107]:

```
array([1.5, 5.5, 9.5])
```

np.min()

In [108]:

```
1 a
```

Out[108]:

```
array([[ 0,  1,  2,  3],
       [ 4,  5,  6,  7],
       [ 8,  9, 10, 11]])
```

In [109]:

```
1 np.min(a)
```

Out[109]:

```
0
```

In [110]:

```
1 np.min(a, axis = 1 )
```

Out[110]:

```
array([0, 4, 8])
```

np.max()

In [111]:

```
1 a
```

Out[111]:

```
array([[ 0,  1,  2,  3],
       [ 4,  5,  6,  7],
       [ 8,  9, 10, 11]])
```

In [112]:

```
1 np.max(a) # maximum value
```

Out[112]:

```
11
```

In [113]:

```
1 np.max(a, axis = 0) # column wise max
```

Out[113]:

```
array([ 8,  9, 10, 11])
```

Logical functions

In [114]:

```
a = np.array([1,2,3,4])
a
```

Out[114]:

```
array([1, 2, 3, 4])
```

np.any()

- any() returns True if **any of the elements** in the argument array is **non-zero**.

In [115]:

```
np.any([True, True, False])
```

Out[115]:

```
True
```

In [116]:

```
a = np.array([1,2,3,4]) # atleast 1 element is non-zero
np.any(a)
```

Out[116]:

```
True
```

In [117]:

```
a = np.array([1,0,0,0]) # atleast 1 element is non-zero
np.any(a)
```

Out[117]:

```
True
```

In [118]:

```
a = np.zeros(4) # all elements are zero
np.any(a)
```

Out[118]:

```
False
```

- any() returns True if **any of the corresponding elements** in the argument arrays follow the **provided condition**.

In [119]:

```
a = np.array([1,2,3,4])
b = np.array([4,3,2,1])
np.any(a<b) # Atleast 1 element in a < corresponding element in b
```

Out[119]:

```
True
```

In [120]:

```
a = np.array([4,5,6,7])
b = np.array([4,3,2,1])
np.any(a<b) # All elements in a >= corresponding elements in b
```

Out[120]:

```
False
```

np.all()

In [121]:

```
a = np.array([1,2,3,4])
b = np.array([4,3,2,1])
a, b
```

Out[121]:

```
(array([1, 2, 3, 4]), array([4, 3, 2, 1]))
```

In [122]:

```
np.all(a<b) # Not all elements in a < corresponding elements in b
```

Out[122]:

```
False
```

In [123]:

```
a = np.array([1,0,0,0])
b = np.array([4,3,2,1])
np.all(a<b) # All elements in a < corresponding elements in b
```

Out[123]:

```
True
```

Multiple conditions for `.all()` function

In [124]:

```
a = np.array([1, 2, 3, 2])
b = np.array([2, 2, 3, 2])
c = np.array([6, 4, 4, 5])
((a <= b) & (b <= c)).all()
```

Out[124]:

```
True
```

Sorting Arrays

- Default axis for sorting is the last axis of the array.

`np.sort()`

- Returns a **sorted copy of an array**.

In [125]:

```
a = np.array([2,30,41,7,17,52])
a
```

Out[125]:

```
array([ 2, 30, 41,  7, 17, 52])
```

In [126]:

```
np.sort(a)
```

Out[126]:

```
array([ 2,  7, 17, 30, 41, 52])
```

In [127]:

```
a
```

Out[127]:

```
array([ 2, 30, 41,  7, 17, 52])
```

In [128]:

```
arr = np.arange(12,0,-1).reshape(4,3)
```

In [129]:

```
arr
```

Out[129]:

```
array([[12, 11, 10],
       [ 9,  8,  7],
       [ 6,  5,  4],
       [ 3,  2,  1]])
```

In [130]:

```
np.sort(arr)
```

Out[130]:

```
array([[10, 11, 12],
       [ 7,  8,  9],
       [ 4,  5,  6],
       [ 1,  2,  3]])
```

np.argsort()

- Returns the **indices** that would sort an array.

In [131]:

```
a = np.array([2,30,41,7,17,52])
a
```

Out[131]:

```
array([ 2, 30, 41,  7, 17, 52])
```

In [132]:

```
np.argsort(a)
```

Out[132]:

```
array([0, 3, 4, 1, 2, 5], dtype=int64)
```

Use Case: Fitness data analysis

In [133]:

```
!gdown 1kXqcJo4YzmwF1G2BPoA17CI49TZVHANF
```

```
'gdown' is not recognized as an internal or external command,
operable program or batch file.
```

In [134]:

```
data = np.loadtxt('fitness.txt', dtype='str')
```

In [135]:

```
data[:5]
```

Out[135]:

```
array([['06-10-2017', '5464', '200', '181', '5', '0', '66'],
       ['07-10-2017', '6041', '100', '197', '8', '0', '66'],
       ['08-10-2017', '25', '100', '0', '5', '0', '66'],
       ['09-10-2017', '5461', '100', '174', '4', '0', '66'],
       ['10-10-2017', '6915', '200', '223', '5', '500', '66']],
      dtype='<U10')
```

What's the shape of the data?

In [136]:

```
data.shape
```

Out[136]:

```
(96, 7)
```

There are 96 records and each record has 7 features. These features are:

- Date
- Step count
- Mood
- Calories Burned
- Hours of sleep
- activity status
- weight

In [137]:

```
data[0]
```

Out[137]:

```
array(['06-10-2017', '5464', '200', '181', '5', '0', '66'], dtype='<U10')
```

Whats the way to change columns to rows and rows to columns?

Transpose

In [138]:

```
data.T[0]
```

Out[138]:

```
array(['06-10-2017', '07-10-2017', '08-10-2017', '09-10-2017',
       '10-10-2017', '11-10-2017', '12-10-2017', '13-10-2017',
       '14-10-2017', '15-10-2017', '16-10-2017', '17-10-2017',
       '18-10-2017', '19-10-2017', '20-10-2017', '21-10-2017',
       '22-10-2017', '23-10-2017', '24-10-2017', '25-10-2017',
       '26-10-2017', '27-10-2017', '28-10-2017', '29-10-2017',
       '30-10-2017', '31-10-2017', '01-11-2017', '02-11-2017',
       '03-11-2017', '04-11-2017', '05-11-2017', '06-11-2017',
       '07-11-2017', '08-11-2017', '09-11-2017', '10-11-2017',
       '11-11-2017', '12-11-2017', '13-11-2017', '14-11-2017',
       '15-11-2017', '16-11-2017', '17-11-2017', '18-11-2017',
       '19-11-2017', '20-11-2017', '21-11-2017', '22-11-2017',
       '23-11-2017', '24-11-2017', '25-11-2017', '26-11-2017',
       '27-11-2017', '28-11-2017', '29-11-2017', '30-11-2017',
       '01-12-2017', '02-12-2017', '03-12-2017', '04-12-2017',
       '05-12-2017', '06-12-2017', '07-12-2017', '08-12-2017',
       '09-12-2017', '10-12-2017', '11-12-2017', '12-12-2017',
       '13-12-2017', '14-12-2017', '15-12-2017', '16-12-2017',
       '17-12-2017', '18-12-2017', '19-12-2017', '20-12-2017',
       '21-12-2017', '22-12-2017', '23-12-2017', '24-12-2017',
       '25-12-2017', '26-12-2017', '27-12-2017', '28-12-2017',
       '29-12-2017', '30-12-2017', '31-12-2017', '01-01-2018',
       '02-01-2018', '03-01-2018', '04-01-2018', '05-01-2018',
       '06-01-2018', '07-01-2018', '08-01-2018', '09-01-2018'],
      dtype='<U10')
```

In [42]:

```
#x = np.ones((5,5))
x = np.array([[2,6,4,9,6],[2,3,4,5,6],[2,3,4,5,6],[2,3,4,5,6],[2,8,4,7,6]])
x[1:-1,1:-1]
```

Out[42]:

```
array([[3, 4, 5],
       [3, 4, 5],
       [3, 4, 5]])
```

In [44]:

```
import numpy as np

def update_height(height,delta):

    height = np.array(height)

    delta = np.array(delta)

    new_height = height+delta

    return new_height
height = [3,4,5,6]
delta = [4,5,6,6]
update_height(height,delta)
```

Out[44]:

```
array([ 7,  9, 11, 12])
```

In [46]:

```
def update_height(hight, delta):
    new_height=[]
    for i in range(len(height)):
        new_height.append(height[i]+delta[i])
    return new_height

height = [3,4,5,6]
delta = [4,5,6,6]
update_height(height,delta)
```

Out[46]:

```
[7, 9, 11, 12]
```

In [143]:

```
1 (data.T)
```

Out[143]:

```
array([['06-10-2017', '07-10-2017', '08-10-2017', '09-10-2017',
        '10-10-2017', '11-10-2017', '12-10-2017', '13-10-2017',
        '14-10-2017', '15-10-2017', '16-10-2017', '17-10-2017',
        '18-10-2017', '19-10-2017', '20-10-2017', '21-10-2017',
        '22-10-2017', '23-10-2017', '24-10-2017', '25-10-2017',
        '26-10-2017', '27-10-2017', '28-10-2017', '29-10-2017',
        '30-10-2017', '31-10-2017', '01-11-2017', '02-11-2017',
        '03-11-2017', '04-11-2017', '05-11-2017', '06-11-2017',
        '07-11-2017', '08-11-2017', '09-11-2017', '10-11-2017',
        '11-11-2017', '12-11-2017', '13-11-2017', '14-11-2017',
        '15-11-2017', '16-11-2017', '17-11-2017', '18-11-2017',
        '19-11-2017', '20-11-2017', '21-11-2017', '22-11-2017',
        '23-11-2017', '24-11-2017', '25-11-2017', '26-11-2017',
        '27-11-2017', '28-11-2017', '29-11-2017', '30-11-2017',
        '01-12-2017', '02-12-2017', '03-12-2017', '04-12-2017',
        '05-12-2017', '06-12-2017', '07-12-2017', '08-12-2017',
        '09-12-2017', '10-12-2017', '11-12-2017', '12-12-2017',
        '13-12-2017', '14-12-2017', '15-12-2017', '16-12-2017',
        '17-12-2017', '18-12-2017', '19-12-2017', '20-12-2017',
        '21-12-2017', '22-12-2017', '23-12-2017', '24-12-2017',
        '25-12-2017', '26-12-2017', '27-12-2017', '28-12-2017',
        '29-12-2017', '30-12-2017', '31-12-2017', '01-01-2018',
        '02-01-2018', '03-01-2018', '04-01-2018', '05-01-2018',
        '06-01-2018', '07-01-2018', '08-01-2018', '09-01-2018'],
       ['5464', '6041', '25', '5461', '6915', '4545', '4340', '1230',
        '61', '1258', '3148', '4687', '4732', '3519', '1580', '2822',
        '181', '3158', '4383', '3881', '4037', '202', '292', '330',
        '2209', '4550', '4435', '4779', '1831', '2255', '539', '5464',
        '6041', '4068', '4683', '4033', '6314', '614', '3149', '4005',
        '4880', '4136', '705', '570', '269', '4275', '5999', '4421',
        '6930', '5195', '546', '493', '995', '1163', '6676', '3608',
        '774', '1421', '4064', '2725', '5934', '1867', '3721', '2374',
        '2909', '1648', '799', '7102', '3941', '7422', '437', '1231',
        '1696', '4921', '221', '6500', '3575', '4061', '651', '753',
        '518', '5537', '4108', '5376', '3066', '177', '36', '299',
        '1447', '2599', '702', '133', '153', '500', '2127', '2203'],
       ['200', '100', '100', '100', '200', '100', '100', '100', '100',
        '100', '100', '100', '300', '100', '100', '100', '100', '200',
        '200', '200', '200', '200', '200', '300', '200', '300', '300',
        '300', '300', '300', '300', '300', '200', '300', '300', '300',
        '300', '300', '300', '300', '300', '300', '300', '200', '300',
        '300', '300', '300', '300', '300', '300', '300', '300', '200',
        '100', '300', '300', '300', '300', '300', '300', '300', '100',
        '200', '200', '100', '100', '200', '200', '300', '200', '200',
        '100', '200', '100', '200', '200', '100', '100', '100', '100',
        '300', '200', '300', '200', '100', '100', '100', '200', '200',
        '100', '100', '300', '200', '200', '300'],
       ['181', '197', '0', '174', '223', '149', '140', '38', '1', '40',
        '101', '152', '150', '113', '49', '86', '6', '99', '143', '125',
        '129', '6', '9', '10', '72', '150', '141', '156', '57', '72',
        '17', '181', '197', '131', '154', '137', '193', '19', '101',
        '139', '164', '137', '22', '17', '9', '145', '192', '146', '234',
        '167', '16', '17', '32', '35', '220', '116', '23', '44', '131',
        '86', '194', '60', '121', '76', '93', '53', '25', '227', '125',
        '243', '14', '39', '55', '158', '7', '213', '116', '129', '21',
        '28', '16', '180', '138', '176', '99', '5', '1', '10', '47',
        '84', '23', '4', '0', '0', '0', '0'],
       ['5', '8', '5', '4', '5', '6', '6', '7', '5', '6', '8', '5', '6',
        '7', '5', '6', '8', '5', '4', '5', '6', '8', '5', '6', '5', '8',
        '5', '4', '5', '4', '5', '4', '3', '2', '9', '5', '6', '4', '5',
        '8', '4', '5', '6', '5', '6', '5', '6', '5', '6', '5', '6', '7',
        '6', '7', '6', '5', '6', '7', '8', '8', '7', '8', '5', '4', '3',
        '3', '4', '5', '5', '5', '3', '4', '4', '5', '5', '5', '5', '5',
        '5', '4', '3', '4', '5', '5', '4', '5', '3', '3', '3', '2', '3',
        '2', '8', '5', '5', '5'],
       ['0', '0', '0', '0', '500', '0', '0', '0', '0', '0', '0', '0',
        '500', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0',
        '0', '500', '0', '0', '0', '0', '500', '0', '0', '0', '0', '0',
        '500', '500', '500', '500', '500', '500', '500', '500', '500',
        '0', '0', '0', '0', '0', '0', '500', '500', '500', '500', '500',
        '500', '500', '500', '500', '500', '500', '500', '500', '0', '500',
        '500', '0', '500', '500', '500', '500', '500', '0', '500', '500',
        '500', '500', '0', '0', '0', '0', '500', '500', '500', '500',
        '0', '0', '0', '0', '0', '0', '0', '0', '500', '0', '500'],
       ['66', '66', '66', '66', '66', '66', '66', '66', '66', '65', '65',
        '65', '65', '65', '65', '65', '65', '64', '64', '64', '64',
        '64', '64', '64', '64', '64', '64', '64', '64', '64', '64', '64',
        '64', '64', '64', '64', '64', '64', '64', '64', '64', '64', '64',
        '64', '64', '64', '64', '64', '64', '64', '64', '64', '64', '64',
        '64', '64', '64', '64', '64', '64', '64', '64', '64', '64', '64',
        '64', '64', '64', '64', '64', '64', '64', '64', '64', '64', '64',
        '64', '64', '64', '64', '64', '64', '64', '64']], dtype='<U10')
```

In [139]:

```
date, step_count, mood, calories_burned, hours_of_sleep, activity_status, weight = data.T
```

In [144]:

```
step_count
```

Out[144]:

```
array(['5464', '6041', '25', '5461', '6915', '4545', '4340', '1230', '61',
       '1258', '3148', '4687', '4732', '3519', '1580', '2822', '181',
       '3158', '4383', '3881', '4037', '202', '292', '330', '2209',
       '4550', '4435', '4779', '1831', '2255', '539', '5464', '6041',
       '4068', '4683', '4033', '6314', '614', '3149', '4005', '4880',
       '4136', '705', '570', '269', '4275', '5999', '4421', '6930',
       '5195', '546', '493', '995', '1163', '6676', '3608', '774', '1421',
       '4064', '2725', '5934', '1867', '3721', '2374', '2909', '1648',
       '799', '7102', '3941', '7422', '437', '1231', '1696', '4921',
       '221', '6500', '3575', '4061', '651', '753', '518', '5537', '4108',
       '5376', '3066', '177', '36', '299', '1447', '2599', '702', '133',
       '153', '500', '2127', '2203'], dtype='<U10')
```

In [145]:

```
step_count.dtype
```

Out[145]:

```
dtype('<U10')
```

Because Numpy type-casted all the data to strings. It's a string type where U means Unicode String. and 10 means 10 bytes.

Step Count

In [146]:

```
step_count = np.array(step_count, dtype = 'int')
step_count.dtype
```

Out[146]:

```
dtype('int32')
```

In [147]:

```
step_count
```

Out[147]:

```
array([5464, 6041,   25, 5461, 6915, 4545, 4340, 1230,   61, 1258, 3148,
       4687, 4732, 3519, 1580, 2822,  181, 3158, 4383, 3881, 4037,  202,
        292,  330, 2209, 4550, 4435, 4779, 1831, 2255,  539, 5464, 6041,
       4068, 4683, 4033, 6314,  614, 3149, 4005, 4880, 4136,  705,  570,
        269, 4275, 5999, 4421, 6930, 5195,  546,  493,  995, 1163, 6676,
       3608,  774, 1421, 4064, 2725, 5934, 1867, 3721, 2374, 2909, 1648,
        799, 7102, 3941, 7422,  437, 1231, 1696, 4921,  221, 6500, 3575,
       4061,  651,  753,  518, 5537, 4108, 5376, 3066,  177,   36,  299,
       1447, 2599,  702,  133,  153,  500, 2127, 2203])
```

Calories Burned

In [148]:

```
calories_burned = np.array(calories_burned, dtype = 'int')
calories_burned.dtype
```

Out[148]:

```
dtype('int32')
```

Hours of Sleep

In [149]:

```
hours_of_sleep = np.array(hours_of_sleep, dtype = 'int')
hours_of_sleep.dtype
```

Out[149]:

```
dtype('int32')
```

Weight

In [150]:

```
weight = np.array(weight, dtype = 'int')
weight.dtype
```

Out[150]:

```
dtype('int32')
```

Mood

Mood is a categorical data type

In [151]:

```
mood
```

Out[151]:

```
array(['200', '100', '100', '100', '200', '100', '100', '100', '100',
       '100', '100', '100', '300', '100', '100', '100', '100', '200',
       '200', '200', '200', '200', '200', '300', '200', '300', '300',
       '300', '300', '300', '300', '300', '200', '300', '300', '200',
       '300', '300', '300', '300', '300', '300', '300', '300', '200',
       '100', '300', '300', '300', '300', '300', '300', '300', '100',
       '200', '200', '100', '100', '200', '200', '300', '200', '200',
       '100', '200', '100', '200', '200', '100', '100', '100', '100',
       '300', '200', '300', '200', '100', '100', '100', '200', '200',
       '100', '100', '300', '200', '200', '300'], dtype='<U10')
```

In [152]:

```
np.unique(mood)
```

Out[152]:

```
array(['100', '200', '300'], dtype='<U10')
```

In [153]:

```
mood[mood == '300'] = 'Happy'
```

In [154]:

```
mood[mood == '200'] = 'Neutral'
```

In [155]:

```
mood[mood == '100'] = 'Sad'
```

In [156]:

```
mood
```

Out[156]:

```
array(['Neutral', 'Sad', 'Sad', 'Sad', 'Neutral', 'Sad', 'Sad', 'Sad',
       'Sad', 'Sad', 'Sad', 'Sad', 'Happy', 'Sad', 'Sad', 'Sad', 'Sad',
       'Neutral', 'Neutral', 'Neutral', 'Neutral', 'Neutral', 'Neutral',
       'Happy', 'Neutral', 'Happy', 'Happy', 'Happy', 'Happy', 'Happy',
       'Happy', 'Happy', 'Neutral', 'Happy', 'Happy', 'Happy', 'Happy',
       'Happy', 'Happy', 'Happy', 'Happy', 'Happy', 'Happy', 'Neutral',
       'Happy', 'Happy', 'Happy', 'Happy', 'Happy', 'Happy', 'Happy',
       'Happy', 'Happy', 'Neutral', 'Sad', 'Happy', 'Happy', 'Happy',
       'Happy', 'Happy', 'Happy', 'Happy', 'Sad', 'Neutral', 'Neutral',
       'Sad', 'Sad', 'Neutral', 'Neutral', 'Happy', 'Neutral', 'Neutral',
       'Sad', 'Neutral', 'Sad', 'Neutral', 'Neutral', 'Sad', 'Sad', 'Sad',
       'Sad', 'Happy', 'Neutral', 'Happy', 'Neutral', 'Sad', 'Sad', 'Sad',
       'Neutral', 'Neutral', 'Sad', 'Sad', 'Happy', 'Neutral', 'Neutral',
       'Happy'], dtype='<U10')
```

Activity Status

Here 0 means Feeling of inactiveness

500 means Feeling of activeness

In [157]:

```
activity_status
```

Out[157]:

```
array(['0', '0', '0', '0', '500', '0', '0', '0', '0', '0', '0', '0',
       '500', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0',
       '500', '0', '0', '0', '0', '500', '0', '0', '0', '0', '0', '500',
       '500', '500', '500', '500', '500', '500', '500', '500', '0', '0',
       '0', '0', '0', '0', '500', '500', '500', '500', '500', '500',
       '500', '500', '500', '500', '500', '500', '0', '500', '500', '0',
       '500', '500', '500', '500', '500', '0', '500', '500', '500', '500',
       '0', '0', '0', '0', '500', '500', '500', '500', '0', '0', '0', '0',
       '0', '0', '0', '0', '500', '0', '500'], dtype='<U10')
```

In [158]:

```
activity_status[activity_status == '500'] = 'Active'
activity_status[activity_status == '0'] = 'Inactive'
```

In [159]:

```
activity_status
```

Out[159]:

```
array(['Inactive', 'Inactive', 'Inactive', 'Inactive', 'Active',
       'Inactive', 'Inactive', 'Inactive', 'Inactive', 'Inactive',
       'Inactive', 'Inactive', 'Active', 'Inactive', 'Inactive',
       'Inactive', 'Inactive', 'Inactive', 'Inactive', 'Inactive',
       'Inactive', 'Inactive', 'Inactive', 'Inactive', 'Inactive',
       'Active', 'Inactive', 'Inactive', 'Inactive', 'Inactive', 'Active',
       'Inactive', 'Inactive', 'Inactive', 'Inactive', 'Inactive',
       'Active', 'Active', 'Active', 'Active', 'Active', 'Active',
       'Active', 'Active', 'Active', 'Inactive', 'Inactive', 'Inactive',
       'Inactive', 'Inactive', 'Inactive', 'Active', 'Active', 'Active',
       'Active', 'Active', 'Active', 'Active', 'Active', 'Active',
       'Active', 'Active', 'Active', 'Inactive', 'Active', 'Active',
       'Inactive', 'Active', 'Active', 'Active', 'Active', 'Active',
       'Inactive', 'Active', 'Active', 'Active', 'Active', 'Inactive',
       'Inactive', 'Inactive', 'Inactive', 'Active', 'Active', 'Active',
       'Active', 'Inactive', 'Inactive', 'Inactive', 'Inactive',
       'Inactive', 'Inactive', 'Inactive', 'Inactive', 'Active',
       'Inactive', 'Active'], dtype='<U10')
```

EDA: Insights from the data.

What's the average step count?

In [160]:

```
step_count.mean()
```

Out[160]:

```
2935.9375
```

On which day the step count was highest?

In [161]:

```
step_count.argmax()

```

Out[161]:

```
69
```

In [162]:

```
date[step_count.argmax()]
```

Out[162]:

```
'14-12-2017'
```

Let's check the calorie burnt on the day

In [164]:

```
calories_burned[step_count.argmax()]
```

Out[164]:

```
243
```

Let's try to get the number of steps on that day as well

In [165]:

```
step_count.max()
```

Out[165]:

```
7422
```

What's the most frequent mood ?

One approach is for each of the category we get count of record and see which one is the highest

In [166]:

```
mood[mood == 'Sad'].shape
```

Out[166]:

```
(29,)
```

In [167]:

```
mood[mood == 'Neutral'].shape
```

Out[167]:

```
(27,)
```

In [168]:

```
mood[mood == 'Happy'].shape
```

Out[168]:

```
(40,)
```

Another approach:

In [169]:

```
np.unique(mood)
```

Out[169]:

```
array(['Happy', 'Neutral', 'Sad'], dtype='<U10')
```

We can get the count by passing in the parameter `return_counts = True`

In [170]:

```
np.unique(mood, return_counts = True)
```

Out[170]:

```
(array(['Happy', 'Neutral', 'Sad'], dtype='<U10'),
 array([40, 27, 29], dtype=int64))
```

The most frequent mood is Happy :)

Comparing step counts on bad mood days and good mood days

Average step count on Sad mood days

In [171]:

```
np.mean(step_count[mood == 'Sad'])
```

Out[171]:

```
2103.0689655172414
```

In [172]:

```
1 np.sort(step_count[mood == 'Sad'])
```

Out[172]:

```
array([  25,   36,   61,  133,  177,  181,  221,  299,  518,  651,  702,
        753,  799, 1230, 1258, 1580, 1648, 1696, 2822, 3148, 3519, 3721,
       4061, 4340, 4545, 4687, 5461, 6041, 6676])
```

In [173]:

```
1 np.std(step_count[mood == 'Sad'])
```

Out[173]:

```
2021.2355035376254
```

Average step count on happy days

In [174]:

```
1 np.mean(step_count[mood == 'Happy'])
```

Out[174]:

```
3392.725
```

In [175]:

```
1 np.sort(step_count[mood == 'Happy'])
```

Out[175]:

```
array([ 153,  269,  330,  493,  539,  546,  614,  705,  774,  995, 1421,
       1831, 1867, 2203, 2255, 2725, 3149, 3608, 4005, 4033, 4064, 4068,
       4136, 4275, 4421, 4435, 4550, 4683, 4732, 4779, 4880, 5195, 5376,
       5464, 5537, 5934, 5999, 6314, 6930, 7422])
```

Average step count on sad days - 2103.

Average step count on happy days - 3392

There may be relation between mood and step count

Let's try to check inverse. Mood when step count was greater/lesser

Mood when step count > 4000

In [176]:

```
1 np.unique(mood[step_count > 4000], return_counts = True)
```

Out[176]:

```
(array(['Happy', 'Neutral', 'Sad'], dtype='<U10'),
 array([22,  9,  7], dtype=int64))
```

Out of 38 days when step count was more than 4000, user was feeling happy on 22 days.

Mood when step count <= 2000

In [177]:

```
1 np.unique(mood[step_count < 2000], return_counts = True)
```

Out[177]:

```
(array(['Happy', 'Neutral', 'Sad'], dtype='<U10'),
 array([13,  8, 18], dtype=int64))
```

Out of 39 days, when step count was less than 2000, user was feeling sad on 18 days.

There may be a correlation between Mood and step count