Math-and-Computing-with-Jupyter

November 5, 2019

In [1]:
```
from __future__ import print_function

import numpy
import matplotlib.pyplot as plt
from __future__ import print_function
from ipywidgets import interact, interactive, fixed, interact_manual
import ipywidgets as widgets
import math
import numpy as np
import time
import pandas as pd
```

In [2]:
```
from IPython.display import HTML

HTML('''<script>
code_show=false;
function code_toggle() {
 if (code_show){
 $('div.input').hide();
 } else {
 $('div.input').show();
 }
 code_show = !code_show
}
$( document ).ready(code_toggle);
</script>
''')
```

Out[2]:
```
<IPython.core.display.HTML object>
```

In [3]:
```
HTML('''<form action="javascript:code_toggle()"><input type="submit" value="Click here
```

Out[3]:
```
<IPython.core.display.HTML object>
```

1 Teaching Math and Computing with Jupyter Hub

Joanna Klukowska
New York University, Courant Institute of Mathematical Sciences

1.1 Lecture Notes and Slides in a Single Document

- markdown
- mathematical notation
- graphics (generated graphs, data visualizations and standard images)
- code writing and execution

1.1.1 Markdown

- easy formatting using markdown ex. ## Slide title

```
- list item 1
- list item 2

Paragraph below with __bold__ and _italic_ text.
```

produces

1.1.2 Mathematical Notation

- mathematical notation using Latex, ex.

```
$$f(x) = \sum_{i=1}^{x}i^2 $$
```

produces

$$f(x) = \sum_{i=1}^{x}i^2 $$

1.1.3 Graphics

- include images using basic HTML
- generate plots of mathematical funcitons (later slides)
- generate data visualizations (later slides)

1.1.4 Code

- editing and execution in a single environment
- run the code in the slides !!!

```
In [ ]: name = input("What's your name? ")
        print("It is great to meet you " + name )
```

1.2 Examples

- credit card payments
- Citywide Payroll Data - a data set from NYC Open Data
- art of Hamid Naderi Yeganeh

1.3 Credit Card Payments - Interactive Mode

Problem Statement

At the end of the month Jane gets a credit card bill for \$200.00.

- How long will it take her to pay back this bill if the interest rate that the credit card charges is 4% per month and she makes a payment of \$50.00 each month?
- How long would it take if interest rate was 2% and she was paying $30.00 each month?
- Why do credit cards require a minimum payment each month? What would happen if someone wanter to pay less than that?

```
In [5]: HTML('''<form action="javascript:code_toggle()"><input type="submit" value="Click here
```

```
Out[5]: <IPython.core.display.HTML object>
```

```
In [6]: #%matplotlib inline
        def credit_card_payment(interest, payment ) :
            bill = 200.00
            total = 0.0
            balance = [bill]
            ind = 1
            while balance[ind-1] > 0 and ind < 120 :
                if balance[ind-1] >= payment:
                    balance.append( (balance[ind-1] - payment) * (1+interest) )
                    total += payment
                else :
                    balance.append( 0 )
                    total  += balance[ind-1]
                ind += 1
            balance.append(0)
            months = np.linspace(0, len(balance)-1, len(balance) )
            plt.figure(figsize=(8,4),dpi=150)
            plt.plot(months, balance, 'ro')
            plt.xlabel('Months/Payments')        # add title to the x-axis
            plt.ylabel('Remaining Balance')      # add title to the y-axis
            plt.show()
            print("Total paid: $", format(total,',.2f'), ".", sep="")

        interact(credit_card_payment, interest=(0.0,0.08,0.01), payment=(0.00, 100.00, 5) )
```

```
interactive(children=(FloatSlider(value=0.04, description='interest', max=0.08, step=0.01), Flo
```

```
Out[6]: <function __main__.credit_card_payment(interest, payment)>
```

1.4 Citywide Payroll Data - a data set from NYC Open Data

```
In [7]: data_file = pd.read_csv("../data/Citywide_Payroll_Data.csv", encoding = "ISO-8859-1")
        data_file
```

```
/opt/anaconda3/lib/python3.6/site-packages/IPython/core/interactiveshell.py:2785: DtypeWarning
  interactivity=interactivity, compiler=compiler, result=result)
```

```
Out[7]:          Fiscal Year  Payroll Number                    Agency Name  \
        0                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        1                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        2                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        3                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        4                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        5                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        6                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        7                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        8                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        9                2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        10               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        11               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        12               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        13               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        14               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        15               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        16               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        17               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        18               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        19               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        20               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        21               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        22               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        23               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        24               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        25               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        26               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        27               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        28               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        29               2016             NaN  DISTRICT ATTORNEY-MANHATTAN
        ...               ...             ...                          ...
        3333338          2019            57.0              FIRE DEPARTMENT
        3333339          2019            57.0              FIRE DEPARTMENT
        3333340          2019            57.0              FIRE DEPARTMENT
```

3333341	2019	72.0	DEPARTMENT OF CORRECTION
3333342	2019	56.0	POLICE DEPARTMENT
3333343	2019	72.0	DEPARTMENT OF CORRECTION
3333344	2019	72.0	DEPARTMENT OF CORRECTION
3333345	2019	57.0	FIRE DEPARTMENT
3333346	2019	57.0	FIRE DEPARTMENT
3333347	2019	72.0	DEPARTMENT OF CORRECTION
3333348	2019	56.0	POLICE DEPARTMENT
3333349	2019	56.0	POLICE DEPARTMENT
3333350	2019	56.0	POLICE DEPARTMENT
3333351	2019	742.0	DEPT OF ED PEDAGOGICAL
3333352	2019	57.0	FIRE DEPARTMENT
3333353	2019	56.0	POLICE DEPARTMENT
3333354	2019	56.0	POLICE DEPARTMENT
3333355	2019	56.0	POLICE DEPARTMENT
3333356	2019	56.0	POLICE DEPARTMENT
3333357	2019	57.0	FIRE DEPARTMENT
3333358	2019	57.0	FIRE DEPARTMENT
3333359	2019	57.0	FIRE DEPARTMENT
3333360	2019	56.0	POLICE DEPARTMENT
3333361	2019	56.0	POLICE DEPARTMENT
3333362	2019	56.0	POLICE DEPARTMENT
3333363	2019	56.0	POLICE DEPARTMENT
3333364	2019	56.0	POLICE DEPARTMENT
3333365	2019	56.0	POLICE DEPARTMENT
3333366	2019	56.0	POLICE DEPARTMENT
3333367	2019	56.0	POLICE DEPARTMENT

	Last Name	First Name	Mid Init	Agency Start Date	\
0	ABA'AHMID	RAHASHEEM	E	07/14/2003	
1	ABENSUR	MARGARET	NaN	06/12/1995	
2	ABOUNAOUM	ANDREA	L	10/11/2011	
3	ABRAHAM	JONATHAN	J	12/01/2014	
4	ABRAMS	JOSEPH	NaN	05/21/2015	
5	ABREU	JENNIFER	NaN	09/04/2012	
6	ABREU	JUAN	D	09/04/2007	
7	ACEVEDO	JENNIFER	NaN	06/06/2016	
8	ACOCELLA	MATTHEW	J	09/02/2014	
9	ACOSTA	RITA	E	05/31/1978	
10	ADAMS	KATHERINE	J	04/22/2013	
11	ADAMS	NEERESHA	NaN	08/25/2014	
12	ADEGBORO	OYINDAMOLA	F	01/13/2014	
13	AGGARWAL	SANCHITA	J	03/28/2005	
14	AGUILAR	YAMIRA	NaN	11/09/2009	
15	AGUIRRE	JORDAN	NaN	05/21/2015	
16	AHMETAJ	ARTEMIS	NaN	04/28/2014	
17	AHN	HELEN	H	09/07/2004	
18	ALCAIDE	SANDRA	NaN	05/21/2015	

19	ALCANTARA	DANIEL	NaN	01/19/2007
20	ALEXANDER	ERIN	L	09/02/2014
21	ALFLEN	PAUL	R	09/21/2008
22	ALI	SHEHARYAR	NaN	06/06/2016
23	ALI	SYEED	A	03/02/2009
24	AL-KAABAH II	JEFFREY	I	06/08/2015
25	NaN	NaN	NaN	08/06/2001
26	ALKHAFAJEE	ABEER	K	08/16/2010
27	ALKHAFAJEE	SHAIMAA	NaN	01/14/2008
28	ALLEN	BENNETT	L	10/20/2014
29	ALLEN	ROBERT	K	01/21/1980
...	...	...	...	...
3333338	LYONS	MICHAEL	J	11/22/1998
3333339	MCKIE	JOSEPH	A	12/05/1988
3333340	GIAMPAOLO	RICHARD	A	08/19/1990
3333341	KNIGHT	LINDA	NaN	12/07/2000
3333342	LAPPIN	ROBERT	NaN	07/18/1996
3333343	FILOSA	EDWARD	NaN	11/20/2008
3333344	BEACHAM	KAREN	NaN	05/26/2011
3333345	CARNEY	CHRISTOPHER	A	01/21/2008
3333346	CASSIDY	STEPHEN	J	02/18/1988
3333347	KHAN	JOAN	L	06/07/2001
3333348	PARGA	DENISE	R	04/30/1995
3333349	BISHOP	DONALD	T	07/13/1981
3333350	COLBAN	KEVIN	R	04/15/1997
3333351	PERAZZO	MICHAEL	J	02/01/1991
3333352	JAKUBOWSKI	DAVID	W	09/02/1978
3333353	WILLIAMSON	ALVANZA	T	06/30/1995
3333354	CROWLEY	MATTHEW	NaN	04/25/1990
3333355	CADIGAN-TELECHE	KATHLEEN	A	01/20/2004
3333356	HENNIG	BLAINE	F	11/30/1992
3333357	CORR	STEPHEN	J	09/19/1988
3333358	DAVIDSON	MICHAEL	R	05/04/2003
3333359	RUGGIRELLO JR	LOUIS	J	04/14/1991
3333360	ROGERS	PETER	J	06/30/1995
3333361	OTERO	DORIS	NaN	07/16/1999
3333362	PARRINO	FRED	T	10/15/1990
3333363	VIOLA	FRANK	P	01/13/1992
3333364	CAINES	CHARLES	L	04/02/1995
3333365	WALKER III	JOHN	J	04/15/1997
3333366	HALLEY	JAMES	M	07/28/1987
3333367	RIOS	DONALD	NaN	01/26/1981

	Work Location Borough \
0	MANHATTAN
1	MANHATTAN
2	MANHATTAN
3	MANHATTAN

4	MANHATTAN
5	MANHATTAN
6	MANHATTAN
7	MANHATTAN
8	MANHATTAN
9	MANHATTAN
10	MANHATTAN
11	MANHATTAN
12	MANHATTAN
13	MANHATTAN
14	MANHATTAN
15	MANHATTAN
16	MANHATTAN
17	MANHATTAN
18	MANHATTAN
19	MANHATTAN
20	MANHATTAN
21	MANHATTAN
22	MANHATTAN
23	MANHATTAN
24	MANHATTAN
25	MANHATTAN
26	MANHATTAN
27	MANHATTAN
28	MANHATTAN
29	MANHATTAN
...	...
3333338	BROOKLYN
3333339	BROOKLYN
3333340	BROOKLYN
3333341	QUEENS
3333342	MANHATTAN
3333343	QUEENS
3333344	QUEENS
3333345	BROOKLYN
3333346	BROOKLYN
3333347	QUEENS
3333348	MANHATTAN
3333349	QUEENS
3333350	MANHATTAN
3333351	OTHER
3333352	BROOKLYN
3333353	MANHATTAN
3333354	MANHATTAN
3333355	MANHATTAN
3333356	MANHATTAN
3333357	BROOKLYN
3333358	BROOKLYN

```
3333359              BROOKLYN
3333360             MANHATTAN
3333361             MANHATTAN
3333362             MANHATTAN
3333363             MANHATTAN
3333364             MANHATTAN
3333365             MANHATTAN
3333366             MANHATTAN
3333367             MANHATTAN

                                          Title Description  \
0        COMMUNITY ASSOCIATE                                ...
1        ADMINISTRATIVE ACCOUNTANT                          ...
2        COMMUNITY ASSOCIATE                                ...
3        COMPUTER SYSTEMS MANAGER                           ...
4        COLLEGE AIDE                                       ...
5        ASSISTANT DISTRICT ATTORNEY                        ...
6        ASSISTANT DISTRICT ATTORNEY                        ...
7        COLLEGE AIDE                                       ...
8        COMMUNITY ASSOCIATE                                ...
9                  PRINCIPAL ADMINISTRATIVE ASSOCIATE
10       COMMUNITY ASSOCIATE                                ...
11       COMMUNITY ASSOCIATE                                ...
12       COMMUNITY COORDINATOR                              ...
13       PRINCIPAL ACCOUNTANT INVESTIGATOR                  ...
14       COMMUNITY ASSOCIATE                                ...
15       COLLEGE AIDE                                       ...
16       COMMUNITY ASSISTANT                                ...
17       ASSISTANT DISTRICT ATTORNEY                        ...
18       COLLEGE AIDE                                       ...
19       COMMUNITY ASSOCIATE                                ...
20       ASSISTANT DISTRICT ATTORNEY                        ...
21       CARPENTER                                          ...
22       COLLEGE AIDE                                       ...
23       ELECTRICIAN'S HELPER                               ...
24       COMMUNITY ASSOCIATE                                ...
25                    RACKETS INVESTIGATOR
26       COMMUNITY ASSOCIATE                                ...
27       COMMUNITY ASSISTANT                                ...
28       COMMUNITY COORDINATOR                              ...
29            CLERICAL ASSOCIATE
...                                                         ...
3333338                                             CAPTAIN
3333339                                      BATTALION CHIEF
3333340                          SUPERVISING FIRE MARSHAL
3333341                                CORRECTION OFFICER
3333342                                        SERGEANT-
3333343                                CORRECTION OFFICER
```

3333344	CORRECTION OFFICER
3333345	FIREFIGHTER
3333346	FIREFIGHTER
3333347	WARDEN-ASSISTANT DEPUTY WARDEN TED < 11/1/92
3333348	CAPTAIN
3333349	P.O. DA DET GR3
3333350	POLICE OFFICER
3333351	ASSISTANT PRINCIPAL
3333352	DEPUTY CHIEF
3333353	POLICE OFFICER
3333354	POLICE OFFICER
3333355	POLICE OFFICER
3333356	POLICE OFFICER
3333357	FIREFIGHTER
3333358	LIEUTENANT
3333359	FIREFIGHTER
3333360	POLICE OFFICER
3333361	POLICE OFFICER
3333362	SERGEANT-
3333363	POLICE OFFICER D/A DETECTIVE 2ND GR
3333364	SERGEANT-
3333365	P.O. DA DET GR3
3333366	POLICE OFFICER D/A DETECTIVE 1ST GR
3333367	POLICE OFFICER D/A DETECTIVE 1ST GR

	Leave Status as of June 30	Base Salary	Pay Basis	Regular Hours	\
0	ACTIVE	47678.00	per Annum	1830.00	
1	ACTIVE	119959.00	per Annum	1831.00	
2	ON LEAVE	39966.00	per Annum	1181.68	
3	ACTIVE	116000.00	per Annum	1831.00	
4	CEASED	1.00	per Hour	0.00	
5	ACTIVE	71500.00	per Annum	1831.00	
6	ACTIVE	88000.00	per Annum	1831.00	
7	ACTIVE	1.00	per Hour	0.00	
8	CEASED	41000.00	per Annum	349.00	
9	ACTIVE	66035.00	per Annum	1830.00	
10	CEASED	38869.00	per Annum	200.70	
11	ACTIVE	42075.00	per Annum	1830.00	
12	ACTIVE	66625.00	per Annum	1830.00	
13	ACTIVE	112592.00	per Annum	1831.00	
14	ACTIVE	52548.00	per Annum	1830.00	
15	CEASED	1.00	per Hour	0.00	
16	ACTIVE	43299.00	per Annum	1830.00	
17	ACTIVE	102500.00	per Annum	1076.00	
18	CEASED	1.00	per Hour	0.00	
19	ACTIVE	40299.00	per Annum	1830.00	
20	ACTIVE	78000.00	per Annum	1509.00	
21	ACTIVE	370.16	per Day	1830.00	

22	ACTIVE	1.00	per Hour	0.00
23	ACTIVE	217.70	per Day	1830.00
24	ACTIVE	53366.00	per Annum	1829.75
25	CEASED	59945.00	per Annum	0.00
26	CEASED	45985.00	per Annum	38.10
27	ACTIVE	36154.00	per Annum	1830.00
28	ACTIVE	65600.00	per Annum	1830.00
29	ACTIVE	56017.00	per Annum	1830.00
...	...	...	...	...
3333338	CEASED	114319.00	per Annum	1114.30
3333339	CEASED	163454.00	per Annum	1611.45
3333340	CEASED	119596.00	per Annum	565.73
3333341	CEASED	85292.00	per Annum	40.00
3333342	CEASED	109360.00	per Annum	0.00
3333343	CEASED	85292.00	per Annum	40.00
3333344	CEASED	85292.00	per Annum	280.00
3333345	CEASED	85292.00	per Annum	817.17
3333346	CEASED	85292.00	per Annum	0.00
3333347	CEASED	121875.00	per Annum	520.00
3333348	CEASED	158693.00	per Annum	0.00
3333349	CEASED	58733.00	per Annum	0.00
3333350	CEASED	70717.00	per Annum	0.00
3333351	CEASED	131797.00	per Annum	0.00
3333352	CEASED	181172.00	per Annum	1234.32
3333353	CEASED	77253.00	per Annum	0.00
3333354	CEASED	77253.00	per Annum	0.00
3333355	CEASED	78806.00	per Annum	0.00
3333356	CEASED	78806.00	per Annum	0.00
3333357	CEASED	82808.00	per Annum	0.00
3333358	CEASED	90457.00	per Annum	0.00
3333359	CEASED	85292.00	per Annum	0.00
3333360	CEASED	78026.00	per Annum	0.00
3333361	CEASED	80788.00	per Annum	0.00
3333362	CEASED	98072.00	per Annum	0.00
3333363	CEASED	98072.00	per Annum	0.00
3333364	CEASED	101044.00	per Annum	0.00
3333365	CEASED	92184.00	per Annum	0.00
3333366	CEASED	108244.00	per Annum	0.00
3333367	CEASED	121875.00	per Annum	0.00

	Regular Gross Paid	OT Hours	Total OT Paid	Total Other Pay
0	47166.03	2.25	57.28	0.00
1	119042.50	0.00	0.00	0.00
2	27452.62	1.00	21.34	33.00
3	115104.57	0.00	0.00	0.00
4	3500.00	0.00	0.00	0.00
5	71967.34	0.00	0.00	0.00
6	87614.01	0.00	0.00	750.00

7	500.00	0.00	0.00	0.00
8	9507.15	0.00	0.00	0.00
9	64357.12	0.00	0.00	3824.72
10	6073.13	0.00	0.00	8.25
11	39895.79	0.00	0.00	74.25
12	65909.63	0.00	0.00	33.00
13	111806.82	0.00	0.00	500.00
14	51890.77	716.25	25943.55	747.93
15	3500.00	0.00	0.00	0.00
16	40052.01	51.75	1413.40	526.11
17	59023.02	0.00	0.00	0.00
18	3500.00	0.00	0.00	0.00
19	39866.21	0.00	0.00	0.00
20	64498.36	0.00	0.00	1750.00
21	139072.14	408.75	50546.28	5060.37
22	1000.00	0.00	0.00	0.00
23	56602.00	173.75	8991.82	7424.72
24	46271.84	276.50	7757.06	755.84
25	7412.58	0.00	13.01	340.12
26	4661.03	1.00	169.90	94.40
27	35765.73	0.00	0.00	0.00
28	64895.59	0.00	0.00	99.50
29	55411.18	0.00	0.00	4424.50
...	...	...	...	...
3333338	82999.83	0.00	0.00	-118452.72
3333339	129421.05	0.00	0.00	-165634.25
3333340	65592.33	0.00	0.00	-101861.95
3333341	11551.98	0.00	0.00	-48668.74
3333342	0.00	0.00	0.00	-39599.15
3333343	3271.48	0.00	0.00	-48439.86
3333344	13085.89	0.00	0.00	-58290.04
3333345	35052.23	0.00	0.00	-82334.33
3333346	23957.51	0.00	0.00	-76675.41
3333347	32722.62	0.00	0.00	-89308.72
3333348	0.00	0.00	0.00	-65277.12
3333349	0.00	0.00	0.00	-70579.40
3333350	0.00	0.00	0.00	-73496.73
3333351	-76223.05	0.00	0.00	0.00
3333352	110690.66	0.00	0.00	-187536.86
3333353	0.00	0.00	0.00	-80289.65
3333354	0.00	0.00	0.00	-80289.65
3333355	0.00	0.00	0.00	-81903.70
3333356	0.00	0.00	0.00	-81903.70
3333357	0.00	0.00	0.00	-82057.04
3333358	4030.81	0.00	0.00	-88139.26
3333359	0.00	0.00	0.00	-88644.65
3333360	0.00	0.00	0.00	-90854.21
3333361	0.00	0.00	0.00	-92505.67

```
3333362                0.00       0.00           0.00       -101927.00
3333363                0.00       0.00           0.00       -101927.00
3333364                0.00       0.00           0.00       -105015.82
3333365                0.00       0.00           0.00       -105407.64
3333366                0.00       0.00           0.00       -112498.84
3333367               95.06       0.00           0.00       -138055.57

[3333368 rows x 17 columns]
```

extract the entries for:

- annual salary (vs. hourly pay)
- year 2018
- active employees

```
In [8]: data_2018 = data_file
        print(format("entire data set:",'20s'), format(len(data_2018),'9,d'), "entries")
        data_2018=data_2018[ data_file['Pay Basis']=='per Annum']
        print(format("annual salaries:",'20s'), format(len(data_2018),'9,d'), "entries")
        data_2018 = data_2018[data_2018['Fiscal Year']==2018]
        print(format("year 2018:",'20s'), format(len(data_2018),'9,d'), "entries")
        data_2018 = data_2018[data_2018['Leave Status as of June 30']=='ACTIVE']
        print(format("active employees:",'20s'), format(len(data_2018),'9,d'), "entries")
```

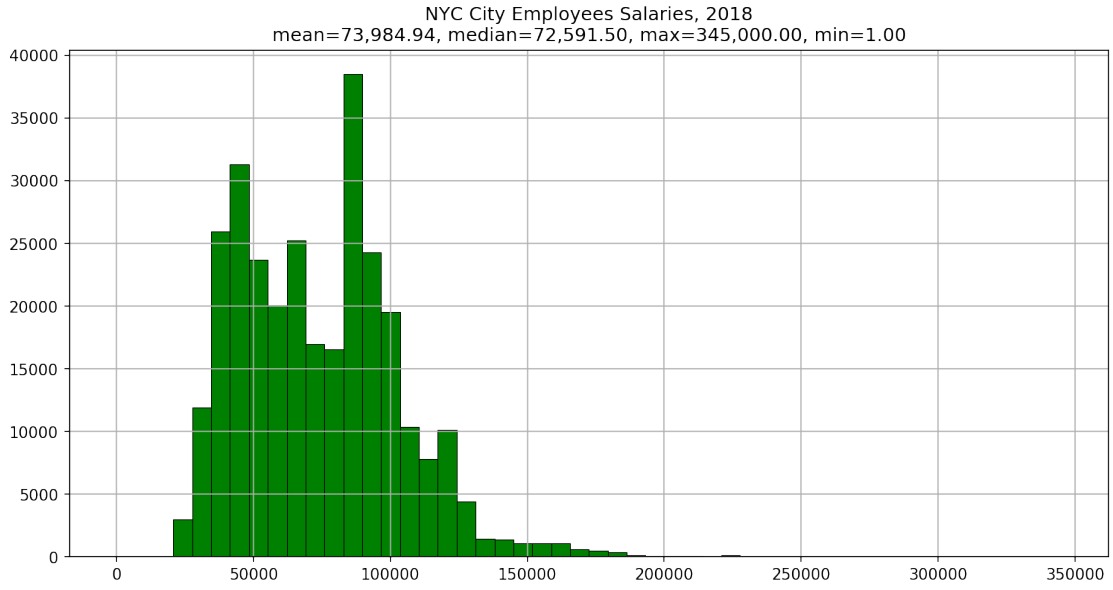
```
entire data set:     3,333,368 entries
annual salaries:       790,398 entries
year 2018:             334,051 entries
active employees:      298,096 entries
```

1.4.1 Histogram of all salaries

```
In [9]: HTML('''<form action="javascript:code_toggle()"><input type="submit" value="Click here
```

```
Out[9]: <IPython.core.display.HTML object>
```

```
In [10]: plt.figure(figsize=(12,6),dpi=150)
         data_2018['Base Salary'].hist(bins=50,color='green' ,
                     edgecolor='black', linewidth=0.5)
         mean = data_2018['Base Salary'].mean()
         median = data_2018['Base Salary'].median()
         max = data_2018['Base Salary'].max()
         min = data_2018['Base Salary'].min()
         plt.title('NYC City Employees Salaries, 2018\nmean='+format(mean,",.2f")+
                     ", median=" + format(median,",.2f")+
                     ", max=" + format(max,",.2f")+ ", min=" + format(min,",.2f") )
         plt.show()
```



In [11]:
```
data_2018[data_2018['Base Salary']==1]
```

Out[11]:

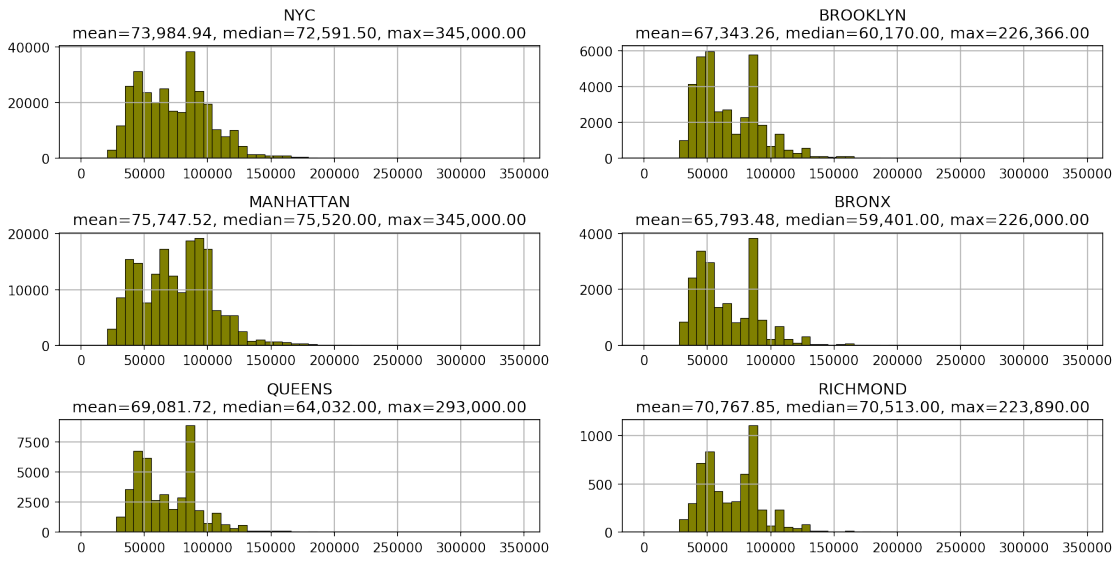
	Fiscal Year	Payroll Number	Agency Name	Last Name	First Name	Mid Init	Agency Start Date	Work Location Borough	Title Description	Leave Status as of June 30	Base Salary	Pay Basis	Regular Hours	Regular Gross Paid	OT Hours	Total OT Paid	Total Other Pay
2194906	2018	2.0	OFFICE OF THE MAYOR	BEEN	VICKI	L	02/07/2017	MANHATTAN	SPECIAL ASSISTANT	ACTIVE	1.0	per Annum	1.0	1.0	0.0	0.0	1000.0
2339350	2018	740.0	DEPARTMENT OF EDUCATION ADMIN	BEYER	CHARLOTTE	B	09/10/2013	BROOKLYN	INVESTMENT TRUSTEE - DEFERRED COMPENSATION	ACTIVE	1.0	per Annum	1.0	1.0	0.0	0.0	0.0

1.4.2 Borough Breakdown

In [12]:
```
HTML('''<form action="javascript:code_toggle()"><input type="submit" value="Click here
```

Out[12]: <IPython.core.display.HTML object>

```
In [13]: maxSal = data_2018['Base Salary'].max()
         fig, axis = plt.subplots(nrows=3,ncols=2,figsize=(12,6),dpi=150)
         bor = ["NYC", "MANHATTAN", "QUEENS","BROOKLYN", "BRONX", "RICHMOND" ]

         data_2018['Base Salary'].hist(bins=50, range=(0,maxSal), color='olive' ,
                     edgecolor='black', linewidth=0.5, ax = axis[0][0])
         mean = data_2018['Base Salary'].mean()
         median = data_2018['Base Salary'].median()
         mx = data_2018['Base Salary'].max()
         mi = data_2018['Base Salary'].min()
         axis[0][0].set_title( bor[0]+"\nmean="+format(mean,',.2f')+", median="+format(median,
                                    ", max="+format(mx,',.2f'));

         for i in range (1,6):
             df = data_2018[ data_2018['Work Location Borough']==bor[i]]
             df['Base Salary'].hist(bins=50, range=(0,maxSal),color='olive' , edgecolor='black
             mean = df['Base Salary'].mean()
             median = df['Base Salary'].median()
             mx = df['Base Salary'].max()
             mi = df['Base Salary'].min()
             axis[i%3][i//3].set_title( bor[i]+"\nmean="+format(mean,',.2f')+", median="+forma
                                    ", max="+format(mx,',.2f'));
         fig.tight_layout()
         plt.show()
```

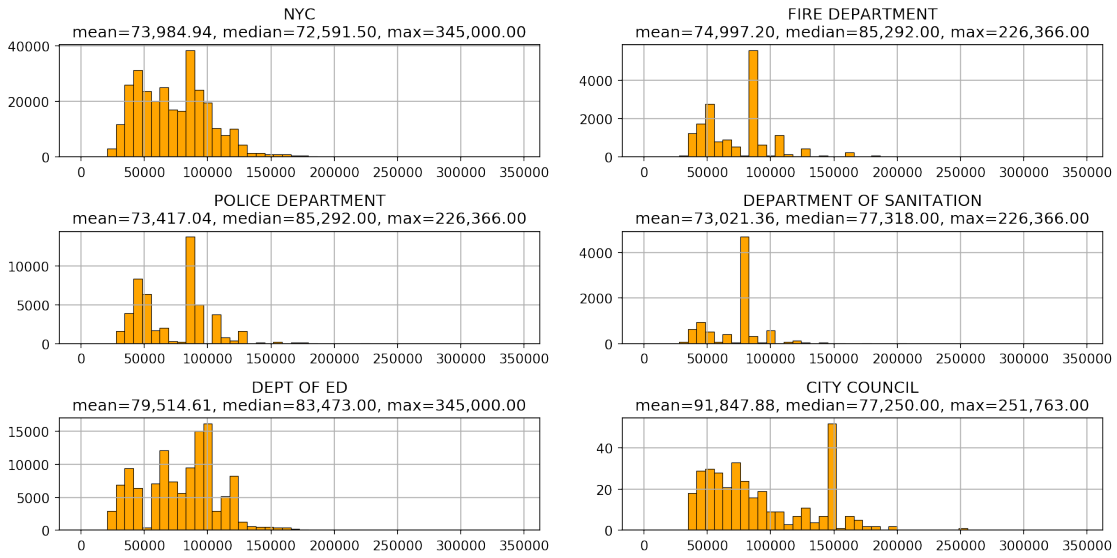


1.4.3 by Department Breakdown

```
In [14]: HTML('''<form action="javascript:code_toggle()"><input type="submit" value="Click here
```

Out[14]: <IPython.core.display.HTML object>

In [15]:
```
fig, axis = plt.subplots(nrows=3,ncols=2,figsize=(12,6),dpi=150)
ag = ["NYC", 'POLICE DEPARTMENT', 'DEPT OF ED', 'FIRE DEPARTMENT', 'DEPARTMENT OF SANI

data_2018['Base Salary'].hist(bins=50, range=(0,maxSal),color='orange' ,
            edgecolor='black', linewidth=0.5, ax = axis[0][0])
mean = data_2018['Base Salary'].mean()
median = data_2018['Base Salary'].median()
mx = data_2018['Base Salary'].max()
mi = data_2018['Base Salary'].min()
axis[0][0].set_title( ag[0]+"\nmean="+format(mean,',.2f')+", median="+format(median,'
                              ", max="+format(mx,',.2f'));
for i in range (1,6):
    df = data_2018[ data_2018['Agency Name'].str.contains(ag[i])]
    df['Base Salary'].hist(bins=50, range=(0,maxSal),color='orange' , edgecolor='blac
    mean = df['Base Salary'].mean()
    median = df['Base Salary'].median()
    mx = df['Base Salary'].max()
    mi = df['Base Salary'].min()
    axis[i%3][i//3].set_title( ag[i]+"\nmean="+format(mean,',.2f')+", median="+format
                              ", max="+format(mx,',.2f'));

fig.tight_layout()
plt.show()
```

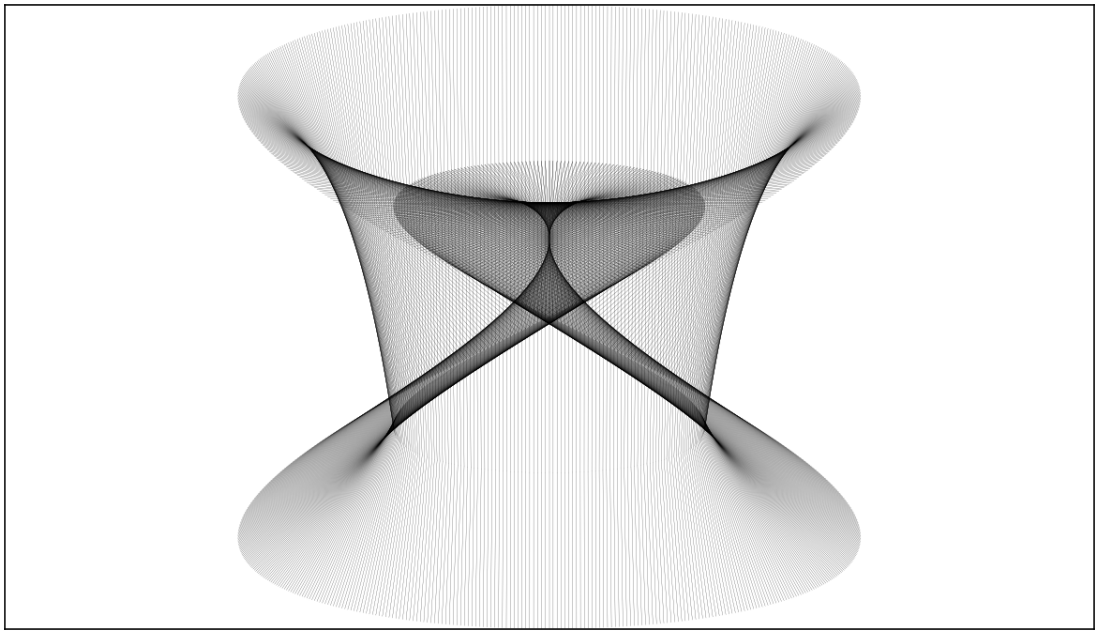


1.5 Would you call this image a work of art?

1.6 Art of Hamid Naderi Yeganeh

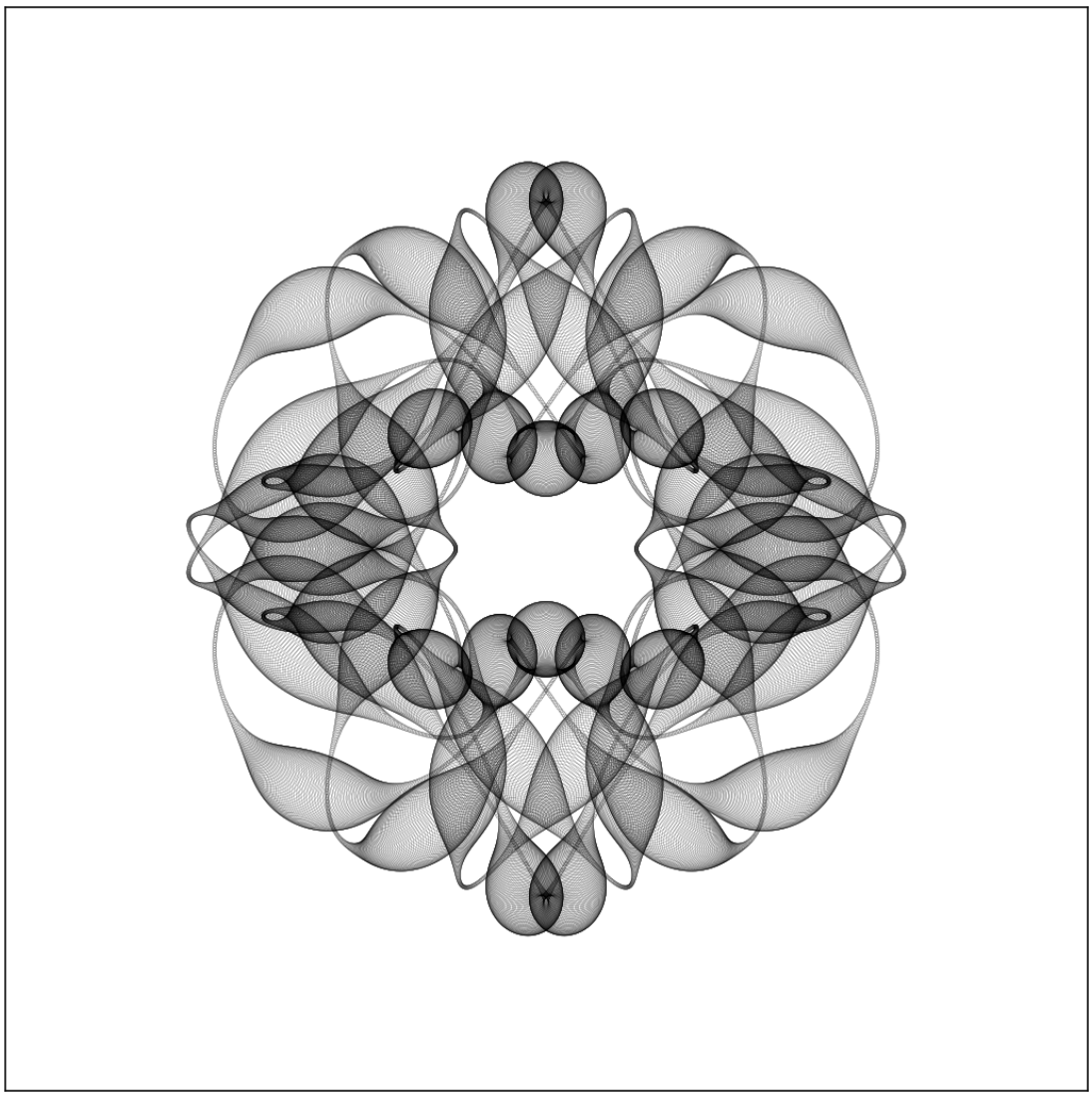
Can math or an algorithm produce art?

```
In [16]: fig, ax = plt.subplots(figsize=(10,8), dpi=150)
         ax.set_xlim(-1.75,1.75)
         ax.set_ylim(-1,1)
         ax.set_aspect(1)
         plt.xticks([])
         plt.yticks([])
         for i in range (1000) :
             x1 = -1 * math.sin(4 * math.pi * i/1000)
             y1 = -1 * math.cos(2 * math.pi * i/1000)
             x2 = (-1/2)*math.sin(8 * math.pi * i/1000)
             y2 = (-1/2)*math.cos(4 * math.pi * i/1000)
             d = np.array([[x1,y1], [x2,y2]])
             plt.plot(d[:,0],d[:,1], color='black', linewidth=0.1)
         plt.show()
```



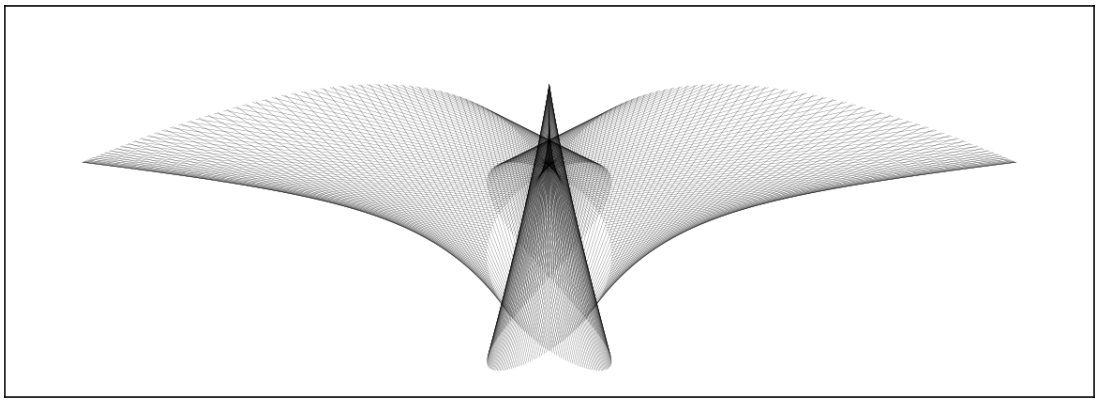
```
In [17]: fig, ax = plt.subplots(figsize=(10,9),dpi=150)
         ax.set_xlim(-1.5, 1.5)
         ax.set_ylim(-1.5,1.5)
         ax.set_aspect(1)
         plt.xticks([])
         plt.yticks([])
```

```
count = 10000
for k in range (10000) :
    x = math.cos(14 * math.pi * k / count) * (1 - 3/4 * (math.cos(20*math.pi*k/count)
    y = math.sin(14 * math.pi * k / count) * (1 - 3/4 * (math.cos(24*math.pi*k/count)
    r = 1/200 + 1/10 * (math.sin(54*math.pi*k/count)**6)

    circle = plt.Circle((x, y), r, color='black', fill=False,linewidth=0.1)
    ax.add_artist(circle)
    #fig.canvas.draw()
plt.show()
```



In [18]:
```
#%matplotlib notebook
fig, ax = plt.subplots(figsize=(10,4),dpi=150)
```

```
ax.set_xlim(-1.75,1.75)
ax.set_ylim(-.75,.5)
ax.set_aspect(1)
plt.xticks([])
plt.yticks([])
for i in range (500) :
    x1 = 3/2 * (math.sin(2 * math.pi * i/500 + math.pi / 3))**7
    y1 = 1/4 * (math.cos(6 * math.pi * i/500) )**2
    x2 = 1/5 * math.sin(6 * math.pi * i/500 + math.pi/5)
    y2 = (-2/3)*(math.sin(2 * math.pi * i/500 - math.pi/3 ) )**2
    d = np.array([[x1,y1], [x2,y2]])
    plt.plot(d[:,0],d[:,1], color='black', linewidth=0.1)
    fig.canvas.draw()

plt.show()
```



2 Thank you!

```
In [19]: print ("Any questions?")
```

```
Any questions?
```