Metadata

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- GitHub Repo URL: https://github.com/bmcgregor22/DS5100_Final_Project_BM3PK

The Monte Carlo Module

In [43]:
```
import pandas as pd
import numpy as np

class Die():
    """
    This class define method for a die object, which represents a variety of ra
    The constructor takes a array object of faces as an argument.

    Attributes:
    -----------
    self.die_obj - the data defining an instance of die as a data frame
    self.faces - an array object of faces established an instance creation. The

    Methods:
    -----------
    init_(self, faces) - initializes the class taking an array of faces as an a
    change_weight(self, a_side, a_weight) - changes the weight of one of the si
    roll_die(self, num_rolls=1) - rolls an instance of a die the number of time
    show_die(self) - displays the die's current defintion of faces and weights
    """

    def __init__(self, faces):
        """
        This is the initializer method for class Die. It creates an instance of
        """

        #save the values in the array as a unique set of values
        self.faces=np.unique(faces)

        #create a die object data frame and initialize all weightd to 1
        self.die_df=pd.DataFrame({'face':self.faces, 'weight':1.0})


    def change_weight(self, a_face, a_weight):
        """
        This method changes the weight of one of the sides of the die to the sp
```

```
        arg[1] specifies  the face that is to be changed
        arg[2] specified the weight that the face will be changed
        """

        self.face=a_face
        self.weight=a_weight

        #check to see that the provided side is defined for the die object.
        if self.face in self.die_df.set_index('face').index:

            #update the value of weight in the data frame to the weight given b
            self.die_df.loc[self.die_df['face'] == self.face, ['weight']] = sel


        else :
            #if the face does not exist in the array then exit
            raise Exception("Value for face not in the face array. Must specify

        #verify that the value passes as a_weight can be converted to a float
        try:
            float(a_weight)
        except:

            # if the conversion to float fails, then exit
            raise Exception("Invalid argument specificed for weight. Weight mus



    def roll_die(self, num_rolls=1):
        """
        Method to roll the die by a specified number of times. The default numb
        """

        self.num_rolls = num_rolls
        outcomes = []


        for i in range(self.num_rolls):
            result = self.die_df.face.sample(weights=self.die_df.weight).values
            outcomes.append(result)
        return outcomes


    def show_die(self):
        """
        Method to show the current set of die faces and weights, reflecting any
        """

        return self.die_df

class Game():
    """
    A class representing a game. A game consists of rolling one or more die of
    but each die may have different weights.

    Attributes
    ----------
    self.die_objects - a list of die objects created by the Die class, defined
```

```
    Methods
    ---------
     __init__(self,l_die_objects) - intializer method to create the game instar

    play(self, num_rolls) - rolls reach die the number of times specified by th

    show_results(self, format="W') - displays the results of the game in wide f

    """

    def __init__(self, l_die_objects):
        """
        Create the game instance based on a list of die objects
        """

        #initialize the game with a list of similarily defined  die objects.
        self.die_objects = l_die_objects

    def play(self,num_rolls):
        """
        Rolls each of the die objects the num_rolls number of times.

        _game_results - private data frame to store results

        """

        #pass in the number of times the dice should be rolled
        self.num_rolls = num_rolls

        #create a data frame to store the game results and set the first columr
        self._game_results = pd.DataFrame({'Roll Number':range(1, self.num_roll


        #for each die object, call the roll_die method and roll the number of t
        for i in range(len(self.die_objects)):

            #get a list of the results of each die object rolled the specified
            results = self.die_objects[i].roll_die(self.num_rolls)

            #create a column for results for each die and concatenate it to the
            self.results = pd.Series(results, name=i+1)
            self._game_results=pd.concat([self._game_results, self.results],axi

        #make the roll number the named index for the data frame
        self._game_results.set_index(['Roll Number'],inplace=True)

        #rename the column axis with descriptive label
        self._game_results.rename_axis(columns="Die Number", inplace=True)


    def show(self, format='W'):
        """
        Displays the result of the data frame in narrow or wide format. Wide fo
        specified as  W for wide, or N for narrow.

        Wide format will have a single column index with the roll number, and e
        Narrow format will have a two-column index with the roll number and die
        rolled

        _game_results_narrow - private dataframe to store the narrow format wit
```

```
        """

        self.format = format
        if self.format == 'W':

            return self._game_results

        elif self.format =='N':

            #convert to a narrow format
            _game_results_narrow = self._game_results.stack().to_frame('Face Ro

            return _game_results_narrow
        else:
            raise TypeError("Invalid argument specificed for format. Format arg


class Analyzer():
    """
    Analyzes the results of a game and produces various statistics about the ga

    Attributes
    ---------
    face_counts_per_roll_df - a dataframe storing the count of the  number of f

    jackpot - the number of jackpots rolled

    jackpot_df - an data frame storing the number of jackpots

    combo_df = a dataframe storing the distinct combinations rolled and their c


    Methods
    ---------
    __init__ (self, a_game_object) - constructor method based on being passed a

    face_counts_per_roll(self) - method to compute how many times a given face

    jackpot(self) - method to compute the number of jackpots in a game

    combo(self) - method to compute the number of distinct combinations produce

    """

    def __init__(self, a_game_object):
        """
        Creates an instance of the Analyzer class provided the game results.

        Arg1 - a game object instance
        """

        #store the dataframe results in the narrow and wide format
        self.game_results_data_n = a_game_object.show('N')
        self.game_results_data_w = a_game_object.show()



    def face_counts_per_roll(self):
        """
```

```
        Computes how many times a given face is rolled in each event. Returns t
        """

        self.face_counts_per_roll_df = \
        self.game_results_data_n.\
        groupby(['Roll Number','Face Rolled']).\
        value_counts().\
        reset_index(name='Counts')

        return self.face_counts_per_roll_df


    def jackpot(self):
        """
        Compute the number of jackpots (rolls with the all the faces of the sam
        """

        #use apply function to compute the lengths of each set, sets with lengt
        jackpot_df= self.game_results_data_w.apply(lambda x: len(set(x)), axis=
        to_frame("jackpot")

        #filter data frame to just the sets of length 1 = these are the jackpot
        jackpot_df=jackpot_df[jackpot_df['jackpot']==1]

        #length of the data frame is the number of jackpots in game
        jackpot = len(jackpot_df)

        return jackpot


    def combo(self):
        """
        Computes the number of distinct combinatinos. Returns the combo_df data
        """

        combo_df = self.game_results_data_w.apply(lambda x: x.sort_values().squ
        value_counts().to_frame('n')

        return combo_df
```

Test Module

In [ ]:

```
import unittest
import pandas as pd
import numpy as np
from montecarlo import Die, Game, Analyzer

class MonteCarloTestSuite(unittest.TestCase):
    '''
    This test suite executes unit tests to verify that all class methods are wo
    '''


    def test_1_create_die_set_weights(self):
        '''
        Unit test to test the initializer method for the Die Class.
        Verify that weights are set to 1 upon object creation for every face of
        '''
```

```
        #create a test die
        test1 = Die(pd.array(data=[1,2,3,4,5,6]))
        print (test1.die_df)

        #test
        message = "The test result is false"

        # check to see if any weights are not equal to 1.0
        if  any(test1.die_df.loc[:,'weight']) != 1.0 :
            test_value = True
        else:
            test_value = False
        self.assertFalse(test_value, message)

    def test_2_change_die_weight(self):
        '''
        Unit test to test method change_weight for the Die class.
        Create a die change its weight passing an integer
        '''
        #create a test die
        test1 = Die(pd.array(data=[1,2,3,4,5,6]))
        print ("Printing the die before changing weight")
        print (test1.die_df)

        #change the weight of the first face to 3
        face = 1
        weight=3
        test1.change_weight(face,weight)

        #test that the resulting weight is a float
        expected = 3.0

        #extract the weight based on the value of the first face

        test_value = test1.die_df[test1.die_df.face==face].weight.item()

        print (test_value)
        self.assertEqual(test_value, expected)
        print ("Printing the die after weight of first face is changed")
        print (test1.die_df)

    def test_3_roll_die(self):
        '''
        Unit test to test the roll_die() method of the Die Class.
        Create a test tie and roll it 10 times. Verify that the resulting outco
        '''
        #create a test die
        test1 = Die(pd.array(data=[1,2,3,4,5,6]))
        print (test1.die_df)
        #roll die 10 times
        outcomes = test1.roll_die(10)
        print ("Printing Outcomes :" + str(outcomes))

        # test
        message = "The test result is false"

        # check to see if 10 results were generated
        self.assertTrue(len(outcomes)==10, message)
```

```
    def test_4_show_die(self):
        """
        Unit test to test that the show_die method returns expected results.
        Create a test die with default weights, change the weights and then sho
        """
        #create a six sided test die
        test1 = Die(pd.array(data=[1,2,3,4,5,6]))
        print (test1.die_df)

        #change weights of three faces of the die
        test1.change_weight(1,2)
        test1.change_weight(2,3)
        test1.change_weight(3,4)

        #test results are a set of tuples with expected results of the die, thr
        expected = [(1,2),(2,3),(3,4),(4,1),(5,1),(6,1)]

        #create a list of tuples of faces and weights from show die method
        df = test1.show_die()
        test_value = list(zip(df.reset_index().face, df.weight))

        #compare the set of tuples to check they are equal
        self.assertEqual(test_value, expected)
        print (test1.die_df)

    def test_5_create_game(self):
        """
         Unit test to test if a game object was initialized correctly from the
         Create a game with three indentical die and verify that three die obje
        """
        # create three 6 sided die
        sides = [1,2,3,4,5,6]
        myDie1 = Die(sides)
        myDie2 = Die(sides)
        myDie3 = Die(sides)

        # create list of three test tie
        test_die = [myDie1, myDie2, myDie3]

        # initialize a game object of three die and check the number of die obj
        test_game = Game(test_die)
        test = len(test_game.die_objects)

        expected = 3
        self.assertEqual(test,expected)

    def test_6_play_game(self):
        """
        Unit test to verify the result of the play method of the Game class.
        Create a game of 2 die and roll them 5 time verify the results includes
        """
        # create two 6 sided die
        sides = [1,2,3,4,5,6]
        myDie1 = Die(sides)
        myDie2 = Die(sides)

        # create list of two test tie
        test_die = [myDie1, myDie2]

        # initialize a game object of two die
```

```
        test_game = Game(test_die)

        #conduct the test
        test_game.play(5)
        test_results = test_game._game_results
        print("printing the test results\n"+ str(test_results))

        test=test_results.size

        #a 10 element data frame is expected from the game results
        expected = 10

        self.assertEqual(test,expected)

    def test_7_show(self):
        """
        Unit test to verify the results of the show method for specifying the N
        Play a game and check the resulting data frame size for a narrow format
        """
         # create two 6 sided die
        sides = [1,2,3,4,5,6]
        myDie1 = Die(sides)
        myDie2 = Die(sides)

        # create list of two test tie
        test_die = [myDie1, myDie2]

        # initialize a game object of two die
        test_game = Game(test_die)

        #conduct the test
        test_game.play(5)
        test_results = test_game.show('N')
        print("printing the test results\n"+ str(test_results))
        test=test_results.size

        #a 10 element data frame is expected from the game results
        expected = 10

        self.assertEqual(test,expected)

    def test_8_analyzer(self):
        """
        Unit test to verify the result of the analyzer object initialization
        """
        # create two 6 sided die
        sides = [1,2,3,4,5,6]
        myDie1 = Die(sides)
        myDie2 = Die(sides)

        # create list of two test tie
        test_die = [myDie1, myDie2]

        # initialize a game object of two die
        test_game = Game(test_die)
        test_game.play(5)

        #conduct the test - check the size of the data frame
        test_analysis = Analyzer(test_game)
        test= test_analysis.game_results_data_n.size
```

```
        #a 10 element data frame is expected from the game results
        expected = 10

        self.assertEqual(test,expected)

    def test_9_face_counts_per_roll(self):
        """
        Unit test to verify face counts per role method produces correct result
        """
        # create two 6 sided die
        sides = [1,2,3,4,5,6]
        myDie1 = Die(sides)
        myDie2 = Die(sides)

        # create list of two test tie
        test_die = [myDie1, myDie2]

        # initialize a game object of two die
        test_game = Game(test_die)
        test_game.play(5)

        #generate the analyzer object
        test_analysis = Analyzer(test_game)
        test= test_analysis.face_counts_per_roll().size

        message="Test Failed"
        #check to see that the method returned a populated dataframe
        self.assertTrue(test > 0, message)

    def test_10_jackpot(self):
        """
        Unit test to verify jackpot return an integer
        """
        # create two 6 sided die
        sides = [1,2,3,4,5,6]
        myDie1 = Die(sides)
        myDie2 = Die(sides)

        # create list of two test tie
        test_die = [myDie1, myDie2]

        # initialize a game object of two die
        test_game = Game(test_die)
        test_game.play(5)

        #generate the analyzer object
        test_analysis = Analyzer(test_game)

        message="Test Failed"
        #check to see that the method returned a populated dataframe
        self.assertTrue(isinstance(test_analysis.jackpot(), int), message)

    def test_11_combo(self):
        """
        Unit test to verify combo returns a populated dataframe
        """
        # create two 6 sided die
        sides = [1,2,3,4,5,6]
        myDie1 = Die(sides)
```

```
        myDie2 = Die(sides)

        # create list of two test tie
        test_die = [myDie1, myDie2]

        # initialize a game object of two die
        test_game = Game(test_die)
        test_game.play(5)

        #generate the analyzer object
        test_analysis = Analyzer(test_game)
        test=test_analysis.combo().size

        message="Test Failed"
        #check to see that the method returned a populated dataframe
        self.assertTrue(test > 0, message)



if __name__ == '__main__':
    unittest.main(verbosity=3)
```

Test Results

test_10_jackpot (**main**.MonteCarloTestSuite) Unit test to verify jackpot return an integer ... ok test_11_combo (**main**.MonteCarloTestSuite) Unit test to verify combo returns a populated dataframe ... ok test_1_create_die_set_weights (**main**.MonteCarloTestSuite) Unit test to test the initializer method for the Die Class. ... ok test_2_change_die_weight (**main**.MonteCarloTestSuite) Unit test to test method change_weight for the Die class. ... /Users/brucemcgregor/opt/anaconda3/lib/python3.9/site-packages/pandas/core/indexes/base.py:6982: FutureWarning: In a future version, the Index constructor will not infer numeric dtypes when passed object-dtype sequences (matching Series behavior) return Index(sequences[0], name=names) ok test_3_roll_die (**main**.MonteCarloTestSuite) Unit test to test the roll_die() method of the Die Class. ... ok test_4_show_die (**main**.MonteCarloTestSuite) Unit test to test that the show_die method returns expected results. ... /Users/brucemcgregor/opt/anaconda3/lib/python3.9/site-packages/pandas/core/indexes/base.py:6982: FutureWarning: In a future version, the Index constructor will not infer numeric dtypes when passed object-dtype sequences (matching Series behavior) return Index(sequences[0], name=names) /Users/brucemcgregor/opt/anaconda3/lib/python3.9/site-packages/pandas/core/indexes/base.py:6982: FutureWarning: In a future version, the Index constructor will not infer numeric dtypes when passed object-dtype sequences (matching Series behavior) return Index(sequences[0], name=names) /Users/brucemcgregor/opt/anaconda3/lib/python3.9/site-packages/pandas/core/indexes/base.py:6982: FutureWarning: In a future version, the Index constructor will not infer numeric dtypes when passed object-dtype sequences (matching Series behavior) return Index(sequences[0], name=names) ok test_5_create_game (**main**.MonteCarloTestSuite) Unit test to test if a game object was initialized correctly from

the Game class. ... ok test_6_play_game (**main**.MonteCarloTestSuite) Unit test to verify the result of the play method of the Game class. ... ok test_7_show (**main**.MonteCarloTestSuite) Unit test to verify the results of the show method for specifying the Narrow format option ... ok test_8_analyzer (**main**.MonteCarloTestSuite) Unit test to verify the result of the analyzer object initialization ... ok test_9_face_counts_per_roll (**main**.MonteCarloTestSuite) Unit test to verify face counts per role method produces correct results ... ok

---

Ran 11 tests in 0.056s

OK

Scenarios

Code blocks with your scenarios and their outputs.

These should have appropriate import statements even though the code is now in the same notebook as the classes it calls.

Scenario 1

In [44]:
```
#Scenario 1: 2-headed Coin
import matplotlib.pyplot as plt
from montecarlo import Die, Game, Analyzer

sides = ['H','T']
fair_die=Die(sides)
unfair_die=Die(sides)
```

In [45]:
```
fair_die.show_die()
```

Out[45]:

	face	weight
0	H	1.0
1	T	1.0

In [46]:
```
unfair_die.change_weight('H',5)
```

In [47]:
```
unfair_die.show_die()
```

Out[47]:

	face	weight
0	H	5.0
1	T	1.0

In [48]:
```
#game is set-up for 1000 flips of three coins 1000 times
n_dice=3
n1=1000
```

In [49]:
```
#scenario 1 , game 1 - three coins with all fair dice
game_1_1_dice=([fair_die for i in range(n_dice)])
```

In [50]:
```
#create and run the first game
game_1_1 = Game(game_1_1_dice)
```

In [51]:
```
game_1_1.play(n1)
game_1_1.show()
```

Out[51]:

Die Number	1	2	3
Roll Number			
1	H	T	T
2	H	T	H
3	T	H	T
4	T	T	T
5	H	H	T
...	...	...	...
996	H	T	T
997	T	T	H
998	H	T	T
999	H	H	H
1000	H	T	T

1000 rows × 3 columns

In [52]:
```
#scenario 1 game 2 -
#set up game die for game 2
#create two unfair die and 1 fair die

game_1_2_dice=([unfair_die for i in range(2)])
game_1_2_dice
```

Out[52]:
```
[<montecarlo.montecarlo.Die at 0x7ff590177880>,
 <montecarlo.montecarlo.Die at 0x7ff590177880>]
```

In [53]:
```
#add a third die which is fair
game_1_2_dice.append(fair_die)
```

In [54]:
```
#create and run the second game
game_1_2 = Game(game_1_2_dice)
game_1_2.play(n1)
game_1_2.show()
```

Out[54]:

Die Number	1	2	3
Roll Number			
1	H	H	H
2	H	H	H
3	T	H	H
4	H	H	H
5	H	H	T
...	...	...	...
996	H	T	T
997	H	H	T
998	T	H	T
999	T	H	T
1000	T	H	T

1000 rows × 3 columns

In [55]:
```
#use the analyzer to determine the relative frequency of jackpots
#analyze games
game_1_1_analysis = Analyzer(game_1_1)
game_1_2_analysis = Analyzer(game_1_2)
```

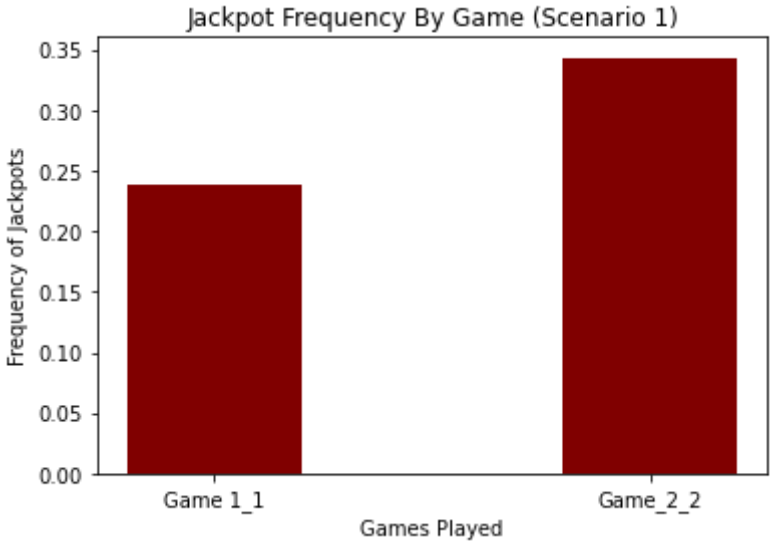
In [56]:
```
#compute the jackpots and their relative frequency
jp_1_1 = game_1_1_analysis.jackpot()
jp_1_2 = game_1_2_analysis.jackpot()
freq_jp_1_1 = jp_1_1/n1
freq_jp_1_2 = jp_1_2/n1
```

In [57]:
```
#plot the results for scenario 1

# creating the dataset
data = {'Game 1_1':freq_jp_1_1, 'Game_2_2':freq_jp_1_2}
games = list(data.keys())
freq = list(data.values())

# creating the bar plot
plt.bar(games, freq, color ='maroon',
        width = 0.4)

plt.xlabel("Games Played")
plt.ylabel("Frequency of Jackpots")
plt.title("Jackpot Frequency By Game (Scenario 1)")
plt.show()
```



Scenario 2

In [58]:
```
#Scenario 2: Six Sided Die
import matplotlib.pyplot as plt
from montecarlo import Die, Game, Analyzer

sides = [1,2,3,4,5,6]
fair_die=Die(sides)
unfair_die1=Die(sides)
unfair_die2=Die(sides)
```

In [59]:
```
#change the weights of the unfair die
unfair_die1.change_weight(6,5)  #Type 1 - side 6 is weighted five more times th
unfair_die2.change_weight(1,5)  #Type 2 - side 1 is weighted five more times th
```

In [60]:
```
unfair_die1.show_die()
```

Out[60]:

	face	weight
0	1	1.0
1	2	1.0
2	3	1.0
3	4	1.0
4	5	1.0
5	6	5.0

In [61]:
```
unfair_die2.show_die()
```

Out[61]:

	face	weight
0	1	5.0
1	2	1.0
2	3	1.0
3	4	1.0
4	5	1.0
5	6	1.0

In [62]:
```
#scenario two will use 5 die rolled 10,000
n2=10000
n_dice=5
```

In [63]:
```
#Scenario 2, Game 1 - 5 fair die
game_2_1=Game([fair_die for i in range(n_dice)])
```

In [72]:
```
game_2_1.play(n2)
game_2_1.show()
```

Out[72]:

Die Number	1	2	3	4	5
Roll Number					
1	5	1	5	6	4
2	2	1	6	5	6
3	2	6	1	6	6
4	4	5	3	5	6
5	2	2	5	2	5
...	...	...	...	...	...
9996	4	1	3	4	1
9997	3	6	1	1	3
9998	2	2	6	1	4
9999	6	4	2	1	2
10000	2	5	2	6	3

10000 rows × 5 columns

In [73]:
```
#Analyze Game 2_1
game_2_1_analysis = Analyzer(game_2_1)
```

In [74]:
```
jp_2_1 = game_2_1_analysis.jackpot()
freq_jp_2_1 = jp_2_1/n2
```

In [75]:
```
jp_2_1
```

Out[75]: 7

In [76]:
```
freq_jp_2_1
```

Out[76]:
```
0.0007
```

In [77]:
```
#Scenario 2 - Game 2 - 2 unfair dice of type 1, 1 unfair dice of type 2 and 2 f
Game_2_die_set =[fair_die for  i in range(2)]
```

In [78]:
```
#two unfair die of type 1
Game_2_die_set_u1 = [unfair_die1 for i in range(2)]
```

In [79]:
```
#1 unfair die of type2
Game_2_die_set_u2 = [unfair_die2 for i in range(1)]
```

In [80]:
```
[Game_2_die_set.extend(l) for l in (Game_2_die_set_u1,Game_2_die_set_u2)]
```

Out[80]:
```
[None, None]
```

In [81]:
```
Game_2_die_set
```

Out[81]:
```
[<montecarlo.montecarlo.Die at 0x7ff5900648e0>,
 <montecarlo.montecarlo.Die at 0x7ff5900648e0>,
 <montecarlo.montecarlo.Die at 0x7ff590064730>,
 <montecarlo.montecarlo.Die at 0x7ff590064730>,
 <montecarlo.montecarlo.Die at 0x7ff590064d00>]
```

In [82]:
```
Game_2_die_set
game_2_2=Game(Game_2_die_set)
game_2_2.play(n2)
game_2_2.show()
```

Out[82]:

Die Number	1	2	3	4	5
Roll Number					
1	6	2	6	4	3
2	5	2	2	2	1
3	5	6	3	6	1
4	6	5	6	5	5
5	1	4	6	6	1
...	...	...	...	...	...
9996	4	6	6	5	6
9997	6	2	5	6	6
9998	2	6	1	5	1
9999	6	1	6	3	1
10000	5	1	6	4	1

10000 rows × 5 columns

In [83]:
```
#Analyze Game 2_2
game_2_2_analysis = Analyzer(game_2_2)
```

```
jp_2_2 = game_2_2_analysis.jackpot()
freq_jp_2_2 = jp_2_2/n2
```

In [84]:
```
jp_2_2
```

Out[84]:
```
10
```

In [85]:
```
freq_jp_2_2
```

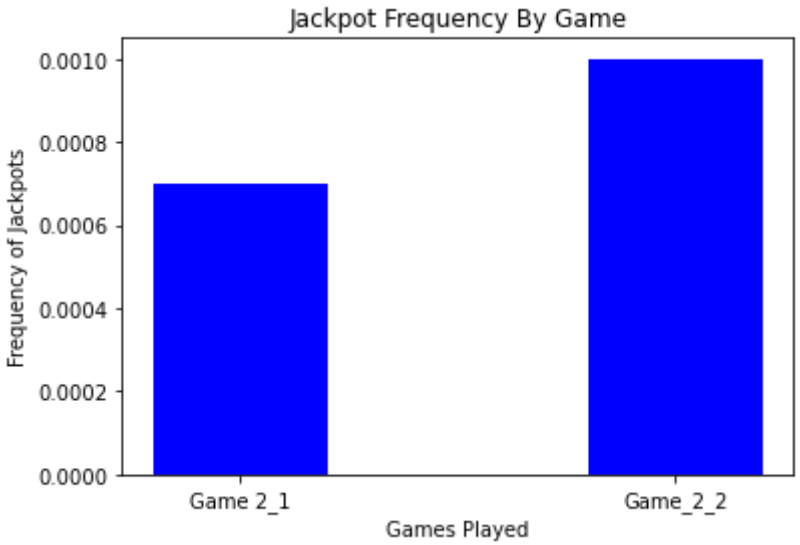
Out[85]:
```
0.001
```

In [88]:
```
#plot the results
import matplotlib.pyplot as plt

# creating the dataset
data = {'Game 2_1':freq_jp_2_1, 'Game_2_2':freq_jp_2_2}
games = list(data.keys())
freq = list(data.values())

# creating the bar plot
plt.bar(games, freq, color ='blue',
        width = 0.4)

plt.xlabel("Games Played")
plt.ylabel("Frequency of Jackpots")
plt.title("Jackpot Frequency By Game")
plt.show()
```



In [89]:
```
#compute combinations game 1
game_2_1_combos = game_2_1_analysis.combo()
game_2_1_combos
```

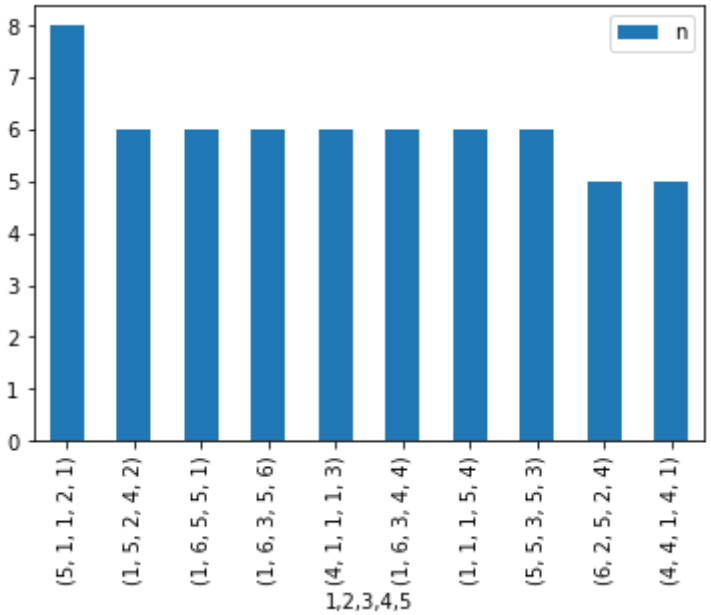
Out[89]:

					n
5	1	1	2	1	8
1	5	2	4	2	6
	6	5	5	1	6
		3	5	6	6
4	1	1	1	3	6
...	...	...	...	...	...
3	5	1	3	4	1
			4	2	1
				5	1
		2	2	1	1
6	6	6	6	6	1

5635 rows × 1 columns

In [90]:
```
#plot the bar chart
x=game_2_1_combos.head(10)
x.plot.bar()
```

Out[90]:
```
<AxesSubplot:xlabel='1,2,3,4,5'>
```



In [91]:
```
#compute combinations game 2
game_2_2_combos = game_2_2_analysis.combo()
game_2_2_combos
```

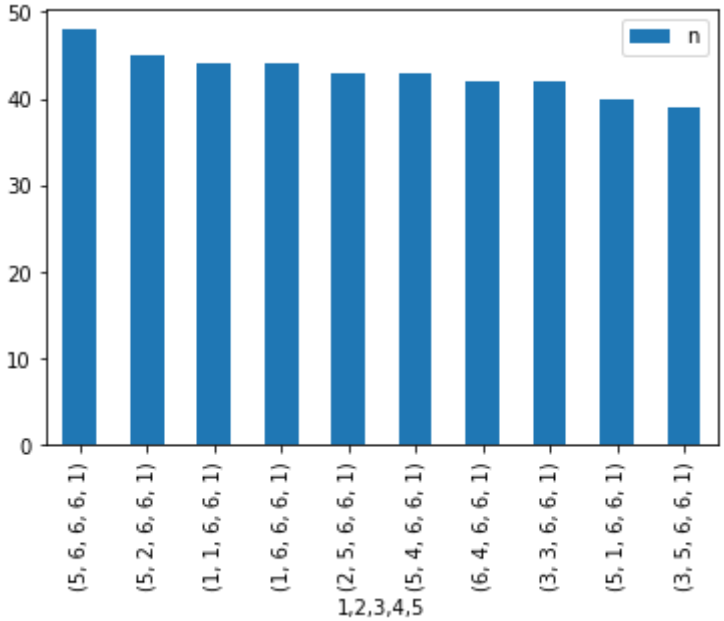
Out[91]:

					n
5	6	6	6	1	48
	2	6	6	1	45
1	1	6	6	1	44
	6	6	6	1	44
2	5	6	6	1	43
...	...	...	...	...	...
4	4	6	4	3	1
2	4	1	2	2	1
4	4	6	3	6	1
				5	1
3	6	6	4	4	1

3727 rows × 1 columns

In [92]:
```
#plot the bar chart
x=game_2_2_combos.head(10)
x.plot.bar()
```

Out[92]:
```
<AxesSubplot:xlabel='1,2,3,4,5'>
```



Scenario 3

In [94]:
```
#scenario 3: Roman Alphabet
import matplotlib.pyplot as plt
from montecarlo import Die, Game, Analyzer
```

```
import string
sides = list(string.ascii_lowercase)
```

In [95]:
```
roman_die=Die(sides)
n3=1000
```

In [96]:
```
letter_freq_dict={"a":8.4966,
                  "b":2.0720,
                  "c":4.5388,
                  "d":3.3844,
                  "e":11.1607,
                  "f":1.8121,
                  "g":2.4705,
                  "h":3.0034,
                  "i":7.5448,
                  "j":0.1965,
                  "k":1.1016,
                  "l":5.4893,
                  "m":3.0129,
                  "n":6.6544,
                  "o":7.1635,
                  "p":3.1671,
                  "q":0.1962,
                  "r":7.5809,
                  "s":5.7351,
                  "t":6.9509,
                  "u":3.6308,
                  "v":1.0074,
                  "w":1.2899,
                  "x":0.2902,
                  "y":1.7779,
                  "z":0.2722
                 }
```

In [97]:
```
#set the weights of the die based on the frequency table
for x in letter_freq_dict:
    roman_die.change_weight(x,letter_freq_dict[x] )
```

In [98]:
```
roman_die.show_die()
```

Out[98]:

	face	weight
0	a	8.4966
1	b	2.0720
2	c	4.5388
3	d	3.3844
4	e	11.1607
5	f	1.8121
6	g	2.4705
7	h	3.0034
8	i	7.5448
9	j	0.1965
10	k	1.1016
11	l	5.4893
12	m	3.0129
13	n	6.6544
14	o	7.1635
15	p	3.1671
16	q	0.1962
17	r	7.5809
18	s	5.7351
19	t	6.9509
20	u	3.6308
21	v	1.0074
22	w	1.2899
23	x	0.2902
24	y	1.7779
25	z	0.2722

In [100…
```
#create a game with 5 roman die
game_3_die_set = [roman_die for i in range(5)]
```

In [101…
```
game_3=Game(game_3_die_set)
game_3.play(n3)
```

In [102…
```
game_3_results=game_3.show()
game_3_results
```

Out[102]:

Die Number	1	2	3	4	5
Roll Number					
1	o	s	r	i	i
2	n	b	t	b	c
3	s	m	s	u	c
4	i	n	p	r	g
5	m	c	a	b	d
...	...	...	...	...	...
996	d	s	e	e	d
997	c	w	i	n	g
998	e	r	r	d	a
999	v	i	s	r	t
1000	e	c	o	e	o

1000 rows × 5 columns

In [103…

```
game_3_results.sample(10)
```

Out[103]:

Die Number	1	2	3	4	5
Roll Number					
954	o	u	p	o	r
90	w	a	c	o	f
945	i	t	a	k	s
238	g	t	e	a	m
720	o	d	r	o	r
282	l	e	t	d	n
583	u	r	l	w	t
11	l	a	h	l	s
321	r	i	n	l	r
988	i	v	n	t	u

In [104…

```
game_3_results.sample(10)
```

Out[104]:

Roll Number	Die Number 1	2	3	4	5
813	r	p	l	g	r
140	t	r	u	p	i
273	p	e	e	c	n
560	w	l	b	r	c
567	l	d	f	c	s
511	e	u	g	i	n
709	f	p	m	s	r
267	r	f	e	p	s
136	a	e	i	a	r
452	e	e	i	s	m

In [105…

```
game_3_results.sample(10)
```

Out[105]:

Roll Number	Die Number 1	2	3	4	5
712	d	t	e	a	e
760	o	a	r	s	o
176	a	e	e	e	b
24	r	h	g	o	o
706	s	i	i	e	n
718	n	e	a	p	b
667	h	r	l	t	l
793	g	l	d	e	r
341	r	n	s	o	s
56	i	i	e	l	c

In [106…

```
game_3_results.sample(10)
```

Out[106]:

Roll Number	Die Number 1	2	3	4	5
326	p	e	e	d	u
991	a	a	a	a	o
150	f	y	k	i	u
833	y	c	r	p	n
499	o	t	i	t	t
937	c	s	u	s	m
6	r	v	e	t	y
136	a	e	i	a	r
997	c	w	i	n	g
943	v	a	i	i	s

In [107…

```
game_3_results.sample(10)
```

Out[107]:

Roll Number	Die Number 1	2	3	4	5
788	o	w	p	w	a
536	l	n	r	e	e
514	p	r	v	t	e
879	a	g	a	r	t
272	c	s	o	m	t
179	a	i	r	l	m
449	s	e	l	c	b
872	r	a	e	l	n
785	o	a	i	o	s
142	a	t	d	s	o

In [108…

```
game_3_results.sample(10)
```

Out[108]:

Roll Number	Die Number 1	2	3	4	5
909	e	i	i	w	n
301	e	s	x	n	r
840	e	s	e	i	o
772	l	s	a	s	i
412	r	s	h	t	l
15	s	a	a	w	u
612	s	d	l	o	i
280	o	n	o	a	b
768	g	b	s	s	i
894	s	i	e	f	e

In [109…
```
game_3_results.sample(10)
```

Out[109]:

Roll Number	Die Number 1	2	3	4	5
932	t	u	o	i	l
55	d	i	e	t	p
712	d	t	e	a	e
850	n	i	h	a	t
551	r	t	l	o	t
230	r	p	a	v	o
435	t	r	l	o	u
104	o	k	t	t	p
786	l	c	c	e	i
90	w	a	c	o	f

In [110…
```
game_3_results.sample(10)
```

Out[110]:

Roll Number	Die Number 1	2	3	4	5
342	n	d	p	n	w
579	u	u	i	r	f
5	m	c	a	b	d
745	g	n	n	s	a
101	b	e	p	t	l
567	l	d	f	c	s
152	e	u	n	n	n
288	p	z	a	d	o
398	u	t	r	e	c
482	c	a	a	h	s

In [111…

```
game_3_results.sample(10)
```

Out[111]:

Roll Number	Die Number 1	2	3	4	5
31	n	a	o	n	e
391	e	l	e	l	n
934	i	n	d	n	p
803	t	p	n	p	t
547	f	s	k	m	s
383	n	i	s	e	s
179	a	i	r	l	m
528	o	l	r	i	i
293	l	e	l	r	a
894	s	i	e	f	e

In [112…

```
game_3_results.sample(10)
```

Out[112]:

Die Number	1	2	3	4	5
Roll Number					
846	k	n	w	a	o
961	t	a	u	s	n
580	o	s	v	a	i
16	e	s	e	l	c
696	t	e	s	l	n
415	f	u	r	n	n
441	i	s	m	u	g
428	e	a	r	o	i
597	i	r	u	t	n
141	i	o	n	i	n

Directory Listing

A code block that executes the following bash command:

```
!ls -lRF -o
```

In [113…

```
!ls -lRF -o
```

```
total 1592
-rw-r--r--@ 1 brucemcgregor  166275 Dec  7 11:04 FinalProjectSubmissionTemplat
e.ipynb
-rw-r--r--  1 brucemcgregor    1073 Dec  2 11:56 LICENSE
-rw-r--r--@ 1 brucemcgregor  630645 Dec  7 08:18 README.html
-rw-r--r--@ 1 brucemcgregor    5897 Dec  7 08:18 README.md
drwxr-xr-x  5 brucemcgregor     160 Dec  7 10:56 demo/
drwxr-xr-x  7 brucemcgregor     224 Dec  7 10:15 montecarlo/
-rw-r--r--@ 1 brucemcgregor     301 Dec  7 10:14 setup.py
drwxr-xr-x  5 brucemcgregor     160 Dec  7 09:31 tests/

./demo:
total 280
-rw-r--r--@ 1 brucemcgregor  141396 Dec  7 10:56 montecarlo_demo.ipynb

./montecarlo:
total 32
-rw-r--r--@ 1 brucemcgregor    45 Dec  2 11:56 __init__.py
drwxr-xr-x  4 brucemcgregor   128 Dec  7 10:34 __pycache__/
-rw-r--r--@ 1 brucemcgregor  9280 Dec  7 08:04 montecarlo.py

./montecarlo/__pycache__:
total 32
-rw-r--r--  1 brucemcgregor   269 Dec  7 10:34 __init__.cpython-39.pyc
-rw-r--r--  1 brucemcgregor  8478 Dec  7 10:34 montecarlo.cpython-39.pyc

./tests:
total 32
-rw-r--r--@ 1 brucemcgregor  2609 Dec  7 09:35 monte_carlo_test_results.txt
-rw-r--r--@ 1 brucemcgregor  8641 Dec  7 09:30 montecarlo_tests.py
```

Installation Output Listing

A code block that executes the code to install your your package and outputs a successful installation.

In [114…

```
pip install .
```

```
Processing /Users/brucemcgregor/Documents/MSDS/DS5100-2022-08-bm3pk/DS5100_Final_Project_BM3PK
  DEPRECATION: A future pip version will change local packages to be built in-place without first copying to a temporary directory. We recommend you use --use-feature=in-tree-build to test your packages with this new behavior before it becomes the default.
   pip 21.3 will remove support for this functionality. You can find discussion regarding this at https://github.com/pypa/pip/issues/7555.
Building wheels for collected packages: montecarlo
  Building wheel for montecarlo (setup.py) ... done
  Created wheel for montecarlo: filename=montecarlo-1.0.0-py3-none-any.whl size=5054 sha256=b5b0ad448fa164c8f4171d634ba25d29ce7116f146c1fa25ab01bfc904c9b640
  Stored in directory: /private/var/folders/1m/r674fl856md6pfz3rqctdbtc0000gn/T/pip-ephem-wheel-cache-jiy1soz1/wheels/3c/33/52/0ad1b2ff3166bc898f0aa256cbca40463f501e70940f5669e4
Successfully built montecarlo
Installing collected packages: montecarlo
  Attempting uninstall: montecarlo
    Found existing installation: montecarlo 1.0.0
    Uninstalling montecarlo-1.0.0:
      Successfully uninstalled montecarlo-1.0.0
Successfully installed montecarlo-1.0.0
Note: you may need to restart the kernel to use updated packages.
```

In [ ]: