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**Simulation of rolling 6 different sided dice 1000000 times:**

**two octahedrons, a regular cube and three tetrahedron.**

**Comparing simulation to calculation, graphing PDF & CDF**

## Description

Project idea is the following, what is the probability of rolling each of the possible values: 6-34 with six dice roll and top values added to each other. The experiment is very interesting because different sums will show different probabilities of being rolled, and in each roll we use two (8) octahedrons, one (6) regular cube, and three (4) tetrahedrons dice. Using Matlab I will simulate this experiment, I am going to graph the cumulative distribution function (CDF). In addition, I will graph probability distribution function (PDF). I will compare calculated values to simulation results.

## Example of calculation

The range of top value sum of rolling 6 different sided dice is 6-34.

For Example, what is the probability rolling the dice sum 6. First, to get the sum equal to 6 when we have six rolls we need to have top value 1 on each die. We roll two octahedrons the probability of getting one is 1/8 on each, 1/8*1/8=1/64. Then we roll regular 6 sided die probability of getting 1 on top is 1/6. Then, we roll three tetrahedrons with probability on each ¼, 1/4*1/4*1/4=1/64. Therefore, we multiply all this probabilities 1/64*1/6*1/64=1/24576 we get probability of getting 6 on rolling six dice.

**Experiment:**

Matlab experiment simulates 24576 different combinations of rolling two octahedrons, a regular cube and three tetrahedron. Top values range 6-34 and it calculates separate probability. *Figure 1* displays probability distribution function of expected values.

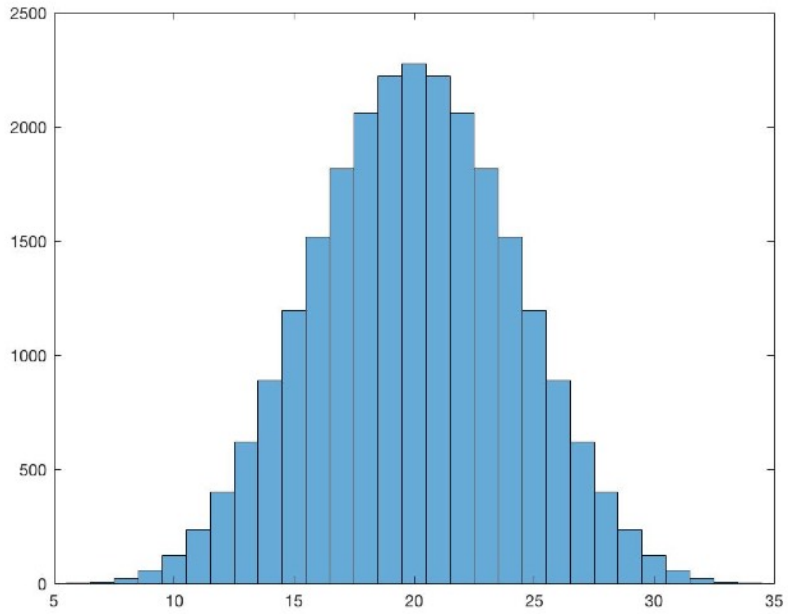


Figure 1. Expected PDF

| **Sum:** | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|
| **Probability (Sum):** | 1/24576 | 6/24576 | 21/24576 | 56/24576 | 123/24576 | 234/24576 |
| | 12 | 13 | 14 | 15 | 16 | 17 |
| | 398/24576 | 618/24576 | 889/24576 | 1196/24576 | 1515/24576 | 1814/24576 |
| | 18 | 19 | 20 | 21 | 22 | 23 |
| | 2059/24576 | 2220/24576 | 2276/24576 | 2220/24576 | 2059/24576 | 1814/24576 |
| | 24 | 25 | 26 | 27 | 28 | 29 |
| | 1515/24576 | 1196/24576 | 889/24576 | 618/24576 | 398/24576 | 234/24576 |
| | 30 | 31 | 32 | 33 | 34 | |
| | 123/24576 | 56/24576 | 21/24576 | 6/24576 | 1/24576 | |

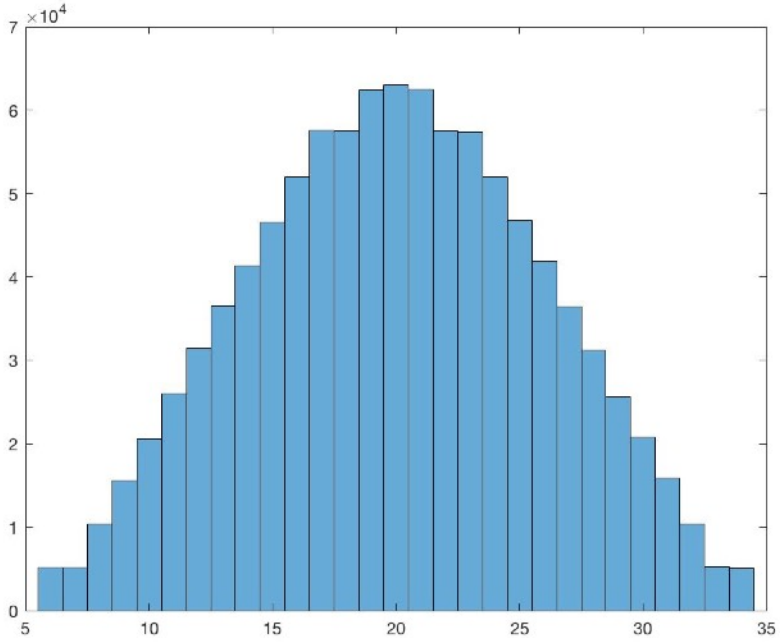

Figure 2. PDF simulation

*Figure 2* shows PDF simulation with 1000000 times dice roll.

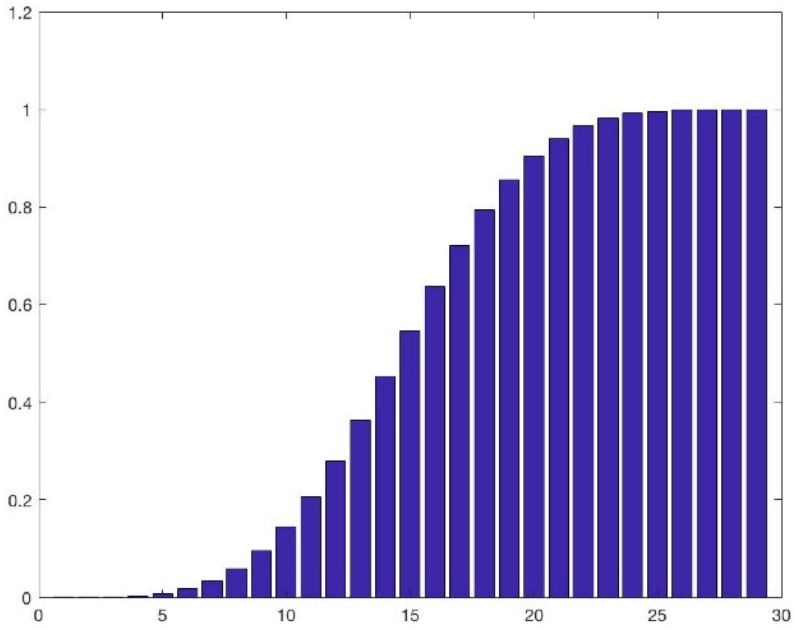

Figure 3. CDF

*Figure 3* shows the cumulative distribution function and below the figure exact calculated values are presented.

| Sum: | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|
| **Probability (X <= sum):** | 0.000041 | 0.000285 | 0.001139 | 0.003418 | 0.008423 | 0.017944 |
| | 12 | 13 | 14 | 15 | 16 | 17 |
| | 0.034139 | 0.059285 | 0.095459 | 0.144124 | 0.205770 | 0.279582 |
| | 18 | 19 | 20 | 21 | 22 | 23 |
| | 0.363363 | 0.453695 | 0.546305 | 0.636637 | 0.720418 | 0.794230 |
| | 24 | 25 | 26 | 27 | 28 | 29 |
| | 0.855876 | 0.904541 | 0.940715 | 0.965861 | 0.982056 | 0.991577 |
| | 30 | 31 | 32 | 33 | 34 | |
| | 0.996582 | 0.998861 | 0.999715 | 0.999959 | 1.000000 | |

**Analysis**

Expected mean of sum values as indicated in PDF is $\bar{x} = \frac{\sum x}{n}$ $580/28 = 20.71428$

Mean of simulations is 19.996507

*Figure 1* histogram shows that the mean and the median are the same so it is the normal distribution. PDF graph is symmetrical to its mean.

Figure 1 shows expected probabilities and Figure 2 shows PDF of simulation of 6 dice roll 1000000 times. The shape of Figure 1 & 2 are not exactly the same but the outline is very similar.

**Source Code**

**function dice**

```
array = zeros(8,8,6,4,4,4);
simupdf = zeros(1);
emeansum = 0;
meansum = 0;
% simulates 1000000 roll
 for a = 1:1000000

r = randi([1 8]);
x = randi([1 6]);
y = randi([1 4]);

    sum = r+r+x+y+y+y;
     simupdf(a) = sum;

     meansum = meansum + simupdf(a);

end

 count=0;
                six=0;
                seven=0;
                eight=0;
                nine=0;
                ten=0;
                eleven=0;
                twelve=0;
                thirteen=0;
                fourteen=0;
                fifteen=0;
                sixteen=0;
                seventeen=0;
                eighteen=0;
                nineteen=0;
                twenty=0;
                twone=0;
                twtwo=0;
                twthree = 0;
                twfour=0;
```

```
                twfive=0;
                twsix=0;
                twseven=0;
                tweight=0;
                twnine=0;
                thrty=0;
                thone=0;
                thtwo=0;
                ththree = 0;
                thfour=0;
%  Expected values
 for a = 1:8
    for b = 1:8
        for c = 1:6
           for d = 1:4
              for e = 1:4
               for f = 1:4

                 count=count+1;
                   sum = a+b+c+d+e+f;

                   array(a,b,c,d,e,f) = sum;
                   emeansum = emeansum + sum;

            %  fprintf('\nN:%d   %d,%d,%d,%d,%d,%d=%d\n',count,
a,b,c,d,e,f,sum);


                if sum == 6
                   six=six+1 ;
                end
                if sum == 7
                   seven=seven+1 ;
                end
                if sum == 8
                   eight=eight+1 ;
                end
                if sum == 9
                   nine=nine+1 ;
                end
                if sum == 10
                   ten=ten+1 ;
```

```
                end
                if sum == 11
                   eleven=eleven+1 ;
                end
                if sum == 12
                   twelve=twelve+1 ;
                end
                if sum == 13
                   thirteen=thirteen+1 ;
                end

                 if sum == 14, fourteen=fourteen+1 ; end
                 if sum == 15, fifteen=fifteen+1 ; end
                 if sum == 16, sixteen=sixteen+1 ; end
                 if sum == 17, seventeen=seventeen+1 ; end
                 if sum == 18, eighteen=eighteen+1 ; end
                 if sum == 19, nineteen=nineteen+1 ; end
                 if sum == 20, twenty=twenty+1 ; end
                 if sum == 21, twone=twone+1 ; end
                 if sum == 22, twtwo=twtwo+1 ; end
                 if sum == 23, twthree=twthree+1 ; end
                 if sum == 24, twfour=twfour+1 ; end
                 if sum == 25, twfive=twfive+1 ; end
                 if sum == 26, twsix=twsix+1 ; end
                 if sum == 27, twseven=twseven+1 ; end
                 if sum == 28, tweight=tweight+1 ; end
                 if sum == 29, twnine=twnine+1 ; end
                 if sum == 30, thrty=thrty+1 ; end
                 if sum == 31, thone=thone+1 ; end
                 if sum == 32, thtwo=thtwo+1 ; end
                 if sum == 33, ththree=ththree+1 ; end
                 if sum == 34, thfour=thfour+1 ; end



                       end
                 end
            end
         end
      end
   end
```

```
 fprintf('Sum:          6            7         8          9
10          11          12           13           14           15
16           17           18           19           20           21
22           23           24           25          26           27
28         29          30          31          32          33
34           \n');
    fprintf('Probability(Sum):      %d/24576   %d/24576   %d/24576
%d/24576   %d/24576   %d/24576   %d/24576   %d/24576   %d/24576
%d/24576   %d/24576   %d/24576   %d/24576   %d/24576   %d/24576
%d/24576   %d/24576   %d/24576   %d/24576   %d/24576   %d/24576
%d/24576   %d/24576    \n', six, seven, eight, nine, ten, eleven,
twelve, thirteen,fourteen,
fifteen,sixteen,seventeen,eighteen,nineteen,twenty,twone,twtwo,twthr
ee,twfour,twfive,twsix,twseven,tweight,twnine,thrty,thone,thtwo,thth
ree,thfour)


%  Mean of expected values
    emean = emeansum / 24576;
    fprintf('Expected Mean:%f \n',emean);
%  Mean
    mean = meansum / 1000000;
    fprintf('Mean:%f \n',mean);



    figure(1)
    histogram(array)
    figure(2)
    histogram(simupdf)



 %sum
 ssix = six / 24576;
 sseven = seven / 24576;
 seight = eight / 24576;
 snine =   nine / 24576;
 sten =    ten / 24576;
 seleven = eleven / 24576;
```

```
stwelve =  twelve / 24576;
sthirteen = thirteen / 24576;
sfourteen = fourteen / 24576;
sfifteen = fifteen / 24576;
ssixteen =  sixteen / 24576;
sseventeen =  seventeen / 24576;
seighteen =  eighteen / 24576;
snineteen =  nineteen / 24576;
stwenty = twenty / 24576;
stwone =  twone / 24576;
stwtwo =  twtwo / 24576;
stwthree =  twthree / 24576;
stwfour =  twfour / 24576;
stwfive =  twfive / 24576;
stwsix = twsix / 24576;
stwseven =  twseven / 24576;
stweight = tweight / 24576;
stwnine = twnine / 24576;
sthrty =  thrty / 24576;
sthone =   thone / 24576;
sthtwo =  thtwo / 24576;
ththree =    ththree / 24576;
sthfour =   thfour / 24576;
```

```
   % (CDF)
   usix            =           ssix       ;
useven  =      usix       +      sseven     ;
ueight  =      useven     +      seight     ;
unine   =      ueight     +      snine      ;
uten    =      unine      +      sten       ;
ueleven       =      uten       +      seleven    ;
utwelve       =      ueleven    +      stwelve    ;
uthirteen     =      utwelve    +      sthirteen  ;
ufourteen     =      uthirteen  +      sfourteen  ;
ufifteen      =      ufourteen  +      sfifteen   ;
usixteen      =      ufifteen   +      ssixteen   ;
useventeen    =      usixteen   +      sseventeen       ;
ueighteen     =      useventeen       +      seighteen  ;
```

```
 unineteen     =      ueighteen  +      snineteen  ;
 utwenty       =      unineteen  +      stwenty    ;
 utwone  =      utwenty    +      stwone     ;
 utwtwo  =      utwone     +      stwtwo     ;
 utwthree      =      utwtwo     +      stwthree   ;
 utwfour       =      utwthree   +      stwfour    ;
 utwfive       =      utwfour    +      stwfive    ;
 utwsix  =      utwfive    +      stwsix     ;
 utwseven      =      utwsix     +      stwseven   ;
 utweight      =      utwseven   +      stweight   ;
 utwnine       =      utweight   +      stwnine    ;
 uthrty  =      utwnine    +      sthrty     ;
 uthone  =      uthrty     +      sthone     ;
 uthtwo  =      uthone     +      sthtwo     ;
 uththree      =      uthtwo     +      sththree   ;
 uthfour       =      uththree   +      sthfour    ;


 fprintf('Sum of Cumulative distribution function:          6
7         8          9         10          11          12
13           14           15          16           17           18
19           20           21           22           23           24
25         26           27         28         29          30
31          32          33       34           \n');
     fprintf('Probability(X <= sum):    %f   %f   %f  %f   %f     %f
%f   %f  %f   %f  %f  %f   %f   %f  %f   %f     %f   %f   %f  %f
%f  %f  %f   %f   %f  %f   %f     %f   %f  \n', usix, useven,
ueight, unine, uten, ueleven, utwelve, uthirteen, ufourteen,
ufifteen, usixteen, useventeen, ueighteen, unineteen, utwenty,
utwone, utwtwo, utwthree, utwfour, utwfive, utwsix, utwseven,
utweight, utwnine, uthrty, uthone, uthtwo, uththree, uthfour);
    CDF = [ usix, useven, ueight, unine, uten, ueleven, utwelve,
uthirteen, ufourteen, ufifteen, usixteen, useventeen, ueighteen,
unineteen, utwenty, utwone, utwtwo, utwthree, utwfour, utwfive,
utwsix, utwseven, utweight, utwnine, uthrty, uthone, uthtwo,
uththree, uthfour];

    figure(3)
    bar(CDF)

end
```

**Conclusion**

To sum up, the project simulated 6 dice roll 1000000 times: two octahedrons, one regular cube, and three tetrahedrons, and calculated probability of getting each sum values in range 6-34. Data was visualized using Matlab. Histograms of probability distribution function and cumulative distribution function were made. Histograms were followed by exact number calculations that also were calculated using Matlab.

**What you learned**

Working on this project helped me to apply the knowledge that I received from EE 300 course in real life problems. In additions, I have learned that using Matlab is a great tool for working big calculations. It gives me flexibility of doing big projects. Also, I have learned visualization of data building histograms and figures that represent results clearly.

**What I'd do differently**

If I were to do the project again and had more time, I would have worked on more complex numbers and do more analysis. However, I think the project already has good complexity compared to the time I had to work on this. Overall, working on the project was good and gave me a lot of experience.

**Time needed to complete the project:**

Estimated time - 27 hours

Time spent - 31 hours