

In[31]:= (* Problem 1 *)

(* Create 3 different sized random arrays *)

small = RandomInteger[{0, 1}, 50];

medium = RandomInteger[{0, 1}, 500];

large = RandomInteger[{0, 1}, 5000];

(* Equipartition of small *)

(* 0 and 1 *)

smallfrq1 = N[Sum[small[[i]], {i, 1, Length[small]}] / Length[small]]

Out[34]= 0.42

In[35]:= smallfrq0 = 1 - smallfrq1

Out[35]= 0.58

(* 00, 01, 10, 11 *)

In[36]:= smallfrq00 = N[
$$\sum_{k=1}^{\text{Length}[\text{small}]-1} ((1 - \text{small}[[k]]) * (1 - \text{small}[[k+1]])) / (\text{Length}[\text{small}] - 1)]$$

Out[36]= 0.306122

NumberForm[smallfrq01, 16]

In[37]:= smallfrq01 = N[
$$\sum_{k=1}^{\text{Length}[\text{small}]-1} ((1 - \text{small}[[k]]) * (\text{small}[[k+1]])) / (\text{Length}[\text{small}] - 1)]$$

Out[37]= 0.265306

In[38]:= smallfrq10 = N[
$$\sum_{k=1}^{\text{Length}[\text{small}]-1} ((\text{small}[[k]]) * (1 - \text{small}[[k+1]])) / (\text{Length}[\text{small}] - 1)]$$

Out[38]= 0.285714

In[39]:= smallfrq11 = 1 - smallfrq00 - smallfrq01 - smallfrq10

Out[39]= 0.142857

In[8]:= (* 000, 001, 010, 011, 100, 101, 110, 111 *)

smallfrq000 = N[
$$\sum_{k=1}^{\text{Length}[\text{small}]-2} ((1 - \text{small}[[k]]) * (1 - \text{small}[[k+1]]) * (1 - \text{small}[[k+2]])) / (\text{Length}[\text{small}] - 2)]$$

Out[8]= 0.0833333

In[9]:= smallfrq001 = N[
$$\sum_{k=1}^{\text{Length}[\text{small}]-2} ((1 - \text{small}[[k]]) * (1 - \text{small}[[k+1]]) * (\text{small}[[k+2]])) / (\text{Length}[\text{small}] - 2)]$$

Out[9]= 0.145833

```
In[10]:= smallfrq010 = N[
  Sum[(1 - small[[k]]) * (small[[k + 1]]) * (1 - small[[k + 2]]) / (Length[small] - 2),
    {k, 1, Length[small] - 2}]
```

```
Out[10]= 0.145833
```

```
In[11]:= smallfrq011 =
  N[Sum[(1 - small[[k]]) * (small[[k + 1]]) * (small[[k + 2]]) / (Length[small] - 2),
    {k, 1, Length[small] - 2}]]
```

```
Out[11]= 0.125
```

```
In[12]:= smallfrq100 = N[
  Sum[(small[[k]]) * (1 - small[[k + 1]]) * (1 - small[[k + 2]]) / (Length[small] - 2),
    {k, 1, Length[small] - 2}]]
```

```
Out[12]= 0.166667
```

```
In[14]:= smallfrq101 =
  N[Sum[(small[[k]]) * (1 - small[[k + 1]]) * (small[[k + 2]]) / (Length[small] - 2),
    {k, 1, Length[small] - 2}]]
```

```
Out[14]= 0.125
```

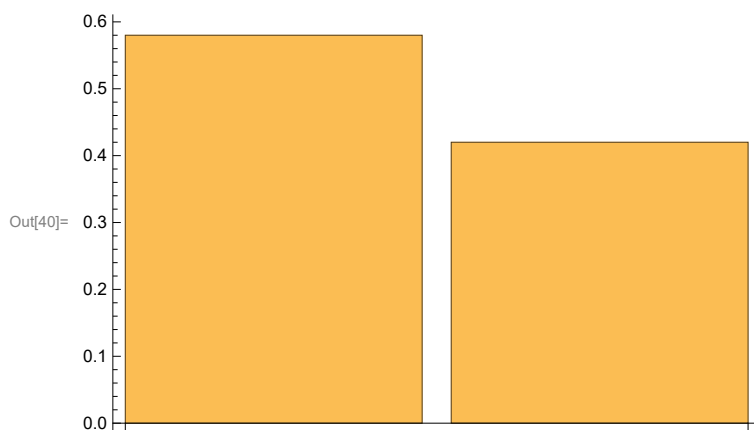
```
In[15]:= smallfrq110 =
  N[Sum[(small[[k]]) * (small[[k + 1]]) * (1 - small[[k + 2]]) / (Length[small] - 2),
    {k, 1, Length[small] - 2}]]
```

```
Out[15]= 0.145833
```

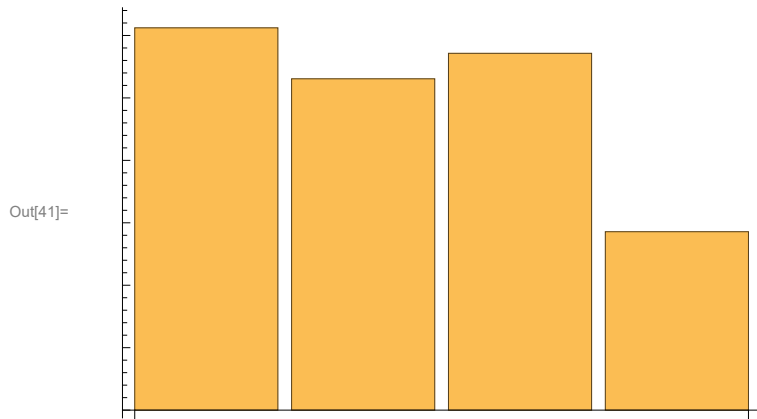
```
In[17]:= smallfrq111 =
  N[Sum[(small[[k]]) * (small[[k + 1]]) * (small[[k + 2]]) / (Length[small] - 2),
    {k, 1, Length[small] - 2}]]
```

```
Out[17]= 0.0625
```

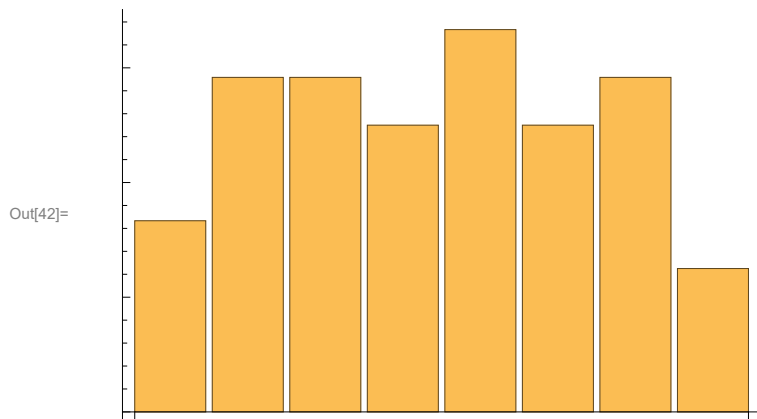
```
In[40]:= (* Graphing small *)
BarChart[{smallfrq0, smallfrq1}]
```



In[41]:= **BarChart**[{smallfrq00, smallfrq01, smallfrq10, smallfrq11}]



In[42]:= **BarChart**[{smallfrq000, smallfrq001, smallfrq010, smallfrq011, smallfrq100, smallfrq101, smallfrq110, smallfrq111}]



(* Equipartition of medium *)
 (* 0 and 1 *)

In[43]:= **mediumfrq1** = **N**[**Sum**[**medium**[**i**]], {**i**, 1, **Length**[**medium**}]] / **Length**[**medium**]

Out[43]= 0.476

In[45]:= **mediumfrq0** = 1 - **mediumfrq1**

Out[45]= 0.524

In[46]:= (* 00, 01, 10, 11 *)

mediumfrq00 =

$$N \left[\sum_{k=1}^{\text{Length}[\text{medium}]-1} ((1 - \text{medium}[[k]]) * (1 - \text{medium}[[k+1]])) / (\text{Length}[\text{medium}] - 1) \right]$$

Out[46]= 0.268537

```
In[48]:= mediumfrq01 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-1} ((1 - \text{medium}[[k]]) * (\text{medium}[[k+1]])) / (\text{Length}[\text{medium}] - 1)]$$

```

```
Out[48]= 0.256513
```

```
In[49]:= mediumfrq11 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-1} ((\text{medium}[[k]]) * (\text{medium}[[k+1]])) / (\text{Length}[\text{medium}] - 1)]$$

```

```
Out[49]= 0.218437
```

```
In[50]:= mediumfrq10 = 1 - mediumfrq00 - mediumfrq01 - mediumfrq11
```

```
Out[50]= 0.256513
```

```
In[51]:= (* 000, 001, 010, 011, 100, 101, 110, 111 *)
mediumfrq000 =
```

```

$$N[\sum_{k=1}^{\text{Length}[\text{medium}]-2} ((1 - \text{medium}[[k]]) * (1 - \text{medium}[[k+1]]) * (1 - \text{medium}[[k+2]])) /$$


$$(\text{Length}[\text{medium}] - 2)]$$

```

```
Out[51]= 0.138554
```

```
In[52]:= mediumfrq001 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-2} ((1 - \text{medium}[[k]]) * (1 - \text{medium}[[k+1]]) * (\text{medium}[[k+2]])) /$$


$$(\text{Length}[\text{medium}] - 2)]$$

```

```
Out[52]= 0.130522
```

```
In[53]:= mediumfrq010 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-2} ((1 - \text{medium}[[k]]) * (\text{medium}[[k+1]]) * (1 - \text{medium}[[k+2]])) /$$


$$(\text{Length}[\text{medium}] - 2)]$$

```

```
Out[53]= 0.148594
```

```
In[54]:= mediumfrq011 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-2} ((1 - \text{medium}[[k]]) * (\text{medium}[[k+1]]) * (\text{medium}[[k+2]])) /$$


$$(\text{Length}[\text{medium}] - 2)]$$

```

```
Out[54]= 0.108434
```

```
In[55]:= mediumfrq100 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-2} ((\text{medium}[[k]]) * (1 - \text{medium}[[k+1]]) * (1 - \text{medium}[[k+2]])) /$$


$$(\text{Length}[\text{medium}] - 2)]$$

```

```
Out[55]= 0.130522
```

```
In[56]:= mediumfrq101 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-2} ((\text{medium}[[k]]) * (1 - \text{medium}[[k+1]]) * (\text{medium}[[k+2]])) /$$


$$(\text{Length}[\text{medium}] - 2)]$$

```

```
Out[56]= 0.126506
```

```
In[57]:= mediumfrq110 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-2} ((\text{medium}[[k]]) * (\text{medium}[[k+1]]) * (1 - \text{medium}[[k+2]])) / (\text{Length}[\text{medium}] - 2)]$$

```

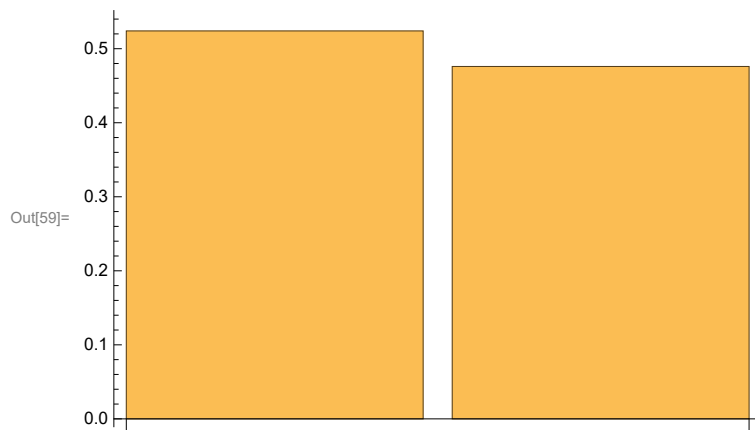
Out[57]= 0.108434

```
In[58]:= mediumfrq111 = N[
$$\sum_{k=1}^{\text{Length}[\text{medium}]-2} ((\text{medium}[[k]]) * (\text{medium}[[k+1]]) * (\text{medium}[[k+2]])) / (\text{Length}[\text{medium}] - 2)]$$

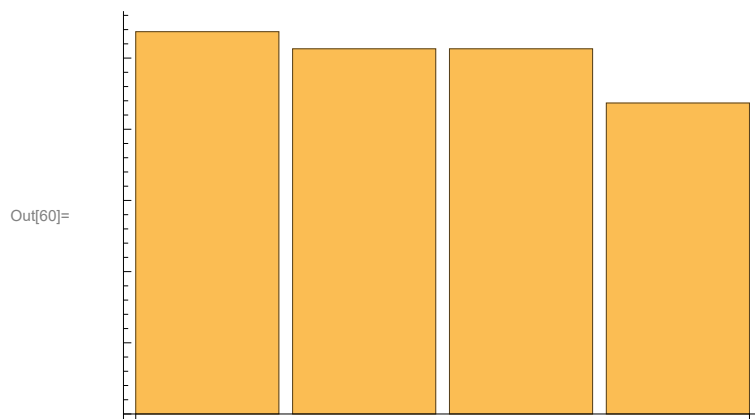
```

Out[58]= 0.108434

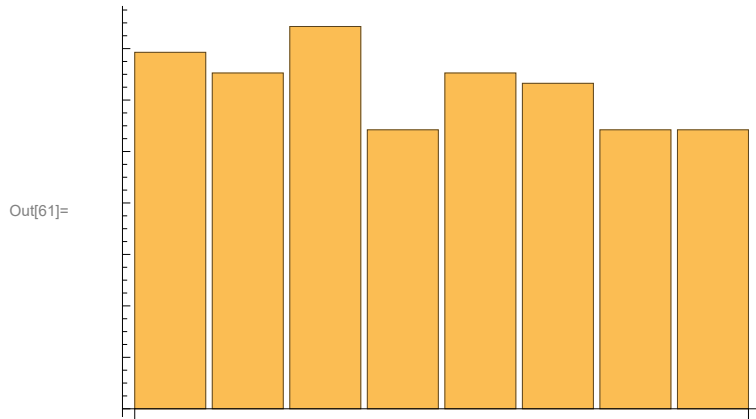
```
In[59]:= (* Graphing medium *)
BarChart[{mediumfrq0, mediumfrq1}]
```



```
In[60]:= BarChart[{mediumfrq00, mediumfrq01, mediumfrq10, mediumfrq11}]
```



```
In[61]:= BarChart[{mediumfrq000, mediumfrq001, mediumfrq010,
  mediumfrq011, mediumfrq100, mediumfrq101, mediumfrq110, mediumfrq111}]
```



```
(* Equipartition of large *)
```

```
(* 0 and 1 *)
```

```
largefrq1 = N[Sum[large[[i]], {i, 1, Length[large]}]] / Length[large]
```

```
Out[62]= 0.5022
```

```
In[63]:= largefrq0 = 1 - largefrq1
```

```
Out[63]= 0.4978
```

```
In[64]:= (* 00, 01, 10, 11 *)
```

```
largefrq01 =
```

```
N[Sum[(1 - large[[i]]) * (large[[i + 1]]), {i, 1, Length[large] - 1}]] / Length[large - 1]
```

```
Out[64]= 0.2552
```

```
In[65]:= largefrq00 =
```

```
N[Sum[(1 - large[[i]]) * (1 - large[[i + 1]]), {i, 1, Length[large] - 1}]] / Length[large - 1]
```

```
Out[65]= 0.2424
```

```
In[66]:= largefrq11 =
```

```
N[Sum[(large[[i]]) * (large[[i + 1]]), {i, 1, Length[large] - 1}]] / Length[large - 1]
```

```
Out[66]= 0.247
```

```
In[67]:= largefrq10 =
```

```
N[Sum[(large[[i]]) * (1 - large[[i + 1]]), {i, 1, Length[large] - 1}]] / Length[large - 1]
```

```
Out[67]= 0.2552
```

```
(* 000, 001, 010, 011, 100, 101, 110, 111 *)
```

```
Set: Cannot assign to raw object 1.
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Set: Cannot assign to raw object 1.
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```
Set: Cannot assign to raw object 1.
```

```
General: Further output of Set::setraw will be suppressed during this calculation.
```

In[96]:= **largefrq000** = $N\left[\sum_{k=1}^{\text{Length}[\text{large}]-2} ((1 - \text{large}[[k]]) * (1 - \text{large}[[k+1]]) * (1 - \text{large}[[k+2]])) / (\text{Length}[\text{large}] - 2)\right]$

Out[96]= 0.117847

In[97]:= **largefrq001** = $N\left[\sum_{k=1}^{\text{Length}[\text{large}]-2} ((1 - \text{large}[[k]]) * (1 - \text{large}[[k+1]]) * (\text{large}[[k+2]])) / (\text{Length}[\text{large}] - 2)\right]$

Out[97]= 0.12465

In[98]:= **largefrq010** = $N\left[\sum_{k=1}^{\text{Length}[\text{large}]-2} ((1 - \text{large}[[k]]) * (\text{large}[[k+1]]) * (1 - \text{large}[[k+2]])) / (\text{Length}[\text{large}] - 2)\right]$

Out[98]= 0.132853

In[99]:= **largefrq011** = $N\left[\sum_{k=1}^{\text{Length}[\text{large}]-2} ((1 - \text{large}[[k]]) * (\text{large}[[k+1]]) * (\text{large}[[k+2]])) / (\text{Length}[\text{large}] - 2)\right]$

Out[99]= 0.122449

In[100]:= **largefrq100** = $N\left[\sum_{k=1}^{\text{Length}[\text{large}]-2} ((\text{large}[[k]]) * (1 - \text{large}[[k+1]]) * (1 - \text{large}[[k+2]])) / (\text{Length}[\text{large}] - 2)\right]$

Out[100]= 0.12445

In[101]:= **largefrq101** = $N\left[\sum_{k=1}^{\text{Length}[\text{large}]-2} ((\text{large}[[k]]) * (1 - \text{large}[[k+1]]) * (\text{large}[[k+2]])) / (\text{Length}[\text{large}] - 2)\right]$

Out[101]= 0.130652

In[102]:= **largefrq110** = $N\left[\sum_{k=1}^{\text{Length}[\text{large}]-2} ((\text{large}[[k]]) * (\text{large}[[k+1]]) * (1 - \text{large}[[k+2]])) / (\text{Length}[\text{large}] - 2)\right]$

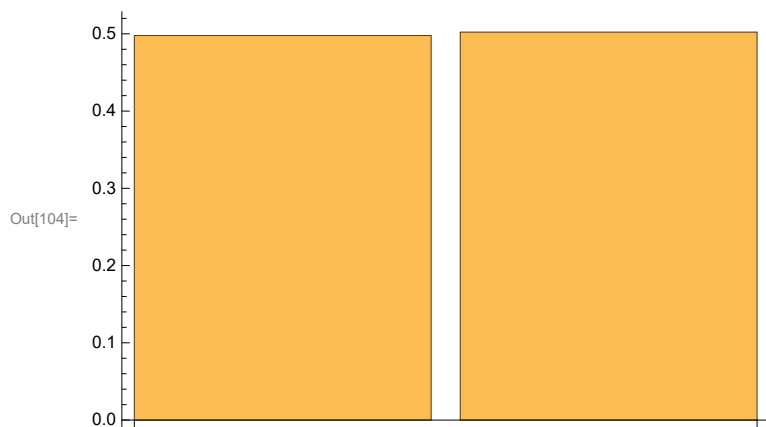
Out[102]= 0.122449

In[103]:= **largefrq111** = $N\left[\sum_{k=1}^{\text{Length}[\text{large}]-2} ((\text{large}[[k]]) * (\text{large}[[k+1]]) * (\text{large}[[k+2]])) / (\text{Length}[\text{large}] - 2)\right]$

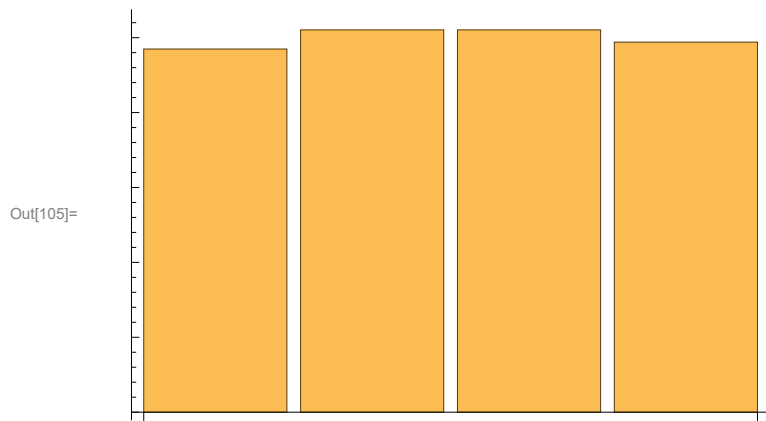
Out[103]= 0.12465

(* Graphing large *)

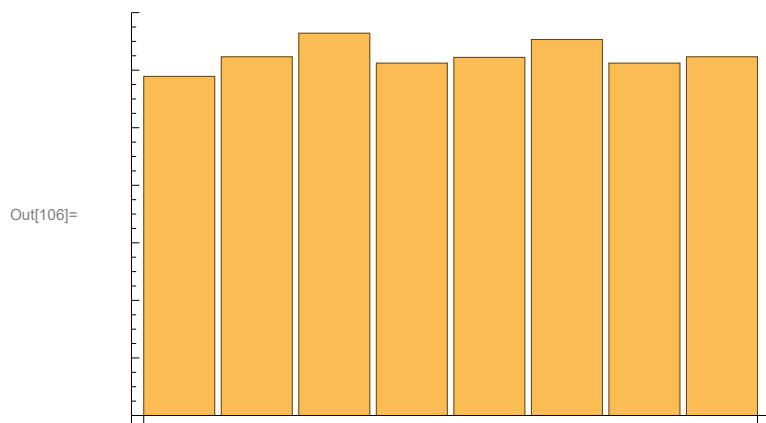
```
In[104]:= BarChart[{largefrq0, largefrq1}]
```



```
In[105]:= BarChart[{largefrq00, largefrq01, largefrq10, largefrq11}]
```



```
In[106]:= BarChart[{largefrq000, largefrq001, largefrq010,
  largefrq011, largefrq100, largefrq101, largefrq110, largefrq111}]
```



```
(* Champernowne String *)
```

```
(* small *)
```

```
a = {}; (* The string *)
```



```
(* Gets the each number 1-50 in a binary list,
loops though each list to append to the master list, a *)
i = 1;
While[i < 51,
  x = IntegerDigits[i, 2];
  For[k = 1, k ≤ Length[x], k++, AppendTo[a, x[[k]]]];
  i++]
```

```
In[204]:= champernowne001 =
  N[Sum[(1 - a[[i]]) * (1 - a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[204]= 0.112033
```

```
In[205]:= champernowne010 =
  N[Sum[(1 - a[[i]]) * (a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[205]= 0.120332
```

```
In[206]:= champernowne011 =
  N[Sum[(1 - a[[i]]) * (a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[206]= 0.141079
```

```
In[207]:= champernowne100 =
  N[Sum[(a[[i]]) * (1 - a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[207]= 0.112033
```

```
In[208]:= champernowne101 =
  N[Sum[(a[[i]]) * (1 - a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[208]= 0.149378
```

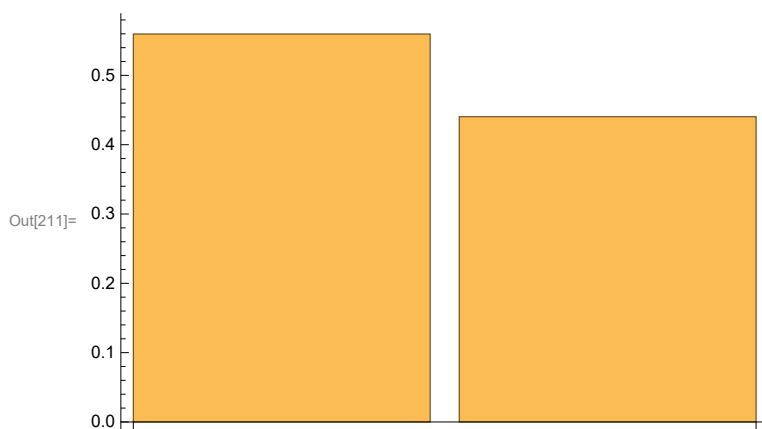
```
In[209]:= champernowne110 =
  N[Sum[(a[[i]]) * (a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[209]= 0.145228
```

```
In[210]:= champernowne111 =
  N[Sum[(a[[i]]) * (a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

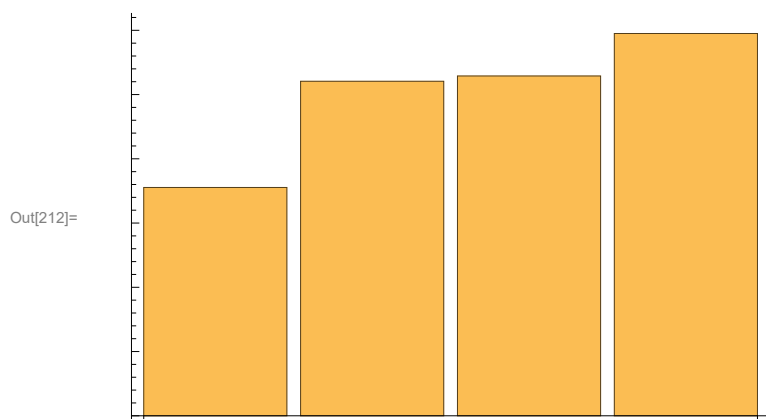
```
Out[210]= 0.153527
```

```
In[211]:= (* Graph 0 and 1 *)
  BarChart[{champernowne0, champernowne1}]
```



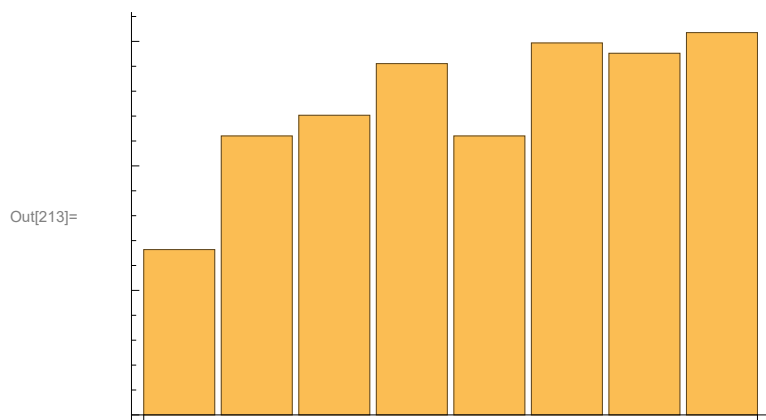
(* Graph 00, 01, 10, 11 *)

BarChart[{champernowne00, champernowne01, champernowne10, champernowne11}]



(* Graph 000, 001, 010, 011, 100, 101, 110, 111 *)

BarChart[{champernowne000, champernowne001, champernowne010, champernowne011, champernowne100, champernowne101, champernowne110, champernowne111}]



(* Champernowne medium *)

(* Append more digits to a, now a contains 500 digits of champernowne *)

```
In[214]:= i = 51;
While[i < 501,
  x = IntegerDigits[i, 2];
  For[k = 1, k ≤ Length[x], k++, AppendTo[a, x[[k]]]];
  i++]
```

(* Frequency 0 and 1 *)

```
In[217]:= champernowne0 = N[Sum[(a[[i]]), {i, 1, Length[a]}]] / Length[a]
```

Out[217]= 0.555778

```
In[218]:= champernowne1 = 1 - champernowne0
```

Out[218]= 0.444222

```

In[220]:= (* Frequency 00, 01, 10, 11 *)
champernowne00 =
  N[Sum[(1 - a[[i]]) * (1 - a[[i + 1]]), {i, 1, Length[a] - 1}]] / (Length[a] - 1)
Out[220]= 0.191394

In[221]:= champernowne01 = N[Sum[(1 - a[[i]]) * (a[[i + 1]]), {i, 1, Length[a] - 1}]] / (Length[a] - 1)
Out[221]= 0.25269

In[222]:= champernowne10 = N[Sum[(a[[i]]) * (1 - a[[i + 1]]), {i, 1, Length[a] - 1}]] / (Length[a] - 1)
Out[222]= 0.25294

In[223]:= champernowne11 = N[Sum[(a[[i]]) * (a[[i + 1]]), {i, 1, Length[a] - 1}]] / (Length[a] - 1)
Out[223]= 0.302977

In[224]:= (* Frequency 000, 001, 010, 011, 100, 101, 110, 111 *)
champernowne000 =
  N[Sum[(1 - a[[i]]) * (1 - a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] /
  (Length[a] - 2)
Out[224]= 0.0800801

In[225]:= champernowne001 =
  N[Sum[(1 - a[[i]]) * (1 - a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
Out[225]= 0.111111

In[226]:= champernowne010 =
  N[Sum[(1 - a[[i]]) * (a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
Out[226]= 0.111612

In[227]:= champernowne011 =
  N[Sum[(1 - a[[i]]) * (a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
Out[227]= 0.141141

In[228]:= champernowne100 =
  N[Sum[(a[[i]]) * (1 - a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
Out[228]= 0.111361

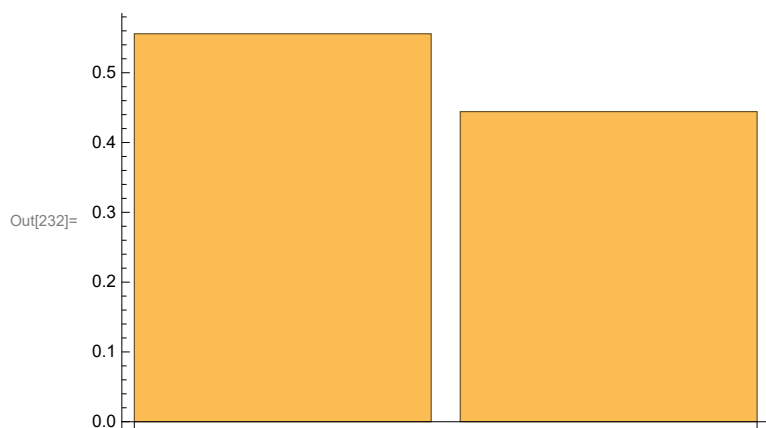
In[229]:= champernowne101 =
  N[Sum[(a[[i]]) * (1 - a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
Out[229]= 0.141642

In[230]:= champernowne110 =
  N[Sum[(a[[i]]) * (a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
Out[230]= 0.141391

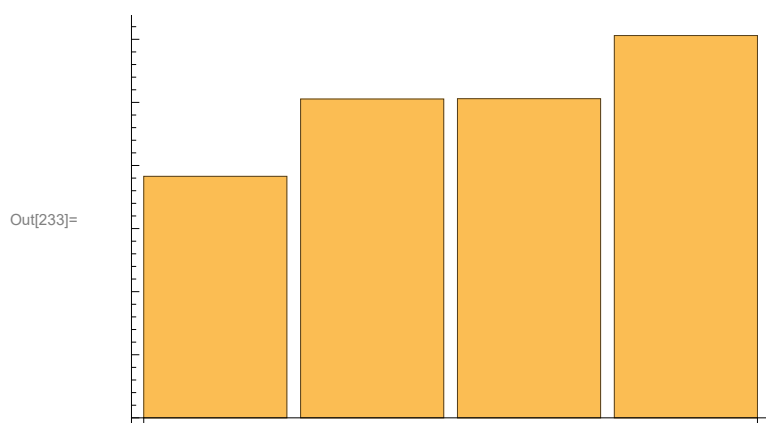
In[231]:= champernowne111 =
  N[Sum[(a[[i]]) * (a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
Out[231]= 0.161662

```

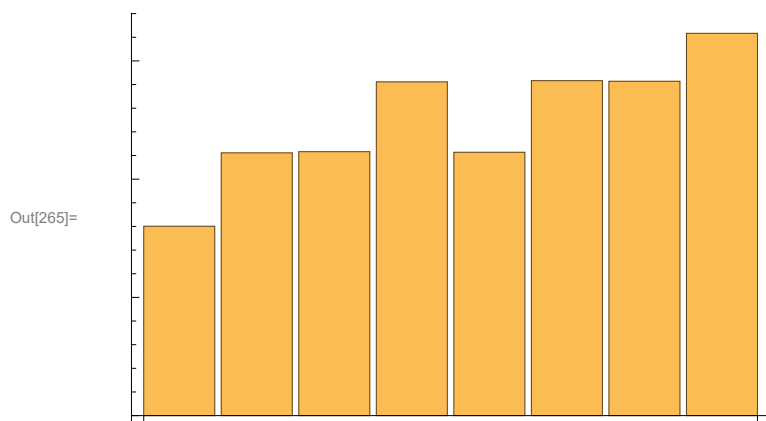
```
In[232]:= (* Graphing medium champernowne *)
BarChart[{champernowne0, champernowne1}]
```



```
In[233]:= BarChart[{champernowne00, champernowne01, champernowne10, champernowne11}]
```



```
In[265]:= BarChart[{champernowne000, champernowne001, champernowne010, champernowne011,
champernowne100, champernowne101, champernowne110, champernowne111}]
```



```

In[274]:= (* Champernowne Large *)
large = {}
i = 1;
While[i < 8197,
  x = IntegerDigits[i, 2];
  For[k = 1, k ≤ Length[x], k++, AppendTo[large, x[[k]]]];
  i++]

```

```
Out[274]:= {}
```

```
In[277]:= Length[large]
```

```
Out[277]:= 98375
```

```

In[279]:= (* Frequencies for 0 and 1 *)
champernowne0 = N[Sum[a[[i]], {i, 1, Length[a]}]] / Length[a]

```

```
Out[279]:= 0.538197
```

```
In[280]:= champernowne1 = 1 - champernowne0
```

```
Out[280]:= 0.461803
```

```

In[282]:= (* Frequency 00, 01, 10, 11 *)
champernowne00 =
  N[Sum[(1 - a[[i]]) * (1 - a[[i + 1]]), {i, 1, Length[a] - 1}]] / (Length[a] - 1)

```

```
Out[282]:= 0.212003
```

```
In[283]:= champernowne01 = N[Sum[(1 - a[[i]]) * (a[[i + 1]]), {i, 1, Length[a] - 1}]] / (Length[a] - 1)
```

```
Out[283]:= 0.249802
```

```
In[284]:= champernowne10 = N[Sum[(a[[i]]) * (1 - a[[i + 1]]), {i, 1, Length[a] - 1}]] / (Length[a] - 1)
```

```
Out[284]:= 0.249802
```

```
In[285]:= champernowne11 = N[Sum[(a[[i]]) * (a[[i + 1]]), {i, 1, Length[a] - 1}]] / (Length[a] - 1)
```

```
Out[285]:= 0.288393
```

```

In[286]:= (* Frequency 000, 001, 010, 011, 100, 101, 110, 111 *)
champernowne000 =
  N[Sum[(1 - a[[i]]) * (1 - a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] /
  (Length[a] - 2)

```

```
Out[286]:= 0.0960299
```

```

In[287]:= champernowne001 =
  N[Sum[(1 - a[[i]]) * (1 - a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)

```

```
Out[287]:= 0.115974
```

```

In[288]:= champernowne010 =
  N[Sum[(1 - a[[i]]) * (a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)

```

```
Out[288]:= 0.115532
```

```
In[289]:= champernowne011 =  
N[Sum[(1 - a[[i]]) * (a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[289]= 0.13427
```

```
In[290]:= champernowne100 =  
N[Sum[(a[[i]]) * (1 - a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[290]= 0.115974
```

```
In[291]:= champernowne101 =  
N[Sum[(a[[i]]) * (1 - a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[291]= 0.133829
```

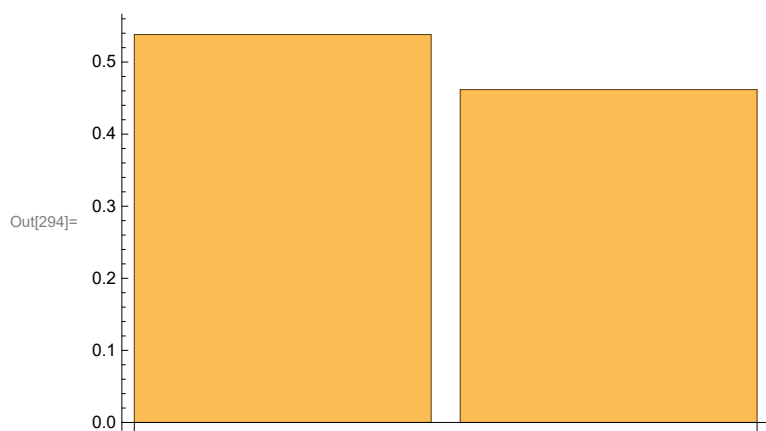
```
In[292]:= champernowne110 =  
N[Sum[(a[[i]]) * (a[[i + 1]]) * (1 - a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[292]= 0.13427
```

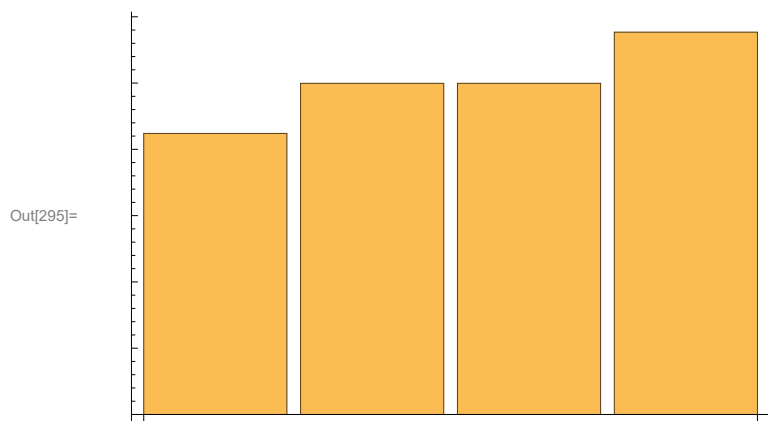
```
In[293]:= champernowne111 =  
N[Sum[(a[[i]]) * (a[[i + 1]]) * (a[[i + 2]]), {i, 1, Length[a] - 2}]] / (Length[a] - 2)
```

```
Out[293]= 0.154121
```

```
In[294]:= (* Grahping champernowne large *)  
BarChart[{champernowne0, champernowne1}]
```



```
In[295]:= BarChart[{champernowne00, champernowne01, champernowne10, champernowne11}]
```



```
In[296]:= BarChart[{champernowne000, champernowne001, champernowne010, champernowne011,  
champernowne100, champernowne101, champernowne110, champernowne111}]
```

