# How to Make a Lumpy Random Number Generator

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"How would you make
a random number generator
with a preference for
certain values?"

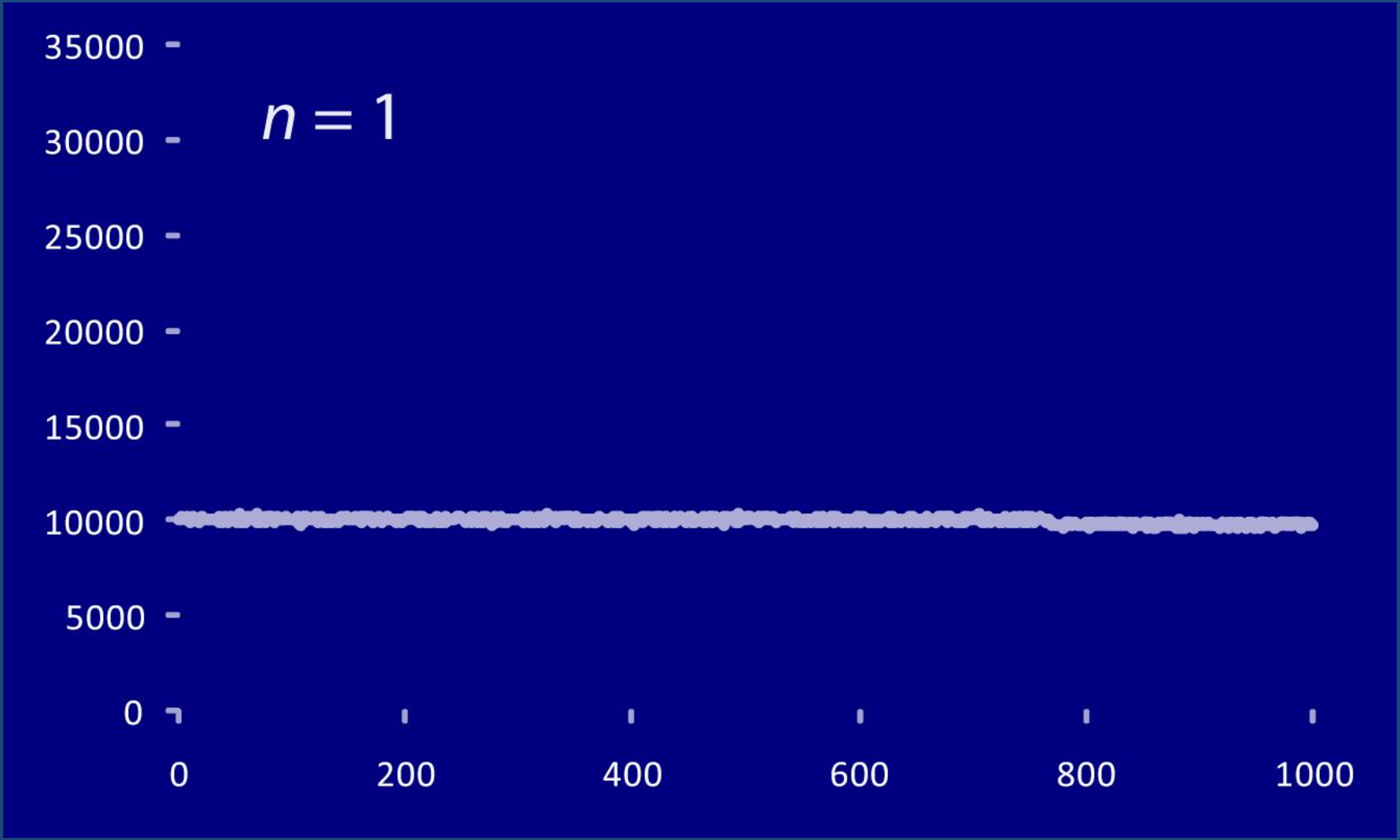
(This not a paper about Plan 9. It’s about some scientific computing that happens to have been done *with* Plan 9.)

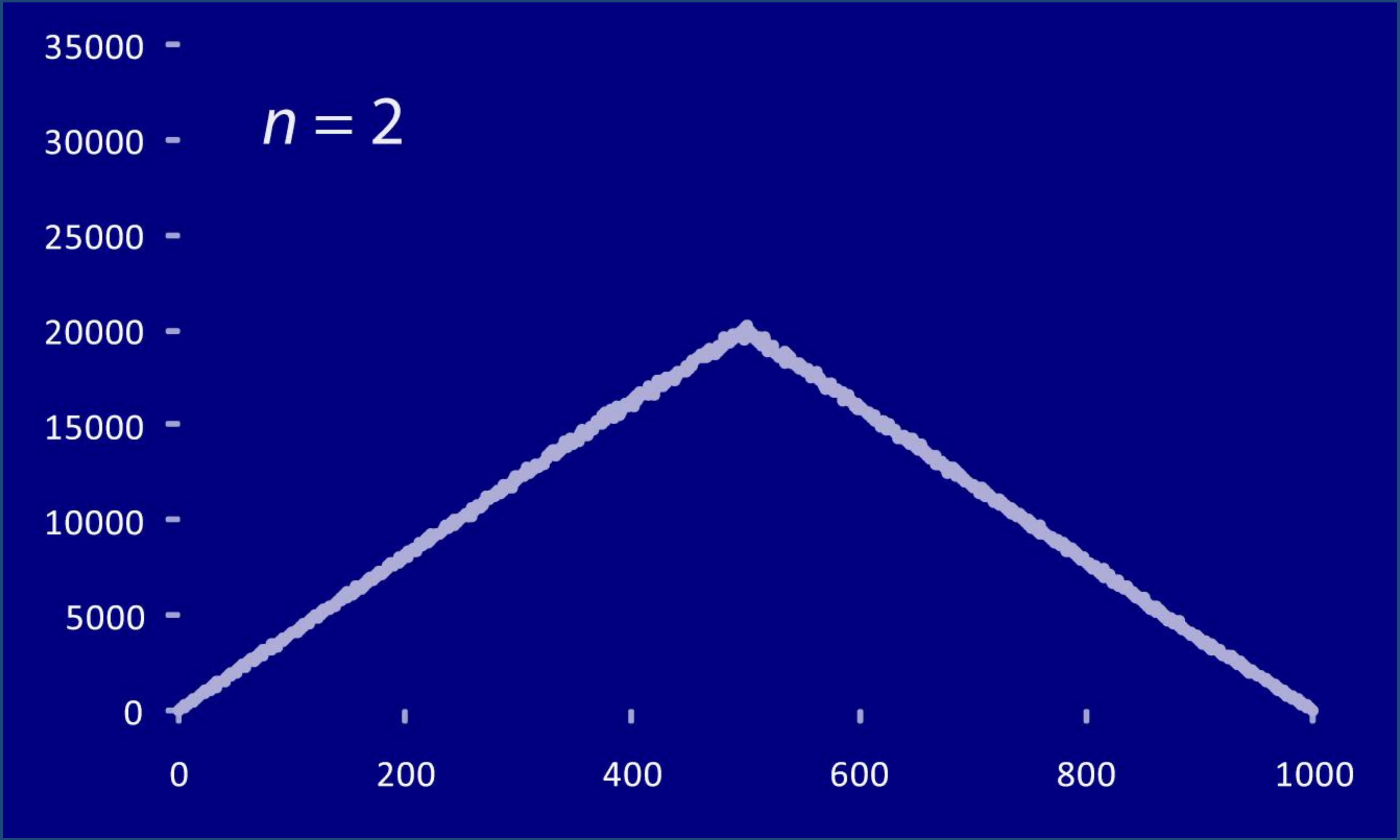
## Why would anybody want a “lumpy” random number generator?

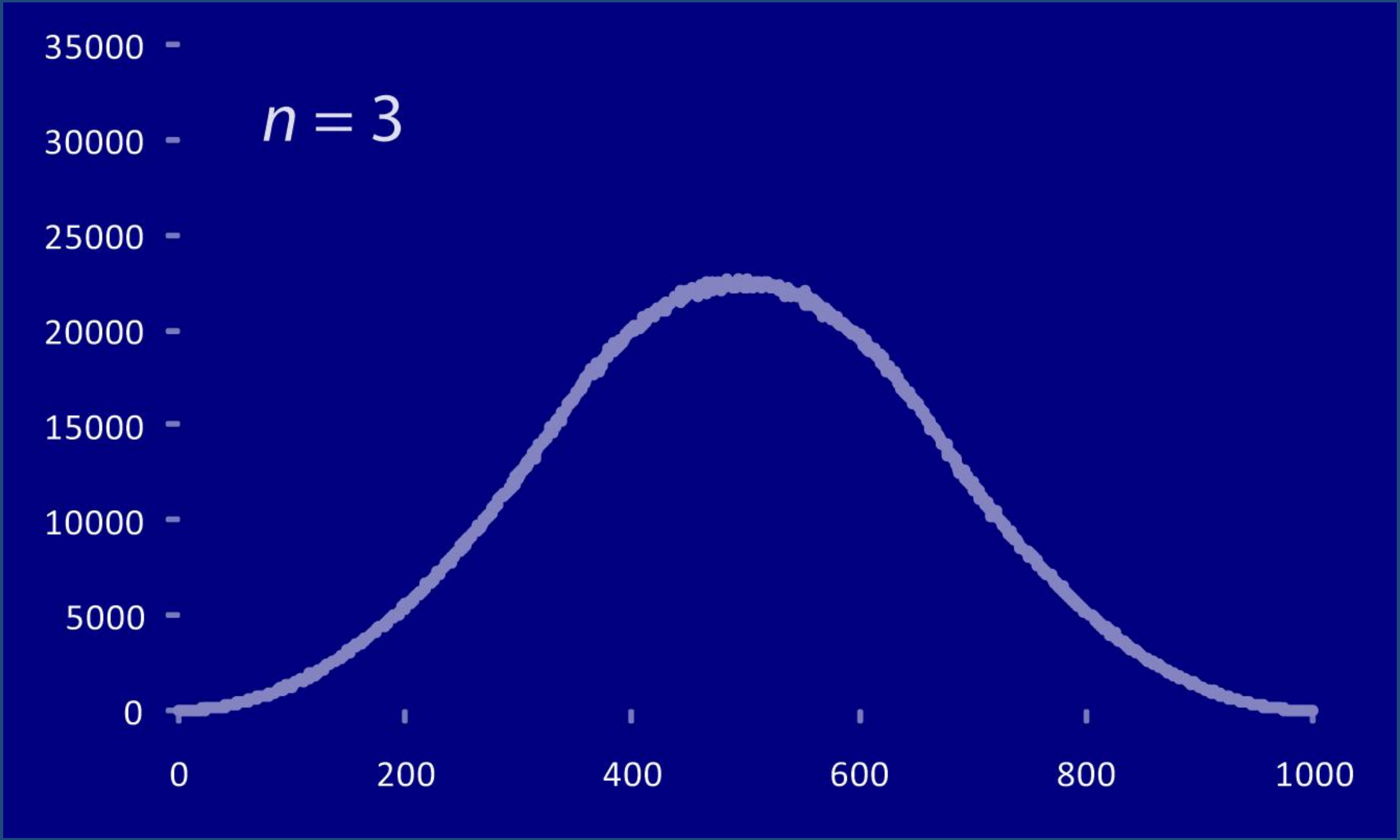
- Simulation
- To equalize wear on machinery, load on networks, etc.
- To compensate for nonlinearity elsewhere in the system
- Because it’s an interesting mathematical problem!

A very simple way to get non-uniform random numbers:

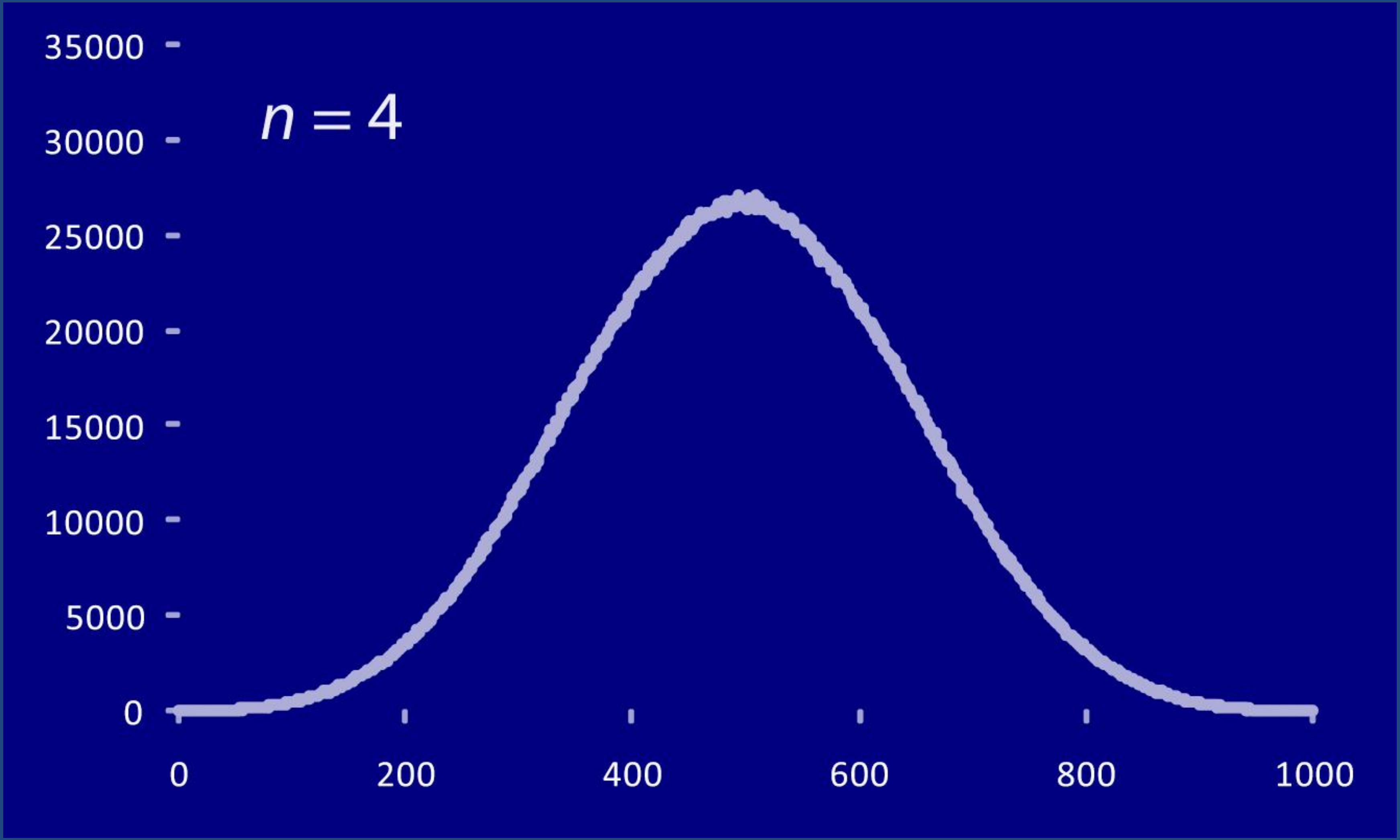
Use your random number generator *n* times, and sum the results.

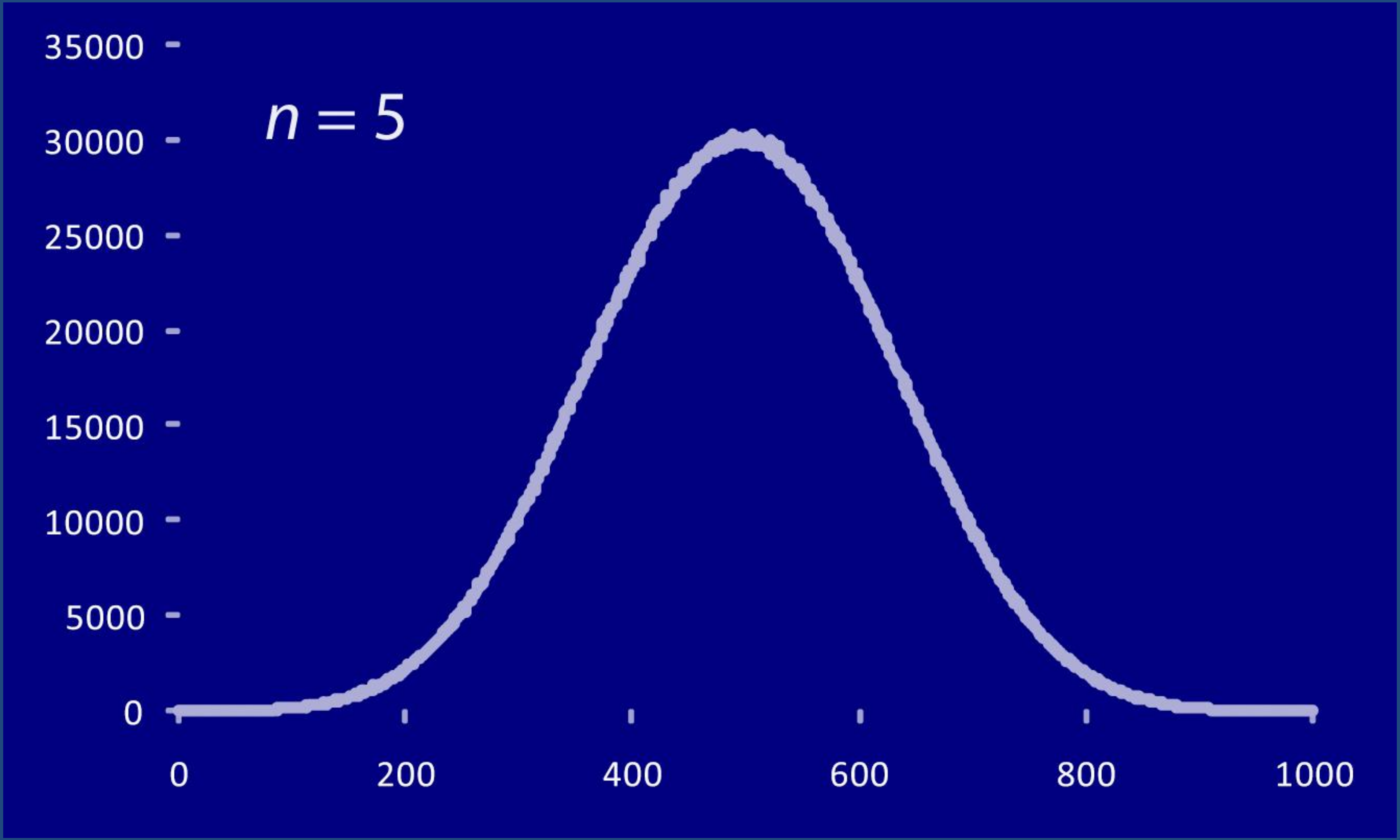

35000
30000
25000
20000
15000
10000
5000
0
$n = 1$
0
200
400
600
800
1000


35000
30000
25000
20000
15000
10000
5000
0
$n = 2$
0
200
400
600
800
1000



$n = 3$
35000
30000
25000
20000
15000
10000
5000
0
0
200
400
600
800
1000

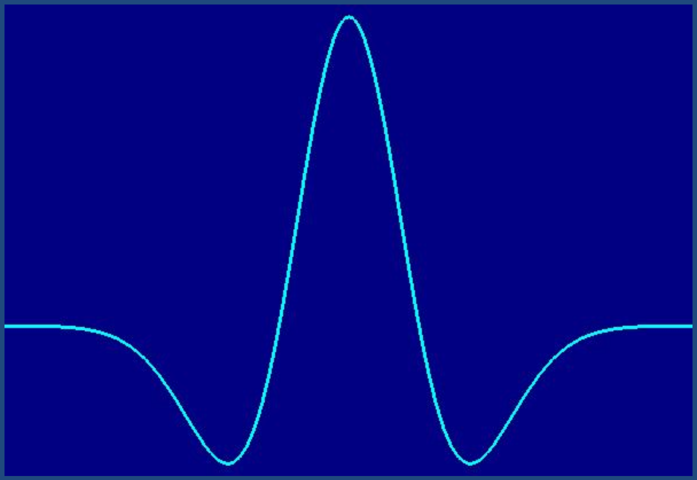

35000
30000
25000
20000
15000
10000
5000
0
$n = 4$
0
200
400
600
800
1000

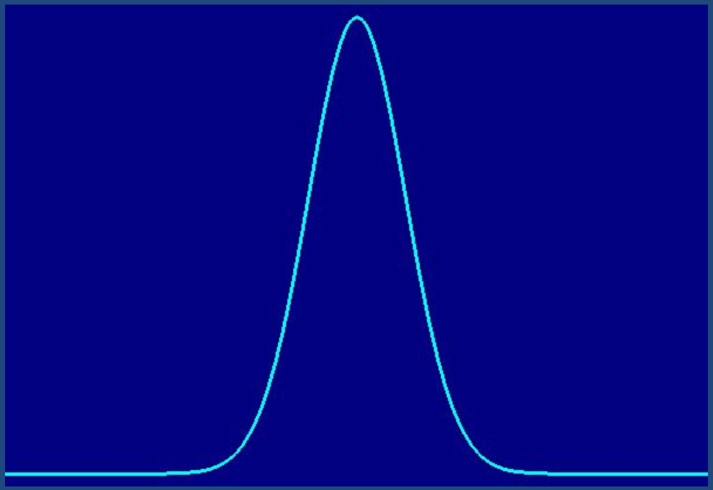

n = 5
35000
30000
25000
20000
15000
10000
5000
0
0
200
400
600
800
1000

But how do you control the nonuniformity?

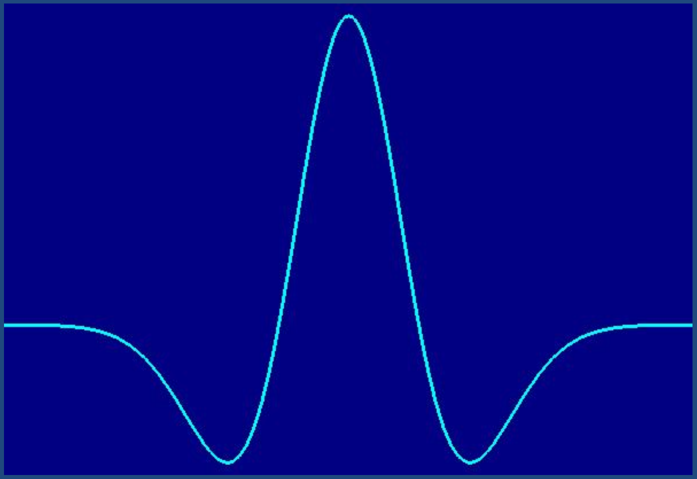
Synthesize any histogram you want, by combining bell curves!

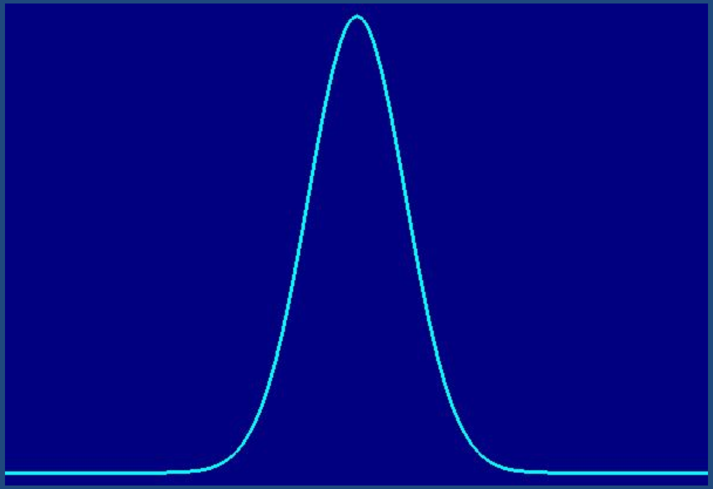
Key idea:
A bell curve is a lot like a wavelet.



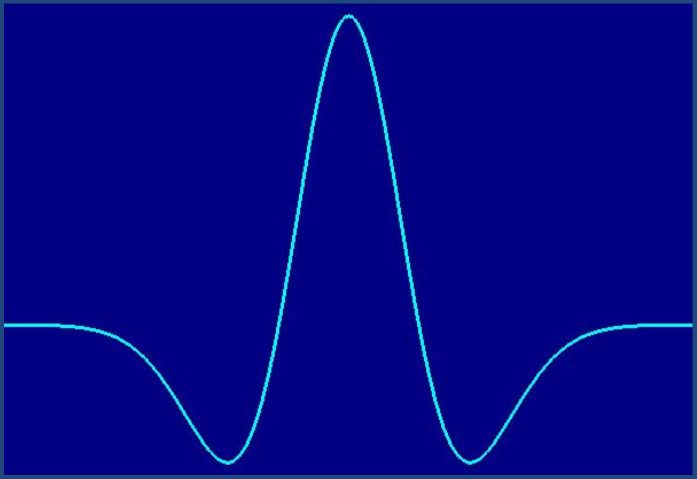


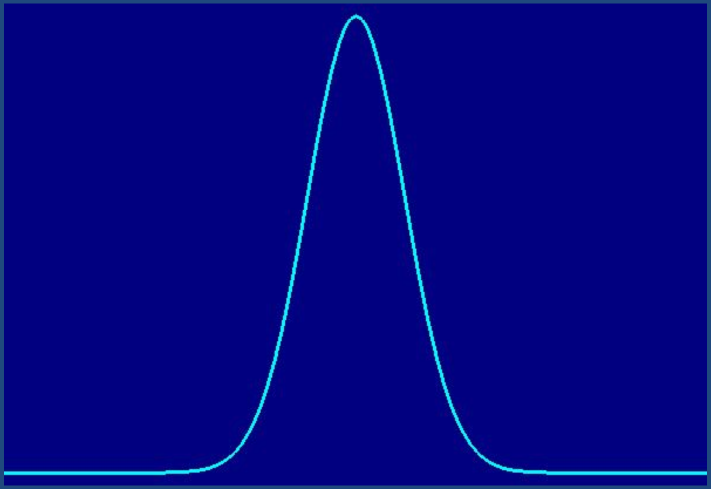
Any (finite) curve can be synthesized by adding wavelets together.



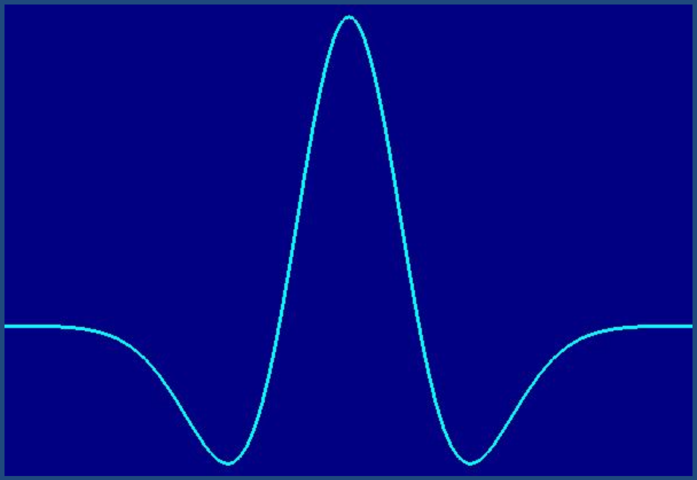


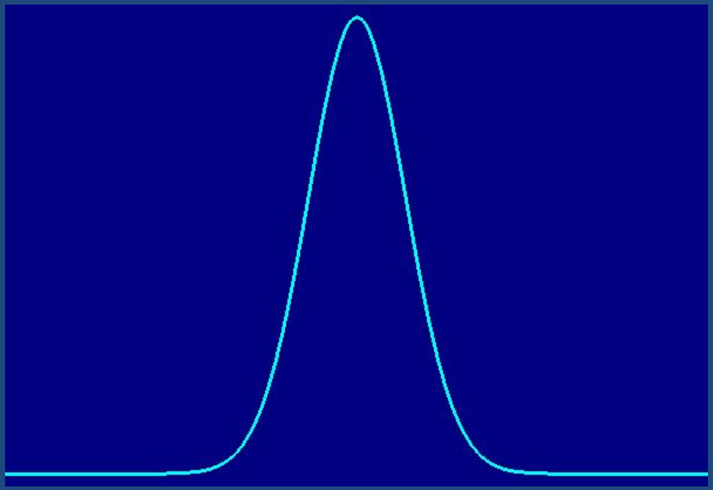
*Difference:* Wavelets go below 0, average to 0, so adding wavelets doesn't change the height of the curve you're building.





*For us, that doesn't matter,* because the height of the histogram is constrained by the fact that it's a histogram!





# Code to make a bell curve with controlled width and position

**Bell curve spans this range**

**But is truncated outside this range**

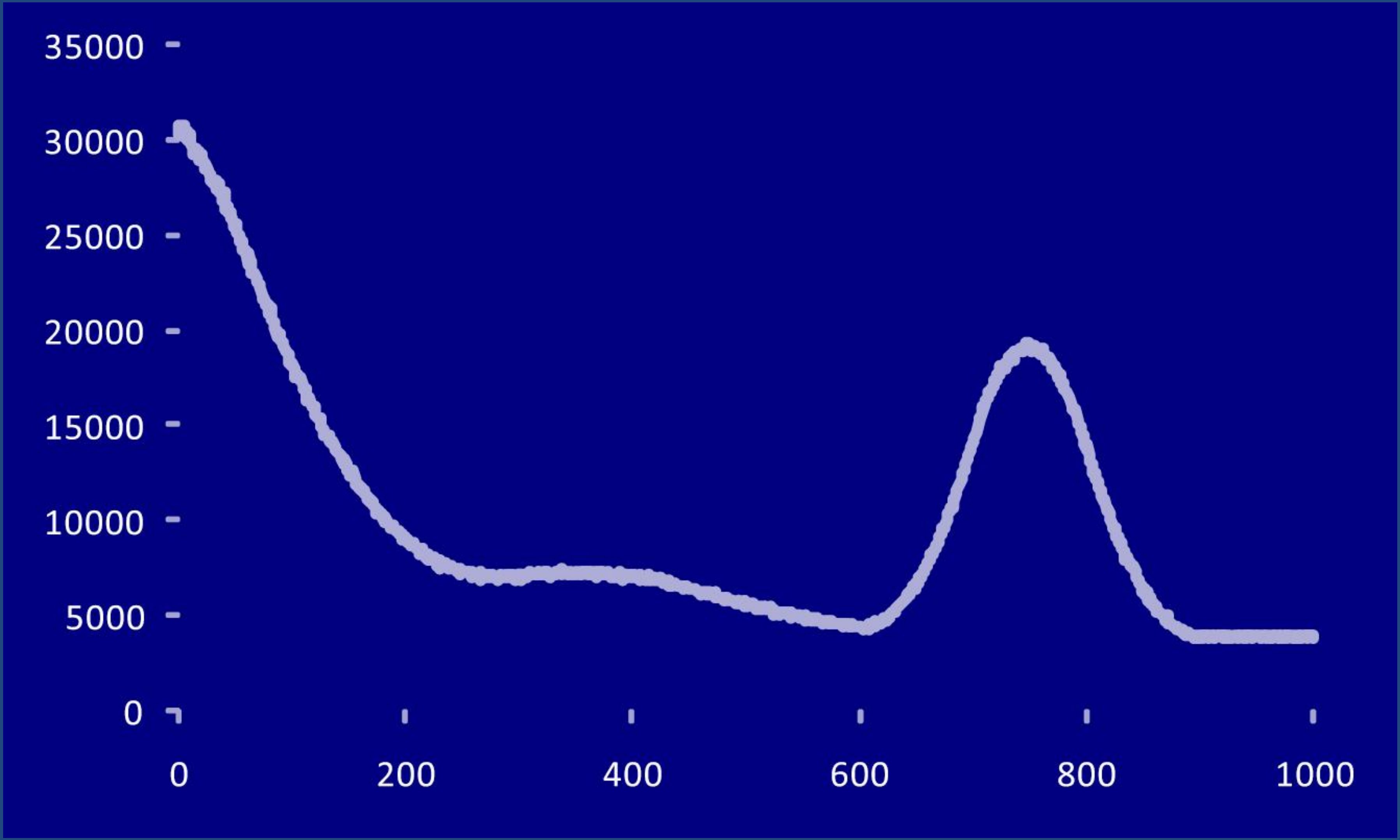
**Number of random variables to sum**

```
int genrand(int bmin, int bmax, int rmin, int rmax, int n)
{
   int i, u, sum;
   do {
      sum = 0;
      for (i=0; i<n; i++) sum += bmin + (rand() % (bmax - bmin));
      if (sum < 0) sum -= n-1;    // prevent pileup at 0
      u = sum / n;
   } while ( ! (rmin <= u && u < rmax) );
   return u;
}
```

# Code to stack several bell curves for a custom shape

```
int customrand(void)
{
   switch (rand() % 10)
   {
      case 0:
      case 1:
      case 2:
      case 3:
         return genrand(0,1000,0,1000,1);    // flat baseline
      case 4:
      case 5:
      case 6:
         return genrand(-400,300,0,300,3);  // peak beyond left edge
      case 7:
      case 8:
         return genrand(600,900,600,900,3); // peak at 750
      default:
         return genrand(0,700,0,700,3);     // low, broad peak at 350
   }
}
```

## The result


35000
30000
25000
20000
15000
10000
5000
0
0
200
400
600
800
1000

## Why do this rather than transform with a polynomial?

- No floating-point math
- Not much code
  (Good for compact embedded systems)

?