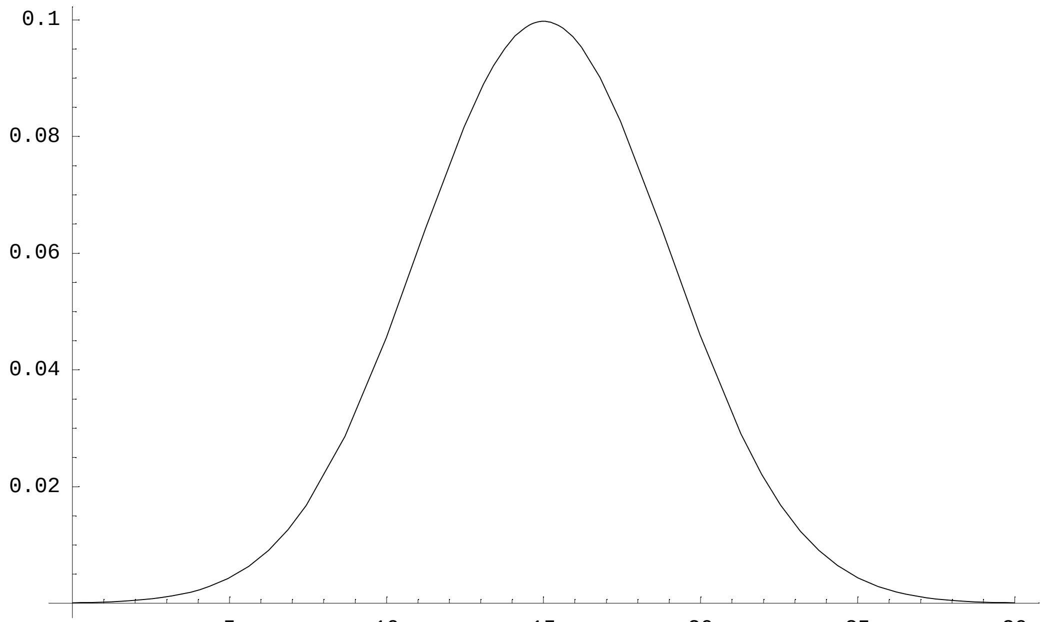
```
<< Statistics`ContinuousDistributions`
```

Assume that the value of a an hour of time is Normally distributed with a mean of $15 and a standard deviation of 4. Here is a picture of the distribution. Thus most people have a value of time somwhere between $8 and $23 which seems reasonable.

```
Plot@PDF@NormalDistribution@15, 4D, xD, 8x, 0, 30<D
```




```
… Graphics …
```

Assume that there are 5000 people who are potential waiters for the ibook. Assume there are 1000 ibooks so in equilibrium only 1000 people will line up. (We ignore the possibility of arriving late and shoving someone else out of the way and we assume that people know all the relevant information.) Efficiency requires that the people with the lowest value of time wait in line so we need to find the lowest value of time such that there are 1000 people, out of the population of 5000, with just that value of time or lower. The CDF gives the proportion of people with a value below x so 5000 times the CDF gives the number of people below this value.

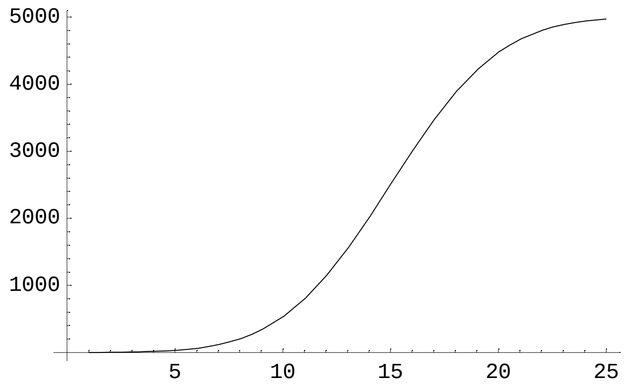
```
Solve@5000 * CDF@NormalDistribution@15, 4D, xD Š 1000., xD
```

```
Solve::ifun : Inverse functions are being used by Solve, so some solutions may not be found.
```

```
88x ® 11.6335<<
```

We can also see this by visual inspection.

```
Plot@5000 * CDF@NormalDistribution@15, 4D, xD, 8x, 1, 25<D
```




```
… Graphics …
```

Now the ibook has a street value of let's say $300 and a monetary price of $50 so the net rent at stake is $250. We know that the marginal person must receive a zero rent because if not there are other people willing to take his place in line. Thus the marginal person, the 1000st person in line if you like, must stand in line for $250/11.6335 hours.

```
250 • 11.6335
```

```
21.4897
```

Everyone must spend the the same amount of time in line (assume zero distribution time) so if everyone had the same value of time the total time cost would be $250,000:

```
1000 * 11.6335 * 21.4897
```

```
250000.
```

But 11.6335 is the highest value of time of those standing in line. Everyone else has a lower value of time. So we will now calculate the value of time for each of the 1000 people who are standing in line from the person with the very lowest value of time all the way to the 1000th person who we just calculated has a value of time of $11,6335

```
Short@values = Flatten@
   N@x •. Table@Solve@5000 * CDF@NormalDistribution@15, 4D, xD Š i, xD, 8i, 1, 1000<DDDD
```

```
Solve::ifun : Inverse functions are being used by Solve, so some solutions may not be found.

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General::stop : Further output of Solve::ifun will be suppressed during this calculation.
```

```
80.839665, 1.58882, 2.04448, † 994 ‡ , 11.6278, 11.6307, 11.6335<
```

What the above tells us is that the person in the line with the least value of time values his time at $0.839 per hour, the range then goes up all the way to $11.6 (the <<994>> indicates the middle 994 values have been suppressed. Everyone spends the same amount of time in line as the marginal person which is 21.489 hours. Thus to find the total time wasted we take each person's value of time per hour and multiply it be 21.489 hours. Then we add all the numbers up.

```
Apply@Plus, 21.489 * valuesD
```

```
202149.
```

So the total time spent wasted in line has a value of $202,149. This compares to the 250,000 we found earlier by assuming everyone had the same marginal value. Or about 80% of the simple calculation.

```
202149 • 250000.
```

```
0.808596
```