

Using Your TI-83/84 Calculator: Binomial Probability Distributions

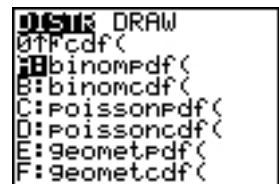
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Statistics I

This handout describes how to use the `binompdf` and `binomcdf` commands to work with binomial probability distributions. It also describes how to find the mean and standard deviation for a discrete probability distribution and how to plot a probability histogram. Note that your TI-83/84 calculator, Fathom, and I use p to signify a population proportion (or, success probability, in this case) and \hat{p} to signify a sample proportion. Your textbook uses the non-standard (and confusing) notation of π and p to signify population and sample proportions, respectively. You should adopt my notation and try not to get confused by your textbook's non-standard notation. Consider the following:

People with type O-negative blood are said to be “universal donors.” About 7% of the U.S. population has this blood type. Suppose that 45 people show up at a blood drive. Let x = the number of universal donors among a random group of 45 people

Let's begin by finding the probability that none of the 45 donors have type O-negative blood.

1. Press `2nd``[VARS]` for the `[DISTR]` menu. Scroll down to `binompdf` (and press `ENTER`. Be aware that this is menu item A if you have a TI-84 calculator, but it is menu item \emptyset on a TI-83 calculator.

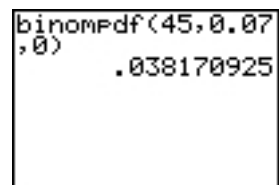


2. The syntax for the binomial probability density function command is `binompdf(n, p, x)`.

- n : This is the number of trials. For this example, $n = 45$ (the number of blood donors).
- p : This is the “success” probability. For this example, $p = 0.07$ (the probability that a randomly selected American has type O-negative blood). Note that p must be in decimal form.
- x : This is the number of “successes.” For this example, we want to know the probability that none of the 45 donors have type-0 negative blood, so $x = 0$. Note that x must be a whole number.

Putting it all together, type `45, 0.07, 0` and press `ENTER`.

3. Your calculator will return the probability that exactly 0 out of the 45 donors have type O-negative blood. You will find that $P(x = 0) = 0.0382$. In other words, there is a 3.82% chance that none of the 45 people are universal donors. *Remember to round all probability values to 3 significant figures.*



Next, let's generate the binomial probability distribution for $n = 45$ and $p = 0.07$.

To generate a binomial probability distribution, we simply use the binomial probability density function command without specifying an x value. In other words, the syntax is `binompdf(n, p)`. Your calculator will output the binomial probability associated with each possible x value between 0 and n , inclusive. The trick is to save all these values in a list. The most efficient way to do so is to work from within the stat editor.

1. Press **[STAT][ENTER]** to enter the stat editor. Clear out both L1 and L2 with the **[CLEAR]** key.
2. Position the cursor on the L2 list name. Type **[2nd][VARS]** to bring up the **[DISTR]** menu. Select **binompdf(** and press **[ENTER]**.
3. You will be returned to the stat editor. Finish off the command by typing **45, 0.07)** and then press **[ENTER]**.
4. Your calculator will fill up L2 with the probabilities for $0 \leq x \leq n$ successes.
5. We kept L1 empty because it is useful to indicate the x value that corresponds to each probability value stored in L2. You could go through and type in each x value manually, but it is often easier to generate these values automatically. Highlight L1 and press **[2nd][STAT]** to bring up the **[LIST]** menu.
6. Use the right arrow key to scroll to the **OPS** menu. Select **5:seq(** and press **[ENTER]**.
7. You will be brought back to the stat editor. Complete the command by typing **X, X, 0, 45)** and press **[ENTER]**. (Note: Press **[ALPHA][STO▶]** to type an "X.") The general syntax for this command is **seq(X, X, 0, n)**.
8. Your calculator will fill L1 with the whole numbers from 0 to 45.
9. Together, L1 and L2 comprise the binomial probability distribution for $n = 45$ and $p = 0.07$. Use the **[▼]** and **[▲]** keys to scroll through all the entries in L1 and L2.

L1	L2	L3	6
-----	-----	-----	
L2=binomPdf(45,...			

L1	L2	L3	6
-----	.03817	-----	
	.12929		
	.21409		
	.23097		
	.18254		
	.11267		
	.05654		
L2(1)=.0381709250...			

NAMES		OPS	MATH
1:	SortA(
2:	SortD(
3:	dim(
4:	Fill(
5:	seq(
6:	cumSum(
7:	List(

L1	L2	L3	5
-----	.03817	-----	
	.12929		
	.21409		
	.23097		
	.18254		
	.11267		
	.05654		
L1=seq(X,X,0,45)			

L1	L2	L3	5
0	.03817	-----	
1	.12929		
2	.21409		
3	.23097		
4	.18254		
5	.11267		
6	.05654		
L1(1)=0			

Working with a binomial probability distribution

1. Let's use the distribution we just generated to find the probability that **at least one** of the 45 donors has type O-negative blood. The tedious approach would be to add up $P(x = 1) + P(x = 2) + P(x = 3) + \dots + P(x = 45)$. Don't! Instead, take advantage of the fact that the complement of "at least one" is "none." Thus, $P(1 \leq x \leq 45) = 1 - P(x = 0) = 1 - 0.0381709250 = 0.962$. Remember to hold off rounding to 3 significant figures until the end.
2. Next, let's find the probability that **no more than three** of the donors have type O-negative blood. To do so, we need to find $P(x = 0) + P(x = 1) + P(x = 2) + P(x = 3)$. You could write down the corresponding probabilities from L2 and then add them up.
3. Alternatively, we can use the **sum** command and specify the range of items in L2 that we wish to add up. The key is to remember that the first item in the list, L2(1), corresponds to $P(x = 0)$; that is, the row number corresponds to $x + 1$. Press **[2nd][STAT]** for the **[LIST]** menu and scroll right for the **MATH** menu. Scroll down to **5:sum(** and press **[ENTER]**.
4. The syntax for the sum command is **sum(list, start, end)**. For this example, type **[2nd][2][,][1][,][4][)]** and press **[ENTER]**. This command

NAMES		OPS	MATH
1:	min(
2:	max(
3:	mean(
4:	median(
5:	sum(
6:	Prod(
7:	stdDev(

sum(L2,1,4)	
	.6125229128

tells your calculator to sum the contents of rows 1 through 4 in L₂. We find that $P(x \leq 3) = 0.613$. In other words, there is a 61.3% chance that no more than three of the 45 donors have type O-negative blood.

5. A third approach is to use the `binomcdf` command. This command finds the cumulative probability of obtaining x or fewer successes. The syntax is `binomcdf(n, p, x)`. This command is a useful whenever you are asked to find the probability of “no more than” x successes. To find the probability that no more than three of the donors have type O-negative blood, use `binomcdf(45, 0.07, 3)`. This command tells your calculator to find $P(x = 0) + P(x = 1) + P(x = 2) + P(x = 3)$, which is exactly what we need to do here. We obtain the same answer as before, $P(x \leq 3) = 0.613$.

```

D:STAT DRAW
1:1Ppdf(
0:Pcdf(
A:binompdf(
B:binomcdf(
C:poissonpdf(
D:poissoncdf(
E:geometpdf(

```

```

binomcdf(45,0.07
,3)
.6125229134

```

6. Through creative combinations of the `binompdf` and `binomcdf` commands, you will find it possible to solve any sort of binomial probability problem that comes your way. Suppose that we want to find the probability that **at least two** of the donors have type O-negative blood. Recognize that this is the complement of no more than one of the donors having this blood type, and you can easily solve this problem. Note from the screenshot that you can add or subtract probabilities directly from the command line. We find that $P(x \geq 2) = 1 - P(x \leq 1) = 0.833$.

```

1-binomcdf(45,0.
07,1)
.8325404579

```

7. As a final example, let’s find the probability that **between 4 and 8** of the donors have type O-negative blood. That is, find $P(4 \leq x \leq 8)$. You could solve this problem using the `sum(` command and your binomial probability distribution. Alternatively, you can strategically use the `binomcdf` command. Note that $P(4 \leq x \leq 8) = P(x \leq 8) - P(x \leq 3)$. By subtracting out $P(x \leq 3)$, we are making sure that $P(x = 4)$ is included in our calculations. Using the `binomcdf` command as shown to the right, we find that $P(4 \leq x \leq 8) = 0.384$. Using this approach saves you from having to generate the binomial probability distribution and figure out the correct rows to add up.

```

sum(L2,5,9)
.3839286062

```

```

binomcdf(45,0.07
,8)-binomcdf(45,
0.07,3)
.3839286056

```

Summary: `binompdf` vs. `binomcdf` commands

Here are some useful applications of the `binomcdf` and `binompdf` commands:

- To find $P(x = k)$, use `binompdf(n, p, k)`
- To find $P(x \leq k)$, use `binomcdf(n, p, k)`
- To find $P(x < k)$, use `binomcdf(n, p, k-1)`
- To find $P(x > k)$, use `1-binomcdf(n, p, k)`
- To find $P(x \geq k)$, use `1-binomcdf(n, p, k-1)`

Note: k refers to some number of successes between 0 and n .

How to find μ_x and σ_x for a discrete probability distribution

1. What is the **expected number** of universal donors out of the 45 people who show up at the blood drive? For all discrete random variables, $E(x) = \mu_x = \sum x \cdot P(x)$. For a binomial probability distribution, $E(x) = \mu_x = np$. For this example, $E = (45)(0.07) = 3.15$ (round to 3.2). We can find both μ and σ for a binomial probability distribution (or any other type of discrete probability distribution) by using the 1-Var Stats command.
2. Press **[STAT]** and scroll right to the CALC menu. Press **[ENTER]** to select 1:1-Var Stats. Type **[2nd][1][,][2nd][2]** and press **[ENTER]**. (You must enter the list containing the x values first, then the list containing the $P(x)$ values.)
3. Your calculator will return the output screen to the right. Note that what it calls \bar{x} is really μ . Rounding to one more decimal place that we started with, we find that the expected number of universal donors out of 45 is 3.2 people, with a standard deviation of 1.7 people.

```
1-Var Stats L1,L2
```

```
1-Var Stats
x=3.15
Σx=3.15
Σx²=12.852
Sx=
σx=1.711578219
n=1
```

How to construct a probability histogram

1. Let's plot a probability histogram. Press **[2nd][Y=]** for the [STAT PLOT] menu. Make sure only Plot1 is turned on. Select the histogram plot Type. The Xlist is L1 (the list containing the x values), and Freq is L2 (the list containing the $P(x)$ values).
2. If you press **[ZOOM][9]**, you will get an inappropriate plot. (Go ahead and see what I mean.) We need to set the window variables. Press **[WINDOW]**. Here are some guidelines on how to choose the proper settings:
 - Xmin: Should always be 0 (the lowest possible value of x)
 - Xmax: Start by using one more than the highest possible value of x in your probability distribution (46, for this example)
 - Xsc1: Should always be 1
 - Ymin: Should always be 0
 - Ymax: Pick a value slightly higher than the largest $P(x)$ value in L2 (Use 0.25 for this example)
 - Ysc1: Sets the spacing for the y -axis tick marks (0.1 is fine for this example)
 - Xres: Leave it set to 1
3. Press **[GRAPH]** to generate the probability histogram. (Don't use **[ZOOM]!**) Then, press **[TRACE]** and use the **[▶]** and **[◀]** keys to confirm that the histogram corresponds to the binomial probability distribution saved in L1 and L2.
4. Change the Xmax window setting to make your histogram easier to read. I used Xmax=14 here. You'll occasionally need to experiment with the window settings to get a plot that captures the shape of the probability distribution, yet is still readable.

