hp calculators

HP 30b Probability Distributions

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- Normal distribution and inverse
- Students t distribution and inverse
- Chi^2 distribution and inverse
- F distribution and inverse
- Binomial distribution

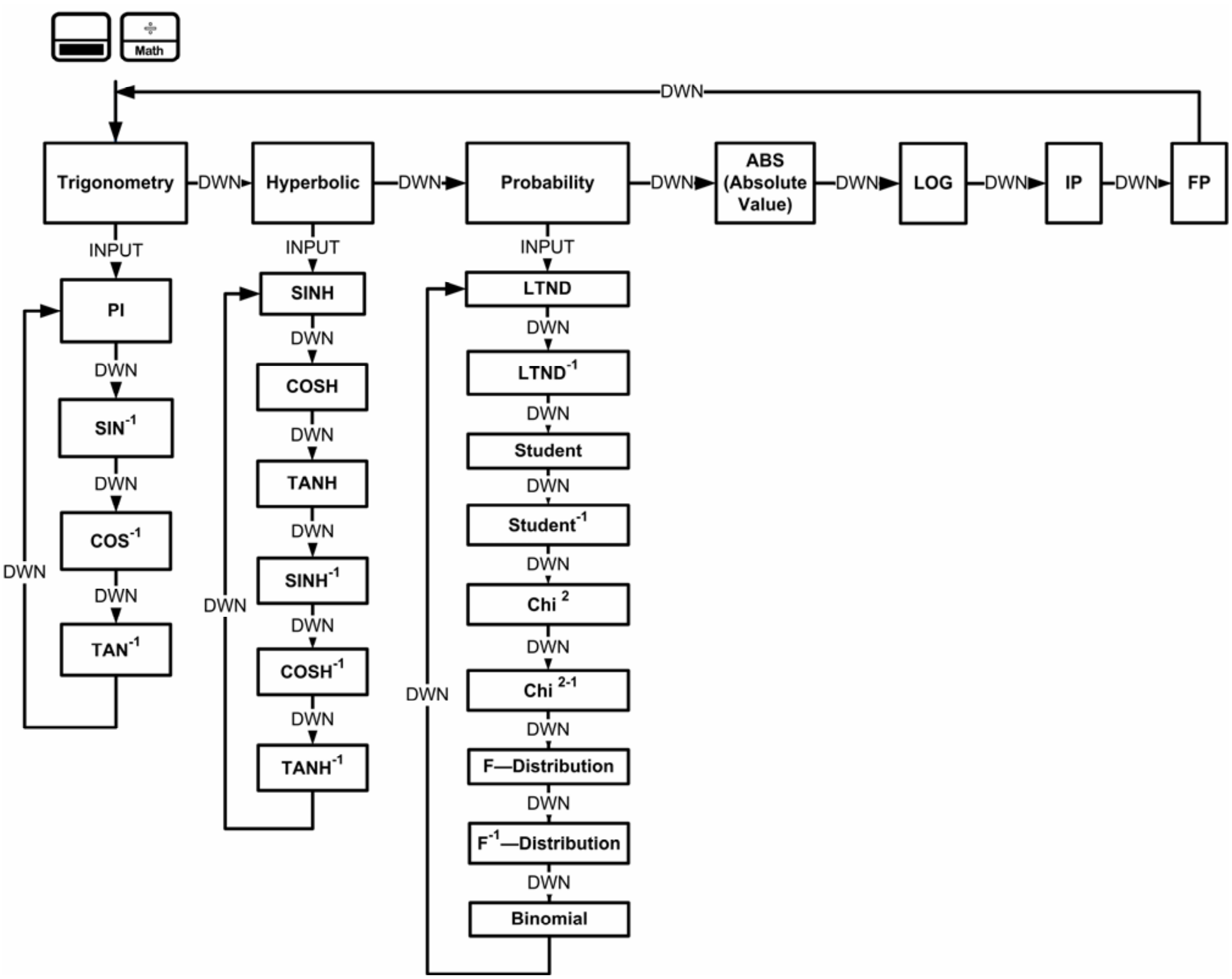
Practice solving problems involving probability distributions

The HP 30b probability distributions

The HP 30b contains functions to compute five probability distributions and the inverse distributions for four of these. This powerful set of features allows the user to work with problems that usually require looking up values in tables of numbers. The probability distributions included are:

- The normal distribution (LTND) and inverse normal distribution ($LTND^{-1}$). LTND stands for Lower tail normal distribution.
- The Students t distribution and inverse Students distribution
- The Chi^2 distribution and inverse Chi^2 distribution
- The F-distribution and inverse F-distribution
- The binomial distribution

These distribution functions are found in the probability portion of the math menu, which is accessed by pressing [shift] [Math] and is shown below. Note that the IP and FP functions at the right of the menu below stand for Integer Part and Fractional Part. These will return the integer or fractional part of the number displayed. They are often used in programming.



After pressing [ ] [Math], press [▼] to scroll through the menu items, starting with *Trigonometry.* The *Trigonometry, Hyperbolic,* and *Probability* items have sub-menus. Press [INPUT] when any of these items are displayed to access the functions within the sub-menus. Press [ON/CE] to cancel and leave the Math menu. Press [ ] [Math] to return to the top of the Math menu at any time.

Each of these distribution functions requires certain values in order to compute the proper value. These values, called arguments, are different for each function. These are shown in the list below.

LTND / normal distribution:	Requires a standard z-score value as input and returns the probability that a value would be less than the z-score input. For example, a z-score input of 0 would return a probability of 0.5 while a z-score input of 1 would return a probability of approximately 0.84. See examples 1 and 2.
$LTND^{-1}$ / inverse normal distribution:	Requires a probability as input and returns the standard z-score. Exact inverse of the LTND. See example 3.
Students t distribution:	Requires two arguments: the number of degrees of freedom, and the t value for which you wish to compute the probability. See example 4.
Inverse Students t distribution:	Requires two arguments: the number of degrees of freedom, and the probability for which you wish to compute the t value. See example 5.
Chi^2 distribution:	Requires two arguments: the number of degrees of freedom, and the t value for which you wish to compute the probability. See example 6.
Inverse Chi^2 distribution:	Requires two arguments: the number of degrees of freedom, and the probability for which you wish to compute the t value. See example 7.
F-Distribution:	Requires three arguments. The two degrees of freedom and the value for which you wish to calculate the probability. See example 8.
Inverse F-Distribution:	Requires three arguments. The two degrees of freedom and probability for which you wish to calculate the value. See example 9.
Binomial Distribution:	Requires three arguments. The number of observations, the probability of a success and the number of successes observed. See examples 10 and 11.

These are illustrated in the examples that follow. In general, to calculate a probability requiring more than one argument, key the arguments, pressing [=] between them, then navigate to the appropriate function in the Probability sub-menu of the Math menu. Use [=] to separate the arguments, even in RPN mode.

Practice solving problems involving probability distributions

<u>Example 1:</u> The results of a process are normally distributed with an average of 120 per hour and a standard deviation of 20 per hour. What is the probability of seeing results less than 150 per hour?

<u>Solution:</u> First, convert the information given into a standard z-score, using the formula $Z = \frac{X - \mu}{\sigma}$, where X is the observation under consideration, μ is the average of the process, and σ is the standard deviation of the process. Z is simply a standardized value of how many standard deviations above (or below) the average an observation is.

In RPN mode, press: [1] [5] [0] [INPUT] [1] [2] [0] [−] [2] [0] [÷]

In chain or algebraic mode, press: [(] [1] [5] [0] [−] [1] [2] [0] [)] [÷] [2] [0] [=]

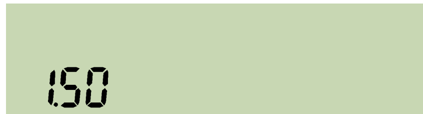


Figure 1

Then, look up the probability that results would have a z-value smaller than 1.5 by doing the following:

In any mode, press: [ ] [Math] [▼] [▼] [INPUT] [INPUT]

Figure 2

<u>Answer:</u> 0.93. This means that 93% of the observations would generate observed values less than the 150 per hour observed. Note that the second [INPUT] is pressed to complete the calculation. If you do not, then in algebraic or chain mode, you would not have finished the calculation, which can lead to unexpected results in the next calculation.

<u>Example 2:</u> The results of a process are normally distributed with an average of 120 per hour and a standard deviation of 20 per hour. What percent of the time would you see more than 135 per hour?

<u>Solution:</u> First, convert the information given into a standard z-score, using the formula $Z = \frac{X - \mu}{\sigma}$, where X is the observation under consideration, μ is the average of the process, and σ is the standard deviation of the process. Z is simply a standardized value of how many standard deviations above (or below) the average an observation is.

In RPN mode, press: [1] [3] [5] [INPUT] [1] [2] [0] [−] [2] [0] [÷]
In chain or algebraic mode, press: [1] [3] [5] [−] [1] [2] [0] [=] [÷] [2] [0] [=]

Figure 3

Then, look up the probability that results would have a z-value smaller than 0.75 by doing the following:

In any mode, press: [ ] [Math] [▼] [▼] [INPUT] [INPUT]

Figure 4

So, 77% of the observations would be less than a z-score of 75 (or an observed 135 per hour). But, that's not what this example asked to be computed. The question given was the percent of observations greater than the 135. Well, if 77% are less than 135, the complement (what makes it add up to 100%) is the answer we want.

In RPN mode, press: [1] [−] [+/-]
In chain or algebraic mode, press: [−] [1] [+/-] [=]

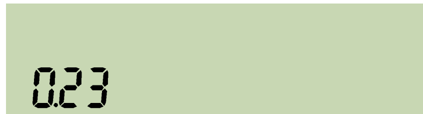


Figure 5

<u>Answer:</u> 0.23. This means that 23% of the observations would be greater than the observed 135 per hour.

<u>Example 3:</u> The results of a process are normally distributed with an average of 120 per hour and a standard deviation of 20 per hour. What value per hour would 90% of the observations be less than?

<u>Solution:</u> In this example, we have the probability and wish to go in the opposite direction. We will use the inverse normal distribution function in the HP 30b first then convert from the returned z-score to the observation desired.
In any mode, press: [0] [•] [9] [▬] [Math] [▼] [▼] [INPUT] [▼]

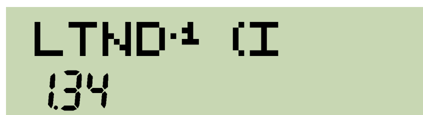


Figure 6

Then, to complete the calculation, press: [INPUT]

Now, convert the information given as a standard z-score to solve for the unknown X, using the formula $Z = \frac{X - \mu}{\sigma}$, where X is the observation under consideration, μ is the average of the process, and σ is the standard deviation of the process. Z is simply a standardized value of how many standard deviations above (or below) the average an observation is.

In RPN mode, press: [2] [0] [×] [1] [2] [0] [+]
In chain or algebraic mode, press: [×] [2] [0] [+] [1] [2] [0] [=]

Figure 7

<u>Answer:</u> 146.9. So, 90% of the observations would be less than 146.9 per hour. Or, stated alternatively, 90% of the time the process would result in observations less than 146.9 per hour. This is an example of using the inverse normal probability distribution.

<u>Example 4:</u> John is evaluating a Hypothesis test with an observed t statistic of -3.16. If the situation has 9 degrees of freedom, what is the probability of seeing an observed t statistics less than this -3.16 value?

<u>Solution:</u> In any mode, press: [9] [=] [3] [•] [1] [6] [+/-] [▬] [Math] [▼] [▼] [INPUT] [▼] [▼]

Figure 8

In any mode, press: [INPUT]

Answer: Only 0.58% of the time would you see an observed t statistic with a value less than -3.16.

Example 5: John is evaluating a Hypothesis test with an observed t statistic of -3.16. The test statistic would be a Students t value with 9 degrees of freedom and a 0.05% significance level. Look up the test statistic using the inverse Students t distribution.

Solution: In any mode, press: [9] [=] [0] [.] [0] [5] [▬] [Math] [▼] [▼] [INPUT] [▼] [▼] [▼] [INPUT]

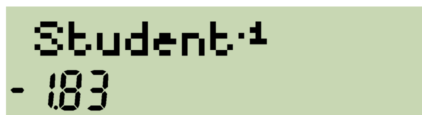


Figure 9

In any mode, press: [INPUT]

Answer: -1.83. This is the value that would be compared to the observed t statistic and used to accept or reject the hypothesis.

Example 6: Cindy is evaluating a hypothesis test that the variance of a population is equal to 18. With 40 samples, she has found the variance to be 16, which implies a Chi^2 observed value of 34.67. What is the probability of this observed value or less? Note that the degrees of freedom would be 40 less 1, or 39.

Solution: In any mode, press: [3] [9] [=] [3] [4] [.] [6] [7]
[▬] [Math] [▼] [▼] [INPUT] [▼] [▼] [▼] [▼]

Figure 10

In any mode, press: [INPUT]

Answer: 33%.

Example 7: Cindy is evaluating a hypothesis test that the variance of a population is equal to 18. At a 0.01 significance level, what is the test statistic? This would mean looking up an inverse Chi^2 value with 39 degrees of freedom at a 0.99 probability. The 0.01 to 0.99 switch is necessary because the HP 30b uses a lower tail calculation method.

Solution: In any mode, press: [3] [9] [=] [0] [.] [9] [9] [▬] [Math] [▼] [▼] [INPUT] [▼] [▼] [▼] [▼] [▼]

Figure 11

In any mode, press: [INPUT]

Answer: The comparison value is approximately 62.43.

Example 8: Given degrees of freedom of 14 and 9, and an F-statistic of 2.65, what is the probability?

Solution: In any mode, press: [1] [4] [=] [9] [=] [2] [.] [6] [5] [ ] [Math] [▼] [▼] [INPUT] [▼] [▼] [▼] [▼] [▼] [▼]

Figure 12

Then, in any mode, press: [INPUT]

Answer: The probability is approximately 93%.

Example 9: Given degrees of freedom of 39 and 29, and a significance level of 0.95, what is the F-statistic?

Solution: In any mode, press: [3] [9] [=] [2] [9] [=] [0] [.] [9] [5] [ ] [Math] [▼] [▼] [INPUT] [▼] [▼] [▼] [▼] [▼] [▼] [▼]

Figure 13

Then, in any mode, press: [INPUT]

Answer: The F-statistic value is approximately 1.81.

Example 10: If you were to flip a coin 10 times, with each flip having a 50% probability of a head being observed, what is the probability that you would see 5 or fewer heads?

Solution: In any mode, press: [1] [0] [=] [0] [.] [5] [=] [5] [ ] [Math] [▼] [▼] [INPUT] [▲]

Figure 14

Then, in any mode, press: [INPUT]

Answer: The probability of observing 5 or fewer heads in 10 coin flips is approximately 62%.

> TIP!! Since the binomial distribution is the bottom menu-item in the Probability sub-menu, you could also press these keystrokes to access it in the math menu. This saves several keypresses:
> [ ] [Math] [▼] [▼] [INPUT] [▲].

Example 11: If you were to flip a coin 10 times, with each flip having a 50% probability of a head being observed, what is the probability that you would see exactly 5 heads?

Solution: Since the binomial distribution present in the HP 30b is the cumulative probability distribution, to determine the probability of an exact result requires computing the cumulative probability observed including the number sought and then subtracting from that result the cumulative probability observed for one less success than before. In other words, to find the probability of exactly 5 heads, compute the probability of 5 or fewer heads and then subtract the probability of 4 or fewer heads. The difference will be the probability of exactly 5 heads.

In any mode, press: [1] [0] [=] [0] [•] [5] [=] [5]
[ ] [Math] [▼] [▼] [INPUT] [▲]

Figure 15

Then, in any mode, press: [INPUT]

In any mode, press: [1] [0] [=] [0] [•] [5] [=] [4]
[ ] [Math] [▼] [▼] [INPUT] [▲]

Figure 16

Then, in any mode, press: [INPUT]

Answer: The probability of observing exactly 5 heads in 10 coin flips is approximately 24%. If the two values are subtracted using more decimal places, the result is more accurately 24.61%.