# APL64 ⎕PDIST: Probability Distributions

# Overview

The APL64 ⎕PDIST system function is an interface to the MathNet Probability and MathNet Random toolkits. The ⎕PDIST system function provides the Samples action to obtain sample values for the supported probability distributions using an APL64 programmer-selected pseudo-random number generators.

# Study the ⎕PDIST and MathNet Documentation

The ⎕PDIST documentation, and the Mathnet Probability and Random toolkits documentation are mandatory reading to effectively use ⎕PDIST.

# Pseudo-Random Number Generators

## Pseudo-Random Number Generators

⎕PDIST requires the APL64 programmer to select an appropriate pseudo-random number generator for each probability distribution used. ⎕PDIST provides a selection of pseudo-random number generators.

## Pseudo-Random Seed

Each instance of a pseudo-random number generator requires a random seed. ⎕PDIST provides a selection of random seed options.

## Repeatability

If the same random seed is used, e.g. a fixed number, all sequences of pseudo-random numbers obtained from a pseudo-random number generator will be the same. This behavior is useful for testing and debugging of an application system but is not appropriate for a production application.

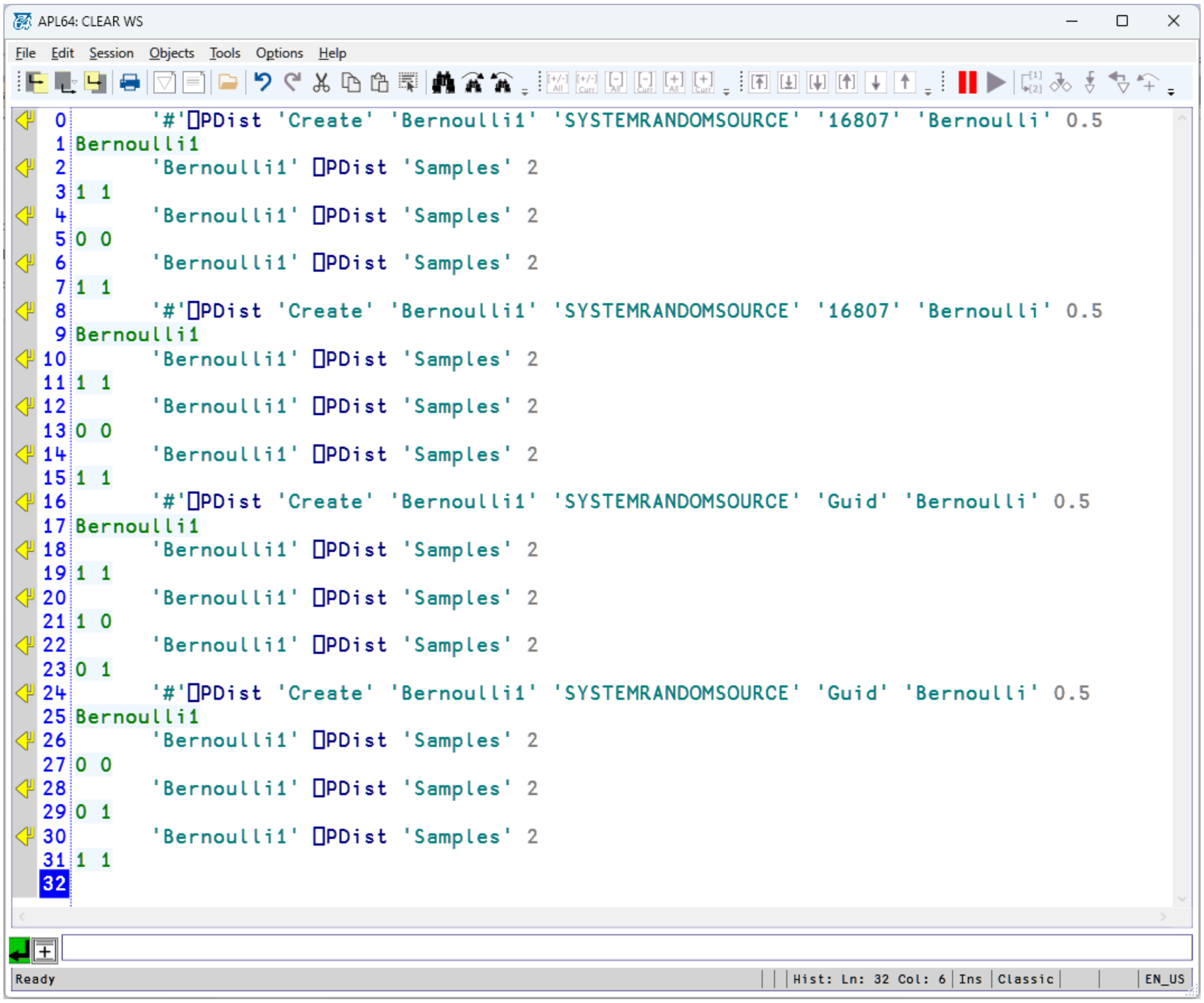
Because of this behavior of pseudo-random number generators, the structure of the ⎕PDIST system function provides for creating instances of probability distributions. Recurring requests for sample values of a probability distribution should be made to the same instance of that probability distribution.

*NOTE: Some examples do not use a fixed numeric random seed, so the illustrated result may not be repeatable. Round off error in printed results can also affect the repeatability of results, even when a fixed numeric random seed is used.*

Example:

```
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' '16807' 'Bernoulli' 0.5
'Bernoulli1' ⎕PDist 'Samples' 2
'Bernoulli1' ⎕PDist 'Samples' 2
'Bernoulli1' ⎕PDist 'Samples' 2
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' '16807' 'Bernoulli' 0.5
'Bernoulli1' ⎕PDist 'Samples' 2
'Bernoulli1' ⎕PDist 'Samples' 2
'Bernoulli1' ⎕PDist 'Samples' 2
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'Guid' 'Bernoulli' 0.5
'Bernoulli1' ⎕PDist 'Samples' 2
'Bernoulli1' ⎕PDist 'Samples' 2
'Bernoulli1' ⎕PDist 'Samples' 2
```

```
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'Guid' 'Bernoulli' 0.5
'Bernoulli1' ⎕PDist 'Samples' 2
'Bernoulli1' ⎕PDist 'Samples' 2
'Bernoulli1' ⎕PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' '16807' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1' ⎕PDist 'Samples' 2
1 1
      'Bernoulli1' ⎕PDist 'Samples' 2
0 0
      'Bernoulli1' ⎕PDist 'Samples' 2
1 1
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' '16807' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1' ⎕PDist 'Samples' 2
1 1
      'Bernoulli1' ⎕PDist 'Samples' 2
0 0
      'Bernoulli1' ⎕PDist 'Samples' 2
1 1
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'Guid' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1' ⎕PDist 'Samples' 2
1 1
      'Bernoulli1' ⎕PDist 'Samples' 2
1 0
      'Bernoulli1' ⎕PDist 'Samples' 2
0 1
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'Guid' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1' ⎕PDist 'Samples' 2
0 0
      'Bernoulli1' ⎕PDist 'Samples' 2
0 1
      'Bernoulli1' ⎕PDist 'Samples' 2
1 1
```

# ⎕PDIST Workflow

## Select the Pseudo-random Number Generator

Select the pseudo-random number generator and random seed used to create a ⎕PDIST probability distribution instance. See the ⎕PDIST RandomSource action for the available options.

## Create a Probability Distribution Instance

Use the ⎕PDIST Create or New action to create a probability distribution instance. Creating a probability distribution instance involves selecting the random seed type, the random number generator, the probability distribution type, and providing the probability distribution initialization parameters.

### Review the Probability Distribution Properties

Use the ⎕PDIST Properties action to verify that the probability distribution instance is appropriate.

### Obtain Probability Distribution Samples

Use the ⎕PDIST Samples action to obtain an APL64 rank-1 array of probability distribution samples.

### Consider the Other ⎕PDIST Actions

⎕PDIST includes additional actions.

## Syntax

Result←[larg] ⎕PDIST Action ActionArg1 …

Result: result of the specified action.  Refer to ⎕PDIST '?' for a summary of result types

larg: text

- '#' for ⎕PDist object actions
- instanceName for ⎕PDist instance actions
- optional for ⎕PDist instance actions, when for ⎕PDistSelf is set to an instance name

The right argument of ⎕PDIST is an APL64 rank-1 array containing the Action text and any necessary action arguments.

Action: Case-insensitive text indicating the user-selected action

ActionArgs1, … required arguments for the selected Action.

Multiple instances of the same or different probability distributions may be created using the ⎕PDIST system function.  All such probability distribution instances are contained within the ⎕PDIST object.

### ⎕PDIST Object Actions Syntax

Syntax: Result← '#' ⎕PDist Action ActionArg1 …

### ⎕PDIST Instance Actions Syntax

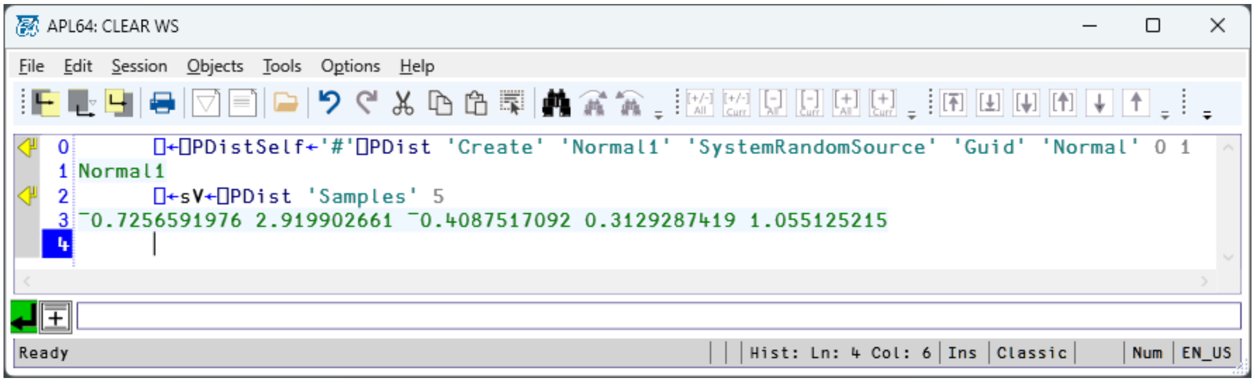
Syntax: Result←[instanceName] ⎕PDist Action ActionArg1 …

The instanceName is optional when the ⎕PDistSelf system variable is set to a ⎕PDIST instance name.

### Object and Instance Example

The APL64 ⎕PDistSelf system variable is set to a ⎕PDIST instance name, no left argument to the ⎕PDIST system function is necessary for actions on that instance:

```
⎕←⎕PDistSelf←'#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'Normal' 0 1
⎕←sV←⎕PDist 'Samples' 5
```



```
      ⎕←⎕PDistSelf←'#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'Normal' 0 1
Normal1
      ⎕←sV←⎕PDist 'Samples' 5
¯0.7256591976 2.919902661 ¯0.4087517092 0.3129287419 1.055125215
```

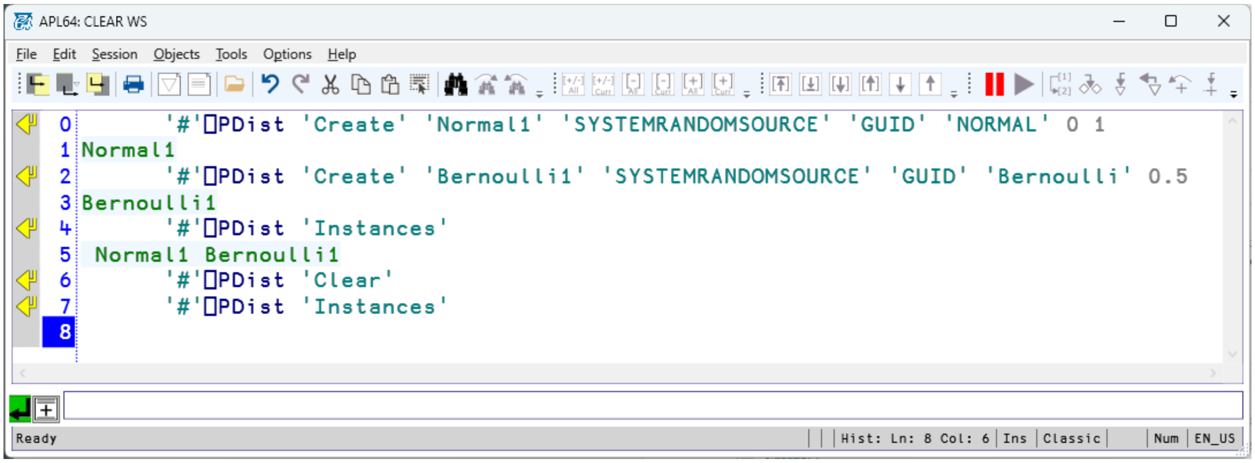
# ⎕PDIST Actions

## ⎕PDIST Object Actions

### Clear

Clear all ⎕PDIST instances

```
'#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'#'⎕PDist 'Instances'
'#'⎕PDist 'Clear'
'#'⎕PDist 'Instances'
```

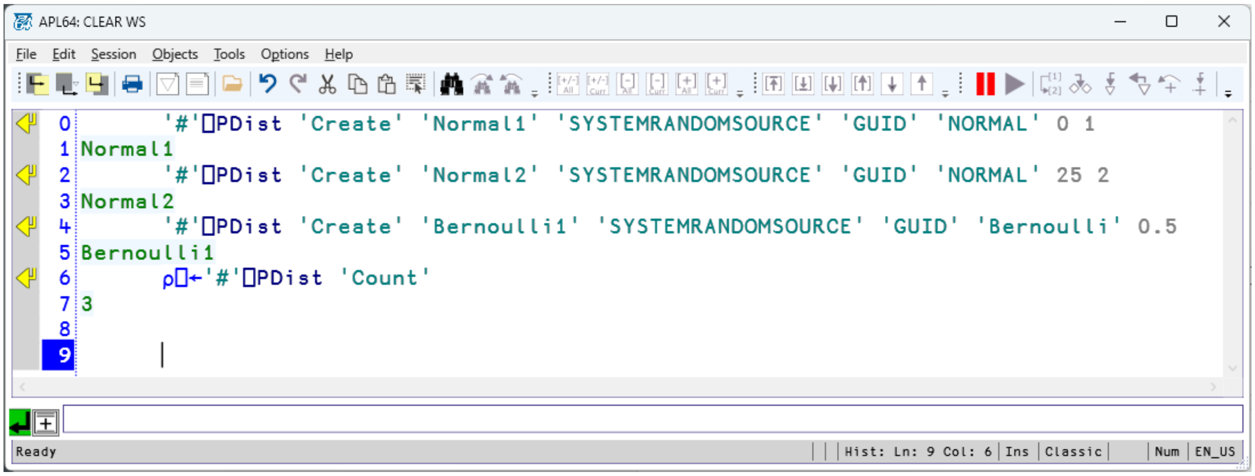


```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      '#'⎕PDist 'Instances'
 Normal1 Bernoulli1
      '#'⎕PDist 'Clear'
      '#'⎕PDist 'Instances'
```

### Count

Return the number of ⎕PDIST instances

```
 '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'#'⎕PDist 'Create' 'Normal2' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 25 2
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
ρ⎕←'#'⎕PDist 'Count'
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      '#'⎕PDist 'Create' 'Normal2' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 25 2
Normal2
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      ρ⎕←'#'⎕PDist 'Count'
3
```

## Create

Create a new ⎕PDIST probability distribution instance, possibly replacing an existing ⎕PDIST instance.

Syntax: instName←'#'⎕PDist 'Create' instName rndSrcName rndSeedName distName param1 ...

Each ⎕PDIST probability distribution instance must have a unique instance name, instName.

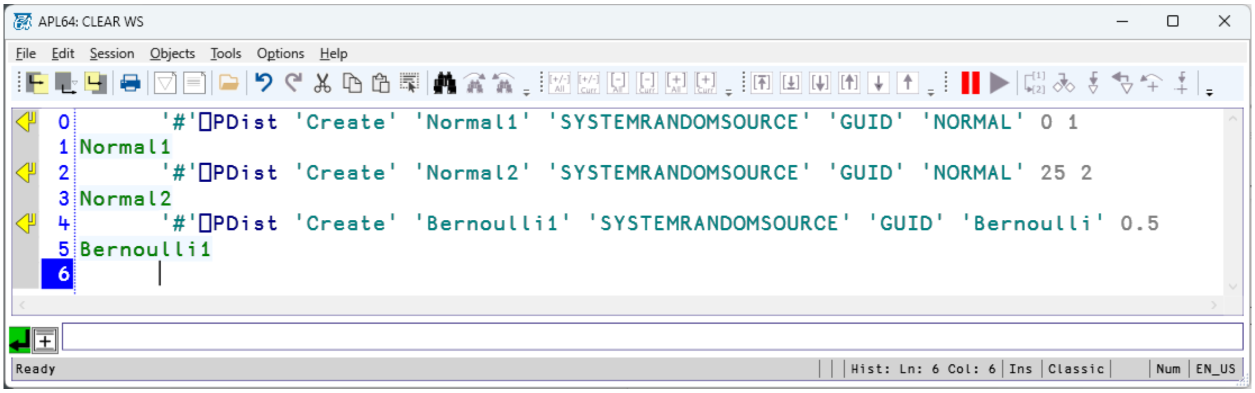
rndSrcName is the name of the selected pseudo-random number generator.

rndSeeName is the name of the selected random seed option.

distName is the name of the selected probability distribution.

param1 ... are the required initialization parameters for the selected probability distribution.

```
'#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'#'⎕PDist 'Create' 'Normal2' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 25 2
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      '#'⎕PDist 'Create' 'Normal2' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 25 2
Normal2
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
```

Each type of ⎕PDIST probability distribution requires initialization parameters. The required initialization parameters differ among ⎕PDIST probability distributions.

The probability distribution names are not case-sensitive.

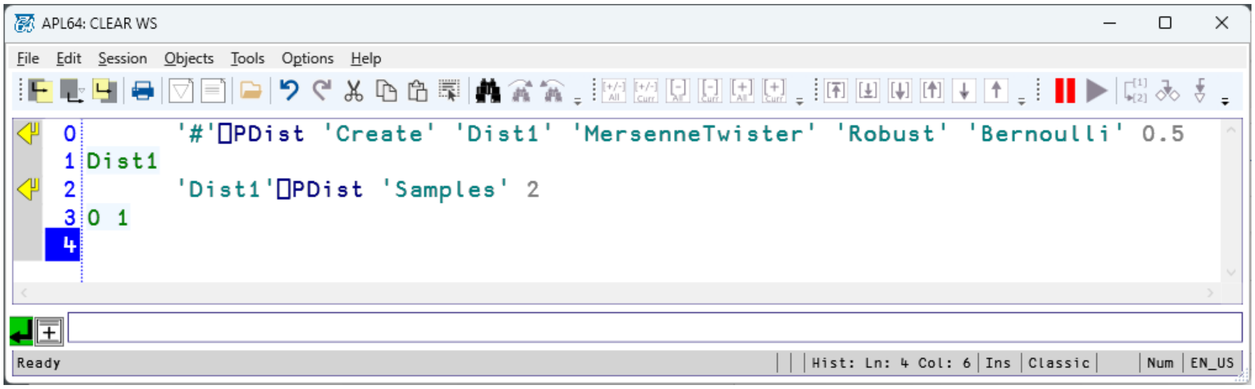
Probability distributions supported by Mathnet:

### Bernoulli

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Bernoulli' prob1

prob1: Double: Probability of generating 1 in range [0, 1]

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Bernoulli' 0.5
'Dist1'⎕PDist 'Samples' 2
```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```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Bernoulli' 0.5
Dist1
      'Dist1'⎕PDist 'Samples' 2
0 1
```

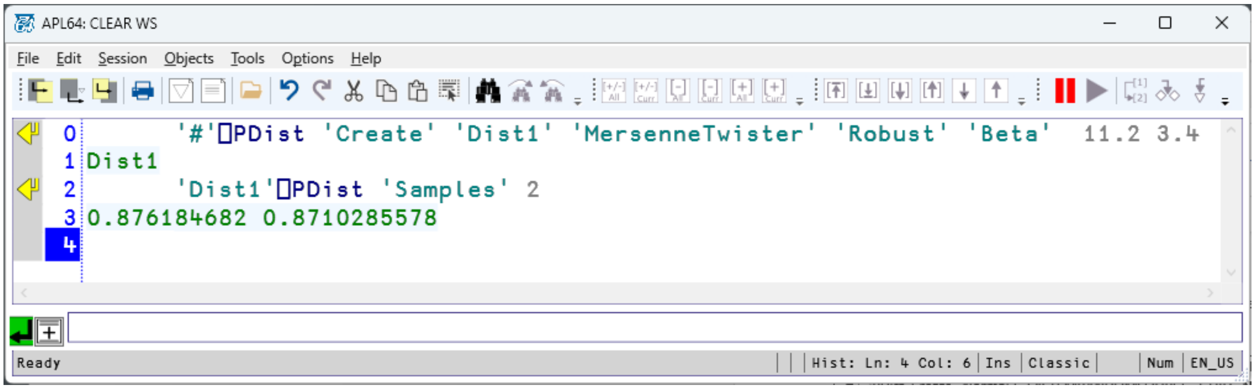
### Beta

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Beta' a b

a: Double: Alpha shape parameter in range: 0≤ a

b: Double: Beta shape parameter in range: 0≤ b

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Beta'  11.2 3.4
'Dist1'⎕PDist 'Samples' 2
```


APL64: CLEAR WS
File Edit Session Objects Tools Options Help
Ready
Hist: Ln: 4 Col: 6 Ins Classic Num EN_US

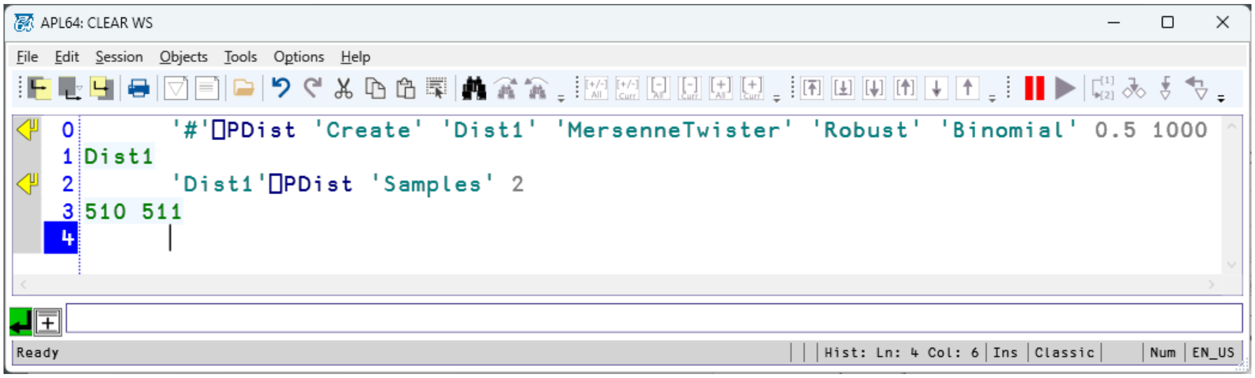
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Beta'  11.2 3.4
Dist1
      'Dist1'⎕PDist 'Samples' 2
0.876184682 0.8710285578
```

### Binomial

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Binomial' pSuccess nTrials

pSuccess: Double: Probability of success in each trial in range [0,1] nTrials: Int32: 0≤#Trials

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Binomial' 0.5 1000
'Dist1'□PDist 'Samples' 2
```



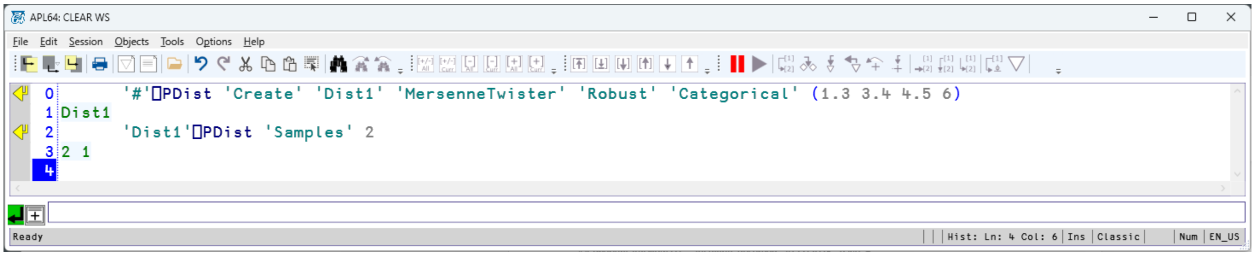
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Binomial' 0.5 1000
Dist1
      'Dist1'⎕PDist 'Samples' 2
510 511
```

### *Categorical*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Categorical' massRatios[]

massRatios[]: Double[]: Mass ratios array: 0≤Each Element

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Categorical' (1.3 3.4 4.5 6)
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Categorical' (1.3 3.4 4.5 6)
Dist1
      'Dist1'⎕PDist 'Samples' 2
2 1
```

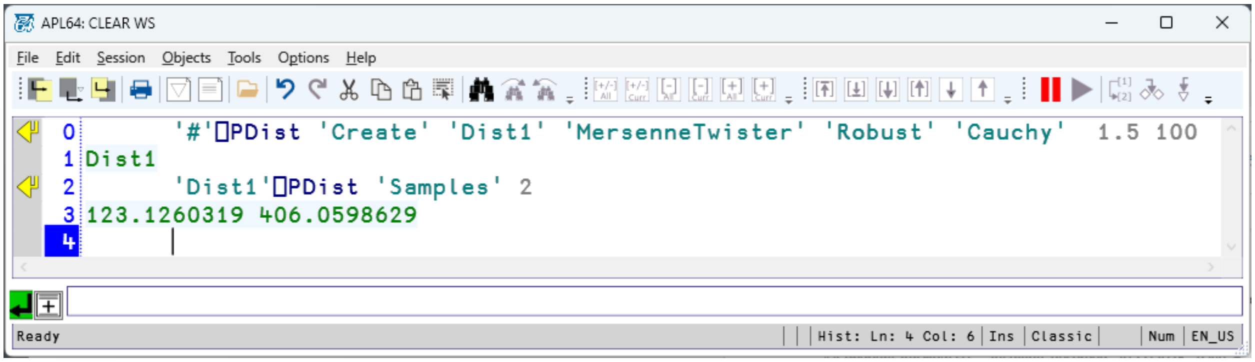
### *Cauchy*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Cauchy' location scale

location: Double: x0 of the distribution in range: 0≤ location

scale: Double: Scale of the distribution in range: 0≤scale

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Cauchy'  1.5 100
'Dist1'□PDist 'Samples' 2
```



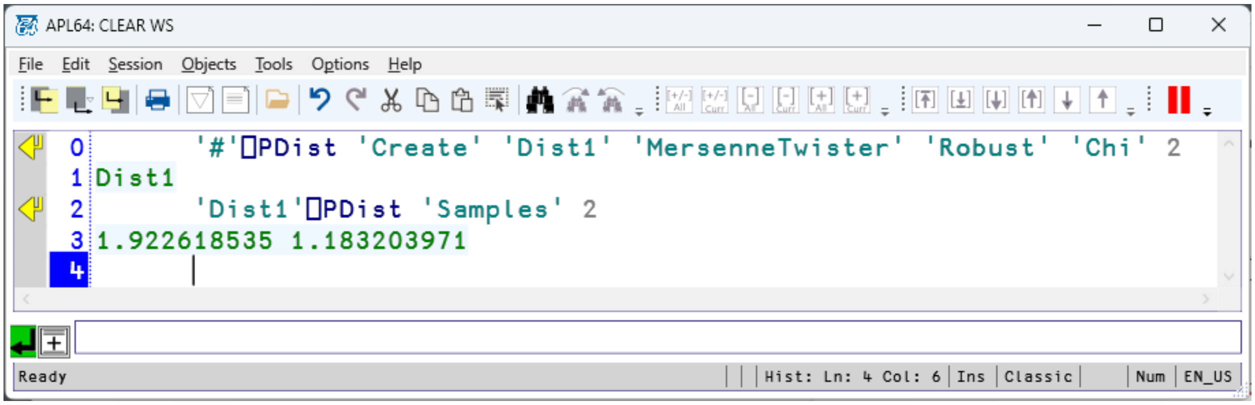
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Cauchy' 1.5 100
Dist1
      'Dist1'⎕PDist 'Samples' 2
123.1260319 406.0598629
```

### *Chi*

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Chi' freedom

freedom: Int32: Degrees of freedom in range: 0<freedom

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Chi' 2
'Dist1'⎕PDist 'Samples' 2
```



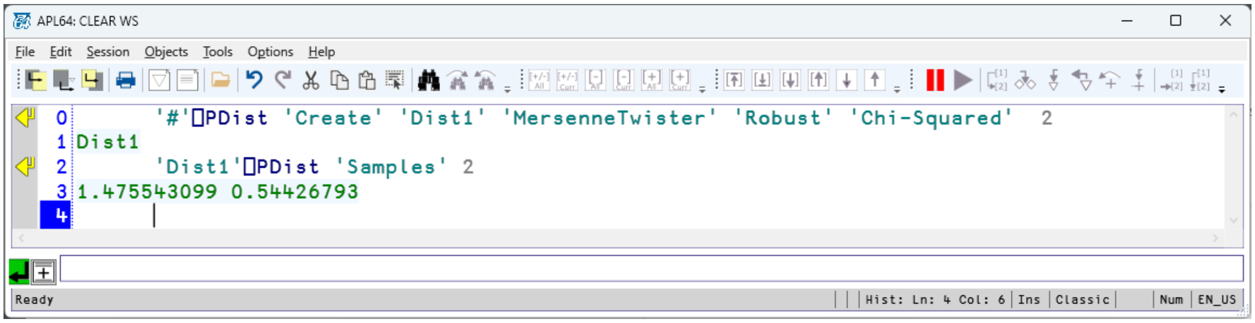
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Chi' 2
Dist1
      'Dist1'⎕PDist 'Samples' 2
1.922618535 1.183203971
```

### *Chi-Squared*

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Chi-Squared' freedom

freedom: Int32: Degrees of freedom in range: 0< freedom

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Chi-Squared'  2
'Dist1'⎕PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Chi-Squared'  2
Dist1
      'Dist1'⎕PDist 'Samples' 2
1.475543099 0.54426793
```

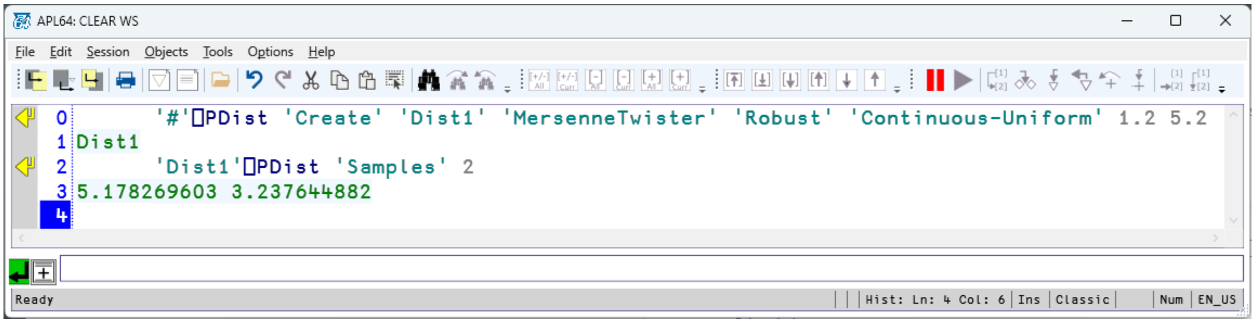
### *Continuous-Uniform*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Continuous-Uniform' lower upper

lower: Double: Lower bound in range: 0≤ lower

upper: Double: Upper bound in range: 0≤ upper and lower < upper

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Continuous-Uniform' 1.2 5.2
'Dist1'□PDist 'Samples' 2
```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```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Continuous-Uniform' 1.2 5.2
Dist1
      'Dist1'⎕PDist 'Samples' 2
5.178269603 3.237644882
```

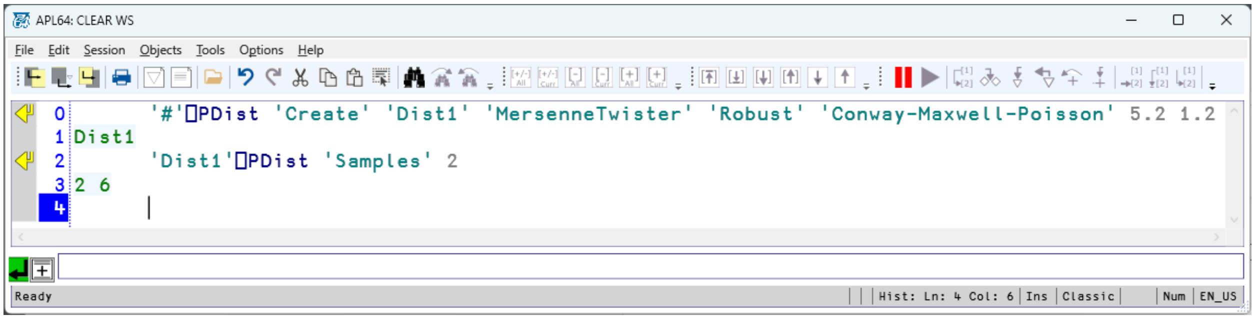
### *Conway-Maxwell-Poisson*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Conway-Maxwell-Poisson' lambda nu

lambda: Double: In range: 0< lambda

nu: Double: Rate of decay: In range: 0≤ nu

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Conway-Maxwell-Poisson' 5.2 1.2
'Dist1'□PDist 'Samples' 2
```


APL64: CLEAR WS
File Edit Session Objects Tools Options Help
Ready
Hist: Ln: 4 Col: 6 | Ins | Classic | Num | EN_US

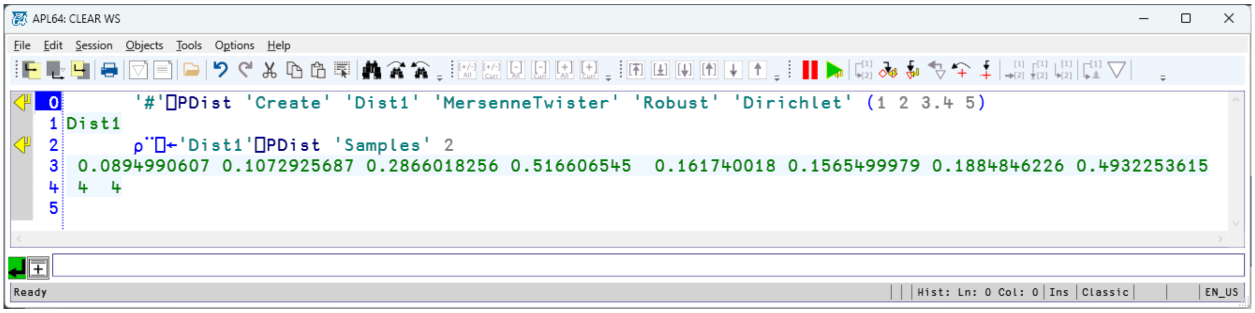
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Conway-Maxwell-Poisson' 5.2 1.2
Dist1
      'Dist1'⎕PDist 'Samples' 2
2 6
```

### *Dirichlet*

Syntax: #'□PDist 'Create' instName rndSrcName rndSeedName 'Dirichlet' (Double[n])

Double[n] is a vector of double numbers, where n is the dimension of the distribution

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Dirichlet' (1 2 3.4 5)
ρ¨□←'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Dirichlet' (1 2 3.4 5)
Dist1
      ρ¨⎕←'Dist1'⎕PDist 'Samples' 2
 0.0894990607 0.1072925687 0.2866018256 0.516606545  0.161740018 0.1565499979 0.1884846226 0.4932253615
 4  4
```

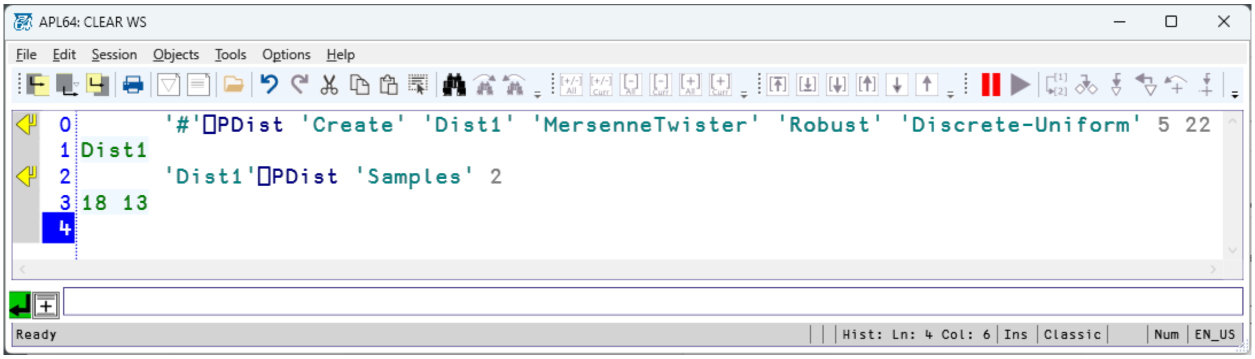
### *Discrete-Uniform*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Discrete-Uniform' lower upper

lower: Int32: lower ≤upper

upper: Int32: lower ≤ upper

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Discrete-Uniform' 5 22
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Discrete-Uniform' 5 22
Dist1
      'Dist1'⎕PDist 'Samples' 2
18 13
```

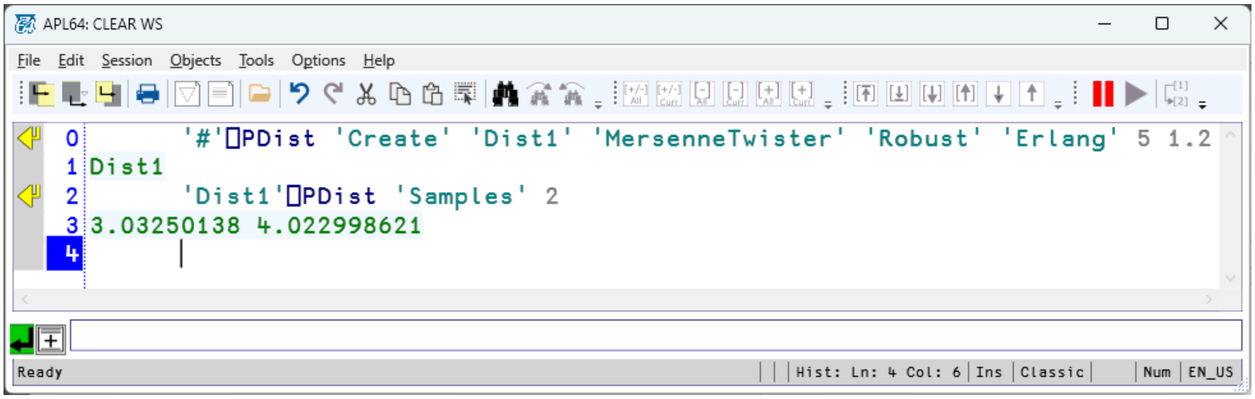
### *Erlang*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Erlang' shape rate

shape: Double: 0≤ shape

rate: Double: 0≤ rate

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Erlang' 5 1.2
'Dist1'□PDist 'Samples' 2
```



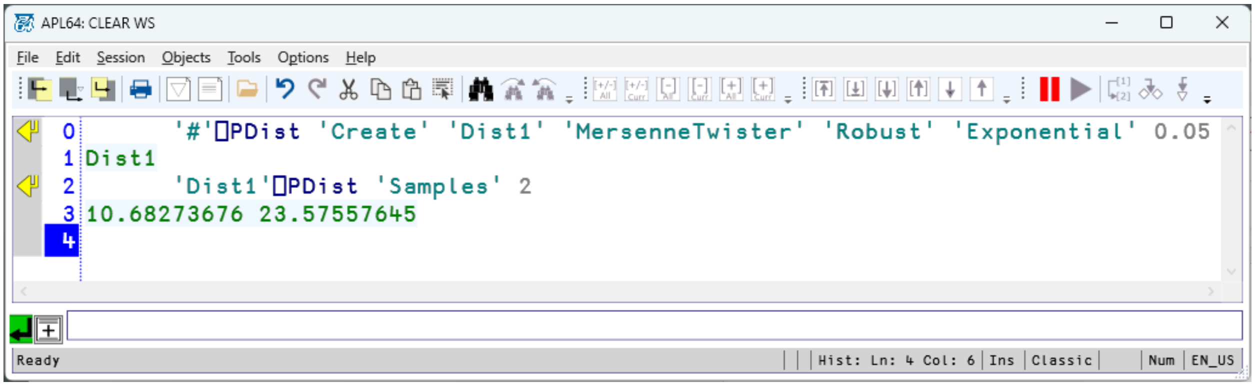
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Erlang' 5 1.2
Dist1
      'Dist1'⎕PDist 'Samples' 2
3.03250138 4.022998621
```

### *Exponential*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Exponential' rate

rate: Double: 0≤rate

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Exponential' 0.05
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Exponential' 0.05
Dist1
      'Dist1'⎕PDist 'Samples' 2
10.68273676 23.57557645
```

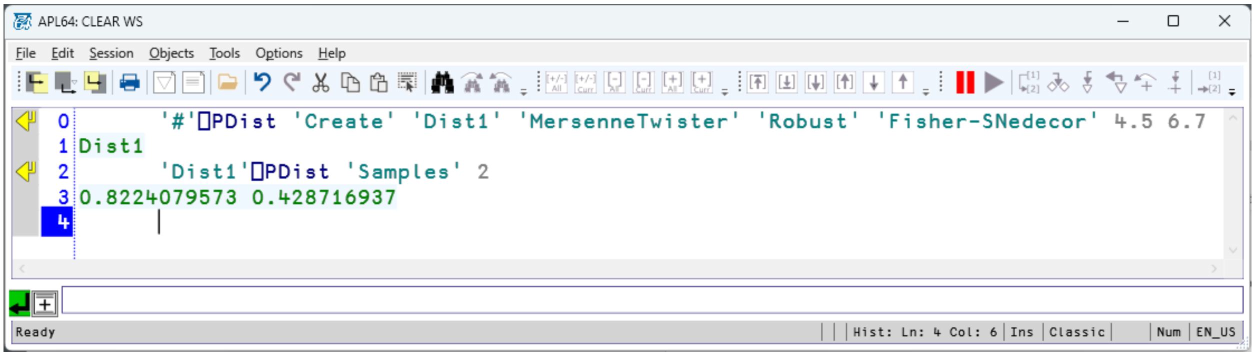
### *Fisher-Snedecor*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Fisher-Snedecor' d1 d2

d1: 1st degree of freedom: Double: 0< d1

d2: 2nd degree of freedom: Double: 0< d2

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Fisher-SNedecor' 4.5 6.7
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Fisher-SNedecor' 4.5 6.7
Dist1
      'Dist1'⎕PDist 'Samples' 2
0.8224079573 0.428716937
```

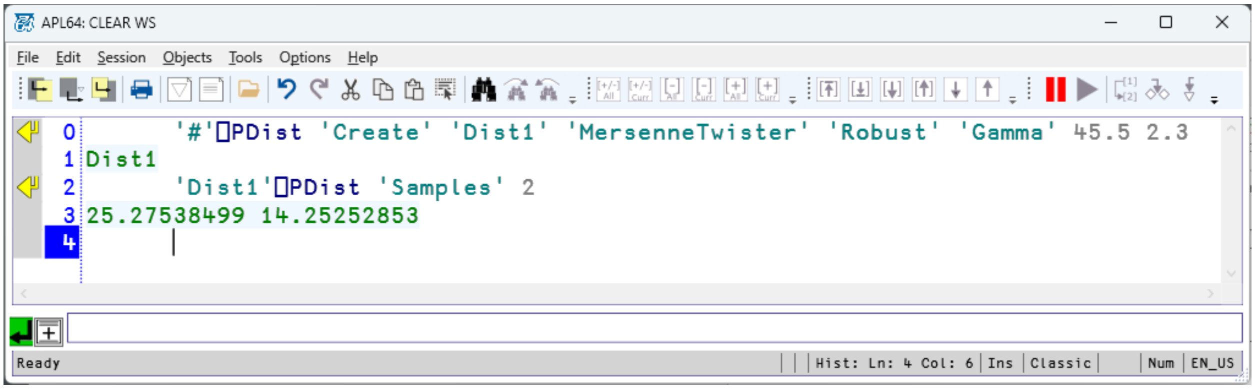
### *Gamma*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Gamma' shape rate

shape: Double: 0≤ shape

rate: Double: 0≤ rate

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Gamma' 45.5 2.3
'Dist1'□PDist 'Samples' 2
```



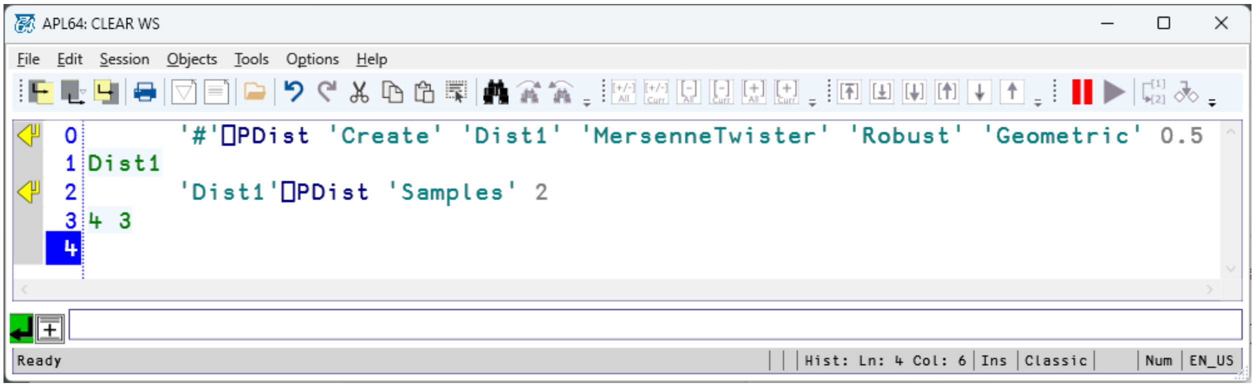
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Gamma' 45.5 2.3
Dist1
      'Dist1'⎕PDist 'Samples' 2
25.27538499 14.25252853
```

### *Geometric*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Geometric' prob1

prob1: Double: Probability of a success for a trial

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Geometric' 0.5
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Geometric' 0.5
Dist1
      'Dist1'⎕PDist 'Samples' 2
4 3
```

### *Hyper-Geometric*

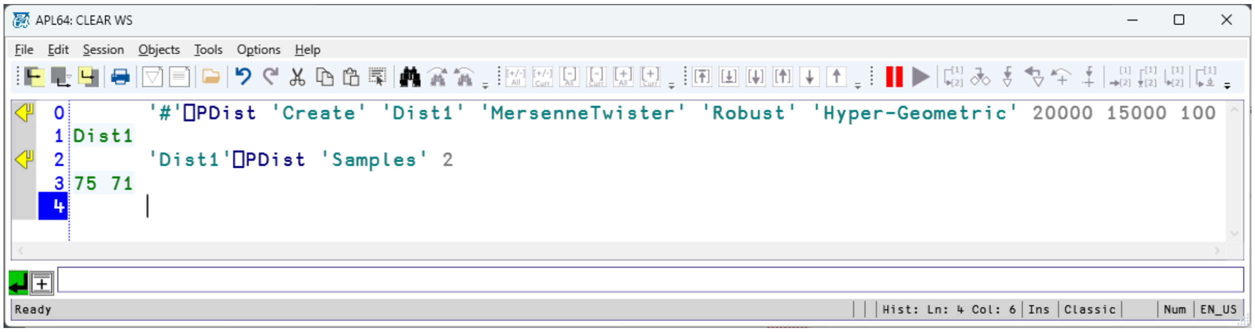
Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Hyper-Geometric' p s d

p: Int32: Population size: 0<p

s: Int32: #successes in the population: 0<s

d: Int32: #draws without replacement: 0<d

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Hyper-Geometric' 20000 15000 100
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Hyper-Geometric' 20000 15000 100
Dist1
      'Dist1'⎕PDist 'Samples' 2
75 71
```

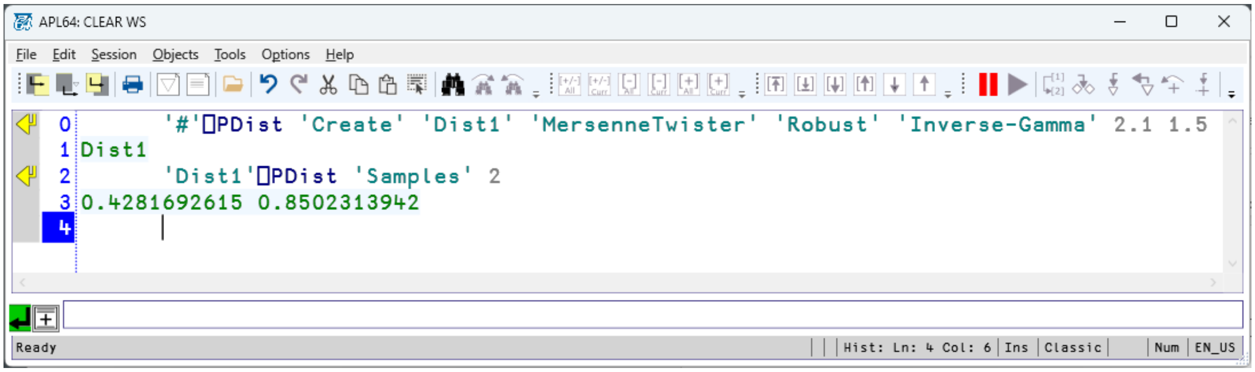
### *Inverse-Gamma*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Inverse-Gamma' shape scale

shape: Double: 0< shape

scale: Double: 0< scale

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Inverse-Gamma' 2.1 1.5
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Inverse-Gamma' 2.1 1.5
Dist1
      'Dist1'⎕PDist 'Samples' 2
0.4281692615 0.8502313942
```

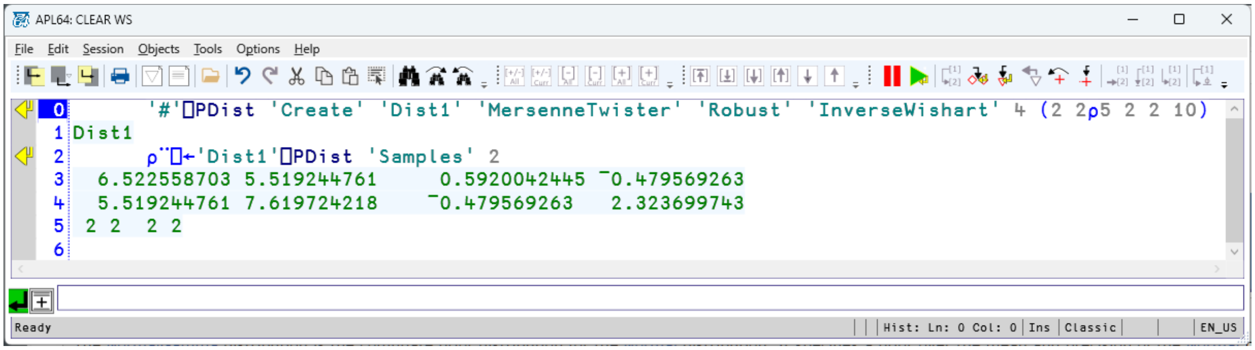
## InverseWishart

Syntax : '#'□PDist 'Create' instName rndSrcName rndSeedName 'InverseWishart' df scaleMat

df: Int: degrees of freedom

scaleMat: real, positive-definite matrix

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'InverseWishart' 4 (2 2ρ5 2 2 10)
ρ¨□←'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'InverseWishart' 4 (2 2ρ5 2 2 10)
Dist1
      ρ¨⎕←'Dist1'⎕PDist 'Samples' 2
  6.522558703 5.519244761      0.5920042445 ¯0.479569263
  5.519244761 7.619724218     ¯0.479569263   2.32369974З
 2 2   2 2
```

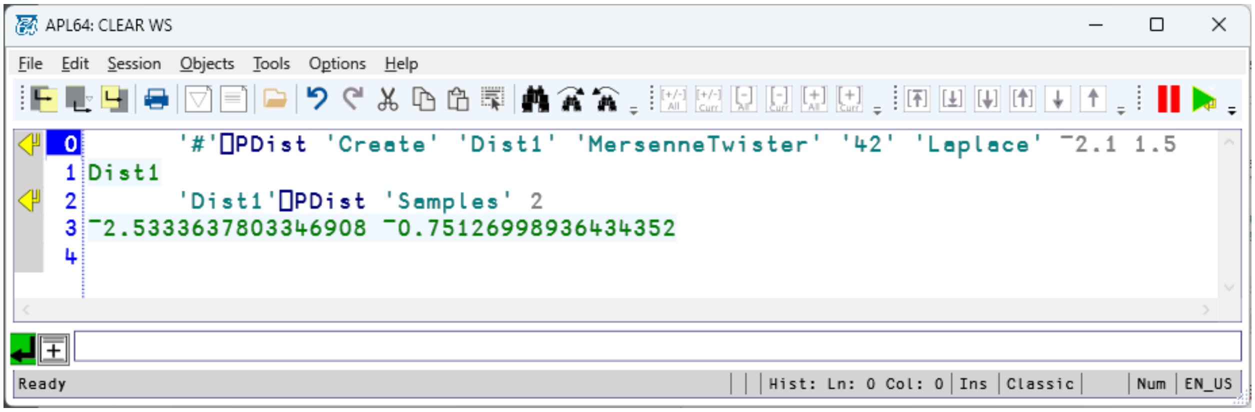
## Laplace

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Laplace' location scale

location: Double

scale: Double: 0<scale

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' '42' 'Laplace' ¯2.1 1.5
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' '42' 'Laplace' ¯2.1 1.5
Dist1
      'Dist1'⎕PDist 'Samples' 2
¯2.5333637803346908 ¯0.75126998936434352
```

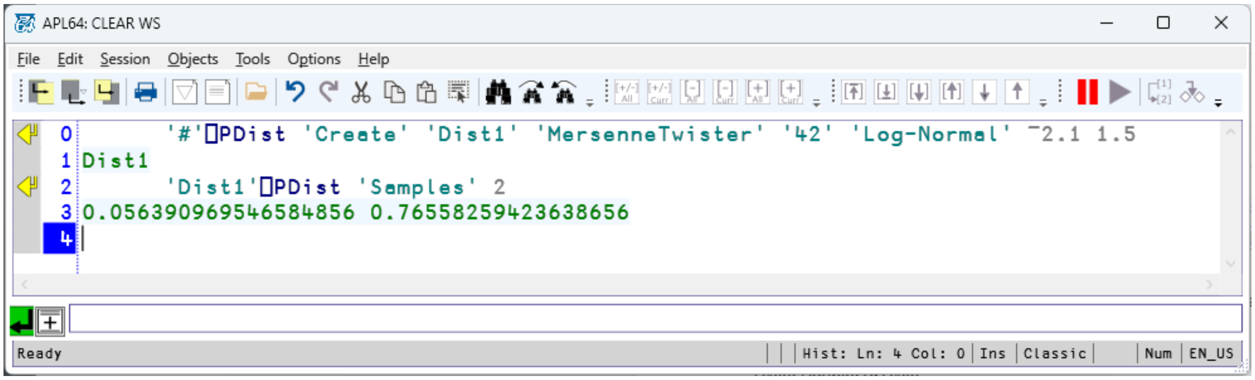
### *Log-Normal*

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Log-Normal' mu sigma

mu: Double: Log-scale of the distribution

sigma: Double : Shape of the distribution: 0≤sigma

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' '42' 'Log-Normal' ¯2.1 1.5
'Dist1'⎕PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' '42' 'Log-Normal' ¯2.1 1.5
Dist1
      'Dist1'⎕PDist 'Samples' 2
0.056390969546584856 0.76558259423638656
```

### *MatrixNormal*

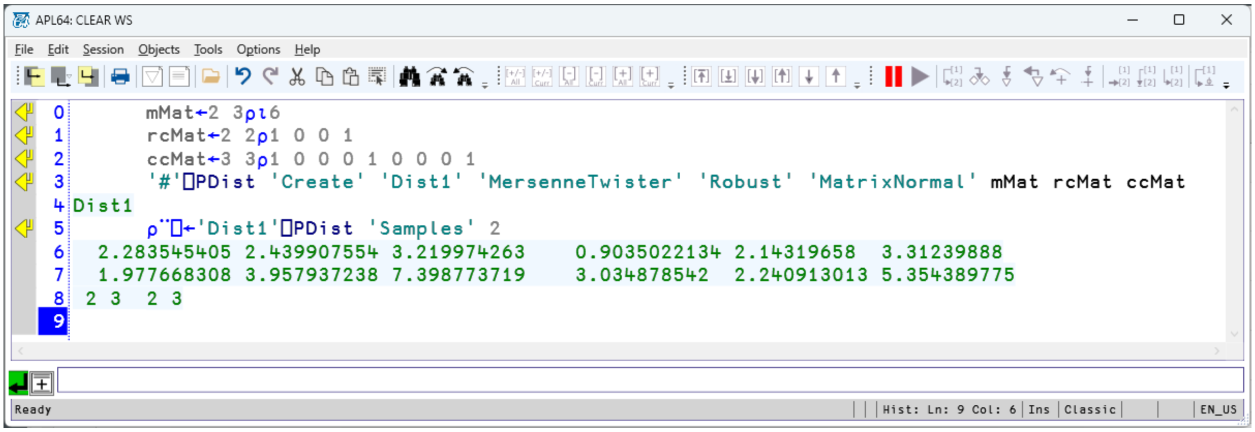
Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'MatrixNorma' mMat rcMat ccMat

mMat: double[n;p]: mean matrix

rcMat : double[n;n]: row covariance matrix

ccMat: double[p;p]: column covariance matrix

```
mMat←2 3⍴⍳6
rcMat←2 2⍴1 0 0 1
ccMat←3 3⍴1 0 0 0 1 0 0 0 1
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'MatrixNormal' mMat rcMat ccMat
⍴¨⎕←'Dist1'⎕PDist 'Samples' 2
```



```
      mMat←2 3⍴⍳6
      rcMat←2 2⍴1 0 0 1
      ccMat←3 3⍴1 0 0 0 1 0 0 0 1
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'MatrixNormal' mMat rcMat ccMat
Dist1
      ⍴¨⎕←'Dist1'⎕PDist 'Samples' 2
  2.283545405 2.439907554 3.219974263    0.9035022134 2.14319658  3.31239888
  1.977668308 3.957937238 7.398773719    3.034878542  2.240913013 5.354389775
 2 3  2 3
```

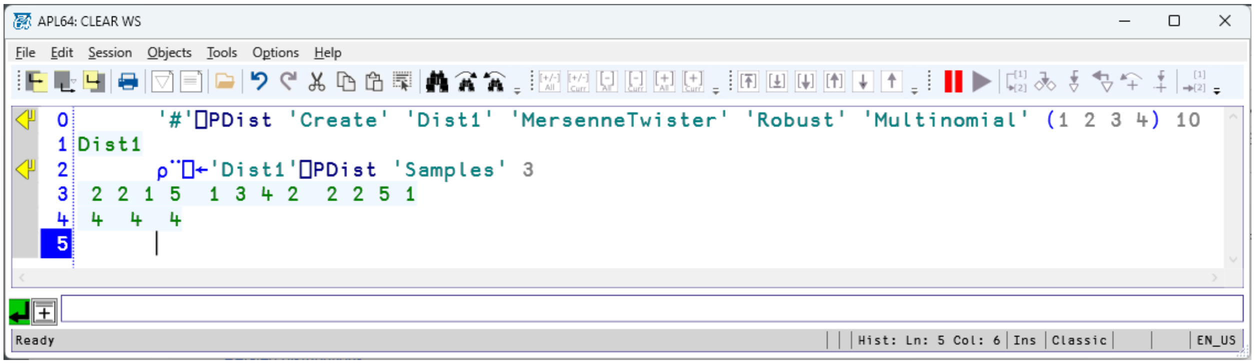
### *Multinomial*

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Multinomial' pRatios nTrials

pRatios: Double[]: probability ratios

nTrials: Int: #Trials

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Multinomial' (1 2 3 4) 10
⍴¨⎕←'Dist1'⎕PDist 'Samples' 3
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Multinomial' (1 2 3 4) 10
Dist1
      ⍴¨⎕←'Dist1'⎕PDist 'Samples' 3
 2 2 1 5  1 3 4 2  2 2 5 1
 4  4  4
```

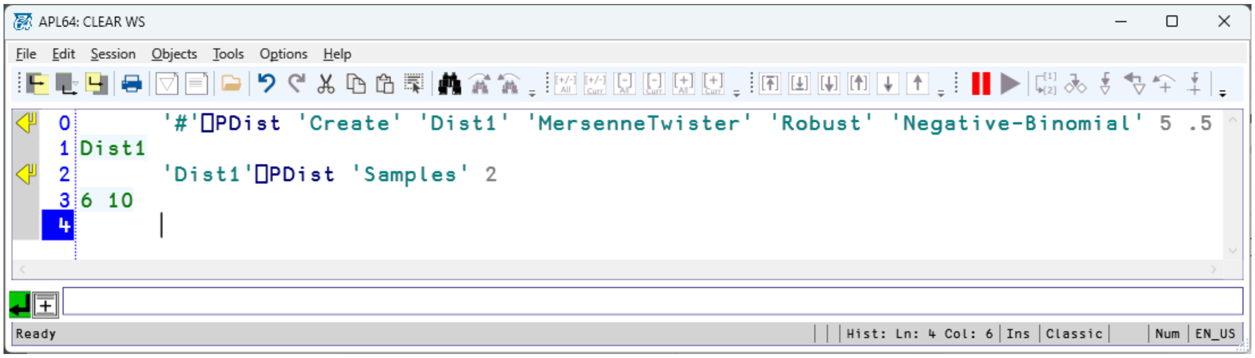
### *Negative-Binomial*

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Negative-Binomial' s p

s: Double: #successes required to stop the experiment: 0≤s

p: Double: probability of a trial resulting in success in range [0,1]

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Negative-Binomial' 5 .5
'Dist1'⎕PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Negative-Binomial' 5 .5
Dist1
      'Dist1'⎕PDist 'Samples' 2
6 10
```

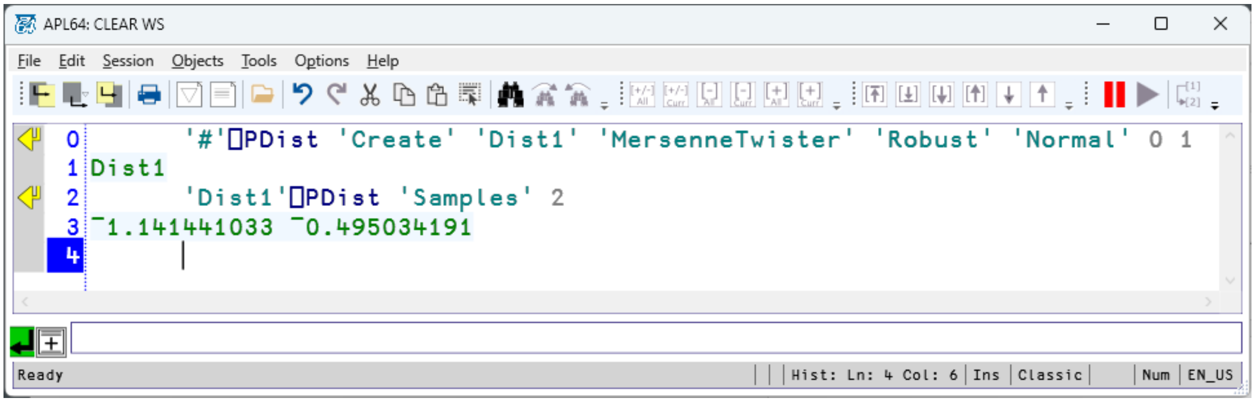
## Normal

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Normal' m s

m: Double: Mean

s: Double: Standard deviation: 0≤s

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Normal' 0 1
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Normal' 0 1
Dist1
      'Dist1'⎕PDist 'Samples' 2
¯1.141441033 ¯0.495034191
```

## NormalGamma

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'NormalGamma' Ml Ms Ps Ips

Ml: double: mean location

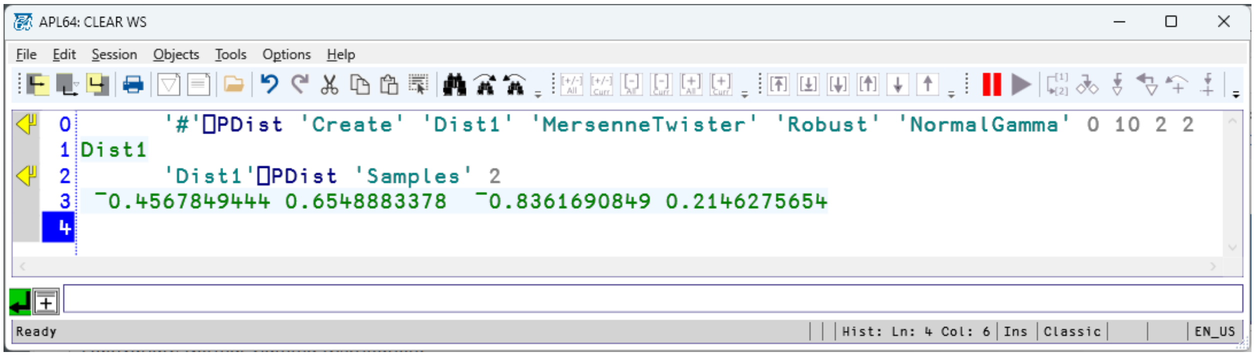
Ms: double: mean scale

Ps: double: precision shape

Ips: double: precision inverse scale

'Dist1'□PDist 'Samples' 2

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'NormalGamma' 0 10 2 2
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'NormalGamma' 0 10 2 2
Dist1
      'Dist1'⎕PDist 'Samples' 2
¯0.4567849444 0.6548883378 ¯0.8361690849 0.2146275654
```

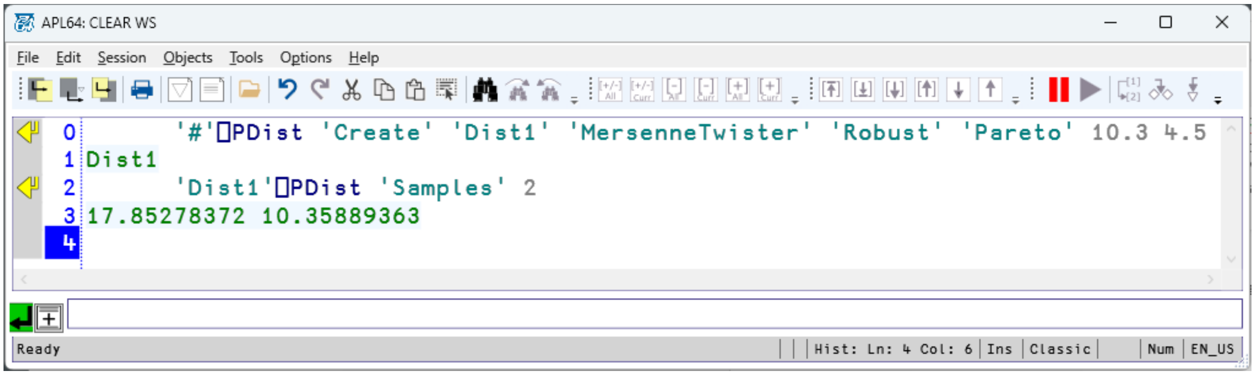
## Pareto

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Pareto' scale shape

scale: Double: 0<scale

shape: Double : 0<shape

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Pareto' 10.3 4.5
'Dist1'□PDist 'Samples' 2
```



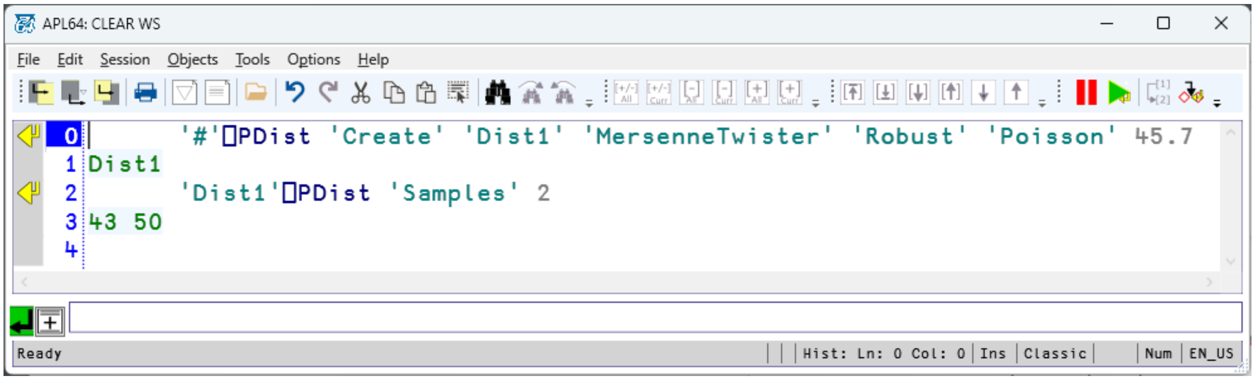
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Pareto' 10.3 4.5
Dist1
      'Dist1'⎕PDist 'Samples' 2
17.85278372 10.35889363
```

## Poisson

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Poisson' lambda

lambda: Double: 0<lambda

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Poisson' 45.7
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Poisson' 45.7
Dist1
      'Dist1'⎕PDist 'Samples' 2
43 50
```

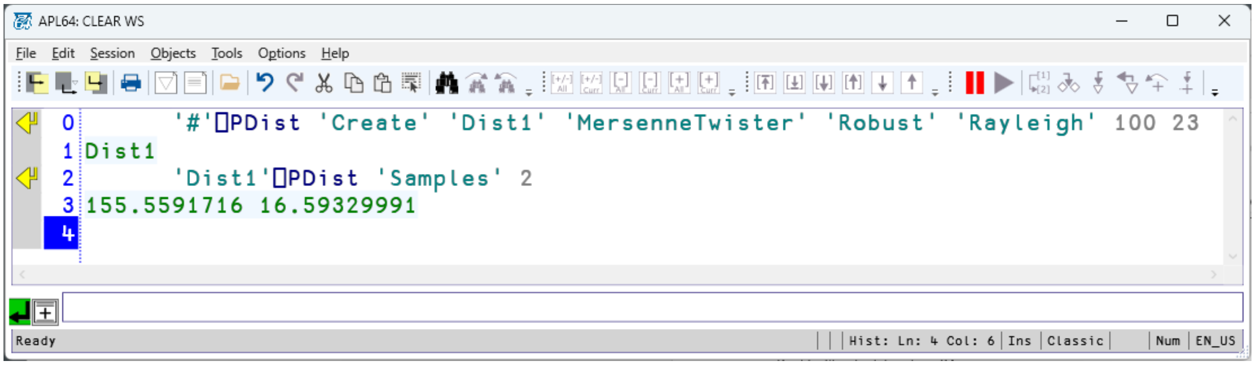
*Rayleigh*

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Raleigh' scale loc

scale: Double: 0<scale

loc: Double: Location:

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Rayleigh' 100 23
'Dist1'⎕PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Rayleigh' 100 23
Dist1
      'Dist1'⎕PDist 'Samples' 2
155.5591716 16.59329991
```

*Stable*

Syntax: '#'⎕PDist 'Create' instName rndSrcName rndSeedName 'Stable' a b scale loc

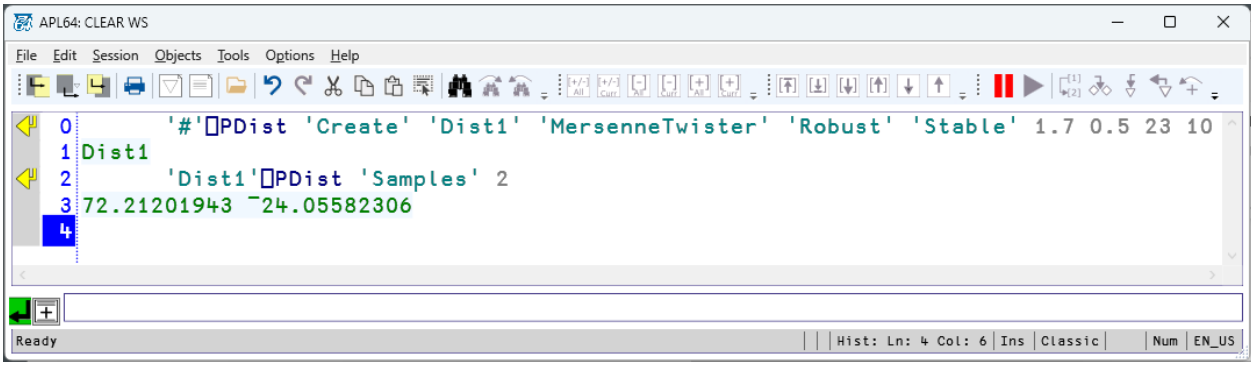
a: Double: In range: (0, 2]

b: Double: In range: [¯1, 1]

scale: Double: 0<scale

loc: Double: Location:

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Stable' 1.7 0.5 23 10
'Dist1'⎕PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Stable' 1.7 0.5 23 10
Dist1
      'Dist1'⎕PDist 'Samples' 2
72.21201943 ¯24.05582306
```

### Student-T

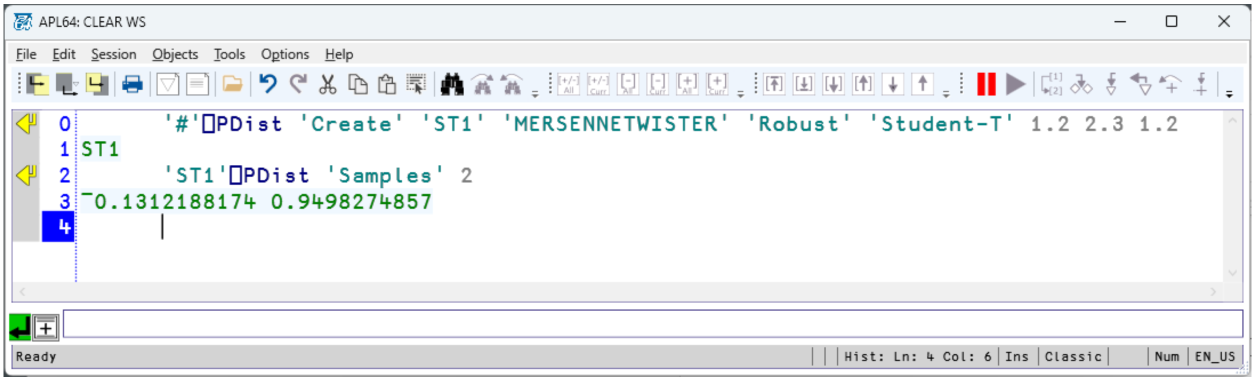
Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Student-T' loc scale freedom

loc: Double: Location

scale: Double: 0<scale

freedom: Double: Degrees of freedom : 0<freedom

```
'#'□PDist 'Create' 'ST1' 'MERSENNETWISTER' 'Robust' 'Student-T' 1.2 2.3 1.2
'ST1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'ST1' 'MERSENNETWISTER' 'Robust' 'Student-T' 1.2 2.3 1.2
ST1
      'ST1'⎕PDist 'Samples' 2
¯0.131218817 4 0.9498274857
```

### Triangular

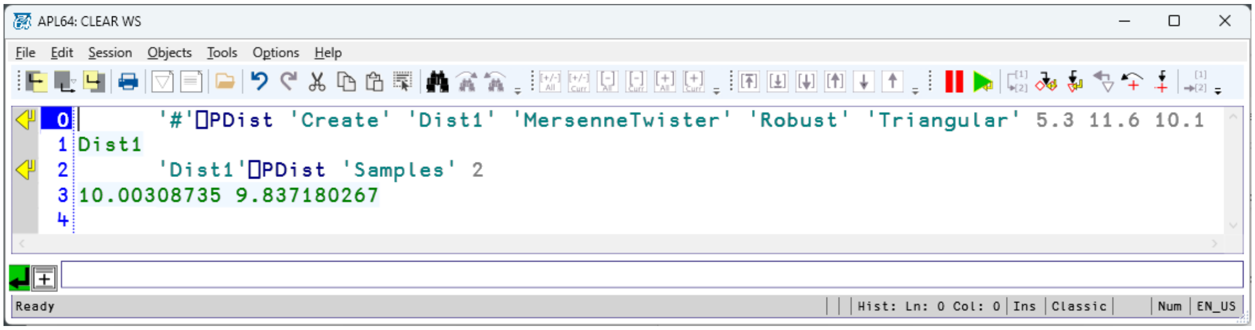
Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Triangular' lower upper mode

lower: Double: lower≤ mode ≤ upper

upper: Double:

mode: Double:

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Triangular' 5.3 11.6 10.1
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Triangular' 5.3 11.6 10.1
Dist1
      'Dist1'⎕PDist 'Samples' 2
10.00308735 9.837180267
```

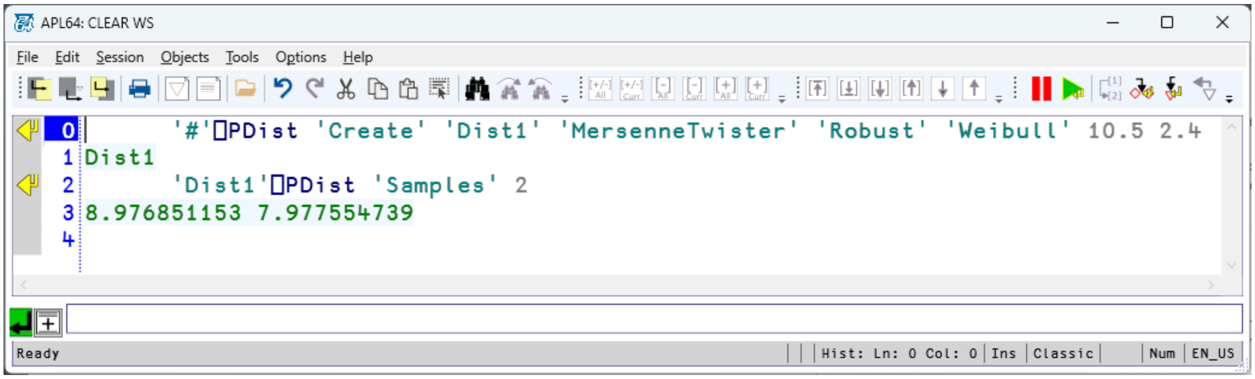
### Weibull

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Weibull' scale shape

scale: Double: 0<scale

shape: Double: 0<shape

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Weibull' 10.5 2.4
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Weibull' 10.5 2.4
Dist1
      'Dist1'⎕PDist 'Samples' 2
8.976851153 7.977554739
```

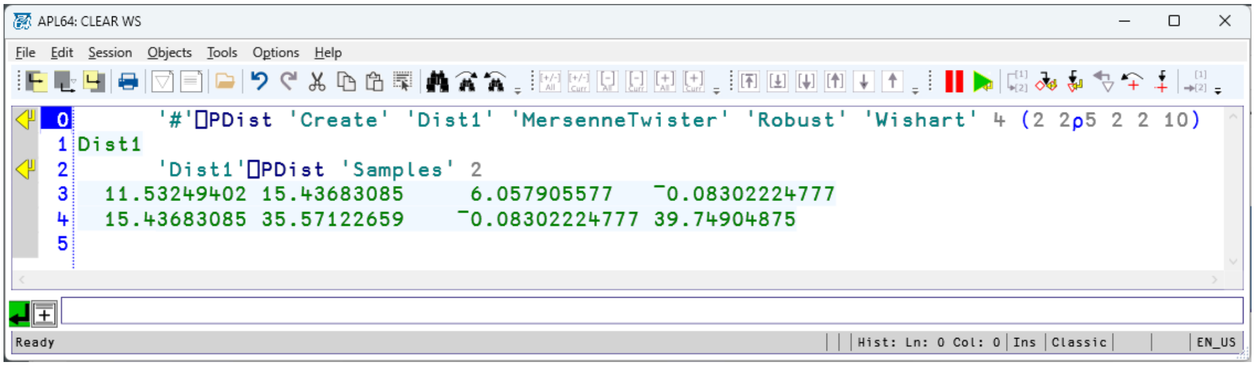
### Wishart

Syntax: '#'□PDist 'Create' 'Create' instName rndSrcName rndSeedName 'Wishart' df scaleMat

df: Int: degrees of freedom

scaleMat: matrix

```
'#'□PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Wishart' 4 (2 2ρ5 2 2 10)
'Dist1'□PDist 'Samples' 2
```



```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Wishart' 4 (2 2⍴5 2 2 10)
Dist1
      'Dist1'⎕PDist 'Samples' 2
  11.53249402 15.43683085       6.057905577    ¯0.08302224777
  15.43683085 35.57122659     ¯0.08302224777 39.74904875
```

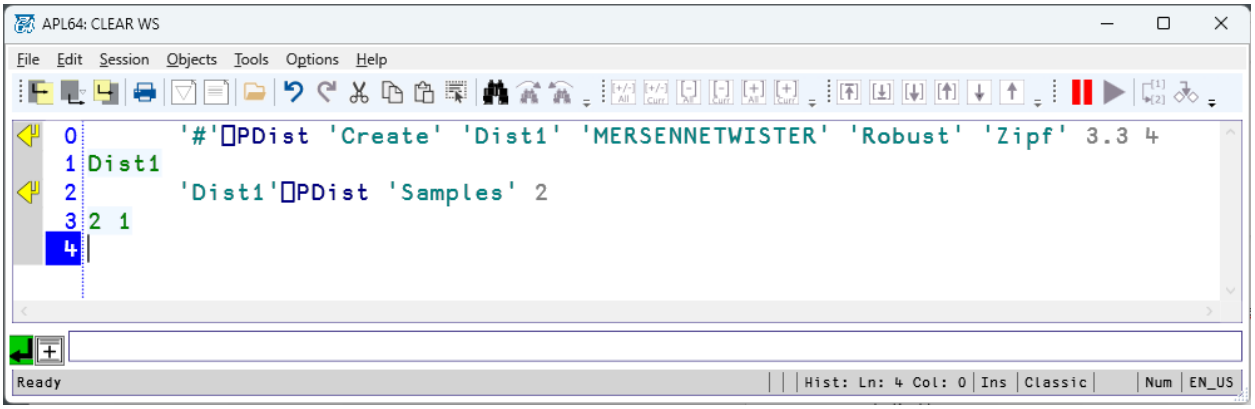
### *Zipf*

Syntax: '#'□PDist 'Create' instName rndSrcName rndSeedName 'Zipf' s n

s: Double

n: Int32

```
'#'□PDist 'Create' 'Dist1' 'MERSENNETWISTER' 'Robust' 'Zipf' 3.3 4
'Dist1'□PDist 'Samples' 2
```

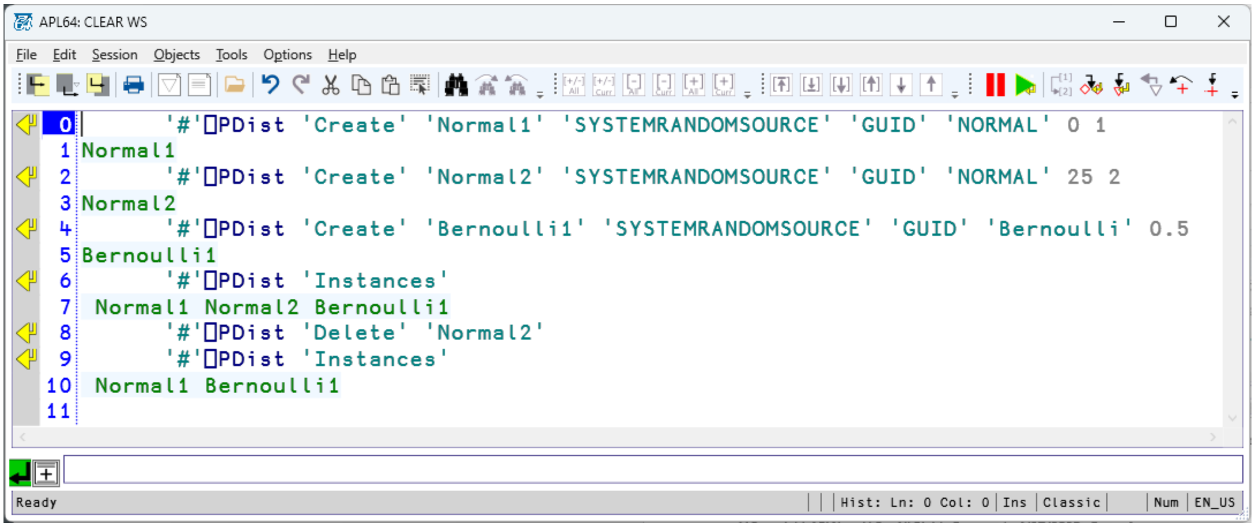


```
      '#'⎕PDist 'Create' 'Dist1' 'MERSENNETWISTER' 'Robust' 'Zipf' 3.3 4
Dist1
      'Dist1'⎕PDist 'Samples' 2
2 1
```

## Delete

Delete an existing □PDIST instance, by specifying its instance name.

```
'#'□PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'#'□PDist 'Create' 'Normal2' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 25 2
'#'□PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'#'□PDist Instances'
'#'□PDist 'Delete' 'Normal2'
'#'□PDist Instances'
```

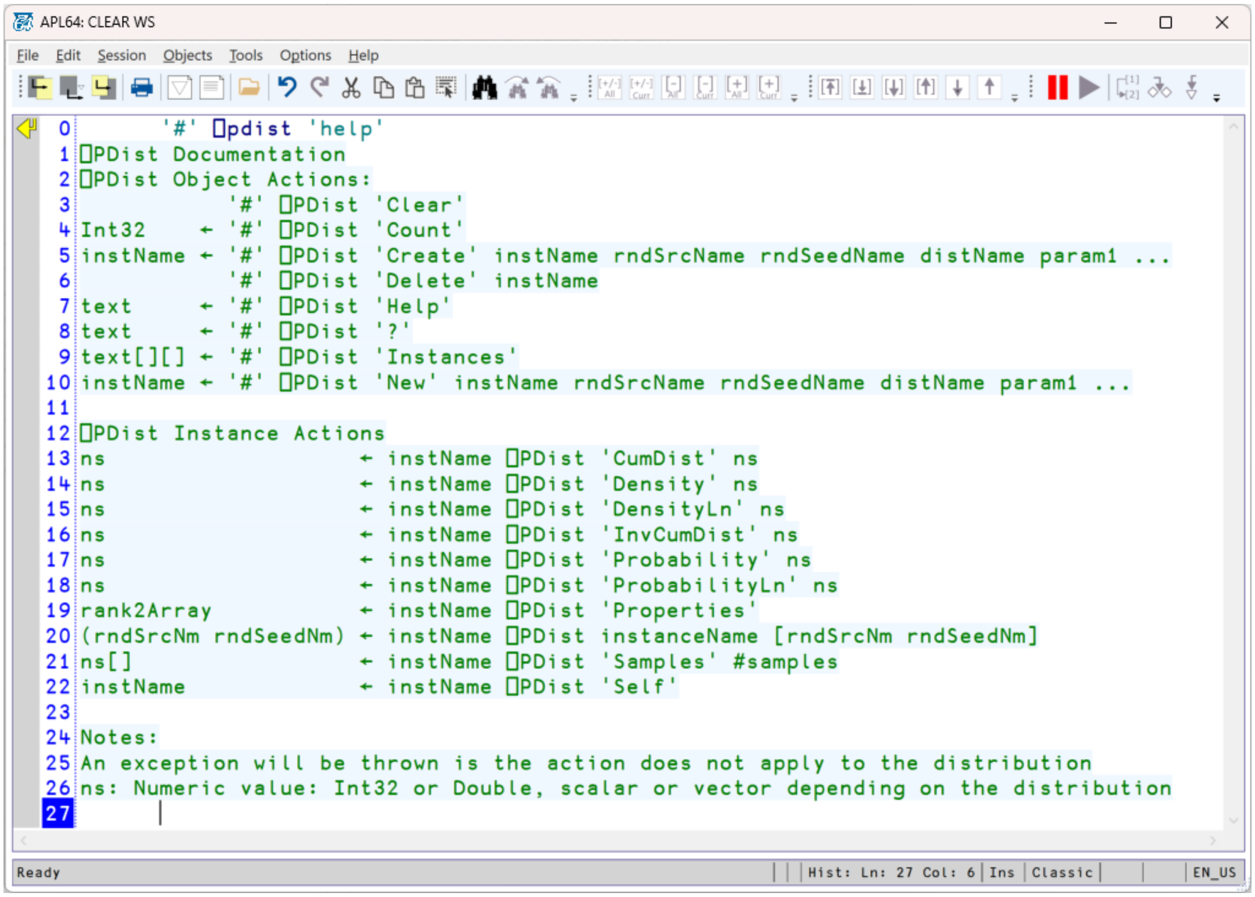


```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      '#'⎕PDist 'Create' 'Normal2' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 25 2
Normal2
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      '#'⎕PDist 'Instances'
 Normal1 Normal2 Bernoulli1
      '#'⎕PDist 'Delete' 'Normal2'
      '#'⎕PDist 'Instances'
 Normal1 Bernoulli1
```

## Help (?)

Return a summary of the ⎕PDIST system function documentation.

```
'#'⎕PDist '?'
```

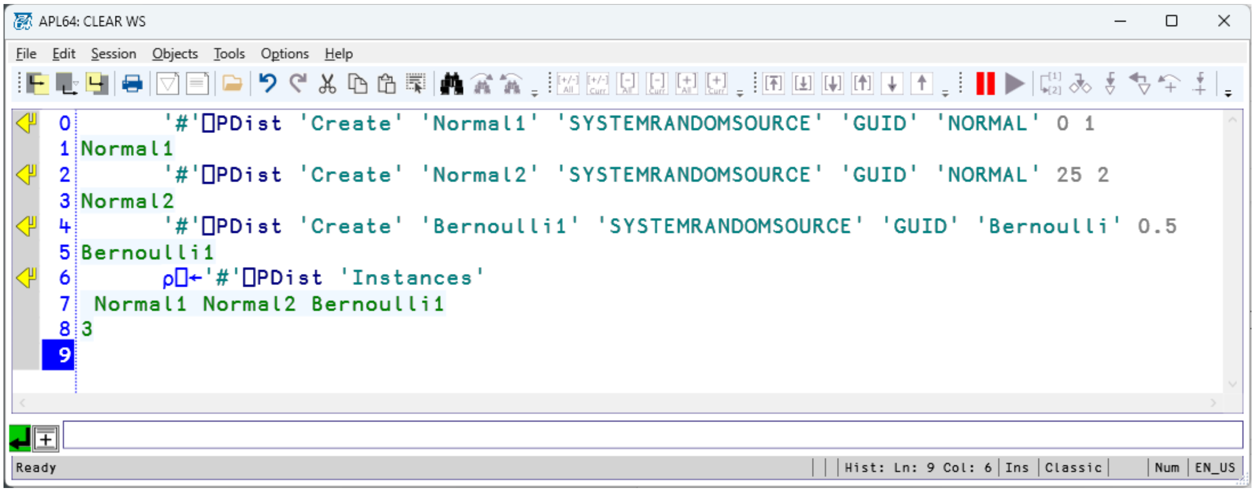


```
      '#' ⎕pdist 'help'
⎕PDist Documentation
⎕PDist Object Actions:
            '#' ⎕PDist 'Clear'
Int32     ← '#' ⎕PDist 'Count'
instName ← '#' ⎕PDist 'Create' instName rndSrcName rndSeedName distName param1 ...
            '#' ⎕PDist 'Delete' instName
text      ← '#' ⎕PDist 'Help'
text      ← '#' ⎕PDist '?'
text[][] ← '#' ⎕PDist 'Instances'
instName ← '#' ⎕PDist 'New' instName rndSrcName rndSeedName distName param1 ...

⎕PDist Instance Actions
ns                    ← instName ⎕PDist 'CumDist' ns
ns                    ← instName ⎕PDist 'Density' ns
ns                    ← instName ⎕PDist 'DensityLn' ns
ns                    ← instName ⎕PDist 'InvCumDist' ns
ns                    ← instName ⎕PDist 'Probability' ns
ns                    ← instName ⎕PDist 'ProbabilityLn' ns
rank2Array            ← instName ⎕PDist 'Properties'
(rndSrcNm rndSeedNm) ← instName ⎕PDist instanceName [rndSrcNm rndSeedNm]
ns[]                  ← instName ⎕PDist 'Samples' #samples
instName              ← instName ⎕PDist 'Self'

Notes:
An exception will be thrown is the action does not apply to the distribution
ns: Numeric value: Int32 or Double, scalar or vector depending on the distribution
```

## Instances

Return a rank-1 array of the names of the existing ⎕PDIST instances.

```
'#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'#'⎕PDist 'Create' 'Normal2' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 25 2
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
ρ⎕←'#'⎕PDist 'Instances'
```

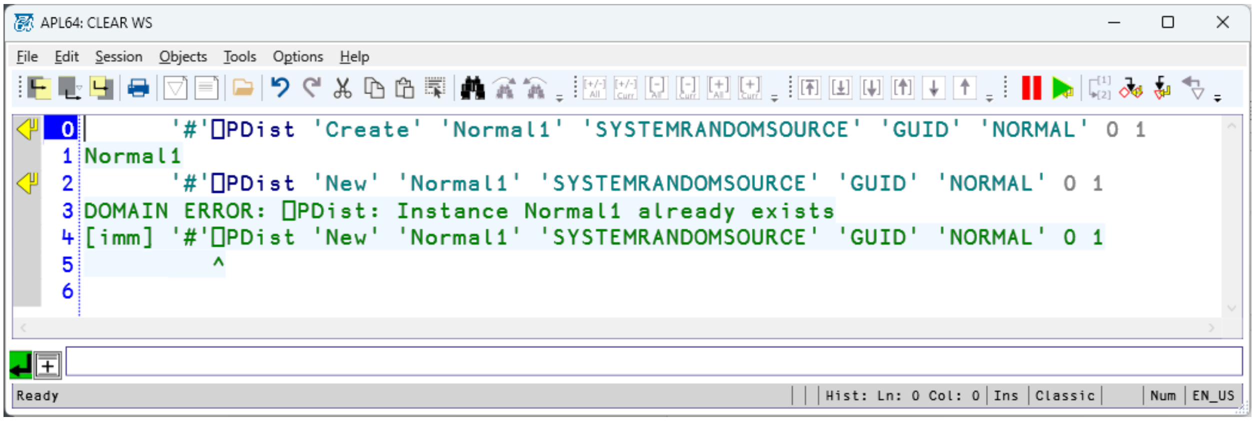


```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      '#'⎕PDist 'Create' 'Normal2' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 25 2
Normal2
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      ρ⎕←'#'⎕PDist 'Instances'
 Normal1 Normal2 Bernoulli1
3
```

## New

Create a new ⎕PDIST instance. The ⎕PDIST New action is analogous to the ⎕PDIST Create action, except that an existing ⎕PDIST cannot be overridden by the ⎕PDIST New action.

```
'#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'#'⎕PDist 'New' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      '#'⎕PDist 'New' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
DOMAIN ERROR: ⎕PDist: Instance Normal1 already exists
[imm] '#'⎕PDist 'New' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
         ^
```

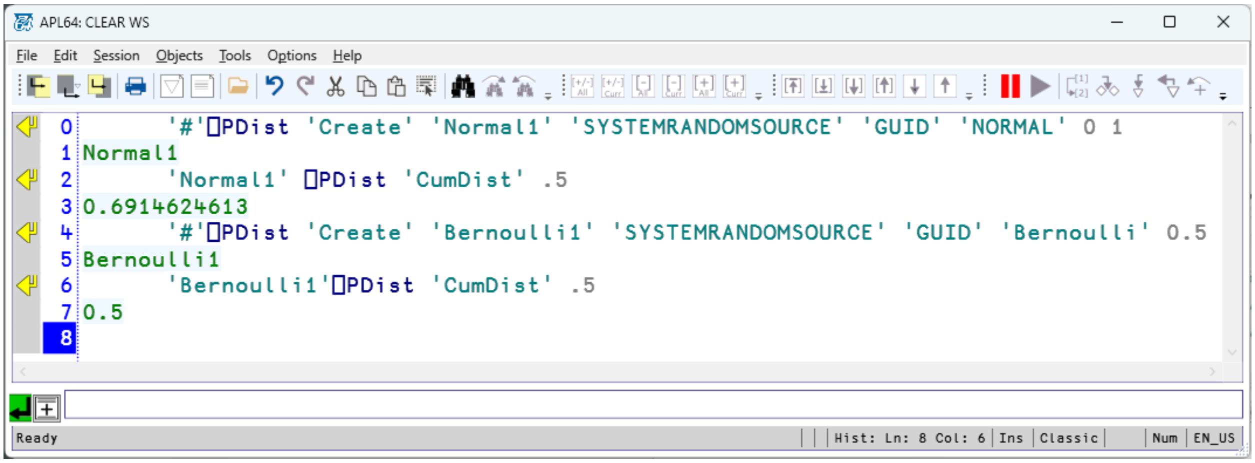
## ⎕PDIST Instance Actions

Some ⎕PDIST instance actions may not apply to some probability distributions, in which case an exception will be thrown.

## CumDist

The cumulative distribution function represents the probability that the random variable, satisfying the specified probability distribution, will have a value less than or equal to a specified value.

```
'#'□PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'Normal1' □PDist 'CumDist' .5
'#'□PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'Bernoulli1'□PDist 'CumDist' .5
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      'Normal1' ⎕PDist 'CumDist' .5
0.6914624613
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1'⎕PDist 'CumDist' .5
0.5
```

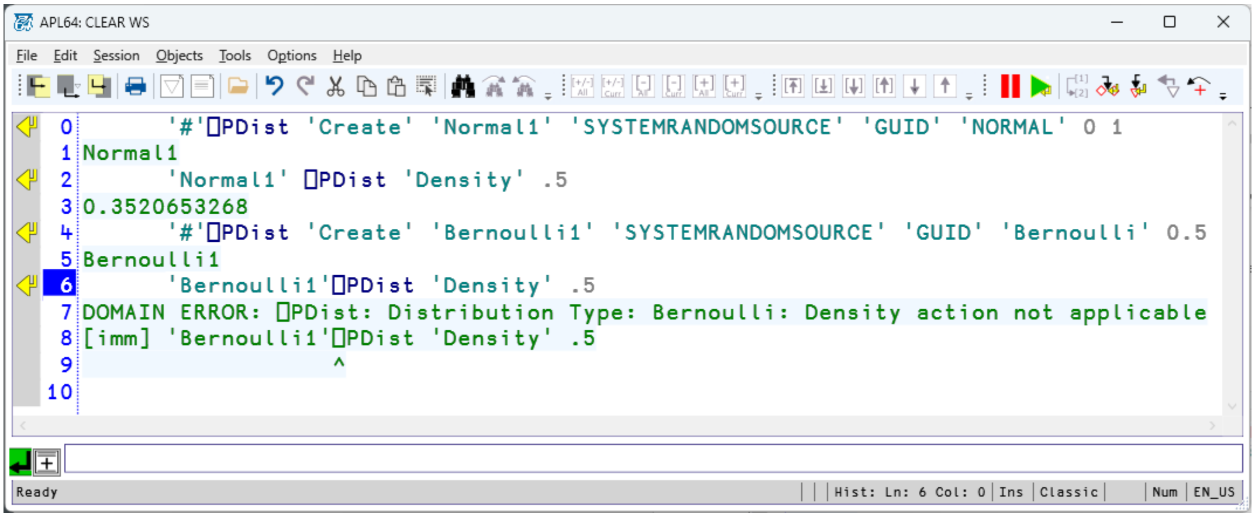
## Density

The probability density function provides the relative likelihood that a random variable, satisfying the specified probability distribution, will have a value equal to a specified value.

### *Most Distributions*

For most distributions, the argument is a scalar double. The result is a scalar double.

```
'#'□PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'Normal1' □PDist 'Density' .5
'#'□PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'Bernoulli1'□PDist 'Density' .5
```



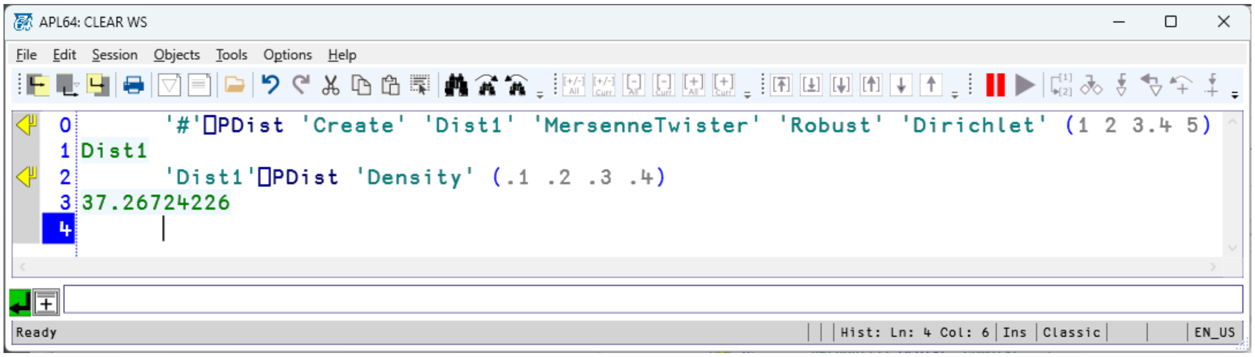
```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      'Normal1' ⎕PDist 'Density' .5
0.3520653268
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1'⎕PDist 'Density' .5
DOMAIN ERROR: ⎕PDist: Distribution Type: Bernoulli: Density action not applicable
[imm] 'Bernoulli1'⎕PDist 'Density' .5
                  ^
```

For certain multi-variate distributions, the arguments and results depend on the distribution type:

### *Dirichlet*

The argument is a vector of doubles. The total of the argument mut equal to 1. The result is a scalar double.

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Dirichlet' (1 2 3.4 5)
'Dist1'⎕PDist 'Density' (.1 .2 .3 .4)
```

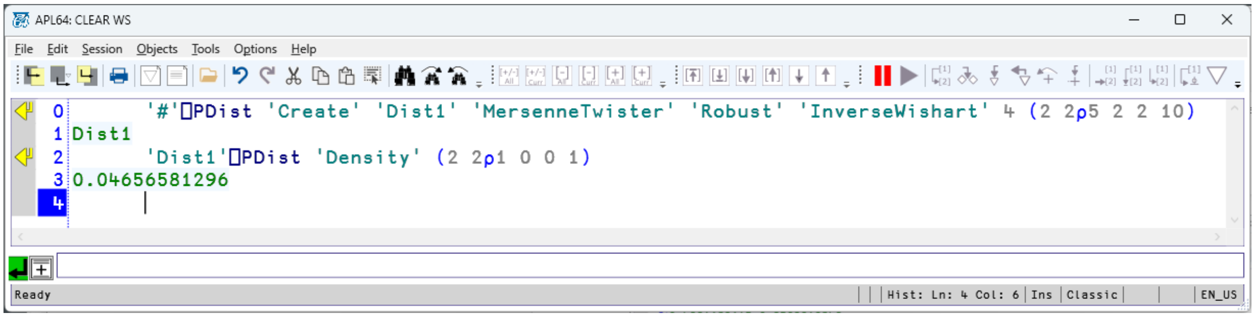


```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Dirichlet' (1 2 3.4 5)
Dist1
      'Dist1'⎕PDist 'Density' (.1 .2 .3 .4)
37.26724226
```

### *Inverse Wishart*

The argument is a rank-2 matrix of doubles. The result is a scalar double.

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'InverseWishart' 4 (2 2⍴5 2 2 10)
'Dist1'⎕PDist 'Density' (2 2⍴1 0 0 1)
```



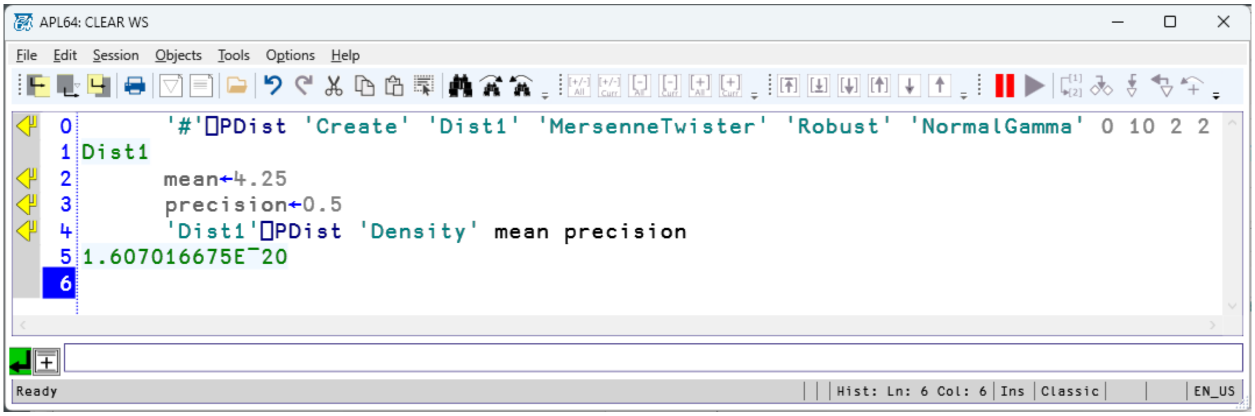
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'InverseWishart' 4 (2 2ρ5 2 2 10)
Dist1
      'Dist1'⎕PDist 'Density' (2 2ρ1 0 0 1)
0.04656581296
```

### *NormalGamma*

mean is a scalar double

precision is a scalar double

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'NormalGamma' 0 10 2 2
mean←4.25
precision←0.5
'Dist1'⎕PDist 'Density' mean precision
```

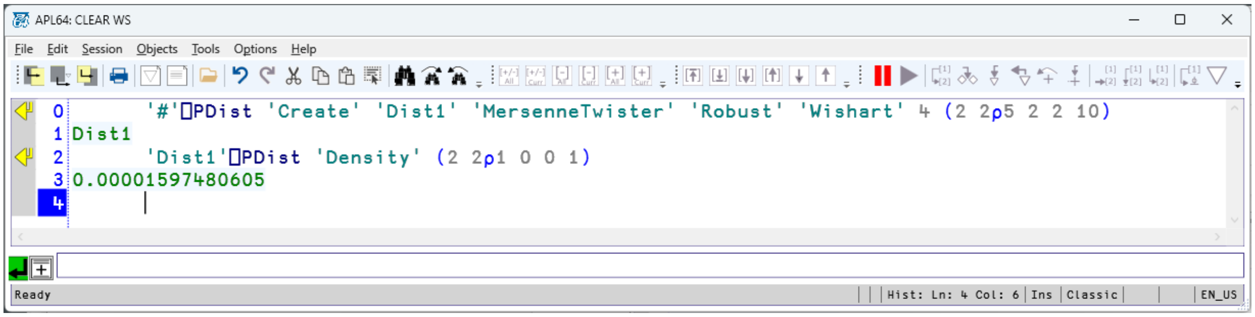


```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'NormalGamma' 0 10 2 2
Dist1
      mean←4.25
      precision←0.5
      'Dist1'⎕PDist 'Density' mean precision
1.607016675E¯20
```

### *Wishart*

The argument is a rank-2 matrix of doubles. The result is a scalar double.

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Wishart' 4 (2 2ρ5 2 2 10)
'Dist1'⎕PDist 'Density' (2 2ρ1 0 0 1)
```



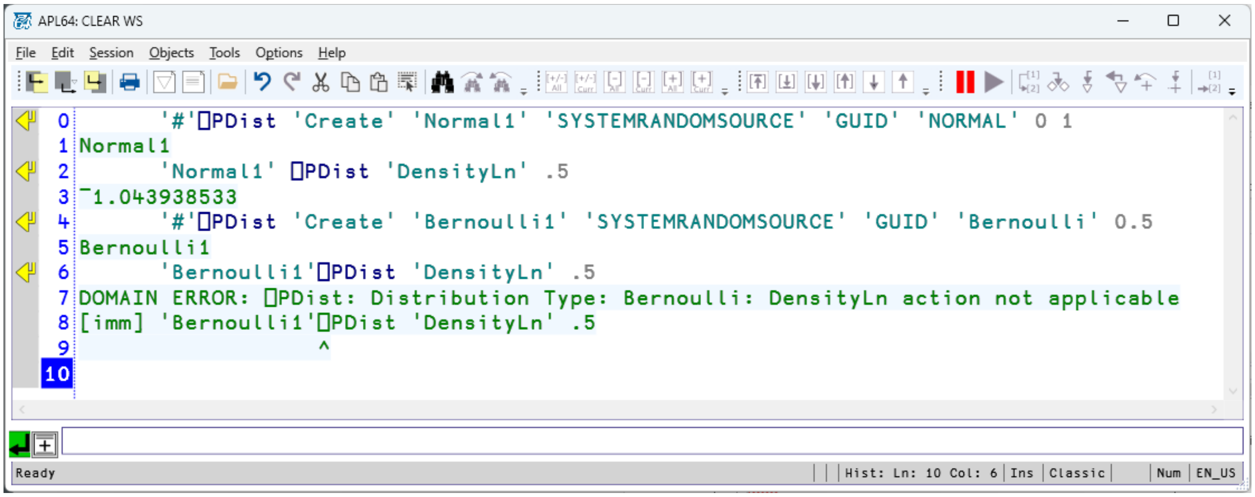
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Wishart' 4 (2 2ρ5 2 2 10)
Dist1
      'Dist1'⎕PDist 'Density' (2 2ρ1 0 0 1)
0.00001597480605
```

## DensityLn

Natural logarithm of the density function value.

The arguments and results are the same as those for the Density action.

```
'#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'Normal1' ⎕PDist 'DensityLn' .5
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'Bernoulli1'⎕PDist 'DensityLn' .5
```

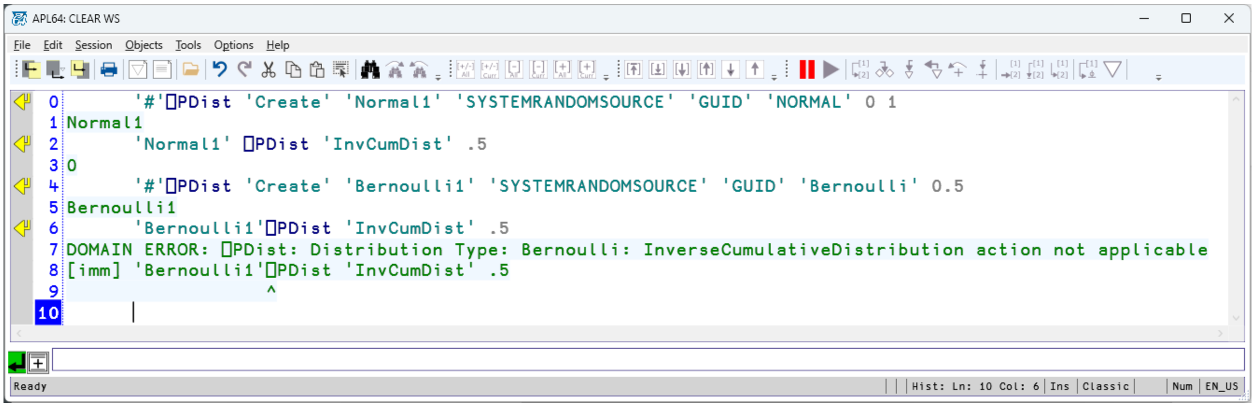


```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      'Normal1' ⎕PDist 'DensityLn' .5
¯1.043938533
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1'⎕PDist 'DensityLn' .5
DOMAIN ERROR: ⎕PDist: Distribution Type: Bernoulli: DensityLn action not applicable
[imm] 'Bernoulli1'⎕PDist 'DensityLn' .5
                   ^
```

## InvCumDist

The inverse cumulative density distribution or quantile returns the value of a random variable, satisfying the specified probability distribution, which has the probability less than or equal to a specified probability.

```
'#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'Normal1' ⎕PDist 'InvCumDist' .5
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'Bernoulli1'⎕PDist 'InvCumDist' .5
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      'Normal1' ⎕PDist 'InvCumDist' .5
0
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1'⎕PDist 'InvCumDist' .5
DOMAIN ERROR: ⎕PDist: Distribution Type: Bernoulli: InverseCumulativeDistribution action not applicable
[imm] 'Bernoulli1'⎕PDist 'InvCumDist' .5
                    ^
```

## Probability

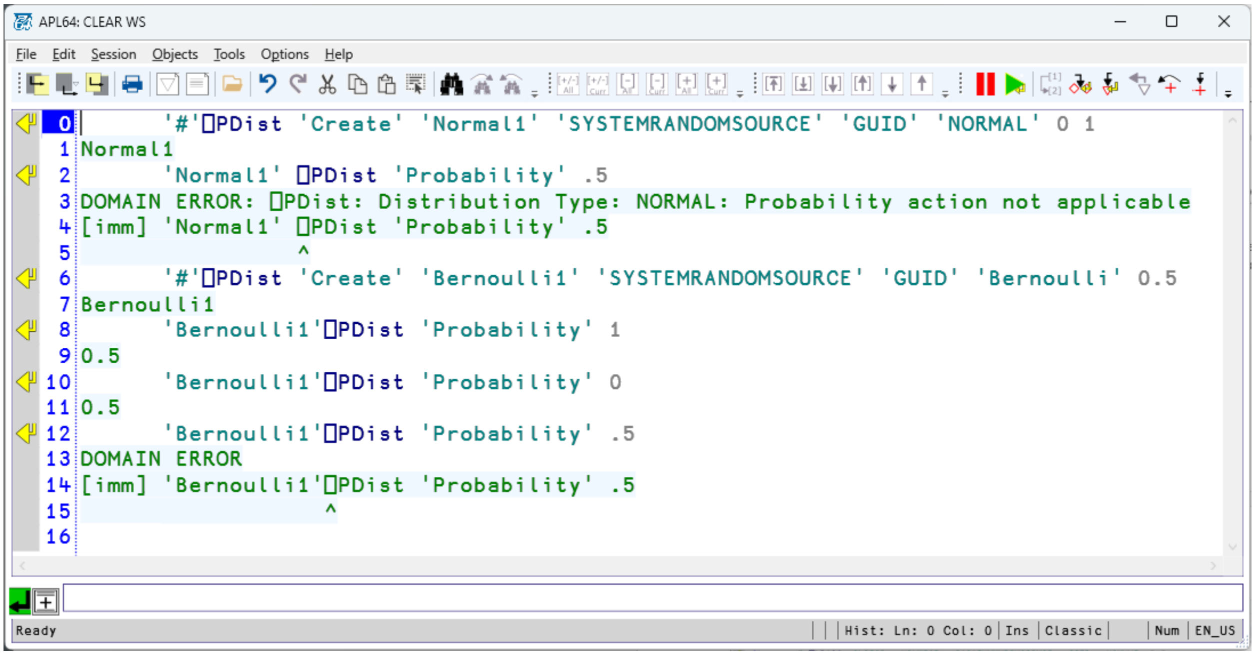
Returns the probability that random variable, satisfying the specified probability distribution, will be equal to a specified value.

### *Most Distributions*

For continuous distributions the argument is a scalar double.  For discrete distributions the argument is a scalar integer.  The result is a scalar double.

Bernoulli distribution

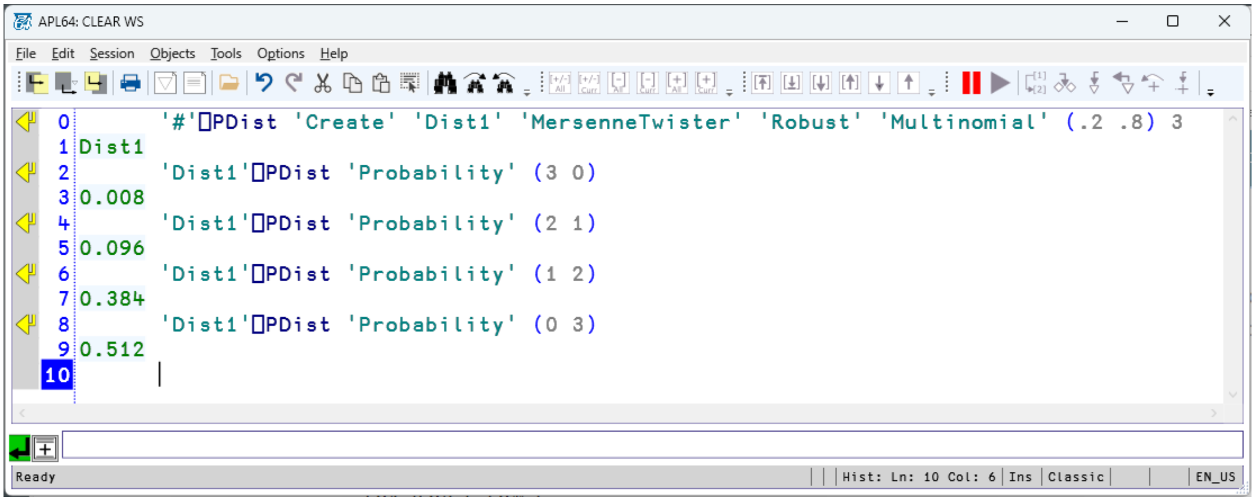
```
'#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'Normal1' ⎕PDist 'Probability' .5
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'Bernoulli1'⎕PDist 'Probability' 1
'Bernoulli1'⎕PDist 'Probability' 0
'Bernoulli1'⎕PDist 'Probability' .5
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      'Normal1' ⎕PDist 'Probability' .5
DOMAIN ERROR: ⎕PDist: Distribution Type: NORMAL: Probability action not applicable
[imm] 'Normal1' ⎕PDist 'Probability' .5
                ^
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1'⎕PDist 'Probability' 1
0.5
      'Bernoulli1'⎕PDist 'Probability' 0
0.5
      'Bernoulli1'⎕PDist 'Probability' .5
DOMAIN ERROR
[imm] 'Bernoulli1'⎕PDist 'Probability' .5
                  ^
```

### *Multinomial distribution*

```
'#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Multinomial' (.2 .8) 3
'Dist1'⎕PDist 'Probability' (3 0)
'Dist1'⎕PDist 'Probability' (2 1)
'Dist1'⎕PDist 'Probability' (1 2)
'Dist1'⎕PDist 'Probability' (0 3)
```



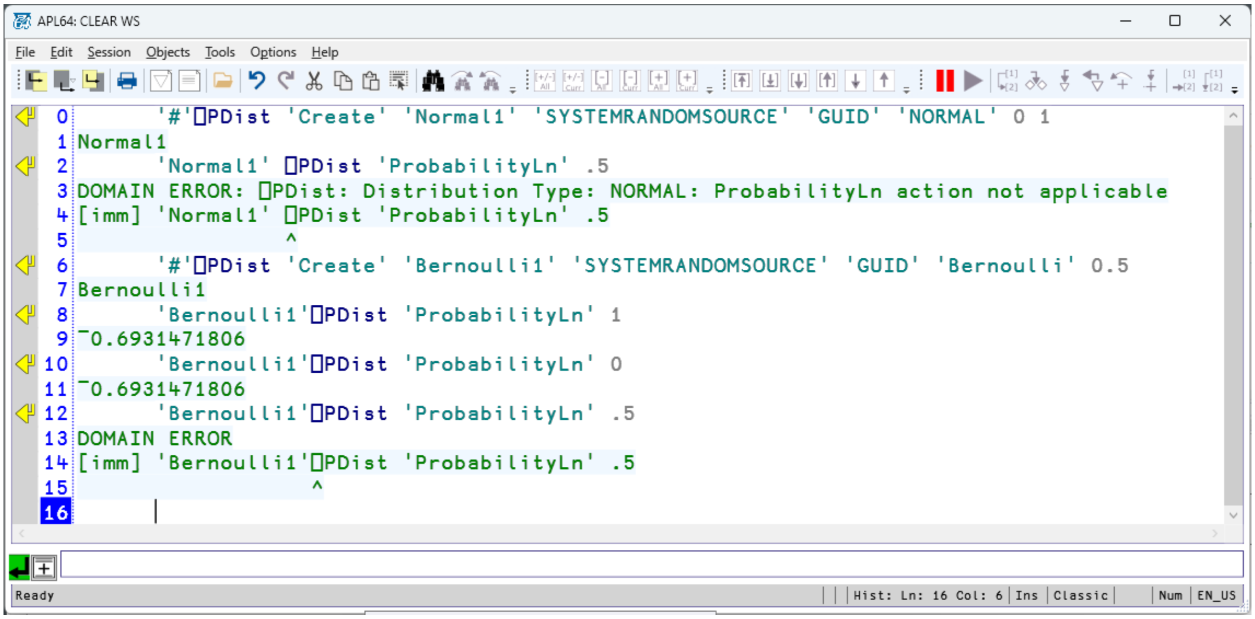
```
      '#'⎕PDist 'Create' 'Dist1' 'MersenneTwister' 'Robust' 'Multinomial' (.2 .8) 3
Dist1
      'Dist1'⎕PDist 'Probability' (3 0)
0.008
      'Dist1'⎕PDist 'Probability' (2 1)
0.096
      'Dist1'⎕PDist 'Probability' (1 2)
0.384
      'Dist1'⎕PDist 'Probability' (0 3)
0.512
```

## ProbabilityLn

Natural logarithm of the probability value.

The arguments and results are the same as those for the Probability action.

```
'#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'Normal1' ⎕PDist 'ProbabilityLn' .5
'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'Bernoulli1'⎕PDist 'ProbabilityLn' 1
'Bernoulli1'⎕PDist 'ProbabilityLn' 0
'Bernoulli1'⎕PDist 'ProbabilityLn' .5
```



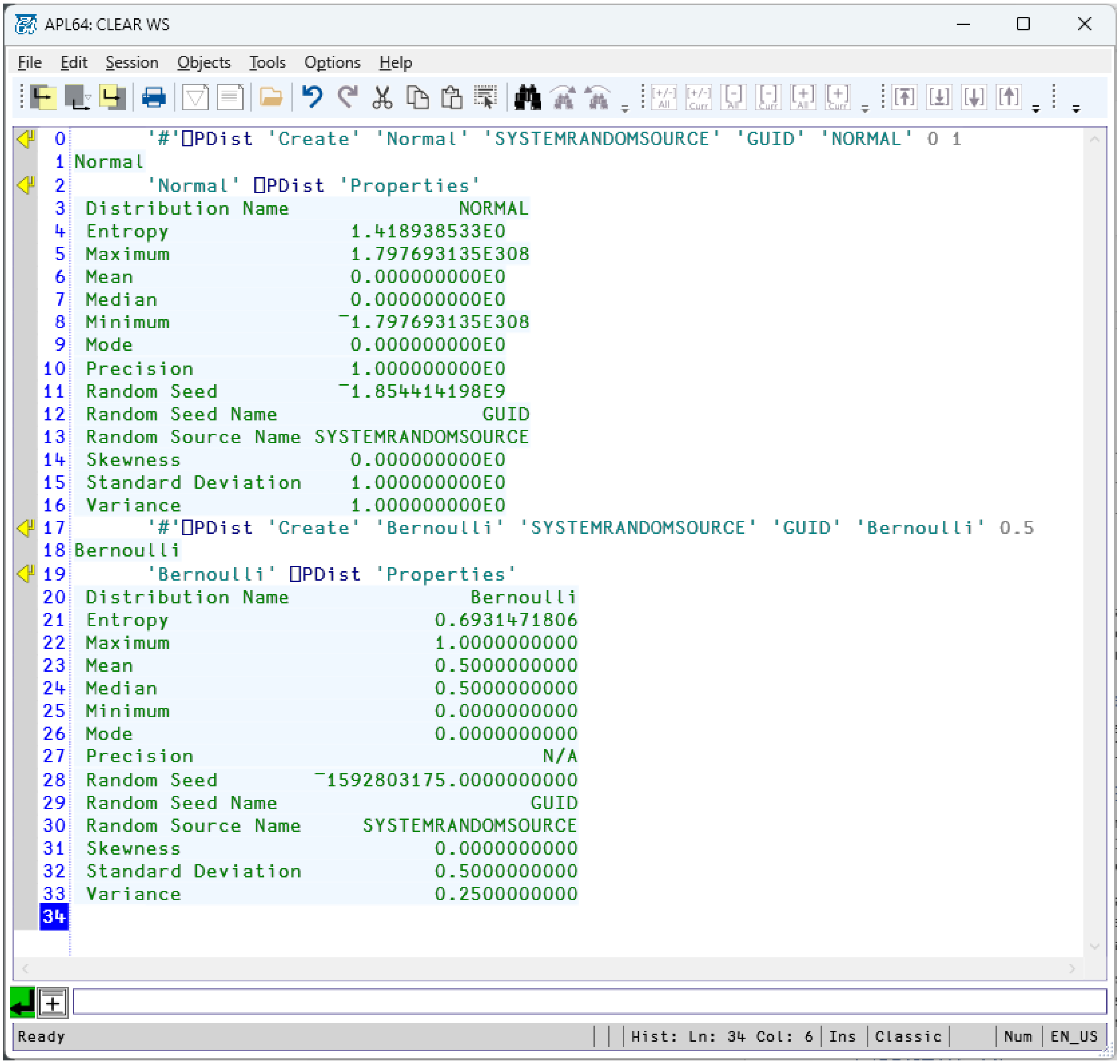
```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      'Normal1' ⎕PDist 'ProbabilityLn' .5
DOMAIN ERROR: ⎕PDist: Distribution Type: NORMAL: ProbabilityLn action not applicable
[imm] 'Normal1' ⎕PDist 'ProbabilityLn' .5
                ^
      '#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli1
      'Bernoulli1'⎕PDist 'ProbabilityLn' 1
¯0.6931471806
      'Bernoulli1'⎕PDist 'ProbabilityLn' 0
¯0.6931471806
      'Bernoulli1'⎕PDist 'ProbabilityLn' .5
DOMAIN ERROR
[imm] 'Bernoulli1'⎕PDist 'ProbabilityLn' .5
                  ^
```

### Properties

Returns a rank-2 array with the available properties of the selected distribution which are supported by the MathNet toolkit.  Column #1 contains the property description.  Column #2 contains the property value.

Some distributions do not support all properties listed.

```
'#'□PDist 'Create' 'Normal' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
'Normal' □PDist 'Properties'
'#'□PDist 'Create' 'Bernoulli' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
'Bernoulli' □PDist 'Properties'
```



```
      '#'⎕PDist 'Create' 'Normal' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal
      'Normal' ⎕PDist 'Properties'
 Distribution Name              NORMAL
 Entropy               1.418938533E0
 Maximum               1.797693135E308
 Mean                  0.000000000E0
 Median                0.000000000E0
 Minimum              ¯1.797693135E308
 Mode                  0.000000000E0
 Precision             1.000000000E0
 Random Seed          ¯1.854414198E9
 Random Seed Name                 GUID
 Random Source Name SYSTEMRANDOMSOURCE
 Skewness              0.000000000E0
 Standard Deviation    1.000000000E0
 Variance              1.000000000E0
      '#'⎕PDist 'Create' 'Bernoulli' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Bernoulli
      'Bernoulli' ⎕PDist 'Properties'
 Distribution Name                Bernoulli
 Entropy                       0.6931471806
 Maximum                       1.0000000000
 Mean                          0.5000000000
 Median                        0.5000000000
 Minimum                       0.0000000000
 Mode                          0.0000000000
 Precision                              N/A
 Random Seed        ¯1592803175.0000000000
 Random Seed Name                      GUID
 Random Source Name     SYSTEMRANDOMSOURCE
 Skewness                      0.0000000000
 Standard Deviation            0.5000000000
 Variance                      0.2500000000
```

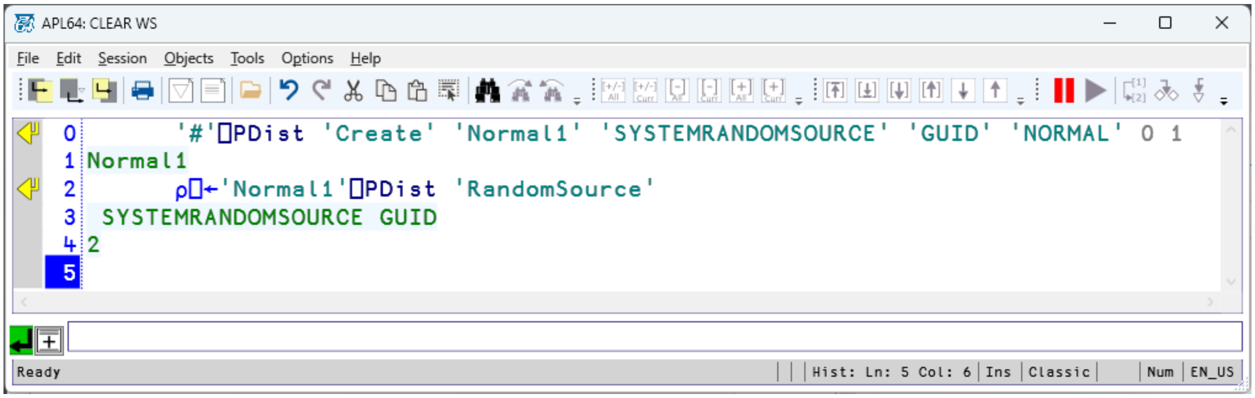
### RandomSource

Use this □PDIST instance method to view or change the random seed and pseudo-random number generator for an existing □PDIST instance.

To obtain the current random source name and random seed name for a specified □PDIST distribution instance.  The result of this format of the RandomSource action is a rank-2 array containing the existing random source name and the random seed name.

Syntax: (rndSrcNm rndSeedNm)←instName'□PDist instanceName

```
'#'□PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
ρ□←'Normal1'□PDist 'RandomSource'
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SYSTEMRANDOMSOURCE' 'GUID' 'NORMAL' 0 1
Normal1
      ρ⎕←'Normal1'⎕PDist 'RandomSource'
 SYSTEMRANDOMSOURCE  GUID
2
```

To set the random source name and random seed name for a specified □PDIST distribution instance. The result of this format of the RandomSource action is a rank-2 array containing the existing random source name and the random seed name.

Syntax: (rndSrcNm rndSeedNm)←instName□PDist instanceName rndSrcNm rndSeedNm

'rndSrcNm' is selected from the pseudo-random number generators supported by MathNet.

*Pseudo-random Number Generators: Source Names:*

| Random Source Name | Description |
|---|---|
| SystemRandomSource | Wraps the .NET System.Random to provide thread-safety |
| MersenneTwister | Mersenne Twister 19937 generator |
| XorShift | Multiply-with-carry XOR-shift generator |
| Mcg31M1 | Multiplicative congruential generator using a modulus of 2^31-1 and a multiplier of 1132489760 |
| Mcg59 | Multiplicative congruential generator using a modulus of 2^59 and a multiplier of 13^13 |
| Wh1982 | Wichmann-Hill's 1982 combined multiplicative congruential generator |
| WH2006 | Wichmann-Hill's 2006 combined multiplicative congruential generator |
| Mrg32K3A | 32-bit combined multiple recursive generator with 2 components of order 3 |
| Palf | Parallel Additive Lagged Fibonacci generator |
| XOSHIRO256STARSTAR | xoshiro256** random number generator |
| CryptoRandomSource | Wraps the .NET RNGCryptoServiceProvider |

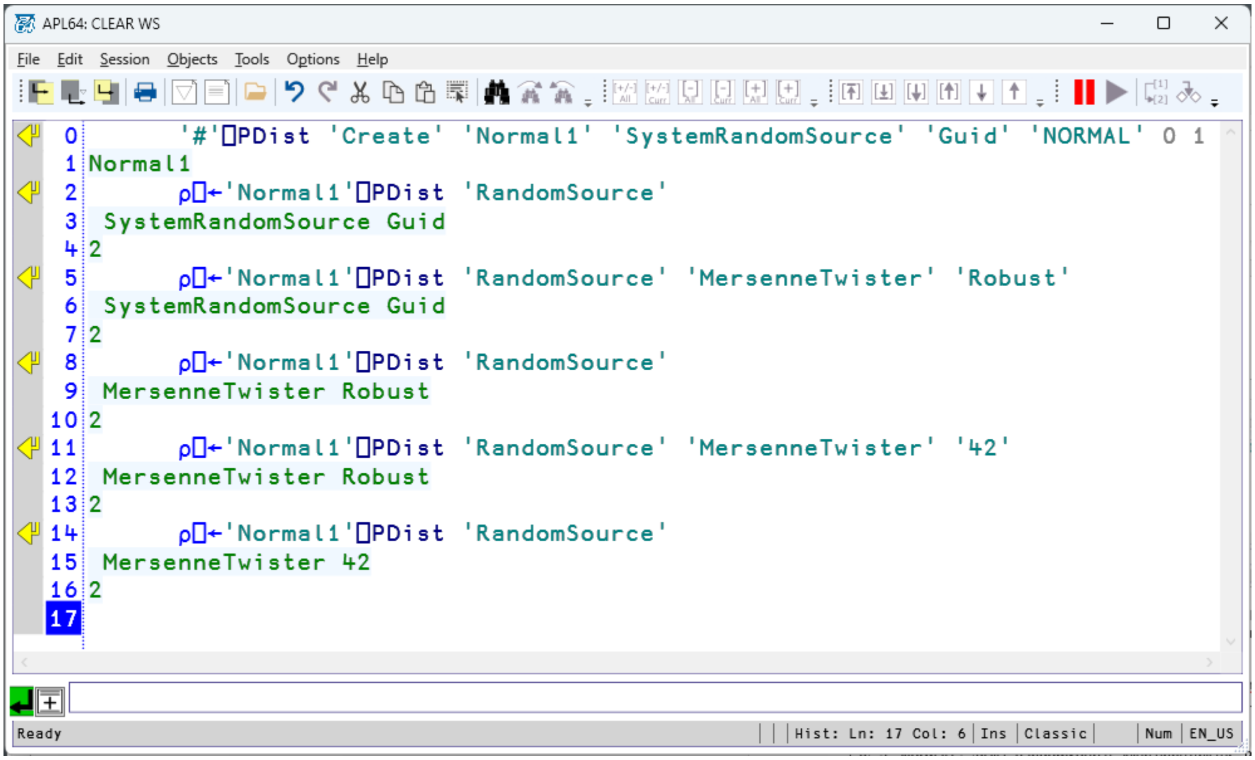
‘rndSeeNm’ is selected from the random seed options supported by Mathnet. The ‘numericValue’ random seed option is useful for testing an application using ⎕Pdist, but this option should not be used for a production application.

### *Random Seed Names:*

These are the random seed options supported by Mathnet:

| Random Seed Name or Explicit Value |
|---|
| Time |
| Guid |
| Robust |
| ‘numericValue’ |

```
'#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'NORMAL' 0 1
ρ⎕←'Normal1'⎕PDist 'RandomSource'
ρ⎕←'Normal1'⎕PDist 'RandomSource' 'MersenneTwister' 'Robust'
ρ⎕←'Normal1'⎕PDist 'RandomSource'
ρ⎕←'Normal1'⎕PDist 'RandomSource' 'MersenneTwister' '42'
ρ⎕←'Normal1'⎕PDist 'RandomSource'
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'NORMAL' 0 1
Normal1
      ρ⎕←'Normal1'⎕PDist 'RandomSource'
 SystemRandomSource Guid
2
      ρ⎕←'Normal1'⎕PDist 'RandomSource' 'MersenneTwister' 'Robust'
 SystemRandomSource Guid
2
      ρ⎕←'Normal1'⎕PDist 'RandomSource'
 MersenneTwister Robust
2
      ρ⎕←'Normal1'⎕PDist 'RandomSource' 'MersenneTwister' '42'
 MersenneTwister Robust
2
      ρ⎕←'Normal1'⎕PDist 'RandomSource'
 MersenneTwister 42
2
```

## Samples

Use this ⎕PDIST instance method obtain an APL64 rank-1 array of sample values of the specified ⎕PDIST probability distribution instance. The result of the Samples method depends on the distribution type.

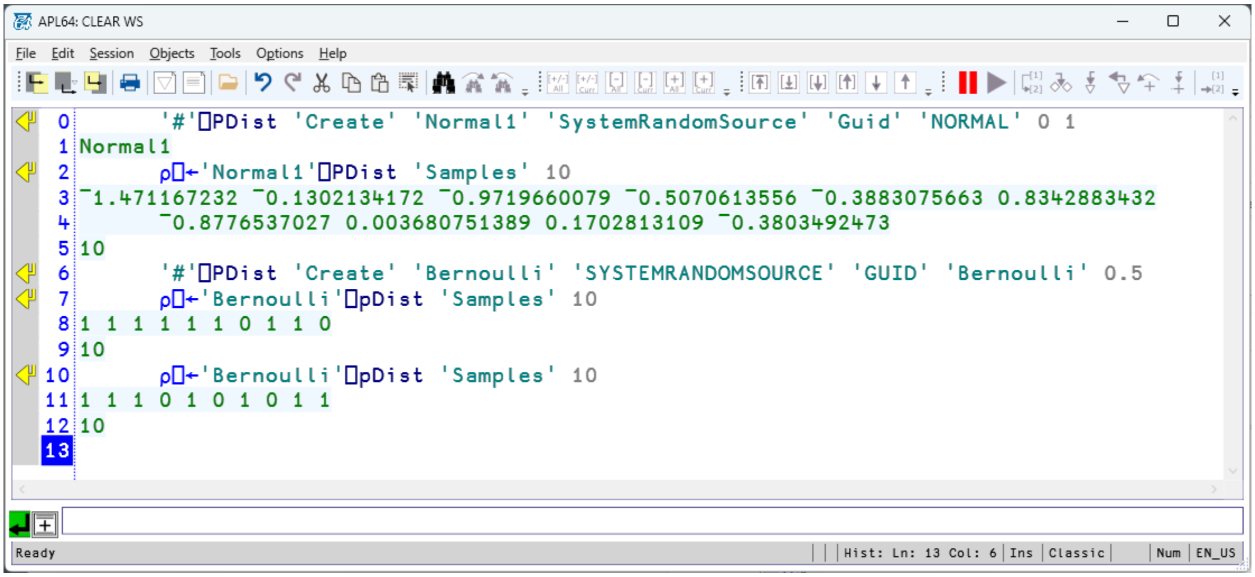
Review the documentation of the ⎕PDIST Create action for examples using the ⎕PDIST Samples action.

### *Most Distributions*

Syntax: double[] ← 'Normal1'⎕PDist 'Samples' int

For most distributions the argument is a scalar integer indicating the desired number of samples in the result. For continuous distributions the result is a vector of doubles. For discrete distributions the result is a vector of integers.

```
'#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'NORMAL' 0 1
ρ⎕←'Normal1'⎕PDist 'Samples' 10
'#'⎕PDist 'Create' 'Bernoulli' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
ρ⎕←'Bernoulli'⎕pDist 'Samples' 10
ρ⎕←'Bernoulli'⎕pDist 'Samples' 10
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'NORMAL' 0 1
Normal1
      ρ⎕←'Normal1'⎕PDist 'Samples' 10
¯1.471167232 ¯0.1302134172 ¯0.9719660079 ¯0.5070613556 ¯0.3883075663 0.8342883432
      ¯0.8776537027 0.003680751389 0.1702813109 ¯0.3803492473
10
      '#'⎕PDist 'Create' 'Bernoulli' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
      ρ⎕←'Bernoulli'⎕pDist 'Samples' 10
1 1 1 1 1 1 0 1 1 0
10
      ρ⎕←'Bernoulli'⎕pDist 'Samples' 10
1 1 1 0 1 0 1 0 1 1
10
```

### *Dirichlet*

Syntax: (double[] double[] ...) ← 'Normal1'⎕PDist 'Samples' int

The argument is a scalar integer. The result is a vector of double[] vectors.

### *InverseWishart, MatrixNormal, Wishart*

Syntax: (double[;] double[;] ...) ← 'Normal1'⎕PDist 'Samples' int

The argument is a scalar integer. The result is a vector of rank-2 matrices.

### *MultiNomial*

Syntax: (Int32[] Int32[] …) ← 'Normal1'⎕PDist 'Samples' int

The argument is a scalar integer. The result is a vector of Int32[] vectors.

### *NormalGamma*

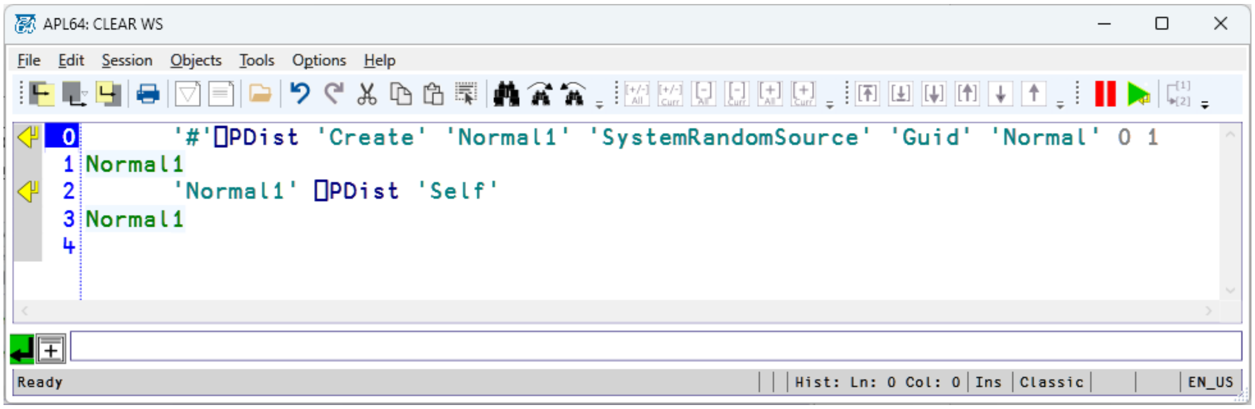
Syntax: (double[2] double[2] …) ← 'Normal1'⎕PDist 'Samples' int

The argument is a scalar integer. The result is a vector of 2-element double vectors. Each double vector contains the mean and precision of the sample.

### Self

Use this ⎕PDIST instance method to obtain the instance name of a selected ⎕PDIST probability distribution instance.

```
'#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'Normal' 0 1
'Normal1' ⎕PDist 'Self'
```



```
      '#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'Normal' 0 1
Normal1
      'Normal1' ⎕PDist 'Self'
Normal1
```

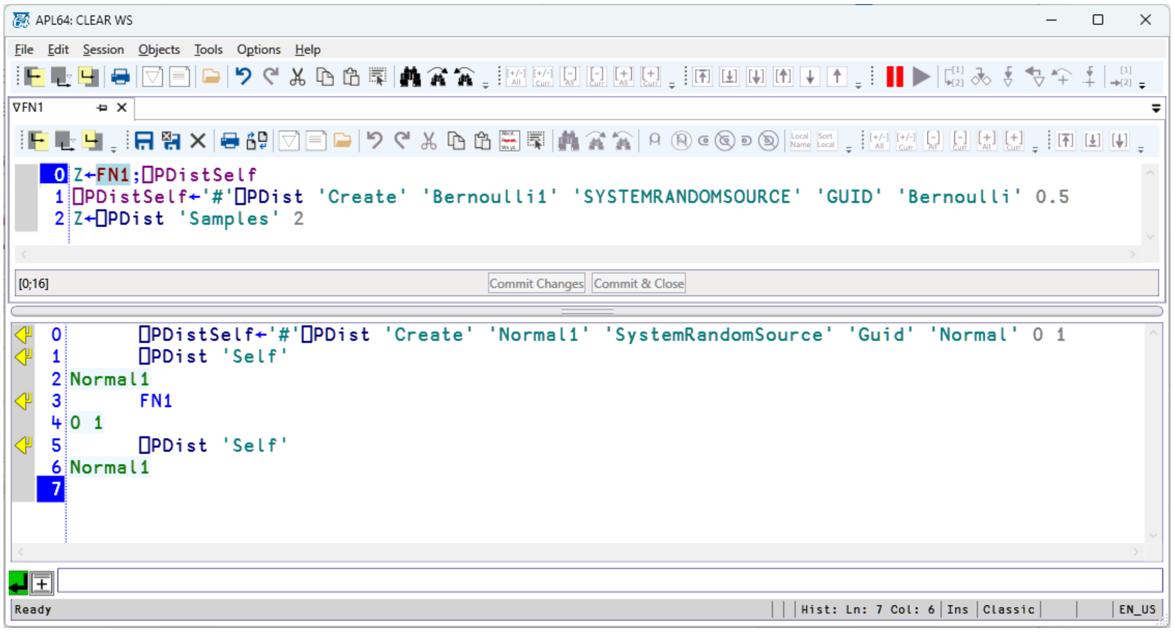
## ⎕PDISTSELF System Variable

When the ⎕PDistSelf system variable is a ⎕Pdist instance, the left argument of ⎕Pdist is not necessary. ⎕PDistSelf can be localized in an APL64 programmer defined function.

**Example**:

Create the FN1 function, which localizes ⎕PDistSelf. Running the FN1 function will not modify the workspace value of ⎕PDistSelf:

```
⎕PDistSelf←'#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'Normal' 0 1
⎕PDist 'Self'
FN1
⎕PDist 'Self'
```



```
Z←FN1;⎕PDistSelf
⎕PDistSelf←'#'⎕PDist 'Create' 'Bernoulli1' 'SYSTEMRANDOMSOURCE' 'GUID' 'Bernoulli' 0.5
Z←⎕PDist 'Samples' 2
```

```
      ⎕PDistSelf←'#'⎕PDist 'Create' 'Normal1' 'SystemRandomSource' 'Guid' 'Normal' 0 1
      ⎕PDist 'Self'
Normal1
      FN1
0 1
      ⎕PDist 'Self'
Normal1
```