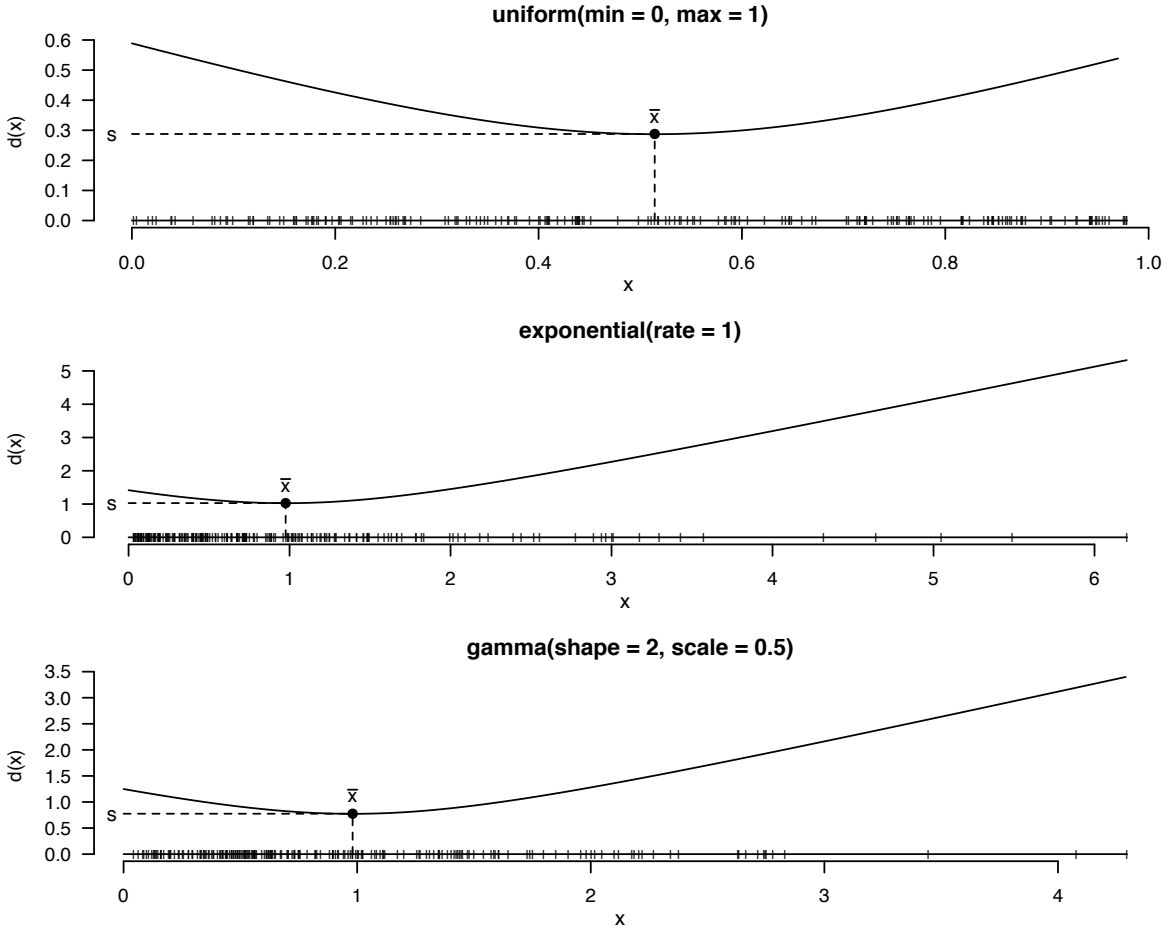
1. Write R code to generate a figure similar to Figure 4.1.1, displaying $d(x)$ computed for a vector of many variates drawn from a common distribution, superimposing $\bar{x}$ and s. Compare the results using `runif` versus `rexp` versus `rgamma`.

- Write a single R function that accepts a vector of variates (from any distribution) and a plot title. Your function will plot exactly one of the $d(x)$ versus x plots shown in the figure below.
  - Your function must automatically determine the min and max plot values based on the given vector of variates.
  - Use `stripchart` (with `pch = '|'`) to produce the stripchart of variates at the bottom of the plot.
  - Given appropriate x and y values, just use `points` with `type = 'l'` to produce the $d(x)$ curve.
  - Use the `text` function to place the $\bar{x}$ text just above the dashed-segments intersection point. Note that `expression(bar(x))` will produce the LaTeX-like $\bar{x}$ (see `?plotmath`).
  - Use the `mtext` function to place the s text just to the left of the horizontal dashed line segment. You should make note of the `at` and `line` arguments to `mtext`, as well as the additional `las` and `cex` parameter arguments (see `?par` for the latter two).



- The "main" section of your R code will then consist of three separate calls to your function:
  - For the 1st call, use 200 *uniform* (0,1) variates.
  - For the 2nd call, use 200 *exponential* (1) variates.
  - For the 3rd call, use 200 *gamma* ($k = 2$, $\Theta = 0.5$) variates, where (k,Θ) are the shape and scale parameters.
- To make all of your plots appear in the same figure, use the `par` function to set the number of rows via `mfrow`, and again to set the margins via `mar`, e.g.,

```
par(mfrow = c(3,1))       # plot three rows, one column
par(mar = c(3, 5, 2, 2))  # margins: B, L, T, R
```

- Rather than plotting to the R plot window, use the `cairo_pdf` function to output directly to a PDF, e.g.,

```
pdfFilename = "dx_vs_x.pdf"
cairo_pdf(pdfFilename, width = 7, height = 5.5)
# your code to set rows/cols and margins
# your code calling your plotting function
dev.off()
```

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2. Implement two separate R functions, each accepting a vector of data values and returning as an R list the sample mean and sample standard deviation:

- The first must be named `onePass` and must use the conventional one-pass approach for computing $\bar{x}$ and s.
- The second must be name `welfords` and must use Welford's algorithm for computing $\bar{x}$ and s (see lecture slides).

You may not use the R-default `mean()` or `sd()` functions in either implementation.

Experiment with the two functions until you are able to see the result of round-off error in s using the conventional approach (hint: think large mean and small variance).

Submitting: Include the following in your submission:

- the source code for generating the $d(x)$-vs-x figure;
- the $d(x)$-vs-x PDF generated by your code above;
- the source code containing your `onePass` and `welfords` functions;
- a README briefly describing the data you used to produce noticeable round-off error in s between `onePass` versus `welfords`.

Package your work into a tarball named similar to `cmsc326_lab8_bo4pz.tgz` and drop into the `lab8` folder within your shared Box folder for this course.