# R Objects, Workflow and Functions

## Vectors

Create a vector

```
set.seed(42)
my_unif <- runif(30)
is.vector(my_unif)
```

```
[1] TRUE
```

Subset that object

```
my_unif[1:10]
```

```
 [1] 0.9148060 0.9370754 0.2861395 0.8304476 0.6417455 0.5190959 0.7365883
 [8] 0.1346666 0.6569923 0.7050648
```

```
my_unif[c(1:3, 15:17)]
```

```
[1] 0.9148060 0.9370754 0.2861395 0.4622928 0.9400145 0.9782264
```

Sort the vector

```
sort(my_unif)
```

```
 [1] 0.08243756 0.11748736 0.13466660 0.13871017 0.25542882 0.28613953
 [7] 0.39020347 0.44696963 0.45774178 0.46229282 0.47499708 0.51421178
[13] 0.51909595 0.56033275 0.64174552 0.65699229 0.70506478 0.71911225
[19] 0.73658831 0.83044763 0.83600426 0.90403139 0.90573813 0.91480604
[25] 0.93467225 0.93707541 0.94001452 0.94666823 0.97822643 0.98889173
```

Create a vector with strings in it

```
char_vec <- c('daf', "adf", "e2", '13da')
sort(char_vec)
```

```
[1] "13da" "adf"  "daf"  "e2"
```

## Data Frame

```
data(trees)
trees
```

```
   Girth Height Volume
1    8.3     70   10.3
2    8.6     65   10.3
3    8.8     63   10.2
4   10.5     72   16.4
5   10.7     81   18.8
6   10.8     83   19.7
7   11.0     66   15.6
8   11.0     75   18.2
9   11.1     80   22.6
10  11.2     75   19.9
11  11.3     79   24.2
12  11.4     76   21.0
13  11.4     76   21.4
14  11.7     69   21.3
15  12.0     75   19.1
16  12.9     74   22.2
17  12.9     85   33.8
18  13.3     86   27.4
19  13.7     71   25.7
20  13.8     64   24.9
21  14.0     78   34.5
22  14.2     80   31.7
23  14.5     74   36.3
24  16.0     72   38.3
25  16.3     77   42.6
26  17.3     81   55.4
```

```
27  17.5     82   55.7
28  17.9     80   58.3
29  18.0     80   51.5
30  18.0     80   51.0
31  20.6     87   77.0
```

```
str(trees)
```

```
'data.frame':   31 obs. of  3 variables:
 $ Girth : num  8.3 8.6 8.8 10.5 10.7 10.8 11 11 11.1 11.2 ...
 $ Height: num  70 65 63 72 81 83 66 75 80 75 ...
 $ Volume: num  10.3 10.3 10.2 16.4 18.8 19.7 15.6 18.2 22.6 19.9 ...
```

Subset a Column

```
trees$Height
```

```
 [1] 70 65 63 72 81 83 66 75 80 75 79 76 76 69 75 74 85 86 71 64 78 80 74 72 77
[26] 81 82 80 80 80 87
```

Get attributes from the data frame

```
attributes(trees)
```

```
$names
[1] "Girth"  "Height" "Volume"

$class
[1] "data.frame"

$row.names
 [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
[26] 26 27 28 29 30 31
```

```
names(trees)
```

```
[1] "Girth"  "Height" "Volume"
```

```r
colnames(trees)[2:3]
```

```
[1] "Height" "Volume"
```

## Lists

Investigating data frame from before

```r
is.list(trees)
```

```
[1] TRUE
```

```r
is.data.frame(trees)
```

```
[1] TRUE
```

Can subset as a list

```r
trees[1]
```

```
   Girth
1    8.3
2    8.6
3    8.8
4   10.5
5   10.7
6   10.8
7   11.0
8   11.0
9   11.1
10  11.2
11  11.3
12  11.4
13  11.4
14  11.7
15  12.0
16  12.9
17  12.9
```

```
18  13.3
19  13.7
20  13.8
21  14.0
22  14.2
23  14.5
24  16.0
25  16.3
26  17.3
27  17.5
28  17.9
29  18.0
30  18.0
31  20.6
```

```
trees[[1]]
```

```
 [1]  8.3  8.6  8.8 10.5 10.7 10.8 11.0 11.0 11.1 11.2 11.3 11.4 11.4 11.7 12.0
[16] 12.9 12.9 13.3 13.7 13.8 14.0 14.2 14.5 16.0 16.3 17.3 17.5 17.9 18.0 18.0
[31] 20.6
```

Look at linear model fit

```
fit <- lm(Volume ~ Height + Girth, data = trees)
```

Look at structure but restrict info

```
str(fit, max.level = 1)
```

```
List of 12
 $ coefficients : Named num [1:3] -57.988 0.339 4.708
  ..- attr(*, "names")= chr [1:3] "(Intercept)" "Height" "Girth"
 $ residuals    : Named num [1:31] 5.462 5.746 5.383 0.526 -1.069 ...
  ..- attr(*, "names")= chr [1:31] "1" "2" "3" "4" ...
 $ effects      : Named num [1:31] -167.985 53.863 69.159 -0.884 -2.007 ...
  ..- attr(*, "names")= chr [1:31] "(Intercept)" "Height" "Girth" "" ...
 $ rank         : int 3
 $ fitted.values: Named num [1:31] 4.84 4.55 4.82 15.87 19.87 ...
  ..- attr(*, "names")= chr [1:31] "1" "2" "3" "4" ...
 $ assign       : int [1:3] 0 1 2
```

```
 $ qr           :List of 5
  ..- attr(*, "class")= chr "qr"
 $ df.residual  : int 28
 $ xlevels      : Named list()
 $ call         : language lm(formula = Volume ~ Height + Girth, data = trees)
 $ terms        :Classes 'terms', 'formula'  language Volume ~ Height + Girth
  .. ..- attr(*, "variables")= language list(Volume, Height, Girth)
  .. ..- attr(*, "factors")= int [1:3, 1:2] 0 1 0 0 0 1
  .. .. ..- attr(*, "dimnames")=List of 2
  .. ..- attr(*, "term.labels")= chr [1:2] "Height" "Girth"
  .. ..- attr(*, "order")= int [1:2] 1 1
  .. ..- attr(*, "intercept")= int 1
  .. ..- attr(*, "response")= int 1
  .. ..- attr(*, ".Environment")=<environment: R_GlobalEnv>
  .. ..- attr(*, "predvars")= language list(Volume, Height, Girth)
  .. ..- attr(*, "dataClasses")= Named chr [1:3] "numeric" "numeric" "numeric"
  .. .. ..- attr(*, "names")= chr [1:3] "Volume" "Height" "Girth"
 $ model        :'data.frame':  31 obs. of  3 variables:
  ..- attr(*, "terms")=Classes 'terms', 'formula'  language Volume ~ Height + Girth
  .. .. ..- attr(*, "variables")= language list(Volume, Height, Girth)
  .. .. ..- attr(*, "factors")= int [1:3, 1:2] 0 1 0 0 0 1
  .. .. .. ..- attr(*, "dimnames")=List of 2
  .. .. ..- attr(*, "term.labels")= chr [1:2] "Height" "Girth"
  .. .. ..- attr(*, "order")= int [1:2] 1 1
  .. .. ..- attr(*, "intercept")= int 1
  .. .. ..- attr(*, "response")= int 1
  .. .. ..- attr(*, ".Environment")=<environment: R_GlobalEnv>
  .. .. ..- attr(*, "predvars")= language list(Volume, Height, Girth)
  .. .. ..- attr(*, "dataClasses")= Named chr [1:3] "numeric" "numeric" "numeric"
  .. .. .. ..- attr(*, "names")= chr [1:3] "Volume" "Height" "Girth"
 - attr(*, "class")= chr "lm"
```

Some helper functions exist

```
fit$coefficients
```

```
(Intercept)      Height       Girth
-57.9876589   0.3392512   4.7081605
```

```
coef(fit)
```

```
(Intercept)      Height       Girth
-57.9876589   0.3392512   4.7081605
```

```
#no helper function for rank: rank(fit)
```

## if/then/else

Fizz buzz challenge - take in a number - if it is divisible by 3 return fizz - if it is divisible by 5 return buzz - if it is divisible by 15 return fizz buzz

```
number <- 2
if((number %% 15) == 0) {
  print("fizz buzz")
  } else if((number %% 5) == 0){
    print("buzz")
  } else if((number %% 3) == 0){
    print("fizz")
  } else {
    print("whoops?")
  }
```

```
[1] "whoops?"
```

```
#if(!(number %% 15))
```

## Loops

Wrap the fizz buzz code into a loop to check for multiple values.

```
for(number in -1:41) {
  if((number %% 15) == 0) {
  print("fizz buzz")
  } else if((number %% 5) == 0){
    print("buzz")
  } else if((number %% 3) == 0){
    print("fizz")
  } else {
    print("whoops?")
  }
}
```

```
[1] "whoops?"
[1] "fizz buzz"
[1] "whoops?"
[1] "whoops?"
[1] "fizz"
[1] "whoops?"
[1] "buzz"
[1] "fizz"
[1] "whoops?"
[1] "whoops?"
[1] "fizz"
[1] "buzz"
[1] "whoops?"
[1] "fizz"
[1] "whoops?"
[1] "whoops?"
[1] "fizz buzz"
[1] "whoops?"
[1] "whoops?"
[1] "fizz"
[1] "whoops?"
[1] "buzz"
[1] "fizz"
[1] "whoops?"
[1] "whoops?"
[1] "fizz"
[1] "buzz"
[1] "whoops?"
[1] "fizz"
[1] "whoops?"
[1] "whoops?"
[1] "fizz buzz"
[1] "whoops?"
[1] "whoops?"
[1] "fizz"
[1] "whoops?"
[1] "buzz"
[1] "fizz"
[1] "whoops?"
[1] "whoops?"
[1] "fizz"
[1] "buzz"
[1] "whoops?"
```

## Writing in R Functions

Normal approximation to the binomial

```
n <- 40
prob <- 0.3

#probabilities from a binomial RV
dbinom(0:n, size = n, prob = prob)
```

```
 [1] 6.366806e-07 1.091452e-05 9.121424e-05 4.951630e-04 1.962968e-03
 [6] 6.057157e-03 1.514289e-02 3.152194e-02 5.572629e-02 8.491625e-02
[11] 1.128173e-01 1.318644e-01 1.365738e-01 1.260681e-01 1.041992e-01
[16] 7.740510e-02 5.183378e-02 3.136161e-02 1.717422e-02 8.522543e-03
[21] 3.835144e-03 1.565365e-03 5.793884e-04 1.943290e-04 5.899274e-05
[26] 1.618087e-05 4.000763e-06 8.890585e-07 1.769045e-07 3.137223e-08
[31] 4.929921e-09 6.815560e-10 8.215184e-11 8.535256e-12 7.531108e-13
[36] 5.533059e-14 3.293487e-15 1.525940e-16 5.162955e-18 1.134715e-19
[41] 1.215767e-21
```

```
#plot with plot
plot(0:n, dbinom(0:n, size = n, prob = prob), type = "h")

norm_x <- seq(from  = 0, to = n, length = 1000)
dnorm(norm_x, mean = n*prob, sd = sqrt(n*prob*(1-prob)))
```

```
   [1] 2.607632e-05 2.760874e-05 2.922563e-05 3.093131e-05 3.273029e-05
   [6] 3.462729e-05 3.662725e-05 3.873533e-05 4.095691e-05 4.329765e-05
  [11] 4.576343e-05 4.836040e-05 5.109499e-05 5.397391e-05 5.700417e-05
  [16] 6.019305e-05 6.354820e-05 6.707756e-05 7.078943e-05 7.469244e-05
  [21] 7.879560e-05 8.310831e-05 8.764033e-05 9.240185e-05 9.740348e-05
  [26] 1.026562e-04 1.081716e-04 1.139616e-04 1.200386e-04 1.264154e-04
  [31] 1.331057e-04 1.401232e-04 1.474826e-04 1.551989e-04 1.632877e-04
  [36] 1.717653e-04 1.806486e-04 1.899551e-04 1.997028e-04 2.099108e-04
  [41] 2.205984e-04 2.317859e-04 2.434943e-04 2.557453e-04 2.685615e-04
  [46] 2.819661e-04 2.959832e-04 3.106379e-04 3.259560e-04 3.419641e-04
  [51] 3.586899e-04 3.761621e-04 3.944100e-04 4.134642e-04 4.333563e-04
  [56] 4.541186e-04 4.757849e-04 4.983898e-04 5.219690e-04 5.465595e-04
  [61] 5.721992e-04 5.989274e-04 6.267844e-04 6.558119e-04 6.860528e-04
  [66] 7.175513e-04 7.503526e-04 7.845037e-04 8.200526e-04 8.570487e-04
  [71] 8.955430e-04 9.355876e-04 9.772363e-04 1.020544e-03 1.065568e-03
```

```
 [76] 1.112366e-03 1.160998e-03 1.211524e-03 1.264008e-03 1.318514e-03
 [81] 1.375108e-03 1.433857e-03 1.494831e-03 1.558101e-03 1.623738e-03
 [86] 1.691818e-03 1.762416e-03 1.835609e-03 1.911477e-03 1.990101e-03
 [91] 2.071564e-03 2.155949e-03 2.243344e-03 2.333836e-03 2.427516e-03
 [96] 2.524473e-03 2.624802e-03 2.728598e-03 2.835956e-03 2.946977e-03
[101] 3.061759e-03 3.180404e-03 3.303017e-03 3.429702e-03 3.560567e-03
[106] 3.695719e-03 3.835270e-03 3.979330e-03 4.128014e-03 4.281435e-03
[111] 4.439712e-03 4.602961e-03 4.771302e-03 4.944855e-03 5.123744e-03
[116] 5.308091e-03 5.498021e-03 5.693661e-03 5.895136e-03 6.102577e-03
[121] 6.316111e-03 6.535869e-03 6.761983e-03 6.994584e-03 7.233806e-03
[126] 7.479781e-03 7.732645e-03 7.992531e-03 8.259576e-03 8.533914e-03
[131] 8.815681e-03 9.105013e-03 9.402047e-03 9.706918e-03 1.001976e-02
[136] 1.034072e-02 1.066991e-02 1.100749e-02 1.135358e-02 1.170832e-02
[141] 1.207183e-02 1.244426e-02 1.282573e-02 1.321636e-02 1.361630e-02
[146] 1.402567e-02 1.444458e-02 1.487316e-02 1.531154e-02 1.575984e-02
[151] 1.621816e-02 1.668663e-02 1.716535e-02 1.765443e-02 1.815399e-02
[156] 1.866412e-02 1.918492e-02 1.971649e-02 2.025892e-02 2.081231e-02
[161] 2.137673e-02 2.195226e-02 2.253899e-02 2.313698e-02 2.374631e-02
[166] 2.436703e-02 2.499921e-02 2.564289e-02 2.629813e-02 2.696496e-02
[171] 2.764343e-02 2.833356e-02 2.903537e-02 2.974889e-02 3.047413e-02
[176] 3.121109e-02 3.195978e-02 3.272017e-02 3.349227e-02 3.427604e-02
[181] 3.507146e-02 3.587849e-02 3.669708e-02 3.752719e-02 3.836875e-02
[186] 3.922170e-02 4.008596e-02 4.096145e-02 4.184806e-02 4.274571e-02
[191] 4.365428e-02 4.457366e-02 4.550371e-02 4.644430e-02 4.739529e-02
[196] 4.835653e-02 4.932784e-02 5.030905e-02 5.130000e-02 5.230048e-02
[201] 5.331029e-02 5.432924e-02 5.535709e-02 5.639363e-02 5.743861e-02
[206] 5.849178e-02 5.955291e-02 6.062171e-02 6.169791e-02 6.278124e-02
[211] 6.387140e-02 6.496809e-02 6.607100e-02 6.717980e-02 6.829418e-02
[216] 6.941380e-02 7.053831e-02 7.166735e-02 7.280057e-02 7.393759e-02
[221] 7.507805e-02 7.622154e-02 7.736769e-02 7.851608e-02 7.966631e-02
[226] 8.081796e-02 8.197062e-02 8.312385e-02 8.427722e-02 8.543029e-02
[231] 8.658260e-02 8.773372e-02 8.888317e-02 9.003049e-02 9.117522e-02
[236] 9.231689e-02 9.345501e-02 9.458911e-02 9.571870e-02 9.684330e-02
[241] 9.796241e-02 9.907554e-02 1.001822e-01 1.012819e-01 1.023741e-01
[246] 1.034584e-01 1.045341e-01 1.056009e-01 1.066583e-01 1.077056e-01
[251] 1.087425e-01 1.097685e-01 1.107829e-01 1.117854e-01 1.127755e-01
[256] 1.137525e-01 1.147162e-01 1.156660e-01 1.166013e-01 1.175218e-01
[261] 1.184270e-01 1.193163e-01 1.201894e-01 1.210458e-01 1.218850e-01
[266] 1.227066e-01 1.235101e-01 1.242952e-01 1.250615e-01 1.258084e-01
[271] 1.265356e-01 1.272428e-01 1.279295e-01 1.285953e-01 1.292400e-01
[276] 1.298631e-01 1.304643e-01 1.310432e-01 1.315997e-01 1.321332e-01
[281] 1.326436e-01 1.331306e-01 1.335938e-01 1.340331e-01 1.344482e-01
[286] 1.348388e-01 1.352047e-01 1.355457e-01 1.358617e-01 1.361525e-01
```

```
[291] 1.364178e-01 1.366575e-01 1.368716e-01 1.370598e-01 1.372220e-01
[296] 1.373583e-01 1.374685e-01 1.375524e-01 1.376102e-01 1.376417e-01
[301] 1.376470e-01 1.376260e-01 1.375787e-01 1.375052e-01 1.374055e-01
[306] 1.372797e-01 1.371278e-01 1.369499e-01 1.367462e-01 1.365167e-01
[311] 1.362616e-01 1.359811e-01 1.356752e-01 1.353441e-01 1.349881e-01
[316] 1.346073e-01 1.342020e-01 1.337724e-01 1.333187e-01 1.328412e-01
[321] 1.323402e-01 1.318158e-01 1.312685e-01 1.306985e-01 1.301062e-01
[326] 1.294918e-01 1.288558e-01 1.281984e-01 1.275200e-01 1.268209e-01
[331] 1.261017e-01 1.253626e-01 1.246040e-01 1.238264e-01 1.230302e-01
[336] 1.222158e-01 1.213835e-01 1.205340e-01 1.196675e-01 1.187846e-01
[341] 1.178857e-01 1.169713e-01 1.160419e-01 1.150978e-01 1.141397e-01
[346] 1.131679e-01 1.121829e-01 1.111854e-01 1.101756e-01 1.091542e-01
[351] 1.081217e-01 1.070784e-01 1.060250e-01 1.049620e-01 1.038897e-01
[356] 1.028088e-01 1.017197e-01 1.006229e-01 9.951901e-02 9.840841e-02
[361] 9.729163e-02 9.616917e-02 9.504152e-02 9.390916e-02 9.277259e-02
[366] 9.163228e-02 9.048872e-02 8.934238e-02 8.819372e-02 8.704322e-02
[371] 8.589133e-02 8.473851e-02 8.358521e-02 8.243187e-02 8.127893e-02
[376] 8.012682e-02 7.897597e-02 7.782680e-02 7.667970e-02 7.553510e-02
[381] 7.439339e-02 7.325494e-02 7.212016e-02 7.098940e-02 6.986303e-02
[386] 6.874142e-02 6.762491e-02 6.651383e-02 6.540852e-02 6.430931e-02
[391] 6.321650e-02 6.213041e-02 6.105132e-02 5.997952e-02 5.891529e-02
[396] 5.785891e-02 5.681062e-02 5.577068e-02 5.473932e-02 5.371679e-02
[401] 5.270330e-02 5.169906e-02 5.070427e-02 4.971914e-02 4.874385e-02
[406] 4.777857e-02 4.682346e-02 4.587869e-02 4.494441e-02 4.402075e-02
[411] 4.310784e-02 4.220581e-02 4.131476e-02 4.043481e-02 3.956605e-02
[416] 3.870857e-02 3.786245e-02 3.702775e-02 3.620454e-02 3.539288e-02
[421] 3.459281e-02 3.380438e-02 3.302761e-02 3.226253e-02 3.150916e-02
[426] 3.076751e-02 3.003758e-02 2.931938e-02 2.861288e-02 2.791808e-02
[431] 2.723495e-02 2.656347e-02 2.590360e-02 2.525530e-02 2.461853e-02
[436] 2.399323e-02 2.337935e-02 2.277683e-02 2.218560e-02 2.160560e-02
[441] 2.103675e-02 2.047896e-02 1.993216e-02 1.939625e-02 1.887115e-02
[446] 1.835677e-02 1.785299e-02 1.735973e-02 1.687688e-02 1.640432e-02
[451] 1.594196e-02 1.548967e-02 1.504733e-02 1.461485e-02 1.419208e-02
[456] 1.377891e-02 1.337522e-02 1.298087e-02 1.259575e-02 1.221972e-02
[461] 1.185266e-02 1.149443e-02 1.114490e-02 1.080393e-02 1.047140e-02
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```
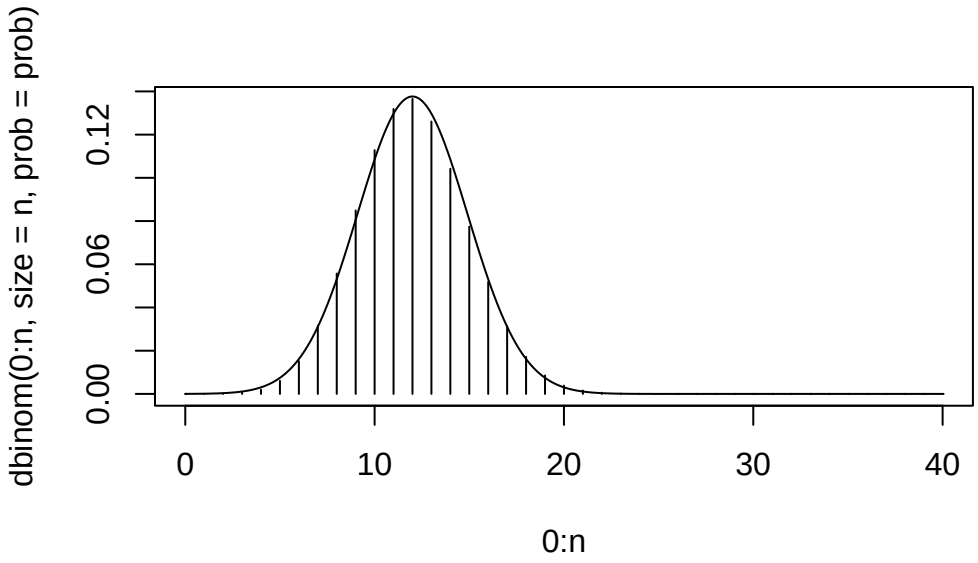

```r
lines(norm_x, dnorm(norm_x, mean = n*prob, sd = sqrt(n*prob*(1-prob))))
```

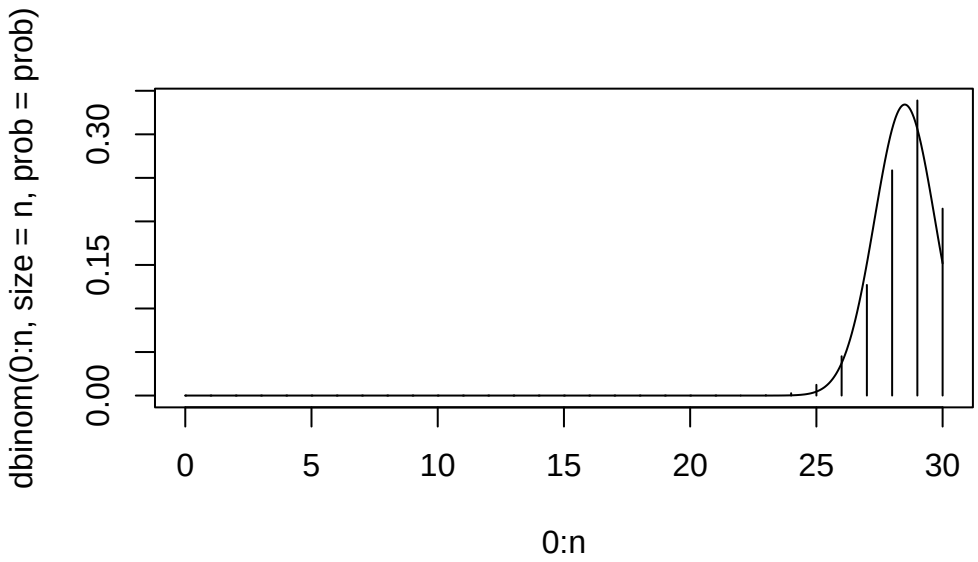



let's write a function to make this plot for any $n$ and $p$

```r
plot_norm_approx <- function(n, prob) {
  #plot with plot
  plot(0:n, dbinom(0:n, size = n, prob = prob), type = "h")

  norm_x <- seq(from  = 0, to = n, length = 1000)
  lines(norm_x, dnorm(norm_x,
                      mean = n*prob,
                      sd = sqrt(n*prob*(1-prob))))
}
```

Test it

```
plot_norm_approx(30, 0.95)
```

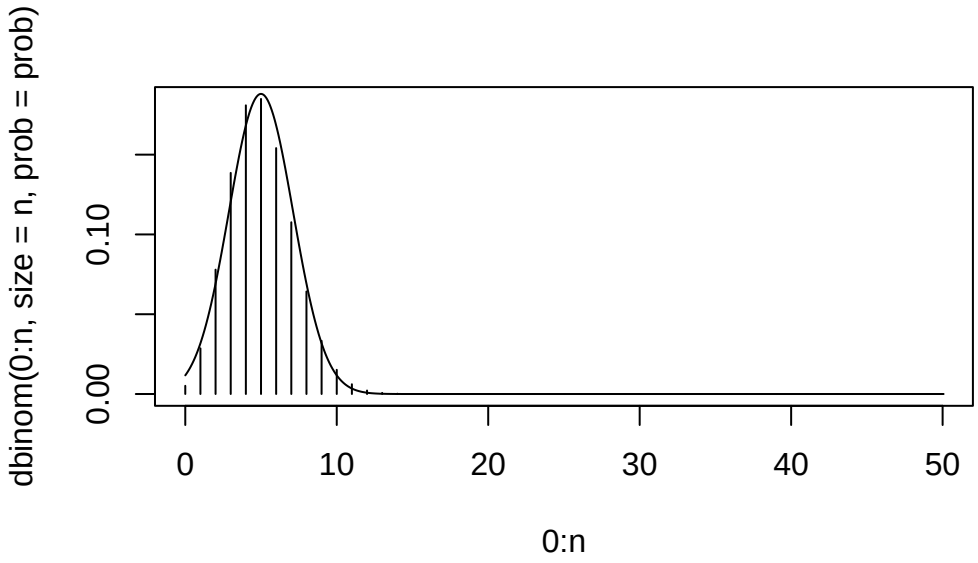



Add some default values

```
plot_norm_approx <- function(n = 30, prob = 0.5) {
  #plot with plot
  plot(0:n, dbinom(0:n, size = n, prob = prob), type = "h")

  norm_x <- seq(from  = 0, to = n, length = 1000)
  lines(norm_x, dnorm(norm_x,
                      mean = n*prob,
                      sd = sqrt(n*prob*(1-prob))))
}
```

Test it

```
plot_norm_approx(prob = 0.1, 50)
```


dbinom(0:n, size = n, prob = prob)
0.00
0.10
0
10
20
30
40
50
0:n