

- `dnorm()`:  $P(X = x)$  = height of normal distribution
- `pnorm()`:  $\text{pnorm}(x, \text{mean}, \text{sd})$ 
  - `lower.tail = TRUE` (default)  $\Rightarrow P(X \leq x) = F(x)$
  - `lower.tail = FALSE`  $\rightarrow P(X \geq x)$
- `qnorm()`: Inverse normal - Find  $c$ , such that  $P(X \leq c) = p$
- `rnorm()`: Random samples of size  $n$

1. Let  $Z \sim N(0, 1)$ . Compute the following probabilities.

a.  $P(Z < 1.35) = 0.911492$

$$f(x) = (2\pi\sigma^2)^{-1/2} \dots$$

```
pnorm(1.35)
```

```
## [1] 0.911492
```

mean = 36, sd = 0.11, Find  $P(X < 35.8)$

1st way:

$$P(X < 35.8) = P(Z < (35.8 - 36)/0.11) = P(Z < -1.82) = \text{pnorm}(-1.82) = 0.0344$$

2nd way:

$$P(X < 35.8) = \text{pnorm}(35.8, 36, 0.11) = 0.0344$$

b.  $P(Z > -0.27)$

```
pnorm(-0.27, lower.tail = FALSE)
```

```
## [1] 0.6064199
```

c.  $P(-0.1 < Z < 1.4)$

```
pnorm(1.4) - pnorm(-0.1)
```

```
## [1] 0.4590712
```

2. Next, find the value  $c$  such that:

a.  $P(Z < c) = 0.025$

```
qnorm(0.025)
```

```
## [1] -1.959964
```

b.  $P(X > c) = 0.05$  where  $X \sim N(10, 5)$

```
qnorm(0.05, 10, 5, lower.tail = FALSE)
```

```
## [1] 18.22427
```

c.  $P(-c < Z < c) = 0.99$ .

$$\$c\$ = 2.5758293$$

```
qnorm(0.995) #P(Z < c) = 0.995 => Find c?
```

```
## [1] 2.575829
```

```
qnorm(0.005, lower.tail = FALSE) #P(Z > c) find c?
```

```
## [1] 2.575829
```

```
qnorm(0.005) #P(Z < c) = 0.005
```

```
## [1] -2.575829
```

```
#qnorm(0.995) : P(Z < c) => find or qnorm(1-0.995, lower.tail = FALSE)
#qnorm(1-0.995) : P(-c < Z)
```

3. Generate a random sample of size  $n = 1000$  from a standard normal distribution. Use the **graphics** package to plot the histogram. Make sure your plot is well-labeled!

```
x <- rnorm(1000)
```

```
x
```

```
## [1] -0.7112681013 1.3128888769 0.1187601441 0.5220786413 0.2480776988
## [6] -1.6838613062 0.5148955719 -0.0141826348 -0.3755275025 -1.1690230008
## [11] -0.9195873229 0.1415013873 0.1564365531 -0.5169711840 0.7079328521
## [16] 1.4385909992 0.4942873416 0.9173607868 0.7976470439 0.1237027092
## [21] 0.2329312343 -0.2544493396 0.3445194441 1.4411930742 -0.3907440193
## [26] -1.3622591092 1.1971365553 0.2440503365 0.2362182817 -0.2894857838
## [31] -0.8371942597 -0.6380701295 0.8941102172 -0.3235251989 -0.9885174743
## [36] 0.4414736350 0.5004741850 -0.9416132992 -0.3374915373 -1.1205405688
## [41] 0.1626809497 -0.7001268132 0.4871257553 0.1791766257 0.3186090151
## [46] -0.6516599138 -0.4480738863 0.2629197200 -0.6810028398 0.2662942166
## [51] -1.9440249231 -0.1394835842 -0.9074719979 1.3223434378 0.1975150141
## [56] 0.4482380231 0.5655084306 0.0653357780 1.0408334650 -1.2173331431
## [61] -0.8563774336 -1.3259208558 1.3387050627 0.1870533329 1.2033743474
## [66] 1.3477156079 -0.8696636254 0.1035600992 1.1298534592 0.7166735371
## [71] -1.1948678503 0.0533304979 -0.6692764365 1.0077572127 -2.3099202029
## [76] 1.8401967081 1.4084867120 -0.2759859812 0.9263364247 -1.7229418782
## [81] 3.8562599473 0.1176707349 -1.8264187280 -0.5467689799 2.1386706893
## [86] 1.6280111994 -1.4574470342 -0.1688129530 0.0152140874 -0.3378301658
## [91] -0.4604185001 0.0886362618 0.3588846347 -0.2353387468 -1.1677252322
## [96] -0.6853322733 -1.3156133925 1.2304606409 0.5713119249 -0.9338506992
## [101] -0.6913976237 0.2598286592 0.2737641786 0.6115013426 -0.1448370168
## [106] 0.5010658853 -1.1918045521 1.1325928532 0.5134738857 -0.5525766901
## [111] -0.8678005765 1.5382753744 -1.9423107023 -1.4805596718 0.3021129699
## [116] 1.1708893527 -0.1720058134 0.3931646255 0.3985207250 1.0260230123
## [121] -0.2043812562 -0.6666741071 -1.4969602566 -1.6269419451 -0.5955485018
## [126] 1.3592944145 0.0446175815 1.3553196255 -1.5713553505 -0.0957873714
## [131] -0.7610377648 -0.4474577245 -0.1843201214 0.1643486090 0.2943056514
## [136] 0.2525929357 -0.6043528010 0.0806552774 -0.2630087217 0.7848296303
## [141] -0.3860263083 -2.1108356491 -0.3192781358 0.1564721997 -0.6553967491
## [146] 0.4955190433 0.9941070655 -0.3298330056 -0.0526311927 -0.4011977578
## [151] -1.5747690329 -0.5647098527 -0.5997477949 -0.4383690691 0.3903649992
## [156] -2.0444202845 0.0216566882 -0.5433507229 -0.3514985398 0.2062420573
## [161] 1.2354971329 -0.3553410330 0.9758657136 -0.8293969615 -1.0380656665
## [166] -1.0128566692 0.0200366437 1.2594467993 2.2824650884 0.0420574754
## [171] 1.3410817618 0.4641922254 0.2000107359 0.5476429498 1.6190581475
## [176] -0.7522202918 0.8744251704 0.6234014639 1.3583397387 -0.8466428185
```

```

## [181] 1.0618624221 1.3757880815 0.6021154507 0.8314406902 -0.4810997879
## [186] 1.0460034288 0.1068575526 -0.1974166018 -0.3622786249 -0.3811099308
## [191] 0.1081680086 0.5222206933 0.5033598589 0.3410182245 1.7755766545
## [196] 1.0481864575 0.5567161220 0.2754959199 -0.6770302528 0.5894520900
## [201] 0.2586158709 -0.9644739654 0.0036599043 -1.0560065299 -0.1134833255
## [206] -0.9429569460 0.2742244265 0.4693555881 -0.2589024042 0.2904118017
## [211] -0.3126515147 0.1159440172 0.3005914321 -0.0193268079 2.7920961941
## [216] 1.0010477111 -1.1252378019 0.3362612189 0.8328350434 -1.4671813688
## [221] 0.5516860299 1.1165797555 0.1204734783 -0.8390376953 -1.2165558542
## [226] -0.5931306631 0.6810996170 -0.5473255377 1.5289350942 0.5597303716
## [231] 0.5115387217 0.3760800850 1.0203014921 1.3454969210 0.6013493664
## [236] 0.5261487957 0.0068544474 0.8922522483 1.2042855019 0.6669084582
## [241] 2.4012558794 -0.1267480365 -1.1436155445 -1.0451514871 2.1364137360
## [246] 0.0853650184 -2.2313488795 1.8408407051 -0.1620910807 -0.1257210877
## [251] 0.1128767550 -0.5505192433 -1.2902176450 0.3880008420 -1.1236842233
## [256] 0.6511563649 1.6022717363 0.6231706741 -0.1616610463 -0.6916861706
## [261] 0.5957977949 0.6754126254 1.6077793052 0.6801660511 1.2986492290
## [266] -0.0749618083 -0.0767453511 -2.3226634988 0.1231148236 -1.1933539017
## [271] -0.0256619601 -0.5772687604 -2.1290721191 -0.5038351703 0.4171822687
## [276] -0.2388543601 0.5572958481 0.5344361321 0.5500234799 1.8150177945
## [281] 0.2497725232 0.1496914090 1.4765398617 -0.7503502251 -0.3012825891
## [286] -1.2345143909 -0.3414992144 0.3820808865 -0.5612693998 0.1451132462
## [291] 0.5076499263 0.1155956693 -0.2787930515 -1.2399259378 -0.0002676912
## [296] -0.9181016154 0.3049492434 0.7650073693 -0.9112404193 -0.2651397657
## [301] 0.5537125595 -0.6840899137 0.5615233467 -0.2587288605 0.4470686951
## [306] 1.0747600936 -0.2038366140 0.3579250959 -0.0977618597 0.5754598906
## [311] 0.4753093135 -0.1549898382 0.4658258277 0.8183774046 -1.4848691973
## [316] -1.3275396648 -0.3570690672 -0.6161922203 0.0240116173 -1.0499161296
## [321] 0.8463032903 -0.7221186558 -0.5218828125 0.2231299811 -0.7276375294
## [326] -0.5497303163 -0.2841582411 0.8727046772 -0.3962975483 -0.1911166089
## [331] 1.9819347125 -0.5656685099 1.5450499634 -0.8506050288 0.2064527711
## [336] -0.6817066374 0.7451669744 -0.1436832777 -1.8592355916 0.6560545325
## [341] -0.4273048494 -1.2250765990 0.2314979984 -0.4680609184 -0.7373419798
## [346] -0.2059868143 1.5063350023 0.0464883979 -0.1517164435 -1.8763630248
## [351] -1.7031708038 -0.3481826062 0.8312867905 -0.4066399928 -0.2360706891
## [356] -0.0835845256 1.9799605553 0.3364331474 -0.4401374160 1.9364880262
## [361] 1.0327967249 -1.1201102857 -1.1030088867 -0.6214502506 0.7135837062
## [366] 3.2929662810 0.2701644776 -1.0557420176 -1.2199481571 0.8122342878
## [371] -0.0903403170 -0.3371373437 0.5206567605 -0.2657358728 -0.7426843967
## [376] -0.5984585481 0.0386801294 -1.3628259455 0.4954800008 -0.1734381383
## [381] 0.2203475948 -0.8071216585 -1.4527051148 0.4087976231 0.5439810227
## [386] -0.5669031043 -0.0301328032 0.3787173153 0.3228818176 -0.3797636746
## [391] 0.7516638283 -0.4041841068 0.2582178720 0.5922186542 1.0667947502
## [396] 0.4853738597 -0.5936217280 -0.5860730162 1.3428936991 -0.6583477239
## [401] 0.7958366655 -0.1167822616 0.1182596343 2.2395706924 -0.5664870171
## [406] 1.6046226515 0.2135395772 1.8364390814 -0.1627976674 -0.2188827275
## [411] -0.4289991208 -0.1994058727 1.0358528726 -1.0195305444 1.0474713714
## [416] -0.6086258513 -1.6647377190 1.0418405334 0.9630085950 -1.0562595698
## [421] 1.2371588956 0.3971246791 -1.8247687670 0.5829165283 0.5804982921
## [426] -1.9204879362 0.6633708830 -0.8023547535 0.9838011649 2.1588271115
## [431] 0.9214004977 0.3112517128 -0.7062179276 0.8430897394 -0.3690751492
## [436] 0.3429474999 -2.3977652582 -1.5784586560 -0.3235985599 -0.4785285287
## [441] 1.0735734346 1.1127659997 -0.5651637827 -1.6402367259 -1.1254703919
## [446] -0.0395433398 0.5050246445 0.2681578424 -1.4951214589 0.3531185238

```

```

## [451] 0.9009289734 0.1312665795 -0.0250533007 -0.3192937081 -0.5522373942
## [456] 0.3139870028 1.9964760260 0.0594285527 0.2377250830 0.8887287250
## [461] 1.6246747093 0.4447826822 0.5306151088 -0.2196462680 -2.1173412923
## [466] -0.1483030089 -2.6048282514 0.1194879220 -1.3142428108 1.8170902860
## [471] -3.0830090807 1.2046532164 0.7815672059 -1.3389880472 -0.4656965986
## [476] -0.5778107407 1.0050350499 1.4886839719 0.3652202483 -0.5779984505
## [481] 1.4206696375 -0.9543645131 -0.1180263799 -0.5052832448 0.6934978542
## [486] -0.6162522616 1.0624636894 -0.4213768271 0.0019228275 -1.5486015236
## [491] 1.6730348158 -2.0951486686 1.5555976160 1.9086253027 -0.8369927405
## [496] 1.3375776797 1.0019415841 -2.2460066399 2.4415257166 -0.2522017873
## [501] 0.1809223405 0.2728991501 -1.9301286523 -1.5762173217 0.1460742921
## [506] 1.4515200393 -1.3056670011 0.4067164652 -0.5756382309 0.7026966707
## [511] -0.6044086952 0.6705506283 1.4614778696 -0.2448437418 -1.7786610593
## [516] -0.4010822034 -0.9674360583 0.5633008068 -1.3236691825 -0.6615054179
## [521] -0.8355629670 0.7156764802 -0.2383245961 -1.0663184085 -0.8960571908
## [526] 0.7703659436 0.7295221195 -0.8481827349 -0.5542610924 -2.3596246999
## [531] 0.6483120967 0.5210291841 0.0293393501 0.1104629919 -0.0395640148
## [536] 1.5139248459 -0.6061894474 -0.5782303619 -0.7050741667 -0.5927706410
## [541] -0.7778585431 0.9539366704 0.8391411476 1.1473706382 1.0870722279
## [546] 0.0921670577 0.2691599244 0.2963025543 0.7688102376 -0.0205477988
## [551] -0.8564398226 0.2474386283 -0.1792574638 -0.1673582819 2.5533053379
## [556] -0.5830111995 1.8416537725 -0.6006557006 -1.1534803445 -0.6304503903
## [561] -0.1328856028 -0.2537344975 0.8352755039 -0.7585907148 -1.4090388415
## [566] -0.2760585591 -0.4717357802 1.2423514206 -1.4083162556 0.6377964370
## [571] 0.1129359235 -1.1079631184 -0.5994302933 -0.0588782338 1.2306942643
## [576] 1.5991414672 1.6549669435 -0.3361763898 -1.0314245993 -1.7083817854
## [581] -1.1881354918 -0.6957426496 -1.1662490638 -0.7261131632 1.9462891508
## [586] -0.5097425414 1.6938742441 0.8671035781 0.4329557989 1.4436763747
## [591] 0.5255333342 1.3119946158 -0.5492166923 -0.4949386625 0.0744528902
## [596] -1.5131637817 1.1994026793 -0.0171504663 0.8905756468 -0.3181216464
## [601] 0.2082662426 0.3076724748 -0.8027496295 1.4738629922 -0.6138740800
## [606] 0.0435767497 -0.6691338737 -0.2369044767 0.8436555455 -0.5393719354
## [611] -0.9773290099 -1.1381322694 0.4415961308 -0.7324817803 -0.9873011969
## [616] 0.8472072614 1.9997756867 0.2302791301 -1.0731509301 -1.8321099865
## [621] 0.7861926774 -1.4563430612 -0.3150201235 -0.5821660061 0.1096695403
## [626] 0.5109461195 -0.5637125320 -0.4962218400 -1.5378541577 -1.0257328196
## [631] -0.0311658465 0.5015873919 -0.5774644455 -0.5896957581 -0.6498087239
## [636] 2.0525550239 -0.2238699709 0.8271573598 0.6696442969 0.9161227272
## [641] -0.6453135043 -1.1052013970 0.3884294678 -0.1865301627 0.2569461398
## [646] -1.2237668383 -0.4905938986 -0.4078948409 0.2621293194 0.5358953908
## [651] -0.2611167718 -0.6334828372 -0.0768439080 -1.6853845564 1.6344332617
## [656] 0.3161046721 -2.1701551004 -0.1313335173 0.6513668844 1.1906831455
## [661] -0.3958135130 -0.6610414681 -0.2126518644 -0.1007481109 -0.7687359626
## [666] -0.0162677996 -0.8143023648 0.4039505786 0.5165948329 -0.5930651551
## [671] -0.4879509367 0.5782351075 -2.1276414258 -0.5327654589 -0.3017865761
## [676] 0.2574154577 -0.1776156839 -0.4253911249 -2.4494369562 -0.3113462208
## [681] -0.9500318748 -1.3444632895 -1.0674660999 -0.9278430674 1.2084428051
## [686] -0.1481871194 -0.2599936546 -0.0156597540 1.7962496615 0.2145488942
## [691] 0.4595188554 1.4732698315 1.7348784556 -0.8669701036 -0.1904422032
## [696] 1.1316480043 -0.9316063728 1.5352062223 -0.0583889026 -0.1393886101
## [701] 0.6680988811 2.6641893610 2.5709366139 -1.3805538216 0.1055129195
## [706] 0.2266918824 0.1074608720 -0.7254807018 1.0989360078 0.9218351593
## [711] 1.1706922816 0.6186592424 -1.5708551453 0.5996650060 -0.0546720101
## [716] -0.1672806498 -0.1123589882 -1.4609221333 1.3924088007 0.6094732778

```

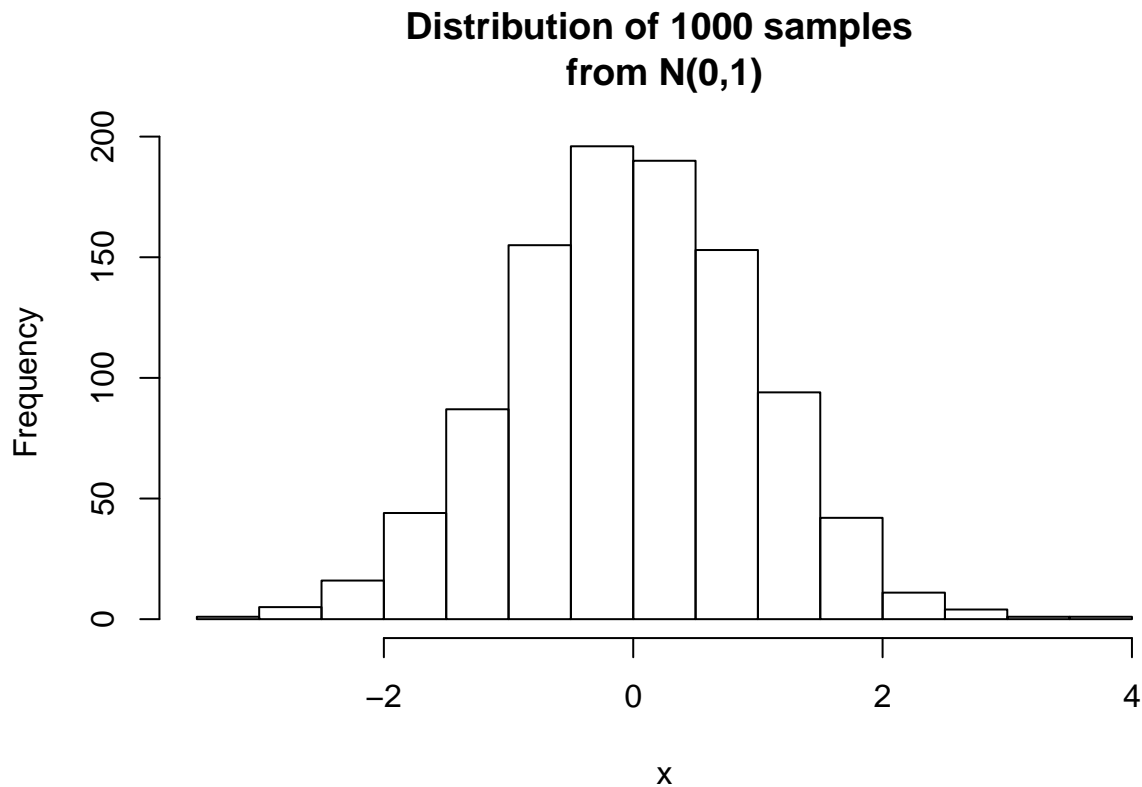
```

## [721] -1.3940693908 -1.6455079628 1.6322719425 -0.6398773150 0.2212472812
## [726] 0.5175168676 0.3166045027 1.0798485315 0.7410342379 -0.1992135632
## [731] 0.5268657756 -0.1243067380 1.4166191928 0.3488340417 -1.1527669462
## [736] -0.3744078721 -0.5918395765 -0.2842554141 1.1728372499 0.7064936417
## [741] -0.7346927020 -0.1073843858 -1.3692624042 -0.5251416810 -1.7564119846
## [746] 1.2491214135 -0.6838765890 0.4029426995 0.5668843112 -1.5594382709
## [751] 0.3597493924 0.8604002693 -0.5332497870 0.9201626043 0.2258602829
## [756] -0.8703586129 1.2320547005 0.1137347806 -0.3987433724 -1.1179181082
## [761] 0.4322600158 0.3237604582 0.0063925096 0.6589377645 0.3031142432
## [766] 1.2634755338 -0.5784670865 -0.3934763231 -0.1188778199 -2.6434550917
## [771] -1.7803250979 1.2017634050 -1.7912330450 1.0937122335 -0.2955426982
## [776] 0.6918364299 0.2675797859 0.1883049673 -0.5386888211 0.6699680366
## [781] 0.9170732261 -1.0870219477 -0.7458357261 -0.4177776801 -0.0977566723
## [786] -0.5115297377 -0.3955017540 0.7617615308 -0.1946597832 0.0053787462
## [791] -0.1932504400 -0.1435104983 1.1511806427 1.8644347629 -0.0839663337
## [796] -1.1158648053 -1.3853966847 -0.3711793255 0.8276637567 0.5140630411
## [801] 0.4866766926 -1.3491041626 -0.5920688035 0.5330299125 -2.1523971732
## [806] 0.1863530109 -1.6875643857 0.9539874016 -0.3442069809 1.7601999990
## [811] 0.6219079771 0.3122993725 0.5561955431 -0.5546022634 -0.3296440435
## [816] 0.1981014224 -2.7649047673 0.5218056494 2.1721030867 -1.9224174849
## [821] 1.0985408370 0.2815002718 0.9832176516 0.7518908783 -1.0104974369
## [826] 0.8174742291 1.3853858034 0.6978925176 0.5210062064 2.3671062290
## [831] 0.8269212515 1.1362809947 0.2541094139 -0.5792895374 -0.1831273019
## [836] -2.6097695942 -0.9829258638 -1.5667972457 -1.5672750785 -0.3435039918
## [841] -2.7945225655 -0.6355311593 0.3437572503 1.2363284461 2.2919438738
## [846] -1.0136114286 -1.1133763468 0.3078212127 0.1843344421 -0.0983168218
## [851] -0.5341248461 1.3381796677 -0.2788591192 0.0399225998 -0.6057371064
## [856] 0.1097475828 0.2132891050 -0.6011971105 -0.5617855662 0.9696974751
## [861] 0.1633992160 1.9892107277 -0.0958938519 0.7291535906 0.3190242505
## [866] 0.2477959456 -0.1999071787 -1.6757371708 -0.3300213518 1.2995619978
## [871] 0.5975999894 -0.0280214809 -0.3734580804 -0.9189215426 -0.1031894001
## [876] -0.5322934325 -0.4718108123 -0.3569240938 0.9086692767 -0.8350429482
## [881] 0.1275271033 0.5444455959 -1.0636439673 -0.1320586673 -0.1836384174
## [886] 0.4560853805 1.9983481333 -0.4068421604 1.1009672218 0.1597187200
## [891] 0.1363742174 0.4540708531 -0.6153298106 -1.5375771542 0.3716271149
## [896] 1.9337238690 0.2099260127 -0.6271554738 0.2242375891 1.4670059610
## [901] -1.1108786947 1.6136536989 -0.4069566578 -0.1986396381 1.1661370922
## [906] -0.1951057374 -0.2383057793 -0.3321704952 0.8548914946 1.0623444213
## [911] 0.2142002083 -0.2831046209 -0.0980190131 -0.4192637132 -0.2956468286
## [916] 0.6825114508 0.1141554548 -0.1537973750 1.0190621476 -0.6729359061
## [921] 0.4972271849 -1.4063516196 0.6511865882 -1.1736817774 0.4591838418
## [926] 1.2540988038 -0.9182768798 -1.4572575632 -0.1301871017 -0.0072080048
## [931] -1.9095534138 1.0404813541 0.3014288093 -0.4388584989 -1.4610711514
## [936] -1.3177516866 0.9540666399 -0.4391792639 -0.9687443117 -0.1843070409
## [941] -0.1219806362 0.8939280005 -1.7781889994 1.5937540812 -0.4401557381
## [946] 0.7006368149 -0.6903599545 0.1404983335 0.6550940537 -0.0235539196
## [951] -0.2002671133 0.5762962740 -1.4951987591 0.4719072864 0.1191625073
## [956] -1.2454066012 0.4246794094 0.5320974932 0.9058241063 1.2205804574
## [961] 1.3185977246 0.2850152345 -1.6390212055 -1.0941794479 0.8837095023
## [966] -1.0257063171 -1.2193028761 0.6431348676 -0.9574263896 0.0146260245
## [971] -0.3291136223 -0.3505173746 -2.4570502950 -1.8124725423 0.8472003247
## [976] -0.0107579382 1.0593135883 -0.4084787979 -1.2991352857 0.5183116260
## [981] 0.1635944148 0.6193632147 -1.6844291588 0.0473716196 0.0756306274
## [986] -0.4105060508 -1.3662533953 -0.9087788469 -0.4800186169 -0.8059303429

```

```
## [991]  0.0483890515 -0.9358612828  1.1569837131  0.3201894933  1.0810341698
## [996] -1.7837854267  0.6474053982 -1.1693227506 -1.5382180639  0.1756565307
```

```
hist(x,
     main = "Distribution of 1000 samples \nfrom N(0,1)",
     xlab = "x",
     ylab = "Frequency")
```



4. Compare your histogram to at least one other person's in the class. Are they the same or different? Why is this the case?
5. Use the **graphics** package to plot the pdf of a standard normal distribution.

```
x <- seq(-3.5, 3.5, 0.1)
x
```

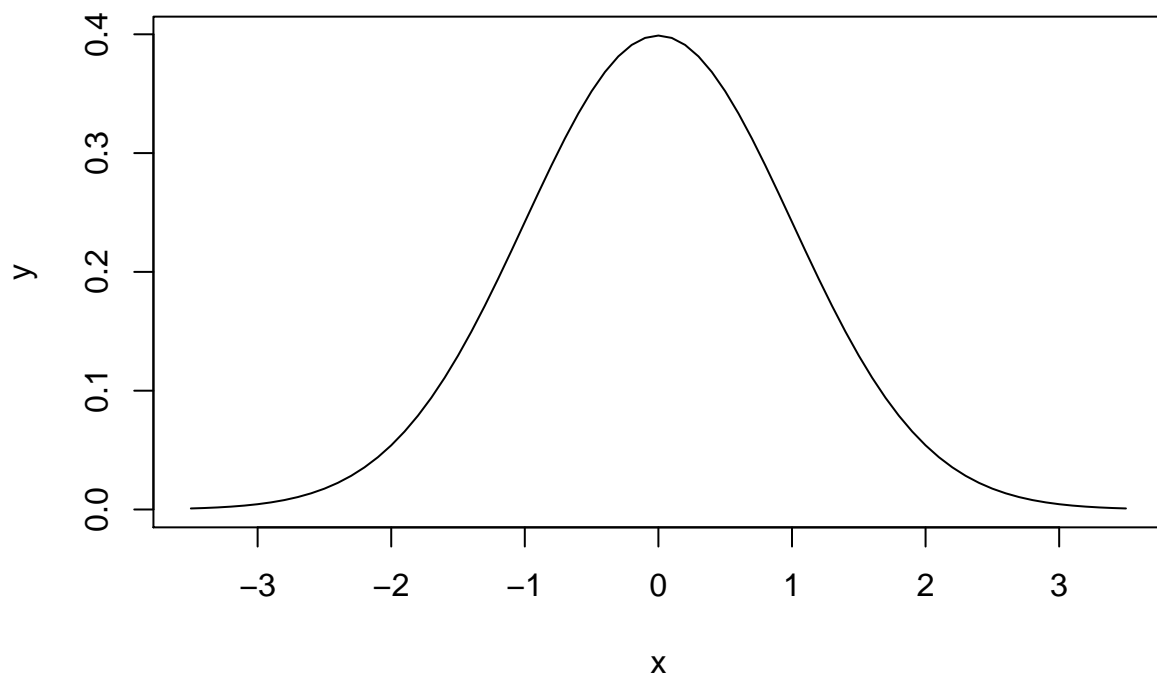
```
## [1] -3.5 -3.4 -3.3 -3.2 -3.1 -3.0 -2.9 -2.8 -2.7 -2.6 -2.5 -2.4 -2.3 -2.2 -2.1
## [16] -2.0 -1.9 -1.8 -1.7 -1.6 -1.5 -1.4 -1.3 -1.2 -1.1 -1.0 -0.9 -0.8 -0.7 -0.6
## [31] -0.5 -0.4 -0.3 -0.2 -0.1  0.0  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  0.9
## [46]  1.0  1.1  1.2  1.3  1.4  1.5  1.6  1.7  1.8  1.9  2.0  2.1  2.2  2.3  2.4
## [61]  2.5  2.6  2.7  2.8  2.9  3.0  3.1  3.2  3.3  3.4  3.5
```

```
y <- dnorm(x)
y
```

```
## [1] 0.0008726827 0.0012322192 0.0017225689 0.0023840882 0.0032668191
## [6] 0.0044318484 0.0059525324 0.0079154516 0.0104209348 0.0135829692
## [11] 0.0175283005 0.0223945303 0.0283270377 0.0354745928 0.0439835960
## [16] 0.0539909665 0.0656158148 0.0789501583 0.0940490774 0.1109208347
```

```
## [21] 0.1295175957 0.1497274656 0.1713685920 0.1941860550 0.2178521770
## [26] 0.2419707245 0.2660852499 0.2896915528 0.3122539334 0.3332246029
## [31] 0.3520653268 0.3682701403 0.3813878155 0.3910426940 0.3969525475
## [36] 0.3989422804 0.3969525475 0.3910426940 0.3813878155 0.3682701403
## [41] 0.3520653268 0.3332246029 0.3122539334 0.2896915528 0.2660852499
## [46] 0.2419707245 0.2178521770 0.1941860550 0.1713685920 0.1497274656
## [51] 0.1295175957 0.1109208347 0.0940490774 0.0789501583 0.0656158148
## [56] 0.0539909665 0.0439835960 0.0354745928 0.0283270377 0.0223945303
## [61] 0.0175283005 0.0135829692 0.0104209348 0.0079154516 0.0059525324
## [66] 0.0044318484 0.0032668191 0.0023840882 0.0017225689 0.0012322192
## [71] 0.0008726827
```

```
plot(x, y, type = "l")
```



6. Plot the following 3 distributions in a single figure.  $X \sim N(10, 3)$ ,  $X \sim N(10, 5)$ , and  $X \sim N(10, 7)$ .

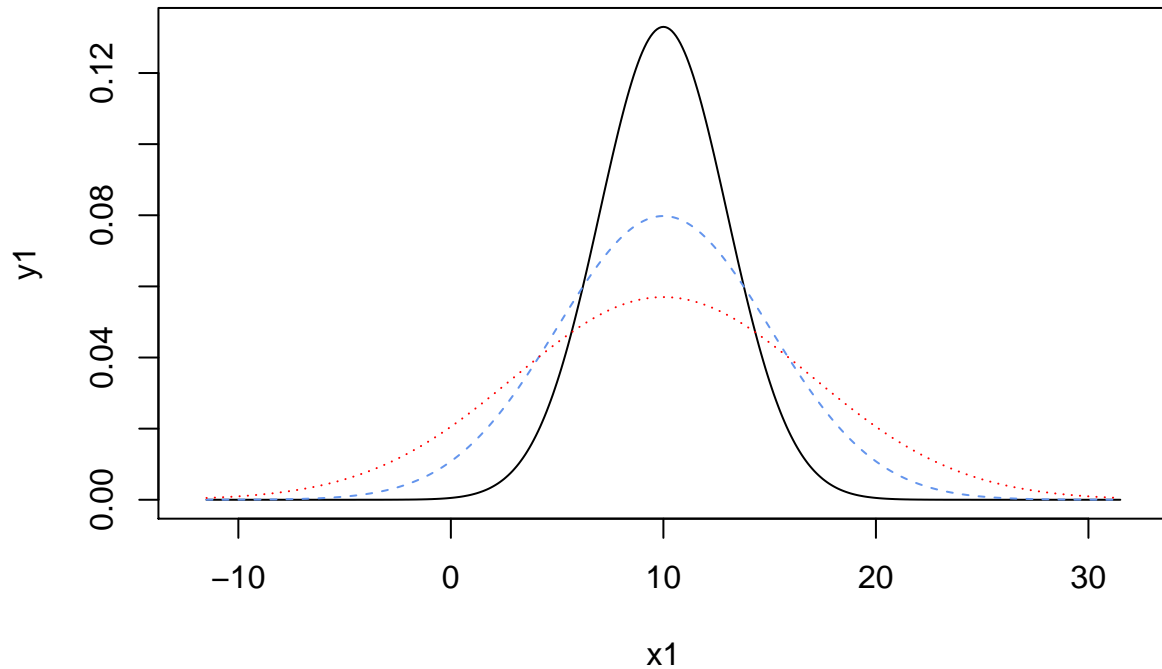
```
x1 <- seq(-11.5, 31.5, 0.1) # N(10, 3)
y1 <- dnorm(x1, mean = 10, sd = 3)

x2 <- seq(-11.5, 31.5, 0.1) #N(10, 5)
y2 <- dnorm(x2, mean = 10, sd = 5)

x3 <- seq(-11.5, 31.5, 0.1) #N(10, 7)
y3 <- dnorm(x3, mean = 10, sd = 7)

plot(x1, y1, type = "l", xlim = c(-12, 32))
lines(x2, y2, lty = 2, col = "cornflowerblue")
```

```
lines(x3, y3, lty = 3, col = "red")
```



7. The following questions refer to the `email` dataset from the `openintro` package.

a. Plot the distribution of the variable `num_char` using `ggplot2`.

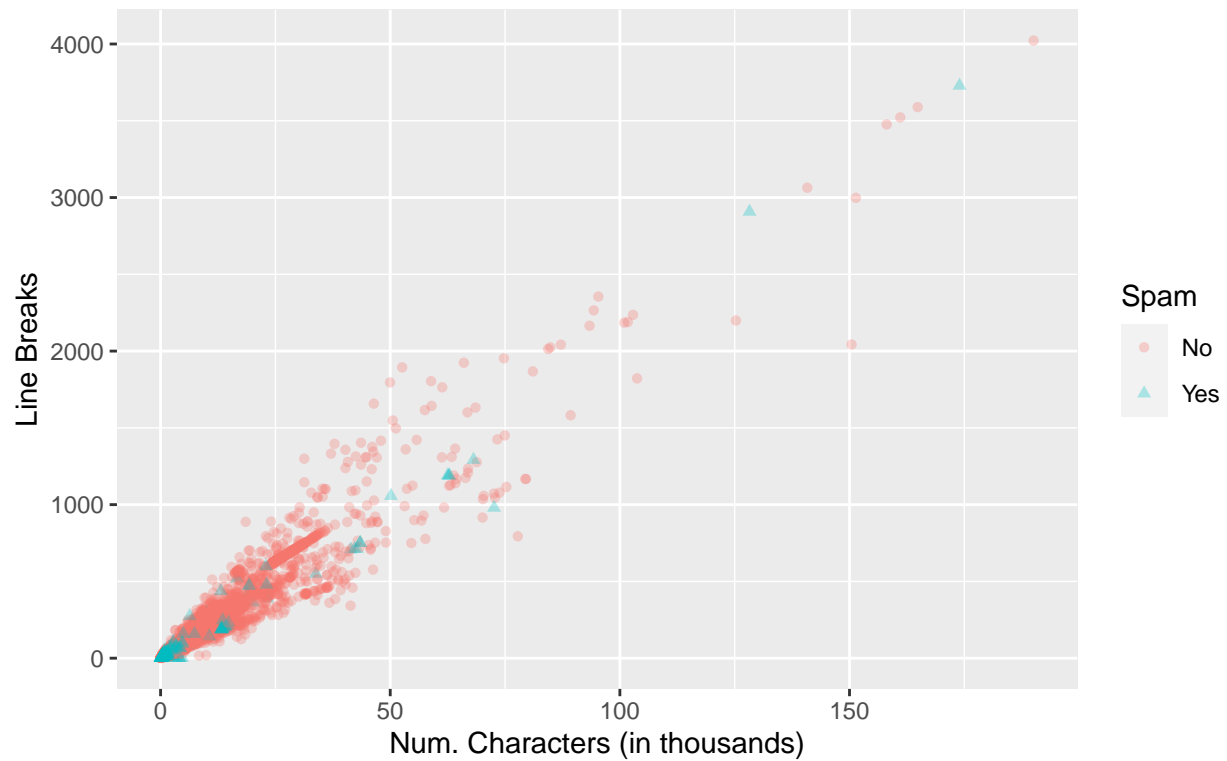
```
library(openintro)
library(ggplot2)
library(dplyr)

data("email")

email %>%
  mutate(spam = factor(spam, labels = c("No", "Yes"))) %>%
  ggplot(aes(x = num_char,
             y = line_breaks,
             col = spam, shape = spam)) +
  geom_point(alpha = 0.3) +
  labs(title = "Relationship between Num. of Characters\n & Line Breaks, by Spam Status",
       x = "Num. Characters (in thousands)",
       y = "Line Breaks",
       col = "Spam",
       shape = "Spam")
```



Relationship between Num. of Characters  
& Line Breaks, by Spam Status



b. Create a qq-plot to assess the normality of this variable.

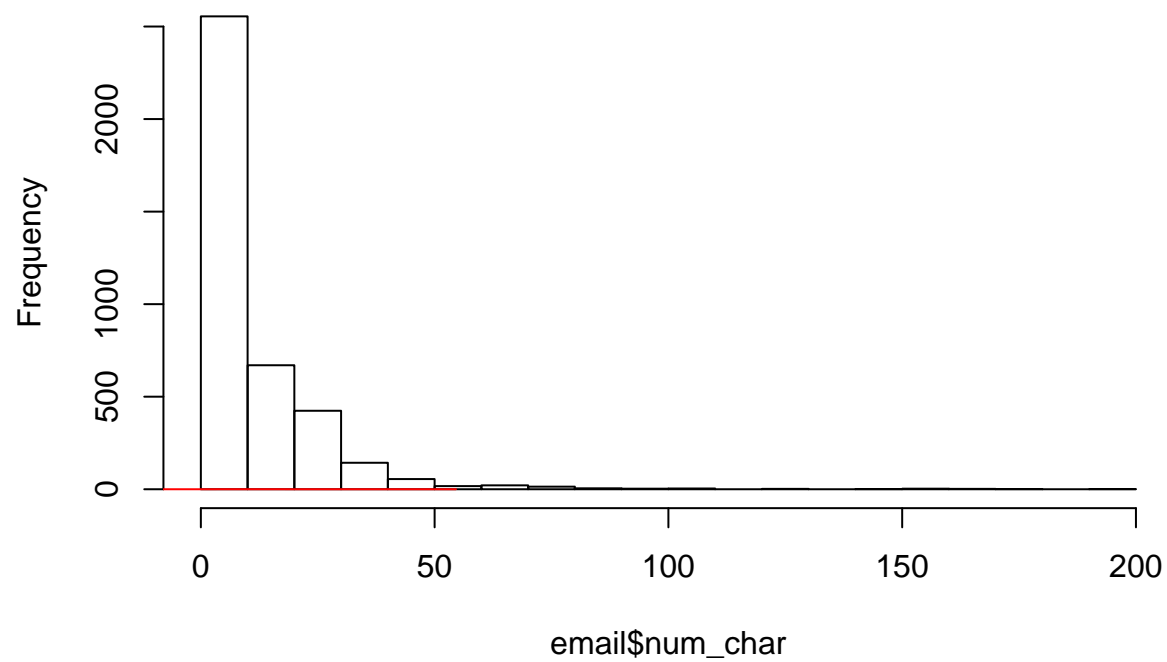
```
# hist(email$num_char, breaks = 15)

mn <- mean(email$num_char)
std_dev <- sd(email$num_char)

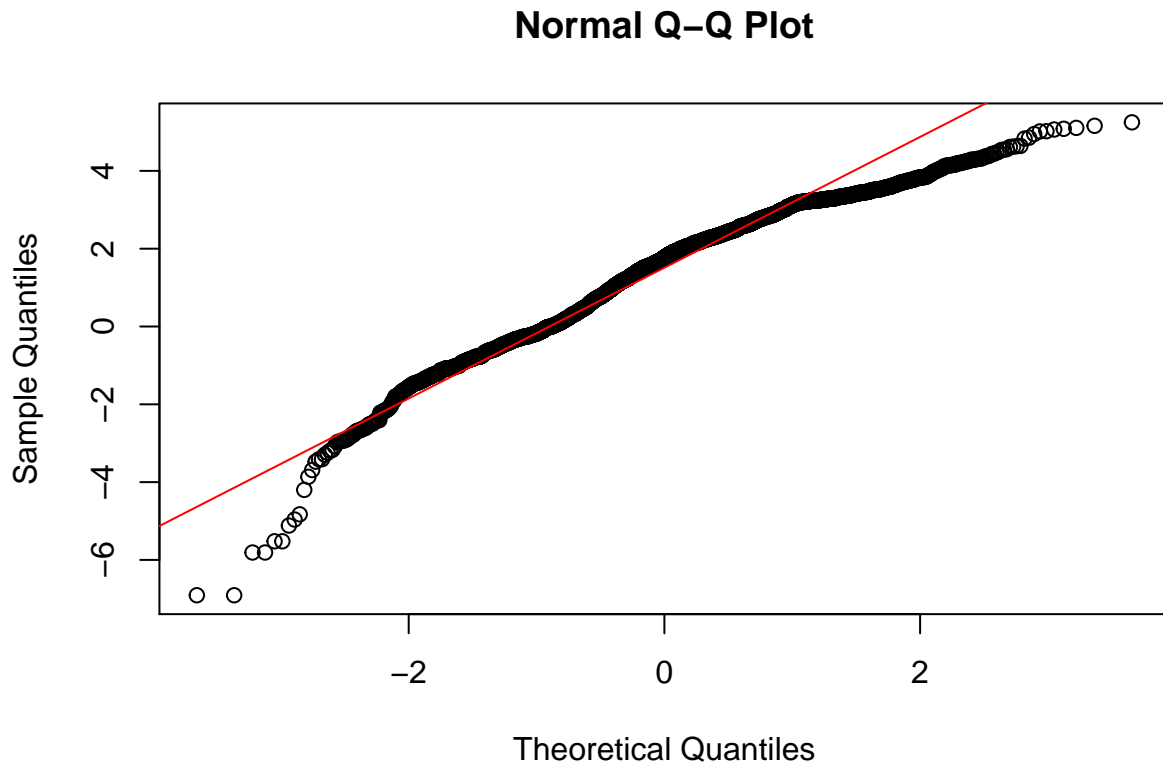
x <- seq(mn-3*std_dev, mn+3*std_dev, 0.1)
y <- dnorm(x, mean = mn, sd = std_dev)

hist(email$num_char, breaks = 15)
lines(x, y, col = "red")
```

**Histogram of email\$num\_char**



```
qqnorm(log(email$num_char))  
qqline(log(email$num_char), col = "red")
```



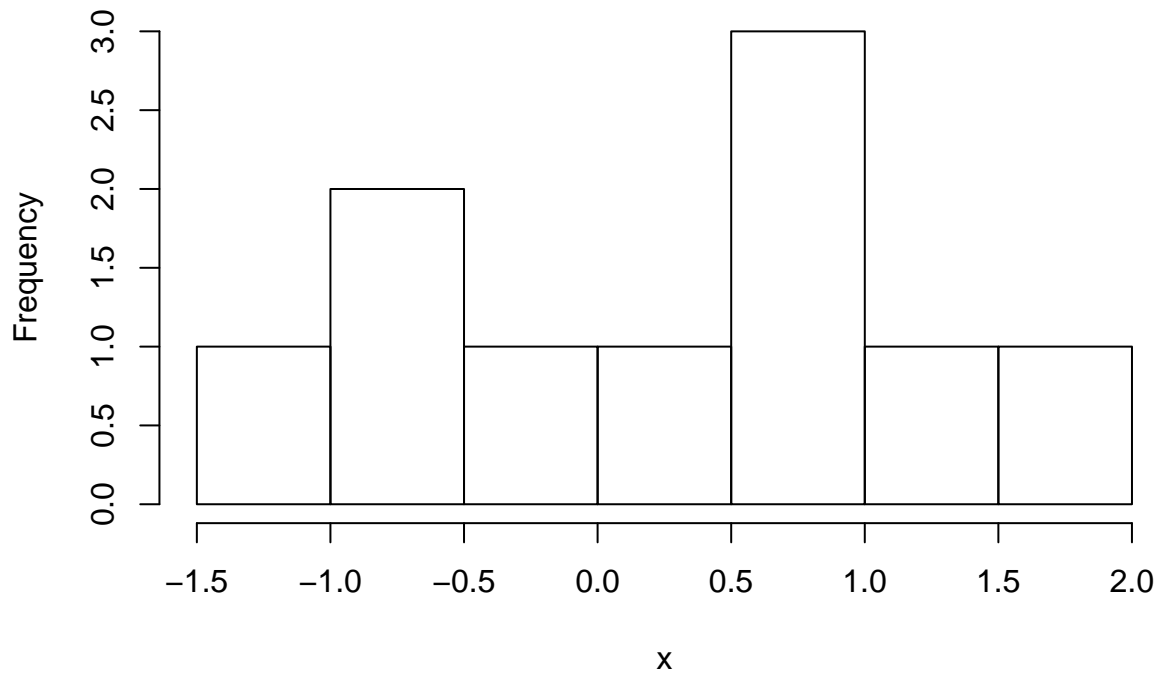
8. Simulations. Simulate three random samples from a standard normal random variables: one with a sample size  $n = 10$ ,  $n = 30$ , and  $n = 100$ . Assess the normality of each of the samples. What do you notice? Why do you think that is happening?

```
x_1 <- rnorm(10)
x_1
```

```
## [1] 0.5769760 -0.1153900 0.5726871 -0.5136320 1.2431356 0.3532944
## [7] -0.9432320 0.7431152 1.7896953 -1.3179163
```

```
hist(x_1,
     main = "Distribution of 10 samples \nfrom N(0,1)",
     xlab = "x",
     ylab = "Frequency")
```

### Distribution of 10 samples from $N(0,1)$

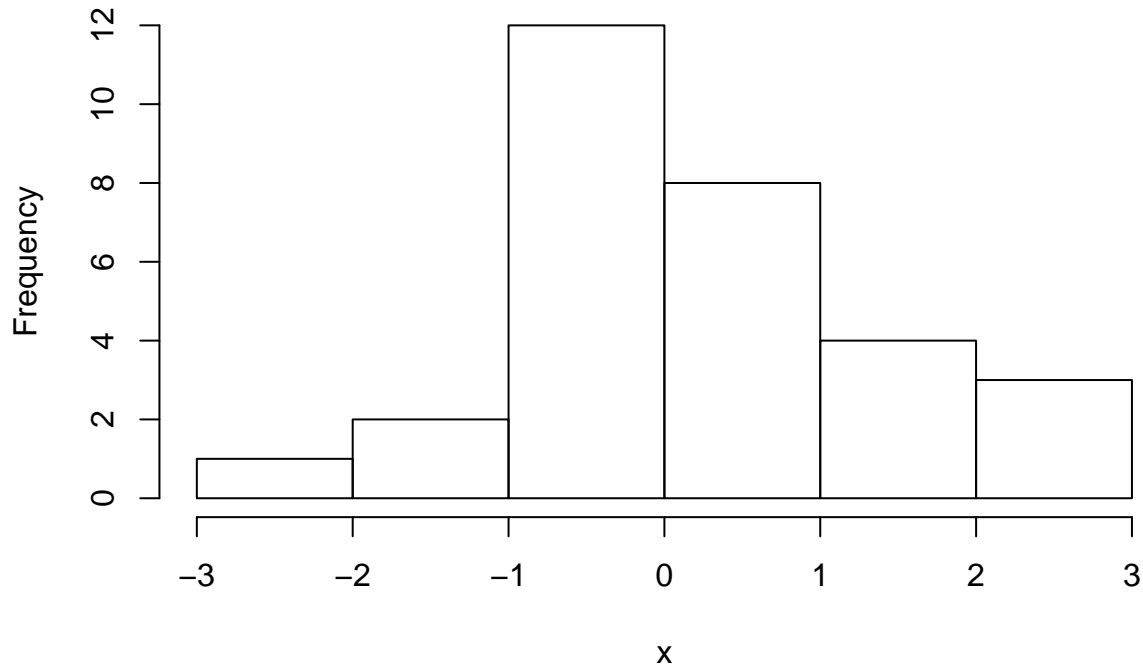


```
x_2 <- rnorm(30)
x_2
```

```
## [1]  0.11170674 -0.28193894  2.51602038  0.96608707 -0.08653151 -0.04066953
## [7]  1.97989286 -1.35195043 -0.02203115  0.50465188 -0.05964073  0.65324510
## [13] -0.44019077 -0.36790085 -0.40669470 -0.02809152  0.91460434  0.22934835
## [19] -0.46812966 -0.91904969  1.44076724 -1.43852456 -2.55752892 -0.30568862
## [25]  0.70929945  1.36312674  0.33709076  2.14675256  1.49570233  2.11299845
```

```
hist(x_2,
     main = "Distribution of 10 samples \nfrom N(0,1)",
     xlab = "x",
     ylab = "Frequency")
```

## Distribution of 10 samples from $N(0,1)$



```
x_3 <- rnorm(100)
x_3
```

```
## [1] 0.94261191 -1.32762198 -0.29491801 -0.55059678 0.29919234 -0.72711049
## [7] 1.08118516 1.28292971 -1.07877756 1.20488040 0.80728970 0.17080895
## [13] -0.91658502 0.25901324 -1.66213753 0.79880216 0.79642726 0.20624995
## [19] -1.28677462 -0.73680531 -0.77634841 -0.97920510 -1.88145291 -0.31360489
## [25] -1.39473595 1.07076933 0.43698724 0.30118908 -0.12467011 -0.78679883
## [31] -0.75910030 -0.00407946 -0.12059425 -0.12399811 1.64388678 0.23603393
## [37] 0.86584726 -2.28844190 0.86494485 0.92333363 0.45889091 -0.98503771
## [43] -0.16461004 -1.30967246 -0.72985136 -0.75409777 -0.71028456 -0.31950805
## [49] 0.78104989 0.13154358 -0.47928796 0.22008525 -0.48158709 -0.68864992
## [55] -0.03682450 -0.75017775 0.23034903 -1.66293576 -0.21671651 -0.42843497
## [61] -0.29720283 -1.71434521 -0.87231531 -0.53897532 0.78121963 0.49574925
## [67] -0.73455405 -0.34368644 0.57189271 0.25957814 0.23941842 0.78280956
## [73] -0.39821546 0.04693808 0.83055161 -1.30897992 0.27491234 -1.00883693
## [79] -0.60408747 0.82456083 -1.39532720 0.90369747 0.75833053 -0.56362477
## [85] 0.04218820 -2.04629799 -1.49277796 -1.37447646 -1.31344602 -1.18441681
## [91] 0.07460907 1.77326984 -0.75729304 -0.52689645 -0.76631324 -0.25402086
## [97] -0.20613757 0.40930738 -0.65197518 2.37541157
```

```
hist(x_3,
     main = "Distribution of 10 samples \nfrom N(0,1)",
     xlab = "x",
     ylab = "Frequency")
```

**Distribution of 10 samples  
from  $N(0,1)$**

