

# HW#4

*Kate Harline feat. T-Bone*

3/3/2019

## Problem 1

### A

When you reject or do not reject a null hypothesis this is only within the constraints of the  $\alpha$  you chose.  $\alpha$  determines the p value and those more extreme at which point you reject the null. It is still possible however, that the data from which you calculated a p-value and compared it to the chosen  $\alpha$  is still drawn from the null distribution by chance and you have therefore incorrectly rejected the null, or committed a type I error.

### B

We precisely set the type I error by choosing an  $\alpha$  at which point we reject the  $H_o$  and cannot reject  $H_o$  but we will never know the true parameter value which is what determines the calculation of the power  $1 - \beta$ .

## Problem 2

### A

The marginal probability distribution for each element follows  $N(\mu = 5.5, \sigma^2 = 0.5)$ . The correlation matrix is a symmetric matrix with each element the pairwise correlation between all  $X_i$ . Therefore, the off diagonal terms are given by:  $Corr(X_1, X_2) = \frac{Cov(X_1, X_2)}{\sqrt{Var(X_1)}\sqrt{Var(X_2)}}$  for i.i.d. samples  $Cov(X_1, X_2) = 0$  which gives 0. For the diagonal elements, this simplifies to  $Corr(X_1, X_1) = \frac{Var(X_1, X_1)}{\sqrt{Var(X_1)}\sqrt{Var(X_1)}}$  which simplifies to 1.

### B

No, the sampling distribution of the statistic need not follow the same distribution as the distribution of the sample from which it is calculated. The transformations involved in calculating the statistic govern the distribution that it follows.

### C

```
# modified from lab 5
sampling_function <- function(sample_size, number_of_samples, sample_mean, sample_var){

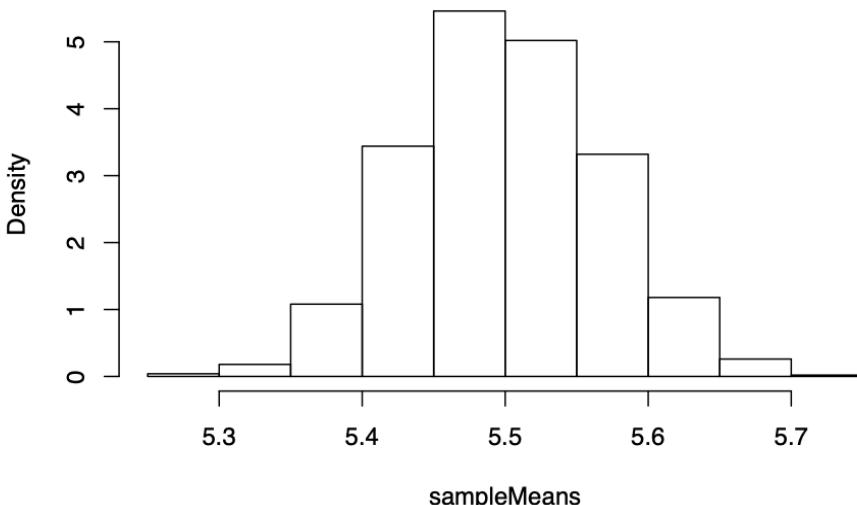
  sample_sd <- sqrt(sample_var)
  normSamples <- matrix(0,nrow=number_of_samples,ncol=sample_size)
  for(i in 1:number_of_samples){
    normSamples[i,] <- rnorm(sample_size, mean = sample_mean, sd = sample_sd)
  }
}
```

```

# param values to use in pnorm
sampleMeans <- apply(normSamples, 1, mean)
# basicR plot
hist(sampleMeans, probability = TRUE)
return(sampleMeans)
}
set.seed(777)
sampling_function(sample_size = 100,
                  number_of_samples = 1000, sample_mean = 5.5, sample_var = 0.5)

```

Histogram of sampleMeans



```

## [1] 5.493758 5.503440 5.592187 5.491742 5.482680 5.624777 5.385140
## [8] 5.551904 5.436128 5.452221 5.605131 5.598826 5.472207 5.557404
## [15] 5.502999 5.522980 5.430003 5.463000 5.469962 5.450467 5.501185
## [22] 5.458583 5.443781 5.461999 5.368469 5.355495 5.459634 5.507985
## [29] 5.470524 5.545891 5.516377 5.554598 5.662472 5.411228 5.587152
## [36] 5.477009 5.530121 5.636234 5.379359 5.563561 5.441881 5.549528
## [43] 5.499069 5.449753 5.544219 5.429686 5.558540 5.588111 5.424897
## [50] 5.543266 5.336677 5.469187 5.635712 5.528084 5.617755 5.495252
## [57] 5.498749 5.465624 5.523095 5.489067 5.558392 5.520219 5.464663
## [64] 5.618616 5.528144 5.514830 5.500342 5.439410 5.383428 5.454055
## [71] 5.481264 5.465118 5.392172 5.390107 5.403914 5.423193 5.412429
## [78] 5.470166 5.479879 5.452333 5.378831 5.438219 5.443954 5.493761
## [85] 5.549327 5.566069 5.499597 5.565852 5.470524 5.530600 5.448987
## [92] 5.597929 5.466373 5.647930 5.421994 5.483427 5.452263 5.483849
## [99] 5.597701 5.404949 5.493917 5.611532 5.388331 5.544316 5.375500
## [106] 5.514057 5.484813 5.547277 5.571157 5.441204 5.522529 5.443203
## [113] 5.424081 5.497960 5.594616 5.582780 5.591646 5.435932 5.539389
## [120] 5.400891 5.526895 5.484693 5.430513 5.460925 5.480590 5.586201
## [127] 5.374761 5.510692 5.558934 5.517769 5.427532 5.565107 5.502042

```

```

## [134] 5.546169 5.514045 5.491612 5.585028 5.475942 5.454801 5.588098
## [141] 5.526271 5.390089 5.575853 5.566761 5.539891 5.578069 5.604320
## [148] 5.440037 5.503940 5.547801 5.631598 5.456994 5.466420 5.522023
## [155] 5.508169 5.608514 5.483833 5.504710 5.570034 5.565557 5.456961
## [162] 5.355624 5.581971 5.501990 5.576141 5.530818 5.491201 5.443947
## [169] 5.410536 5.523214 5.469907 5.446814 5.547962 5.577128 5.512562
## [176] 5.478401 5.502275 5.504498 5.503004 5.497195 5.623986 5.564312
## [183] 5.451188 5.492721 5.416057 5.520754 5.479011 5.519505 5.411506
## [190] 5.536687 5.508265 5.421169 5.452961 5.550232 5.597266 5.374131
## [197] 5.429867 5.489691 5.530181 5.561510 5.412484 5.452487 5.453114
## [204] 5.561388 5.449904 5.527693 5.533900 5.449693 5.624079 5.647415
## [211] 5.595535 5.548222 5.392325 5.676571 5.572724 5.539157 5.530764
## [218] 5.524584 5.605064 5.465865 5.607437 5.469367 5.486359 5.522557
## [225] 5.402734 5.458410 5.495305 5.514603 5.449050 5.446152 5.507322
## [232] 5.438580 5.492656 5.518968 5.547725 5.496072 5.619380 5.416794
## [239] 5.556710 5.359282 5.535177 5.454526 5.354888 5.419138 5.617811
## [246] 5.474885 5.513193 5.670447 5.528301 5.435233 5.545970 5.521186
## [253] 5.533137 5.409401 5.410760 5.579514 5.475107 5.485329 5.544545
## [260] 5.539546 5.578046 5.579344 5.376789 5.471567 5.602327 5.516238
## [267] 5.431618 5.414004 5.524264 5.440286 5.440996 5.467439 5.587492
## [274] 5.362197 5.464533 5.642925 5.506252 5.438794 5.423062 5.501275
## [281] 5.458336 5.457034 5.496475 5.480039 5.478259 5.560624 5.482845
## [288] 5.471039 5.427132 5.562722 5.443183 5.451009 5.527160 5.435232
## [295] 5.598481 5.456558 5.536491 5.443681 5.455879 5.609700 5.433905
## [302] 5.417891 5.419616 5.475675 5.574842 5.506931 5.530829 5.465414
## [309] 5.539445 5.591101 5.478732 5.546940 5.563885 5.431338 5.648629
## [316] 5.531519 5.468853 5.425917 5.434014 5.501372 5.370899 5.522623
## [323] 5.495115 5.468657 5.402320 5.528805 5.489076 5.587717 5.608081
## [330] 5.551564 5.476850 5.471806 5.544678 5.568636 5.543421 5.578037
## [337] 5.627825 5.450325 5.387477 5.688577 5.528694 5.432376 5.537494
## [344] 5.568995 5.595153 5.291303 5.484307 5.520427 5.534326 5.499696
## [351] 5.503121 5.529739 5.514103 5.446732 5.503189 5.530493 5.571904
## [358] 5.553793 5.532866 5.524726 5.461593 5.694650 5.497090 5.438705
## [365] 5.541272 5.425879 5.473204 5.658561 5.554320 5.388952 5.586937
## [372] 5.580896 5.484505 5.545112 5.428101 5.585517 5.428741 5.505859
## [379] 5.557396 5.398266 5.465162 5.351411 5.494100 5.533303 5.311634
## [386] 5.397563 5.430016 5.441641 5.429260 5.470264 5.400065 5.564167
## [393] 5.490349 5.401474 5.602880 5.598032 5.477744 5.370786 5.462685
## [400] 5.476686 5.392497 5.483517 5.414889 5.482593 5.529000 5.493271
## [407] 5.325903 5.506372 5.514844 5.558212 5.455391 5.497283 5.484910
## [414] 5.485570 5.481493 5.468048 5.439019 5.501306 5.448357 5.463620
## [421] 5.461753 5.626898 5.405094 5.573215 5.430460 5.474297 5.650212
## [428] 5.486223 5.491019 5.556382 5.522691 5.435102 5.327609 5.525498
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## [442] 5.384548 5.505390 5.490425 5.575331 5.472375 5.436481 5.420437
## [449] 5.660221 5.469206 5.518024 5.465516 5.426132 5.541565 5.408362
## [456] 5.482220 5.595138 5.578601 5.572828 5.493462 5.567437 5.497019
## [463] 5.442467 5.541032 5.410456 5.544627 5.532873 5.545159 5.473454
## [470] 5.460399 5.403828 5.535323 5.615456 5.363374 5.455180 5.449043
## [477] 5.542339 5.527838 5.478774 5.369138 5.524823 5.525017 5.440655
## [484] 5.530483 5.535008 5.396820 5.505965 5.470383 5.552590 5.492002
## [491] 5.387490 5.419652 5.518367 5.536521 5.561389 5.536772 5.595280
## [498] 5.438623 5.503725 5.528900 5.443837 5.449252 5.584608 5.547204
## [505] 5.451298 5.562925 5.567645 5.548349 5.438491 5.461409 5.546547

```

```

## [512] 5.411553 5.466531 5.413031 5.466901 5.596721 5.532777 5.547086
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## [526] 5.668924 5.607833 5.492000 5.626344 5.549022 5.474031 5.488530
## [533] 5.408344 5.497598 5.356931 5.378359 5.513075 5.554255 5.465953
## [540] 5.554518 5.551457 5.520889 5.556889 5.437256 5.468833 5.477148
## [547] 5.468098 5.546174 5.584364 5.313829 5.574966 5.521618 5.571263
## [554] 5.464872 5.506450 5.438328 5.423879 5.495492 5.483609 5.568648
## [561] 5.494509 5.537652 5.513548 5.499948 5.531693 5.441390 5.508752
## [568] 5.579782 5.535356 5.568484 5.496200 5.464139 5.502403 5.360285
## [575] 5.444685 5.595897 5.539588 5.743048 5.507524 5.563750 5.490852
## [582] 5.463785 5.364682 5.527717 5.574231 5.460577 5.475333 5.506033
## [589] 5.465413 5.599744 5.530007 5.485461 5.534728 5.480273 5.470103
## [596] 5.471972 5.431512 5.456903 5.459359 5.522709 5.472111 5.431811
## [603] 5.593383 5.511469 5.481437 5.522145 5.490096 5.524579 5.456642
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## [638] 5.506705 5.585362 5.461771 5.488079 5.515365 5.426433 5.456363
## [645] 5.486756 5.634184 5.423647 5.584455 5.481358 5.509365 5.431269
## [652] 5.477915 5.579457 5.541985 5.416829 5.564804 5.483917 5.456520
## [659] 5.502862 5.339914 5.516883 5.480805 5.397961 5.571835 5.571744
## [666] 5.427178 5.509366 5.421557 5.615654 5.607155 5.649687 5.597271
## [673] 5.476711 5.519451 5.600546 5.429776 5.443517 5.495188 5.534209
## [680] 5.464816 5.496177 5.475891 5.491592 5.526018 5.533829 5.401029
## [687] 5.526703 5.539499 5.626193 5.571175 5.487464 5.476166 5.527944
## [694] 5.507000 5.435417 5.443691 5.380915 5.412567 5.635577 5.670583
## [701] 5.553686 5.456742 5.564491 5.622136 5.621726 5.463496 5.526884
## [708] 5.595107 5.492302 5.446590 5.478775 5.683328 5.580321 5.445497
## [715] 5.402440 5.479587 5.602162 5.554709 5.347992 5.527990 5.496393
## [722] 5.506327 5.447075 5.491820 5.488789 5.610359 5.569042 5.488532
## [729] 5.517840 5.533161 5.572387 5.470887 5.358929 5.642963 5.465288
## [736] 5.587714 5.515921 5.512750 5.571867 5.390671 5.476409 5.514069
## [743] 5.504306 5.637988 5.530805 5.486067 5.459447 5.443412 5.566137
## [750] 5.506338 5.508221 5.496339 5.540606 5.416372 5.574018 5.627658
## [757] 5.517356 5.541223 5.521320 5.524182 5.558058 5.551355 5.488014
## [764] 5.450861 5.573622 5.558198 5.570639 5.514854 5.506079 5.356144
## [771] 5.605135 5.471001 5.556438 5.431093 5.516213 5.647777 5.512707
## [778] 5.526614 5.407786 5.494458 5.505813 5.473026 5.581437 5.397146
## [785] 5.557697 5.540451 5.543748 5.538850 5.443122 5.544864 5.575921
## [792] 5.488081 5.448989 5.514124 5.419948 5.444652 5.472622 5.480208
## [799] 5.592602 5.444150 5.464675 5.531702 5.551988 5.604408 5.459179
## [806] 5.426367 5.437504 5.482557 5.525113 5.582695 5.505952 5.514371
## [813] 5.614706 5.563922 5.562164 5.376493 5.461451 5.596918 5.484465
## [820] 5.468502 5.427803 5.601869 5.658020 5.433540 5.485550 5.567430
## [827] 5.438856 5.604577 5.448481 5.539315 5.464816 5.557475 5.558528
## [834] 5.646739 5.587542 5.473773 5.576000 5.505576 5.417729 5.530338
## [841] 5.417508 5.467732 5.346129 5.297166 5.514857 5.419336 5.414536
## [848] 5.355416 5.529877 5.564743 5.525018 5.387805 5.460069 5.517651
## [855] 5.463440 5.465489 5.411386 5.426163 5.522772 5.499497 5.503336
## [862] 5.495253 5.531918 5.587364 5.456523 5.571732 5.555388 5.594625
## [869] 5.363857 5.552069 5.576171 5.425968 5.497360 5.528495 5.536964
## [876] 5.517376 5.433319 5.448700 5.410814 5.430049 5.546012 5.415863
## [883] 5.481820 5.417075 5.450125 5.602220 5.486479 5.424959 5.506243

```

```

## [890] 5.431585 5.497361 5.452048 5.518734 5.523112 5.488021 5.521600
## [897] 5.484835 5.498826 5.494368 5.488951 5.552593 5.423702 5.496136
## [904] 5.547898 5.563181 5.496920 5.617624 5.469628 5.464355 5.443641
## [911] 5.324322 5.427574 5.436849 5.536829 5.559847 5.482104 5.452116
## [918] 5.440815 5.549046 5.422506 5.476685 5.466371 5.514547 5.563288
## [925] 5.454696 5.429578 5.409214 5.489698 5.510280 5.508914 5.553441
## [932] 5.481862 5.575362 5.416000 5.416602 5.551696 5.484911 5.383288
## [939] 5.408941 5.543733 5.535048 5.514464 5.560468 5.441424 5.450353
## [946] 5.465637 5.591860 5.486015 5.494842 5.596342 5.425815 5.461880
## [953] 5.443888 5.452211 5.471992 5.593609 5.477722 5.525613 5.559172
## [960] 5.454994 5.504141 5.504118 5.558003 5.572039 5.476395 5.456215
## [967] 5.509202 5.545689 5.524090 5.548394 5.584637 5.434320 5.358562
## [974] 5.536777 5.548756 5.427705 5.524305 5.433065 5.592381 5.393729
## [981] 5.400748 5.439612 5.498529 5.552392 5.453798 5.520459 5.577367
## [988] 5.438029 5.457552 5.548854 5.445876 5.517144 5.543721 5.555794
## [995] 5.622496 5.564020 5.574548 5.487676 5.540584 5.385033

```

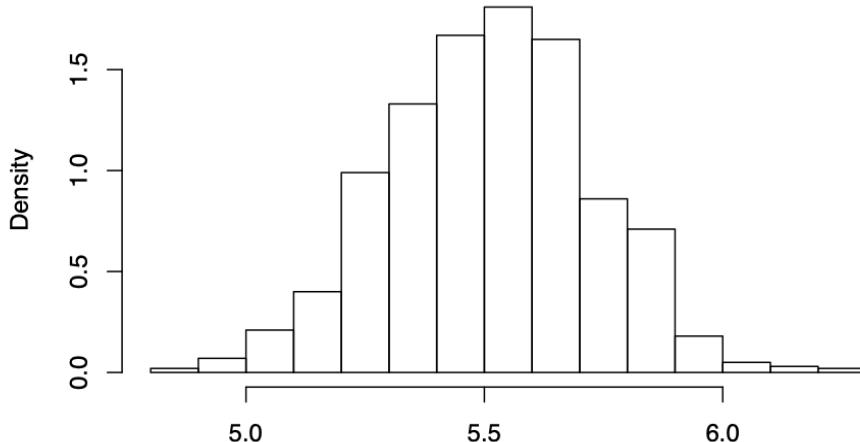
D

```

sampling_function(sample_size = 10,
                  number_of_samples = 1000, sample_mean = 5.5, sample_var = 0.5)

```

**Histogram of sampleMeans**



**sampleMeans**

```

## [1] 5.634672 5.574512 5.635998 5.311683 5.460070 5.448140 5.307149
## [8] 4.970521 5.321975 5.599024 5.316614 5.522675 5.219141 5.478135
## [15] 5.199107 5.135241 5.526367 5.131649 5.100679 5.630437 5.360818
## [22] 5.413817 5.521855 5.500917 5.860568 5.497352 5.376715 5.738369
## [29] 4.882397 5.398628 5.991125 5.272140 5.694249 5.658341 5.424253
## [36] 5.371369 5.790358 5.820030 5.535208 5.951962 5.595224 5.492424

```

```

## [43] 5.055117 5.274272 5.310925 5.322220 5.626175 5.390428 5.221443
## [50] 5.490652 5.404302 5.420288 5.601304 5.755195 5.603898 5.630817
## [57] 5.327776 5.691578 5.490595 5.462842 5.331066 5.202387 5.550545
## [64] 5.649438 5.911749 5.310963 5.464787 5.334143 5.565166 5.511112
## [71] 5.591125 5.892002 5.544122 5.644918 5.464477 5.688342 5.448758
## [78] 4.958171 5.264280 5.422152 5.267024 5.797749 5.355967 5.765398
## [85] 5.661648 5.361449 5.368770 5.338576 6.096401 5.723131 5.813775
## [92] 5.686443 5.450838 5.441307 5.217130 5.666018 5.547996 6.037770
## [99] 5.630766 5.491430 5.399841 5.582341 5.624631 5.275057 5.543649
## [106] 5.562025 5.776332 5.837819 5.317583 5.322145 5.442224 5.332461
## [113] 5.444558 5.516327 5.412393 5.712917 5.581194 5.766580 5.495147
## [120] 5.440390 5.613662 5.662283 5.641688 5.507645 5.578622 5.018447
## [127] 5.474959 5.598154 5.761268 5.556460 5.228168 5.667349 5.640686
## [134] 5.794686 5.856586 5.517793 5.260682 5.323263 5.599899 5.481372
## [141] 5.641171 5.712118 5.166773 5.792021 5.689756 5.289323 5.316084
## [148] 5.432153 5.488935 5.014069 5.009051 5.284804 5.533039 5.490718
## [155] 5.335735 5.097633 5.232673 5.705963 5.402588 5.815316 5.485346
## [162] 5.651123 5.578459 5.157950 5.550474 5.767452 5.565060 5.572655
## [169] 5.593275 5.711820 5.536663 5.364822 5.227303 5.705860 5.241949
## [176] 5.891066 5.362773 5.954212 5.538798 5.477974 5.571832 5.438795
## [183] 5.514215 5.652866 5.658024 5.309567 5.691567 5.294317 5.531346
## [190] 5.337866 5.475978 5.220299 5.766666 5.486602 5.355222 6.013226
## [197] 5.709680 5.817401 5.554292 5.277015 5.326946 5.604301 5.612616
## [204] 5.574272 5.505480 5.232511 5.644004 4.994567 5.401342 5.651153
## [211] 5.577435 5.672141 5.595437 5.562024 5.453654 5.544212 5.274696
## [218] 5.499219 5.031672 5.097688 5.745330 5.356096 5.682342 5.684284
## [225] 5.704569 5.155068 5.413651 5.691576 5.794705 5.328026 5.225598
## [232] 5.628932 5.352738 5.103176 5.366643 5.721208 5.632777 5.791874
## [239] 5.664098 5.716041 5.751742 5.545167 5.456458 5.694874 5.514413
## [246] 5.551541 5.529487 5.656049 5.486506 5.264629 5.823469 5.559466
## [253] 5.202431 5.613524 5.539036 5.760338 5.009980 5.404351 5.363166
## [260] 5.698754 5.763490 5.452752 5.144944 5.811121 5.156739 5.454059
## [267] 5.261259 5.803694 5.491946 5.233687 5.752270 5.679402 5.445212
## [274] 5.273988 5.479353 5.587916 5.434779 5.582685 5.596008 5.487983
## [281] 5.709756 5.351902 5.630409 5.544563 5.471674 5.514028 5.472994
## [288] 5.400631 5.575236 5.828122 5.321877 5.455458 5.561072 5.702445
## [295] 5.866227 4.960703 5.669442 5.700186 5.628123 5.386215 5.715029
## [302] 5.556683 5.621092 6.185899 5.278694 5.478166 5.574080 5.943508
## [309] 5.534135 5.725453 5.447751 5.801646 5.479165 5.718859 5.062814
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## [778] 5.235494 5.687366 5.685449 5.659525 5.641915 5.452804 5.827118
## [785] 5.154894 5.643880 5.122228 5.562768 5.444141 5.368646 5.681729
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## [974] 5.761689 5.646203 5.526361 5.309483 5.831257 5.860448 5.800263
## [981] 5.527419 5.269021 5.419174 5.617357 5.762168 5.566798 5.531707
## [988] 5.329553 4.943225 5.559436 5.839464 5.835725 5.650569 5.392732
## [995] 5.400874 5.560090 5.900860 5.586396 5.913594 5.541800

```

## E

The sampling distribution of the mean follows  $N(\mu = 5, \sigma^2 = \frac{0.5}{n})$

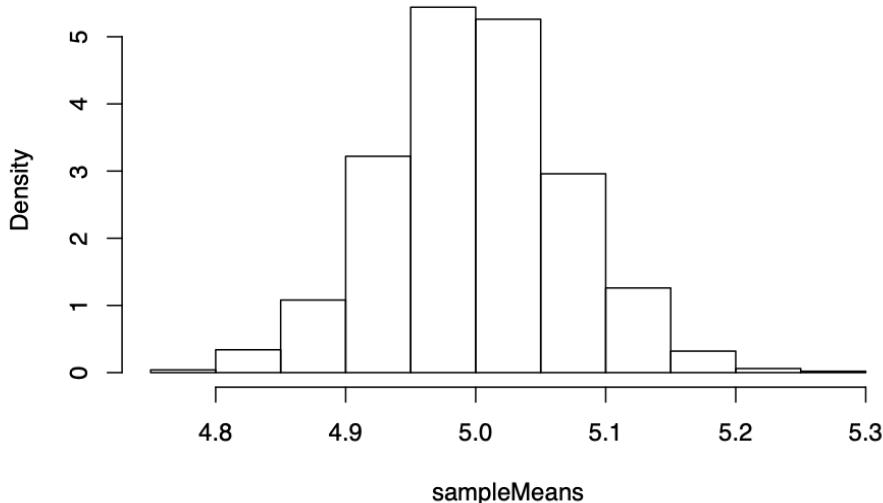
## F

```

sampling_function(sample_size = 100,
                  number_of_samples = 1000, sample_mean = 5, sample_var = 0.5)

```

**Histogram of sampleMeans**



```
## [1] 4.949542 5.089144 4.888399 5.043278 4.998876 4.895484 4.929746
## [8] 5.026103 4.965665 4.918847 4.991953 4.969618 5.058599 4.981387
## [15] 5.002987 5.040910 5.148858 5.049732 5.009871 5.101884 5.055468
## [22] 4.974888 5.086108 4.983794 4.991322 4.943922 5.010504 4.947226
## [29] 5.026952 5.101124 5.072114 5.025685 5.138321 5.028020 4.918073
## [36] 5.004328 4.996883 5.080124 4.897363 4.986103 5.014920 5.061392
## [43] 4.977770 5.043266 4.908025 4.974977 4.991425 5.022158 5.034615
## [50] 4.978541 5.033635 5.049414 5.057741 4.993496 5.019453 4.884876
## [57] 4.977187 5.113005 5.039051 4.919589 4.974323 4.954598 5.009279
## [64] 5.004760 4.926924 4.997517 5.061921 4.990986 5.076593 5.057158
## [71] 4.830159 5.049194 5.169813 5.017141 5.037537 5.034841 4.891833
## [78] 5.057413 4.838962 5.073700 5.063327 5.048385 5.067379 5.024463
## [85] 4.912709 4.998918 5.017883 4.962696 4.971080 4.843641 4.844163
## [92] 4.988536 4.955083 4.989388 4.968088 5.094014 4.985704 4.965092
## [99] 5.038872 5.021522 4.921046 5.065322 4.941350 4.944221 4.948467
## [106] 4.923464 4.971781 4.864611 5.070829 4.928791 4.917702 5.035574
## [113] 4.924437 4.994889 5.019270 4.903941 5.074543 5.022022 4.925486
## [120] 5.015219 4.883611 5.042457 5.130468 4.935162 4.959615 4.934745
## [127] 4.935044 4.901003 4.988761 4.991417 5.023628 4.982646 4.986917
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## [141] 5.021125 5.132102 4.882744 5.021687 5.000102 5.062606 4.985662
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## [155] 4.886936 4.850146 4.820553 5.046084 4.935594 4.951042 4.967346
## [162] 4.954769 4.932031 5.268336 4.954532 5.000971 4.907354 4.922689
## [169] 5.027852 4.934835 5.026234 5.018495 4.982788 5.092939 5.008973
## [176] 4.932284 4.952095 5.055929 5.100234 4.955066 4.990990 4.976239
## [183] 4.989804 4.901934 5.042125 5.029392 4.943615 4.962300 4.969724
## [190] 4.989025 5.122247 5.031018 5.072598 5.174071 4.941147 5.036948
## [197] 4.971381 5.077163 5.026992 4.847456 4.991671 4.937835 5.045310
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## [204] 4.997648 4.835494 4.798367 4.930365 5.007224 5.007895 4.908696
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## [225] 4.992347 4.970444 4.954086 4.988164 4.978746 5.119737 5.141205
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## [358] 4.960764 5.225843 4.953686 5.055837 5.094312 5.101959 5.031544
## [365] 4.995480 4.923387 5.139656 4.880639 5.129117 4.942854 5.014167
## [372] 5.060131 4.972615 4.848312 4.983410 4.994770 4.961984 5.002057
## [379] 4.989771 5.018506 5.167352 5.032918 4.990101 5.091636 4.818989
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## [743] 5.140104 5.099371 5.066757 4.952229 4.979748 4.915129 4.956173
## [750] 5.075877 4.989531 5.020791 4.991537 5.003333 4.905043 4.994838
## [757] 5.020234 4.991506 5.038133 4.996506 4.971429 4.962126 5.178789
## [764] 5.156984 5.023485 5.142177 5.039170 4.876987 5.013611 5.008913
## [771] 5.003148 5.045077 5.036486 5.022614 4.965971 4.939788 4.908228
## [778] 4.965927 5.008620 5.142264 4.923406 4.829149 4.944398 5.019519
## [785] 4.949033 5.013386 4.984057 4.994806 4.995572 5.009674 4.928588
## [792] 4.804259 5.092802 5.120925 5.038863 4.865652 5.055363 4.966406
## [799] 4.991007 4.966820 4.946245 5.010038 5.082117 5.031267 5.097922
## [806] 5.057775 4.970936 5.032664 4.944730 5.050956 5.034375 5.135730
## [813] 4.886244 4.994111 5.041894 4.954312 5.043310 5.127549 5.118936
## [820] 5.032723 5.005669 4.948573 5.056770 5.135859 4.950795 4.894327
## [827] 4.944808 5.053644 5.097605 4.928385 4.955202 5.031535 4.992539
## [834] 4.912160 4.969035 4.984769 5.154706 4.915621 4.946784 4.939708
## [841] 4.950102 4.973845 5.021871 4.972743 4.957404 5.036600 5.062876
## [848] 5.029780 5.004447 5.054821 4.921675 5.041037 5.040336 5.095403
## [855] 5.015072 4.900168 5.024386 5.052146 4.753917 5.084875 5.003696
## [862] 5.059067 4.995019 5.129148 5.118168 5.104902 4.975043 4.970488
## [869] 4.985864 4.988271 5.052164 4.970541 4.980181 5.084759 5.070431
## [876] 5.102168 5.006600 5.066637 5.001655 4.992161 4.935050 5.051155
## [883] 4.997113 5.018876 5.029819 4.992681 4.982919 4.987531 5.022457
## [890] 5.052378 4.989024 5.070002 4.930385 4.988631 5.004831 5.129130
## [897] 5.089816 5.021970 4.902529 5.057396 5.050886 4.970832 5.047631
## [904] 5.085602 5.036821 4.965126 4.912611 5.033810 4.977470 5.000691
## [911] 4.859188 5.059339 5.031102 4.974669 5.090507 5.030464 4.941240
## [918] 4.994519 4.826751 5.046058 5.060090 5.057312 4.988359 4.921367
## [925] 4.957559 4.838552 5.047904 4.973724 4.903104 4.935417 5.015551
## [932] 5.087637 5.020267 4.948806 4.960574 4.937103 4.967953 5.027130
## [939] 4.991394 5.051586 5.072307 5.026950 5.173347 4.928708 5.002756
## [946] 4.997636 5.000482 5.013709 5.155997 4.895002 5.064247 4.900120
## [953] 4.996288 5.035102 4.984588 4.984371 5.085880 4.931179 5.062403

```

```

## [960] 4.876928 5.088392 4.915616 4.994158 4.861837 4.889609 5.102583
## [967] 5.067599 4.934517 4.923165 4.968907 5.002655 5.012899 4.970314
## [974] 4.944940 5.067565 4.918211 5.072268 4.953050 5.048276 4.974655
## [981] 4.907718 4.992483 5.083720 5.017355 4.995786 4.967489 4.950702
## [988] 4.968826 4.933269 5.004539 4.931752 5.013196 5.093738 4.998322
## [995] 5.063952 4.922992 5.027247 4.942626 5.075475 5.018586

```

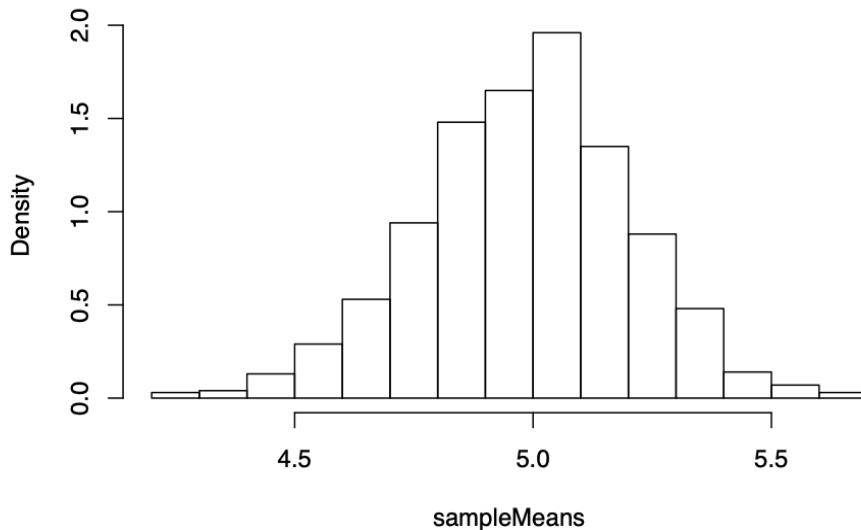
G

```

sampling_function(sample_size = 10,
                  number_of_samples = 1000, sample_mean = 5, sample_var = 0.5)

```

**Histogram of sampleMeans**



```

## [1] 5.051271 5.347319 4.873303 5.045419 4.889141 4.879782 5.324035
## [8] 4.922696 5.046472 4.542754 4.780225 5.235359 5.335323 4.954761
## [15] 5.048238 4.950253 5.250549 4.969635 4.855761 4.924138 4.524562
## [22] 5.186008 5.086890 4.664577 5.024828 5.326157 5.021410 5.351656
## [29] 5.183740 5.258388 4.755712 4.951782 4.796582 5.070334 4.938242
## [36] 5.080686 5.005790 4.903928 5.227083 4.598143 4.896095 5.047143
## [43] 4.870060 5.017255 4.823197 5.081531 4.796195 4.911154 5.044294
## [50] 5.127478 4.681517 5.077077 4.928802 5.282440 4.966912 5.142041
## [57] 5.099523 5.548069 5.061031 5.129135 4.850675 5.161473 4.760134
## [64] 5.097090 4.666494 4.991480 4.896177 4.796788 5.049295 4.650167
## [71] 4.728743 4.733837 4.863522 4.783361 5.168920 4.908119 5.114784
## [78] 4.877863 5.053487 5.452092 5.072381 5.187250 4.620197 4.668318
## [85] 4.853999 4.913131 5.105399 5.129022 4.793086 4.509700 5.166529
## [92] 4.512609 5.050140 5.248753 4.941435 4.698924 4.952774 5.268616
## [99] 5.010558 5.012009 4.769687 5.049120 4.842963 5.147811 4.915892
## [106] 4.814395 4.929628 4.792566 5.078219 4.967388 4.969533 4.779326

```

```

## [113] 4.251045 5.434232 5.097895 5.021157 4.868814 4.828488 5.025794
## [120] 5.171627 5.192453 5.119742 4.801795 4.621659 4.976914 4.644799
## [127] 5.104513 4.943771 4.823137 5.003067 5.274054 4.861308 4.838036
## [134] 4.856621 5.058333 5.399147 4.975294 5.187260 4.974706 4.971720
## [141] 4.951116 4.718908 5.212482 5.388245 5.302388 4.790782 4.832325
## [148] 5.093507 4.816539 4.873230 5.035349 5.125335 4.576559 4.550883
## [155] 5.009623 5.062539 5.065215 5.120670 4.717518 5.270585 5.406065
## [162] 5.114727 5.654750 5.042086 5.104040 4.873628 5.096857 4.882170
## [169] 5.451352 4.717503 5.158675 4.820549 4.983916 4.436405 4.743057
## [176] 4.841578 5.006037 4.969256 5.078649 5.122635 4.944765 5.129925
## [183] 5.286121 5.094402 4.712149 4.994781 4.550742 4.911571 5.248884
## [190] 4.953493 4.846236 4.863924 4.844712 4.951613 5.043248 5.036844
## [197] 4.970218 4.929889 5.244049 4.861198 4.724895 4.688229 4.910701
## [204] 4.998791 5.079933 4.790077 4.880076 4.944670 4.859915 5.081927
## [211] 5.204242 4.745593 5.118230 4.548802 5.034613 5.056193 4.986152
## [218] 5.021310 5.111142 4.652614 4.966580 5.164463 4.852919 4.739839
## [225] 4.900563 5.042390 5.187453 4.696012 5.049941 4.533552 4.844009
## [232] 4.977316 5.112667 5.202679 5.230050 4.617708 4.614539 5.081967
## [239] 4.891237 4.897691 4.748353 5.093034 4.881832 5.019480 4.997076
## [246] 4.596971 5.041270 4.751587 5.016964 4.654128 5.623861 4.815597
## [253] 4.884352 4.994789 5.001172 5.188304 5.155481 5.009694 5.058370
## [260] 4.616339 5.191020 4.903495 4.817745 5.113468 5.074499 4.856671
## [267] 4.924136 4.917546 5.227937 5.081965 5.178150 4.790644 4.926985
## [274] 4.835513 4.901366 4.755287 5.374912 4.745837 4.607542 4.786328
## [281] 4.889758 4.872198 5.151721 4.738451 4.591166 5.288230 4.693088
## [288] 5.223620 5.208721 4.891594 5.191062 4.947922 5.083921 5.551968
## [295] 4.873344 5.153638 4.859240 4.604133 5.245132 4.806086 5.007473
## [302] 4.786202 5.334518 4.995942 5.240371 4.925590 5.452205 4.974934
## [309] 4.897337 4.921958 5.047468 5.103391 4.868159 5.307041 5.031285
## [316] 5.159456 5.073660 4.767501 4.717874 5.066182 5.156172 5.175404
## [323] 5.012842 4.925911 4.599347 5.125784 5.133670 4.857348 4.852744
## [330] 4.824348 4.845827 5.118835 4.775532 5.257576 5.012604 4.896551
## [337] 5.087346 4.960747 4.963918 5.036395 5.080339 5.009125 4.945188
## [344] 5.051089 4.973596 5.079983 4.812310 5.101937 5.190216 5.310397
## [351] 5.370280 4.521596 4.429317 4.978742 5.373735 4.937898 5.036019
## [358] 4.909868 5.077233 5.117675 4.893077 4.639085 4.509120 4.535058
## [365] 5.241445 5.435061 4.576160 4.963601 4.777649 4.917822 4.899682
## [372] 4.620865 5.251087 4.653857 4.827106 4.676595 4.870102 4.492736
## [379] 4.847831 5.348297 4.959370 5.338933 5.151974 4.666204 5.187957
## [386] 4.680618 4.966908 4.933792 4.708762 4.703111 5.231393 4.848780
## [393] 5.071212 4.778671 5.656334 5.058961 5.227181 4.872031 4.315472
## [400] 5.156015 4.841338 4.813280 5.217787 5.261599 4.975743 5.106335
## [407] 4.740112 5.394261 5.016399 5.295196 4.987492 5.052991 4.707017
## [414] 5.121789 5.057315 4.973128 5.135953 5.162815 5.081933 4.814833
## [421] 4.998651 5.204546 5.186339 4.842273 5.192973 4.583799 4.580336
## [428] 5.322646 5.091876 5.203001 5.058821 4.605791 4.891316 5.036062
## [435] 4.749094 4.902430 5.010687 4.887469 5.334126 4.757919 4.897132
## [442] 5.039666 4.979805 4.869103 5.332950 4.979428 4.945428 4.953527
## [449] 5.367380 5.482604 5.190079 4.904076 4.896697 4.709032 5.211177
## [456] 5.194106 4.752644 5.039876 4.951756 4.935968 5.192847 4.838780
## [463] 4.793440 5.065805 4.884483 5.528683 4.931606 5.205731 4.898773
## [470] 4.465575 5.194027 4.612784 5.136962 5.272188 4.843698 5.185777
## [477] 4.278000 5.044039 5.050892 5.515901 5.266939 5.291616 4.730774
## [484] 5.271348 4.862800 5.198006 5.136194 5.340135 5.316992 5.579997

```

```

## [491] 4.955612 4.906459 5.222708 5.251878 4.981192 5.242653 5.172766
## [498] 5.208136 4.809790 4.836357 4.762071 5.112463 4.431400 5.251808
## [505] 5.372001 5.268377 5.073511 5.357919 4.789213 4.894208 5.175120
## [512] 4.913380 4.622159 4.680389 5.145545 5.071084 5.277386 5.192342
## [519] 4.997749 5.051425 5.223344 4.892944 4.983208 4.901036 4.428557
## [526] 4.942532 5.261110 5.206468 4.810275 4.779911 4.801965 5.368117
## [533] 5.040411 5.411170 4.884807 5.010248 4.762230 5.296326 4.826286
## [540] 5.032674 5.077448 5.050018 5.155516 4.628629 5.067338 5.192522
## [547] 4.886992 5.069654 4.872719 5.348217 5.161252 4.717055 4.903718
## [554] 5.083897 4.753764 5.323992 4.748595 5.163352 5.007398 5.016727
## [561] 5.062192 4.970350 5.074196 4.721328 5.019395 5.181305 4.860743
## [568] 4.971779 4.960926 5.058153 5.276432 5.479017 5.034873 5.164669
## [575] 5.452178 5.171030 5.112092 5.023981 4.641764 4.638914 5.095272
## [582] 4.957706 4.777708 4.687113 5.001965 4.937865 4.715029 4.627837
## [589] 5.118962 4.529973 4.716473 4.701479 4.838790 5.319636 5.302429
## [596] 5.059842 5.032530 4.928643 5.135543 5.186798 5.279067 5.005392
## [603] 4.922458 5.060408 4.858037 4.772298 4.858037 4.345286 4.561970
## [610] 5.107740 5.271812 4.742521 4.951144 4.602238 5.143537 5.243271
## [617] 5.132031 4.810168 5.358052 5.212638 5.258459 4.692671 4.777803
## [624] 4.956922 4.778694 4.896284 4.917629 5.131878 4.840496 5.159954
## [631] 4.895678 5.205924 4.987219 4.870917 5.128654 4.467226 5.510937
## [638] 4.812793 5.019291 5.145136 4.847585 5.242704 5.329275 4.820941
## [645] 4.830362 4.552645 4.879596 4.775848 5.081390 5.471193 4.976086
## [652] 5.572528 4.885084 5.018675 5.122600 5.051070 5.323782 5.305050
## [659] 5.055316 4.581229 5.124131 4.861258 4.835564 5.038830 4.981946
## [666] 5.005340 4.812735 4.932936 4.713081 5.026244 4.732845 5.230086
## [673] 5.003325 4.761344 4.772930 5.116821 5.213792 5.049455 5.114362
## [680] 4.802336 4.914486 5.268817 5.146436 4.593660 5.315908 5.278310
## [687] 4.930301 5.172257 5.064098 4.850101 5.084352 4.953465 5.040989
## [694] 5.020515 5.137412 4.480159 4.957363 5.105499 5.383807 4.999540
## [701] 5.080236 4.463546 5.001700 4.965432 4.913157 4.686544 4.843902
## [708] 5.011604 5.095345 5.040379 4.900065 4.912089 4.773405 4.634834
## [715] 4.922275 5.156208 5.122336 5.121517 5.156915 5.267197 4.560071
## [722] 5.102996 5.099619 4.418348 5.140958 5.058516 5.262447 4.728295
## [729] 5.303617 5.077111 4.642675 5.152961 4.802141 4.776513 4.769135
## [736] 4.904452 5.287738 5.210129 5.176185 4.846590 4.406723 5.062187
## [743] 5.007717 4.907432 4.717731 4.893377 4.710696 4.927300 5.250539
## [750] 4.875206 5.188592 4.958413 5.253093 4.979997 5.028562 4.674462
## [757] 5.054740 5.037452 4.377861 4.875848 4.649368 5.069795 5.173643
## [764] 5.092048 4.746942 4.837844 5.029960 5.082412 5.033505 4.817070
## [771] 5.138273 4.749100 5.042999 4.897159 4.775852 5.141735 4.920092
## [778] 5.097662 4.777444 4.811713 4.599077 5.129728 4.691577 4.916251
## [785] 5.216489 5.030461 5.277675 4.721156 4.818300 4.995445 4.460856
## [792] 5.390874 5.206214 4.854388 4.594327 5.392864 4.876409 4.884231
## [799] 5.206994 5.352684 4.944694 5.472856 5.154116 5.004961 5.276440
## [806] 4.989659 4.960428 5.175534 5.006975 4.880632 5.206657 5.329021
## [813] 4.908328 4.893849 5.055298 4.876621 5.033670 4.854270 5.146294
## [820] 5.085140 5.213593 5.053406 4.627849 4.689425 4.979894 5.025807
## [827] 5.037600 5.136260 5.214813 5.214854 4.844082 5.304093 5.101876
## [834] 4.904487 5.066566 5.005213 4.788098 4.868012 4.459517 4.972368
## [841] 4.641656 5.035672 4.728656 4.779559 5.006001 4.578864 5.163735
## [848] 4.850213 4.979352 5.081686 4.954103 5.186523 4.955052 5.028389
## [855] 4.982278 4.983893 5.146038 5.071651 5.028358 4.620837 4.991159
## [862] 5.066953 5.333420 4.979819 5.279276 4.836700 4.745710 5.274391

```

```

## [869] 4.799188 4.997059 4.979877 5.102758 5.462940 5.000589 5.200141
## [876] 4.810524 5.155339 5.086924 5.272990 5.098115 4.938003 5.095396
## [883] 4.757914 5.142594 5.058772 4.958588 4.888307 4.656691 4.927349
## [890] 5.331543 5.256832 5.099478 4.706596 4.872759 4.920373 5.321056
## [897] 5.264862 4.284441 4.950837 4.634501 4.574119 4.902291 5.006577
## [904] 4.675860 5.152644 5.127335 4.946011 4.859127 4.984979 5.112305
## [911] 5.186978 4.791830 5.112360 4.674397 5.064262 5.079162 5.256983
## [918] 5.212863 4.892530 4.743997 5.382084 4.993968 4.829034 5.381485
## [925] 5.137062 4.720461 5.010772 4.982658 4.314158 4.921252 4.977206
## [932] 4.987273 4.776106 5.260452 4.929039 4.963986 5.079914 5.046606
## [939] 4.949721 5.284398 5.032522 5.013144 4.972476 4.896374 4.694212
## [946] 5.051672 4.958028 4.601077 5.101356 5.068222 5.025533 4.860733
## [953] 4.811032 4.898026 5.167495 4.755160 4.945272 4.970167 5.112087
## [960] 4.947405 5.127676 5.053368 4.617797 4.900484 5.074839 5.064857
## [967] 4.958850 5.093130 4.820562 4.906260 4.825926 4.987935 4.901693
## [974] 4.713877 5.083208 4.700770 5.200492 5.319868 4.881456 4.878490
## [981] 5.026284 4.817815 5.079546 5.122328 5.014383 5.121341 4.912568
## [988] 5.279440 5.425170 5.022949 4.819075 4.939755 4.892558 5.121529
## [995] 5.139019 5.106644 5.064101 4.712309 5.012229 4.713897

```

## H

It makes sense that the histograms are “shifted” because you are using a different  $\mu$  to generate the random samples, therefore the distribution of the statistic  $T(x)$  changes to be centered around these different  $\mu$ .

## I

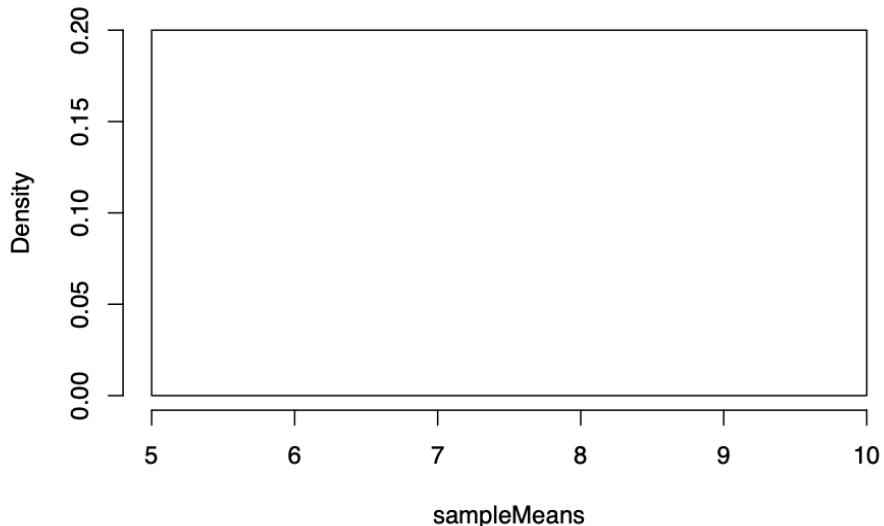
```

p_calc <- function(s, sample_mean, sample_var, sample_size) {
  p_val <- 2*(1- pnorm(abs(s), mean = sample_mean, sd = sqrt(sample_var/sample_size)))
  return(p_val)
}

big_x <- sampling_function(sample_size = 100,
                            number_of_samples = 1, sample_mean = 5.5, sample_var = 0.5)

```

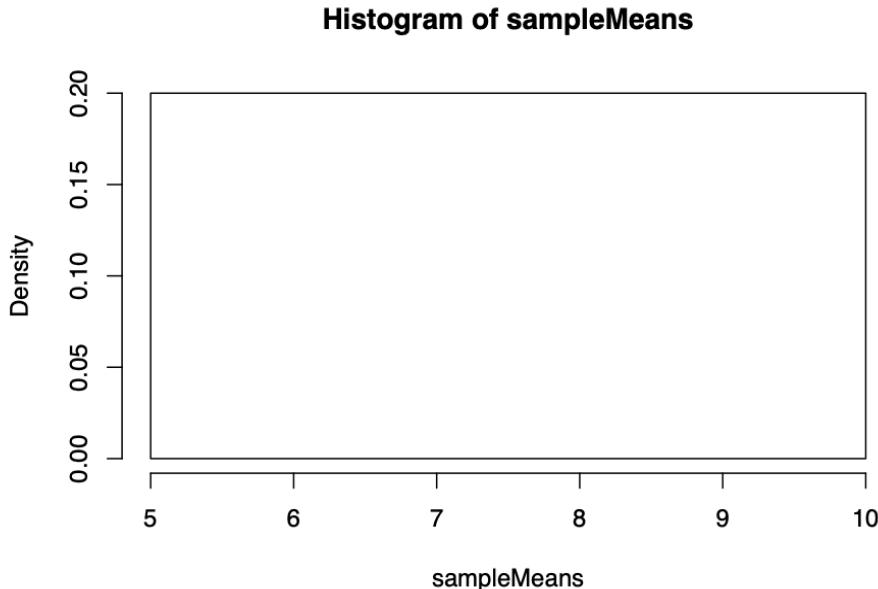
**Histogram of sampleMeans**



```
big_x
## [1] 5.616664
big_p <- p_calc(big_x, sample_mean = 5, sample_var = 0.5, sample_size = 100)
print(paste('T(x) = ', big_x, ' p value = ', big_p))
## [1] "T(x) = 5.61666449213767 p value = 0"
Based on this p value, you reject the  $H_o$  because  $0 < .05$ 
```

J

```
small_x <- sampling_function(sample_size = 10,
                               number_of_samples = 1, sample_mean = 5.5, sample_var = 0.5)
```



```
small_p <- p_calc(big_x, sample_mean = 5, sample_var = 0.5, sample_size = 10)
print(paste('T(x) = ', small_x, ' p value = ', small_p))

## [1] "T(x) = 5.57349971303157 p value = 0.00581904636620689"
```

Based on this p value, you cannot reject the  $H_0$  because  $0.00581904636620689 > .05$  This makes sense because increasing sample size decreases the type I error.

### Problem 3

From the definition of a p-value  $p = Pr(T(x) \geq t | H_0 : c = \theta)$

Which can be written to consider the other side of the distribution as  $p = 1 - Pr(T(x) < t | H_0)$

$Pr(T(x) < t | H_0)$  is the cdf for the null hypothesis such that  $p = 1 - F_o(t)$  From the definition of cdf  $Pr(T(x) \geq t | H_0) = Pr(F_o(T) \geq F_o(t))$

which can also be changed to  $Pr(T(x) \geq t | H_0) = 1 - Pr(F_o(T) \leq F_o(t))$   
setting these equal to each other gives  $Pr(F_o(T) \leq F_o(t)) = F_o(t)$   
Thus  $F_o(T), 1 - F_o(T), p \sim U(0, 1)$