Homework 04 T-tests, Sampling Distributions, and the Bootstrap

Due by 11:59pm, Friday, February 14, 2025, 11:59pm

S&DS 230/530/ENV 757

## Submission Details

This homework assignment contains 3 problems. Edit this .Rmd file and insert your responses under the appropriate problems. Submit the knitted output of this file as a .pdf to Gradescope. Be sure to match pages in your submitted PDF to the requested subquestions on Gradescope.

For full credit, your document should look nicely formatted, with R code, plots, and text descriptions nicely integrated.

**DELETE ALL LINES FROM HERE UP THROUGH ‘Submission Details’ BEFORE KNITTING AND SUBMITTING! ALSO REMOVE ALL INSTANCES OF eval = F**

**(1) Practice with Loops.** *(10 points)* For this problem, use loops even if you could do the task without them.

(1.1) A Tribonacci sequence is a series of integers where each number after the third number is found by adding together the three integers before it. Starting with 0, 1, 1, the sequence goes:

0, 1, 1, 2, 4, 7, …

Write a loop that fills a vector called myTrib with this sequence going up to a total length of 21 numbers. Display the final value of myTrib AND write a line of code that calculates how many digits are in the final number in myTrib.

(1.2) Here is the link to the World Bank data from 2024:

<http://www.reuningscherer.net/s&ds230/data/WB_2024.csv>

Read the data into a dataframe called wb. Write a loop to fill a vector called compVals having length equal to the number of columns in the World Bank data frame. The i-th entry in compVals should be a number (>= 0) equal to the total number of non-missing values in the i-th column of World Bank data frame. Make a histogram of compVals and label as appropriate. In addition, make a histogram that displays the units on the horizonal axis in terms of percentages (not proportions) for each variable (rather than totals). Write a sentence or two about what these plots tell you about the dataset.

*(For full credit, use only one for-loop to do part 1.2)*

myTrib <- c(0, 1, 1)  
for (i in 4:21) {  
 myTrib[i] = myTrib[i-1] + myTrib[i-2] + myTrib[i-3]  
}  
myTrib

## [1] 0 1 1 2 4 7 13 24 44 81 149 274  
## [13] 504 927 1705 3136 5768 10609 19513 35890 66012

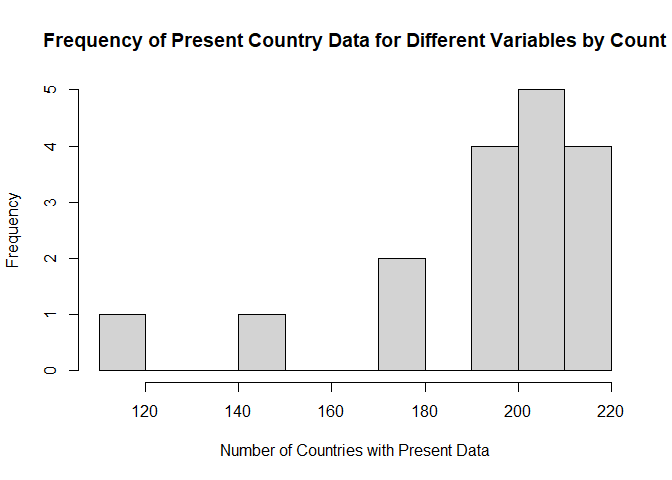
nchar(as.character(myTrib[21]))

## [1] 5

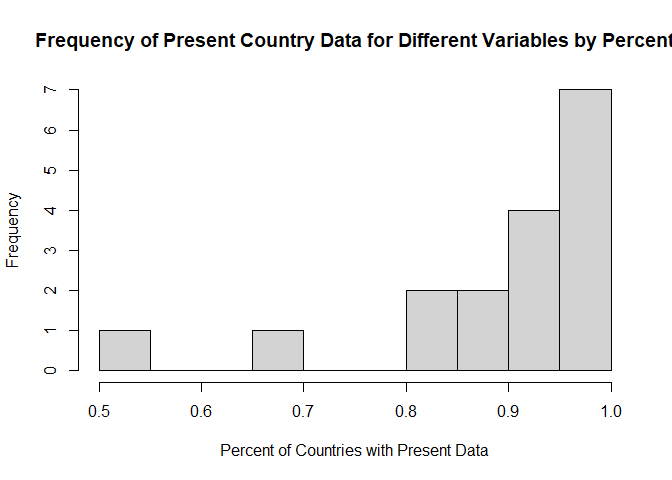
wb <- read.csv('http://www.reuningscherer.net/s&ds230/data/WB\_2024.csv')  
wb

## Country Population Rural GNI Imports  
## 1 Afghanistan 42239854 73.067 360 37.069564  
## 2 Albania 2745972 35.397 6770 44.708821  
## 3 Algeria 45606480 24.732 4490 23.388395  
## 4 American Samoa 43914 12.765 NA 92.533333  
## 5 Andorra 80088 12.226 50080 NA  
## 6 Angola 36684202 31.312 1870 26.719223  
## 7 Antigua and Barbuda 94298 75.668 18710 54.139404  
## 8 Argentina 46654581 7.537 11590 14.933436  
## 9 Armenia 2777970 36.261 5960 43.763449  
## 10 Aruba 106277 55.746 33410 70.830378  
## 11 Australia 26638544 13.383 60820 17.725541  
## 12 Austria 9132383 40.470 55720 55.033121  
## 13 Azerbaijan 10112555 42.423 5670 29.798119  
## 14 Bahamas, The 412623 16.375 31030 43.454512  
## 15 Bahrain 1485509 10.131 27710 70.191721  
## 16 Bangladesh 172954319 59.527 2820 17.061226  
## 17 Barbados 281995 68.575 20210 39.641005  
## 18 Belarus 9178298 19.269 7230 65.182413  
## 19 Belgium 11822592 1.811 53890 86.137595  
## 20 Belize 410825 53.392 6630 51.486413  
## 21 Benin 13712828 49.900 1400 27.136055  
## 22 Bermuda 63489 0.000 134640 23.519108  
## 23 Bhutan 787424 55.650 3590 48.383710  
## 24 Bolivia 12388571 28.814 3490 31.196051  
## 25 Bosnia and Herzegovina 3210847 49.731 7650 53.912587  
## 26 Botswana 2675352 27.133 7420 46.844288  
## 27 Brazil 216422446 12.212 8240 18.546900  
## 28 British Virgin Islands 31538 50.252 NA NA  
## 29 Brunei Darussalam 452524 20.851 31410 66.954202  
## 30 Bulgaria 6430370 23.299 13350 59.573569  
## 31 Burkina Faso 23251485 67.480 850 29.705252  
## 32 Burundi 13238559 85.216 240 23.818370  
## 33 Cabo Verde 598682 32.018 4060 53.605260  
## 34 Cambodia 16944826 74.430 1690 62.356989  
## 35 Cameroon 28647293 40.685 1630 20.230227  
## 36 Canada 40097761 18.138 53300 31.207811  
## 37 Cayman Islands 69310 0.000 68790 NA  
## 38 Central African Republic 5742315 56.386 480 30.931660  
## 39 Chad 18278568 75.634 680 44.234650  
## 40 Channel Islands 175346 68.841 NA NA  
## 41 Chile 19629590 11.988 15430 32.864864  
## 42 China 1410710000 35.430 12890 17.358017  
## 43 Colombia 52085168 17.646 6630 23.862140  
## 44 Comoros 852075 69.868 1610 31.470407  
## 45 Congo, Dem. Rep. 102262808 52.556 610 40.095482  
## 46 Congo, Rep. 6106869 30.812 2290 32.709632  
## 47 Costa Rica 5212173 17.378 12920 34.605285  
## 48 Cote d'Ivoire 28873034 46.851 2620 22.817765  
## 49 Croatia 3853200 41.425 19650 52.079404  
## 50 Cuba 11194449 22.477 NA 45.130213  
## 51 Curacao 147862 10.977 20590 NA  
## 52 Cyprus 1260138 33.013 31520 85.450518  
## 53 Czechia 10873689 25.448 26140 69.766778  
## 54 Denmark 5946952 11.505 73520 52.009264  
## 55 Djibouti 1136455 21.448 3370 120.998169  
## 56 Dominica 73040 27.994 8470 NA  
## 57 Dominican Republic 11332972 15.554 9070 30.982165  
## 58 Ecuador 18190484 35.208 6520 26.146489  
## 59 Egypt, Arab Rep. 112716598 56.900 4100 19.295823  
## 60 El Salvador 6364943 24.607 4670 53.063581  
## 61 Equatorial Guinea 1714671 25.552 4870 31.839098  
## 62 Eritrea 3748901 56.733 NA NA  
## 63 Estonia 1366188 30.190 27200 81.272170  
## 64 Eswatini 1210822 75.210 4400 44.897165  
## 65 Ethiopia 126527060 76.843 1020 16.713338  
## 66 Faroe Islands 53270 57.013 74420 52.134483  
## 67 Fiji 936375 41.287 5390 54.471880  
## 68 Finland 5584264 14.227 54730 39.444037  
## 69 France 68170228 18.223 45290 31.917320  
## 70 French Polynesia 308872 37.712 NA 38.534807  
## 71 Gabon 2436566 8.971 7530 18.949785  
## 72 Gambia, The 2773168 35.528 800 35.480648  
## 73 Georgia 3760365 39.273 5690 58.926546  
## 74 Germany 84482267 22.235 54030 41.881574  
## 75 Ghana 34121985 40.762 2380 32.652711  
## 76 Gibraltar 32688 0.000 NA NA  
## 77 Greece 10361295 19.327 21810 48.714126  
## 78 Greenland 56865 12.060 NA 49.716131  
## 79 Grenada 126183 62.941 9350 NA  
## 80 Guam 172952 4.834 NA 58.742380  
## 81 Guatemala 17602431 46.902 5340 31.779428  
## 82 Guinea 14190612 61.915 1180 62.813260  
## 83 Guinea-Bissau 2150842 54.534 870 30.872334  
## 84 Guyana 813834 72.838 14920 NA  
## 85 Haiti 11724763 40.344 1610 30.027851  
## 86 Honduras 10593798 39.788 2710 64.007245  
## 87 Hong Kong SAR, China 7536100 0.000 54000 198.445418  
## 88 Hungary 9589872 27.136 19050 79.747136  
## 89 Iceland 393600 5.958 73930 39.042086  
## 90 India 1428627663 63.636 2400 24.023930  
## 91 Indonesia 277534122 41.428 4580 18.788203  
## 92 Iran, Islamic Rep. 89172767 22.743 3980 21.534602  
## 93 Iraq 45504560 28.401 5440 24.181615  
## 94 Ireland 5262382 35.534 79730 93.665435  
## 95 Isle of Man 84710 46.518 NA NA  
## 96 Israel 9756700 7.146 55140 25.797651  
## 97 Italy 58761146 28.027 38370 29.955032  
## 98 Jamaica 2825544 42.622 5760 NA  
## 99 Japan 124516650 7.957 42550 18.646007  
## 100 Jordan 11337052 7.980 4350 50.182184  
## 101 Kazakhstan 19900177 41.821 9610 25.023746  
## 102 Kenya 55100586 70.480 2170 19.915101  
## 103 Kiribati 133515 42.238 3320 69.785462  
## 104 Korea, Dem. People's Rep. 26160821 36.797 NA NA  
## 105 Korea, Rep. 51712619 18.544 36160 38.322227  
## 106 Kosovo 1756374 NA 5600 65.229248  
## 107 Kuwait 4310108 0.000 40730 NA  
## 108 Kyrgyz Republic 7100800 62.199 1490 64.455787  
## 109 Lao PDR 7633779 61.753 2310 NA  
## 110 Latvia 1881750 31.329 21970 67.742790  
## 111 Lebanon 5353930 10.568 4410 52.802993  
## 112 Lesotho 2330318 69.585 1220 93.209258  
## 113 Liberia 5418377 46.433 690 NA  
## 114 Libya 6888388 18.394 10290 52.346775  
## 115 Liechtenstein 39584 85.383 NA NA  
## 116 Lithuania 2871897 31.306 23860 75.570610  
## 117 Luxembourg 668606 7.922 89200 179.918519  
## 118 Macao SAR, China 704149 0.000 43940 76.750321  
## 119 Madagascar 30325732 59.444 510 31.682752  
## 120 Malawi 20931751 81.720 640 NA  
## 121 Malaysia 34308525 21.284 11830 63.394865  
## 122 Maldives 521021 58.029 10880 NA  
## 123 Mali 23293698 53.811 850 39.342799  
## 124 Malta 553214 5.059 33330 148.505357  
## 125 Marshall Islands 41996 21.132 7270 71.251259  
## 126 Mauritania 4862989 42.301 2080 48.450850  
## 127 Mauritius 1261041 59.133 10500 53.798295  
## 128 Mexico 128455567 18.418 10810 42.613382  
## 129 Micronesia, Fed. Sts. 115224 76.621 4050 67.505974  
## 130 Moldova 2486891 56.627 5500 57.822099  
## 131 Monaco 36297 0.000 NA NA  
## 132 Mongolia 3447157 30.911 4260 60.549214  
## 133 Montenegro 616177 31.498 10480 62.195638  
## 134 Morocco 37840044 34.879 3670 42.448383  
## 135 Mozambique 33897354 61.247 490 71.728466  
## 136 Myanmar 54577997 67.888 1280 NA  
## 137 Namibia 2604172 45.114 4840 51.587892  
## 138 Nauru 12780 0.000 20920 80.000000  
## 139 Nepal 30896590 78.097 1340 37.934633  
## 140 Netherlands 17879488 6.821 60230 72.850961  
## 141 New Caledonia 267940 27.281 NA NA  
## 142 New Zealand 5223100 13.015 48530 26.212347  
## 143 Nicaragua 7046310 40.151 2090 60.077875  
## 144 Niger 27202843 82.946 580 27.022173  
## 145 Nigeria 223804632 45.717 2160 NA  
## 146 North Macedonia 1811980 40.521 7500 81.277547  
## 147 Northern Mariana Islands 49796 7.924 NA NA  
## 148 Norway 5519594 16.005 96770 28.186412  
## 149 Oman 4644384 11.600 20020 41.389544  
## 150 Pakistan 240485658 61.960 1570 17.978821  
## 151 Palau 18058 17.592 13570 75.855760  
## 152 Panama 4468087 30.488 17050 37.656600  
## 153 Papua New Guinea 10329931 86.277 2700 NA  
## 154 Paraguay 6861524 36.851 5900 34.255181  
## 155 Peru 34352719 21.078 6810 26.128896  
## 156 Philippines 117337368 51.713 3950 37.732575  
## 157 Poland 36685849 39.782 18960 54.382469  
## 158 Portugal 10525347 32.094 25950 44.224193  
## 159 Puerto Rico 3205691 6.366 24760 42.330865  
## 160 Qatar 2716391 0.646 70070 34.053142  
## 161 Romania 19056116 45.328 15490 46.262124  
## 162 Russian Federation 143826130 24.669 12810 20.425227  
## 163 Rwanda 14094683 82.108 930 35.119070  
## 164 Samoa 225681 82.492 3660 49.203196  
## 165 San Marino 33642 2.164 NA 158.155892  
## 166 Sao Tome and Principe 231856 23.599 2420 NA  
## 167 Saudi Arabia 36947025 15.050 27500 24.368160  
## 168 Senegal 17763163 50.421 1620 44.736392  
## 169 Serbia 6618026 42.887 9300 62.883436  
## 170 Seychelles 119773 41.180 15000 103.506944  
## 171 Sierra Leone 8791092 55.700 600 41.462686  
## 172 Singapore 5917648 0.000 66970 146.774442  
## 173 Sint Maarten (Dutch part) 41163 0.000 36960 NA  
## 174 Slovak Republic 5426740 45.973 22080 92.140564  
## 175 Slovenia 2120937 43.912 29590 77.722742  
## 176 Solomon Islands 740424 73.963 2290 39.464516  
## 177 Somalia 18143378 52.080 600 66.512774  
## 178 South Africa 60414495 31.181 6780 24.973305  
## 179 South Sudan 11088796 78.805 NA NA  
## 180 Spain 48373336 18.448 32090 33.214867  
## 181 Sri Lanka 22037000 80.789 3620 24.308554  
## 182 St. Kitts and Nevis 47755 68.904 20670 NA  
## 183 St. Lucia 180251 80.828 11500 NA  
## 184 St. Martin (French part) 32077 NA NA NA  
## 185 St. Vincent and the Grenadines 103698 45.701 9440 NA  
## 186 Sudan 48109006 63.658 760 1.877678  
## 187 Suriname 623236 33.589 4970 NA  
## 188 Sweden 10536632 11.262 63900 41.749545  
## 189 Switzerland 8849852 25.798 95490 58.968607  
## 190 Syrian Arab Republic 23227014 42.591 NA 73.056226  
## 191 Tajikistan 10143543 71.766 1390 47.644008  
## 192 Tanzania 67438106 62.591 1200 15.795162  
## 193 Thailand 71801279 46.392 7240 58.592266  
## 194 Timor-Leste 1360596 67.544 1980 36.325242  
## 195 Togo 9053799 55.510 1000 33.955465  
## 196 Tonga 107773 76.840 5000 60.844805  
## 197 Trinidad and Tobago 1534937 46.561 16190 NA  
## 198 Tunisia 12458223 29.456 3810 52.207997  
## 199 Turkiye 85326000 22.537 10640 35.338747  
## 200 Turkmenistan 6516100 45.997 NA 12.497572  
## 201 Turks and Caicos Islands 46062 5.753 24300 NA  
## 202 Tuvalu 11396 33.759 7160 NA  
## 203 Uganda 48582334 73.229 930 25.932623  
## 204 Ukraine 37000000 29.905 4280 42.009621  
## 205 United Arab Emirates 9516871 12.221 49160 NA  
## 206 United Kingdom 68350000 15.358 48640 29.751335  
## 207 United States 334914895 16.702 76590 14.445505  
## 208 Uruguay 3423108 4.229 17800 24.841653  
## 209 Uzbekistan 36412350 49.468 2200 40.171568  
## 210 Vanuatu 334506 74.024 3570 52.454746  
## 211 Venezuela, RB 28838499 11.562 NA NA  
## 212 Viet Nam 98858950 60.520 4020 92.825626  
## 213 Virgin Islands (U.S.) 104917 3.773 NA 91.471647  
## 214 West Bank and Gaza 5165775 22.418 4720 55.742449  
## 215 Yemen, Rep. 34449825 60.169 NA NA  
## 216 Zambia 20569737 53.665 1170 33.992421  
## 217 Zimbabwe 16665409 67.483 1720 28.071888  
## Exports Military Cell Fertility Measles InfMort LifeExp  
## 1 14.342153 NA 56.55443 4.523000 68 44.8 62.87900  
## 2 31.309161 1.58488092 92.31992 1.376000 86 8.4 76.83300  
## 3 23.882508 4.77943829 106.42354 2.829000 79 18.7 77.12900  
## 4 44.266667 NA NA NA NA NA NA  
## 5 NA NA 118.67298 NA 98 2.6 NA  
## 6 47.745276 1.32872233 44.42373 5.209000 37 45.7 61.92900  
## 7 46.983479 NA 197.38254 1.580000 99 8.1 79.23600  
## 8 17.996588 0.41121130 130.45501 1.876000 83 8.4 76.06400  
## 9 35.906440 4.31710667 128.96136 1.575000 95 9.2 73.37200  
## 10 69.069709 NA 132.34963 1.179000 NA NA 74.99200  
## 11 21.976819 1.89882435 104.51721 1.630000 96 3.2 83.20000  
## 12 55.951837 0.77260716 121.96948 1.410000 95 2.6 81.09268  
## 13 46.488747 4.54596854 104.88781 1.670000 93 16.1 73.48800  
## 14 29.497137 NA 97.42269 1.380000 80 11.2 74.35800  
## 15 89.681260 3.17213705 131.44871 1.797000 99 5.6 79.24600  
## 16 10.662779 1.12882011 108.90944 1.950000 97 24.1 73.69800  
## 17 30.227798 NA 112.60064 1.634000 85 10.1 77.70600  
## 18 70.832038 1.20328257 122.78013 1.495000 98 1.9 73.11146  
## 19 87.901398 1.17973708 101.10837 1.530000 96 3.1 81.69756  
## 20 47.660590 0.86116711 65.99489 1.989000 81 9.4 70.96200  
## 21 20.918806 0.55746126 97.96018 4.895000 68 53.6 59.95400  
## 22 48.683564 NA 105.94376 1.300000 NA NA 81.57100  
## 23 29.198742 NA 100.06714 1.398000 97 20.1 72.22900  
## 24 27.825346 1.48373193 99.62307 2.584000 69 19.6 64.92800  
## 25 42.573321 0.81044224 113.99694 1.346000 58 5.2 75.29300  
## 26 41.910844 2.74395956 160.73698 2.754000 90 31.2 65.91300  
## 27 19.109430 1.05342201 102.48887 1.626000 81 12.5 73.42500  
## 28 NA NA 120.94660 1.015000 NA 11.6 76.37300  
## 29 80.168911 2.36964741 135.50125 1.764000 97 8.5 74.55100  
## 30 61.401084 1.50812345 114.76775 1.780000 91 5.0 74.36098  
## 31 32.887710 3.09476704 111.66313 4.665000 88 50.1 59.76600  
## 32 5.000290 2.76041458 61.67128 4.980000 89 36.4 61.97700  
## 33 23.849798 0.54807628 100.38202 1.879000 95 10.6 74.72200  
## 34 66.754462 2.09964232 119.95758 2.322000 83 20.3 69.89600  
## 35 16.515641 0.94915423 79.96768 4.383000 65 47.0 60.95800  
## 36 31.216353 1.23665591 88.09066 1.330000 92 4.3 81.29561  
## 37 NA NA 146.76529 NA NA NA NA  
## 38 13.227460 1.69643629 33.55229 5.918000 41 73.5 54.47700  
## 39 38.750127 2.92548684 60.22303 6.215000 56 64.1 52.99700  
## 40 NA NA NA 1.469000 NA NA 81.58300  
## 41 31.973584 1.83398147 136.31341 1.539000 94 5.4 79.51900  
## 42 19.943974 1.59538074 121.53825 1.175000 99 4.8 78.58700  
## 43 16.197006 3.07910775 145.69317 1.692000 88 10.6 73.65900  
## 44 10.807322 NA 103.87317 3.912000 86 38.2 63.68000  
## 45 40.385830 0.57889437 48.89330 6.106000 56 60.1 59.74300  
## 46 52.836571 1.84718916 96.78757 4.095000 65 31.2 63.05300  
## 47 36.176357 NA 152.00816 1.522000 90 6.9 77.32000  
## 48 22.296268 0.88918359 162.17010 4.342000 65 52.4 58.91600  
## 49 49.353899 2.16749052 108.42529 1.530000 90 3.9 77.57561  
## 50 34.893572 NA 63.10467 1.449000 99 6.2 78.15500  
## 51 NA NA 88.26771 1.300000 NA NA NA  
## 52 89.409089 1.81479665 148.73806 1.311000 86 2.7 81.88900  
## 53 72.728234 1.35806383 126.41243 1.617747 97 2.1 79.02927  
## 54 58.702944 1.41896037 125.78229 1.550000 95 3.1 81.30488  
## 55 143.022084 NA 44.26176 2.757000 50 44.1 62.85900  
## 56 NA NA 85.85732 1.588000 83 30.8 72.98100  
## 57 21.752702 0.71763760 87.56486 2.247000 91 26.8 74.17000  
## 58 27.004710 2.15522187 94.33559 2.003000 74 10.5 77.89400  
## 59 10.561150 1.06181004 94.68028 2.878000 96 15.5 70.15900  
## 60 28.781495 1.32039410 175.33703 1.785000 65 10.2 71.47500  
## 61 45.127551 1.09726208 49.96672 4.170000 53 55.1 61.19000  
## 62 NA NA 49.74709 3.786000 93 28.0 66.60400  
## 63 80.269095 2.08666579 149.08079 1.410000 82 1.5 77.94390  
## 64 44.054892 1.64512139 120.05249 2.785000 83 39.7 56.36000  
## 65 7.631702 0.90389201 53.62353 4.063000 56 33.9 65.64500  
## 66 52.613165 NA 111.95923 2.049700 NA NA 83.30000  
## 67 27.253328 1.39581320 107.23440 2.462000 99 23.6 68.31200  
## 68 39.477548 1.72168290 129.15481 1.320000 94 1.9 81.18780  
## 69 30.034994 1.93872342 116.69350 1.794000 94 3.3 82.22927  
## 70 13.102801 NA 106.21185 1.688000 NA NA 83.55000  
## 71 55.542178 1.25778434 134.31732 3.460000 52 28.8 65.69400  
## 72 6.617335 0.69394000 101.44088 4.586000 74 32.8 62.90600  
## 73 42.674361 1.43098610 147.75488 2.063000 90 8.3 71.58700  
## 74 47.279520 1.39005501 127.56485 1.455000 97 3.0 80.70561  
## 75 30.055119 0.35007062 123.21151 3.507000 95 31.6 63.94500  
## 76 NA NA 104.52709 1.837000 NA NA 82.83000  
## 77 40.941800 3.69207450 110.03931 1.430000 97 3.3 80.63659  
## 78 35.436175 NA 118.42363 1.839000 NA NA 71.54049  
## 79 NA NA 81.06733 1.986000 76 14.4 75.33500  
## 80 3.095926 NA NA 2.550000 NA NA 78.33000  
## 81 17.712104 0.46249177 125.64875 2.354000 83 18.8 68.67400  
## 82 42.989751 2.03715762 101.94425 4.303000 47 62.2 58.98500  
## 83 24.679004 1.61476445 108.53051 3.925000 75 48.6 59.86100  
## 84 NA 0.56984755 106.39263 2.369000 95 22.3 65.98900  
## 85 7.137551 0.06918422 63.93497 2.773000 65 44.0 63.72800  
## 86 39.365398 1.52909744 73.55960 2.340000 77 13.8 70.72800  
## 87 204.014264 NA 319.42627 0.701000 NA NA 83.66098  
## 88 79.941138 1.52573721 106.92779 1.520000 99 3.3 76.01707  
## 89 37.254628 NA 118.07418 1.589000 91 2.0 82.17073  
## 90 21.399158 2.42522712 81.98893 2.011000 95 25.5 67.74400  
## 91 21.416556 0.70258760 133.65054 2.153000 84 18.1 68.25000  
## 92 22.839232 2.58586768 154.55428 1.681000 99 10.3 74.55600  
## 93 37.321653 1.66696774 93.60441 3.445000 88 20.0 71.33600  
## 94 133.739356 0.22510912 107.76771 1.700000 90 2.7 83.05610  
## 95 NA NA NA 1.571000 NA NA 80.76200  
## 96 29.397271 4.51139144 140.44851 2.890000 99 2.7 82.70000  
## 97 32.112914 1.67909234 131.86107 1.240000 94 2.2 82.90000  
## 98 NA 1.31337260 102.74832 1.340000 91 16.1 70.62900  
## 99 18.125477 1.07773444 160.88174 1.260000 98 1.7 83.99634  
## 100 30.307058 4.84048780 65.26177 2.786000 76 12.2 74.21500  
## 101 33.644862 0.50936439 127.47660 3.050000 99 8.7 74.44000  
## 102 10.774181 1.00120092 122.79024 3.296000 90 30.5 62.05500  
## 103 3.715626 NA 40.83989 3.271000 85 43.9 67.66100  
## 104 NA NA 23.10188 1.793000 0 13.6 73.57800  
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## 106 33.409183 1.12830725 NA 1.510000 NA 8.7 79.52400  
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## 109 NA NA 64.95536 2.448000 76 32.7 68.99900  
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## 207 7.814858 14.564046119 4.24 10.9 NA  
## 208 10.571792 2.495475918 2.94 57.8 NA  
## 209 31.960429 3.715022680 7.55 1.0 60.401455  
## 210 14.082412 0.667503214 5.17 24.6 39.936124  
## 211 15.256580 3.424702887 8.32 33.7 NA  
## 212 20.801064 3.339607900 3.85 24.2 37.704187  
## 213 8.633428 0.001897299 NA 5.9 NA  
## 214 26.363626 NA 3.13 15.4 NA  
## 215 34.832360 0.363929741 2.07 3.7 NA  
## 216 24.308592 0.463125713 7.82 83.0 98.412566  
## 217 19.494180 0.626431594 14.77 82.4 51.607617

compVals <- c()  
for (i in 1:17) {  
 compVals[i] = sum(!is.na(wb[,i]))  
}  
hist(compVals,   
 breaks=10,  
 xlab="Number of Countries with Present Data",  
 main="Frequency of Present Country Data for Different Variables by Count")



compPers <- compVals / 217  
hist(compPers,  
 breaks=10,  
 xlab="Percent of Countries with Present Data",  
 main="Frequency of Present Country Data for Different Variables by Percent")



*Most of the countries in the dataset record/report data about most of the different variables in the dataset, except for 2 variables.*

**(2) Simulations with the Exponential Distribution** *(40 points)*.

For this problem, we’ll investigate the sampling distributional characteristics of three statistics. In particular, suppose we take a sample of size 20 from an exponential distribution. We can use the CLT to say something about how far the sample mean is likely to be from the true mean, but how far are the sample median or the sample variance likely to be from the true values in an exponential distribution where we take a sample of size 20? Also, what do we expect the distribution of these statistics to look like?

(2.1) *(10 points)* First, let’s get a quick sense of what an exponential distribution looks like where the mean is 4. By the way, it’s handy to know that for an exponential distribution with mean 4, the variance is 16 and the median is 4\*ln(2). You can read about the exponential distribution [HERE](https://en.wikipedia.org/wiki/Exponential_distribution).

The code below gives a quick plot of this distribution. Your job is to succinctly answer what each part of the code does. You’ll probably need to get help on the function dexp(), seq() and on a few of the graphics parameters in par().

Then, add additional code that repeats the original code but uses the option by = 4 in the seq() function. Why did I choose by = .1 in the original code?

Finally, modify the code to produce a plot that shows the shape of exponential distributions with means of 1, 2, and 4 all on the same plot using different colors and line types for each distribution. Be sure to add a legend to your plot.

#Get exponential probabilities - note that rate = .5 gives us mean of 2 (mean is 1/rate)  
probs <- dexp(seq(0, 20, by = .1), rate = .25)  
  
#dexp: gets the y values of an exponential distribution at a specified rate for various x values  
#rate: specifies the rate of the exp dist, which is one over the expected time between two events  
#by: the increments between adjacent x levels  
  
#Plot sampling distribution  
plot(seq(0, 20, by = .1), probs,   
 type = 'l',   
 lwd = 3,   
 col = "blue",  
 main = "Probability Distribution Function for Exponential Dist with Mean = 4",  
 xlab = "X",  
 ylab = "Density")  
  
#type = 'l' DESCRIBE HERE  
#lwd DESCRIBE HERE)  
  
#Add code below based on instructions  
dexp(c(0, 1), rate = .25)

*The first line gets the y levels of an exponential distribution with rate 0.25 at various x levels, namely the points generated by seq(0, 20, by = .1), which are 0, 0.1, 0.2, …, 19.9, 20.*

(2.2) *(4 points)* Following the example in class 8, get a random sample of 20 observations from an exponential distribution with mean 4. Repeat this process 10000 times. Save your results in a matrix called samples with 10,000 rows and 20 columns. Display the dimension of samples'. Show the first 3 rows ofsamples` but round the values to two decimal places.

# To make grading easier, please leave the following line of code in your assignment  
set.seed(230)   
  
# FILL IN REMAINING CODE

(2.3) *(4 points)* Calculate the sample mean for each sample of size 20 (i.e. calculate the mean for each row of samples). Repeat this process to get the sample median and the sample variance for each sample of size 20. Save these values in objects called, respectively, smeans, smedians, svariance.

*REPLACE THIS TEXT WITH YOUR R-chunk Code*`

(2.4) *(9 points)*

* Create a sample histogram of the sample means (make the bars green, make sure you label your axes and put on a clear title).
* Make a normal quantile plot of the sample means using the qqPlot() function in the car package. Comment on whether the CLT seems to be in effect.
* Get summary statistics OF THE SAMPLE MEANS and save this to an object called ans1. Using code, display only the element of ans1 that is the sample mean, rounded to two decimal places. Is this the value you expect?
* Calculate and display the sample standard deviation of the sample means (use the function sd())and display rounded to two decimal places. Then, use code to calculate the value you’d expect based on the CLT, again rounded to two decimal places. Are the two values similar?

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

*REPLACE THIS TEXT WITH YOUR Answer - make sure it’s in italics*

(2.5) *(7 points)*

* Create a sample histogram of the sample MEDIANS (make the bars red, make sure you label your axes and put on a clear title).
* Make a normal quantile plot of the sample medians using the qqPlot() function in the car package. Do the medians seem normally distributed?
* Display summary statistics OF THE SAMPLE MEDIANS. Is the median of the sample medians the value you expect?
* Calculate and display the sample standard deviation of the sample medians and display rounded to two decimal places. Is this value similar to the value you would expect? *Note that (despite what AI may tell you - I was given an incorrect answer twice), the standard deviation of the sample median is the same as the standard deviation of the sample mean.*

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

*REPLACE THIS TEXT WITH YOUR Answer - make sure it’s in italics*

(2.6) *(6 points)*

* Create a sample histogram of the sample VARIANCES (make the bars blue, make sure you label your axes and put on a clear title).
* Make a normal quantile plot of the sample VARIANCES using the qqPlot() function in the car package. Do the variances seem normally distributed?
* Display summary statistics OF THE SAMPLE VARIANCES Is the mean of the sample variances the value you expect?

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

*REPLACE THIS TEXT WITH YOUR Answer - make sure it’s in italics*

**(3) Iron Concentration and the Bootstrap** *(50 points, 5 points each part, parts 3.5 and 3.8 count double*.

This problem examines results of a study looking at iron concentration in the the water runoff of watersheds with different mining histories above different rock types. The data is [HERE](http://reuningscherer.net/S&DS230/data/ironminerock.csv). The variables are Rock, Mine, Iron (concentration) and LogIron which is the natural log of iron concentration.

(3.1) Read the data into an object called iron. Show the first 6 rows of the data. Show the unique values of Rock and Mine. Then modify iron so that it only contains data for Unmined locations. How many observations remain? How many remaining observations do you have for each rock type? Incidentally, the rock types are Limestone and Sandstone.

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

*REPLACE THIS TEXT WITH YOUR Answer - make sure it’s in italics*

(3.2) Make side by side boxplots of iron concentration by rock type. Make this same plot for the natural log of the iron concentration. Write a sentence or two about what you observe. Which scale do you prefer?

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

*REPLACE THIS TEXT WITH YOUR Answer - make sure it’s in italics*

(3.3) Calculate summary statistics for iron concentration by treatment on the raw scale and the log scale.

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

(3.4) Calculate a two-sample t-test comparing mean log iron concentration between treatments. Save results in an object called test1 and display the results. Use alpha = .01 (i.e. make a 99% CI). Is there evidence of a difference between rock types?

Create an object called ‘test2’ that has similar results for the raw iron concentration. Is there evidence of a difference between rock types?

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

*REPLACE THIS TEXT WITH YOUR Answer - make sure it’s in italics*

(3.5) Get 10,000 boostrap samples from the data and calculate the difference the in mean log iron concentration between rock types for each bootstrap sample. Save these means in an object called diffLogIron. In your code, use variable names that make sense.

# To make grading easier, please leave the following line of code in your assignment  
set.seed(230)   
  
# FILL IN REMAINING CODE

(3.6) Calculate a 99% Bootstrap confidence interval. Show your results.

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

(3.7) Make a histogram of bootstrap differences in means and add vertical lines for the theoretical and bootstrapped confidence intervals. Make a normal quantile plot of the bootstrapped differences. Discuss what you observe in both plots.

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

*REPLACE THIS TEXT WITH YOUR Answer - make sure it’s in italics*

3.8) Finally, repeat 3.5 through 3.7 for iron concentrations on the raw scale. Discuss your results. Note that you’ll need to add the option xlim = c(-1, 12) to your histogram.

*REPLACE THIS TEXT WITH YOUR R-chunk Code*

*REPLACE THIS TEXT WITH YOUR Answer - make sure it’s in italics*