**Scientific Methods for Health Sciences: Fundamentals (HS550): Fall 2014**

[**http://www.socr.umich.edu/people/dinov/2014/Fall/HS550/**](http://www.socr.umich.edu/people/dinov/2014/Fall/HS550/)

**Homework 2[[1]](#footnote-1) Solutions**

**Problem 1**

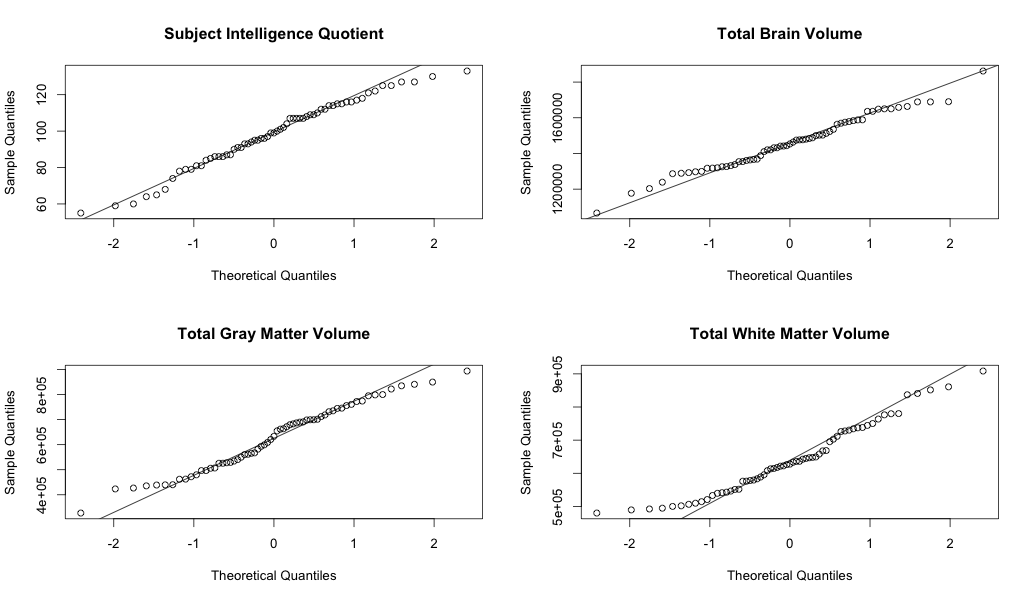
For the data:

FS\_IQ: Subject Intelligence Quotient. Mean = 98.57, Median = 99.00, Q1 = 86, Q3 = 113.00; standard deviation = 18.77345, variance = 352.4424.

TBV: Total Brain Volume. Mean = 1457412, Median = 1453510, Q1 = 1345940, Q3 = 1572110; standard deviation = 149031.2, variance = 22210301914.

GMV: Total Gray Matter Volume. Mean = 625505, Median = 633171, Q1 = 525699, Q3 = 725130; standard deviation = 132095.3, variance = 17449170245.

WMV: Total White Matter Volume. Mean = 640832, Median = 627691, Q1 = 551516, Q3 = 726837; standard deviation = 105770.7, variance = 11187445353.



By fitting a normal distribution to the four variables listed above, we can see that the Subject Intelligence Quotient follows a normal distribution pretty well except for a slight heavy tails on the ends with several outliers on the right end. Total Brian Volume has a heavier tail on the right end while the dataset as a whole follow the normal distribution decently. The Total Gray Matter Volume has heavy tails on both ends compared to the other three variables and Total White Matter Volume didn’t follow a normal distribution as tightly as other three variables given there is several discordance in the middle as well as heavy tails on both ends.

RCODE:

data <- read.csv('~/HW2Prob1.csv')

attach(data)

dim(data)

summary(data)

sd(FS\_IQ)

var(FS\_IQ)

sd(TBV)

var(TBV)

sd(GMV)

var(GMV)

sd(WMV)

var(WMV)

par(mfrow=c(2,2))

qqnorm(FS\_IQ,main='Subject Intelligence Quotient')

qqline(FS\_IQ)

qqnorm(TBV,main='Total Brain Volume')

qqline(TBV)

qqnorm(GMV,main='Total Gray Matter Volume')

qqline(GMV)

qqnorm(WMV,main='Total White Matter Volume')

qqline(WMV)

**Problem 2**

In R simulate a timeseries of a clinical data with 1000 observations with two parameter sets for and , the plot of the two time series are plotted as below. It is obvious that they are two completely different timeseries of data. They all became stationary after some point in the time series. For the first timeseries, it became stationary when t is around 237 and the second one reaches a stationary status when t is around 123. Both series have an increasing pattern but the shape of the two series are totally different: the slope first series increases slowly at first then with it began to increase sharply and achieves a stationary at infinity when t is around 237 while the second series increases sharply from the beginning and achieves stationary when t is round 123, so it’s a lot faster in approaching a stationary status, which should be caused by the fact that the second timeseries is generated using a bigger v as well as a much .

Below we demonstrate how to solve the problem using a simple spreadsheet software or using R.

1. **Spreadsheet data generation**

Open any spreadsheet software (e.g, Excel) and enter the first rows in these 3 columns as show below. Note that columns 1, 2, 3 and 4 contain the time variable (0≤t≤999), the [randomly sampled Z values](http://wiki.socr.umich.edu/index.php/SOCR_EduMaterials_Activities_RNG), and two explicit instances of the time-series (generically expressed as: , were we have chosen the triples of parameters (, v, sigma) differently in the two series. Everyone’s solutions will be different, as the Z samples will be distinct and the triples of parameters will vary. Here are the explicit functions for the columns 3 (C) and 4 (D):

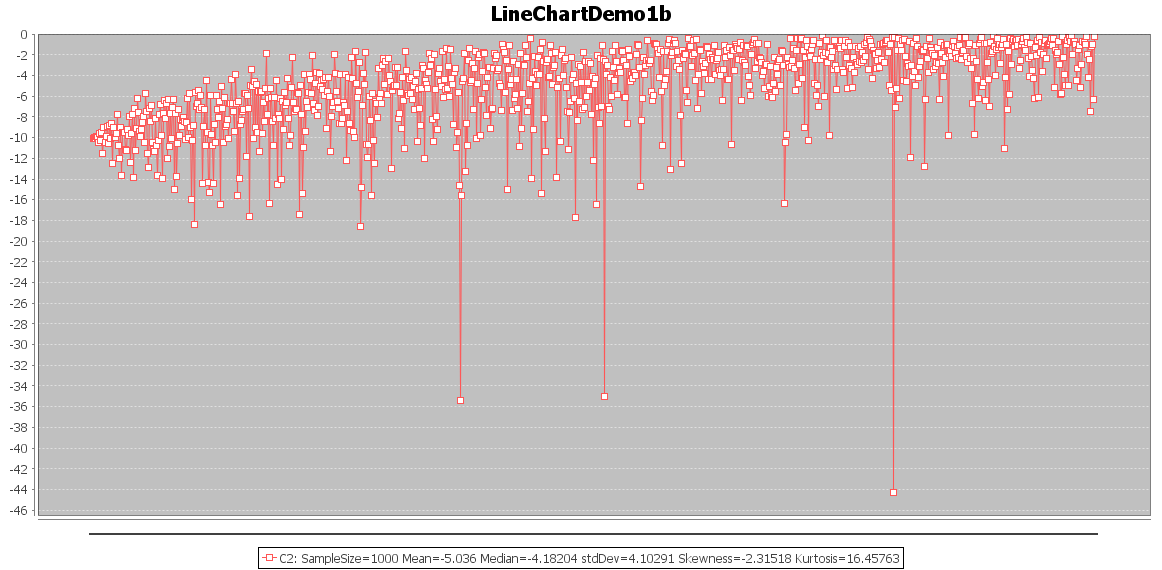
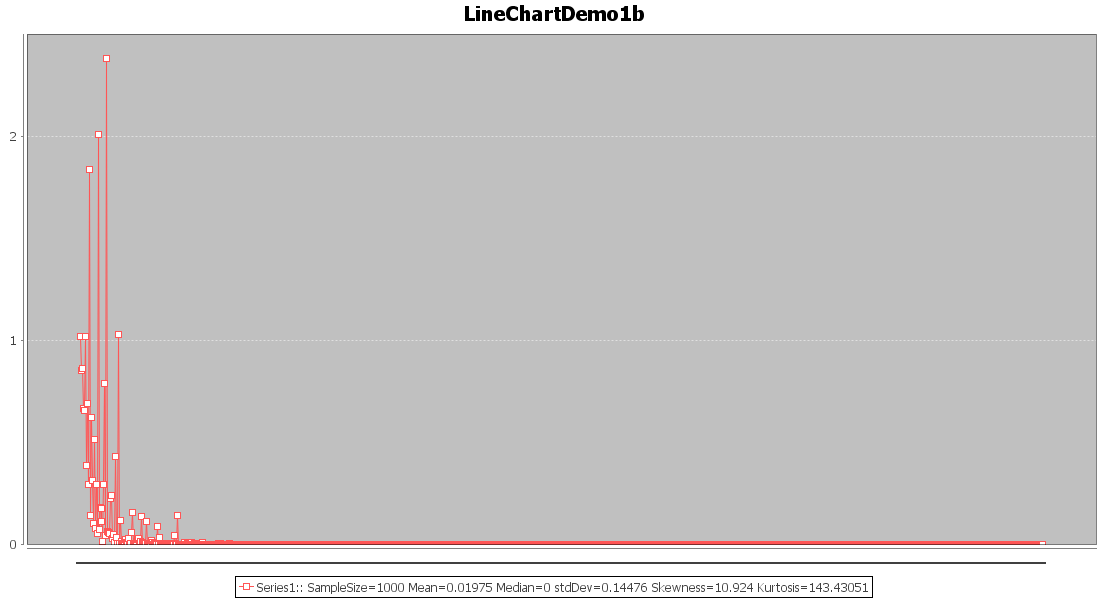
= 1\*EXP(-0.1\*A2+SQRT(0.1)\*SQRT(A2)\*B2)

=-10\*EXP(-0.002\*A2+SQRT(0.001)\*SQRT(A2)\*B2)

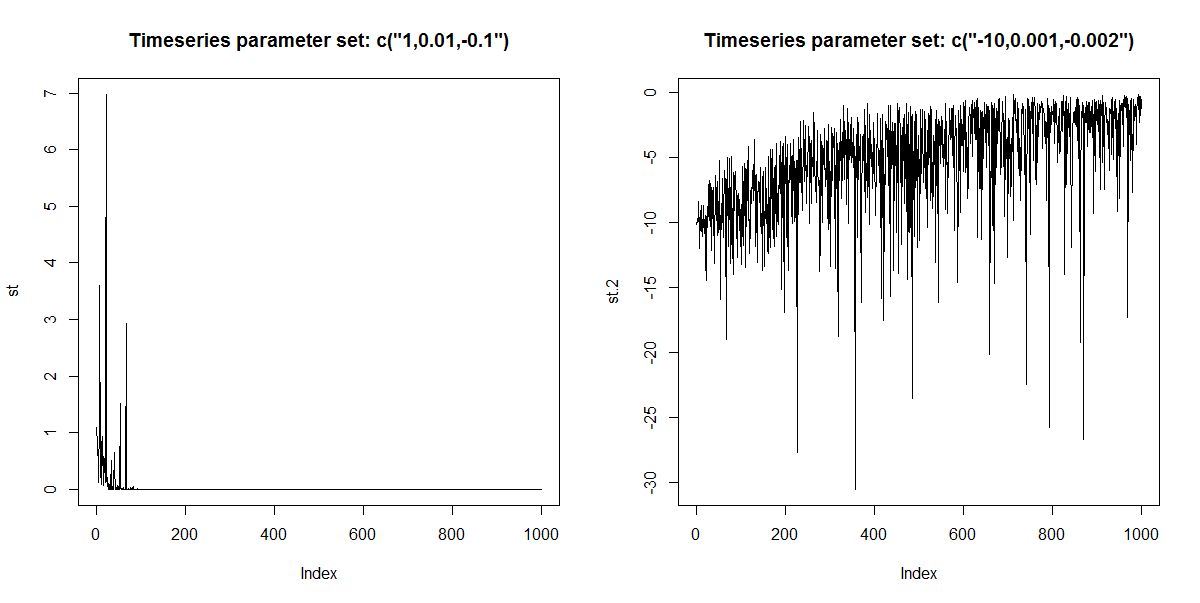
|  |  |  |  |
| --- | --- | --- | --- |
| Time | Z\_scores | Series1: 1\*exp(-0.1\*t+sqrt(0.1)\*sqrt(t)\*z) | Series2: -10\*exp(-0.002\*t+sqrt(0.001)\*sqrt(t)\*z) |
| 1 | 0.964149356 | 1.227391023 | -10.28898775 |
| 2 | -0.743054415 | 0.587250363 | -9.634541264 |
| 3 | 0.294293276 | 0.870394315 | -10.10170478 |
| 4 | 0.125028527 | 0.725477648 | -9.999075026 |
| 5 | -0.533244979 | 0.416003693 | -9.534139408 |
| 6 | 0.114662343 | 0.599785654 | -9.968865637 |
| 7 | 0.663462724 | 0.86510252 | -10.42382829 |
| 8 | -0.598492884 | 0.263077054 | -9.328313729 |
| 9 | -0.28341978 | 0.310716111 | -9.561049791 |
| 10 | -1.457651263 | 0.085635851 | -8.472452064 |
| 11 | -0.683980244 | 0.162453328 | -9.10522696 |
| 12 | 1.557027241 | 1.658042824 | -11.57848786 |
| 13 | -0.10032077 | 0.243075478 | -9.632538221 |
| 14 | 1.535400471 | 1.516963042 | -11.66107214 |
| 15 | -0.683107755 | 0.096652547 | -8.925584548 |
| 16 | 1.290650667 | 1.033094129 | -11.40259457 |
| 17 | -0.846743198 | 0.060566214 | -8.655398992 |
| 18 | -1.192371448 | 0.033382143 | -8.220340868 |
| 19 | 0.352147736 | 0.243023327 | -10.10595959 |
| 20 | -1.017887459 | 0.032080393 | -8.319765489 |
| … | … | … See appendix at the end … | … |

Finally, you can copy and paste these series into SOCR Line Chart

(<http://wiki.socr.umich.edu/index.php/SOCR_EduMaterials_Activities_LineChart>) to get the individual plots:



1. **R data generation**



RCODE:

z <- rnorm(1000,0,1)

t <- seq(0,999,by=1)

# set 1 parameters

**s0** <- 1 # arbitrary value for s0

**sig2** <- 0.1 # arbitrary value for sigma^2

**v** <- -0.1 # arbitrary value for the slope constant v

st <- s0\*exp(v\*t+sqrt(sig2)\*sqrt(t)\*z)

# set 2 parameters

**s0.2** <- -10 # arbitrary value for s0

**sig2.2** <- 0.001 # arbitrary value for sigma^2

**v.2** <- -0.002 # arbitrary value for the slope constant v

**st.2** <- s0.2\*exp(v.2\*t+sqrt(sig2.2)\*sqrt(t)\*z)

par(mfrow=c(1,2))

plot(st,main='Timeseries parameter set: c("1,0.01,-0.1")',type='l')

plot(st.2,main='Timeseries parameter set: c("-10,0.001,-0.002")',type='l')

min(which((st=='Inf')=='TRUE')) # when the timeesries get stationary # 238

t[min(which((st=='Inf')=='TRUE'))] # 237

min(which((st.2=='0')=='TRUE')) # when the timeesries get stationary #124

t[min(which((st.2=='0')=='TRUE'))] # 123

**Problem 3**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | Disease Status | | Test Performance |
|  | | Disease | No Disease |  |
| Screening Test | Positive | TP=123 | FP=13 | PPV=TP/(TP + FP) |
| Negative | FN=23 | TN=856 | NPV=TN/(FN + TN) |
| Test Performance | | Sensitivity=  TP/(TP + FN) | Specificity=  TN/(FP + TN) |  |

* PPV (positive predictive values)
* NPV (negative predictive values)

**Problem 4**

The CLT provides the means to estimate , in general for any sample-size . With a sample of 10 TBI patient, the sampling standard deviation where is the standard deviation of the raw cognitive performance measure.

only depends on the process standard deviation, , which is affected by the shape of the original process.

For , the cohort study should have 4 patients, and , the cohort should have 100 patients.

From the SOCR Modeler of Beta(generalized) Distribution, we have the probability that a randomly chosen TBI patient will have a cognitive test exceeding 90 is 0. 011806, that is 1.11806%. (<http://socr.ucla.edu/htmls/dist/BetaGeneral_Distribution.html>)

Generating 1000 random scores following a Generalized Beta using SOCR Modeler: there are 26 scores greater than 90 out of 1000, so, the proportion of cognitive scores above 90 is 0.026, that is 2.6%. This value is a bigger compared to what we got in the theoretical case, which is not unexpected since a sample size of 1000 may not be sufficiently enough to mimic a theoretical case of randomly chosen TBI patient, and the random essence of simulation could have contributed to this discrepancy as well.

Here is the list of random cognitive scores generated in SOCR Modeler for reference:

|  |  |  |  |
| --- | --- | --- | --- |
| Time | Z\_scores | Series1: 1\*exp(-0.1\*t+sqrt(0.1)\*sqrt(t)\*z) | Series2: -10\*exp(-0.002\*t+sqrt(0.001)\*sqrt(t)\*z) |
| 1 | 0.370828067 | 1.017416052 | -10.0977407 |
| 2 | 0.08653249 | 0.85103545 | -9.998698591 |
| 3 | 0.271281576 | 0.859492688 | -10.08898058 |
| 4 | -0.012406854 | 0.665080772 | -9.912537942 |
| 5 | 0.106029781 | 0.653753034 | -9.975005665 |
| 6 | 0.795699267 | 1.016480329 | -10.50887032 |
| 7 | -0.304519062 | 0.384897226 | -9.612912054 |
| 8 | 0.478112448 | 0.689103896 | -10.27125041 |
| 9 | -0.350213367 | 0.291638117 | -9.500656826 |
| 10 | 1.608061121 | 1.836866483 | -11.51201422 |
| 11 | -0.823101881 | 0.140397649 | -8.973335337 |
| 12 | 0.659769517 | 0.620481987 | -10.49458303 |
| 13 | 0.117859195 | 0.311729379 | -9.875165881 |
| 14 | -0.757118771 | 0.100677291 | -8.890662706 |
| 15 | 0.678217421 | 0.51203787 | -10.5449748 |
| 16 | -0.753458206 | 0.077843286 | -8.804644187 |
| 17 | 0.359609993 | 0.291963661 | -10.12970807 |
| 18 | -0.863739181 | 0.051879699 | -8.590889846 |
| 19 | 1.884666109 | 2.009393535 | -12.48300836 |
| 20 | -0.471114953 | 0.069511911 | -8.988620401 |
| 21 | 0.257486554 | 0.177840796 | -9.953243118 |
| 22 | 0.307894224 | 0.174938803 | -10.01669486 |
| 23 | 0.064711646 | 0.110597264 | -9.644608939 |
| 24 | -1.341842407 | 0.011347324 | -7.742369372 |
| 25 | 0.802745681 | 0.292074132 | -10.79961332 |
| 26 | 1.465243631 | 0.788702856 | -12.02332519 |
| 27 | -0.319990856 | 0.039724044 | -8.989032562 |
| 28 | 2.192351437 | 2.383346573 | -13.64585285 |
| 29 | 0.055104862 | 0.060436636 | -9.525468563 |
| 30 | 0.076706546 | 0.056861297 | -9.543602707 |
| 31 | 0.060941559 | 0.050151778 | -9.500220052 |
| 32 | 0.947008426 | 0.221808734 | -11.1116167 |
| 33 | 1.022112058 | 0.236161062 | -11.27131462 |
| 34 | -0.078281009 | 0.028887594 | -9.208719327 |
| 35 | 0.243605842 | 0.047631775 | -9.758703689 |
| 36 | -0.797247883 | 0.006019979 | -7.99901127 |
| 37 | 1.486214398 | 0.431188675 | -12.35998379 |
| 38 | 0.173541006 | 0.031376179 | -9.587061824 |
| 39 | -0.90882493 | 0.003363459 | -7.729982123 |
| 40 | 2.014090796 | 1.028582449 | -13.81014203 |
| 41 | -1.21586562 | 0.001413141 | -7.202232656 |
| 42 | 0.986496139 | 0.113235617 | -11.2543716 |
| 43 | -0.005840666 | 0.013405215 | -9.164835632 |
| 44 | -1.839853741 | 0.000258838 | -6.225502217 |
| 45 | -0.882851275 | 0.001707354 | -7.578414857 |
| 46 | 0.167004794 | 0.014381471 | -9.453675719 |
| 47 | 0.402074879 | 0.021746066 | -9.931910434 |
| 48 | 0.084011038 | 0.009892869 | -9.253399422 |
| 49 | -0.253111828 | 0.004252336 | -8.572474249 |
| 50 | -0.577407032 | 0.001852681 | -7.952393525 |
| 51 | 0.671146771 | 0.027755058 | -10.50815238 |
| 52 | -2.008073771 | 5.6622E-05 | -5.7011837 |
| 53 | -0.782429583 | 0.000824043 | -7.511658467 |
| 54 | 1.069438994 | 0.054212252 | -11.50866532 |
| 55 | 1.548621991 | 0.154407587 | -12.88120333 |
| 56 | -0.931287824 | 0.000408169 | -7.172126332 |
| 57 | -0.215288865 | 0.002001226 | -8.475550281 |
| 58 | -1.067780913 | 0.000231355 | -6.885580181 |
| 59 | 0.6689848 | 0.01391147 | -10.45500631 |
| 60 | 0.921832072 | 0.023707074 | -11.11601558 |
| 61 | 0.993623341 | 0.026097092 | -11.31344628 |
| 62 | -0.304019996 | 0.000951945 | -8.189761074 |
| 63 | 0.807489664 | 0.013936876 | -10.7969468 |
| 64 | 1.742855644 | 0.136574473 | -13.6740048 |
| 65 | 0.602024359 | 0.006977023 | -10.23764682 |
| 66 | -0.460920365 | 0.000416291 | -7.784795272 |
| 67 | -0.99046367 | 9.4799E-05 | -6.768029145 |
| 68 | 0.440953792 | 0.003517048 | -9.792059224 |
| 69 | 1.79354471 | 0.112057464 | -13.95322614 |
| 70 | -0.49282322 | 0.000247553 | -7.630827745 |
| 71 | -1.161561803 | 3.73537E-05 | -6.366675064 |
| 72 | -0.212337229 | 0.000422314 | -8.179320148 |
| 73 | -0.9673597 | 4.94939E-05 | -6.654004771 |
| 74 | 1.208010781 | 0.016344638 | -11.97953232 |
| 75 | -1.149874669 | 2.37231E-05 | -6.281940602 |
| 76 | 0.847208479 | 0.005172457 | -10.84977511 |
| 77 | -0.399007082 | 0.000149652 | -7.674208194 |
| 78 | 0.602173713 | 0.002202372 | -10.12252419 |
| 79 | -0.667789807 | 5.67444E-05 | -7.077281194 |
| 80 | -1.069138884 | 1.63059E-05 | -6.297715515 |
| 81 | 1.993354596 | 0.088317822 | -14.9978035 |
| 82 | -0.364589395 | 9.66876E-05 | -7.645999567 |
| 83 | 1.695005649 | 0.03281938 | -13.80335232 |
| 84 | 0.770234435 | 0.002096159 | -10.56789087 |
| 85 | -0.503532828 | 4.68744E-05 | -7.284736787 |
| 86 | 0.528258806 | 0.00086668 | -9.830609976 |
| 87 | -0.065406643 | 0.000137358 | -8.242411056 |
| 88 | 0.192487627 | 0.000266806 | -8.878975252 |
| 89 | -0.067573157 | 0.000111488 | -8.20239416 |
| 90 | -0.119940992 | 8.61153E-05 | -8.057495654 |
| 91 | 0.029479019 | 0.000122051 | -8.410473669 |
| 92 | 0.669495683 | 0.000769847 | -10.19251052 |
| 93 | 0.093572046 | 0.000121616 | -8.543072597 |
| 94 | -0.952638835 | 4.45833E-06 | -6.187378906 |
| 95 | 0.598410296 | 0.000473397 | -9.944578551 |
| 96 | -1.177326761 | 1.7642E-06 | -5.73050545 |
| 97 | 0.283290576 | 0.000148089 | -8.99631853 |
| 98 | 2.116003921 | 0.041758179 | -15.94266898 |
| 99 | 0.706871938 | 0.000463882 | -10.24712477 |
| 100 | 0.232380864 | 9.46668E-05 | -8.811611801 |
| 101 | 2.556863422 | 0.138877792 | -18.41506354 |
| 102 | -1.136834312 | 9.84869E-07 | -5.671815892 |
| 103 | -0.480272531 | 7.20044E-06 | -6.97580885 |
| 104 | -0.596362839 | 4.4473E-06 | -6.701047492 |
| 105 | -1.233551032 | 5.05781E-07 | -5.435050837 |
| 106 | -0.337436489 | 8.30533E-06 | -7.247986686 |
| 107 | -0.924000714 | 1.09749E-06 | -5.967550635 |
| 108 | -0.409357503 | 5.31336E-06 | -7.043156878 |
| 109 | 1.777936644 | 0.006538053 | -14.46270848 |
| 110 | 0.309547486 | 4.66262E-05 | -8.892874869 |
| 111 | -0.271183488 | 6.12279E-06 | -7.317259009 |
| 112 | 0.895456087 | 0.000273768 | -10.78614045 |
| 113 | -1.727807856 | 3.71572E-08 | -4.462790826 |
| 114 | 0.530776943 | 6.71964E-05 | -9.52381987 |
| 115 | 1.747011789 | 0.003789221 | -14.36831758 |
| 116 | 1.921857221 | 0.006381257 | -15.25864269 |
| 117 | -0.860151034 | 4.37509E-07 | -5.896554349 |
| 118 | 0.590103982 | 5.69734E-05 | -9.672554746 |
| 119 | 0.909293994 | 0.000156373 | -10.7861033 |
| 120 | 1.743369694 | 0.002577874 | -14.38960499 |
| 121 | 0.290196792 | 1.52558E-05 | -8.68441643 |
| 122 | 0.819595552 | 8.80791E-05 | -10.43178622 |
| 123 | -0.775417939 | 2.99996E-07 | -5.957408127 |
| 124 | -0.181282578 | 2.17526E-06 | -7.321014491 |
| 125 | 0.100171561 | 5.31042E-06 | -8.068770271 |
| 126 | -0.484902439 | 6.0307E-07 | -6.543432024 |
| 127 | 2.104958571 | 0.005524588 | -16.42378236 |
| 128 | -1.197954996 | 3.79903E-08 | -5.0429523 |
| 129 | -0.209435763 | 1.17738E-06 | -7.166109867 |
| 130 | 0.839309405 | 4.66039E-05 | -10.43538466 |
| 131 | -0.621247894 | 2.15881E-07 | -6.145567646 |
| 132 | 0.414295347 | 8.33714E-06 | -8.927229205 |
| 133 | 0.352247243 | 6.05041E-06 | -8.715009084 |
| 134 | 0.190770844 | 3.04605E-06 | -8.20233351 |
| 135 | 0.749312958 | 2.15131E-05 | -10.05329311 |
| 136 | -0.346798657 | 3.45273E-07 | -6.703917572 |
| 137 | -0.328866412 | 3.32293E-07 | -6.731917942 |
| 138 | -1.499845244 | 3.86356E-09 | -4.346701639 |
| 139 | -0.314461188 | 2.84539E-07 | -6.735186224 |
| 140 | -0.025720178 | 7.55236E-07 | -7.485452599 |
| 141 | 0.596389036 | 7.06356E-06 | -9.435969956 |
| 142 | -1.772870389 | 8.54344E-10 | -3.859417792 |
| 143 | -0.313961106 | 1.87919E-07 | -6.671599463 |
| 144 | 1.931815596 | 0.00085085 | -15.60603299 |
| 145 | -0.350549912 | 1.32743E-07 | -6.547607158 |
| 146 | 1.630440586 | 0.000231693 | -13.92346528 |
| 147 | 0.423500431 | 2.09433E-06 | -8.766675081 |
| 148 | 0.305205446 | 1.20884E-06 | -8.364528546 |
| 149 | 0.011742705 | 3.53751E-07 | -7.456736396 |
| 150 | -0.035950925 | 2.66142E-07 | -7.305747444 |
| 151 | -0.661784672 | 2.11503E-08 | -5.716884851 |
| 152 | -0.626472385 | 2.17764E-08 | -5.779638821 |
| 153 | 1.200442646 | 2.48056E-05 | -11.77690969 |
| 154 | -0.535233788 | 2.50997E-08 | -5.956864116 |
| 155 | -0.045837298 | 1.54904E-07 | -7.20329767 |
| 156 | 2.221022899 | 0.001083388 | -17.59859114 |
| 157 | -0.984400746 | 3.0733E-09 | -4.945775438 |
| 158 | -1.923422665 | 6.57308E-11 | -3.394103649 |
| 159 | -0.906552685 | 3.34814E-09 | -5.068774062 |
| 160 | 0.816758112 | 2.95218E-06 | -10.06725762 |
| 161 | -1.153349793 | 9.95482E-10 | -4.562203517 |
| 162 | 0.540383529 | 8.11E-07 | -8.989752054 |
| 163 | -0.980034349 | 1.59448E-09 | -4.85939183 |
| 164 | 0.680027269 | 1.18461E-06 | -9.487500045 |
| 165 | -0.641627321 | 5.03777E-09 | -5.539780301 |
| 166 | 1.121570789 | 5.9604E-06 | -11.33106166 |
| 167 | -0.567754304 | 5.49095E-09 | -5.67782763 |
| 168 | -0.635013196 | 3.74524E-09 | -5.508581422 |
| 169 | 0.71416072 | 8.61912E-07 | -9.565604276 |
| 170 | -0.182455583 | 1.95111E-08 | -6.601895 |
| 171 | 0.407591513 | 2.02096E-07 | -8.407573708 |
| 172 | -0.719154325 | 1.71725E-09 | -5.261052298 |
| 173 | -3.255431036 | 4.03816E-14 | -1.826761844 |
| 174 | 0.241769211 | 7.60785E-08 | -7.810234795 |
| 175 | -0.311328195 | 6.82701E-09 | -6.186361834 |
| 176 | 2.012759051 | 0.000105584 | -16.36238158 |
| 177 | -0.694515556 | 1.10666E-09 | -5.240374148 |
| 178 | -0.300863838 | 5.22743E-09 | -6.169701768 |
| 179 | 0.432337659 | 1.04838E-07 | -8.393857622 |
| 180 | 1.016554341 | 1.13699E-06 | -10.73889904 |
| 181 | -0.302272151 | 3.80866E-09 | -6.122595713 |
| 182 | 0.372648477 | 6.11322E-08 | -8.146288027 |
| 183 | -1.019611595 | 1.43923E-10 | -4.483529426 |
| 184 | 1.721874376 | 1.64698E-05 | -14.48606155 |
| 185 | 0.272253621 | 2.9793E-08 | -7.765460839 |
| 186 | 0.400656576 | 4.70498E-08 | -8.193811124 |
| 187 | -0.219026844 | 2.93327E-09 | -6.258059964 |
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1. <http://www.socr.umich.edu/people/dinov/2014/Fall/HS550/HWs.html> [↑](#footnote-ref-1)