NOTE AD: DIEHARD-II AND -III OUTPUT FOR RAND, EXCEL 2003

DIEHARD-II OUTPUT, WH EQUATIONS

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      NOTE: Most of the tests in DIEHARD return a p-value, which
      should be uniform on [0,1) if the input file contains truly
      independent random bits.   Those p-values are obtained by
      p=F(X), where F is the assumed distribution of the sample
      random variable X---often normal. But that assumed F is just
      an asymptotic approximation, for which the fit will be worst
      in the tails. Thus you should not be surprised with
      occasional p-values near 0 or 1, such as .0012 or .9983.
      When a bit stream really FAILS BIG, you will get p's of 0 or
      1 to six or more places.  By all means, do not, as a
      Statistician might, think that a p < .025 or p> .975 means
      that the RNG has "failed the test at the .05 level".  Such
      p's happen among the hundreds that DIEHARD produces, even
      with good RNG's.  So keep in mind that " p happens".
    ::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
    ::            This is the BIRTHDAY SPACINGS TEST                ::
    :: Choose m birthdays in a year of n days.  List the spacings   ::
    :: between the birthdays.  If j is the number of values that    ::
    :: occur more than once in that list, then j is asymptotically  ::
    :: Poisson distributed with mean m^3/(4n).  Experience shows n  ::
    :: must be quite large, say n>=2^18, for comparing the results  ::
    :: to the Poisson distribution with that mean.  This test uses  ::
    :: n=2^24 and m=2^9,  so that the underlying distribution for j ::
    :: is taken to be Poisson with lambda=2^27/(2^26)=2.  A sample  ::
    :: of 500 j's is taken, and a chi-square goodness of fit test   ::
    :: provides a p value.  The first test uses bits 1-24 (counting ::
    :: from the left) from integers in the specified file.          ::
    ::   Then the file is closed and reopened. Next, bits 2-25 are  ::
    :: used to provide birthdays, then 3-26 and so on to bits 9-32. ::
    :: Each set of bits provides a p-value, and the nine p-values   ::
    :: provide a sample for a KSTEST.                               ::
    ::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
 BIRTHDAY SPACINGS TEST, M= 512 N=2**24 LAMBDA=  2.0000
           Results for E:\NEWRAND.BIN
                   For a sample of size 500:     mean
           E:\NEWRAND.BIN  using bits  1 to 24   1.946
  duplicate       number       number
  spacings       observed     expected
        0          76.       67.668
        1         130.      135.335
        2         134.      135.335
        3          94.       90.224
        4          44.       45.112
        5          16.       18.045
  6 to INF          6.        8.282
 Chisquare with  6 d.o.f. =     2.30 p-value=  .109371
  :::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
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          E:\NEWRAND.BIN  using bits  2 to 25   1.970
 duplicate       number       number
 spacings       observed     expected
       0          62.       67.668
       1         145.      135.335
       2         136.      135.335
       3          93.       90.224
       4          42.       45.112
       5          14.       18.045
 6 to INF          8.        8.282
Chisquare with  6 d.o.f. =     2.38 p-value=  .118831
 :::::::::::::::::::::::::::::::::::::::::
                  For a sample of size 500:     mean
          E:\NEWRAND.BIN  using bits  3 to 26   2.022
 duplicate       number       number
 spacings       observed     expected
       0          67.       67.668
       1         139.      135.335
       2         122.      135.335
       3          97.       90.224
       4          44.       45.112
       5          27.       18.045
 6 to INF          4.        8.282
Chisquare with  6 d.o.f. =     8.61 p-value=  .803541
 :::::::::::::::::::::::::::::::::::::::::
                  For a sample of size 500:     mean
          E:\NEWRAND.BIN  using bits  4 to 27   2.094
 duplicate       number       number
 spacings       observed     expected
       0          56.       67.668
       1         138.      135.335
       2         132.      135.335
       3         100.       90.224
       4          41.       45.112
       5          22.       18.045
 6 to INF         11.        8.282
Chisquare with  6 d.o.f. =     5.34 p-value=  .498964
 :::::::::::::::::::::::::::::::::::::::::
                  For a sample of size 500:     mean
          E:\NEWRAND.BIN  using bits  5 to 28   2.038
 duplicate       number       number
 spacings       observed     expected
       0          72.       67.668
       1         119.      135.335
       2         139.      135.335
       3          95.       90.224
       4          48.       45.112
       5          20.       18.045
 6 to INF          7.        8.282
Chisquare with  6 d.o.f. =     3.20 p-value=  .216172
 :::::::::::::::::::::::::::::::::::::::::
                  For a sample of size 500:     mean
          E:\NEWRAND.BIN  using bits  6 to 29   2.078
 duplicate       number       number
 spacings       observed     expected
       0          68.       67.668
       1         118.      135.335
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       2          131.      135.335
       3          110.       90.224
       4           50.       45.112
       5           13.       18.045
  6 to INF         10.        8.282
 Chisquare with  6 d.o.f. =     8.99 p-value=  .825993
  :::::::::::::::::::::::::::::::::::::::::
                 For a sample of size 500:     mean
         E:\NEWRAND.BIN  using bits  7 to 30   2.006
  duplicate       number       number
  spacings       observed     expected
       0           67.       67.668
       1          135.      135.335
       2          129.      135.335
       3          100.       90.224
       4           44.       45.112
       5           19.       18.045
  6 to INF          6.        8.282
 Chisquare with  6 d.o.f. =     2.07 p-value=  .086851
  :::::::::::::::::::::::::::::::::::::::::
                 For a sample of size 500:     mean
         E:\NEWRAND.BIN  using bits  8 to 31   1.942
  duplicate       number       number
  spacings       observed     expected
       0           74.       67.668
       1          131.      135.335
       2          132.      135.335
       3          103.       90.224
       4           40.       45.112
       5           15.       18.045
  6 to INF          5.        8.282
 Chisquare with  6 d.o.f. =     5.02 p-value=  .458284
  :::::::::::::::::::::::::::::::::::::::::
                 For a sample of size 500:     mean
         E:\NEWRAND.BIN  using bits  9 to 32   1.910
  duplicate       number       number
  spacings       observed     expected
       0           82.       67.668
       1          127.      135.335
       2          135.      135.335
       3           98.       90.224
       4           35.       45.112
       5           15.       18.045
  6 to INF          8.        8.282
 Chisquare with  6 d.o.f. =     7.01 p-value=  .680077
  :::::::::::::::::::::::::::::::::::::::::
   The 9 p-values were
        .109371   .118831   .803541   .498964   .216172
        .825993   .086851   .458284   .680077
  A KSTEST for the 9 p-values yields  .408544

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::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::            THE OVERLAPPING 5-PERMUTATION TEST                 ::
:: This is the OPERM5 test.  It looks at a sequence of one mill- :
:: ion 32-bit random integers.  Each set of five consecutive    ::
:: integers can be in one of 120 states, for the 5! possible or- :
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:: derings of five numbers.  Thus the 5th, 6th, 7th,...numbers  ::
:: each provide a state. As many thousands of state transitions ::
:: are observed,  cumulative counts are made of the number of   ::
:: occurences of each state.  Then the quadratic form in the    ::
:: weak inverse of the 120x120 covariance matrix yields a test  ::
:: equivalent to the likelihood ratio test that the 120 cell    ::
:: counts came from the specified (asymptotically) normal dis-  ::
:: tribution with the specified 120x120 covariance matrix (with ::
:: rank 99).  This version uses 1,000,000 integers, twice.      ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
           OPERM5 test for file E:\NEWRAND.BIN
     For a sample of 1,000,000 consecutive 5-tuples,
 chisquare for 99 degrees of freedom=122.767; p-value= .947040
           OPERM5 test for file E:\NEWRAND.BIN
     For a sample of 1,000,000 consecutive 5-tuples,
 chisquare for 99 degrees of freedom= 67.016; p-value= .005756

:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
:: This is the BINARY RANK TEST for 31x31 matrices. The leftmost::
:: 31 bits of 31 random integers from the test sequence are used::
:: to form a 31x31 binary matrix over the field {0,1}. The rank ::
:: is determined. That rank can be from 0 to 31, but ranks< 28  ::
:: are rare, and their counts are pooled with those for rank 28.::
:: Ranks are found for 40,000 such random matrices and a chisqua-:
:: re test is performed on counts for ranks 31,30,29 and <=28.  ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
   Binary rank test for E:\NEWRAND.BIN
         Rank test for 31x31 binary matrices:
        rows from leftmost 31 bits of each 32-bit integer
      rank   observed  expected (o-e)^2/e  sum
        28       218     211.4   .204914     .205
        29      5162    5134.0   .152595     .358
        30     23004   23103.0   .424632     .782
        31     11616   11551.5   .359875    1.142
  chisquare= 1.142 for 3 d. of f.; p-value= .375672
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:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
:: This is the BINARY RANK TEST for 32x32 matrices. A random 32x::
:: 32 binary matrix is formed, each row a 32-bit random integer.::
:: The rank is determined. That rank can be from 0 to 32, ranks ::
:: less than 29 are rare, and their counts are pooled with those::
:: for rank 29.  Ranks are found for 40,000 such random matrices::
:: and a chisquare test is performed on counts for ranks  32,31,::
:: 30 and <=29.                                                 ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
    Binary rank test for E:\NEWRAND.BIN
         Rank test for 32x32 binary matrices:
        rows from leftmost 32 bits of each 32-bit integer
      rank   observed  expected (o-e)^2/e  sum
        29       210     211.4   .009511     .010
        30      5056    5134.0  1.185350    1.195
        31     23178   23103.0   .243170    1.438
        32     11556   11551.5   .001734    1.440
  chisquare= 1.440 for 3 d. of f.; p-value= .418849
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:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
:: This is the BINARY RANK TEST for 6x8 matrices.  From each of ::
:: six random 32-bit integers from the generator under test, a  ::
:: specified byte is chosen, and the resulting six bytes form a ::
:: 6x8 binary matrix whose rank is determined.  That rank can be::
:: from 0 to 6, but ranks 0,1,2,3 are rare; their counts are    ::
:: pooled with those for rank 4. Ranks are found for 100,000    ::
:: random matrices, and a chi-square test is performed on       ::
:: counts for ranks 6,5 and <=4.                                ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
         Binary Rank Test for E:\NEWRAND.BIN
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG E:\NEWRAND.BIN
     b-rank test for bits  1 to  8
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          950       944.3        .034         .034
          r =5        21681     21743.9        .182         .216
          r =6        77369     77311.8        .042         .259
                        p=1-exp(-SUM/2)= .12132
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG E:\NEWRAND.BIN
     b-rank test for bits  2 to  9
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          953       944.3        .080         .080
          r =5        21638     21743.9        .516         .596
          r =6        77409     77311.8        .122         .718
                        p=1-exp(-SUM/2)= .30166
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG E:\NEWRAND.BIN
     b-rank test for bits  3 to 10
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          939       944.3        .030         .030
          r =5        21630     21743.9        .597         .626
          r =6        77431     77311.8        .184         .810
                        p=1-exp(-SUM/2)= .33308
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG E:\NEWRAND.BIN
     b-rank test for bits  4 to 11
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          952       944.3        .063         .063
          r =5        21637     21743.9        .526         .588
          r =6        77411     77311.8        .127         .716
                        p=1-exp(-SUM/2)= .30079
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG E:\NEWRAND.BIN
     b-rank test for bits  5 to 12
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          918       944.3        .733         .733
          r =5        21651     21743.9        .397        1.129
          r =6        77431     77311.8        .184        1.313
                        p=1-exp(-SUM/2)= .48140
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG E:\NEWRAND.BIN
     b-rank test for bits  6 to 13
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          990       944.3       2.212        2.212
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r =5	21815	21743.9	.232	2.444
r =6	77195	77311.8	.176	2.621

p=1-exp(-SUM/2)= .73025

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 7 to 14

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	905	944.3	1.636	1.636
r =5	21698	21743.9	.097	1.733
r =6	77397	77311.8	.094	1.826

p=1-exp(-SUM/2)= .59878

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 8 to 15

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	941	944.3	.012	.012
r =5	21791	21743.9	.102	.114
r =6	77268	77311.8	.025	.138

p=1-exp(-SUM/2)= .06685

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 9 to 16

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	951	944.3	.048	.048
r =5	21605	21743.9	.887	.935
r =6	77444	77311.8	.226	1.161

p=1-exp(-SUM/2)= .44034

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 10 to 17

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	926	944.3	.355	.355
r =5	21733	21743.9	.005	.360
r =6	77341	77311.8	.011	.371

p=1-exp(-SUM/2)= .16939

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 11 to 18

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	946	944.3	.003	.003
r =5	21749	21743.9	.001	.004
r =6	77305	77311.8	.001	.005

p=1-exp(-SUM/2)= .00242

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 12 to 19

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	1012	944.3	4.853	4.853
r =5	21800	21743.9	.145	4.998
r =6	77188	77311.8	.198	5.196

p=1-exp(-SUM/2)= .92559

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 13 to 20

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	927	944.3	.317	.317
r =5	21912	21743.9	1.300	1.617

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     r =6        77161     77311.8        .294       1.911
                   p=1-exp(-SUM/2)= .61532
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 14 to 21
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          962       944.3        .332         .332
     r =5        21758     21743.9        .009         .341
     r =6        77280     77311.8        .013         .354
                   p=1-exp(-SUM/2)= .16220
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 15 to 22
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          992       944.3       2.409       2.409
     r =5        21654     21743.9        .372       2.781
     r =6        77354     77311.8        .023       2.804
                   p=1-exp(-SUM/2)= .75391
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 16 to 23
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          912       944.3       1.105       1.105
     r =5        21617     21743.9        .741       1.846
     r =6        77471     77311.8        .328       2.173
                   p=1-exp(-SUM/2)= .66266
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 17 to 24
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          980       944.3       1.350       1.350
     r =5        21571     21743.9       1.375       2.724
     r =6        77449     77311.8        .243       2.968
                   p=1-exp(-SUM/2)= .77326
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 18 to 25
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          966       944.3        .499         .499
     r =5        21749     21743.9        .001         .500
     r =6        77285     77311.8        .009         .509
                   p=1-exp(-SUM/2)= .22473
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 19 to 26
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          975       944.3        .998         .998
     r =5        21906     21743.9       1.208       2.206
     r =6        77119     77311.8        .481       2.687
                   p=1-exp(-SUM/2)= .73910
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG E:\NEWRAND.BIN
b-rank test for bits 20 to 27
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          960       944.3        .261         .261
     r =5        21742     21743.9        .000         .261
     r =6        77298     77311.8        .002         .264
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                     p=1-exp(-SUM/2)= .12349
         Rank of a 6x8 binary matrix,
      rows formed from eight bits of the RNG E:\NEWRAND.BIN
      b-rank test for bits 21 to 28
                      OBSERVED   EXPECTED     (O-E)^2/E      SUM
           r<=4          913       944.3       1.038       1.038
           r =5        21604     21743.9        .900       1.938
           r =6        77483     77311.8        .379       2.317
                     p=1-exp(-SUM/2)= .68601
         Rank of a 6x8 binary matrix,
      rows formed from eight bits of the RNG E:\NEWRAND.BIN
      b-rank test for bits 22 to 29
                      OBSERVED   EXPECTED     (O-E)^2/E      SUM
           r<=4          949       944.3        .023        .023
           r =5        21671     21743.9        .244        .268
           r =6        77380     77311.8        .060        .328
                     p=1-exp(-SUM/2)= .15124
         Rank of a 6x8 binary matrix,
      rows formed from eight bits of the RNG E:\NEWRAND.BIN
      b-rank test for bits 23 to 30
                      OBSERVED   EXPECTED     (O-E)^2/E      SUM
           r<=4          974       944.3        .934        .934
           r =5        21757     21743.9        .008        .942
           r =6        77269     77311.8        .024        .966
                     p=1-exp(-SUM/2)= .38296
         Rank of a 6x8 binary matrix,
      rows formed from eight bits of the RNG E:\NEWRAND.BIN
      b-rank test for bits 24 to 31
                      OBSERVED   EXPECTED     (O-E)^2/E      SUM
           r<=4          977       944.3       1.132       1.132
           r =5        21641     21743.9        .487       1.619
           r =6        77382     77311.8        .064       1.683
                     p=1-exp(-SUM/2)= .56893
         Rank of a 6x8 binary matrix,
      rows formed from eight bits of the RNG E:\NEWRAND.BIN
      b-rank test for bits 25 to 32
                      OBSERVED   EXPECTED     (O-E)^2/E      SUM
           r<=4          960       944.3        .261        .261
           r =5        21821     21743.9        .273        .534
           r =6        77219     77311.8        .111        .646
                     p=1-exp(-SUM/2)= .27594
    TEST SUMMARY, 25 tests on 100,000 random 6x8 matrices
  These should be 25 uniform [0,1] random variables:
      .121317     .301659     .333080     .300786     .481400
      .730249     .598776     .066852     .440342     .169387
      .002422     .925594     .615324     .162198     .753907
      .662660     .773257     .224733     .739105     .123492
      .686007     .151235     .382956     .568930     .275943
    brank test summary for E:\NEWRAND.BIN
        The KS test for those 25 supposed UNI's yields
                     KS p-value= .727290
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:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::                  THE BITSTREAM TEST                            ::
:: The file under test is viewed as a stream of bits. Call them   ::
:: b1,b2,... .  Consider an alphabet with two "letters", 0 and 1::
:: and think of the stream of bits as a succession of 20-letter  ::
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:: "words", overlapping.  Thus the first word is b1b2...b20, the::
:: second is b2b3...b21, and so on.  The bitstream test counts  ::
:: the number of missing 20-letter (20-bit) words in a string of::
:: 2^21 overlapping 20-letter words.  There are 2^20 possible 20::
:: letter words.  For a truly random string of 2^21+19 bits, the::
:: number of missing words j should be (very close to) normally ::
:: distributed with mean 141,909 and sigma 428.  Thus           ::
::  (j-141909)/428 should be a standard normal variate (z score)::
:: that leads to a uniform [0,1) p value.  The test is repeated ::
:: twenty times.                                                ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
 THE OVERLAPPING 20-tuples BITSTREAM  TEST, 20 BITS PER WORD, N words
   This test uses N=2^21 and samples the bitstream 20 times.
  No. missing words should average  141909. with sigma=428.
---------------------------------------------------------
 tst no  1: 142071 missing words,  .38 sigmas from mean,p-value= .64719
 tst no  2: 141696 missing words, -.50 sigmas from mean,p-value= .30909
 tst no  3: 141613 missing words, -.69 sigmas from mean,p-value= .24436
 tst no  4: 141792 missing words, -.27 sigmas from mean,p-value= .39199
 tst no  5: 142063 missing words,  .36 sigmas from mean,p-value= .64022
 tst no  6: 140700 missing words,-2.83 sigmas from mean p-value= .00236
 tst no  7: 141502 missing words, -.95 sigmas from mean,p-value= .17062
 tst no  8: 142487 missing words, 1.35 sigmas from mean,p-value= .91144
 tst no  9: 142223 missing words,  .73 sigmas from mean,p-value= .76818
 tst no 10: 141045 missing words, 2.02 sigmas from mean,p-value= .02172
 tst no 11: 141989 missing words,  .19 sigmas from mean,p-value= .57384
 tst no 12: 141505 missing words, -.94 sigmas from mean,p-value= .17241
 tst no 13: 141499 missing words, -.96 sigmas from mean,p-value= .16885
 tst no 14: 142248 missing words,  .79 sigmas from mean,p-value= .78561
 tst no 15: 141288 missing words,-1.45 sigmas from mean,p-value= .07329
 tst no 16: 142147 missing words,  .56 sigmas from mean,p-value= .71066
 tst no 17: 141536 missing words, -.87 sigmas from mean,p-value= .19153
 tst no 18: 142070 missing words,  .38 sigmas from mean,p-value= .64632
 tst no 19: 141732 missing words, -.41 sigmas from mean,p-value= .33932
 tst no 20: 141223 missing words,-1.60 sigmas from mean,p-value= .05440
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::             The tests OPSO, OQSO and DNA                     ::
::         OPSO means Overlapping-Pairs-Sparse-Occupancy        ::
:: The OPSO test considers 2-letter words from an alphabet of   ::
:: 1024 letters.  Each letter is determined by a specified ten  ::
:: bits from a 32-bit integer in the sequence to be tested. OPSO::
:: generates  2^21 (overlapping) 2-letter words  (from 2^21+1   ::
:: "keystrokes")  and counts the number of missing words---that ::
:: is 2-letter words which do not appear in the entire sequence.::
:: That count should be very close to normally distributed with ::
:: mean 141,909, sigma 290. Thus (missingwrds-141909)/290 should::
:: be a standard normal variable. The OPSO test takes 32 bits at::
:: a time from the test file and uses a designated set of ten   ::
:: consecutive bits. It then restarts the file for the next de- ::
:: signated 10 bits, and so on.                                 ::
::                                                              ::
::     OQSO means Overlapping-Quadruples-Sparse-Occupancy       ::
::   The test OQSO is similar, except that it considers 4-letter::
:: words from an alphabet of 32 letters, each letter determined ::
:: by a designated string of 5 consecutive bits from the test   ::
:: file, elements of which are assumed 32-bit random integers.  ::
```

```
:: The mean number of missing words in a sequence of 2^21 four- ::
:: letter words,  (2^21+3 "keystrokes"), is again 141909, with  ::
:: sigma = 295.  The mean is based on theory; sigma comes from  ::
:: extensive simulation.                                        ::
::                                                              ::
::    The DNA test considers an alphabet of 4 letters::  ,G,A,T,::
:: determined by two designated bits in the sequence of random  ::
:: integers being tested.  It considers 10-letter words, so that::
:: as in OPSO and OQSO, there are 2^20 possible words, and the  ::
:: mean number of missing words from a string of 2^21  (over-   ::
:: lapping)  10-letter  words (2^21+9 "keystrokes") is 141909.  ::
:: The standard deviation sigma=339 was determined as for OQSO  ::
:: by simulation.  (Sigma for OPSO, 290, is the true value (to  ::
:: three places), not determined by simulation.                 ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
 OPSO test for generator E:\NEWRAND.BIN
  Output: No. missing words (mw), equiv normal variate (z), p-value (p)
                                                           mw     z     p
    OPSO for E:\NEWRAND.BIN  using bits 23 to 32 141824  -.294  .3843
    OPSO for E:\NEWRAND.BIN  using bits 22 to 31 141780  -.446  .3278
    OPSO for E:\NEWRAND.BIN  using bits 21 to 30 142043   .461  .6776
    OPSO for E:\NEWRAND.BIN  using bits 20 to 29 142054   .499  .6911
    OPSO for E:\NEWRAND.BIN  using bits 19 to 28 141888  -.074  .4707
    OPSO for E:\NEWRAND.BIN  using bits 18 to 27 141815  -.325  .3725
    OPSO for E:\NEWRAND.BIN  using bits 17 to 26 141553 -1.229  .1096
    OPSO for E:\NEWRAND.BIN  using bits 16 to 25 142008   .340  .6332
    OPSO for E:\NEWRAND.BIN  using bits 15 to 24 141704  -.708  .2395
    OPSO for E:\NEWRAND.BIN  using bits 14 to 23 142454  1.878  .9698
    OPSO for E:\NEWRAND.BIN  using bits 13 to 22 141960   .175  .5694
    OPSO for E:\NEWRAND.BIN  using bits 12 to 21 141260 -2.239  .0126
    OPSO for E:\NEWRAND.BIN  using bits 11 to 20 141796  -.391  .3480
    OPSO for E:\NEWRAND.BIN  using bits 10 to 19 141782  -.439  .3303
    OPSO for E:\NEWRAND.BIN  using bits  9 to 18 142184   .947  .8282
    OPSO for E:\NEWRAND.BIN  using bits  8 to 17 141936   .092  .5366
    OPSO for E:\NEWRAND.BIN  using bits  7 to 16 141697  -.732  .2320
    OPSO for E:\NEWRAND.BIN  using bits  6 to 15 141908  -.005  .4982
    OPSO for E:\NEWRAND.BIN  using bits  5 to 14 141892  -.060  .4762
    OPSO for E:\NEWRAND.BIN  using bits  4 to 13 141479 -1.484  .0689
    OPSO for E:\NEWRAND.BIN  using bits  3 to 12 141603 -1.056  .1454
    OPSO for E:\NEWRAND.BIN  using bits  2 to 11 141530 -1.308  .0954
    OPSO for E:\NEWRAND.BIN  using bits  1 to 10 142182   .940  .8265
 OQSO test for generator E:\NEWRAND.BIN
  Output: No. missing words (mw), equiv normal variate (z), p-value (p)
                                                           nw     z     p
    OQSO for E:\NEWRAND.BIN  using bits 28 to 32 141905  -.015  .4941
    OQSO for E:\NEWRAND.BIN  using bits 27 to 31 141633  -.937  .1745
    OQSO for E:\NEWRAND.BIN  using bits 26 to 30 142307  1.348  .9112
    OQSO for E:\NEWRAND.BIN  using bits 25 to 29 141825  -.286  .3875
    OQSO for E:\NEWRAND.BIN  using bits 24 to 28 142290  1.290  .9015
    OQSO for E:\NEWRAND.BIN  using bits 23 to 27 142313  1.368  .9144
    OQSO for E:\NEWRAND.BIN  using bits 22 to 26 141969   .202  .5802
    OQSO for E:\NEWRAND.BIN  using bits 21 to 25 141567 -1.160  .1229
    OQSO for E:\NEWRAND.BIN  using bits 20 to 24 141842  -.228  .4097
    OQSO for E:\NEWRAND.BIN  using bits 19 to 23 142035   .426  .6649
    OQSO for E:\NEWRAND.BIN  using bits 18 to 22 141300 -2.066  .0194
    OQSO for E:\NEWRAND.BIN  using bits 17 to 21 141752  -.533  .2969
    OQSO for E:\NEWRAND.BIN  using bits 16 to 20 141979   .236  .5934
```

```
     OQSO for E:\NEWRAND.BIN  using bits 15 to 19 142013   .351  .6374
     OQSO for E:\NEWRAND.BIN  using bits 14 to 18 141698  -.716  .2369
     OQSO for E:\NEWRAND.BIN  using bits 13 to 17 142002   .314  .6233
     OQSO for E:\NEWRAND.BIN  using bits 12 to 16 141644  -.899  .1842
     OQSO for E:\NEWRAND.BIN  using bits 11 to 15 141909  -.001  .4996
     OQSO for E:\NEWRAND.BIN  using bits 10 to 14 142032   .416  .6612
     OQSO for E:\NEWRAND.BIN  using bits  9 to 13 142321  1.395  .9186
     OQSO for E:\NEWRAND.BIN  using bits  8 to 12 141886  -.079  .4685
     OQSO for E:\NEWRAND.BIN  using bits  7 to 11 141690  -.743  .2286
     OQSO for E:\NEWRAND.BIN  using bits  6 to 10 142036   .429  .6662
     OQSO for E:\NEWRAND.BIN  using bits  5 to  9 141872  -.127  .4497
     OQSO for E:\NEWRAND.BIN  using bits  4 to  8 142496  1.989  .9766
     OQSO for E:\NEWRAND.BIN  using bits  3 to  7 141523 -1.310  .0952
     OQSO for E:\NEWRAND.BIN  using bits  2 to  6 142244  1.134  .8717
     OQSO for E:\NEWRAND.BIN  using bits  1 to  5 142288  1.284  .9004

   DNA test for generator E:\NEWRAND.BIN   Output: No. missing words
 (mw), equiv normal variate (z), p-value (p)
                                                       mw     z     p
      DNA for E:\NEWRAND.BIN  using bits 31 to 32 141667  -.715  .2374
      DNA for E:\NEWRAND.BIN  using bits 30 to 31 141808  -.299  .3825
      DNA for E:\NEWRAND.BIN  using bits 29 to 30 141658  -.741  .2292
      DNA for E:\NEWRAND.BIN  using bits 28 to 29 141463 -1.317  .0940
      DNA for E:\NEWRAND.BIN  using bits 27 to 28 141310 -1.768  .0385
      DNA for E:\NEWRAND.BIN  using bits 26 to 27 142301  1.155  .8760
      DNA for E:\NEWRAND.BIN  using bits 25 to 26 141513 -1.169  .1212
      DNA for E:\NEWRAND.BIN  using bits 24 to 25 142394  1.430  .9236
      DNA for E:\NEWRAND.BIN  using bits 23 to 24 142604  2.049  .9798
      DNA for E:\NEWRAND.BIN  using bits 22 to 23 141574  -.989  .1613
      DNA for E:\NEWRAND.BIN  using bits 21 to 22 142076   .492  .6885
      DNA for E:\NEWRAND.BIN  using bits 20 to 21 141115 -2.343  .0096
      DNA for E:\NEWRAND.BIN  using bits 19 to 20 141844  -.193  .4236
      DNA for E:\NEWRAND.BIN  using bits 18 to 19 141564 -1.019  .1542
      DNA for E:\NEWRAND.BIN  using bits 17 to 18 142367  1.350  .9115
      DNA for E:\NEWRAND.BIN  using bits 16 to 17 141709  -.591  .2773
      DNA for E:\NEWRAND.BIN  using bits 15 to 16 141877  -.095  .4620
      DNA for E:\NEWRAND.BIN  using bits 14 to 15 142308  1.176  .8802
      DNA for E:\NEWRAND.BIN  using bits 13 to 14 142228   .940  .8264
      DNA for E:\NEWRAND.BIN  using bits 12 to 13 141947   .111  .5442
      DNA for E:\NEWRAND.BIN  using bits 11 to 12 141866  -.128  .4491
      DNA for E:\NEWRAND.BIN  using bits 10 to 11 141565 -1.016  .1549
      DNA for E:\NEWRAND.BIN  using bits  9 to 10 141743  -.491  .3118
      DNA for E:\NEWRAND.BIN  using bits  8 to  9 141638  -.800  .2117
      DNA for E:\NEWRAND.BIN  using bits  7 to  8 141633  -.815  .2075
      DNA for E:\NEWRAND.BIN  using bits  6 to  7 142042   .391  .6522
      DNA for E:\NEWRAND.BIN  using bits  5 to  6 142317  1.203  .8854
      DNA for E:\NEWRAND.BIN  using bits  4 to  5 141427 -1.423  .0774
      DNA for E:\NEWRAND.BIN  using bits  3 to  4 141474 -1.284  .0995
      DNA for E:\NEWRAND.BIN  using bits  2 to  3 141797  -.331  .3702
      DNA for E:\NEWRAND.BIN  using bits  1 to  2 142204   .869  .8076
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
 :::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
 ::      This is the COUNT-THE-1's TEST on a stream of bytes.     ::
 :: Consider the file under test as a stream of bytes (four per  ::
 :: 32 bit integer).  Each byte can contain from 0 to 8 1's,     ::
 :: with probabilities 1,8,28,56,70,56,28,8,1 over 256.  Now let ::
 :: the stream of bytes provide a string of overlapping  5-letter::
```

```
:: words, each "letter" taking values A,B,C,D,E. The letters are::
:: determined by the number of 1's in a byte::  0,1,or 2 yieldA,::
:: 3 yields B, 4 yields C, 5 yields D and 6,7 or 8 yield E. Thus::
:: we have a monkey at a typewriter hitting five keys with vari-::
:: ous probabilities (37,56,70,56,37 over 256).  There are 5^5  ::
:: possible 5-letter words, and from a string of 256,000 (over- ::
:: lapping) 5-letter words, counts are made on the frequencies  ::
:: for each word.   The quadratic form in the weak inverse of   ::
:: the covariance matrix of the cell counts provides a chisquare::
:: test::  Q5-Q4, the difference of the naive Pearson sums of   ::
:: (OBS-EXP)^2/EXP on counts for 5- and 4-letter cell counts.   ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
   Test results for E:\NEWRAND.BIN
 Chi-square with 5^5-5^4=2500 d.of f. for sample size:2560000
                               chisquare  equiv normal  p-value
  Results fo COUNT-THE-1's in successive bytes:
 byte stream for E:\NEWRAND.BIN   2638.24      1.955      .974710
 byte stream for E:\NEWRAND.BIN   2523.83       .337      .631966
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::     This is the COUNT-THE-1's TEST for specific bytes.       ::
:: Consider the file under test as a stream of 32-bit integers. ::
:: From each integer, a specific byte is chosen , say the left- ::
:: most::  bits 1 to 8. Each byte can contain from 0 to 8 1's,  ::
:: with probabilitie 1,8,28,56,70,56,28,8,1 over 256.  Now let  ::
:: the specified bytes from successive integers provide a string::
:: of (overlapping) 5-letter words, each "letter" taking values ::
:: A,B,C,D,E. The letters are determined  by the number of 1's, ::
:: in that byte::  0,1,or 2 ---> A, 3 ---> B, 4 ---> C, 5 --->D,::
:: and  6,7 or 8 ---> E.  Thus we have a monkey at a typewriter ::
:: hitting five keys with with various probabilities:: 37,56,70,::
:: 56,37 over 256. There are 5^5 possible 5-letter words, and   ::
:: from a string of 256,000 (overlapping) 5-letter words, counts::
:: are made on the frequencies for each word. The quadratic form::
:: in the weak inverse of the covariance matrix of the cell     ::
:: counts provides a chisquare test::  Q5-Q4, the difference of ::
:: the naive Pearson  sums of (OBS-EXP)^2/EXP on counts for 5-  ::
:: and 4-letter cell counts.                                    ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
 Chi-square with 5^5-5^4=2500 d.of f. for sample size: 256000
                      chisquare  equiv normal  p value
  Results for COUNT-THE-1's in specified bytes:
           bits  1 to  8  2443.36      -.801      .211576
           bits  2 to  9  2468.03      -.452      .325607
           bits  3 to 10  2615.71      1.636      .949120
           bits  4 to 11  2417.00     -1.174      .120242
           bits  5 to 12  2459.10      -.578      .281507
           bits  6 to 13  2343.22     -2.217      .013305
           bits  7 to 14  2557.17       .809      .790605
           bits  8 to 15  2491.90      -.114      .454428
           bits  9 to 16  2499.81      -.003      .498932
           bits 10 to 17  2429.40      -.998      .159020
           bits 11 to 18  2493.17      -.097      .461551
           bits 12 to 19  2431.89      -.963      .167705
           bits 13 to 20  2483.46      -.234      .407534
           bits 14 to 21  2486.50      -.191      .424294
           bits 15 to 22  2454.75      -.640      .261094
```

```
           bits 16 to 23  2610.64      1.565      .941167
           bits 17 to 24  2473.63      -.373      .354604
           bits 18 to 25  2538.05       .538      .704738
           bits 19 to 26  2553.24       .753      .774266
           bits 20 to 27  2486.59      -.190      .424808
           bits 21 to 28  2491.85      -.115      .454137
           bits 22 to 29  2464.06      -.508      .305630
           bits 23 to 30  2420.80     -1.120      .131347
           bits 24 to 31  2384.78     -1.629      .051611
           bits 25 to 32  2493.77      -.088      .464876
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::               THIS IS A PARKING LOT TEST                    ::
:: In a square of side 100, randomly "park" a car---a circle of ::
:: radius 1.   Then try to park a 2nd, a 3rd, and so on, each   ::
:: time parking "by ear".  That is, if an attempt to park a car ::
:: causes a crash with one already parked, try again at a new   ::
:: random location. (To avoid path problems, consider parking   ::
:: helicopters rather than cars.)   Each attempt leads to either::
:: a crash or a success, the latter followed by an increment to ::
:: the list of cars already parked. If we plot n:  the number of::
:: attempts, versus k::  the number successfully parked, we geta::
:: curve that should be similar to those provided by a perfect  ::
:: random number generator.  Theory for the behavior of such a  ::
:: random curve seems beyond reach, and as graphics displays are::
:: not available for this battery of tests, a simple characteriz::
:: ation of the random experiment is used: k, the number of cars::
:: successfully parked after n=12,000 attempts. Simulation shows::
:: that k should average 3523 with sigma 21.9 and is very close ::
:: to normally distributed.  Thus (k-3523)/21.9 should be a st- ::
:: andard normal variable, which, converted to a uniform varia- ::
:: ble, provides input to a KSTEST based on a sample of 10.     ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
           CDPARK: result of ten tests on file E:\NEWRAND.BIN
            Of 12,000 tries, the average no. of successes
                 should be 3523 with sigma=21.9
            Successes: 3548    z-score:  1.142 p-value: .873180
            Successes: 3524    z-score:   .046 p-value: .518210
            Successes: 3588    z-score:  2.968 p-value: .998501
            Successes: 3541    z-score:   .822 p-value: .794438
            Successes: 3518    z-score:  -.228 p-value: .409702
            Successes: 3496    z-score: -1.233 p-value: .108811
            Successes: 3514    z-score:  -.411 p-value: .340551
            Successes: 3544    z-score:   .959 p-value: .831196
            Successes: 3535    z-score:   .548 p-value: .708135
            Successes: 3526    z-score:   .137 p-value: .554479

           square size   avg. no.  parked   sample sigma
             100.            3533.400       23.487
            KSTEST for the above 10: p=  .692472
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::               THE MINIMUM DISTANCE TEST                      :
:: It does this 100 times::   choose n=8000 random points in a  ::
:: square of side 10000.  Find d, the minimum distance between  ::
:: the (n^2-n)/2 pairs of points.  If the points are truly inde-::
:: pendent uniform, then d^2, the square of the minimum distance::
```

```
:: should be (very close to) exponentially distributed with mean::
:: .995 .  Thus 1-exp(-d^2/.995) should be uniform on [0,1) and ::
:: a KSTEST on the resulting 100 values serves as a test of uni-::
:: formity for random points in the square. Test numbers=0 mod 5::
:: are printed but the KSTEST is based on the full set of 100   ::
:: random choices of 8000 points in the 10000x10000 square.     ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
               This is the MINIMUM DISTANCE test
              for random integers in the file E:\NEWRAND.BIN
     Sample no.    d^2     avg     equiv uni
           5     .4354   1.0814     .354438
          10    1.8414   1.0164     .842858
          15     .0311    .9865     .030809
          20     .1058    .9136     .100870
          25    1.8697    .9003     .847266
          30    1.0065    .8355     .636356
          35     .3919    .8092     .325524
          40     .2176    .8023     .196451
          45     .3603    .7705     .303765
          50    3.4379    .7985     .968418
          55    1.0189    .8330     .640836
          60     .2207    .8066     .198935
          65    2.9250    .8299     .947118
          70     .0925    .8119     .088729
          75    2.4958    .8291     .918596
          80     .6725    .8448     .491282
          85     .1108    .8622     .105404
          90    1.6608    .8570     .811593
          95     .0296    .8352     .029272
         100     .5591    .8139     .429895
     MINIMUM DISTANCE TEST for E:\NEWRAND.BIN
          Result of KS test on 20 transformed mindist^2's:
                                  p-value= .939413
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::              THE 3DSPHERES TEST                              ::
:: Choose  4000 random points in a cube of edge 1000.  At each  ::
:: point, center a sphere large enough to reach the next closest::
:: point. Then the volume of the smallest such sphere is (very  ::
:: close to) exponentially distributed with mean 120pi/3.  Thus ::
:: the radius cubed is exponential with mean 30. (The mean is   ::
:: obtained by extensive simulation).  The 3DSPHERES test gener-::
:: ates 4000 such spheres 20 times.  Each min radius cubed leads::
:: to a uniform variable by means of 1-exp(-r^3/30.), then a    ::
::  KSTEST is done on the 20 p-values.                          ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
               The 3DSPHERES test for file E:\NEWRAND.BIN
 sample no:  1     r^3=  42.584     p-value= .75816
 sample no:  2     r^3=  25.599     p-value= .57399
 sample no:  3     r^3=   3.328     p-value= .10499
 sample no:  4     r^3=  43.015     p-value= .76160
 sample no:  5     r^3=  51.697     p-value= .82151
 sample no:  6     r^3=    .168     p-value= .00558
 sample no:  7     r^3=  47.010     p-value= .79133
 sample no:  8     r^3=  71.915     p-value= .90902
 sample no:  9     r^3=  20.629     p-value= .49723
 sample no: 10     r^3=  43.043     p-value= .76183
```

```
 sample no: 11     r^3=  34.530     p-value= .68368
 sample no: 12     r^3=   2.826     p-value= .08989
 sample no: 13     r^3=  51.081     p-value= .81781
 sample no: 14     r^3=  31.707     p-value= .65247
 sample no: 15     r^3=    .533     p-value= .01759
 sample no: 16     r^3=  17.362     p-value= .43940
 sample no: 17     r^3=   8.951     p-value= .25796
 sample no: 18     r^3=  52.034     p-value= .82351
 sample no: 19     r^3=   5.494     p-value= .16735
 sample no: 20     r^3=  64.399     p-value= .88312
  A KS test is applied to those 20 p-values.
---------------------------------------------------------
       3DSPHERES test for file E:\NEWRAND.BIN       p-value= .714182
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::      This is the SQEEZE test                                   ::
::  Random integers are floated to get uniforms on [0,1). Start- ::
::  ing with k=2^31=2147483647, the test finds j, the number of  ::
::  iterations necessary to reduce k to 1, using the reduction   ::
::  k=ceiling(k*U), with U provided by floating integers from    ::
::  the file being tested.  Such j's are found 100,000 times,    ::
::  then counts for the number of times j was <=6,7,...,47,>=48  ::
::  are used to provide a chi-square test for cell frequencies.  ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
            RESULTS OF SQUEEZE TEST FOR E:\NEWRAND.BIN
         Table of standardized frequency counts
     ( (obs-exp)/sqrt(exp) )^2
        for j taking values <=6,7,8,...,47,>=48:
       .6      .9     -.1     1.8     1.0     1.4
      1.0     -.4     -.1     2.6     -.2      .3
     -1.3    -1.0     -.6     -.4      .1     -.3
       .0      .9     -.3      .1     1.8     -.5
      -.5      .5      .2     -.7     -.3     -.4
       .2    -1.8      .0     1.4     -.2     -.1
     -1.2    -1.0    -1.2     -.7     -.6    -1.0
       .8
           Chi-square with 42 degrees of freedom: 36.679
              z-score=  -.581  p-value= .296586
___________________________________________________________
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::             The  OVERLAPPING SUMS test                         ::
:: Integers are floated to get a sequence U(1),U(2),... of uni-  ::
:: form [0,1) variables.  Then overlapping sums,                  ::
::   S(1)=U(1)+...+U(100), S2=U(2)+...+U(101),... are formed.    ::
:: The S's are virtually normal with a certain covariance mat-   ::
:: rix.  A linear transformation of the S's converts them to a   ::
:: sequence of independent standard normals, which are converted ::
:: to uniform variables for a KSTEST. The  p-values from ten     ::
:: KSTESTs are given still another KSTEST.                        ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
                Test no.  1      p-value  .469993
                Test no.  2      p-value  .210033
                Test no.  3      p-value  .797027
                Test no.  4      p-value  .769048
                Test no.  5      p-value  .793608
                Test no.  6      p-value  .300951
```

```
                Test no.  7      p-value  .216807
                Test no.  8      p-value  .101375
                Test no.  9      p-value  .853153
                Test no. 10      p-value  .390223
   Results of the OSUM test for E:\NEWRAND.BIN
        KSTEST on the above 10 p-values:  .142921
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::     This is the RUNS test.  It counts runs up, and runs down, ::
:: in a sequence of uniform [0,1) variables, obtained by float-  ::
:: ing the 32-bit integers in the specified file. This example   ::
:: shows how runs are counted:  .123,.357,.789,.425,.224,.416,.95::
:: contains an up-run of length 3, a down-run of length 2 and an ::
:: up-run of (at least) 2, depending on the next values.  The    ::
:: covariance matrices for the runs-up and runs-down are well    ::
:: known, leading to chisquare tests for quadratic forms in the  ::
:: weak inverses of the covariance matrices.  Runs are counted   ::
:: for sequences of length 10,000.  This is done ten times. Then ::
:: repeated.                                                     ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
           The RUNS test for file E:\NEWRAND.BIN
     Up and down runs in a sample of 10000
_________________________________________________
                 Run test for E:\NEWRAND.BIN :
       runs up; ks test for 10 p's: .541349
     runs down; ks test for 10 p's: .169944
                 Run test for E:\NEWRAND.BIN :
       runs up; ks test for 10 p's: .143399
     runs down; ks test for 10 p's: .540852

$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
:: This is the CRAPS TEST. It plays 200,000 games of craps, finds::
:: the number of wins and the number of throws necessary to end  ::
:: each game.  The number of wins should be (very close to) a    ::
:: normal with mean 200000p and variance 200000p(1-p), with      ::
:: p=244/495.  Throws necessary to complete the game can vary    ::
:: from 1 to infinity, but counts for all>21 are lumped with 21. ::
:: A chi-square test is made on the no.-of-throws cell counts.   ::
:: Each 32-bit integer from the test file provides the value for ::
:: the throw of a die, by floating to [0,1), multiplying by 6    ::
:: and taking 1 plus the integer part of the result.             ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
                Results of craps test for E:\NEWRAND.BIN
  No. of wins:  Observed Expected
                                98239    98585.86
                  98239= No. of wins, z-score=-1.551 pvalue= .06041
   Analysis of Throws-per-Game:
 Chisq=  40.25 for 20 degrees of freedom, p=  .99536
               Throws Observed Expected  Chisq     Sum
                  1    66980    66666.7   1.473    1.473
                  2    37296    37654.3   3.410    4.882
                  3    27022    26954.7    .168    5.050
                  4    19210    19313.5    .554    5.605
                  5    14044    13851.4   2.678    8.282
                  6    10154     9943.5   4.454   12.737
                  7     7076     7145.0    .667   13.403
```

```
            8     5063     5139.1   1.126   14.529
            9     3517     3699.9   9.038   23.567
           10     2657     2666.3    .032   23.600
           11     1993     1923.3   2.524   26.124
           12     1450     1388.7   2.702   28.826
           13      974     1003.7    .880   29.706
           14      699      726.1   1.014   30.720
           15      485      525.8   3.171   33.891
           16      392      381.2    .309   34.200
           17      244      276.5   3.829   38.029
           18      215      200.8   1.000   39.029
           19      152      146.0    .248   39.277
           20       97      106.2    .800   40.076
           21      280      287.1    .176   40.252
      SUMMARY  FOR E:\NEWRAND.BIN
          p-value for no. of wins: .060408
          p-value for throws/game: .995359
```

DIEHARD-II OUTPUT, ACTUAL EXCEL 2003 CELL RAND VALUES

```
     NOTE: Most of the tests in DIEHARD return a p-value, which
       should be uniform on [0,1) if the input file contains truly
       independent random bits.   Those p-values are obtained by
       p=F(X), where F is the assumed distribution of the sample
       random variable X---often normal. But that assumed F is just
       an asymptotic approximation, for which the fit will be worst
       in the tails. Thus you should not be surprised with
       occasional p-values near 0 or 1, such as .0012 or .9983.
       When a bit stream really FAILS BIG, you will get p's of 0 or
       1 to six or more places.  By all means, do not, as a
       Statistician might, think that a p < .025 or p> .975 means
       that the RNG has "failed the test at the .05 level".  Such
       p's happen among the hundreds that DIEHARD produces, even
       with good RNG's.  So keep in mind that " p happens".
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::            This is the BIRTHDAY SPACINGS TEST                  ::
:: Choose m birthdays in a year of n days.  List the spacings     ::
:: between the birthdays.  If j is the number of values that      ::
:: occur more than once in that list, then j is asymptotically    ::
:: Poisson distributed with mean m^3/(4n).  Experience shows n    ::
:: must be quite large, say n>=2^18, for comparing the results    ::
:: to the Poisson distribution with that mean.  This test uses    ::
:: n=2^24 and m=2^9,  so that the underlying distribution for j   ::
:: is taken to be Poisson with lambda=2^27/(2^26)=2.  A sample    ::
:: of 500 j's is taken, and a chi-square goodness of fit test     ::
:: provides a p value.  The first test uses bits 1-24 (counting   ::
:: from the left) from integers in the specified file.            ::
::   Then the file is closed and reopened. Next, bits 2-25 are    ::
:: used to provide birthdays, then 3-26 and so on to bits 9-32.   ::
:: Each set of bits provides a p-value, and the nine p-values     ::
:: provide a sample for a KSTEST.                                 ::
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
BIRTHDAY SPACINGS TEST, M= 512 N=2**24 LAMBDA=  2.0000
           Results for C:\NEWTRIAL.BIN
```

```
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  1 to 24   2.070
  duplicate       number       number
  spacings       observed     expected
        0          59.       67.668
        1         126.      135.335
        2         139.      135.335
        3         102.       90.224
        4          51.       45.112
        5          17.       18.045
  6 to INF          6.        8.282
 Chisquare with  6 d.o.f. =     4.85 p-value=  .436587
:::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  2 to 25   2.046
  duplicate       number       number
  spacings       observed     expected
        0          78.       67.668
        1         112.      135.335
        2         140.      135.335
        3          95.       90.224
        4          41.       45.112
        5          26.       18.045
  6 to INF          8.        8.282
 Chisquare with  6 d.o.f. =     9.91 p-value=  .871355
:::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  3 to 26   2.060
  duplicate       number       number
  spacings       observed     expected
        0          65.       67.668
        1         123.      135.335
        2         150.      135.335
        3          84.       90.224
        4          48.       45.112
        5          20.       18.045
  6 to INF         10.        8.282
 Chisquare with  6 d.o.f. =     4.00 p-value=  .323469
:::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  4 to 27   1.978
  duplicate       number       number
  spacings       observed     expected
        0          74.       67.668
        1         129.      135.335
        2         140.      135.335
        3          93.       90.224
        4          35.       45.112
        5          18.       18.045
  6 to INF         11.        8.282
 Chisquare with  6 d.o.f. =     4.29 p-value=  .363066
:::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  5 to 28   2.004
  duplicate       number       number
  spacings       observed     expected
        0          72.       67.668
```

```
       1         128.      135.335
       2         135.      135.335
       3          94.       90.224
       4          42.       45.112
       5          22.       18.045
 6 to INF          7.        8.282
 Chisquare with  6 d.o.f. =     2.11 p-value=  .091066
:::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  6 to 29   2.088
  duplicate       number       number
  spacings       observed     expected
       0          65.       67.668
       1         122.      135.335
       2         144.      135.335
       3          88.       90.224
       4          49.       45.112
       5          21.       18.045
  6 to INF         11.        8.282
 Chisquare with  6 d.o.f. =     3.74 p-value=  .288186
:::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  7 to 30   1.980
  duplicate       number       number
  spacings       observed     expected
       0          70.       67.668
       1         132.      135.335
       2         139.      135.335
       3          85.       90.224
       4          52.       45.112
       5          18.       18.045
  6 to INF          4.        8.282
 Chisquare with  6 d.o.f. =     3.83 p-value=  .300316
:::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  8 to 31   2.128
  duplicate       number       number
  spacings       observed     expected
       0          55.       67.668
       1         128.      135.335
       2         128.      135.335
       3         110.       90.224
       4          52.       45.112
       5          20.       18.045
  6 to INF          7.        8.282
 Chisquare with  6 d.o.f. =     8.96 p-value=  .824360
:::::::::::::::::::::::::::::::::::::::::
                   For a sample of size 500:     mean
           C:\NEWTRIAL.BIN using bits  9 to 32   2.026
  duplicate       number       number
  spacings       observed     expected
       0          69.       67.668
       1         127.      135.335
       2         139.      135.335
       3          87.       90.224
       4          52.       45.112
       5          18.       18.045
```

```
  6 to INF          8.        8.282
 Chisquare with  6 d.o.f. =     1.82 p-value=  .064139
:::::::::::::::::::::::::::::::::::::::::
   The 9 p-values were
        .436587   .871355   .323469   .363066   .091066
        .288186   .300316   .824360   .064139
  A KSTEST for the 9 p-values yields  .619251

$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::            THE OVERLAPPING 5-PERMUTATION TEST                 ::
:: This is the OPERM5 test.  It looks at a sequence of one mill- ::
:: ion 32-bit random integers.  Each set of five consecutive     ::
:: integers can be in one of 120 states, for the 5! possible or- ::
:: derings of five numbers.  Thus the 5th, 6th, 7th,...numbers   ::
:: each provide a state. As many thousands of state transitions  ::
:: are observed,  cumulative counts are made of the number of    ::
:: occurences of each state.  Then the quadratic form in the     ::
:: weak inverse of the 120x120 covariance matrix yields a test   ::
:: equivalent to the likelihood ratio test that the 120 cell     ::
:: counts came from the specified (asymptotically) normal dis-   ::
:: tribution with the specified 120x120 covariance matrix (with  ::
:: rank 99).  This version uses 1,000,000 integers, twice.       ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
           OPERM5 test for file C:\NEWTRIAL.BIN
     For a sample of 1,000,000 consecutive 5-tuples,
 chisquare for 99 degrees of freedom=132.103; p-value= .985283
           OPERM5 test for file C:\NEWTRIAL.BIN
     For a sample of 1,000,000 consecutive 5-tuples,
 chisquare for 99 degrees of freedom= 97.785; p-value= .484315
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
:: This is the BINARY RANK TEST for 31x31 matrices. The leftmost ::
:: 31 bits of 31 random integers from the test sequence are used ::
:: to form a 31x31 binary matrix over the field {0,1}. The rank  ::
:: is determined. That rank can be from 0 to 31, but ranks< 28   ::
:: are rare, and their counts are pooled with those for rank 28. ::
:: Ranks are found for 40,000 such random matrices and a chisqua-::
:: re test is performed on counts for ranks 31,30,29 and <=28.   ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
    Binary rank test for C:\NEWTRIAL.BIN
         Rank test for 31x31 binary matrices:
        rows from leftmost 31 bits of each 32-bit integer
      rank   observed  expected (o-e)^2/e  sum
        28       187     211.4  2.820192    2.820
        29      4954    5134.0  6.311575    9.132
        30     23339   23103.0  2.409807   11.542
        31     11520   11551.5   .086031   11.628
  chisquare=11.628 for 3 d. of f.; p-value= .991551
--------------------------------------------------------------
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
:: This is the BINARY RANK TEST for 32x32 matrices. A random 32x ::
:: 32 binary matrix is formed, each row a 32-bit random integer. ::
:: The rank is determined. That rank can be from 0 to 32, ranks  ::
:: less than 29 are rare, and their counts are pooled with those ::
:: for rank 29.  Ranks are found for 40,000 such random matrices ::
:: and a chisquare test is performed on counts for ranks  32,31, ::
:: 30 and <=29.                                                  ::
```

```
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
    Binary rank test for C:\NEWTRIAL.BIN
         Rank test for 32x32 binary matrices:
        rows from leftmost 32 bits of each 32-bit integer
      rank   observed  expected (o-e)^2/e  sum
        29       228     211.4  1.300562    1.301
        30      5105    5134.0   .163925    1.464
        31     23126   23103.0   .022804    1.487
        32     11541   11551.5   .009589    1.497
  chisquare= 1.497 for 3 d. of f.; p-value= .427586
--------------------------------------------------------------
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
:: This is the BINARY RANK TEST for 6x8 matrices.  From each of  ::
:: six random 32-bit integers from the generator under test, a   ::
:: specified byte is chosen, and the resulting six bytes form a  ::
:: 6x8 binary matrix whose rank is determined.  That rank can be ::
:: from 0 to 6, but ranks 0,1,2,3 are rare; their counts are     ::
:: pooled with those for rank 4. Ranks are found for 100,000     ::
:: random matrices, and a chi-square test is performed on        ::
:: counts for ranks 6,5 and <=4.                                 ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
         Binary Rank Test for C:\NEWTRIAL.BIN
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
     b-rank test for bits  1 to  8
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          948       944.3        .014         .014
          r =5        21737     21743.9        .002         .017
          r =6        77315     77311.8        .000         .017
                        p=1-exp(-SUM/2)= .00837
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
     b-rank test for bits  2 to  9
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          968       944.3        .595         .595
          r =5        21724     21743.9        .018         .613
          r =6        77308     77311.8        .000         .613
                        p=1-exp(-SUM/2)= .26404
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
     b-rank test for bits  3 to 10
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          900       944.3       2.078        2.078
          r =5        21643     21743.9        .468        2.547
          r =6        77457     77311.8        .273        2.819
                        p=1-exp(-SUM/2)= .75577
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
     b-rank test for bits  4 to 11
                     OBSERVED   EXPECTED     (O-E)^2/E      SUM
          r<=4          971       944.3        .755         .755
          r =5        21714     21743.9        .041         .796
          r =6        77315     77311.8        .000         .796
                        p=1-exp(-SUM/2)= .32838
        Rank of a 6x8 binary matrix,
     rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
```

```
b-rank test for bits  5 to 12
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          919       944.3        .678         .678
     r =5        21689     21743.9        .139         .817
     r =6        77392     77311.8        .083         .900
                   p=1-exp(-SUM/2)= .36228
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits  6 to 13
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          921       944.3        .575         .575
     r =5        21627     21743.9        .628        1.203
     r =6        77452     77311.8        .254        1.458
                   p=1-exp(-SUM/2)= .51753
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits  7 to 14
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          988       944.3       2.022        2.022
     r =5        21603     21743.9        .913        2.935
     r =6        77409     77311.8        .122        3.057
                   p=1-exp(-SUM/2)= .78319
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits  8 to 15
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          883       944.3       3.979        3.979
     r =5        21932     21743.9       1.627        5.607
     r =6        77185     77311.8        .208        5.815
                   p=1-exp(-SUM/2)= .94538
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits  9 to 16
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          929       944.3        .248         .248
     r =5        21738     21743.9        .002         .250
     r =6        77333     77311.8        .006         .255
                   p=1-exp(-SUM/2)= .11986
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 10 to 17
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          949       944.3        .023         .023
     r =5        22010     21743.9       3.256        3.280
     r =6        77041     77311.8        .949        4.228
                   p=1-exp(-SUM/2)= .87927
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 11 to 18
                OBSERVED   EXPECTED     (O-E)^2/E      SUM
     r<=4          963       944.3        .370         .370
     r =5        21770     21743.9        .031         .402
     r =6        77267     77311.8        .026         .428
                   p=1-exp(-SUM/2)= .19247
   Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 12 to 19
```

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	955	944.3	.121	.121
r =5	21744	21743.9	.000	.121
r =6	77301	77311.8	.002	.123

p=1-exp(-SUM/2)= .05952

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 13 to 20

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	999	944.3	3.168	3.168
r =5	21714	21743.9	.041	3.210
r =6	77287	77311.8	.008	3.218

p=1-exp(-SUM/2)= .79986

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 14 to 21

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	920	944.3	.625	.625
r =5	21870	21743.9	.731	1.357
r =6	77210	77311.8	.134	1.491

p=1-exp(-SUM/2)= .52544

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 15 to 22

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	961	944.3	.295	.295
r =5	21870	21743.9	.731	1.027
r =6	77169	77311.8	.264	1.290

p=1-exp(-SUM/2)= .47543

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 16 to 23

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	951	944.3	.048	.048
r =5	21666	21743.9	.279	.327
r =6	77383	77311.8	.066	.392

p=1-exp(-SUM/2)= .17806

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 17 to 24

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	945	944.3	.001	.001
r =5	21697	21743.9	.101	.102
r =6	77358	77311.8	.028	.129

p=1-exp(-SUM/2)= .06260

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 18 to 25

	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=4	945	944.3	.001	.001
r =5	21741	21743.9	.000	.001
r =6	77314	77311.8	.000	.001

p=1-exp(-SUM/2)= .00048

Rank of a 6x8 binary matrix,
rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
b-rank test for bits 19 to 26

	OBSERVED	EXPECTED	(O-E)^2/E	SUM

```
        r<=4          976       944.3       1.064       1.064
        r =5        21766     21743.9        .022       1.087
        r =6        77258     77311.8        .037       1.124
                        p=1-exp(-SUM/2)= .42993
      Rank of a 6x8 binary matrix,
   rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
   b-rank test for bits 20 to 27
                   OBSERVED   EXPECTED     (O-E)^2/E      SUM
        r<=4          921       944.3        .575        .575
        r =5        21630     21743.9        .597       1.172
        r =6        77449     77311.8        .243       1.415
                        p=1-exp(-SUM/2)= .50714
      Rank of a 6x8 binary matrix,
   rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
   b-rank test for bits 21 to 28
                   OBSERVED   EXPECTED     (O-E)^2/E      SUM
        r<=4          969       944.3        .646        .646
        r =5        21427     21743.9       4.619       5.265
        r =6        77604     77311.8       1.104       6.369
                        p=1-exp(-SUM/2)= .95860
      Rank of a 6x8 binary matrix,
   rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
   b-rank test for bits 22 to 29
                   OBSERVED   EXPECTED     (O-E)^2/E      SUM
        r<=4          919       944.3        .678        .678
        r =5        21816     21743.9        .239        .917
        r =6        77265     77311.8        .028        .945
                        p=1-exp(-SUM/2)= .37666
      Rank of a 6x8 binary matrix,
   rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
   b-rank test for bits 23 to 30
                   OBSERVED   EXPECTED     (O-E)^2/E      SUM
        r<=4          940       944.3        .020        .020
        r =5        21573     21743.9       1.343       1.363
        r =6        77487     77311.8        .397       1.760
                        p=1-exp(-SUM/2)= .58518
      Rank of a 6x8 binary matrix,
   rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
   b-rank test for bits 24 to 31
                   OBSERVED   EXPECTED     (O-E)^2/E      SUM
        r<=4          913       944.3       1.038       1.038
        r =5        21525     21743.9       2.204       3.241
        r =6        77562     77311.8        .810       4.051
                        p=1-exp(-SUM/2)= .86807
      Rank of a 6x8 binary matrix,
   rows formed from eight bits of the RNG C:\NEWTRIAL.BIN
   b-rank test for bits 25 to 32
                   OBSERVED   EXPECTED     (O-E)^2/E      SUM
        r<=4          992       944.3       2.409       2.409
        r =5        21746     21743.9        .000       2.410
        r =6        77262     77311.8        .032       2.442
                        p=1-exp(-SUM/2)= .70501
 TEST SUMMARY, 25 tests on 100,000 random 6x8 matrices
These should be 25 uniform [0,1] random variables:
   .008369     .264039     .755767     .328377     .362281
   .517533     .783187     .945379     .119861     .879273
   .192474     .059518     .799863     .525440     .475433
```

```
     .178058     .062596     .000483     .429927     .507144
     .958599     .376658     .585181     .868069     .705014
   brank test summary for C:\NEWTRIAL.BIN
       The KS test for those 25 supposed UNI's yields
                    KS p-value= .332375
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::                   THE BITSTREAM TEST                          ::
:: The file under test is viewed as a stream of bits. Call them  ::
:: b1,b2,... .  Consider an alphabet with two "letters", 0 and 1 ::
:: and think of the stream of bits as a succession of 20-letter  ::
:: "words", overlapping.  Thus the first word is b1b2...b20, the ::
:: second is b2b3...b21, and so on.  The bitstream test counts   ::
:: the number of missing 20-letter (20-bit) words in a string of ::
:: 2^21 overlapping 20-letter words.  There are 2^20 possible 20 ::
:: letter words.  For a truly random string of 2^21+19 bits, the ::
:: number of missing words j should be (very close to) normally  ::
:: distributed with mean 141,909 and sigma 428.  Thus            ::
::  (j-141909)/428 should be a standard normal variate (z score) ::
:: that leads to a uniform [0,1) p value.  The test is repeated  ::
:: twenty times.                                                 ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
 THE OVERLAPPING 20-tuples BITSTREAM  TEST, 20 BITS PER WORD, N words
   This test uses N=2^21 and samples the bitstream 20 times.
  No. missing words should average  141909. with sigma=428.
----------------------------------------------------------
tst no  1: 142337 missing words, 1.00 sigmas from mean, p-value= .84116
tst no  2: 141719 missing words, -.44 sigmas from mean, p-value= .32827
tst no  3: 142101 missing words,  .45 sigmas from mean, p-value= .67286
tst no  4: 142246 missing words,  .79 sigmas from mean, p-value= .78425
tst no  5: 142713 missing words, 1.88 sigmas from mean, p-value= .96979
tst no  6: 141813 missing words, -.23 sigmas from mean, p-value= .41096
tst no  7: 141095 missing words,-1.90 sigmas from mean, p-value= .02854
tst no  8: 141979 missing words,  .16 sigmas from mean, p-value= .56466
tst no  9: 141978 missing words,  .16 sigmas from mean, p-value= .56374
tst no 10: 141448 missing words,-1.08 sigmas from mean, p-value= .14055
tst no 11: 142475 missing words, 1.32 sigmas from mean, p-value= .90686
tst no 12: 141784 missing words, -.29 sigmas from mean, p-value= .38483
tst no 13: 142061 missing words,  .35 sigmas from mean, p-value= .63847
tst no 14: 141996 missing words,  .20 sigmas from mean, p-value= .58024
tst no 15: 142554 missing words, 1.51 sigmas from mean, p-value= .93400
tst no 16: 142208 missing words,  .70 sigmas from mean, p-value= .75736
tst no 17: 142268 missing words,  .84 sigmas from mean, p-value= .79899
tst no 18: 141631 missing words, -.65 sigmas from mean, p-value= .25775
tst no 19: 142037 missing words,  .30 sigmas from mean, p-value= .61726
tst no 20: 142568 missing words, 1.54 sigmas from mean, p-value= .93809
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::             The tests OPSO, OQSO and DNA                      ::
::         OPSO means Overlapping-Pairs-Sparse-Occupancy         ::
:: The OPSO test considers 2-letter words from an alphabet of    ::
:: 1024 letters.  Each letter is determined by a specified ten   ::
:: bits from a 32-bit integer in the sequence to be tested. OPSO ::
:: generates  2^21 (overlapping) 2-letter words  (from 2^21+1    ::
:: "keystrokes")  and counts the number of missing words---that  ::
:: is 2-letter words which do not appear in the entire sequence. ::
:: That count should be very close to normally distributed with  ::
```

```
:: mean 141,909, sigma 290. Thus (missingwrds-141909)/290 should ::
:: be a standard normal variable. The OPSO test takes 32 bits at ::
:: a time from the test file and uses a designated set of ten    ::
:: consecutive bits. It then restarts the file for the next de-  ::
:: signated 10 bits, and so on.                                  ::
::                                                               ::
::     OQSO means Overlapping-Quadruples-Sparse-Occupancy        ::
::   The test OQSO is similar, except that it considers 4-letter ::
:: words from an alphabet of 32 letters, each letter determined  ::
:: by a designated string of 5 consecutive bits from the test    ::
:: file, elements of which are assumed 32-bit random integers.   ::
:: The mean number of missing words in a sequence of 2^21 four-  ::
:: letter words,  (2^21+3 "keystrokes"), is again 141909, with   ::
:: sigma = 295.  The mean is based on theory; sigma comes from   ::
:: extensive simulation.                                         ::
::                                                               ::
::    The DNA test considers an alphabet of 4 letters::  C,G,A,T,::
:: determined by two designated bits in the sequence of random   ::
:: integers being tested.  It considers 10-letter words, so that ::
:: as in OPSO and OQSO, there are 2^20 possible words, and the   ::
:: mean number of missing words from a string of 2^21  (over-    ::
:: lapping)  10-letter  words (2^21+9 "keystrokes") is 141909.   ::
:: The standard deviation sigma=339 was determined as for OQSO   ::
:: by simulation.  (Sigma for OPSO, 290, is the true value (to   ::
:: three places), not determined by simulation.                  ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
 OPSO test for generator C:\NEWTRIAL.BIN
  Output: No. missing words (mw), equiv normal variate (z), p-value (p)
                                                           mw     z     p
OPSO for C:\NEWTRIAL.BIN using bits 23 to 32       142407  1.716  .9569
OPSO for C:\NEWTRIAL.BIN using bits 22 to 31       141978   .237  .5936
OPSO for C:\NEWTRIAL.BIN using bits 21 to 30       141547 -1.249  .1058
OPSO for C:\NEWTRIAL.BIN using bits 20 to 29       142198   .995  .8402
OPSO for C:\NEWTRIAL.BIN using bits 19 to 28       141791  -.408  .3416
OPSO for C:\NEWTRIAL.BIN using bits 18 to 27       142334  1.464  .9285
OPSO for C:\NEWTRIAL.BIN using bits 17 to 26       142053   .495  .6898
OPSO for C:\NEWTRIAL.BIN using bits 16 to 25       142485  1.985  .9764
OPSO for C:\NEWTRIAL.BIN using bits 15 to 24       141743  -.574  .2831
OPSO for C:\NEWTRIAL.BIN using bits 14 to 23       141908  -.005  .4982
OPSO for C:\NEWTRIAL.BIN using bits 13 to 22       141575 -1.153  .1245
OPSO for C:\NEWTRIAL.BIN using bits 12 to 21       142416  1.747  .9597
OPSO for C:\NEWTRIAL.BIN using bits 11 to 20       141666  -.839  .2007
OPSO for C:\NEWTRIAL.BIN using bits 10 to 19       141198 -2.453  .0071
OPSO for C:\NEWTRIAL.BIN using bits  9 to 18       141936   .092  .5366
OPSO for C:\NEWTRIAL.BIN using bits  8 to 17       141741  -.580  .2808
OPSO for C:\NEWTRIAL.BIN using bits  7 to 16       141493 -1.436  .0756
OPSO for C:\NEWTRIAL.BIN using bits  6 to 15       141502 -1.405  .0801
OPSO for C:\NEWTRIAL.BIN using bits  5 to 14       141764  -.501  .3081
OPSO for C:\NEWTRIAL.BIN using bits  4 to 13       142181   .937  .8256
OPSO for C:\NEWTRIAL.BIN using bits  3 to 12       142318  1.409  .9206
OPSO for C:\NEWTRIAL.BIN using bits  2 to 11       142220  1.071  .8580
OPSO for C:\NEWTRIAL.BIN using bits  1 to 10       142331  1.454  .9270
OQSO test for generator C:\NEWTRIAL.BIN
  Output: No. missing words (mw), equiv normal variate (z), p-value (p)
                                                           mw     z     p
OQSO for C:\NEWTRIAL.BIN using bits 28 to 32       141818  -.310  .3784
OQSO for C:\NEWTRIAL.BIN using bits 27 to 31       142423  1.741  .9592
```

```
OQSO for C:\NEWTRIAL.BIN using bits 26 to 30       141466 -1.503  .0664
OQSO for C:\NEWTRIAL.BIN using bits 25 to 29       141940   .104  .5414
OQSO for C:\NEWTRIAL.BIN using bits 24 to 28       141917   .026  .5104
OQSO for C:\NEWTRIAL.BIN using bits 23 to 27       141704  -.696  .2432
OQSO for C:\NEWTRIAL.BIN using bits 22 to 26       142065   .528  .7011
OQSO for C:\NEWTRIAL.BIN using bits 21 to 25       141829  -.272  .3927
OQSO for C:\NEWTRIAL.BIN using bits 20 to 24       141681  -.774  .2195
OQSO for C:\NEWTRIAL.BIN using bits 19 to 23       141667  -.821  .2057
OQSO for C:\NEWTRIAL.BIN using bits 18 to 22       141789  -.408  .3417
OQSO for C:\NEWTRIAL.BIN using bits 17 to 21       141618  -.988  .1617
OQSO for C:\NEWTRIAL.BIN using bits 16 to 20       142117   .704  .7593
OQSO for C:\NEWTRIAL.BIN using bits 15 to 19       141947   .128  .5508
OQSO for C:\NEWTRIAL.BIN using bits 14 to 18       142089   .609  .7288
OQSO for C:\NEWTRIAL.BIN using bits 13 to 17       141922   .043  .5171
OQSO for C:\NEWTRIAL.BIN using bits 12 to 16       142332  1.433  .9240
OQSO for C:\NEWTRIAL.BIN using bits 11 to 15       142244  1.134  .8717
OQSO for C:\NEWTRIAL.BIN using bits 10 to 14       141868  -.140  .4443
OQSO for C:\NEWTRIAL.BIN using bits  9 to 13       142271  1.226  .8899
OQSO for C:\NEWTRIAL.BIN using bits  8 to 12       141644  -.899  .1842
OQSO for C:\NEWTRIAL.BIN using bits  7 to 11       142075   .562  .7128
OQSO for C:\NEWTRIAL.BIN using bits  6 to 10       141214 -2.357  .0092
OQSO for C:\NEWTRIAL.BIN using bits  5 to  9       141833  -.259  .3979
OQSO for C:\NEWTRIAL.BIN using bits  4 to  8       141601 -1.045  .1480
OQSO for C:\NEWTRIAL.BIN using bits  3 to  7       142746  2.836  .9977
OQSO for C:\NEWTRIAL.BIN using bits  2 to  6       141963   .182  .5722
OQSO for C:\NEWTRIAL.BIN using bits  1 to  5       141772  -.466  .3208
  DNA test for generator C:\NEWTRIAL.BIN
  Output: No. missing words (mw), equiv normal variate (z), p-value (p)
                                                       mw     z     p
DNA for C:\NEWTRIAL.BIN using bits 31 to 32        141804  -.311  .3780
DNA for C:\NEWTRIAL.BIN using bits 30 to 31        141684  -.665  .2531
DNA for C:\NEWTRIAL.BIN using bits 29 to 30        141976   .197  .5780
DNA for C:\NEWTRIAL.BIN using bits 28 to 29        142491  1.716  .9569
DNA for C:\NEWTRIAL.BIN using bits 27 to 28        141179 -2.154  .0156
DNA for C:\NEWTRIAL.BIN using bits 26 to 27        142259  1.031  .8488
DNA for C:\NEWTRIAL.BIN using bits 25 to 26        141822  -.258  .3984
DNA for C:\NEWTRIAL.BIN using bits 24 to 25        141653  -.756  .2248
DNA for C:\NEWTRIAL.BIN using bits 23 to 24        141651  -.762  .2230
DNA for C:\NEWTRIAL.BIN using bits 22 to 23        142240   .975  .8353
DNA for C:\NEWTRIAL.BIN using bits 21 to 22        142327  1.232  .8910
DNA for C:\NEWTRIAL.BIN using bits 20 to 21        141742  -.494  .3108
DNA for C:\NEWTRIAL.BIN using bits 19 to 20        141095 -2.402  .0081
DNA for C:\NEWTRIAL.BIN using bits 18 to 19        141421 -1.440  .0749
DNA for C:\NEWTRIAL.BIN using bits 17 to 18        142054   .427  .6652
DNA for C:\NEWTRIAL.BIN using bits 16 to 17        141750  -.470  .3192
DNA for C:\NEWTRIAL.BIN using bits 15 to 16        141698  -.623  .2665
DNA for C:\NEWTRIAL.BIN using bits 14 to 15        141687  -.656  .2560
DNA for C:\NEWTRIAL.BIN using bits 13 to 14        142306  1.170  .8790
DNA for C:\NEWTRIAL.BIN using bits 12 to 13        141990   .238  .5940
DNA for C:\NEWTRIAL.BIN using bits 11 to 12        141734  -.517  .3025
DNA for C:\NEWTRIAL.BIN using bits 10 to 11        141845  -.190  .4247
DNA for C:\NEWTRIAL.BIN using bits  9 to 10        141576  -.983  .1627
DNA for C:\NEWTRIAL.BIN using bits  8 to  9        141871  -.113  .4550
DNA for C:\NEWTRIAL.BIN using bits  7 to  8        141516 -1.160  .1230
DNA for C:\NEWTRIAL.BIN using bits  6 to  7        141539 -1.092  .1373
DNA for C:\NEWTRIAL.BIN using bits  5 to  6        141987   .229  .5906
DNA for C:\NEWTRIAL.BIN using bits  4 to  5        142059   .442  .6706
```

```
DNA for C:\NEWTRIAL.BIN using bits  3 to  4        141607  -.892  .1862
DNA for C:\NEWTRIAL.BIN using bits  2 to  3        141955   .135  .5536
DNA for C:\NEWTRIAL.BIN using bits  1 to  2        142075   .489  .6875
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::     This is the COUNT-THE-1's TEST on a stream of bytes.      ::
:: Consider the file under test as a stream of bytes (four per   ::
:: 32 bit integer).  Each byte can contain from 0 to 8 1's,      ::
:: with probabilities 1,8,28,56,70,56,28,8,1 over 256.  Now let  ::
:: the stream of bytes provide a string of overlapping  5-letter ::
:: words, each "letter" taking values A,B,C,D,E. The letters are ::
:: determined by the number of 1's in a byte::  0,1,or 2 yield A,::
:: 3 yields B, 4 yields C, 5 yields D and 6,7 or 8 yield E. Thus ::
:: we have a monkey at a typewriter hitting five keys with vari- ::
:: ous probabilities (37,56,70,56,37 over 256).  There are 5^5   ::
:: possible 5-letter words, and from a string of 256,000 (over-  ::
:: lapping) 5-letter words, counts are made on the frequencies   ::
:: for each word.   The quadratic form in the weak inverse of    ::
:: the covariance matrix of the cell counts provides a chisquare ::
:: test::  Q5-Q4, the difference of the naive Pearson sums of    ::
:: (OBS-EXP)^2/EXP on counts for 5- and 4-letter cell counts.    ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
   Test results for C:\NEWTRIAL.BIN
 Chi-square with 5^5-5^4=2500 d.of f. for sample size:2560000
                               chisquare  equiv normal  p-value
  Results fo COUNT-THE-1's in successive bytes:
 byte stream for C:\NEWTRIAL.BIN  2542.57       .602      .726423
 byte stream for C:\NEWTRIAL.BIN  2509.56       .135      .553763
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::     This is the COUNT-THE-1's TEST for specific bytes.        ::
:: Consider the file under test as a stream of 32-bit integers.  ::
:: From each integer, a specific byte is chosen , say the left-  ::
:: most::  bits 1 to 8. Each byte can contain from 0 to 8 1's,   ::
:: with probabilitie 1,8,28,56,70,56,28,8,1 over 256.  Now let   ::
:: the specified bytes from successive integers provide a string ::
:: of (overlapping) 5-letter words, each "letter" taking values  ::
:: A,B,C,D,E. The letters are determined  by the number of 1's,  ::
:: in that byte::  0,1,or 2 ---> A, 3 ---> B, 4 ---> C, 5 ---> D,::
:: and  6,7 or 8 ---> E.  Thus we have a monkey at a typewriter  ::
:: hitting five keys with with various probabilities::  37,56,70,::
:: 56,37 over 256. There are 5^5 possible 5-letter words, and    ::
:: from a string of 256,000 (overlapping) 5-letter words, counts ::
:: are made on the frequencies for each word. The quadratic form ::
:: in the weak inverse of the covariance matrix of the cell      ::
:: counts provides a chisquare test::  Q5-Q4, the difference of  ::
:: the naive Pearson  sums of (OBS-EXP)^2/EXP on counts for 5-   ::
:: and 4-letter cell counts.                                     ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
 Chi-square with 5^5-5^4=2500 d.of f. for sample size: 256000
                      chisquare  equiv normal  p value
  Results for COUNT-THE-1's in specified bytes:
           bits  1 to  8  2377.10     -1.738      .041096
           bits  2 to  9  2503.83       .054      .521602
           bits  3 to 10  2491.66      -.118      .453029
           bits  4 to 11  2532.00       .453      .674558
           bits  5 to 12  2554.97       .777      .781531
```

```
           bits  6 to 13  2551.51       .729      .766847
           bits  7 to 14  2429.62      -.995      .159801
           bits  8 to 15  2493.81      -.088      .465095
           bits  9 to 16  2369.62     -1.844      .032598
           bits 10 to 17  2519.32       .273      .607642
           bits 11 to 18  2684.09      2.603      .995386
           bits 12 to 19  2510.65       .151      .559833
           bits 13 to 20  2465.64      -.486      .313487
           bits 14 to 21  2543.91       .621      .732707
           bits 15 to 22  2606.80      1.510      .934522
           bits 16 to 23  2566.30       .938      .825770
           bits 17 to 24  2614.41      1.618      .947164
           bits 18 to 25  2464.74      -.499      .308990
           bits 19 to 26  2599.10      1.401      .919463
           bits 20 to 27  2463.24      -.520      .301600
           bits 21 to 28  2581.93      1.159      .876716
           bits 22 to 29  2638.38      1.957      .974829
           bits 23 to 30  2469.93      -.425      .335340
           bits 24 to 31  2456.57      -.614      .269546
           bits 25 to 32  2505.13       .073      .528916
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::                THIS IS A PARKING LOT TEST                      ::
:: In a square of side 100, randomly "park" a car---a circle of  ::
:: radius 1.   Then try to park a 2nd, a 3rd, and so on, each    ::
:: time parking "by ear".  That is, if an attempt to park a car  ::
:: causes a crash with one already parked, try again at a new    ::
:: random location. (To avoid path problems, consider parking    ::
:: helicopters rather than cars.)   Each attempt leads to either ::
:: a crash or a success, the latter followed by an increment to  ::
:: the list of cars already parked. If we plot n:  the number of ::
:: attempts, versus k::  the number successfully parked, we get a::
:: curve that should be similar to those provided by a perfect   ::
:: random number generator.  Theory for the behavior of such a   ::
:: random curve seems beyond reach, and as graphics displays are ::
:: not available for this battery of tests, a simple characteriz ::
:: ation of the random experiment is used: k, the number of cars ::
:: successfully parked after n=12,000 attempts. Simulation shows ::
:: that k should average 3523 with sigma 21.9 and is very close  ::
:: to normally distributed.  Thus (k-3523)/21.9 should be a st-  ::
:: andard normal variable, which, converted to a uniform varia-  ::
:: ble, provides input to a KSTEST based on a sample of 10.      ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
          CDPARK: result of ten tests on file C:\NEWTRIAL.BIN
            Of 12,000 tries, the average no. of successes
                 should be 3523 with sigma=21.9
            Successes: 3493    z-score: -1.370 p-value: .085365
            Successes: 3527    z-score:   .183 p-value: .572463
            Successes: 3523    z-score:   .000 p-value: .500000
            Successes: 3520    z-score:  -.137 p-value: .445521
            Successes: 3556    z-score:  1.507 p-value: .934075
            Successes: 3537    z-score:   .639 p-value: .738676
            Successes: 3573    z-score:  2.283 p-value: .988788
            Successes: 3494    z-score: -1.324 p-value: .092718
            Successes: 3594    z-score:  3.242 p-value: .999407
            Successes: 3552    z-score:  1.324 p-value: .907282
```

```
          square size   avg. no.  parked   sample sigma
            100.            3536.900       30.815
           KSTEST for the above 10: p=  .937632
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::               THE MINIMUM DISTANCE TEST                       ::
:: It does this 100 times::   choose n=8000 random points in a   ::
:: square of side 10000.  Find d, the minimum distance between   ::
:: the (n^2-n)/2 pairs of points.  If the points are truly inde- ::
:: pendent uniform, then d^2, the square of the minimum distance ::
:: should be (very close to) exponentially distributed with mean ::
:: .995 .  Thus 1-exp(-d^2/.995) should be uniform on [0,1) and  ::
:: a KSTEST on the resulting 100 values serves as a test of uni- ::
:: formity for random points in the square. Test numbers=0 mod 5 ::
:: are printed but the KSTEST is based on the full set of 100    ::
:: random choices of 8000 points in the 10000x10000 square.      ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
               This is the MINIMUM DISTANCE test
               for random integers in the file C:\NEWTRIAL.BIN
     Sample no.    d^2     avg     equiv uni
           5    1.0496   1.7265     .651763
          10    3.7585   1.7693     .977119
          15     .1927   1.4565     .176092
          20    1.2579   1.4485     .717539
          25     .0388   1.3062     .038204
          30     .3881   1.3274     .323009
          35    1.6405   1.2555     .807706
          40     .2165   1.3474     .195546
          45     .4151   1.3345     .341100
          50    1.1583   1.2903     .687805
          55     .3658   1.2666     .307604
          60    1.0225   1.2174     .642149
          65     .5886   1.1981     .446520
          70     .1915   1.1542     .175110
          75    1.0674   1.1113     .657936
          80     .2990   1.1034     .259577
          85     .8494   1.0974     .574165
          90     .0339   1.0734     .033501
          95     .7040   1.0668     .507132
         100    3.3530   1.1130     .965604
     MINIMUM DISTANCE TEST for C:\NEWTRIAL.BIN
          Result of KS test on 20 transformed mindist^2's:
                                  p-value= .394877
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::              THE 3DSPHERES TEST                               ::
:: Choose  4000 random points in a cube of edge 1000.  At each   ::
:: point, center a sphere large enough to reach the next closest ::
:: point. Then the volume of the smallest such sphere is (very   ::
:: close to) exponentially distributed with mean 120pi/3.  Thus  ::
:: the radius cubed is exponential with mean 30. (The mean is    ::
:: obtained by extensive simulation).  The 3DSPHERES test gener- ::
:: ates 4000 such spheres 20 times.  Each min radius cubed leads ::
:: to a uniform variable by means of 1-exp(-r^3/30.), then a     ::
::  KSTEST is done on the 20 p-values.                           ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
               The 3DSPHERES test for file C:\NEWTRIAL.BIN
```

```
 sample no:  1     r^3=  43.520     p-value= .76558
 sample no:  2     r^3=  34.289     p-value= .68112
 sample no:  3     r^3=  55.659     p-value= .84359
 sample no:  4     r^3=  46.601     p-value= .78847
 sample no:  5     r^3=   9.307     p-value= .26672
 sample no:  6     r^3=  29.105     p-value= .62098
 sample no:  7     r^3= 183.193     p-value= .99777
 sample no:  8     r^3=   6.726     p-value= .20086
 sample no:  9     r^3=  25.453     p-value= .57191
 sample no: 10     r^3=   9.712     p-value= .27655
 sample no: 11     r^3=  33.646     p-value= .67421
 sample no: 12     r^3=   6.372     p-value= .19136
 sample no: 13     r^3=   6.948     p-value= .20674
 sample no: 14     r^3=  55.552     p-value= .84303
 sample no: 15     r^3=  17.992     p-value= .45104
 sample no: 16     r^3=  50.923     p-value= .81685
 sample no: 17     r^3=  48.009     p-value= .79817
 sample no: 18     r^3=  11.319     p-value= .31429
 sample no: 19     r^3=  27.822     p-value= .60442
 sample no: 20     r^3=  49.011     p-value= .80479
  A KS test is applied to those 20 p-values.
---------------------------------------------------------
       3DSPHERES test for file C:\NEWTRIAL.BIN      p-value= .818458
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::      This is the SQEEZE test                                  ::
::  Random integers are floated to get uniforms on [0,1). Start- ::
::  ing with k=2^31=2147483647, the test finds j, the number of  ::
::  iterations necessary to reduce k to 1, using the reduction   ::
::  k=ceiling(k*U), with U provided by floating integers from    ::
::  the file being tested.  Such j's are found 100,000 times,    ::
::  then counts for the number of times j was <=6,7,...,47,>=48  ::
::  are used to provide a chi-square test for cell frequencies.  ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
           RESULTS OF SQUEEZE TEST FOR C:\NEWTRIAL.BIN
         Table of standardized frequency counts
     ( (obs-exp)/sqrt(exp) )^2
        for j taking values <=6,7,8,...,47,>=48:
    -1.5      .1     -.6    -1.3    -2.0    -1.7
      .2      .3     -.6      .2     1.7      .2
     -.6     -.3      .2      .6      .9      .0
     -.2    -1.1    -1.2      .4     -.5     -.2
     1.3      .2      .6     -.2      .7    -1.4
     -.5     1.4      .4     -.1     -.5     -.1
      .5    -1.0     -.8      .4      .1     1.0
     -.1
           Chi-square with 42 degrees of freedom: 29.578
              z-score= -1.355  p-value= .074415
______________________________________________________________

$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::             The  OVERLAPPING SUMS test                        ::
:: Integers are floated to get a sequence U(1),U(2),... of uni-  ::
:: form [0,1) variables.  Then overlapping sums,                 ::
::   S(1)=U(1)+...+U(100), S2=U(2)+...+U(101),... are formed.    ::
:: The S's are virtually normal with a certain covariance mat-   ::
```

```
:: rix.  A linear transformation of the S's converts them to a   ::
:: sequence of independent standard normals, which are converted ::
:: to uniform variables for a KSTEST. The  p-values from ten     ::
:: KSTESTs are given still another KSTEST.                       ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
                Test no.  1      p-value  .805616
                Test no.  2      p-value  .430210
                Test no.  3      p-value  .676714
                Test no.  4      p-value  .167088
                Test no.  5      p-value  .319450
                Test no.  6      p-value  .081973
                Test no.  7      p-value  .361865
                Test no.  8      p-value  .350203
                Test no.  9      p-value  .328437
                Test no. 10      p-value  .948970
   Results of the OSUM test for C:\NEWTRIAL.BIN
        KSTEST on the above 10 p-values:  .296157
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
::     This is the RUNS test.  It counts runs up, and runs down, ::
:: in a sequence of uniform [0,1) variables, obtained by float-  ::
:: ing the 32-bit integers in the specified file. This example   ::
:: shows how runs are counted:  .123,.357,.789,.425,.224,.416,.95::
:: contains an up-run of length 3, a down-run of length 2 and an ::
:: up-run of (at least) 2, depending on the next values.  The    ::
:: covariance matrices for the runs-up and runs-down are well    ::
:: known, leading to chisquare tests for quadratic forms in the  ::
:: weak inverses of the covariance matrices.  Runs are counted   ::
:: for sequences of length 10,000.  This is done ten times. Then ::
:: repeated.                                                     ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
          The RUNS test for file C:\NEWTRIAL.BIN
     Up and down runs in a sample of 10000
_________________________________________________
                 Run test for C:\NEWTRIAL.BIN:
       runs up; ks test for 10 p's: .086549
     runs down; ks test for 10 p's: .000898
                 Run test for C:\NEWTRIAL.BIN:
       runs up; ks test for 10 p's: .461576
     runs down; ks test for 10 p's: .808507
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
:: This is the CRAPS TEST. It plays 200,000 games of craps, finds::
:: the number of wins and the number of throws necessary to end  ::
:: each game.  The number of wins should be (very close to) a    ::
:: normal with mean 200000p and variance 200000p(1-p), with      ::
:: p=244/495.  Throws necessary to complete the game can vary    ::
:: from 1 to infinity, but counts for all>21 are lumped with 21. ::
:: A chi-square test is made on the no.-of-throws cell counts.   ::
:: Each 32-bit integer from the test file provides the value for ::
:: the throw of a die, by floating to [0,1), multiplying by 6    ::
:: and taking 1 plus the integer part of the result.             ::
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
                Results of craps test for C:\NEWTRIAL.BIN
  No. of wins:  Observed Expected
                                98678    98585.86
                 98678= No. of wins, z-score=  .412 pvalue= .65987
```

Analysis of Throws-per-Game:
Chisq= 30.00 for 20 degrees of freedom, p= .93012

Throws	Observed	Expected	Chisq	Sum
1	66577	66666.7	.121	.121
2	37670	37654.3	.007	.127
3	26751	26954.7	1.540	1.667
4	19319	19313.5	.002	1.669
5	13930	13851.4	.446	2.114
6	10031	9943.5	.769	2.884
7	7030	7145.0	1.852	4.735
8	5117	5139.1	.095	4.830
9	3824	3699.9	4.165	8.995
10	2799	2666.3	6.605	15.600
11	1931	1923.3	.031	15.630
12	1333	1388.7	2.237	17.868
13	1013	1003.7	.086	17.954
14	692	726.1	1.605	19.559
15	531	525.8	.051	19.609
16	386	381.2	.062	19.671
17	272	276.5	.075	19.746
18	222	200.8	2.232	21.977
19	164	146.0	2.223	24.201
20	90	106.2	2.475	26.676
21	318	287.1	3.322	29.998

SUMMARY FOR C:\NEWTRIAL.BIN
p-value for no. of wins: .659869
p-value for throws/game: .930116
$$

DIEHARD-III OUTPUT, ACTUAL EXCEL 2003 CELL RAND VALUES

NOTE
Most of the tests in DIEHARD return a p-value, which should be uniform on [0,1), if the input file contains truly independent random bits. Those p-values are obtained by p=F(X), where F is the assumed distribution of the sample random variable X---often normal. But that assumed F is often just an approximation, for which the fit will likely be worst in the tails. Thus you should not be surprised with occasional p-values near 0 or 1, such as .0012 or .9983. When a bit stream really FAILS BIG, you will get p`s of 0 or 1 to six or more places. By all means, do not, as a Statistician might, think that a p < .025 or p> .975 means that the RNG has "failed the test at the .05 level". Such p`s happen among the hundreds that DIEHARD produces, even with good RNGs.

So keep in mind that "p happens"

Which tests do you want to perform?

HERE ARE YOUR CHOICES:
1 Birthday Spacings
2 GCD
3 Gorilla
4 Overlapping Permutations
5 Ranks of 31x31 and 32x32 matrices
6 Ranks of 6x8 Matrices
7 Monkey Tests on 20-bit Words

8 Monkey Tests OPSO,OQSO,DNA
9 Count the 1`s in a Stream of Bytes
10 Count the 1`s in Specific Bytes
11 Parking Lot Test
12 Minimum Distance Test
13 Random Spheres Test
14 The Sqeeze Test
15 Overlapping Sums Test
16 Runs Up and Down Test
17 The Craps Test

(All tests were selected)

```
|-------------------------------------------------------------|
|           This is the BIRTHDAY SPACINGS TEST                 |
|Choose m birthdays in a "year" of n days.  List the spacings |
|between the birthdays.  Let j be the number of values that   |
|occur more than once in that list, then j is asymptotically  |
|Poisson distributed with mean m^3/(4n).  Experience shows n  |
|must be quite large, say n>=2^18, for comparing the results  |
|to the Poisson distribution with that mean.  This test uses  |
|n=2^24 and m=2^10, so that the underlying distribution for j |
|is taken to be Poisson with lambda=2^30/(2^26)=16. A sample  |
|of 200 j's is taken, and a chi-square goodness of fit test   |
|provides a p value.  The first test uses bits 1-24 (counting |
|from the left) from 32-bit integers in the specified file.   |
|The file is closed and reopened, then bits 2-25 of the same  |
|integers are used to provide birthdays, and so on to bits    |
|9-32. Each set of bits provides a p-value, and the nine  p-  |
|values provide a sample for a KSTEST.                        |
|------------------------------------------------------------ |
```

RESULTS OF BIRTHDAY SPACINGS FOR newrand2.bin
(no_bdays=1024, no_days/yr=2^24, lambda=16.00, sample size=500)

Bits used	mean	chisqr	p-value
1 to 24	15.73	34.6204	0.993025
2 to 25	15.63	20.2460	0.738159
3 to 26	15.93	16.1953	0.489963
4 to 27	15.75	14.5046	0.368881
5 to 28	15.97	6.1816	0.008120
6 to 29	15.77	13.0799	0.269176
7 to 30	15.61	16.8332	0.534279
8 to 31	15.60	14.4463	0.364705
9 to 32	15.60	22.6172	0.837866

Chisquare degrees of freedom: 17

----

p-value for KStest on those 9 p-values: 0.787217

```
|-------------------------------------------------------------|
|         This is the "tough" BIRTHDAY SPACINGS TEST           |
|Choose 4096 birthdays in a "year" of 2^32 days. Thus each    |
|birthday is a 32-bit integer and the test uses 2^12 of them, |
|so that j, the number of duplicate spacings, is asympotically|
|Poisson distributed with lambda=4 .  Generators that pass the|
|earlier tests for m=1024 and n=2^24 often fail this test, yet|
|those that pass this test seem to pass the "weaker" test.    |
```

```
         |Each set of 4096 birthdays provide a Poisson variate j, and  |
         |500 such j's lead to a chisquare test to see if the result   |
         |is consistent with the Poisson distribution with lambda=16.  |
         |------------------------------------------------------------ |

Tough bday spacings test for newrand2.bin: 4096 birthdays, year=2^32 days
                   Table of Expected vs. Observed counts:
Duplicates   0     1     2     3     4     5     6     7     8     9   >=10
Expected    9.2  36.6  73.3  97.7  97.7  78.1  52.1  29.8  14.9   6.6   4.1
Observed    11    28    75    83   116    74    52    41    14     5     1
(O-E)^2/E   0.4   2.0   0.0   2.2   3.4   0.2   0.0   4.2   0.1   0.4   2.3
                Birthday Spacings: Sum(O-E)^2/E= 15.303, p= 0.879

         |-------------------------------------------------------------|
         |This is the GCD TEST.   Let the (32-bit) RNG produce two     |
         |successive integers u,v.  Use Euclids algorithm to find the|
         |gcd, say x, of u and v. Let k be the number of steps needed|
         |to get x.   Then k is approximately binomial with p=.376    |
         |and n=50,  while the distribution of x is very close to     |
         |  Pr(x=i)=c/i^2, with c=6/pi^2.   The gcd test uses ten     |
         |million such pairs u,v to see if the resulting frequencies |
         |of k's and x's are consistent with the above distributions.|
         |Congruential RNG's---even those with prime modulus---fail  |
         |this test for the distribution of k, the number of steps,  |
         |and often for the distribution of gcd values x as well.    |
         |-------------------------------------------------------------|
                RESULTS OF GCD FOR newrand2.bin
Euclid's algorithm:
 p-value, steps to gcd:   0.209418
 p-value, dist. of gcd's: 0.820534

         |-------------------------------------------------------------|
         |This is the GORILLA test, a strong version of the monkey    |
         |tests that I developed in the 70's. It concerns strings     |
         |formed from specified bits in 32-bit integers from the RNG.|
         |We specify the bit position to be studied, from 0 to 31,   |
         |say bit 3. Then we generate 67,108,889 (2^26+25) numbers   |
         |from the generator and form a string of 2^26+25 bits by     |
         |taking bit 3 from each of those numbers. In that string of |
         |2^26+25 bits we count the number of 26-bit segments that   |
         |do not appear. That count should be approximately normal   |
         |with mean 24687971 and std. deviation 4170. This leads to  |
         |a normal z-score and hence to a p-value. The test is        |
         |applied for each bit position 0 (leftmost) to 31.          |
         |(Some older tests use Fortran's 1-32 for most- to least-   |
         |significant bits. Gorilla and newer tests use C's 0 to 31.)|
         |-------------------------------------------------------------|

 Gorilla test for 2^26 bits, positions 0 to 31 for newrand2.bin:
 Note: lengthy test---for example, ~20 minutes for 850MHz PC
 Bits  0 to  7---> 0.360 0.382 0.529 0.211 0.741 0.021 0.969 0.457
 Bits  8 to 15---> 0.606 0.918 0.975 0.247 0.398 0.213 0.979 0.456
 Bits 16 to 23---> 0.808 0.263 0.008 0.400 0.517 0.642 0.740 0.156
 Bits 24 to 31---> 0.788 0.429 0.551 0.795 0.999 0.615 0.558 0.284
 KS test for the above 32 p values:  0.489
```

```
|-------------------------------------------------------------|
|           THE OVERLAPPING 5-PERMUTATION TEST                |
|This is the OPERM5 test.  It looks at a sequence of ten mill-|
|ion 32-bit random integers.  Each set of five consecutive    |
|integers can be in one of 120 states, for the 5! possible or-|
|derings of five numbers.  Thus the 5th, 6th, 7th,...numbers  |
|each provide a state. As many thousands of state transitions |
|are observed,  cumulative counts are made of the number of   |
|occurences of each state.  Then the quadratic form in the    |
|weak inverse of the 120x120 covariance matrix yields a test  |
|that the 120 cellcounts came from the specified (asymptotic) |
|distribution with the specified means and 120x120 covariance.|
|-------------------------------------------------------------|
```

The OPERM5 test for 10 million (overlapping) 5-tuples for newrand2.bin,
p-values for 5 runs: 0.6344, 0.2554, 0.1665, 0.7111, 0.0663

```
|-------------------------------------------------------------|
|This is the BINARY RANK TEST for 31x31 matrices. The leftmost|
|31 bits of 31 random integers from the test sequence are used|
|to form a 31x31 binary matrix over the field {0,1}. The rank |
|is determined. That rank can be from 0 to 31, but ranks< 28  |
|are rare, and their counts are pooled with those for rank 28.|
|Ranks are found for 40,000 such random matrices and a chisqu-|
|are test is performed on counts for ranks 31,30,28 and <=28. |
| (The 31x31 choice is based on the unjustified popularity of |
|  the proposed "industry standard" generator                 |
|  x(n) = 16807*x(n-1) mod 2^31-1, not a very good one.)      |
|-------------------------------------------------------------|
```

Rank test for binary matrices (31x31) for newrand2.bin

RANK	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=28	216	211.4	0.099	0.099
r= 29	5171	5134.0	0.267	0.366
r= 30	23045	23103.0	0.146	0.512
r= 31	11568	11551.5	0.024	0.535

chi-square = 0.535 with df = 3; p-value = 0.089

```
|-------------------------------------------------------------|
|This is the BINARY RANK TEST for 32x32 matrices. A random 32x|
|32 binary matrix is formed, each row a 32-bit random integer.|
|The rank is determined. That rank can be from 0 to 32. Ranks |
|less than 29 are rare, and their counts are pooled with those|
|for rank 29.  Ranks are found for 40,000 such random matrices|
|and a chisquare test is performed on counts for ranks  32,31,|
|30 and <=29.                                                 |
|-------------------------------------------------------------|
```

Rank test for binary matrices (32x32) for newrand2.bin

RANK	OBSERVED	EXPECTED	(O-E)^2/E	SUM
r<=29	207	211.4	0.092	0.092
r= 30	5203	5134.0	0.927	1.019
r= 31	23090	23103.0	0.007	1.027
r= 32	11500	11551.5	0.230	1.257

chi-square = 1.257 with df = 3; p-value = 0.261

```
 |-------------------------------------------------------------|
 |This is the BINARY RANK TEST for 6x8 matrices.  From each of |
 |six random 32-bit integers from the generator under test, a  |
 |specified byte is chosen, and the resulting six bytes form a |
 |6x8 binary matrix whose rank is determined.  That rank can be|
 |from 0 to 6, but ranks 0,1,2,3 are rare; their counts are    |
 |pooled with those for rank 4. Ranks are found for 100,000    |
 |random matrices, and a chi-square test is performed on       |
 |counts for ranks <=4, 5 and 6.                               |
 |-------------------------------------------------------------|

        Rank test for binary matrices (6x8) for newrand2.bin
b-rank test for bits  1 to  8, p=0.09272
b-rank test for bits  2 to  9, p=0.32264
b-rank test for bits  3 to 10, p=0.89311
b-rank test for bits  4 to 11, p=0.72728
b-rank test for bits  5 to 12, p=0.21117
b-rank test for bits  6 to 13, p=0.72898
b-rank test for bits  7 to 14, p=0.56802
b-rank test for bits  8 to 15, p=0.18166
b-rank test for bits  9 to 16, p=0.29537
b-rank test for bits 10 to 17, p=0.41754
b-rank test for bits 11 to 18, p=0.31572
b-rank test for bits 12 to 19, p=0.92350
b-rank test for bits 13 to 20, p=0.61903
b-rank test for bits 14 to 21, p=0.01732
b-rank test for bits 15 to 22, p=0.52955
b-rank test for bits 16 to 23, p=0.93552
b-rank test for bits 17 to 24, p=0.80753
b-rank test for bits 18 to 25, p=0.20906
b-rank test for bits 19 to 26, p=0.76386
b-rank test for bits 20 to 27, p=0.41064
b-rank test for bits 21 to 28, p=0.04802
b-rank test for bits 22 to 29, p=0.48897
b-rank test for bits 23 to 30, p=0.02318
b-rank test for bits 24 to 31, p=0.54197
b-rank test for bits 25 to 32, p=0.26187
 TEST SUMMARY, 25 tests, each on 100,000 random 6x8 matrices
 The above should be 25 uniform [0,1] random variables:
 The KS test for those 25 supposed UNI's yields p = 0.759780

 |-------------------------------------------------------------|
 |                  THE BITSTREAM TEST                         |
 |The file under test is viewed as a stream of bits. Call them |
 |b1,b2,... .  Consider an alphabet with two "letters", 0 and 1|
 |and think of the stream of bits as a succession of 20-letter |
 |"words", overlapping.  Thus the first word is b1b2...b20, the|
 |second is b2b3...b21, and so on.  The bitstream test counts  |
 |the number of missing 20-letter (20-bit) words in a string of|
 |2^21 overlapping 20-letter words.  There are 2^20 possible 20|
 |letter words.  For a truly random string of 2^21+19 bits, the|
 |number of missing words j should be (very close to) normally |
 |distributed with mean 141,909 and sigma 428.  Thus          |
 | (j-141909)/428 should be a standard normal variate (z score)|
 |that leads to a uniform [0,1) p value.  The test is repeated |
 |twenty times.                                                |
 |-------------------------------------------------------------|
```

```
  THE OVERLAPPING 20-TUPLES BITSTREAM TEST for newrand2.bin
 (20 bits/word, 2097152 words 20 bitstreams. No. missing words
  should average 141909.33 with sigma=428.00.)
---------------------------------------------------------------
           BITSTREAM test results.

Bitstream     No. missing words       z-score         p-value
   1          142076                   0.39           0.651516
   2          141843                  -0.15           0.438420
   3          141562                  -0.81           0.208534
   4          141618                  -0.68           0.248038
   5          142151                   0.56           0.713844
   6          140896                  -2.37           0.008952
   7          141373                  -1.25           0.105083
   8          142360                   1.05           0.853822
   9          142243                   0.78           0.782188
   10         141206                  -1.64           0.050161
   11         141982                   0.17           0.567412
   12         141362                  -1.28           0.100482
   13         141512                  -0.93           0.176615
   14         142128                   0.51           0.695293
   15         141272                  -1.49           0.068232
   16         142355                   1.04           0.851128
   17         141516                  -0.92           0.179049
   18         142208                   0.70           0.757357
   19         141690                  -0.51           0.304167
   20         141207                  -1.64           0.050403
---------------------------------------------------------------
|-------------------------------------------------------------|
|        OPSO means Overlapping-Pairs-Sparse-Occupancy        |
|The OPSO test considers 2-letter words from an alphabet of   |
|1024 letters.  Each letter is determined by a specified ten  |
|bits from a 32-bit integer in the sequence to be tested. OPSO|
|generates  2^21 (overlapping) 2-letter words  (from 2^21+1   |
|"keystrokes")  and counts the number of missing words---that |
|is,2-letter words which do not appear in the entire sequence.|
|That count should be very close to normally distributed with |
|mean 141,909, sigma 290. Thus (missingwrds-141909)/290 should|
|be a standard normal variable. The OPSO test takes 32 bits at|
|a time from the test file and uses a designated set of ten   |
|consecutive bits. It then restarts the file for the next de- |
|signated 10 bits, and so on.                                 |
|------------------------------------------------------------ |

                   OPSO test for newrand2.bin

Bits used       No. missing words       z-score          p-value
23 to 32               141615          -1.0149          0.155069
22 to 31               141780          -0.4460          0.327811
21 to 30               142043           0.4609          0.677576
20 to 29               142054           0.4989          0.691062
19 to 28               141888          -0.0736          0.470684
18 to 27               141815          -0.3253          0.372486
17 to 26               141553          -1.2287          0.109588
16 to 25               142008           0.3402          0.633163
15 to 24               141704          -0.7080          0.239462
```

14 to 23	142454	1.8782	0.969821
13 to 22	141960	0.1747	0.569352
12 to 21	141260	-2.2391	0.012576
11 to 20	141796	-0.3908	0.347975
10 to 19	141782	-0.4391	0.330306
9 to 18	142183	0.9437	0.827336
8 to 17	141936	0.0920	0.536637
7 to 16	141697	-0.7322	0.232032
6 to 15	141908	-0.0046	0.498170
5 to 14	141892	-0.0598	0.476174
4 to 13	141479	-1.4839	0.068918
3 to 12	141603	-1.0563	0.145413
2 to 11	141530	-1.3080	0.095431
1 to 10	142182	0.9402	0.826453

```
-----------------------------------------------------------------
|-------------------------------------------------------------- |
|    OQSO means Overlapping-Quadruples-Sparse-Occupancy         |
|  The test OQSO is similar, except that it considers 4-letter|
|words from an alphabet of 32 letters, each letter determined |
|by a designated string of 5 consecutive bits from the test   |
|file, elements of which are assumed 32-bit random integers.  |
|The mean number of missing words in a sequence of 2^21 four- |
|letter words,  (2^21+3 "keystrokes"), is again 141909, with  |
|sigma = 295.  The mean is based on theory; sigma comes from  |
|extensive simulation.                                        |
|-------------------------------------------------------------- |
```

OQSO test for newrand2.bin

Bits used	No. missing words	z-score	p-value
28 to 32	141904	-0.0181	0.492792
27 to 31	141632	-0.9401	0.173583
26 to 30	142306	1.3446	0.910630
25 to 29	141824	-0.2893	0.386193
24 to 28	142291	1.2938	0.902132
23 to 27	142313	1.3684	0.914402
22 to 26	141968	0.1989	0.578822
21 to 25	141567	-1.1604	0.122935
20 to 24	141842	-0.2282	0.409731
19 to 23	142036	0.4294	0.666180
18 to 22	141301	-2.0621	0.019597
17 to 21	141752	-0.5333	0.296905
16 to 20	141978	0.2328	0.592034
15 to 19	142013	0.3514	0.637365
14 to 18	141698	-0.7164	0.236881
13 to 17	142000	0.3074	0.620714
12 to 16	141644	-0.8994	0.184214
11 to 15	141908	-0.0045	0.498201
10 to 14	142032	0.4158	0.661233
9 to 13	142321	1.3955	0.918566
8 to 12	141886	-0.0791	0.468483
7 to 11	141689	-0.7469	0.227568
6 to 10	142035	0.4260	0.664946
5 to 9	141871	-0.1299	0.448310
4 to 8	142496	1.9887	0.976634
3 to 7	141523	-1.3096	0.095167
2 to 6	142243	1.1311	0.870990
1 to 5	142287	1.2802	0.899769

```
---------------------------------------------------------------
|------------------------------------------------------------- |
|    The DNA test considers an alphabet of 4 letters: C,G,A,T,|
|determined by two designated bits in the sequence of random  |
|integers being tested.  It considers 10-letter words, so that|
|as in OPSO and OQSO, there are 2^20 possible words, and the  |
|mean number of missing words from a string of 2^21  (over-   |
|lapping)  10-letter  words (2^21+9 "keystrokes") is 141909.  |
|The standard deviation sigma=339 was determined as for OQSO  |
|by simulation.  (Sigma for OPSO, 290, is the true value (to  |
|three places), not determined by simulation.                 |
|------------------------------------------------------------- |
```

DNA test for newrand2.bin

Bits used	No. missing words	z-score	p-value
31 to 32	141671	-0.7030	0.241016
30 to 31	141809	-0.2960	0.383631
29 to 30	141658	-0.7414	0.229230
28 to 29	141462	-1.3196	0.093491
27 to 28	141310	-1.7679	0.038536
26 to 27	142301	1.1554	0.876030
25 to 26	141513	-1.1691	0.121179
24 to 25	142393	1.4268	0.923175
23 to 24	142607	2.0580	0.980206
22 to 23	141578	-0.9774	0.164192
21 to 22	142077	0.4946	0.689559
20 to 21	141114	-2.3461	0.009485
19 to 20	141843	-0.1957	0.422437
18 to 19	141566	-1.0128	0.155584
17 to 18	142368	1.3530	0.911974
16 to 17	141710	-0.5880	0.278268
15 to 16	141876	-0.0983	0.460840
14 to 15	142305	1.1672	0.878429
13 to 14	142229	0.9430	0.827154
12 to 13	141947	0.1111	0.544240
11 to 12	141865	-0.1308	0.447980
10 to 11	141566	-1.0128	0.155584
9 to 10	141742	-0.4936	0.310795
8 to 9	141640	-0.7945	0.213457
7 to 8	141635	-0.8092	0.209191
6 to 7	142044	0.3973	0.654411
5 to 6	142317	1.2026	0.885428
4 to 5	141423	-1.4346	0.075700
3 to 4	141474	-1.2842	0.099543
2 to 3	141796	-0.3343	0.369074
1 to 2	142205	0.8722	0.808446

```
---------------------------------------------------------------
|-------------------------------------------------------------|
|    This is the COUNT-THE-1's TEST on a stream of bytes.     |
|Consider the file under test as a stream of bytes (four per  |
|32 bit integer).  Each byte can contain from 0 to 8 1's      |
|with probabilities 1,8,28,56,70,56,28,8,1 over 256.  Now let |
|the stream of bytes provide a string of overlapping  5-letter|
|words, each "letter" taking values A,B,C,D,E. The letters are|
|determined by the number of 1's in a byte: 0,1,or 2 yield A  |
|3 yields B, 4 yields C, 5 yields D and 6,7 or 8 yield E. Thus|
|we have a monkey at a typewriter hitting five keys with vari-|
```

```
|ous probabilities (37,56,70,56,37 over 256).  There are 5^5  |
|possible 5-letter words, and from a string of 256,000 (over- |
|lapping) 5-letter words, counts are made on the frequencies  |
|for each word.   The quadratic form in the weak inverse of   |
|the covariance matrix of the cell counts provides a chisquare|
|test: Q5-Q4, the difference of the naive Pearson sums of     |
|(OBS-EXP)^2/EXP on counts for 5- and 4-letter cell counts.   |
|-------------------------------------------------------------|
```

Test result COUNT-THE-1's in bytes for newrand2.bin
(Degrees of freedom: 5^4-5^3=2500; sample size: 2560000)

chisquare	z-score	p-value
2526.64	0.377	0.646833

```
|-------------------------------------------------------------|
|    This is the COUNT-THE-1's TEST for specific bytes.       |
|Consider the file under test as a stream of 32-bit integers. |
|From each integer, a specific byte is chosen , say the left- |
|most: bits 1 to 8. Each byte can contain from 0 to 8 1's,    |
|with probabilitie 1,8,28,56,70,56,28,8,1 over 256.  Now let  |
|the specified bytes from successive integers provide a string|
|of (overlapping) 5-letter words, each "letter"  taking values|
|A,B,C,D,E. The letters are determined  by the number of 1's, |
|in that byte: 0,1,or 2 ---> A, 3 ---> B, 4 ---> C, 5 ---> D, |
|and  6,7 or 8 ---> E.  Thus we have a monkey at a typewriter |
|hitting five keys with with various probabilities: 37,56,70, |
|56,37 over 256. There are 5^5 possible 5-letter words, and   |
|from a string of 256,000 (overlapping) 5-letter words, counts|
|are made on the frequencies for each word. The quadratic form|
|in the weak inverse of the covariance matrix of the cell     |
|counts provides a chisquare test: Q5-Q4, the difference of   |
|the naive Pearson  sums of (OBS-EXP)^2/EXP on counts for 5-  |
|and 4-letter cell  counts.                                   |
|-------------------------------------------------------------|
```

Test results for specific bytes for newrand2.bin
(Degrees of freedom: 5^4-5^3=2500; sample size: 256000)

bits used	chisquare	z-score	p-value
1 to 8	2456.36	-0.617	0.268587
2 to 9	2452.14	-0.677	0.249260
3 to 10	2589.52	1.266	0.897245
4 to 11	2407.69	-1.305	0.095867
5 to 12	2424.68	-1.065	0.143396
6 to 13	2372.58	-1.802	0.035773
7 to 14	2543.39	0.614	0.730290
8 to 15	2491.48	-0.121	0.452038
9 to 16	2471.22	-0.407	0.341982
10 to 17	2429.95	-0.991	0.160927
11 to 18	2469.52	-0.431	0.333210
12 to 19	2429.83	-0.992	0.160509
13 to 20	2471.39	-0.405	0.342888
14 to 21	2482.94	-0.241	0.404698
15 to 22	2433.80	-0.936	0.174565
16 to 23	2615.54	1.634	0.948873
17 to 24	2466.07	-0.480	0.315665
18 to 25	2537.98	0.537	0.704407
19 to 26	2536.60	0.518	0.697632

```
20 to 27        2476.77        -0.329         0.371253
21 to 28        2480.30        -0.279         0.390294
22 to 29        2487.76        -0.173         0.431298
23 to 30        2405.35        -1.339         0.090366
24 to 31        2396.29        -1.467         0.071235
25 to 32        2487.18        -0.181         0.428055
|------------------------------------------------------------|
|              THIS IS A PARKING LOT TEST                    |
|In a square of side 100, randomly "park" a car---a circle of |
|radius 1.   Then try to park a 2nd, a 3rd, and so on, each   |
|time parking "by ear".  That is, if an attempt to park a car |
|causes a crash with one already parked, try again at a new   |
|random location. (To avoid path problems, consider parking   |
|helicopters rather than cars.)   Each attempt leads to either|
|a crash or a success, the latter followed by an increment to |
|the list of cars already parked. If we plot n: the number of |
|attempts, versus k: the number successfully parked, we get a |
|curve that should be similar to those provided by a perfect  |
|random number generator.  Theory for the behavior of such a  |
|random curve seems beyond reach, and as graphics displays are|
|not available for this battery of tests, a simple characteriz|
|ation of the random experiment is used: k, the number of cars|
|successfully parked after n=12,000 attempts. Simulation shows|
|that k should average 3523 with sigma 21.9 and be approximate|
|to normally distributed.  Thus (k-3523)/21.9 should serve as |
|a standard normal variable, which, converted to a p  uniform |
|in [0,1), provides input to a KSTEST based on a sample of 10.|
|------------------------------------------------------------|

        CDPARK for newrand2.bin: result of 10 tests
  (Of 12000 tries, the average no. of successes should be
   3523.0 with sigma=21.9)

   No. succeses         z-score         p-value
        3538             0.6849         0.753306
        3513            -0.4566         0.323972
        3537             0.6393         0.738676
        3511            -0.5479         0.291865
        3510            -0.5936         0.276387
        3483            -1.8265         0.033889
        3522            -0.0457         0.481790
        3519            -0.1826         0.427537
        3552             1.3242         0.907282
        3565             1.9178         0.972432
  Square side=100, avg. no. parked=3525.00 sample std.=22.40
     p-value of the KSTEST for those 10 p-values: 0.943103

|------------------------------------------------------------|
|              THE MINIMUM DISTANCE TEST                     |
|It does this ten times:  choose n=8000 random points in a    |
|square of side 10000.  Find d, the minimum distance between  |
|the (n^2-n)/2 pairs of points.  If the points are truly inde-|
|pendent uniform, then d^2, the square of the minimum distance|
|should be (very close to) exponentially distributed with mean|
|.995 .  Thus 1-exp(-d^2/.995) should provide a p-value and  a|
|KSTEST on the resulting 10 values serves as a test of uni-   |
|formity for those samples of 8000 random points in a square. |
```

```
        |-------------------------------------------------------------|

                Results for the MINIMUM DISTANCE test for newrand2.bin

0.3149,0.8560,0.9121,0.2217,0.3543,0.1292,0.2830,0.6699,0.7417,0.8427,
 The KS test for those 10 p-values: 0.838067

        |-------------------------------------------------------------|
        |             THE 3DSPHERES TEST                              |
        |Choose  4000 random points in a cube of edge 1000.  At each  |
        |point, center a sphere large enough to reach the next closest|
        |point. Then the volume of the smallest such sphere is (very  |
        |close to) exponentially distributed with mean 120pi/3.  Thus |
        |the radius cubed is exponential with mean 30. (The mean is   |
        |obtained by extensive simulation).  The 3DSPHERES test gener-|
        |ates 4000 such spheres 20 times.  Each min radius cubed leads|
        |to a uniform variable by means of 1-exp(-r^3/30.), then a    |
        | KSTEST is done on the 20 p-values.                          |
        |-------------------------------------------------------------|

                    The 3DSPHERES test for newrand2.bin

                sample no       r^3             equiv. uni.
                   1            12.453          0.339731
                   2            62.464          0.875336
                   3            43.959          0.768994
                   4            37.578          0.714238
                   5            27.934          0.605899
                   6            37.830          0.716630
                   7            33.715          0.674969
                   8            10.352          0.291817
                   9            13.539          0.363210
                   10           15.376          0.401025
                   11           2.634           0.084042
                   12           21.688          0.514680
                   13           1.541           0.050064
                   14           60.051          0.864893
                   15           39.279          0.729994
                   16           40.294          0.738973
                   17           178.645         0.997407
                   18           13.945          0.371755
                   19           8.834           0.255072
                   20           4.757           0.146626
        --------------------------------------------------------------
                p-value for KS test on those 20 p-values: 0.852290

        |-------------------------------------------------------------|
        |                 This is the SQUEEZE test                    |
        | Random integers are floated to get uniforms on [0,1). Start-|
        | ing with k=2^31=2147483647, the test finds j, the number of |
        | iterations necessary to reduce k to 1, using the reduction  |
        | k=ceiling(k*U), with U provided by floating integers from   |
        | the file being tested.  Such j's are found 100,000 times,   |
        | then counts for the number of times j was <=6,7,...,47,>=48 |
        | are used to provide a chi-square test for cell frequencies. |
        |-------------------------------------------------------------|
```

```
            RESULTS OF SQUEEZE TEST FOR newrand2.bin

        Table of standardized frequency counts
    (obs-exp)^2/exp  for j=(1,..,6), 7,...,47,(48,...)
    -0.8     0.1     0.6    -1.1    -0.5    -0.4
    -0.9     0.3    -0.3    -0.2    -0.1    -0.7
     0.2    -0.1    -0.5     0.3     0.3     0.6
     0.7     0.6    -0.4    -0.5    -0.5     0.5
    -0.2    -0.7     0.1     0.2    -0.3    -0.7
     0.8     1.2     1.2    -0.8     1.7    -0.3
    -1.6    -0.4     1.7    -0.7    -0.6     0.0
    -1.1
    Chi-square with 42 degrees of freedom:23.294176
    z-score=-2.040973, p-value=0.008561
```

```
|-------------------------------------------------------------|
|            The  OVERLAPPING SUMS test                       |
|Integers are floated to get a sequence U(1),U(2),... of uni- |
|form [0,1) variables.  Then overlapping sums,                |
|  S(1)=U(1)+...+U(100), S2=U(2)+...+U(101),... are formed.   |
|The S's are virtually normal with a certain covariance mat-  |
|rix.  A linear transformation of the S's converts them to a  |
|sequence of independent standard normals, which are converted|
|to uniform variables for a KSTEST.                           |
|-------------------------------------------------------------|
             Results of the OSUM test for newrand2.bin

              Test no                  p-value
                1                      0.067823
                2                      0.222069
                3                      0.559032
                4                      0.468270
                5                      0.098649
                6                      0.266906
                7                      0.344521
                8                      0.303990
                9                      0.261359
                10                     0.152020
```

```
        p-value for 10 kstests on 100 sums: 0.017349

|-------------------------------------------------------------|
|This is the UP-DOWN RUNS test. An up-run of length n has     |
|x_1<...<x_n and x_n>x_(n+1), while a down-run of length n    |
|has x_1>...>x_n and x_n<x_(n+1). The value that ends a run   |
|is not part of the run that follows, so a long sequence of   |
|numbers contains independent runs, up or down, of length k   |
|with probability 2*k/(k+1)!. This test generates values      |
|until 100,000 up- and 100,000 down-runs are found, then it   |
|tests to see of the frequencies of lengths for 100,000 of    |
|each type are consistent with underlying theory. It also     |
|tests to see if the number of values needed to get 100,000   |
|of each type is consistent with theory.                      |
|-------------------------------------------------------------|
```

Test for lengths of runs up and runs down, 100,000 each for newrand2.bin:
(for k>=2, the prob. of a run of length k is 2*k/(k+1)!)

Length	Expected	UpRuns	(O-E)^2/E	DownRuns	(O-E)^2/E
2	66666.67	66825	0.38	66629	0.02
3	25000.00	24946	0.12	25011	0.00
4	6666.67	6596	0.75	6740	0.81
5	1388.89	1348	1.20	1350	1.09
6	238.10	249	0.50	223	0.96
7	34.72	32	0.21	42	1.53
8	4.96	3	0.77	4	0.19
		p=0.31421		p=0.40276	

Number of rngs required: 687038, p-value: 0.055

```
|-------------------------------------------------------------|
|This the CRAPS TEST.  It plays 200,000 games of craps, counts|
|the number of wins and the number of throws necessary to end |
|each game.  The number of wins should be (very close to) a   |
|normal with mean 200000p and variance 200000p(1-p), and      |
|p=244/495.  Throws necessary to complete the game can vary   |
|from 1 to infinity, but counts for all>21 are lumped with 21.|
|A chi-square test is made on the no.-of-throws cell counts.  |
|Each 32-bit integer from the test file provides the value for|
|the throw of a die, by floating to [0,1), multiplying by 6   |
|and taking 1 plus the integer part of the result.            |
|-------------------------------------------------------------|
```

RESULTS OF CRAPS TEST for newrand2.bin

No. of wins:	Observed	Expected
	98516	98585.9

z-score=-0.312, pvalue=0.37735

Analysis of Throws-per-Game:

Throws	Observed	Expected	Chisq	Sum of (O-E)^2/E
1	66424	66666.7	0.883	0.883
2	37596	37654.3	0.090	0.974
3	27007	26954.7	0.101	1.075
4	19294	19313.5	0.020	1.095
5	13902	13851.4	0.185	1.279
6	10119	9943.5	3.096	4.375
7	7113	7145.0	0.144	4.519
8	5103	5139.1	0.253	4.772
9	3822	3699.9	4.032	8.804
10	2655	2666.3	0.048	8.852
11	1882	1923.3	0.888	9.740
12	1391	1388.7	0.004	9.743
13	1033	1003.7	0.854	10.598
14	777	726.1	3.562	14.160
15	508	525.8	0.605	14.765
16	383	381.2	0.009	14.774
17	288	276.5	0.475	15.249
18	182	200.8	1.765	17.014
19	135	146.0	0.827	17.841
20	108	106.2	0.030	17.871
21	278	287.1	0.289	18.160

Chisq= 18.16 for 20 degrees of freedom, p= 0.42315

SUMMARY of craptest
p-value for no. of wins: 0.377350
p-value for throws/game: 0.423151

```
|-------------------------------------------------------------|
|This is the CRAPS TEST with different dice. Each die value is|
|determined by the rightmost three bits of the 32-bit random  |
|integer; values 1 to 6 are accepted, others rejected.  As in |
|the first test, 200,000 games of craps are played, counting  |
|the number of wins and the number of throws necessary to end |
|each game.  The number of wins should be (very close to) a   |
|normal with mean 200000p and variance 200000p(1-p), and      |
|p=244/495.  Throws necessary to complete the game can vary   |
|from 1 to infinity, but counts for all>21 are lumped with 21.|
|A chi-square test is made on the no.-of-throws cell counts.  |
|-------------------------------------------------------------|
```

RESULTS OF CRAPS TEST2 for newrand2.bin

No. of wins:	Observed	Expected
	98583	98585.9

z-score=-0.013, pvalue=0.49490

Analysis of Throws-per-Game:

Throws	Observed	Expected	Chisq	Sum of (O-E)^2/E
1	66587	66666.7	0.095	0.095
2	37875	37654.3	1.293	1.389
3	26712	26954.7	2.186	3.574
4	19308	19313.5	0.002	3.576
5	13931	13851.4	0.457	4.033
6	9701	9943.5	5.916	9.949
7	7234	7145.0	1.108	11.057
8	5203	5139.1	0.795	11.852
9	3774	3699.9	1.485	13.338
10	2746	2666.3	2.383	15.720
11	1910	1923.3	0.092	15.813
12	1354	1388.7	0.869	16.682
13	1021	1003.7	0.298	16.980
14	713	726.1	0.238	17.217
15	534	525.8	0.127	17.344
16	387	381.2	0.090	17.434
17	267	276.5	0.329	17.763
18	174	200.8	3.584	21.347
19	145	146.0	0.007	21.354
20	107	106.2	0.006	21.360
21	317	287.1	3.111	24.471

Chisq= 24.47 for 20 degrees of freedom, p= 0.77756

SUMMARY of craptest
p-value for no. of wins: 0.494900
p-value for throws/game: 0.777559

***** TEST SUMMARY *****

```
All p-values:
0.9930,0.7382,0.4900,0.3689,0.0081,0.2692,0.5343,0.3647,0.8379,0.7872,
0.8786,0.2094,0.8205,0.3602,0.3823,0.5289,0.2113,0.7410,0.0210,0.9688,
0.4565,0.6064,0.9177,0.9747,0.2474,0.3979,0.2128,0.9790,0.4561,0.8079,
0.2626,0.0084,0.3999,0.5171,0.6421,0.7397,0.1561,0.7885,0.4287,0.5508,
0.7950,0.9995,0.6153,0.5583,0.2837,0.4886,0.6344,0.2554,0.1665,0.7111,
0.0663,0.0889,0.2605,0.0927,0.3226,0.8931,0.7273,0.2112,0.7290,0.5680,
0.1817,0.2954,0.4175,0.3157,0.9235,0.6190,0.0173,0.5296,0.9355,0.8075,
0.2091,0.7639,0.4106,0.0480,0.4890,0.0232,0.5420,0.2619,0.7598,0.6515,
0.4384,0.2085,0.2480,0.7138,0.0090,0.1051,0.8538,0.7822,0.0502,0.5674,
0.1005,0.1766,0.6953,0.0682,0.8511,0.1790,0.7574,0.3042,0.0504,0.1551,
0.3278,0.6776,0.6911,0.4707,0.3725,0.1096,0.6332,0.2395,0.9698,0.5694,
0.0126,0.3480,0.3303,0.8273,0.5366,0.2320,0.4982,0.4762,0.0689,0.1454,
0.0954,0.8265,0.4928,0.1736,0.9106,0.3862,0.9021,0.9144,0.5788,0.1229,
0.4097,0.6662,0.0196,0.2969,0.5920,0.6374,0.2369,0.6207,0.1842,0.4982,
0.6612,0.9186,0.4685,0.2276,0.6649,0.4483,0.9766,0.0952,0.8710,0.8998,
0.2410,0.3836,0.2292,0.0935,0.0385,0.8760,0.1212,0.9232,0.9802,0.1642,
0.6896,0.0095,0.4224,0.1556,0.9120,0.2783,0.4608,0.8784,0.8272,0.5442,
0.4480,0.1556,0.3108,0.2135,0.2092,0.6544,0.8854,0.0757,0.0995,0.3691,
0.8084,0.6468,0.2686,0.2493,0.8972,0.0959,0.1434,0.0358,0.7303,0.4520,
0.3420,0.1609,0.3332,0.1605,0.3429,0.4047,0.1746,0.9489,0.3157,0.7044,
0.6976,0.3713,0.3903,0.4313,0.0904,0.0712,0.4281,0.7533,0.3240,0.7387,
0.2919,0.2764,0.0339,0.4818,0.4275,0.9073,0.9724,0.9431,0.3149,0.8560,
0.9121,0.2217,0.3543,0.1292,0.2830,0.6699,0.7417,0.8427,0.8381,0.3397,
0.8753,0.7690,0.7142,0.6059,0.7166,0.6750,0.2918,0.3632,0.4010,0.0840,
0.5147,0.0501,0.8649,0.7300,0.7390,0.9974,0.3718,0.2551,0.1466,0.8523,
0.0086,0.0678,0.2221,0.5590,0.4683,0.0986,0.2669,0.3445,0.3040,0.2614,
0.1520,0.0173,0.3142,0.4028,0.0551,0.3773,0.4232,0.4949,0.7776,

Overall p-value after applying KStest on 269 p-values = 0.036998
```

In response to requests, we have provided a list of all the p-values produced by the tests you have chosen for this run. The individual p-values are supposed to be uniform in [0,1), but they are not necessarily independent. So even though we have applied a KSTEST to the accumulated p-values, the result is not necessarily---even if your file contains truly random bits---uniform in [0,1). But it is probably pretty close, so take that last p-value with a grain of salt. In particular, there may be some values so close to 0 or 1 that the tests they came from should be applied several more times, or new, related tests should be undertaken.