REPUBLIC OF SOUTH AFRICA
DEPARTMENT OF MINERALS AND ENERGY
EXAMINATION FOR THE MINE SURVEYOR'S CERTIFICATE OF COMPETENCY

DATE: 13 October 2005 (Thursday) TOTAL MARKS: 100
TIME: 12:30 – 15:30 (3 Hours) TO PASS: 50

MINING ECONOMICS II

NOTE:

1. Any pocket calculator may be used and intermediate results need not be shown. The make and model number of the calculator used must be noted on the front cover of the answer book.
2. Tables that may be used are attached hereto.
3. Graph, Probability and Log paper will be supplied if required
4. Your examination number must be written on all graph paper and loose sheets that are handed in with your examination script.

QUESTION 1

Explain what is meant by the following:

a) Nugget Effect
b) Skewness
c) Anisotropy
d) Semi-variogram
e) Regularisation

[9]

QUESTION 2

Name 4 essential assumptions made when attempting to describe a population's statistics from its sampled data.

[4]

QUESTION 3

A proposed installation of a conveyor belt at a cost of R2 000 000 is expected to reduce transport costs by R0.05 per ton milled. If the mine has a life of 20 years and a milling rate of 2 000 000 tons per annum, is the project feasible when the cost of capital is 5%? Revenue from the sale of trucks amounts to R250 000.

[5]

QUESTION 4

A loan of R20 000 at 8% is redeemed over 5 years. The sinking fund has accrued a value of R21 000 over this period and once the loan is redeemed, the surplus is paid to the borrower. What is the effective interest rate to the: a) Lender and b) the Borrower?

[13]

QUESTION 5

A waste screening project is expected to generate the following nominal cash flow stream:

Year	Nominal Cash Flow (R'000)
0	(R1500)
1	R900
2	R700
3	R300

Calculate the NPV at discounted rates of 0%, 5%, 10%, 15% and 20%. What is the IRR and if the company has a cost of capital of 12%, is the project acceptable?

[8]

QUESTION 6

Given the following information:

Area	2 000 m x 1 500m
Dip of the orebody	30^{o}
Average Stope width	140 cm
Payability for ore reserve purposes	60%
Length of back	270m
Density	2.75 t/m^3

One stope machine per panel
Machine efficiency of 10m^2 per shift
50 000 tons of ore milled per month of 26 working shifts
75% of the tons mined are obtained from ore reserves

Calculate the following:

a) Life of mine to the nearest year.
b) Amount of reef raising necessary to maintain the ore reserve position monthly.
c) Number of ore reserve panels to be worked monthly to maintain the milling rate.

[5]

QUESTION 7

The following widths, in centimetres, were taken from an ore body, known to be normally distributed:

176	187	190	186	177	174	186	182	177	183	183	175	185
183	178	190	176	172	170	182	169	181	175	183	180	

Determine the following:

a) Mean, mode, median and range
b) Variance and standard deviation of the samples
c) Coefficient of variation of the samples
d) Standard deviation of the population
e) 90% confidence limits for the population standard deviation
f) 90% confidence limits for the population mean

[11]

QUESTION 8

A 20 million ton manganese deposit has been valued as having an average grade of 52% MnO_2 with a standard deviation of 4% MnO_2 based on 2 ton units. Investigate the sensitivity of the reserve to cut-offs varying from 50% MnO_2 to 54% MnO_2, using 9 calculations to provide grade tonnage graphs based on 20 ton mining units.

[15]

QUESTION 9

a) State the formula used to determine an additive constant for a log-normal distribution and explain how it is applied.

(3)

b) The following values were obtained from a mineral deposit where the additive constant is known to be 120 cm.g/t.

90 130 230 310 400 420 500 720

Calculate the mean value of the deposit and 90% confidence limits for the mean.

(7)

[10]

QUESTION 10

a) Determine the semi-variance value (γ) for the following sample values taken in a reef drive at 2 metre intervals.

13 19 17 11 15 12

(5)

b) Given the following samples:

Point	Y Co-ords	X Co-ords	Value (cm.g/t)
1	4 170	2 332	400
2	4 200	2 340	380
3	4 160	2 370	450
4	4 150	2 310	280
5	4 080	2 340	320
A	4 150	2 340	

Determine:

a) Estimate value for A
b) Kriging variance
c) Kriging standard error
d) 90% confidence limits for the estimate value

(15)

[20]

Total Marks [100]

TABLE 5

TABLE FOR THE COMPUTATION OF TONNAGE AND GRADE CUT-OFF FOR THE NORMAL DISTRIBUTION				
Cut-off below the mean		Reduced cut-off = Z PV=MV+ ωσ	Cut-off above the mean	
Tonnage proportion	ω - factor		ω - factor	Tonnage proportion
50.00	0.798	0.00	0.798	50.00
51.99	0.766	0.05	0.830	48.01
53.98	0.735	0.10	0.863	46.02
55.96	0.705	0.15	0.896	44.04
57.93	0.675	0.20	0.929	42.07
59.87	0.645	0.25	0.964	40.13
61.79	0.617	0.30	0.998	38.21
63.68	0.589	0.35	1.034	36.32
65.54	0.562	0.40	1.069	34.45
67.36	0.535	0.45	1.106	32.64
69.15	0.509	0.50	1.142	30.85
70.88	0.484	0.55	1.180	29.12
72.57	0.459	0.60	1.217	27.43
74.22	0.435	0.65	1.256	25.78
75.80	0.411	0.70	1.295	24.20
77.34	0.389	0.75	1.334	22.66
78.81	0.367	0.80	1.375	21.19
80.23	0.346	0.85	1.415	19.77
81.59	0.326	0.90	1.457	18.41
82.89	0.306	0.95	1.499	17.11
84.13	0.287	1.00	1.542	15.87
85.31	0.269	1.05	1.586	14.69
86.43	0.251	1.10	1.631	13.57
87.49	0.235	1.15	1.677	12.51
88.49	0.219	1.20	1.724	11.51
89.44	0.204	1.25	1.772	10.56
90.32	0.189	1.30	1.821	9.63
91.15	0.175	1.35	1.872	8.35
91.92	0.162	1.40	1.923	8.08
92.65	0.150	1.45	1.977	7.35
93.32	0.133	1.50	2.033	6.68
93.94	0.127	1.55	2.098	6.06
94.52	0.117	1.60	2.147	5.48
95.05	0.107	1.65	2.208	4.95
95.34	0.098	1.70	2.270	4.46
95.99	0.090	1.75	2.335	4.01
96.41	0.082	1.80	2.403	3.59
96.78	0.074	1.85	2.473	3.22
97.13	0.067	1.90	2.546	2.87
97.44	0.061	1.95	2.622	2.56
97.72	0.055	2.00	2.701	2.28
97.98	0.050	2.05	2.784	2.02
98.21	0.045	2.10	2.870	1.79
98.42	0.040	2.15	2.961	1.58
98.61	0.036	2.20	3.055	1.39
98.78	0.032	2.25	3.155	1.22

TABLE 7

Factor $\Psi_{0,10}(V;n)$ for estimation of the one-sided lower 90 per cent confidence limit of the mean of a lognormal population.

V \ n	5	10	15	20
0,00	1,0000	1,0000	1,0000	1,0000
0,02	0,9192	0,9464	0,9575	0,9635
0,04	0,8882	0,9254	0,9401	0,9479
0,06	0,8652	0,9095	0,9267	0,9364
0,08	0,8468	0,8961	0,9158	0,9205
0,10	0,8307	0,8843	0,9061	0,9181
0,12	0,8164	0,8743	0,8977	0,9106
0,14	0,8030	0,8649	0,8898	0,9036
0,16	0,7919	0,8562	0,8826	0,8971
0,18	0,7811	0,8480	0,8757	0,8910
0,20	0,7709	0,8405	0,8691	0,8849
0,30	0,7283	0,8075	0,8404	0,8598
0,40	0,6944	0,7802	0,8173	0,8385
0,50	0,6659	0,7566	0,7967	0,8194
0,60	0,6415	0,7357	0,7811	0,8024
0,70	0,6202	0,7167	0,7609	0,7865
0,80	0,6014	0,6994	0,7451	0,7718
0,90	0,5847	0,6835	0,7305	0,7581
1,00	0,5698	0,6687	0,7167	0,7450
1,10	0,5564	0,6551	0,7038	0,7326
1,20	0,5444	0,6423	0,6915	0,7209
1,30	0,5337	0,6304	0,6800	0,7098
1,40	0,5241	0,6193	0,6690	0,6991
1,50	0,5155	0,6089	0,6586	0,6890
1,60	0,5079	0,5991	0,6488	0,6793
1,70	0,5011	0,5898	0,6394	0,6700
1,80	0,4952	0,5813	0,6305	0,6611
1,90	0,4900	0,5733	0,6220	0,6525
2,00	0,4855	0,5658	0,6139	0,6443
2,10	0,4817	0,5587	0,6062	0,6364
2,20	0,4785	0,5521	0,5988	0,6289
2,30	0,4760	0,5459	0,5918	0,6216
2,40	0,4740	0,5402	0,5852	0,6146
2,50	0,4725	0,5348	0,5788	0,6079
2,60	0,4710	0,5208	0,5728	0,6007
2,70	0,4712	0,5252	0,5670	0,5932
2,80	0,4713	0,5210	0,5618	0,5892
2,90	0,4718	0,5170	0,5564	0,5835
3,00	0,4728	0,5131	0,5515	0,5780
3,10	0,4743	0,5102	0,5409	0,5728
3,20	0,4762	0,5072	0,5425	0,5677
3,30	0,4786	0,5045	0,5383	0,5629
3,40	0,4813	0,5021	0,5344	0,5582
3,50	0,4815	0,5000	0,5307	0,5538
3,60	0,4881	0,4982	0,5272	0,5496
3,70	0,4921	0,4960	0,5240	0,5455
3,80	0,4966	0,4953	0,5209	0,5416
3,90	0,5014	0,4942	0,5181	0,5379
4,00	0,5067	0,4934	0,5134	0,5344
4,10	0,5123	0,4929	0,5130	0,5310
4,20	0,5184	0,4926	0,5108	0,5278
4,30	0,5249	0,4925	0,5087	0,5248
4,40	0,5318	0,4926	0,5068	0,5219
4,50	0,5391	0,4930	0,5051	0,5192
4,60	0,5469	0,4936	0,5036	0,5166
4,70	0,5551	0,4915	0,5023	0,5142
4,80	0,5637	0,4955	0,5011	0,5119
4,90	0,5728	0,4968	0,5001	0,5098
5,00	0,5824	0,4983	0,4993	0,5078

TABLE 6

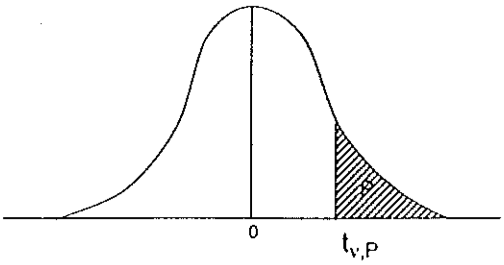
Factor $\Psi_{0,90}(V;n)$ for estimation of the one-sided upper 90 per cent confidence limit of the mean of a lognormal population.

V \ n	5	10	15	20
0,00	1,0000	1,0000	1,0000	1,0000
0,02	1,1624	1,0845	1,0621	1,0499
0,04	1,2409	1,1230	1,0894	1,0734
0,06	1,3070	1,1542	1,1124	1,0917
0,08	1,3662	1,1826	1,1321	1,1081
0,10	1,4218	1,2085	1,1506	1,1226
0,12	1,4755	1,2319	1,1671	1,1360
0,14	1,5273	1,2549	1,1832	1,1489
0,16	1,5785	1,2771	1,1984	1,1610
0,18	1,6287	1,2987	1,2132	1,1730
0,20	1,6703	1,3196	1,2280	1,1850
0,30	1,9294	1,4209	1,2971	1,2392
0,40	2,1910	1,5197	1,3623	1,2895
0,50	2,4712	1,6190	1,4266	1,3399
0,60	2,7750	1,7208	1,4803	1,3893
0,70	3,1065	1,8261	1,5580	1,4395
0,80	3,4724	1,9358	1,6257	1,4903
0,90	3,8761	2,0509	1,6949	1,5420
1,00	4,3212	2,1718	1,7669	1,5954
1,10	4,8163	2,2988	1,8416	1,6501
1,20	5,3639	2,4336	1,9196	1,7064
1,30	5,9732	2,5757	2,0002	1,7643
1,40	6,6509	2,7259	2,0842	1,8246
1,50	7,4033	2,8854	2,1718	1,8863
1,60	8,2396	2,0543	2,2634	1,9501
1,70	9,1719	3,2340	2,3590	2,0167
1,80	10,2090	3,4248	2,4586	2,0856
1,90	11,3639	3,6268	2,5629	2,1571
2,00	12,6453	3,8422	2,6726	2,2312
2,10	14,1724	4,0715	2,7872	2,3086
2,20	15,6607	4,3156	2,9073	2,3885
2,30	17,4272	4,5749	3,0333	2,4719
2,40	19,3905	4,8513	3,1651	2,5587
2,50	21,5768	5,1462	3,3040	2,6483
2,60	24,0062	5,4592	3,4488	2,7523
2,70	26,7035	5,7935	3,6010	2,8397
2,80	29,7036	6,1496	3,7011	2,9413
2,90	33,0419	6,5290	3,9288	3,0465
3,00	36,7305	6,9343	4,0153	3,1566
3,10	40,8558	7,3655	4,2897	3,2713
3,20	45,4243	7,8259	4,4846	3,3903
3,30	50,4954	8,3176	4,6884	3,5150
3,40	50,1259	8,8406	4,9031	3,6443
3,50	62,3641	9,4009	5,1287	3,7792
3,60	69,2927	9,9975	5,3657	3,9200
3,70	76,9813	10,6344	5,6148	4,0662
3,80	85,5018	11,3130	5,8767	4,2194
3,90	94,9440	12,0395	6,1521	4,3788
4,00	105,4420	12,8142	6,4419	4,5452
4,10	117,0160	13,6407	6,7469	4,7190
4,20	129,8730	14,5216	7,0670	4,8999
4,30	144,1010	15,4682	7,4050	5,0888
4,40	159,8810	16,4759	7,7600	5,2856
4,50	177,3280	17,5525	8,1340	5,4913
4,60	196,6590	18,7030	8,5282	5,7064
4,70	218,0330	19,9328	8,9426	5,9313
4,80	241,6880	21,2155	9,3784	6,1649
4,90	267,8710	22,6468	9,8391	6,4101
5,00	296,7890	24,1460	10,3227	6,6659

TABLE 3

The t-Distribution :
Upper Probability Points
$P = P(t \geq t_{\nu,P}) = P(t \leq -t_{\nu,P})$
with $t_{\nu,P} = -t_{\nu,1-P}$ so that
$P(|t| \geq t_{\nu,P}) = 2P, \quad t_{\nu,P} > 0$.

Entries in the table are the values $t_{\nu,P}$ of the t-distribution for various degrees of freedom ν and one tailed probabilities P.



ν \ P	0.25	0.10	0.05	0.025	0.01	0.005
1	1.000	3.078	6.314	12.706	31.821	63.657
2	0.816	1.886	2.920	4.303	6.965	9.925
3	0.765	1.638	2.353	3.182	4.541	5.841
4	0.741	1.533	2.132	2.776	3.747	4.604
5	0.727	1.476	2.015	2.571	3.365	4.032
6	0.718	1.440	1.943	2.447	3.143	3.707
7	0.711	1.415	1.895	2.365	2.998	3.499
8	0.706	1.397	1.860	2.306	2.896	3.355
9	0.703	1.383	1.833	2.262	2.821	3.250
10	0.700	1.372	1.812	2.228	2.764	3.169
11	0.697	1.363	1.796	2.201	2.718	3.106
12	0.695	1.356	1.782	2.179	2.681	3.055
13	0.694	1.350	1.771	2.160	2.650	3.012
14	0.692	1.345	1.761	2.145	2.624	2.977
15	0.691	1.341	1.753	2.131	2.602	2.947
16	0.690	1.337	1.746	2.120	2.583	2.921
17	0.689	1.333	1.740	2.110	2.567	2.898
18	0.688	1.330	1.734	2.101	2.552	2.878
19	0.688	1.328	1.729	2.093	2.539	2.861
20	0.687	1.325	1.725	2.086	2.528	2.845
21	0.686	1.323	1.721	2.080	2.518	2.831
22	0.686	1.321	1.717	2.074	2.508	2.819
23	0.685	1.319	1.714	2.069	2.500	2.807
24	0.685	1.318	1.711	2.064	2.492	2.797
25	0.684	1.316	1.708	2.060	2.485	2.787
26	0.684	1.315	1.706	2.056	2.479	2.779
27	0.684	1.314	1.703	2.052	2.473	2.771
28	0.683	1.313	1.701	2.048	2.467	2.763
29	0.683	1.311	1.699	2.045	2.462	2.756
30	0.683	1.310	1.697	2.042	2.457	2.750
35	0.682	1.306	1.690	2.030	2.438	2.724
40	0.681	1.303	1.684	2.021	2.423	2.704
60	0.679	1.296	1.671	2.000	2.390	2.660
100	0.677	1.290	1.660	1.984	2.364	2.626
∞	0.675	1.282	1.645	1.960	2.326	2.576

AREAS under the
STANDARD
NORMAL CURVE
from 0 to z

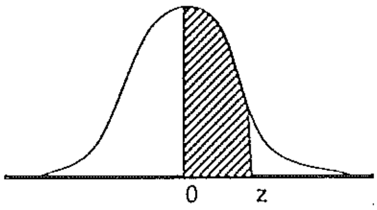


TABLE 1

Z	0	1	2	3	4	5	6	7	8	9
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0754
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1803	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2258	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2518	0.2549
0.7	0.2580	0.2612	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2996	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998
3.5	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998
3.6	0.4998	0.4998	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.7	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.8	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.9	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000

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TABLE 4

FACTOR $\gamma_n(v)$ FOR ESTIMATION OF MEAN OF LOGNORMAL POPULATION

v \ η	2	3	4	5	6	7	8	9	10	11	12
0.00	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.02	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010
0.04	1.020	1.020	1.020	1.020	1.020	1.020	1.020	1.020	1.020	1.020	1.020
0.06	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030
0.08	1.040	1.040	1.040	1.040	1.040	1.041	1.041	1.041	1.041	1.041	1.041
0.10	1.050	1.051	1.051	1.051	1.051	1.051	1.051	1.051	1.051	1.051	1.051
0.12	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.061	1.062	1.062
0.14	1.071	1.071	1.071	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072
0.16	1.081	1.082	1.082	1.082	1.082	1.082	1.082	1.083	1.083	1.083	1.083
0.18	1.091	1.092	1.092	1.093	1.093	1.093	1.093	1.093	1.093	1.093	1.094
0.20	1.102	1.102	1.103	1.103	1.104	1.104	1.104	1.104	1.104	1.104	1.104
0.3	1.154	1.156	1.157	1.158	1.158	1.159	1.159	1.159	1.160	1.160	1.160
0.4	1.207	1.210	1.212	1.214	1.215	1.216	1.216	1.217	1.217	1.217	1.218
0.5	1.260	1.266	1.269	1.272	1.273	1.275	1.276	1.276	1.277	1.278	1.278
0.6	1.315	1.323	1.328	1.332	1.334	1.336	1.337	1.338	1.339	1.340	1.341
0.7	1.371	1.382	1.389	1.393	1.397	1.399	1.401	1.403	1.404	1.406	1.406
0.8	1.427	1.442	1.451	1.457	1.462	1.465	1.468	1.470	1.472	1.473	1.475
0.9	1.485	1.503	1.515	1.523	1.529	1.533	1.537	1.540	1.542	1.544	1.546
1.0	1.543	1.566	1.580	1.591	1.598	1.604	1.608	1.612	1.615	1.618	1.620
1.1	1.602	1.630	1.648	1.661	1.670	1.677	1.682	1.687	1.691	1.694	1.697
1.2	1.662	1.696	1.718	1.733	1.744	1.752	1.759	1.765	1.770	1.774	1.777
1.3	1.724	1.764	1.789	1.807	1.820	1.831	1.839	1.846	1.851	1.856	1.860
1.4	1.786	1.832	1.862	1.884	1.900	1.912	1.922	1.930	1.936	1.942	1.947
1.5	1.848	1.903	1.938	1.963	1.981	1.996	2.007	2.017	2.025	2.032	2.037
1.6	1.912	1.975	2.015	2.044	2.066	2.082	2.096	2.107	2.116	2.124	2.131
1.7	1.977	2.049	2.095	2.128	2.153	2.172	2.188	2.201	2.212	2.221	2.229
1.8	2.043	2.124	2.177	2.214	2.243	2.265	2.283	2.298	2.310	2.321	2.330
1.9	2.110	2.201	2.260	2.303	2.336	2.361	2.382	2.399	2.413	2.425	2.436
2.0	2.178	2.280	2.347	2.395	2.431	2.460	2.484	2.503	2.519	2.533	2.545
2.1	2.247	2.360	2.435	2.489	2.530	2.563	2.589	2.611	2.633	2.645	2.659
2.2	2.317	2.442	2.526	2.586	2.632	2.669	2.698	2.723	2.744	2.762	2.778
2.3	2.388	2.526	2.618	2.686	2.737	2.778	2.811	2.839	2.863	2.883	2.900
2.4	2.460	2.612	2.714	2.788	2.846	2.801	2.928	2.959	2.986	3.008	3.028
2.5	2.533	2.699	2.812	2.894	2.957	3.008	3.049	3.084	3.113	3.138	3.160
2.6	2.607	2.789	2.912	3.003	3.073	3.128	3.174	3.213	3.245	3.274	3.298
2.7	2.682	2.880	3.015	3.114	3.191	3.253	3.304	3.346	3.382	3.414	3.441
2.8	2.759	2.973	3.120	3.229	3.314	3.382	3.437	3.484	3.524	3.559	3.589
2.9	2.836	3.068	3.228	3.347	3.440	3.514	3.576	3.627	3.671	3.710	3.743
3.0	2.914	3.166	3.339	3.469	3.570	3.651	3.718	3.775	3.824	3.866	3.902
3.1	2.994	3.265	3.453	3.593	3.703	3.792	3.866	3.928	3.981	4.028	4.068
3.2	3.075	3.366	3.569	3.721	3.841	3.938	4.018	4.086	4.145	4.195	4.240
3.3	3.157	3.469	3.688	3.853	3.983	4.088	4.176	4.250	4.314	4.369	4.418
3.4	3.240	3.574	3.810	3.988	4.129	4.243	4.338	4.419	4.489	4.549	4.603
3.5	3.324	3.682	3.935	4.127	4.279	4.403	4.506	4.594	4.670	4.736	4.794
3.6	3.409	3.792	4.063	4.270	4.434	4.568	4.680	4.775	4.858	4.929	4.993
3.7	3.496	3.903	4.194	4.416	4.593	4.738	4.859	4.962	5.052	5.130	5.198
3.8	3.583	4.017	4.329	4.567	4.757	4.913	5.044	5.156	5.252	5.337	5.412
3.9	3.672	4.134	4.466	4.721	4.925	5.093	5.234	5.355	5.460	5.552	5.633
4.0	3.762	4.252	4.607	4.880	5.099	5.279	5.431	5.562	5.675	5.774	5.862
4.1	3.853	4.373	4.751	5.042	5.277	5.471	5.634	5.775	5.897	6.004	6.099
4.2	3.946	4.496	4.898	5.209	5.460	5.668	5.844	5.995	6.127	6.242	6.345
4.3	4.040	4.622	5.049	5.380	5.649	5.872	6.060	6.223	6.364	6.489	6.599
4.4	4.135	4.750	5.203	5.556	5.843	6.081	6.283	6.458	6.610	6.744	6.863
4.5	4.231	4.881	5.361	5.736	6.042	6.297	6.513	6.700	6.863	7.008	7.136
4.6	4.328	5.014	5.522	5.921	6.247	6.519	6.750	6.950	7.126	7.281	7.419
4.7	4.427	5.149	5.687	6.111	6.457	6.747	6.995	7.209	7.397	7.563	7.711
4.8	4.527	5.288	5.856	6.305	6.674	6.983	7.247	7.476	7.677	7.855	8.014
4.9	4.629	5.428	6.029	6.505	6.896	7.225	7.507	7.751	7.966	8.157	8.328
5.0	4.732	5.572	6.205	6.709	7.124	7.474	7.774	8.036	8.265	8.470	8.652
5.1	4.836	5.718	6.386	6.919	7.359	7.731	8.050	8.329	8.574	8.792	8.988
5.2	4.941	5.866	6.570	7.134	7.600	7.995	8.335	8.631	8.893	9.126	9.335
5.3	5.048	6.018	6.759	7.354	7.847	8.266	8.628	8.944	9.222	9.471	9.695
5.4	5.156	6.172	6.951	7.579	8.102	8.546	8.930	9.265	9.563	9.828	10.07
5.5	5.266	6.329	7.148	7.811	8.363	8.833	9.240	9.598	9.914	10.20	10.45
5.6	5.376	6.489	7.350	8.048	8.631	9.129	9.561	9.940	10.28	10.58	10.85
5.7	5.489	6.652	7.555	8.290	8.906	9.433	9.890	10.29	10.65	10.97	11.26
5.8	5.603	6.818	7.766	8.539	9.188	9.745	10.23	10.66	11.04	11.38	11.68
5.9	5.718	6.987	7.980	8.794	9.478	10.07	10.58	11.03	11.44	11.80	
6.0	5.834	7.159	8.200	9.054	9.776	10.84	10.84	11.42	11.85		

SOME USEFUL FORMULAE

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N} (x_i - u)^2 \qquad \sigma^2 = \frac{1}{N}\sum_{i=1}^{N} x_i^{\,2} - u^2$$

$$s^2 = \frac{1}{n-1}\sum(x-\bar{x})^2 \qquad \gamma(h) = C\left(\frac{3h}{2a} - \frac{h^3}{2a^3}\right)$$

$$s^2 = \frac{1}{n-1}\left[\sum x^2 - n\bar{x}^2\right] \qquad \gamma(h) = C\left(1 - \exp\left(\frac{-h}{a}\right)\right)$$

$$T = \frac{\bar{x}-\mu}{s\sqrt{n}} \qquad T = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

$$P = PV\frac{i}{1-(1+i)^n} \qquad PV = A/(1+r)^n$$

$$PV = P(1-(1+i)^n)/i \qquad PV = \frac{P[(1+r)^n - 1]}{r(1+r)^n}$$

$$\theta = \frac{Mx^2 - x_p x_{1-p}}{x_p + x_{1-p} - 2Mx} \qquad b = \frac{n\sum xy - \sum x\sum y}{n\sum x^2 - (\sum x)^2}$$

$$2\gamma(h) = \frac{1}{n}\sum\left[g(x) - g(x+h)\right]$$

$$r = \frac{\sum xy - \sum x\sum y/n}{[\sum x^2 - (\sum x)^2/n][\sum y^2 - (\sum y)^2/n]} \qquad \sigma^c = \hat{s}_y\sqrt{1-r^2}$$

1) $z = \frac{x-\mu}{\sigma}$

2) $\mu = \bar{x} \pm t_\nu(P)\sigma_e$

3) $\chi^2 \leq \frac{(n-1)\sigma^2}{\sigma^2} \geq \chi^2$

4) $\chi^2_\ell \leq \frac{(n-1) * \sigma^2}{\sigma^2} \geq \chi^2_u$

TONNAGE & GRADE TABLE

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T DISTRIBUTION

STANDARD NORMAL DIST

SICHEL'S TABLE

90% UPPER & LOWER CONF. LIMITS FOR MEAN OF LOGNORMAL

$\sigma^2_K = W_1\gamma(S_1,A) + W_2\gamma(S_2,A) + W_3\gamma(S_3,A) + W_4\gamma(S_4,A) + W_5\gamma(S_5,A) + \lambda$