UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2007/2008

Peperiksaan Semester Kedua
Sidang Akademik 2007/2008

APRIL 2008

EPM 332/3 – QUALITY AND RELIABILITY
KUALITI DAN KEBOLEHPERCAYAAN

Duration : 3 hour
Masa : 3 jam

INSTRUCTIONS TO CANDIDATE :
ARAHAN KEPADA CALON :

Please check that this paper contains **FOURTHEEN** (14) printed pages and **SIX** (6) questions before you begin the examination.
*Sila pastikan bahawa kertas soalan ini mengandungi **EMPAT BELAS** (14) mukasurat dan **ENAM** (6) soalan yang bercetak sebelum anda memulakān peperiksaan.*

Answer **FIVE** (5) questions only.
*Sila jawab **LIMA** (5) soalan sahaja.*

Answer all questions in **English** OR **Bahasa Malaysia** OR a combination of both.
*Calon boleh menjawab semua soalan dalam **Bahasa Inggeris** ATAU **Bahasa Malaysia** ATAU kombinasi kedua-duanya.*

APPENDIX
LAMPIRAN

1. Lampiran 1
2. Lampiran 2
3. Lampiran 3
4. Lampiran 4

Each answer must begin from a new page.
Setiap jawapan mestilah dimulakan pada mukasurat yang baru.

Q1. [a] **Classify the basic seven QC tools into data analysis and cause analysis tool (some tool can be in both category).**

Kelaskan tujuh perkakasan kawalan mutu kepada alatan untuk analisis data dan alatan untuk analisa sebab (ada alatan boleh dikategori dalam kedua dua kelas).

(20 marks/*markah*)

[b] **Discuss the differences between enumerative and analytic studies**

Bincangkan perbedaan antara kajian penghitungan dengan kajian analisis.

(30 marks/*markah*)

[c] **A grade of polystyrene is used in an injection molding process used to manufacture dolls for children. A study of the process has revealed the following defect frequency information shown in Table Q1[c].**

Sejenis gred polystyrene digunakan pada proses acuan suntik untuk membuat patung bagi kanak kanak. Kajian terhadap proses menampilkan maklumat kekerapan defek seperti di Jadual S1[c].

Quality Characteristic *Ciri Kualiti*	**at head** *kepala*	**at arm** *lengan*	**at body (torso)** *badan*	**at leg** *kaki*
Scratches *calar*		22	2	
Flow lines *terguris*		100	11	78
Flash *lelebih*				17
Voids *lompong*		6		90
Short shots *Terpendek*	8		28	
Splay *rencung*	8			

Table Q1[c]
Jadual S1[c]

i) **Analyze the data in Table Q1[c] and give your comments**
ii) **Construct a Pareto chart for the defect information. Give comment based on the chart.**

i) Lakukan analisis terhadap data di Jadual S1[c] dan berikan komen anda.
ii) Bina carta Pareto bagi maklumat defek tersebut. Beri komen berdasarkan carta itu.

(50 marks/*markah*)

Q2. [a] Two main features of modern quality control is application of in-process control and statistics.

i) Explain the differences between process capability and statistical control.
ii) Can a process be in control but not capable? Explain your answer by giving an example.
iii) Can a process be capable but not in control? Explain your answer by giving an example.

Dua ciri utama kawalan kualiti moden adalah penggunaan kawalan dalam proses dan kaedah statistik.

i) Terangkan perbezaan antara keupayaan proses dengan kawalan berstastistik.
ii) Bolehkah sesuatu proses itu masih terkawal tetapi tidak berupaya? Terangkan jawapan anda dengan memberi contoh.
iii) Bolehkah sesuatu proses itu berupaya walaupun tidak terkawal? Terangkan jawapan anda dengan memberi contoh.,

(40 marks/*markah*)

b] Four components A, B, C and D are assembled as in Figure Q2[b] at three workstations as in Table Q2[b]i):

i) If the specification is 106 ± 4 mm, calculate the proportion of assemblies which are within the specification
ii) If tolerance range for assembly is 1.0 mm in the assembly sequence as in Table Q2[b]i), calculate tolerance range at each workstation.
iii) If the assembly order is changed as in Table Q2[b]ii), calculate tolerance ranges at each workstation.
iv) Provide two assumptions you used in the above calculations.

Empat komponen seperti di Rajah S2[b] di pasang pada setesen-kerja seperti di Jadual S2[b]i):

i) Jika spesifikasi pemasangan ialah *106 ± 4 mm, kira kadaran produk yang menuruti spesifikasi.*
ii) Jika julat had terima pemasangan ialah 1 mm dan menuruti jujukan kerja seperti di Jadual S2[b]i), kira julat had terima bagi setiap stesen kerja.
iii) Jika jujukan pemasangan berubah seperti di Jadual S2[b]ii), kira julat had terima bagi setiap stesen kerja.
iv) *Berikan dua andaian yang anda guna untuk pengiraan di atas.*

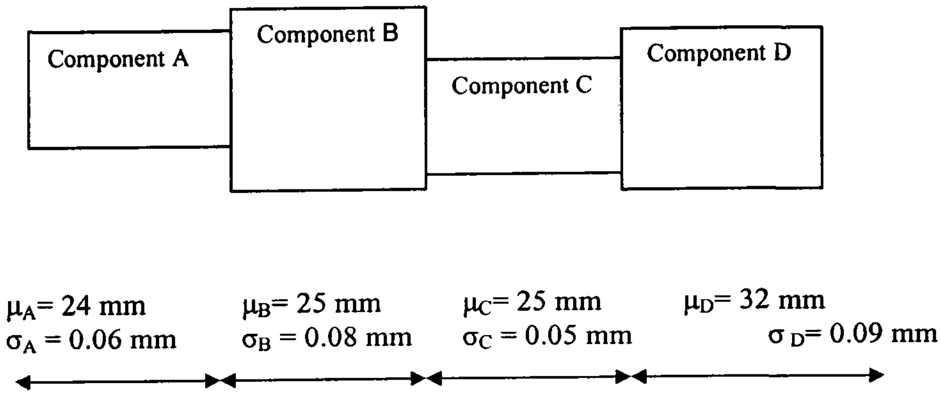


Table Q2[b]
Jadual S2[b]

workstation	Component assembled	result
1	*A & B*	*AB*
2	*C& AB*	*ABC*
3	*D & ABC*	*ABCD*

Table Q2[b]i)
Jadual S2[b]i)

workstation	Component assembled	result
1	*C&D*	*CD*
2	*B & CD*	*BCD*
3	*A & BCD*	*ABCD*

Table Q2[b[ii)
Jadual S2[b]ii)

(60 marks/*markah*)

Q3. [a] Shewhart's control charts are important tools.

i) State TWO purposes and TWO types of control charts
ii) List FIVE information that can be gained from the charts
iii) Explain how this information be used to improve the quality of manufacturing process.

Carta kawal Shewhart adalah alatan yang penting.

i) Nyatakan DUA tujuan dan DUA jenis carta kawal.
ii) Senaraikan LIMA maklumat yang dapat diperolehi dari carta carta tersebut.
iii) Terangkan bagaimana maklumat tersebut boleh digunakan bagi meningkatkan kualiti pada proses pembuatan.

(40 marks/*markah*)

[b] Control charts are to be constructed for turning the outside diameter of a cylinder. The diameter has specifications of 45 ±0.50 mm.

i) If $\Sigma X = 1578.518$ mm and $\Sigma R = 21.875$ mm for 35 samples of size n = 5, Calculate the centerlines and control limits for the control charts. The estimator factors for sample size of n = 5 are $A_2 = 0.577$, $A_3 = 1.427$, $A_6 = 0.691$, $D_3 = 0$, $D_4 = 2.11$.
ii) If process is in good statistical control, calculate percentage of the parts produced that is within tolerance limit. (give assumption used for calculation).
iii) Calculate percentage within the specifications if the process were adjusted to centered at nominal
iv) Present the situations in parts (ii) and (iii) graphically in terms of the distributions of the individual measurements.

Carta kawal dibina bagi proses melarik garispusat luar sebuah silinder. Spesifikasi garispusat ialah 450. ±50 *mm.*

i) Jika $\Sigma X =$ 1578.518 mm *dan* $\Sigma R =$ 21.875 *mm bagi 35 sampel bersaiz n = 5, Kira nilai garis tengah dan had kawalan bagi carta kawal. Nilai estimator bagi saiz sample 5 adalah A1.*
ii) Jika proses secara stastistiknya terkawal, kira peratus bahagian dihasilkan yang dalam lingkung had terima (Berikan andaian anda untuk pengiraan ini).
iii) Kira peratus dalam lingkung had terima jika proses dilaras agar nilai purata adalah sama dengan nominal.
iv) Bentangkan keadaan jawapan bahagian (ii) dan (iii) secara grafik dari segi taburan pada pengukuran individu.

(60 marks/*markah*)

Q4. [a] **In drafting a reliability specification, four elements are particularly important. Please indicate the elements with brief explaination.**

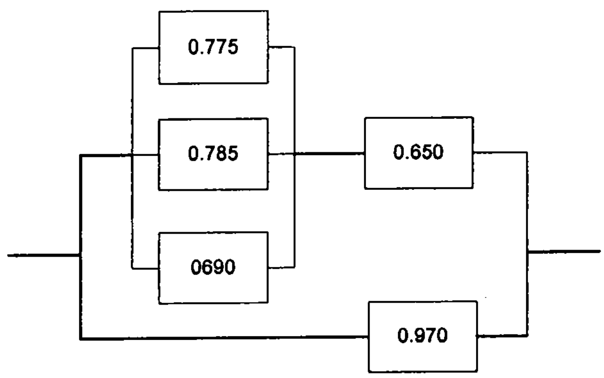
Dalam penyediaan satu spesifikasi kebolehpercayaan, empat unsur perlu diberi tumpuan. Sila nyatakan empat unsur berkenaan dengan huraian yang ringkas.

(30 marks/*markah*)

[b] **Four types of alarm system, A, B, C and D as shown in figure Q4[b], has been proposed to add security to a factory. The systems contain series, parallel, backup and standby components. Calculate the reliability of the system A, B, C and D, as configured in diagram i, ii, iii & iv in figure Q4[b] (Assuming for 100 hrs).**

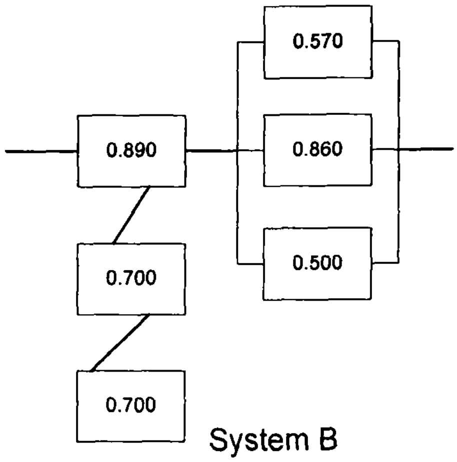
Empat jenis sistem penggera, A, B, C dan D, seperti yang ditunjukkan dalam gambarajah S4[b], telah dicadangkan kepada sesebuah kilang untuk menambahkan keselamatan. Sistem-sistem tersebut mengandungi pemasangan komponen-komponen secara seri, selari, sokongan dan penganti. Sila kirakan kebolehpercayaan A, B, C dan D, yang ditunjukkan pada tatarajah i, ii, iii, & iv dalam rajah S4[b] (Dianggap beroperasi selama 100 jam).

i.



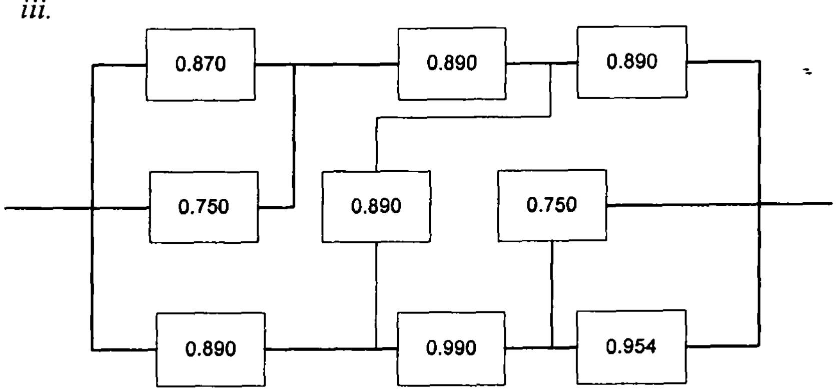
System A

ii.

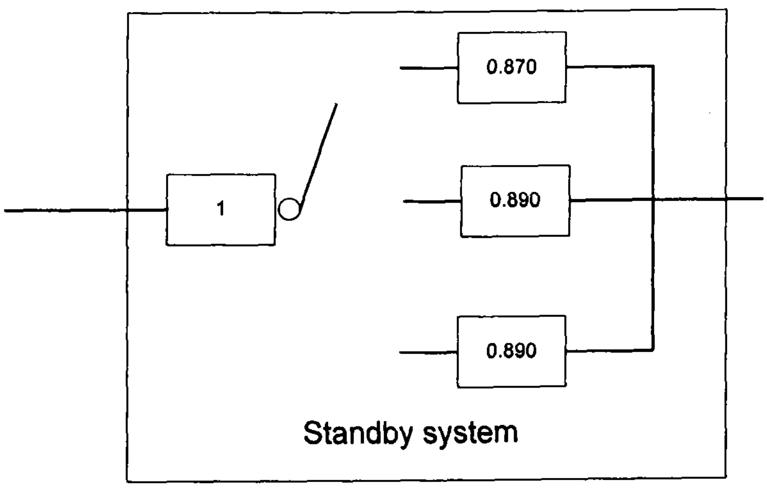


System B

iii.



System C



System D

Figure Q4[b]
Rajah S4[b]

(70 marks/*markah*)

Q5. [a] Three distinct phases exist in reliability bathtub curve. Recreate the table Q5[a] in your answer sheet and fill in the respective information, to show your understanding for the curve.

Terdapat tiga fasa yang berbeza dalam lengkung tab mandi kebolehpercayaan. Salin jadual S5[a] ke atas kertas jawapan dan isi dengan maklumat yang berkaitan, bagi menunjukkan kefahaman anda terhadap lengkung ini.

	Phase *Fasa*	**Characteristic** *Ciri-ciri*	**Potential causes** *Punca-punca*	**Actions to improve the reliability** *Tindakan untuk menambahbaik kebolehpercayaan pada fasal ini*
1				
2				
3				

Table Q5[a]
Jadual S5[a]1

(40 marks/*markah*)

[b] Developing a sampling plan for reliability needs to consider producer's risk (R_α) as well as consumer's risk (R_β). Find the total test time T and the acceptance criteria C when

$ARL = r_1 = 0.07$ fph
$LTRFD = r_2 = 0.31$ fph
$R_\alpha = 0.05$
$R_\beta = 0.15$.

(Required tables can be found in Attachment 2)
Explain how the T and C are applied in reliability sampling.

Dalam membina satu rancangan pensampelan kebolehpercayaan perlu mengambil kira risiko pengeluar (R_α) dan risiko pengguna (R_β). Kirakan jumlah masa ujian T dan kriteria penerimaan C apabila

$ARL = r_1 = 0.07$ fph,
$LTRFD = r_2 = 0.31$ fph
$R_\alpha = 0.05$
$R_\beta = 0.15$.

(Jadual yang diperlukan terdapat pada Lampiran 2)
Jelaskan bagaimana T dan C berkenaan digunakan dalam satu rancangan pensampelan.

(40 marks/*markah*)

[c] **100 switches were tested for a period of 1000 cycles. For the first 500 cycles in testing, 10 switches have failed and had immediately been repaired and continued in test. For the second 500 cycles in testing, another 10 switches have failed without any log of failure times was kept.**

i) **Calculate the reliability of a switch at 300 cycles *with normal distribution (Assume* $s = 150$ *cycles)***

ii) **Calculate the reliability of a switch at 300 cycles *with Weibull distribution (Assume* $B = 3.5, G = \overline{m}$*)***

iii) Calculate with Weibull distribution the new mean for reliability of 95% for operating for 600 cycles (Assume $B = 3.5$***)***

iv) An engineer claimed the result obtained in 5[c]iii) is similar to the result calculated with exponential distribution. Without any calculation, show whether the judgment by this engineer is true or not.

100 suis telah diuji kebolehpercayaan dalam tempoh 1000 kitar. Dalam kitaran 500 yang pertama, 10 suis telah gagal tetapi dibaiki serta-merta dan ujian diteruskan. Pada 500 kitar kedua, 10 suis gagal tanpa rekod ke atas masa kegagalan suis berkenaan.

i) Kirakan peratus kebolehpercayaan suis pada 300 kitar dengan Taburan normal (jika $s = 150$ *kitar)*

ii) Kirakan peratus kebolehpercayaan suis pada 300 kitar dengan Taburan Weibull (Assume $B = 3.5, G = \overline{m}$*)*

v) Dengan menggunakan taburan Weibull, kirakan purata hayat baru suis jika peratus kebolehpercayaan ditetapkan pada 95% dalam masa 600 kitar. (Assume $B = 3.5$*)*

vi) Seorang jurutera berpendapat jawapan yang diperolehi di 5[c]iii) adalah serupa dengan jawapan yang diperolehi dengan menggunakan taburan exponential. Tanpa sebarang pengiraan, tunjukkan adakah pendapat jurutera tersebut benar.

(20 marks/*markah*)

Q6. There are a set of maintenance tasks with the details as below:

Butir-butir mengenai tiga tugas penyenggaraan ialah seperti berikut.

Task A
Exponential distribution. MTTR = 2.65.

Tugas A
Taburan exponential. MTTR = 2.65

Task B
Normal distribution. MTTR = 3.5, s= 0.955.

Tugas B
Taburan normal. MTTR = 3.5, s =0.955

Task C

Log-normal distribution. The times to repair a certain system are as follows : 0.5, 1.7, 1.9, 2.4, 2.5, 2.6, 3.0, 3.3, 3.5, 4.2, 4.8 and 5.0 hr.

Tugas C

Taburan log-normal. Tempoh masa untuk membaiki sesuatu sistem adalah seperti berikut: 0.5, 1.7, 1.9, 2.4, 2.5, 2.6, 3.0, 3.3, 3.5, 4.2, 4.8 dan 5.0 jam.

Please answer the following questions:
Sila jawab soalan-soalan berikut:

[a] **For each task, calculate the maintainability for an allowed downtime (D) of 3.0 hour.**

Bagi setiap tugas, kirakan kebolehsenggaraan bagi masa henti dibenar (D) selama 3.0 jam.

(**20 marks**/*markah*)

[b] **For each task, calculate the allowed downtime (D) for a maintainability of 95%?**

Bagi setiap tugas, kirakan masa henti dibenar (D) bagi 95% kebolehsenggaraan?

(**25 marks**/*markah*)

[c] **For each task, calculate the new MTTR for 90% maintainability at an allowed downtime (D) of 3.0 hours?**

Bagi setiap tugas, kirakan MTTR yang baru bagi 90% kebolehsenggaraan dan masa henti dibenar (D) selama 3.0 jam?

(**25 marks**/*markah*)

[d] **For each task, MTTR from (iii) and if the system has a MTBF of 70 hours, calculate the inherent availability.**

Bagi setiap tugas, dengan MTTR dari (iii) dan sekiranya sistem mempunyai MTBF selama 70 jam, kirakan kebolehsediaan semula jadi?

(**15 marks**/*markah*)

[e] **A complex maintenance program consists of Task A, Task B and Task C, performed simultaneously. Calculate the maintainability of an allowable downtime of 3.0 hr.**

Satu rancangan penyenggaraan yang kompleks terdiri daripada Tugas A, Tugas B dan Tugas C yang dijalani pada masa yang sama. Kirakan Kebolehsenggaran rancangan berkenaan jika masa henti dibenar ialah 3.0 jam.

(**15 marks**/*markah*)

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LAMPIRAN 1

Formula Sheet

$R = e^{-(1/\overline{m})T}$

$R = e^{-\lambda T}$

$R = (1-\lambda)^T$

$R = e^{-\lambda T}(1 + P_{sw}\lambda T)$

$R = e^{-\lambda T}[1/(\lambda/\lambda_s)(1-e^{-\lambda_s T})]$

$G = \exp[(-0.00033 - a)/B]$

$T = G(-\ln R)^{1/B}$

$R(T_{o,t}) = \dfrac{R(T_o + t)}{R(T_o)}$

$\dfrac{e^{-\lambda(T+t)}}{e^{-\lambda T}} = \dfrac{e^{-\lambda T} \times e^{-\lambda t}}{e^{-\lambda T}} = e^{-\lambda t}$

$\overline{m} = \exp\{\ln T - [\ln\ln(1/R)]/B\}$

$z = (T - \overline{m})/\sigma$

$R = \exp[-(T/G)^B]$

$B = \dfrac{\{\sum(\ln X)\ln\ln[1/(1-Y)]\} - (\sum\{\ln X)\sum(\ln\ln[1/(1-Y)]\})/n}{\sum(\ln X)^2 - (\sum \ln X)^2/n}$

$a = \{\sum \ln\ln[1/(1-Y)]\}/n - B[\sum(\ln X)/n]$

$R = \dfrac{\lambda_2\lambda_3\cdots\lambda_n e^{-\lambda_1 T}}{(\lambda_2-\lambda_1)(\lambda_3-\lambda_1)\cdots(\lambda_n-\lambda_1)} + \dfrac{\lambda_1\lambda_3\cdots\lambda_n e^{-\lambda_2 T}}{(\lambda_1-\lambda_2)(\lambda_3-\lambda_2)\cdots(\lambda_n-\lambda_2)} + \cdots$ (for all λ's up to λ_n)

$R = e^{-\lambda T}[1 + \lambda T + (\lambda T)^2/2! + \cdots + (\lambda T)^{n-1}/(n-1)!]$

$\lambda = 1/m_1 + 1/m_2 + \cdots + 1/m_n$

$A = \dfrac{MTBF}{MTBF + MTTR}$

$a = (\sum \ln \quad t)/n$

$s = \sqrt{[\sum(\ln \quad t)^2 - (\sum \ln \quad t)^2/n]/(n-1)}$

$z_\alpha = (\ln \quad D - a)/s$

$M = 1 - e^{-(D/MTTR)}$

$D = MTTR[\ln(1/(1-M)]$

$z_\alpha = (D - MTTR)/s$

$MTTR = D/\ln[1/(1-M)]$

$M = 1 - \mathrm{ex}$

$MTTR = \exp[\ln D - \{\ln\ln[1/(1-M)\}/B]$

$UF = (t/MTBF)(1-M) = (t/\overline{m})(1-M)$

Spares = $\lambda T + Z_{1-\alpha}\sqrt{\lambda T}$

LAMPIRAN 2

Table Summation of Terms of Poisson's Exponential Binomial Limit[a]

(1000 × Probability of c or Less Occurrences of Event That Has Average Number of Occurrences Equal to np or λT)

c / np, λT	0	1	2	3	4	5	6	7	8	9
0.02	980	1,000								
0.04	961	999	1,000							
0.06	942	998	1,000							
0.08	923	997	1,000							
0.10	.905	995	1,000							
0.15	861	990	999	1,000						
0.20	819	982	999	1,000						
0.25	779	974	998	1,000						
0.30	741	963	996	1,000						
0.35	705	951	994	1,000						
0.40	670	938	992	999	1,000					
0.45	638	925	989	999	1,000					
0.50	607	910	986	998	1,000					
0.55	577	894	982	998	1,000					
0.60	549	878	977	997	1,000					
0.65	522	861	972	996	999	1,000				
0.70	497	844	966	994	999	1,000				
0.75	472	827	959	993	999	1,000				
0.80	449	809	953	991	999	1,000				
0.85	427	791	945	989	998	1,000				
0.90	407	772	937	987	998	1,000				
0.95	387	754	929	984	997	1,000				
1.00	368	736	920	981	996	999	1,000			
1.1	333	699	900	974	995	999	1,000			
1.2	301	663	879	966	992	998	1,000			
1.3	273	627	857	957	989	998	1,000			
1.4	247	592	833	946	986	997	999	1,000		
1.5	223	558	809	934	981	996	999	1,000		
1.6	202	525	783	921	976	994	999	1,000		
1.7	183	493	757	907	970	992	998	1,000		
1.8	165	463	731	891	964	990	997	999	1,000	
1.9	150	434	704	875	956	987	997	999	1,000	
2.0	135	406	677	857	947	983	995	999	1,000	

LAMPIRAN 3

Table Summation of Terms of Poisson's Exponential Binomial Limit *(Continued)*

np / λT \ c	0	1	2	3	4	5	6	7	8	9
2.2	111	355	623	819	928	975	993	998	1,000	
2.4	091	308	570	779	904	964	988	997	999	1,000
2.6	074	267	518	736	877	951	983	995	999	1,000
2.8	061	231	469	692	848	935	976	992	998	999
3.0	050	199	423	647	815	916	966	988	996	999
3.2	041	171	380	603	781	895	955	983	994	998
3.4	033	147	340	558	744	871	942	977	992	997
3.6	027	126	303	515	706	844	927	969	988	996
3.8	022	107	269	473	668	816	909	960	984	994
4.0	018	092	238	433	629	785	889	949	979	992
4.2	015	078	210	395	590	753	867	936	972	989
4.4	012	066	185	359	551	720	844	921	964	985
4.6	010	056	163	326	513	686	818	905	955	980
4.8	008	048	143	294	476	651	791	887	944	975
5.0	007	040	125	265	440	616	762	867	932	968
5.2	006	034	109	238	406	581	732	845	918	960
5.4	005	029	095	213	373	546	702	822	903	951
5.6	004	024	082	191	342	512	670	797	886	941
5.8	003	021	072	170	313	478	638	771	867	929
6.0	002	017	062	151	285	446	606	744	847	916

	10	11	12	13	14	15	16
2.8	1,000						
3.0	1,000						
3.2	1,000						
3.4	999	1,000					
3.6	999	1,000					
3.8	998	999	1,000				
4.0	997	999	1,000				
4.2	996	999	1,000				
4.4	994	998	999	1,000			
4.6	992	997	999	1,000			
4.8	990	996	999	1,000			
5.0	986	995	998	999	1,000		
5.2	982	993	997	999	1,000		
5.4	977	990	996	999	1,000		
5.6	972	988	995	998	999	1,000	
5.8	965	984	993	997	999	1,000	
6.0	957	980	991	996	999	999	1,000

LAMPIRAN 4

Table Summation of Terms of Poisson's Exponential Binomial Limit *(Continued)*

c / *np* / λ*T*	0	1	2	3	4	5	6	7	8	9
6.2	002	015	054	134	259	414	574	716	826	902
6.4	002	012	046	119	235	384	542	687	803	886
6.6	001	010	040	105	213	355	511	658	780	869
6.8	001	009	034	093	192	327	480	628	755	850
7.0	001	007	030	082	173	301	450	599	729	830
7.2	001	006	025	072	156	276	420	569	703	810
7.4	001	005	022	063	140	253	392	539	676	788
7.6	001	004	019	055	125	231	365	510	648	765
7.8	000	004	016	048	112	210	338	481	620	741
8.0	000	003	014	042	100	191	313	453	593	717
8.5	000	002	009	030	074	150	256	386	523	653
9.0	000	001	006	021	055	116	207	324	456	587
9.5	000	001	004	015	040	089	165	269	392	522
10.0	000	000	003	010	029	067	130	220	333	458
	10	11	12	13	14	15	16	17	18	19
6.2	949	975	989	995	998	999	1,000			
6.4	939	969	986	994	997	999	1,000			
6.6	927	963	982	992	997	999	999	1,000		
6.8	915	955	978	990	996	998	999	1,000		
7.0	901	947	973	987	994	998	999	1,000		
7.2	887	937	967	984	993	997	999	999	1,000	
7.4	871	926	961	980	991	996	998	999	1,000	
7.6	854	915	954	976	989	995	998	999	1,000	
7.8	835	902	945	971	986	993	997	999	1,000	
8.0	816	888	936	966	983	992	996	998	999	1,000
8.5	763	849	909	949	973	986	993	997	999	999
9.0	706	803	876	926	959	978	989	995	998	999
9.5	645	752	836	898	940	967	982	991	996	998
10.0	583	697	792	864	917	951	973	986	993	997
	20	21	22							
8.5	1,000									
9.0	1,000									
9.5	999	1,000								
10.0	998	999	1,000							