

PGDM, Batch-2013-15
Statistics for Business Analysis
DM-106

Trimester – I, End-Term Examination: September 2013

Time allowed: 2.5 Hours

Max Marks: 50

Roll No: _____

Instruction: Students are required to write Roll No on every page of the question paper, writing anything except the Roll No will be treated as **Unfair Means**. In case of rough work please use answer sheet.

Section-A

Attempt any 3 out of 5 questions, each question carries equal marks. (3*5 = 15 Marks)

Question 1: The time needed to complete a final examination in a particular college course is normally distributed with a mean of 80 minutes and a standard deviation of 10 minutes.

- a. What is the probability of completing the exam in one hour or less?
- b. Assume that the class has 60 students and that the examination period is 90 minutes in length. How many students do you expect will be unable to complete the exam in the allotted time?

Question 2: According to the U.S. Census Bureau, approximately 6% of all workers in Jackson, Mississippi, are unemployed. In a random telephone survey in Jackson, what is the probability of getting two or fewer unemployed workers in a sample of 20?

Question 3: During the first quarter of 2003, the price/earnings (P/E) ratio for stocks listed on the New York Stock Exchange generally ranged from 5 to 60. Assume that we want to estimate the population mean P/E ratio for all stocks listed on the exchange. How many stocks should be included in the sample if we want a margin of error of 3? Use 95% confidence.

Question 4: The unemployment rate is 20%. Suppose that 16 employable people are selected randomly.

- a. What is the expected number who are unemployed?
- b. What are the standard deviation of the number who are unemployed?
- c. What is the probability that at least four employable persons are unemployed?

Question 5:

- a) What are the chief characteristics of normal distribution? What do you understand by z-score?
- b) What are the types of sampling? Enumerate the various methods of probability sampling.

Section-B

Attempt any 2 out of 3 Short Questions, each question carries equal marks. (2*10=20 Marks)

Question 1: Before the 2003 Super Bowl, ABC predicted that 22% of the Super Bowl audience would express an interest in seeing one of its forthcoming new television shows. ABC ran commercials for these television shows during the Super Bowl. The day after the Super Bowl, Intermediate Advertising Group of New York sampled 1532 viewers who saw the commercials and found that 414 said that they would watch one of the ABC advertised television shows.

- What is the point estimate of the proportion of the audience that said they would watch the television shows after seeing the television commercials?
- At $\alpha = .05$, determine whether the intent to watch the ABC television shows significantly increased after seeing the television commercials. Formulate the appropriate hypotheses, compute the p-value, and state your conclusion.
- Why are such studies valuable to companies and advertising firms?

Question 2: The average score for male golfers is 95 and the average score for female golfers is 106. Use these values as the population means for men and women and assume that the population standard deviation is $\sigma = 14$ strokes for both. A simple random sample of 30 male golfers and another simple random sample of 45 female golfers will be taken.

- Show the sampling distribution of \bar{x} for male golfers.
- What is the probability that the sample mean is within 3 strokes of the population mean for the sample of male golfers?
- What is the probability that the sample mean is within 3 strokes of the population mean for the sample of female golfers?
- In which case, part (b) or part (c) is the probability of obtaining sample mean within 3 strokes of the population mean higher? Why?

Question 3: Wageweb conducts surveys of salary data and presents summaries on its Web site. Based on salary data as of October 1, 2002, Wageweb reported that the average annual salary for sales vice presidents was \$142,111, with an average annual bonus of \$15,432. Assume the following data are a sample of the annual salary and bonus for 10 sales vice presidents. Data are in thousands of dollars.

Vice President	Salary	Bonus
1	135	12
2	115	14
3	146	16
4	167	19
5	165	22
6	176	24
7	98	7
8	136	17
9	163	18
10	119	11

- Use the least squares method to develop the estimated regression equation.
- Provide an interpretation for the slope of the estimated regression equation.
- Predict the bonus for a vice president with an annual salary of \$120,000.

Section-C

Compulsory Case Study (15 Marks)

In 1985, a company called In-Process Technology was set up to produce and sell a thermal oxidation process that could be used to reduce industrial pollution. The initial investors acquired the rights to technology developed at the U.S. Department of Energy's Lawrence Livermore National Laboratory to more efficiently convert energy in burners, process heaters, and others. For several years, the company performed dismally and by 1991, was earning \$264,000 annually.

In 1992, the company realized that there was potential for utilizing this technology for the control and destruction of volatile organic compounds and hazardous air pollutants in improving the environment, and the company was reorganized and renamed thermatrix. More than \$20 million in private equity offerings was raised over a period of several years to produce, market, and distribute the new product. In June 1996, there was a successful public of Thermatrix in the financial markets. This allowed the company to expand its global presence and increase its market penetration in the United States. In 1997, as a result of research and development, the company engineers were able to develop a more effective treatment of waste streams with significantly less cost to the customer.

Thermatrix's philosophy has been to give their customers more then their competitors did without charging more. During this time period, the company targeted large corporations as customers, hoping to use its client list as a selling tool. In addition, realizing that they were a small, thinly capitalized company, Thermatrix partnered with many of its clients in developing solutions to the clients' specific environmental problems.

In April 2002, Thermatrix was acquired by Linde AG, through its subsidiary seas Fluid processing Corporation (SFPC)of Blue Bell, Pennsylvania. SFPC specializes in the design and engineering of fired process heaters, LNG vaporizers, and thermal oxidizers. Presently, Thermatrix offers a wide range of flameless thermal oxidizers and has the capability of providing stand-alone emission devices in a variety of ways. Thermatrix is located in Blue Bell, Pennsylvania, as a part of the seals fluid processing Corporation, where there are 90 employees.

Discussion

1. Thermatrix has grown and flourished because of its good customer relationships, which include partnering, delivering a quality product on tome, and listening to the customer's needs, suppose company management wants to formally measure customer satisfaction at least once a year and develops a brief survey that includes the following four questions. Suppose 115 customers participated in this survey with the results shown.

	Question	Yes	No
1	In General, were deliveries on time?	63	52
2	Were the contact people at Thermatrix helpful and courteous?	86	29

- a) Do the majority of Thermatrix customers believe that deliveries are on time?
 - b) It was claimed that 75% of customers believe that the contact people at Thermatrix are helpful and courteous. Does the sample survey corroborate this hypothesis?
 - c) What would you conclude about customer perception based on the above conclusions?
2. Now suppose Thermatrix officers want to ascertain employee satisfaction with the company. They randomly sample nine employees and ask them to complete a satisfaction survey under the supervision of an independent testing organization. As part of this survey, employees are asked to respond to questions on a 5-point scale where 1 is low satisfaction and 5 is high satisfaction. Assume that the overall responses on questions are normally distributed. The questions and the results of the survey are shown in the next column.

	Question	Mean	SD
1	Are you treated fairly as an employee?	3.79	0.86
2	Is the compensation for your work adequate and fair?	3.95	0.21

Can we say that

- a) For Question1, can we say with reasonable (95%) confidence that the average score for all employees is 3.65?
- b) What is the 98% confidence interval for the population mean for perception of fairness in "compensation"?

Formula Sheet

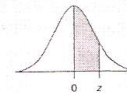
1	$\frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$	$\frac{\bar{X} - \mu}{s/\sqrt{n}}$	$\frac{\hat{p} - p}{\sqrt{\frac{p(1-p)}{n}}}$
2	$\frac{\bar{X} - \mu_0}{\sigma/\sqrt{n}}$	$\frac{\bar{X} - \mu_0}{s/\sqrt{n}}$	$\frac{(\hat{p} - p_0)}{\sqrt{\frac{p_0(1-p_0)}{n}}}$
3	$\frac{(\bar{X} - \bar{Y}) - D_0}{\sqrt{\frac{\sigma_X^2}{n_X} + \frac{\sigma_Y^2}{n_Y}}}$	$\frac{(\bar{X} - \bar{Y}) - D_0}{\sqrt{\frac{s_X^2}{n_X} + \frac{s_Y^2}{n_Y}}}$	$\frac{\hat{p}_X - \hat{p}_Y}{\sqrt{\frac{\hat{p}_0(1-\hat{p}_0)}{n_X} + \frac{\hat{p}_0(1-\hat{p}_0)}{n_Y}}}$
4	$\frac{(\bar{X} - \bar{Y}) - D_0}{s\sqrt{\frac{n_X + n_Y}{n_X n_Y}}}$	$\frac{\bar{X} - \bar{Y} - D_0}{\sqrt{\frac{s_{\bar{X}-\bar{Y}}^2}{n}}}$	$\frac{(n_X - 1)s_X^2 + (n_Y - 1)s_Y^2}{(n_X + n_Y - 2)}$
5	$\sum_i \sum_j (X_{ij} - \bar{X})^2$	$\sum_i \sum_j (\bar{X}_j - \bar{X})^2$	$\sum_i \sum_j (X_{ij} - \bar{X}_j)^2$
6	$\sum_i \sum_j R_i^2$	$\sum_i \sum_j C_j^2$	$\sum_i \sum_j e_{ij}^2$
7	$\frac{CSS/(c-1)}{ESS/(N-c)}$	$\frac{RSS/(r-1)}{ESS/[(r-1)(c-1)]}$	$\frac{CSS/(c-1)}{ESS/[(r-1)(c-1)]}$
8	$\frac{ESS}{n-k-1}$	$1 - \frac{ESS/(n-k-1)}{TSS/(n-1)}$	$\frac{RSS/k}{ESS/(n-k-1)}$
9	$\frac{s^2}{\sum (x_i - \bar{x})^2}$	$s^2 \frac{\sum x_i^2}{n \sum (x_i - \bar{x})^2}$	$\frac{b - \beta_0}{s_b}$
10	$\frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$	$\frac{r}{\sqrt{(1-r^2)/(n-2)}}$	$\sum_{i,j} \frac{(x_{ij} - e_{ij})^2}{e_{ij}}$
11	$\frac{(R_U^2 - R_R^2)/q}{(1 - R_U^2)/(n-k-1)}$	$\frac{(ESS_R - ESS_U)/m}{ESS_U/(n-k-1)}$	$\frac{(ESS - ESS^*)/(k+1)}{ESS^*/(n_1 + n_2 - 2k - 2)}$

APPENDIX

C-1

STANDARD NORMAL AREAS

Example: $P(0 < z < 1.96) = .4750$



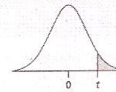
This table shows the normal area between 0 and z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.49865	.49869	.49874	.49878	.49882	.49886	.49889	.49893	.49896	.49900
3.1	.49903	.49906	.49910	.49913	.49916	.49918	.49921	.49924	.49926	.49929
3.2	.49931	.49934	.49936	.49938	.49940	.49942	.49944	.49946	.49948	.49950
3.3	.49952	.49953	.49955	.49957	.49958	.49960	.49961	.49962	.49964	.49965
3.4	.49966	.49968	.49969	.49970	.49971	.49972	.49973	.49974	.49975	.49976
3.5	.49977	.49978	.49978	.49979	.49980	.49981	.49981	.49982	.49983	.49983
3.6	.49984	.49985	.49985	.49986	.49986	.49987	.49987	.49988	.49988	.49989
3.7	.49989	.49990	.49990	.49990	.49991	.49991	.49992	.49992	.49992	.49992

APPENDIX

D

STUDENT'S t CRITICAL VALUES



This table shows the t -value that defines the area for the stated degrees of freedom (ν).

ν	Confidence Level					ν	Confidence Level				
	.80	.90	.95	.98	.99		.80	.90	.95	.98	.99
	Significance Level for Two-Tailed Test						Significance Level for Two-Tailed Test				
	.20	.10	.05	.02	.01		.20	.10	.05	.02	.01
	Significance Level for One-Tailed Test						Significance Level for One-Tailed Test				
	.10	.05	.025	.01	.005		.10	.05	.025	.01	.005
1	3.078	6.314	12.706	31.821	63.656	36	1.306	1.688	2.028	2.434	2.719
2	1.886	2.920	4.303	6.965	9.925	37	1.305	1.687	2.026	2.431	2.715
3	1.638	2.353	3.182	4.541	5.841	38	1.304	1.686	2.024	2.429	2.712
4	1.533	2.132	2.776	3.747	4.604	39	1.304	1.685	2.023	2.426	2.708
5	1.476	2.015	2.571	3.365	4.032	40	1.303	1.684	2.021	2.423	2.704
6	1.440	1.943	2.447	3.143	3.707	41	1.303	1.683	2.020	2.421	2.701
7	1.415	1.895	2.365	2.998	3.499	42	1.302	1.682	2.018	2.418	2.698
8	1.397	1.860	2.306	2.896	3.355	43	1.302	1.681	2.017	2.416	2.695
9	1.383	1.833	2.262	2.821	3.250	44	1.301	1.680	2.015	2.414	2.692
10	1.372	1.812	2.228	2.764	3.169	45	1.301	1.679	2.014	2.412	2.690
11	1.363	1.796	2.201	2.718	3.106	46	1.300	1.679	2.013	2.410	2.687
12	1.356	1.782	2.179	2.681	3.055	47	1.300	1.678	2.012	2.408	2.685
13	1.350	1.771	2.160	2.650	3.012	48	1.299	1.677	2.011	2.407	2.682
14	1.345	1.761	2.145	2.624	2.977	49	1.299	1.677	2.010	2.405	2.680
15	1.341	1.753	2.131	2.602	2.947	50	1.299	1.676	2.009	2.403	2.678
16	1.337	1.746	2.120	2.583	2.921	55	1.297	1.673	2.004	2.396	2.668
17	1.333	1.740	2.110	2.567	2.898	60	1.296	1.671	2.000	2.390	2.660
18	1.330	1.734	2.101	2.552	2.878	65	1.295	1.669	1.997	2.385	2.654
19	1.328	1.729	2.093	2.539	2.861	70	1.294	1.667	1.994	2.381	2.648
20	1.325	1.725	2.086	2.528	2.845	75	1.293	1.665	1.992	2.377	2.643
21	1.323	1.721	2.080	2.518	2.831	80	1.292	1.664	1.990	2.374	2.639
22	1.321	1.717	2.074	2.508	2.819	85	1.292	1.663	1.988	2.371	2.635
23	1.319	1.714	2.069	2.500	2.807	90	1.291	1.662	1.987	2.368	2.632
24	1.318	1.711	2.064	2.492	2.797	95	1.291	1.661	1.985	2.366	2.629
25	1.316	1.708	2.060	2.485	2.787	100	1.290	1.660	1.984	2.364	2.626
26	1.315	1.706	2.056	2.479	2.779	110	1.289	1.659	1.982	2.361	2.621
27	1.314	1.703	2.052	2.473	2.771	120	1.289	1.658	1.980	2.358	2.617
28	1.313	1.701	2.048	2.467	2.763	130	1.288	1.657	1.978	2.355	2.614
29	1.311	1.699	2.045	2.462	2.756	140	1.288	1.656	1.977	2.353	2.611
30	1.310	1.697	2.042	2.457	2.750	150	1.287	1.655	1.976	2.351	2.609
31	1.309	1.696	2.040	2.453	2.744	∞	1.282	1.645	1.960	2.326	2.576
32	1.309	1.694	2.037	2.449	2.738						
33	1.308	1.692	2.035	2.445	2.733						
34	1.307	1.691	2.032	2.441	2.728						
35	1.306	1.690	2.030	2.438	2.724						

Note: As n increases, critical values of Student's t approach the z -values in the last line of this table. A common rule of thumb is to use z when $n > 30$, but that is not conservative.

APPENDIX

A

EXACT BINOMIAL PROBABILITIES



		π																	
n	X	.01	.02	.05	.10	.15	.20	.30	.40	.50	.60	.70	.80	.85	.90	.95	.98	.99	
2	0	.9801	.9604	.9025	.8100	.7225	.6400	.4900	.3600	.2500	.1600	.0900	.0400	.0225	.0100	.0025	.0004	.0001	
	1	.0198	.0392	.0950	.1800	.2550	.3200	.4200	.4800	.5000	.4800	.4200	.3200	.2550	.1800	.0950	.0392	.0198	
	2	.0001	.0004	.0025	.0100	.0225	.0400	.0900	.1600	.2500	.3600	.4900	.6400	.7225	.8100	.9025	.9604	.9801	
3	0	.9703	.9412	.8574	.7290	.6141	.5120	.3430	.2160	.1250	.0640	.0270	.0080	.0034	.0010	.0001	—	—	
	1	.0294	.0576	.1354	.2430	.3251	.3840	.4410	.4320	.3750	.2880	.1890	.0960	.0574	.0270	.0071	.0012	.0003	
	2	.0003	.0012	.0071	.0270	.0574	.0960	.1890	.2880	.3750	.4320	.4410	.4320	.3750	.2880	.1890	.0960	.0574	.0270
	3	—	—	.0001	.0010	.0034	.0080	.0270	.0640	.1250	.2160	.3430	.5120	.6141	.7290	.8574	.9412	.9703	
4	0	.9606	.9224	.8145	.6561	.5220	.4096	.2401	.1296	.0625	.0256	.0081	.0016	.0005	.0001	—	—	—	
	1	.0388	.0753	.1715	.2916	.3685	.4096	.4116	.3456	.2500	.1536	.0756	.0256	.0115	.0036	.0005	—	—	
	2	.0006	.0023	.0135	.0486	.0975	.1536	.2646	.3456	.3750	.3456	.2646	.1536	.0975	.0486	.0135	.0023	.0006	
	3	—	—	.0005	.0036	.0115	.0256	.0756	.1536	.2500	.3456	.4116	.4096	.3685	.2916	.1715	.0753	.0388	
5	0	.9510	.9039	.7738	.5905	.4437	.3277	.1681	.0778	.0313	.0102	.0024	.0003	.0001	—	—	—	—	
	1	.0480	.0922	.2036	.3281	.3915	.4096	.3602	.2592	.1563	.0768	.0284	.0064	.0022	.0005	—	—	—	
	2	.0010	.0038	.0214	.0729	.1382	.2048	.3087	.3456	.3125	.2304	.1323	.0512	.0244	.0081	.0011	.0001	—	
	3	—	.0001	.0011	.0081	.0244	.0512	.1323	.2304	.3125	.3456	.3087	.2048	.1382	.0729	.0214	.0038	.0010	
	4	—	—	—	.0005	.0022	.0064	.0284	.0768	.1563	.2592	.3602	.4096	.3915	.3281	.2036	.0922	.0480	
6	0	.9415	.8858	.7351	.5314	.3771	.2621	.1176	.0467	.0156	.0041	.0007	.0001	—	—	—	—	—	
	1	.0571	.1085	.2321	.3543	.3993	.3932	.3025	.1866	.0938	.0369	.0102	.0015	.0004	.0001	—	—	—	
	2	.0014	.0055	.0305	.0984	.1762	.2458	.3241	.3110	.2344	.1382	.0595	.0154	.0055	.0012	.0001	—	—	
	3	—	.0002	.0021	.0146	.0415	.0819	.1852	.2765	.3125	.2765	.1852	.0819	.0415	.0146	.0021	.0002	—	
	4	—	—	.0001	.0012	.0055	.0154	.0595	.1382	.2344	.3110	.3241	.2458	.1762	.0984	.0305	.0055	.0014	
	5	—	—	—	.0001	.0004	.0015	.0102	.0369	.0938	.1866	.3025	.3932	.3993	.3543	.2321	.1085	.0571	
7	0	.9321	.8681	.6983	.4783	.3206	.2097	.0824	.0280	.0078	.0016	.0002	—	—	—	—	—	—	
	1	.0659	.1240	.2573	.3720	.3960	.3670	.2471	.1306	.0547	.0172	.0036	.0004	.0001	—	—	—	—	
	2	.0020	.0076	.0406	.1240	.2097	.2753	.3177	.2613	.1641	.0774	.0250	.0043	.0012	.0002	—	—	—	
	3	—	.0003	.0036	.0230	.0617	.1147	.2269	.2903	.2734	.1935	.0972	.0287	.0109	.0026	.0002	—	—	
	4	—	—	.0002	.0026	.0109	.0287	.0972	.1935	.2734	.2903	.2269	.1147	.0617	.0230	.0036	.0003	—	
	5	—	—	—	.0002	.0043	.0250	.0774	.1641	.2613	.3177	.2753	.2097	.1240	.0406	.0076	.0020	—	
	6	—	—	—	—	.0001	.0004	.0036	.0172	.0547	.1306	.2471	.3670	.3960	.3720	.2573	.1240	.0659	
8	0	.9227	.8508	.6634	.4305	.2725	.1678	.0576	.0168	.0039	.0007	.0001	—	—	—	—	—	—	
	1	.0746	.1389	.2793	.3826	.3847	.3355	.1977	.0896	.0313	.0079	.0012	.0001	—	—	—	—	—	
	2	.0026	.0099	.0515	.1488	.2376	.2936	.2965	.2090	.1094	.0413	.0100	.0011	.0002	—	—	—	—	
	3	.0001	.0004	.0054	.0331	.0839	.1468	.2541	.2787	.2188	.1239	.0467	.0092	.0026	.0004	—	—	—	
	4	—	—	.0004	.0046	.0185	.0459	.1361	.2322	.2734	.2322	.1361	.0459	.0185	.0046	.0004	—	—	
	5	—	—	—	.0004	.0026	.0092	.0467	.1239	.2188	.2787	.2541	.1468	.0839	.0331	.0054	.0004	.0001	
	6	—	—	—	—	.0002	.0011	.0100	.0413	.1094	.2090	.2965	.2936	.2376	.1488	.0515	.0099	.0026	
	7	—	—	—	—	—	.0001	.0012	.0079	.0313	.0896	.1977	.3355	.3847	.3826	.2793	.1389	.0746	
9	0	.9135	.8337	.6302	.3874	.2316	.1342	.0404	.0101	.0020	.0003	—	—	—	—	—	—	—	
	1	.0830	.1531	.2985	.3874	.3679	.3020	.1556	.0605	.0176	.0035	.0004	—	—	—	—	—	—	
	2	.0034	.0125	.0629	.1722	.2597	.3020	.2668	.1612	.0703	.0212	.0039	.0003	—	—	—	—	—	
	3	.0001	.0006	.0077	.0446	.1069	.1762	.2668	.2508	.1641	.0743	.0210	.0028	.0006	.0001	—	—	—	
	4	—	—	.0006	.0074	.0283	.0661	.1715	.2508	.2461	.1672	.0735	.0165	.0050	.0008	—	—	—	
	5	—	—	—	.0008	.0050	.0165	.0735	.1672	.2461	.2508	.1715	.0661	.0283	.0074	.0006	—	—	
	6	—	—	—	.0001	.0006	.0028	.0210	.0743	.1641	.2508	.2668	.1762	.1069	.0446	.0077	.0006	.0001	
	7	—	—	—	—	—	.0003	.0039	.0212	.0703	.1612	.2668	.3020	.2597	.1722	.0629	.0125	.0034	
	8	—	—	—	—	—	—	.0004	.0035	.0176	.0605	.1556	.3020	.3679	.3874	.2985	.1531	.0830	
9	—	—	—	—	—	—	—	.0003	.0020	.0101	.0404	.1342	.2316	.3874	.6302	.8337	.9135		

		π																	
n	X	.01	.02	.05	.10	.15	.20	.30	.40	.50	.60	.70	.80	.85	.90	.95	.98	.99	
10	0	.9044	.8171	.5987	.3487	.1969	.1074	.0282	.0060	.0010	.0001	—	—	—	—	—	—	—	
	1	.0914	.1667	.3151	.3874	.3474	.2684	.1211	.0403	.0098	.0016	.0001	—	—	—	—	—	—	
	2	.0042	.0153	.0746	.1937	.2759	.3020	.2335	.1209	.0439	.0106	.0014	.0001	—	—	—	—	—	—
	3	.0001	.0008	.0105	.0574	.1298	.2013	.2668	.2150	.1172	.0425	.0090	.0008	.0001	—	—	—	—	—
	4	—	—	.0010	.0112	.0401	.0881	.2001	.2508	.2051	.1115	.0368	.0055	.0012	.0001	—	—	—	—
	5	—	—	.0001	.0015	.0085	.0264	.1029	.2007	.2461	.2007	.1029	.0264	.0085	.0015	.0001	—	—	—
	6	—	—	—	.0001	.0012	.0055	.0368	.1115	.2051	.2508	.2001	.0881	.0401	.0112	.0010	—	—	—
	7	—	—	—	—	.0001	.0008	.0090	.0425	.1172	.2150	.2668	.2013	.1298	.0574	.0105	.0008	.0001	—
	8	—	—	—	—	—	.0001	.0014	.0106	.0439	.1209	.2335	.3020	.2759	.1937	.0746	.0153	.0042	.0001
	9	—	—	—	—	—	—	.0001	.0016	.0098	.0403	.1211	.2684	.3474	.3874	.3151	.1667	.0914	—
10	—	—	—	—	—	—	—	.0001	.0010	.0060	.0282	.1074	.1969	.3487	.5987	.8171	.9044	—	
12	0	.8864	.7847	.5404	.2824	.1422	.0687	.0138	.0022	.0002	—	—	—	—	—	—	—	—	
	1	.1074	.1922	.3413	.3766	.3012	.2062	.0712	.0174	.0029	.0003	—	—	—	—	—	—	—	
	2	.0060	.0216	.0988	.2301	.2924	.2835	.1678	.0639	.0161	.0025	.0002	—	—	—	—	—	—	—
	3	.0002	.0015	.0173	.0852	.1720	.2362	.2397	.1419	.0537	.0125	.0015	.0001	—	—	—	—	—	—
	4	—	.0001	.0021	.0213	.0683	.1329	.2311	.2128	.1208	.0420	.0078	.0005	.0001	—	—	—	—	—
	5	—	—	.0002	.0038	.0193	.0532	.1585	.2270	.1934	.1009	.0291	.0033	.0006	—	—	—	—	—
	6	—	—	—	.0005	.0040	.0155	.0792	.1766	.2256	.1766	.0792	.0155	.0040	.0005	—	—	—	—
	7	—	—	—	—	.0006	.0033	.0291	.1009	.1934	.2270	.1585	.0532	.0193	.0038	.0002	—	—	—
	8	—	—	—	—	.0001	.0005	.0078	.0420	.1208	.2128	.2311	.1329	.0683	.0213	.0021	.0001	—	—
	9	—	—	—	—	—	.0001	.0015	.0125	.0537	.1419	.2397	.2362	.1720	.0852	.0173	.0015	.0002	—
	10	—	—	—	—	—	—	.0002	.0025	.0161	.0639	.1678	.2835	.2924	.2301	.0988	.0216	.0060	—
	11	—	—	—	—	—	—	—	.0003	.0029	.0174	.0712	.2062	.3012	.3766	.3413	.1922	.1074	—
12	—	—	—	—	—	—	—	—	.0002	.0022	.0138	.0687	.1422	.2824	.5404	.7847	.8864	—	
14	0	.8687	.7536	.4877	.2288	.1028	.0440	.0068	.0008	.0001	—	—	—	—	—	—	—	—	
	1	.1229	.2153	.3593	.3559	.2539	.1539	.0407	.0073	.0009	.0001	—	—	—	—	—	—	—	
	2	.0081	.0286	.1229	.2570	.2912	.2501	.1134	.0317	.0056	.0005	—	—	—	—	—	—	—	
	3	.0003	.0023	.0259	.1142	.2056	.2501	.1943	.0845	.0222	.0033	.0002	—	—	—	—	—	—	
	4	—	.0001	.0037	.0349	.0998	.1720	.2290	.1549	.0611	.0136	.0014	—	—	—	—	—	—	
	5	—	—	.0004	.0078	.0352	.0860	.1963	.2066	.1222	.0408	.0066	.0003	—	—	—	—	—	
	6	—	—	—	.0013	.0093	.0322	.1262	.2066	.1833	.0918	.0232	.0020	.0003	—	—	—	—	
	7	—	—	—	.0002	.0019	.0092	.0618	.1574	.2095	.1574	.0618	.0092	.0019	.0002	—	—	—	
	8	—	—	—	—	.0003	.0020	.0232	.0918	.1833	.2066	.1262	.0322	.0093	.0013	—	—	—	
	9	—	—	—	—	—	.0003	.0066	.0408	.1222	.2066	.1963	.0860	.0352	.0078	.0004	—	—	
	10	—	—	—	—	—	—	.0014	.0136	.0611	.1549	.2290	.1720	.0998	.0349	.0037	.0001	—	
	11	—	—	—	—	—	—	.0002	.0033	.0222	.0845	.1943	.2501	.2056	.1142	.0259	.0023	.0003	
	12	—	—	—	—	—	—	—	.0005	.0056	.0317	.1134	.2501	.2912	.2570	.1229	.0286	.0081	
	13	—	—	—	—	—	—	—	.0001	.0009	.0073	.0407	.1539	.2539	.3593	.3593	.2153	.1229	
14	—	—	—	—	—	—	—	—	.0001	.0008	.0068	.0440	.1028	.2288	.4877	.7536	.8687		
16	0	.8515	.7238	.4401	.1853	.0743	.0281	.0033	.0003	—	—	—	—	—	—	—	—	—	
	1	.1376	.2363	.3706	.3294	.2097	.1126	.0228	.0030	.0002	—	—	—	—	—	—	—	—	
	2	.0104	.0362	.1463	.2745	.2775	.2111	.0732	.0150	.0018	.0001	—	—	—	—	—	—	—	
	3	.0005	.0034	.0359	.1423	.2285	.2463	.1465	.0468	.0085	.0008	—	—	—	—	—	—	—	
	4	—	.0002	.0061	.0514	.1311	.2001	.2040	.1014	.0278	.0040	.0002	—	—	—	—	—	—	
	5	—	—	.0008	.0137	.0555	.1201	.2099	.1623	.0667	.0142	.0013	—	—	—	—	—	—	
	6	—	—	.0001	.0028	.0180	.0550	.1649	.1983	.1222	.0392	.0056	.0002	—	—	—	—	—	
	7	—	—	—	.0004	.0045	.0197	.1010	.1889	.1746	.0840	.0185	.0012	.0001	—	—	—	—	
	8	—	—	—	.0001	.0009	.0055	.0487	.1417	.1964	.1417	.0487	.0055	.0009	.0001	—	—	—	
	9	—	—	—	—	.0001	.0012	.0185	.0840	.1746	.1889	.1010	.0197	.0045	.0004	—	—	—	
	10	—	—	—	—	—	.0002	.0056	.0392	.1222	.1983	.1649	.0550	.0180	.0028	.0001	—	—	
	11	—	—	—	—	—	—	.0013	.0142	.0667	.1623	.2099	.1201	.0555	.0137	.0008	—	—	
	12	—	—	—	—	—	—	.0002	.0040	.0278	.1014	.2040	.2001	.1311	.0514	.0061	.0002	—	
	13	—	—	—	—	—	—	—	.0008	.0085	.0468	.1465	.2463	.2285	.1423	.0359	.0034	.0005	
	14	—	—	—	—	—	—	—	.0001	.0018	.0150	.0732	.2111	.2775	.2745	.1463	.0362	.0104	
	15	—	—	—	—	—	—	—	—	.0002	.0030	.0228	.1126	.2097	.3294	.3706	.2363	.1376	
16	—	—	—	—	—	—	—	—	—	.0003	.0033	.0281	.0743	.1853	.4401	.7238	.8515		

APPENDIX

B

EXACT POISSON PROBABILITIES



		λ													
X	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
0	.9048	.8187	.7408	.6703	.6065	.5488	.4966	.4493	.4066	.3679	.3329	.3012	.2725	.2466	.2231
1	.0905	.1637	.2222	.2681	.3033	.3293	.3476	.3595	.3659	.3679	.3662	.3614	.3543	.3452	.3347
2	.0045	.0164	.0333	.0536	.0758	.0988	.1217	.1438	.1647	.1839	.2014	.2169	.2303	.2417	.2510
3	.0002	.0011	.0033	.0072	.0126	.0198	.0284	.0383	.0494	.0613	.0738	.0867	.0998	.1128	.1255
4	—	.0001	.0003	.0007	.0016	.0030	.0050	.0077	.0111	.0153	.0203	.0260	.0324	.0395	.0471
5	—	—	—	.0001	.0002	.0004	.0007	.0012	.0020	.0031	.0045	.0062	.0084	.0111	.0141
6	—	—	—	—	—	—	.0001	.0002	.0003	.0005	.0008	.0012	.0018	.0026	.0035
7	—	—	—	—	—	—	—	—	—	.0001	.0001	.0002	.0003	.0005	.0008
8	—	—	—	—	—	—	—	—	—	—	—	—	.0001	.0001	.0001

		λ													
X	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
0	.2019	.1827	.1653	.1496	.1353	.1225	.1108	.1003	.0907	.0821	.0743	.0672	.0608	.0550	.0498
1	.3230	.3106	.2975	.2842	.2707	.2572	.2438	.2306	.2177	.2052	.1931	.1815	.1703	.1596	.1494
2	.2584	.2640	.2678	.2700	.2707	.2700	.2681	.2652	.2613	.2565	.2510	.2450	.2384	.2314	.2240
3	.1378	.1496	.1607	.1710	.1804	.1890	.1966	.2033	.2090	.2138	.2176	.2205	.2225	.2237	.2240
4	.0551	.0636	.0723	.0812	.0902	.0992	.1082	.1169	.1254	.1336	.1414	.1488	.1557	.1622	.1680
5	.0176	.0216	.0260	.0309	.0361	.0417	.0476	.0538	.0602	.0668	.0735	.0804	.0872	.0940	.1008
6	.0047	.0061	.0078	.0098	.0120	.0146	.0174	.0206	.0241	.0278	.0319	.0362	.0407	.0455	.0504
7	.0011	.0015	.0020	.0027	.0034	.0044	.0055	.0068	.0083	.0099	.0118	.0139	.0163	.0188	.0216
8	.0002	.0003	.0005	.0006	.0009	.0011	.0015	.0019	.0025	.0031	.0038	.0047	.0057	.0068	.0081
9	—	.0001	.0001	.0001	.0002	.0003	.0004	.0005	.0007	.0009	.0011	.0014	.0018	.0022	.0027
10	—	—	—	—	—	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0006	.0008
11	—	—	—	—	—	—	—	—	—	—	.0001	.0001	.0001	.0002	.0002
12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.0001

		λ													
X	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5
0	.0450	.0408	.0369	.0334	.0302	.0273	.0247	.0224	.0202	.0183	.0166	.0150	.0136	.0123	.0111
1	.1397	.1304	.1217	.1135	.1057	.0984	.0915	.0850	.0789	.0733	.0679	.0630	.0583	.0540	.0500
2	.2165	.2087	.2008	.1929	.1850	.1771	.1692	.1615	.1539	.1465	.1393	.1323	.1254	.1188	.1125
3	.2237	.2226	.2209	.2186	.2158	.2125	.2087	.2046	.2001	.1954	.1904	.1852	.1798	.1743	.1687
4	.1733	.1781	.1823	.1858	.1888	.1912	.1931	.1944	.1951	.1954	.1951	.1944	.1933	.1917	.1898
5	.1075	.1140	.1203	.1264	.1322	.1377	.1429	.1477	.1522	.1563	.1600	.1633	.1662	.1687	.1708
6	.0555	.0608	.0662	.0716	.0771	.0826	.0881	.0936	.0989	.1042	.1093	.1143	.1191	.1237	.1281
7	.0246	.0278	.0312	.0348	.0385	.0425	.0466	.0508	.0551	.0595	.0640	.0686	.0732	.0778	.0824
8	.0095	.0111	.0129	.0148	.0169	.0191	.0215	.0241	.0269	.0298	.0328	.0360	.0393	.0428	.0463
9	.0033	.0040	.0047	.0056	.0066	.0076	.0089	.0102	.0116	.0132	.0150	.0168	.0188	.0209	.0232
10	.0010	.0013	.0016	.0019	.0023	.0028	.0033	.0039	.0045	.0053	.0061	.0071	.0081	.0092	.0104
11	.0003	.0004	.0005	.0006	.0007	.0009	.0011	.0013	.0016	.0019	.0023	.0027	.0032	.0037	.0043
12	.0001	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0005	.0006	.0008	.0009	.0011	.0013	.0016
13	—	—	—	—	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0004	.0005	.0006	.0008
14	—	—	—	—	—	—	—	—	.0001	.0001	.0001	.0001	.0001	.0001	.0002
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.0001

λ

X	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0
0	.0101	.0091	.0082	.0074	.0067	.0061	.0055	.0050	.0045	.0041	.0037	.0033	.0030	.0027	.0025
1	.0462	.0427	.0395	.0365	.0337	.0311	.0287	.0265	.0244	.0225	.0207	.0191	.0176	.0162	.0149
2	.1063	.1005	.0948	.0894	.0842	.0793	.0746	.0701	.0659	.0618	.0580	.0544	.0509	.0477	.0446
3	.1631	.1574	.1517	.1460	.1404	.1348	.1293	.1239	.1185	.1133	.1082	.1033	.0985	.0938	.0892
4	.1875	.1849	.1820	.1789	.1755	.1719	.1681	.1641	.1600	.1558	.1515	.1472	.1428	.1383	.1339
5	.1725	.1738	.1747	.1753	.1755	.1753	.1748	.1740	.1728	.1714	.1697	.1678	.1656	.1632	.1606
6	.1323	.1362	.1398	.1432	.1462	.1490	.1515	.1537	.1555	.1571	.1584	.1594	.1601	.1605	.1606
7	.0869	.0914	.0959	.1002	.1044	.1086	.1125	.1163	.1200	.1234	.1267	.1298	.1326	.1353	.1377
8	.0500	.0537	.0575	.0614	.0653	.0692	.0731	.0771	.0810	.0849	.0887	.0925	.0962	.0998	.1033
9	.0255	.0281	.0307	.0334	.0363	.0392	.0423	.0454	.0486	.0519	.0552	.0586	.0620	.0654	.0688
10	.0118	.0132	.0147	.0164	.0181	.0200	.0220	.0241	.0262	.0285	.0309	.0334	.0359	.0386	.0413
11	.0049	.0056	.0064	.0073	.0082	.0093	.0104	.0116	.0129	.0143	.0157	.0173	.0190	.0207	.0225
12	.0019	.0022	.0026	.0030	.0034	.0039	.0045	.0051	.0058	.0065	.0073	.0082	.0092	.0102	.0113
13	.0007	.0008	.0009	.0011	.0013	.0015	.0018	.0021	.0024	.0028	.0032	.0036	.0041	.0046	.0052
14	.0002	.0003	.0003	.0004	.0005	.0006	.0007	.0008	.0009	.0011	.0013	.0015	.0017	.0019	.0022
15	.0001	.0001	.0001	.0001	.0002	.0002	.0002	.0003	.0003	.0004	.0005	.0006	.0007	.0008	.0009
16	—	—	—	—	—	.0001	.0001	.0001	.0001	.0001	.0002	.0002	.0002	.0003	.0003
17	—	—	—	—	—	—	—	—	—	—	.0001	.0001	.0001	.0001	.0001

λ

X	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5
0	.0022	.0020	.0018	.0017	.0015	.0014	.0012	.0011	.0010	.0009	.0008	.0007	.0007	.0006	.0006
1	.0137	.0126	.0116	.0106	.0098	.0090	.0082	.0076	.0070	.0064	.0059	.0054	.0049	.0045	.0041
2	.0417	.0390	.0364	.0340	.0318	.0296	.0276	.0258	.0240	.0223	.0208	.0194	.0180	.0167	.0156
3	.0848	.0806	.0765	.0726	.0688	.0652	.0617	.0584	.0552	.0521	.0492	.0464	.0438	.0413	.0389
4	.1294	.1249	.1205	.1162	.1118	.1076	.1034	.0992	.0952	.0912	.0874	.0836	.0799	.0764	.0729
5	.1579	.1549	.1519	.1487	.1454	.1420	.1385	.1349	.1314	.1277	.1241	.1204	.1167	.1130	.1094
6	.1605	.1601	.1595	.1586	.1575	.1562	.1546	.1529	.1511	.1490	.1468	.1445	.1420	.1394	.1367
7	.1399	.1418	.1435	.1450	.1462	.1472	.1480	.1486	.1489	.1490	.1489	.1486	.1481	.1474	.1465
8	.1066	.1099	.1130	.1160	.1188	.1215	.1240	.1263	.1284	.1304	.1321	.1337	.1351	.1363	.1373
9	.0723	.0757	.0791	.0825	.0858	.0891	.0923	.0954	.0985	.1014	.1042	.1070	.1096	.1121	.1144
10	.0441	.0469	.0498	.0528	.0558	.0588	.0618	.0649	.0679	.0710	.0740	.0770	.0800	.0829	.0858
11	.0244	.0265	.0285	.0307	.0330	.0353	.0377	.0401	.0426	.0452	.0478	.0504	.0531	.0558	.0585
12	.0124	.0137	.0150	.0164	.0179	.0194	.0210	.0227	.0245	.0263	.0283	.0303	.0323	.0344	.0366
13	.0058	.0065	.0073	.0081	.0089	.0099	.0108	.0119	.0130	.0142	.0154	.0168	.0181	.0196	.0211
14	.0025	.0029	.0033	.0037	.0041	.0046	.0052	.0058	.0064	.0071	.0078	.0086	.0095	.0104	.0113
15	.0010	.0012	.0014	.0016	.0018	.0020	.0023	.0026	.0029	.0033	.0037	.0041	.0046	.0051	.0057
16	.0004	.0005	.0005	.0006	.0007	.0008	.0010	.0011	.0013	.0014	.0016	.0019	.0021	.0024	.0026
17	.0001	.0002	.0002	.0002	.0003	.0003	.0004	.0004	.0005	.0006	.0007	.0008	.0009	.0010	.0012
18	—	.0001	.0001	.0001	.0001	.0001	.0001	.0002	.0002	.0003	.0003	.0004	.0004	.0004	.0005
19	—	—	—	—	—	—	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0002	.0002
20	—	—	—	—	—	—	—	—	—	—	—	—	.0001	.0001	.0001

