FORELESNING 2

Våren 2004

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TMA4275 LEVETIDSANALYSE

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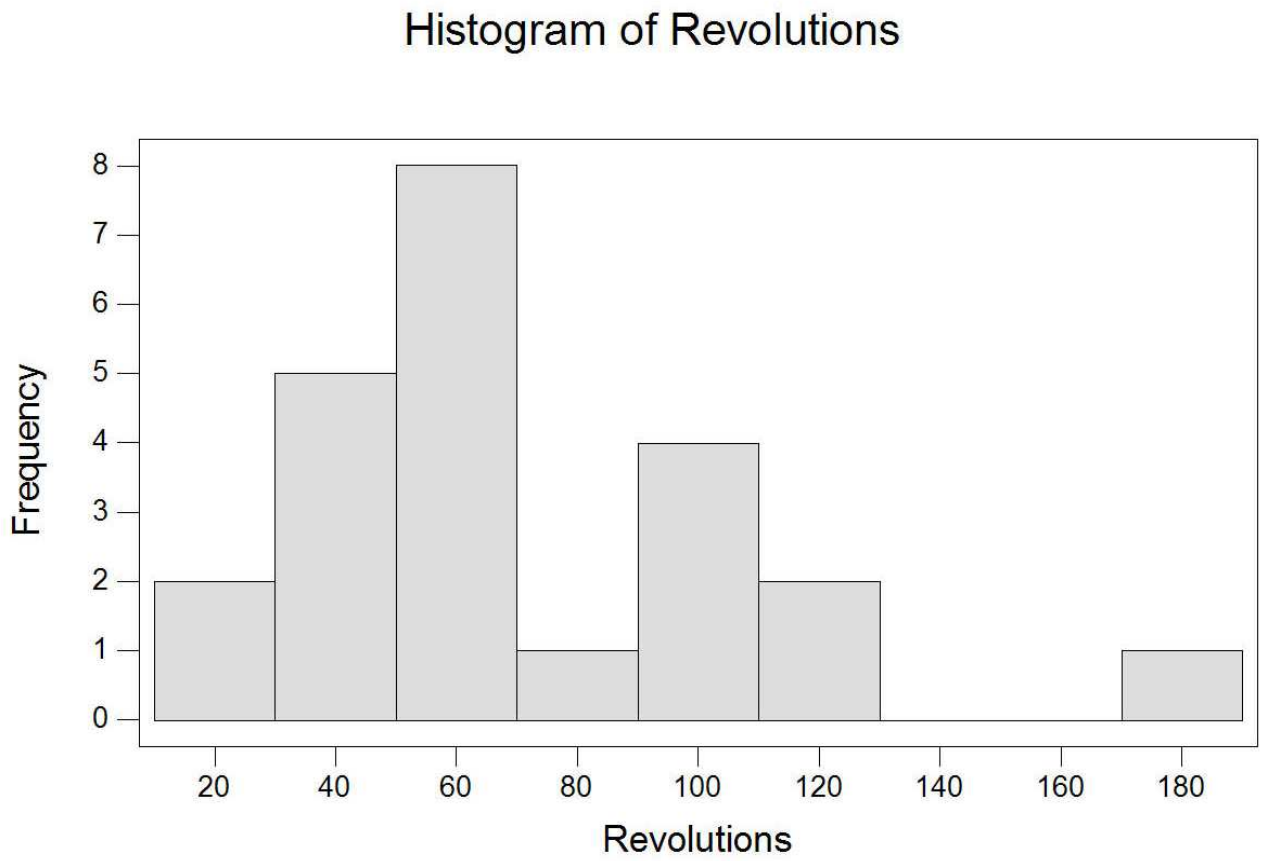
BALL BEARINGS FAILURE DATA

Data: Millioner av omdreininger til tretthetsfeil for 23 enheter

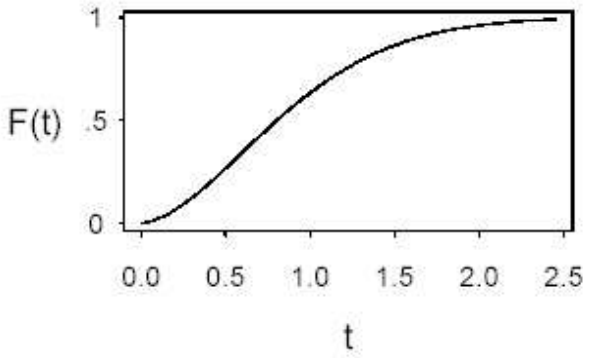
17,88	28,92	33,00	41,52	42,12	45,60	48,40	51,84
51,96	54,12	55,56	67,80	68,64	68,64	68,88	84,12
93,12	98,64	105,12	105,84	127,92	128,04	173,40	



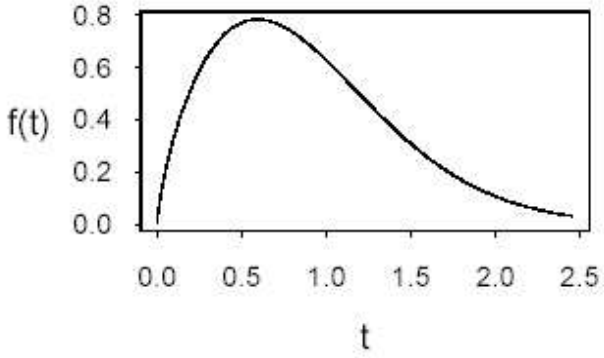
Typical Failure-time cdf, pdf, hf, and sf

$$F(t) = 1 - \exp(-t^{1.7}); \quad f(t) = 1.7 \times t^{.7} \times \exp(-t^{1.7})$$
$$S(t) = \exp(-t^{1.7}); \quad h(t) = 1.7 \times t^{.7}$$

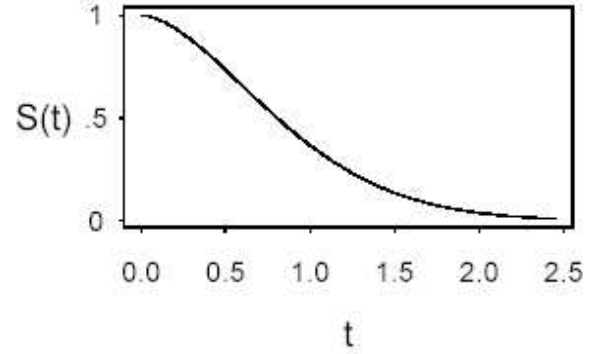
Cumulative Distribution Function



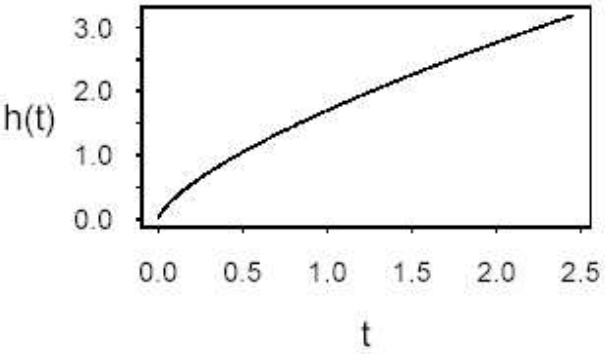
Probability Density Function



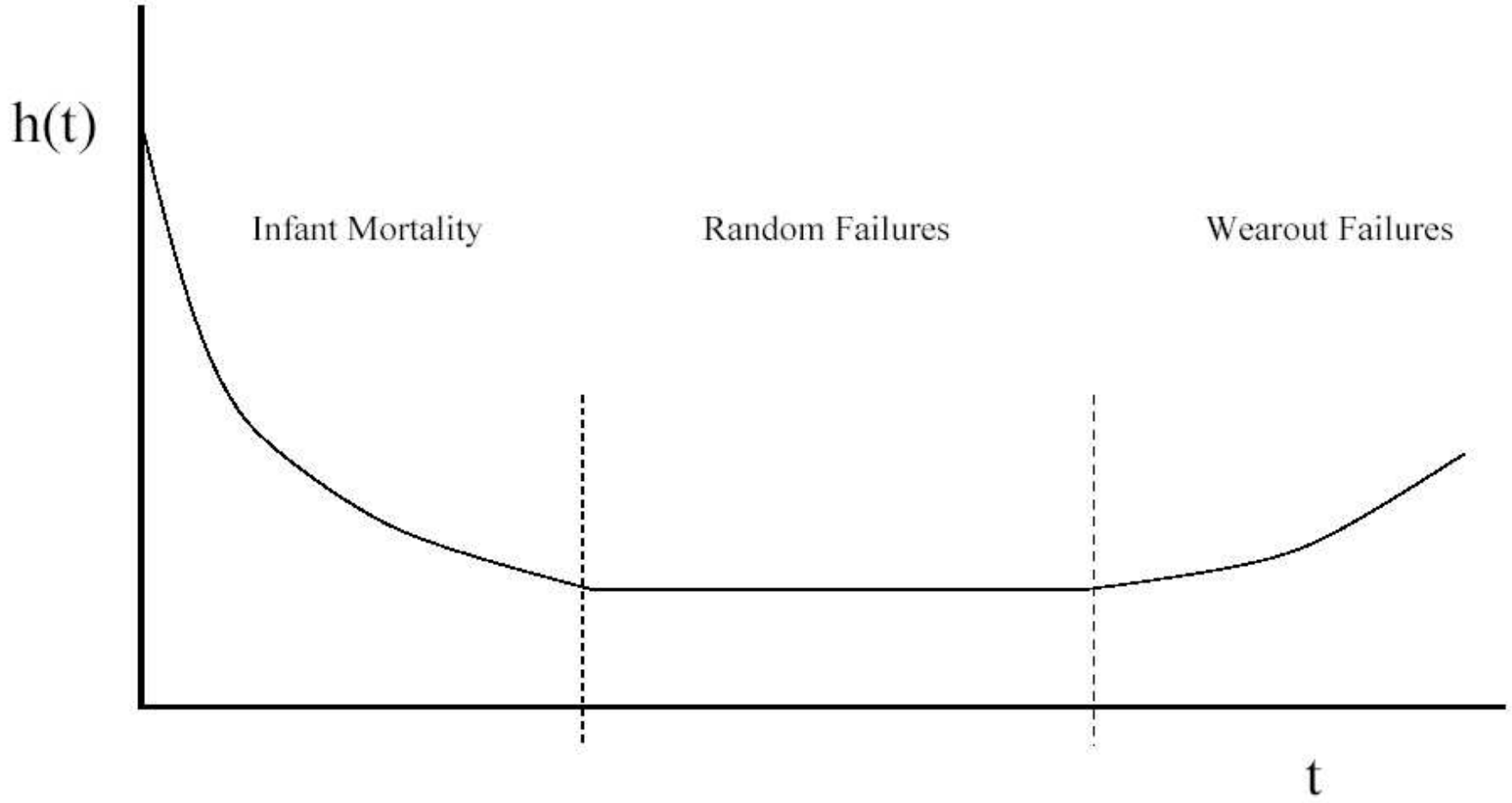
Survival Function



Hazard Function



Bathtub Curve Hazard Function



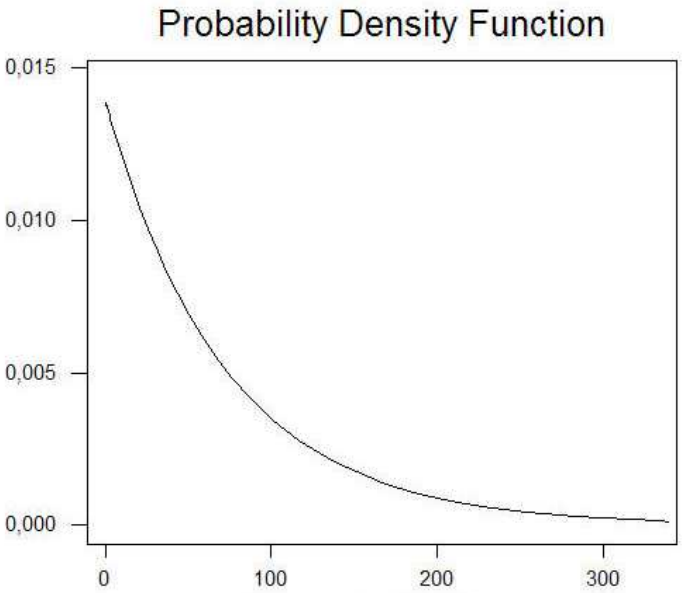
10 Dødelighetstabeller [1]. 2001

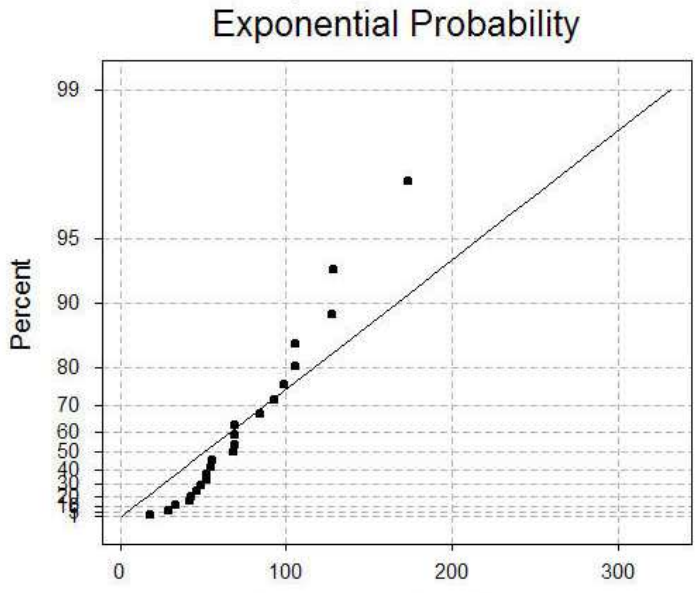
Alder x	Levende ved alder x		Døde i alder x til x+1		Forventet gjenstående levetid ved alder x		Dødssannsynlighet for alder x, Promille, (Uglattet).	
	lx		dx		e0x		qx	
	Menn	Kvinner	Menn	Kvinner	Menn	Kvinner	Menn	Kvinner
0	100 000	100 000	424	343	76,21	81,53	4,24	3,43
1	99 576	99 657	39	27	75,53	80,81	0,39	0,28
2	99 537	99 630	33	7	74,56	79,83	0,33	0,07
3	99 504	99 623	32	17	73,58	78,84	0,33	0,17
4	99 472	99 606	13	10	72,61	77,85	0,13	0,10
5	99 459	99 596	6	10	71,62	76,86	0,06	0,10
6	99 453	99 586	22	17	70,62	75,87	0,22	0,17
7	99 431	99 569	10	3	69,64	74,88	0,10	0,03
8	99 422	99 566	9	13	68,64	73,88	0,09	0,13
9	99 412	99 552	9	3	67,65	72,89	0,09	0,03
10	99 403	99 549	12	3	66,66	71,89	0,12	0,03
11	99 390	99 546	3	10	65,66	70,89	0,03	0,10
12	99 387	99 536	16	3	64,67	69,90	0,16	0,03
13	99 371	99 532	10	11	63,68	68,90	0,10	0,11
14	99 361	99 522	7	7	62,68	67,91	0,07	0,07
15	99 354	99 514	32	11	61,69	66,92	0,32	0,11
16	99 322	99 503	33	23	60,71	65,92	0,33	0,23
17	99 289	99 480	77	39	59,73	64,94	0,77	0,39
18	99 212	99 441	90	35	58,77	63,96	0,91	0,35
19	99 122	99 407	123	34	57,83	62,99	1,24	0,34
20	98 999	99 373	155	60	56,90	62,01	1,57	0,60
21	98 844	99 313	142	15	55,99	61,04	1,44	0,15

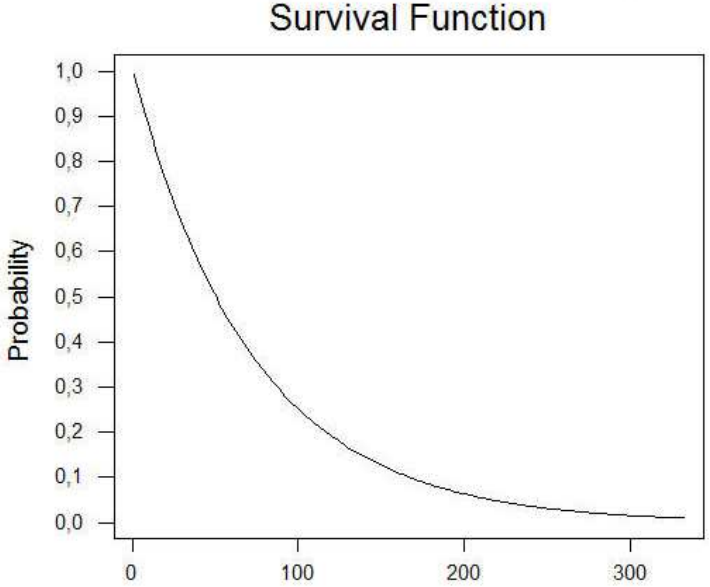
40	96 600	98 433	147	85	38,05	42,49	1,53	0,86
41	96 453	98 348	144	110	37,11	41,53	1,49	1,12
42	96 309	98 239	208	100	36,16	40,58	2,16	1,02
43	96 101	98 138	181	110	35,24	39,62	1,89	1,12
44	95 919	98 029	205	112	34,31	38,66	2,14	1,15
45	95 715	97 916	190	153	33,38	37,70	1,98	1,57
46	95 525	97 763	256	172	32,44	36,76	2,68	1,76
47	95 268	97 591	256	160	31,53	35,83	2,68	1,64
48	95 013	97 431	324	191	30,61	34,88	3,41	1,96
49	94 689	97 240	310	197	29,72	33,95	3,28	2,03
50	94 379	97 042	324	233	28,81	33,02	3,43	2,40
51	94 055	96 810	387	265	27,91	32,10	4,11	2,74
52	93 668	96 545	332	255	27,02	31,18	3,54	2,64
53	93 336	96 290	461	293	26,12	30,27	4,94	3,04
54	92 875	95 997	504	343	25,25	29,36	5,42	3,58
55	92 371	95 653	546	342	24,38	28,46	5,91	3,57
56	91 825	95 311	583	362	23,52	27,56	6,35	3,80
57	91 242	94 949	647	400	22,67	26,66	7,09	4,22
58	90 595	94 549	593	435	21,83	25,77	6,55	4,60
59	90 002	94 115	713	554	20,97	24,89	7,92	5,89
60	89 289	93 560	797	543	20,13	24,04	8,93	5,81
61	88 492	93 017	853	543	19,31	23,17	9,64	5,83
62	87 639	92 475	911	626	18,49	22,31	10,39	6,77
63	86 728	91 848	1 200	781	17,68	21,45	13,84	8,50
64	85 528	91 068	1 359	795	16,92	20,63	15,89	8,73
65	84 168	90 273	1 356	763	16,19	19,81	16,11	8,45
66	82 812	89 509	1 349	883	15,44	18,98	16,29	9,86
67	81 463	88 627	1 572	897	14,69	18,16	19,30	10,12
68	79 891	87 730	1 746	1 070	13,97	17,34	21,86	12,19
69	78 145	86 660	1 869	1 056	13,27	16,55	23,91	12,19

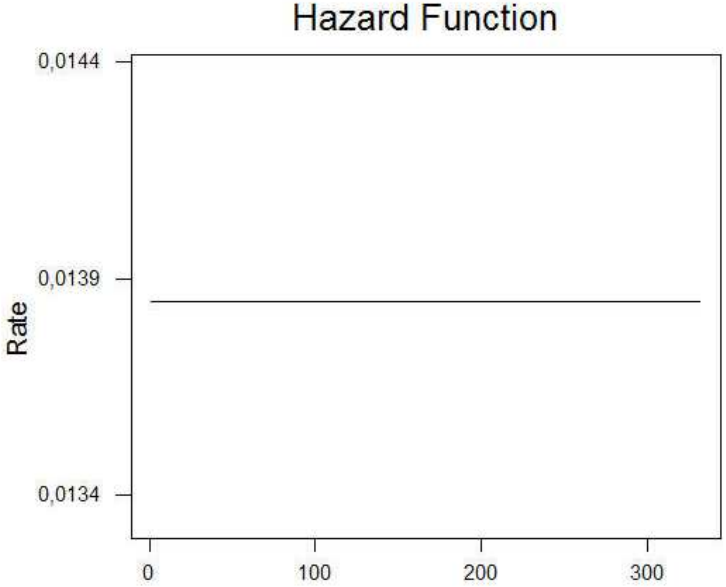
Ball Bearings Failure Data

ML Estimates - Complete Data









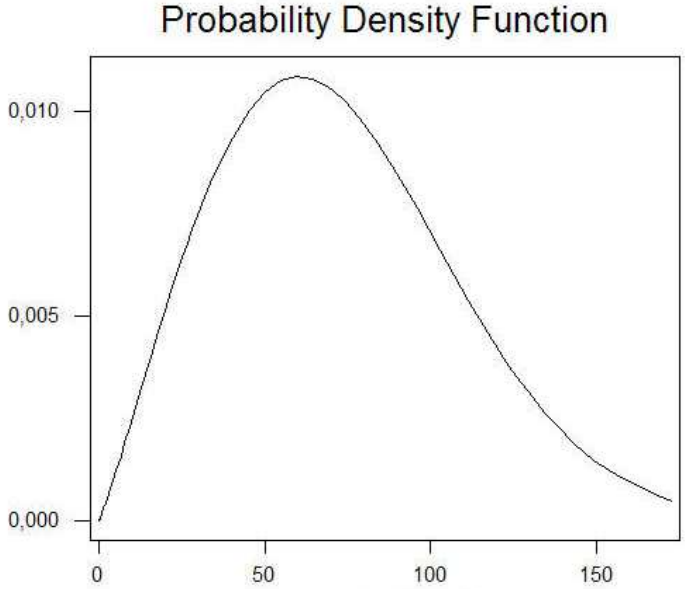
Shape	1
Scale	72,221
MTTF	72,221
Failure	23
Censor	0

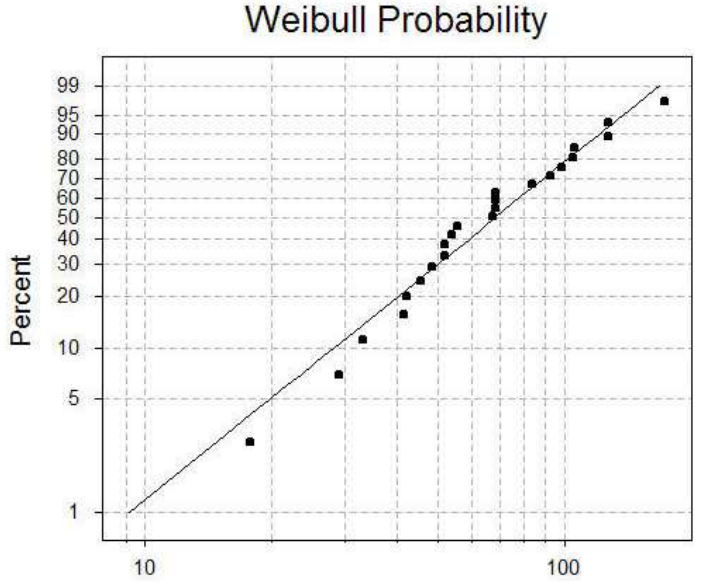
Goodness of Fit

AD*	3,341

Ball Bearings Failure Data

ML Estimates - Complete Data

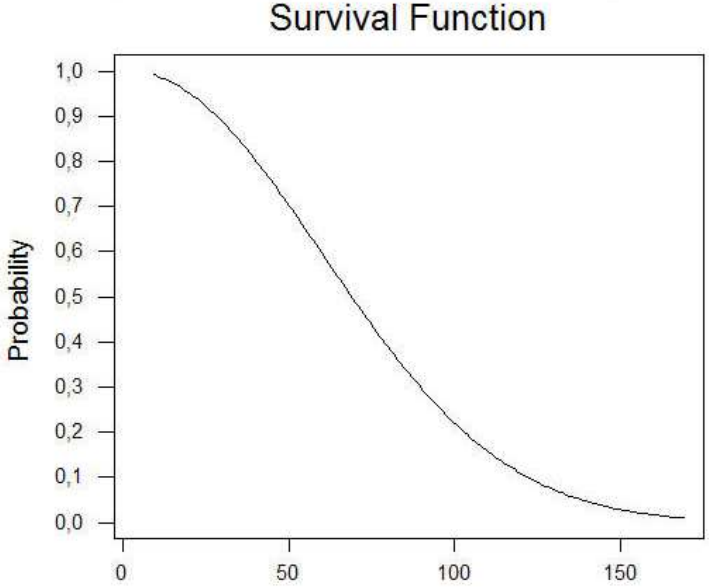


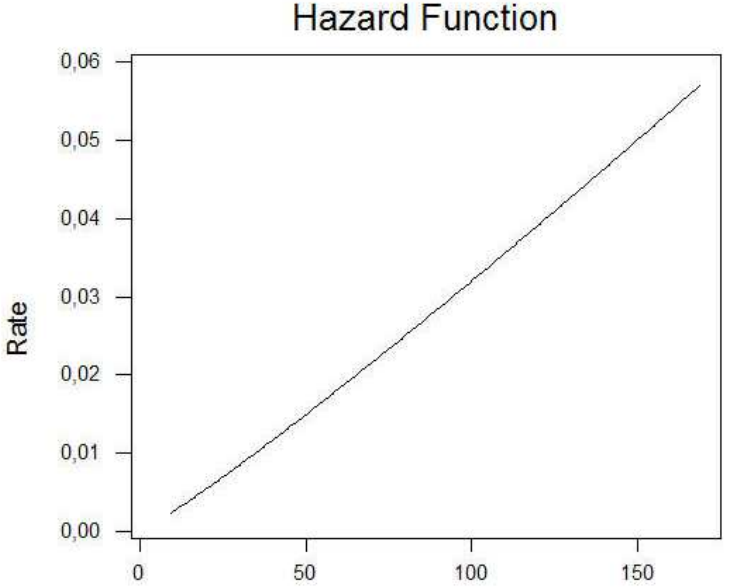


Shape	2,1018
Scale	81,875
MTTF	72,515
Failure	23
Censor	0

Goodness of Fit

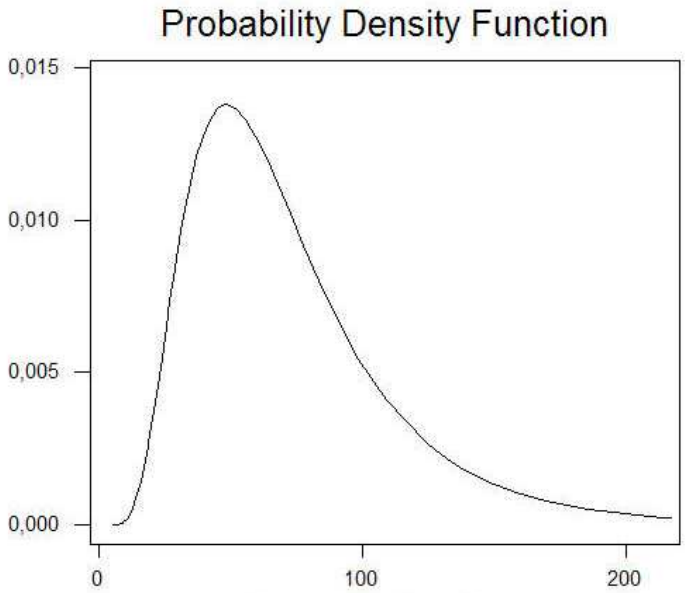
AD*	0,802

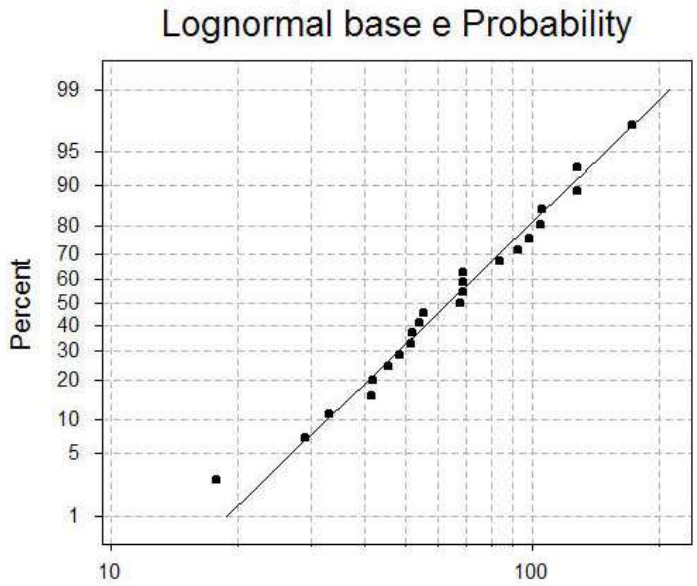




Ball Bearings Failure Data

ML Estimates - Complete Data

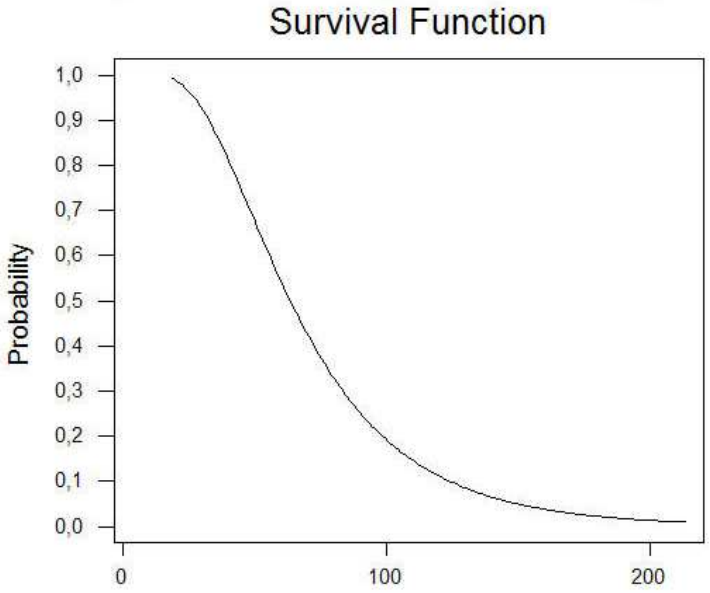


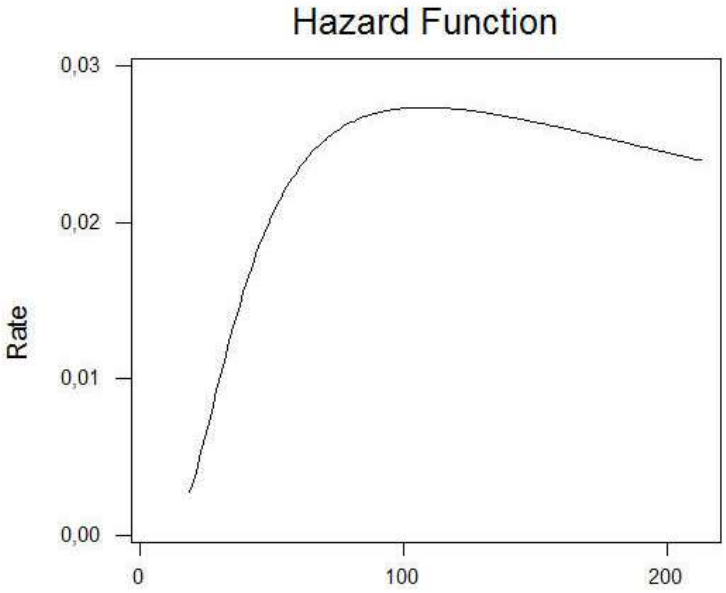


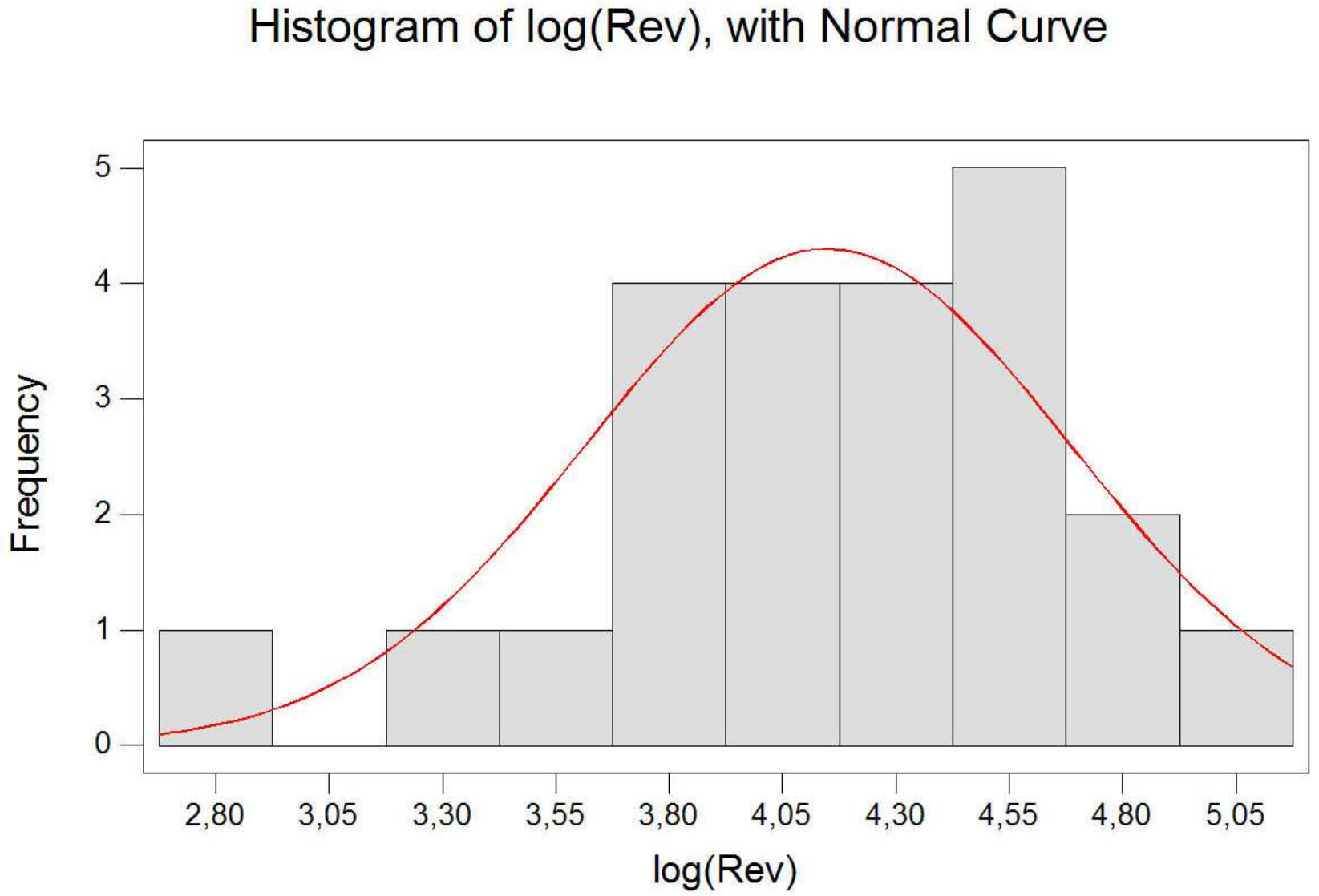
Location	4,1504
Scale	0,5217
MTTF	72,709
Failure	23
Censor	0

Goodness of Fit

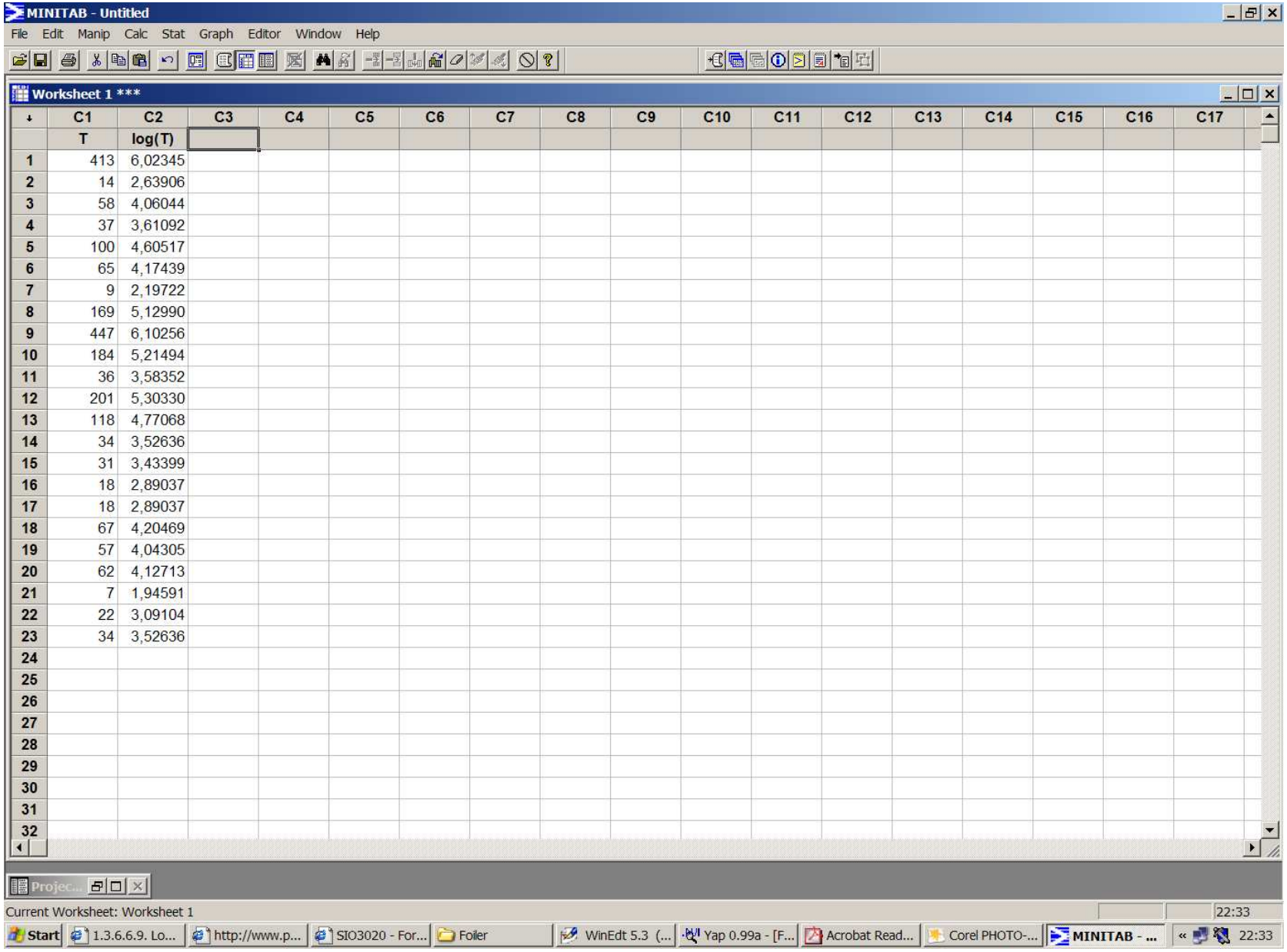
AD*	0,647



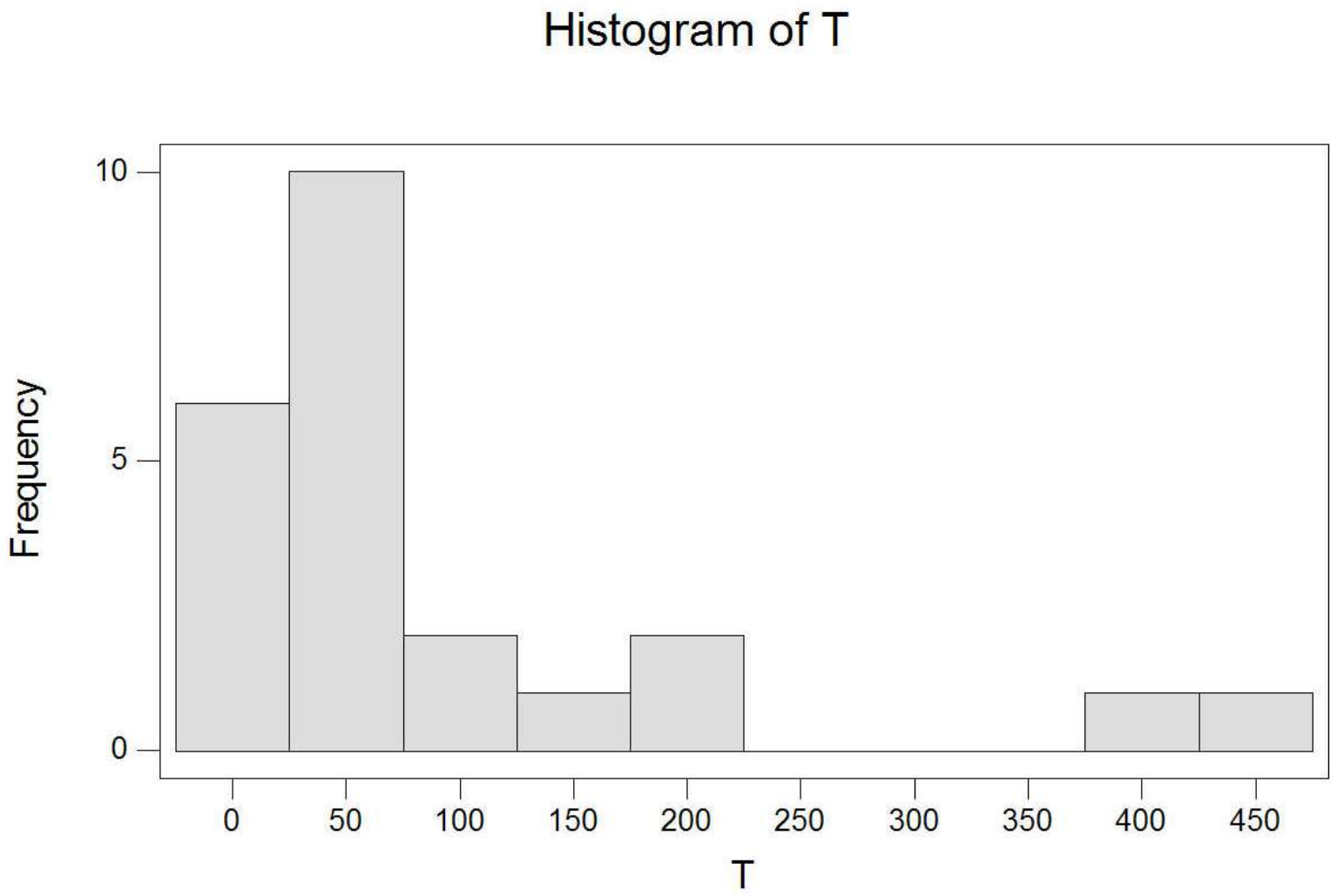


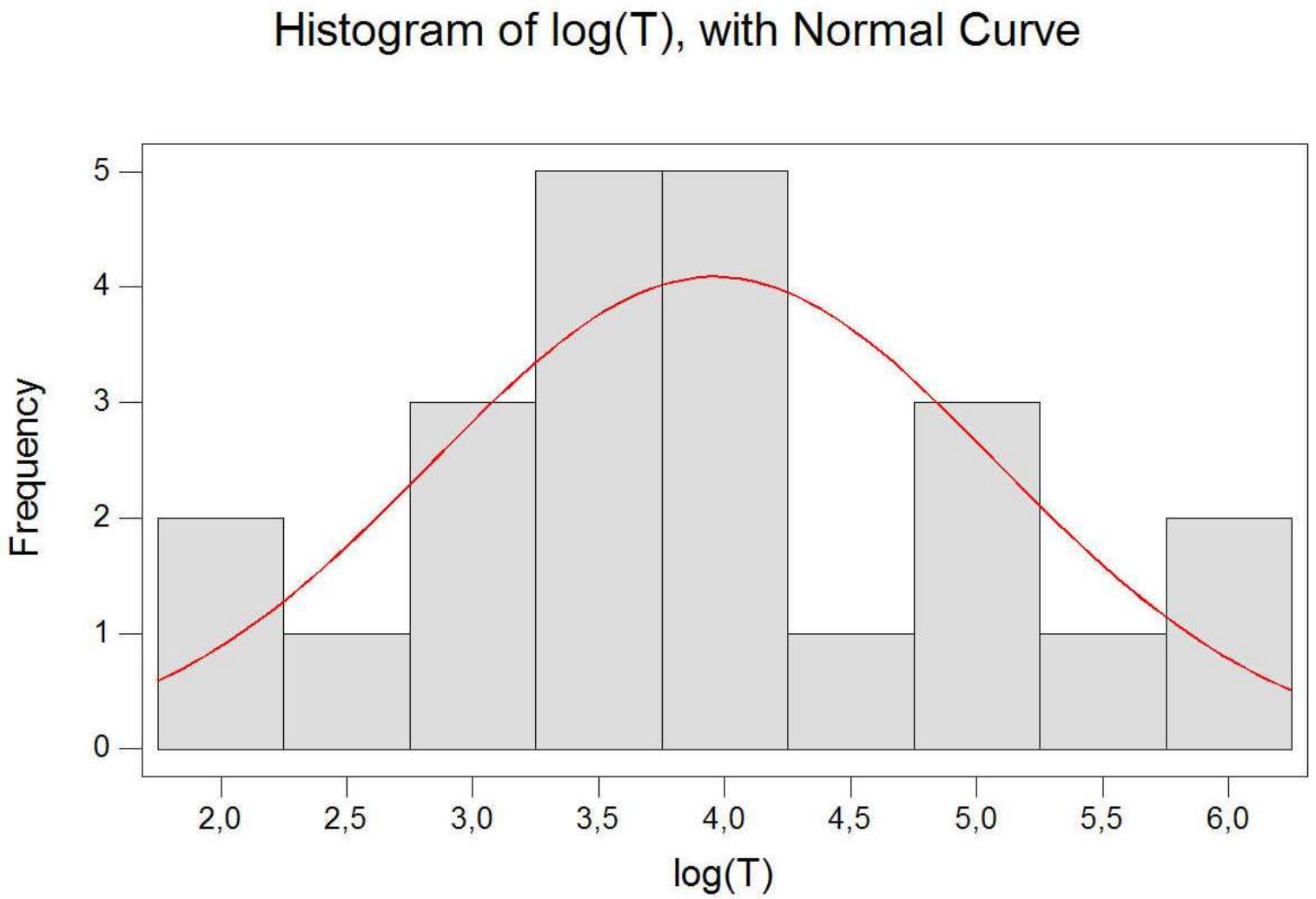

Histogram of log(Rev), with Normal Curve
Frequency
0
1
2
3
4
5
2,80
3,05
3,30
3,55
3,80
4,05
4,30
4,55
4,80
5,05
log(Rev)

AIRCONDITION FAILURES ON BOEING AIRPLANES (PROSCHAN, 1963)



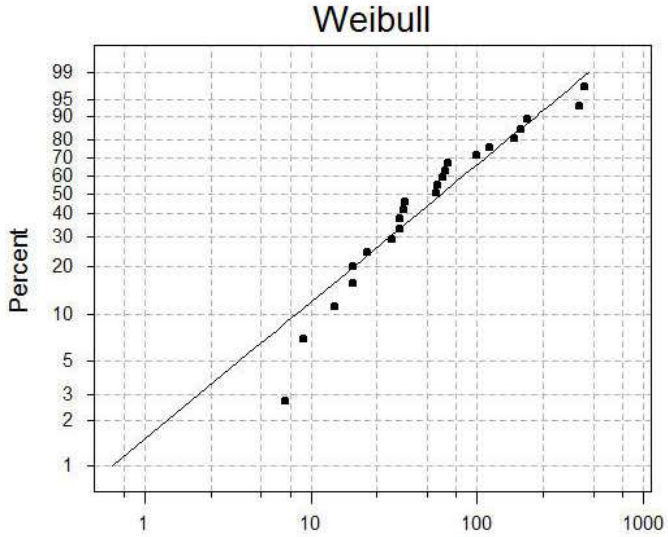
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
	T	log(T)															
1	413	6,02345															
2	14	2,63906															
3	58	4,06044															
4	37	3,61092															
5	100	4,60517															
6	65	4,17439															
7	9	2,19722															
8	169	5,12990															
9	447	6,10256															
10	184	5,21494															
11	36	3,58352															
12	201	5,30330															
13	118	4,77068															
14	34	3,52636															
15	31	3,43399															
16	18	2,89037															
17	18	2,89037															
18	67	4,20469															
19	57	4,04305															
20	62	4,12713															
21	7	1,94591															
22	22	3,09104															
23	34	3,52636															
24																	
25																	
26																	
27																	
28																	
29																	
30																	
31																	
32																	

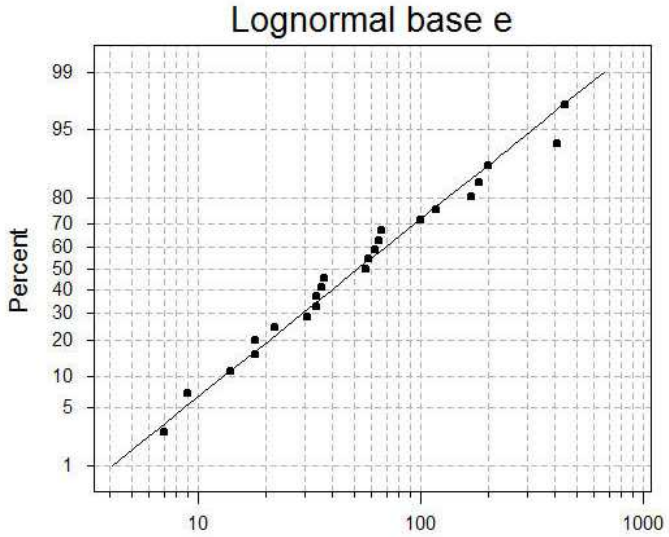

Histogram of T
Frequency
10
5
0
0
50
100
150
200
250
300
350
400
450
T

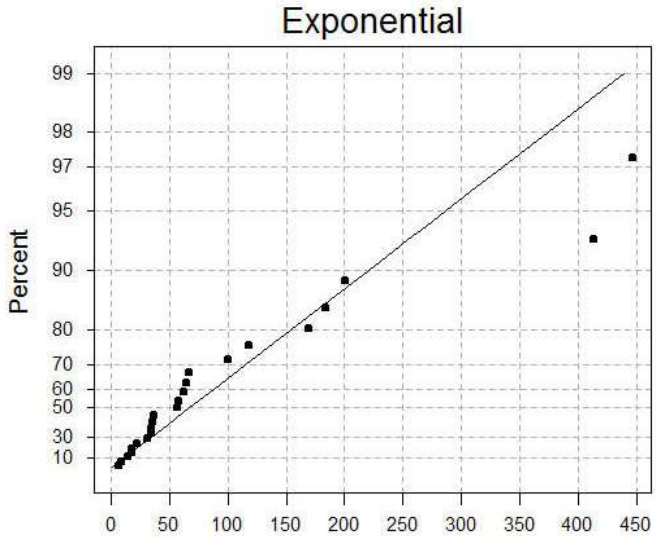

Histogram of log(T), with Normal Curve
Frequency
0
1
2
3
4
5
2,0
2,5
3,0
3,5
4,0
4,5
5,0
5,5
6,0
log(T)

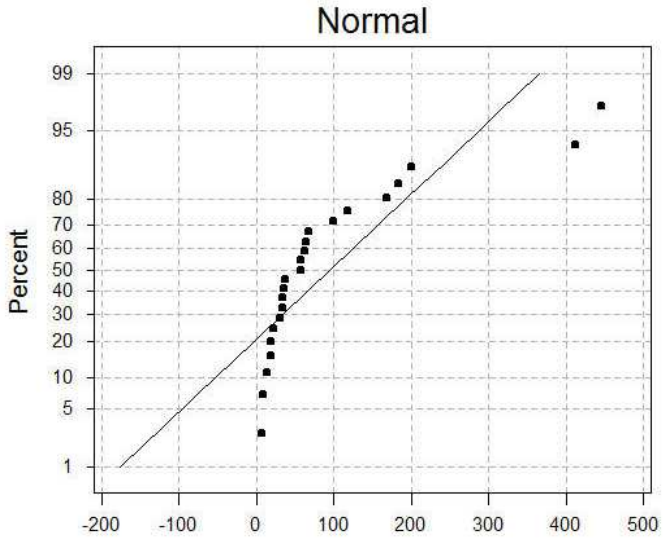
Four-way Probability Plot for T

ML Estimates - Complete Data









Anderson-Darling (adj)

Weibull

0,999

Lognormal base e

0,675

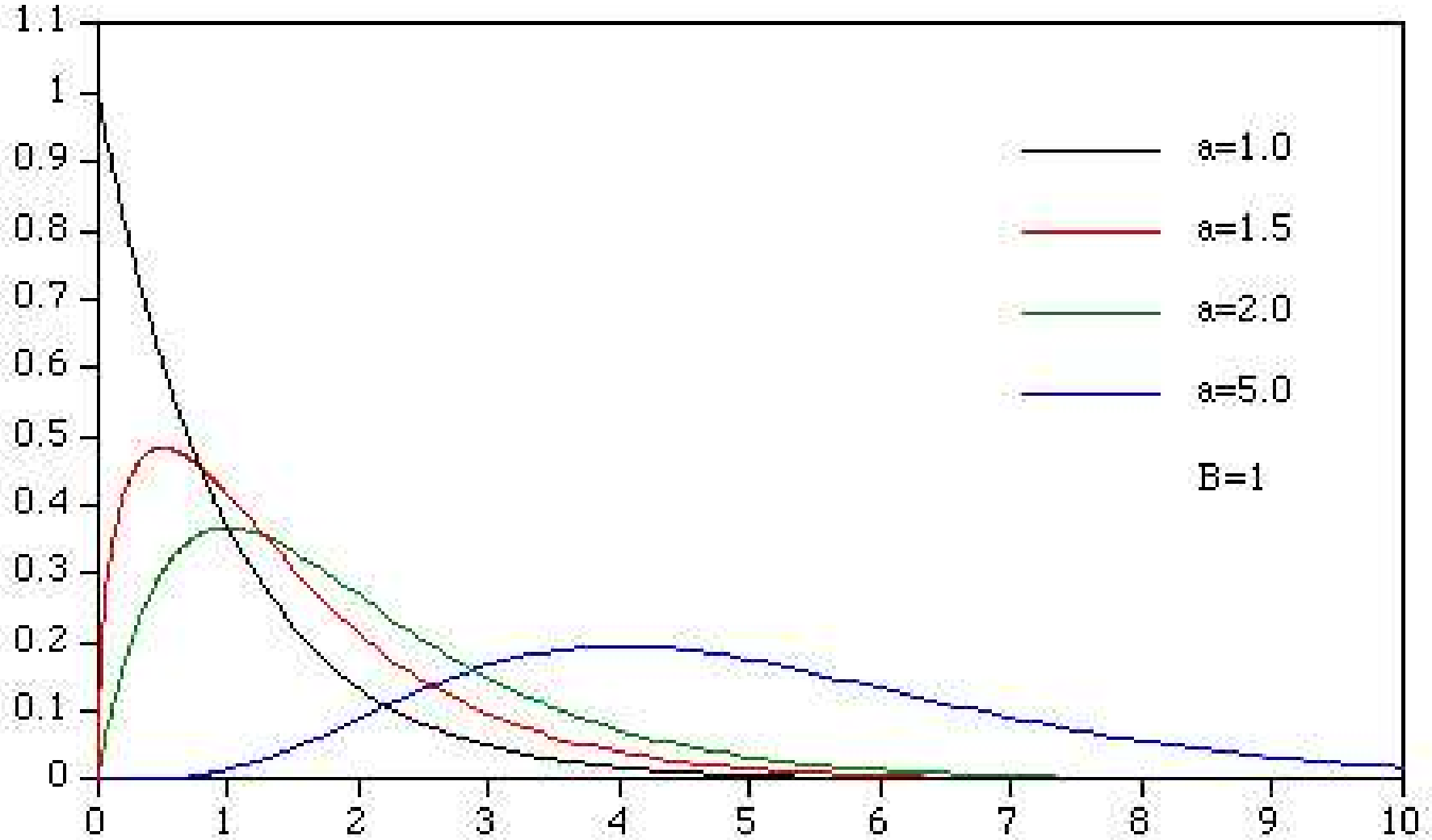
Exponential

1,110

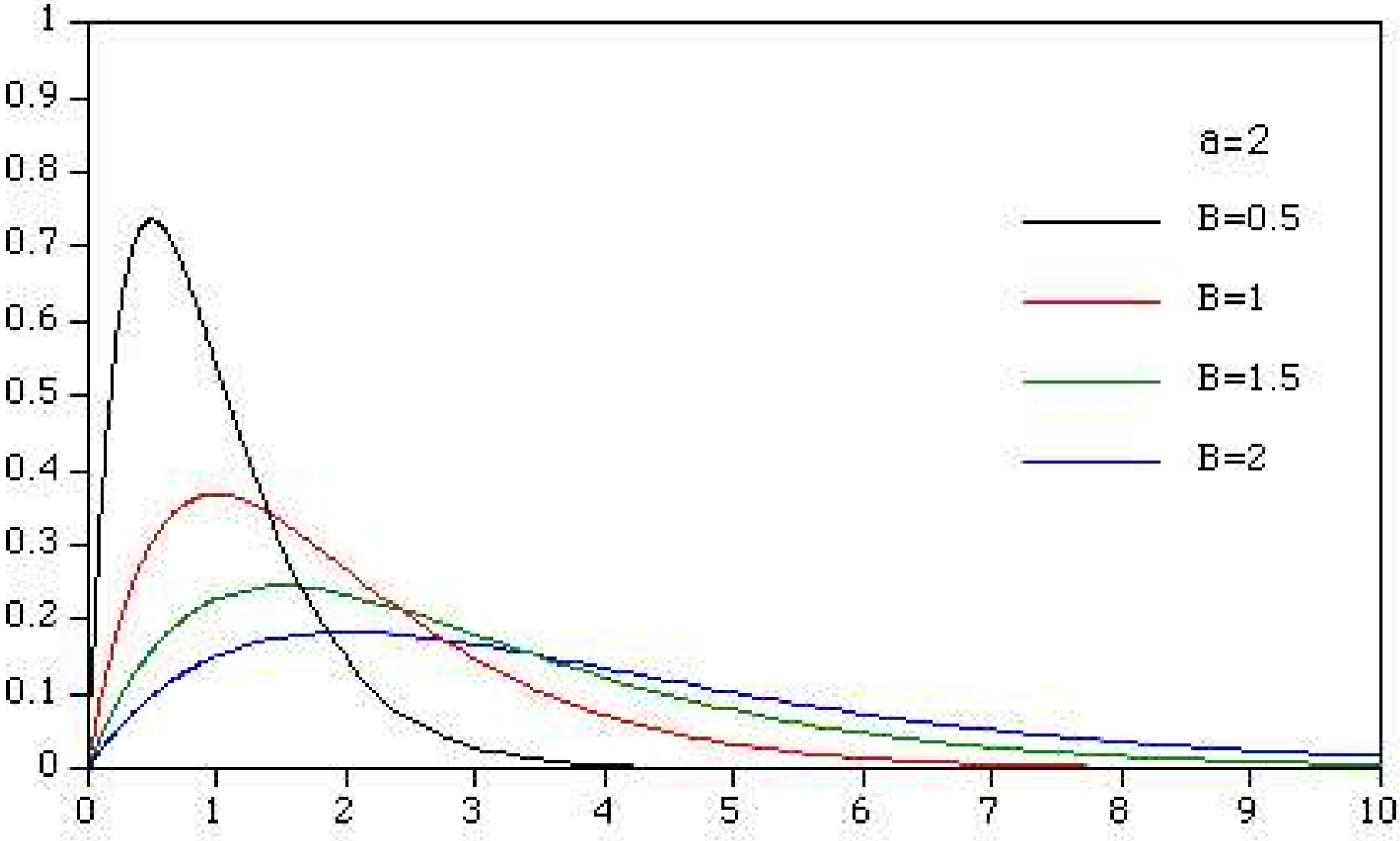
Normal

2,957

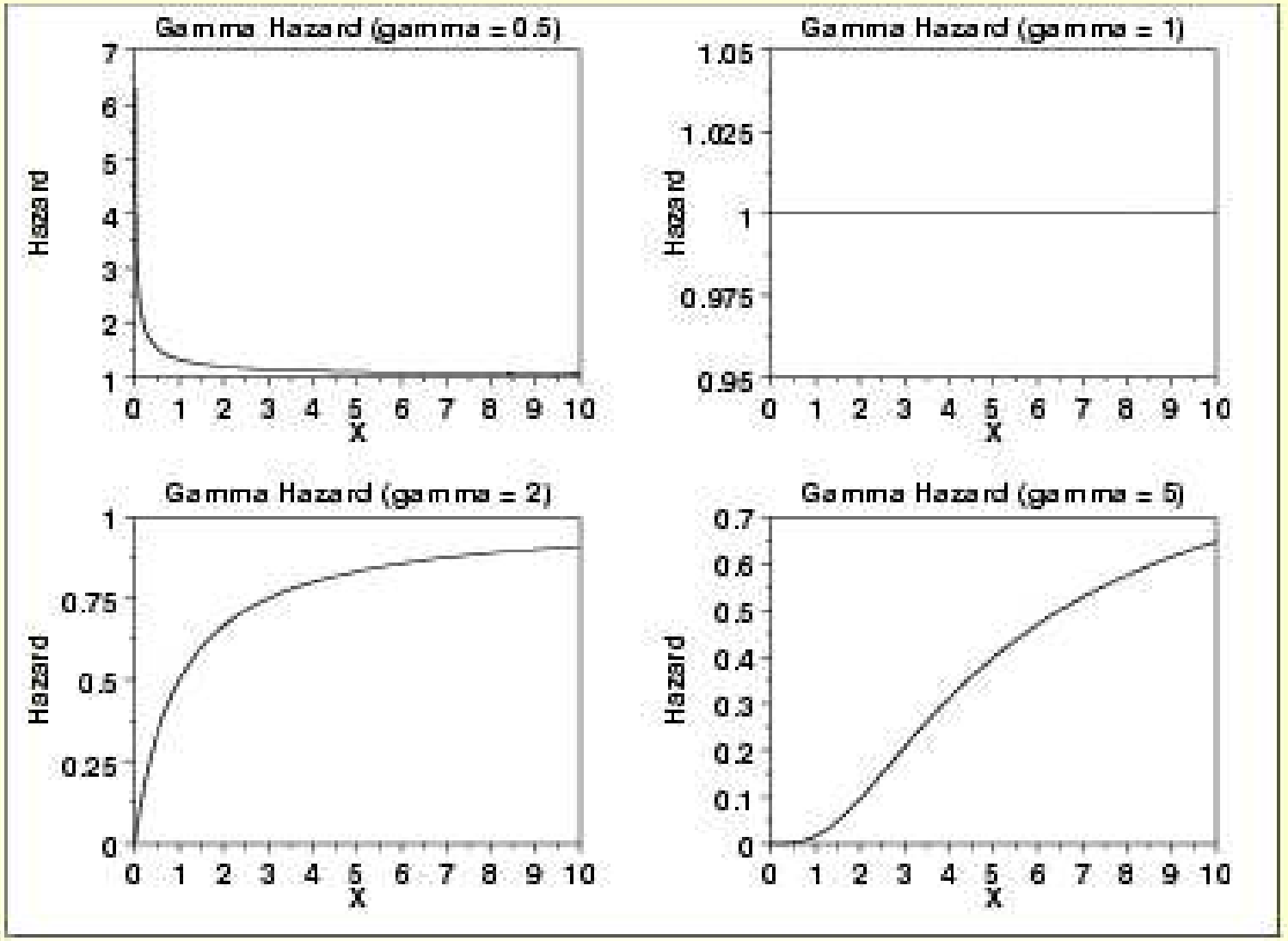
GAMMA-FORDELING ($\kappa = a$, $1/\lambda = B$ i bokas terminologi)



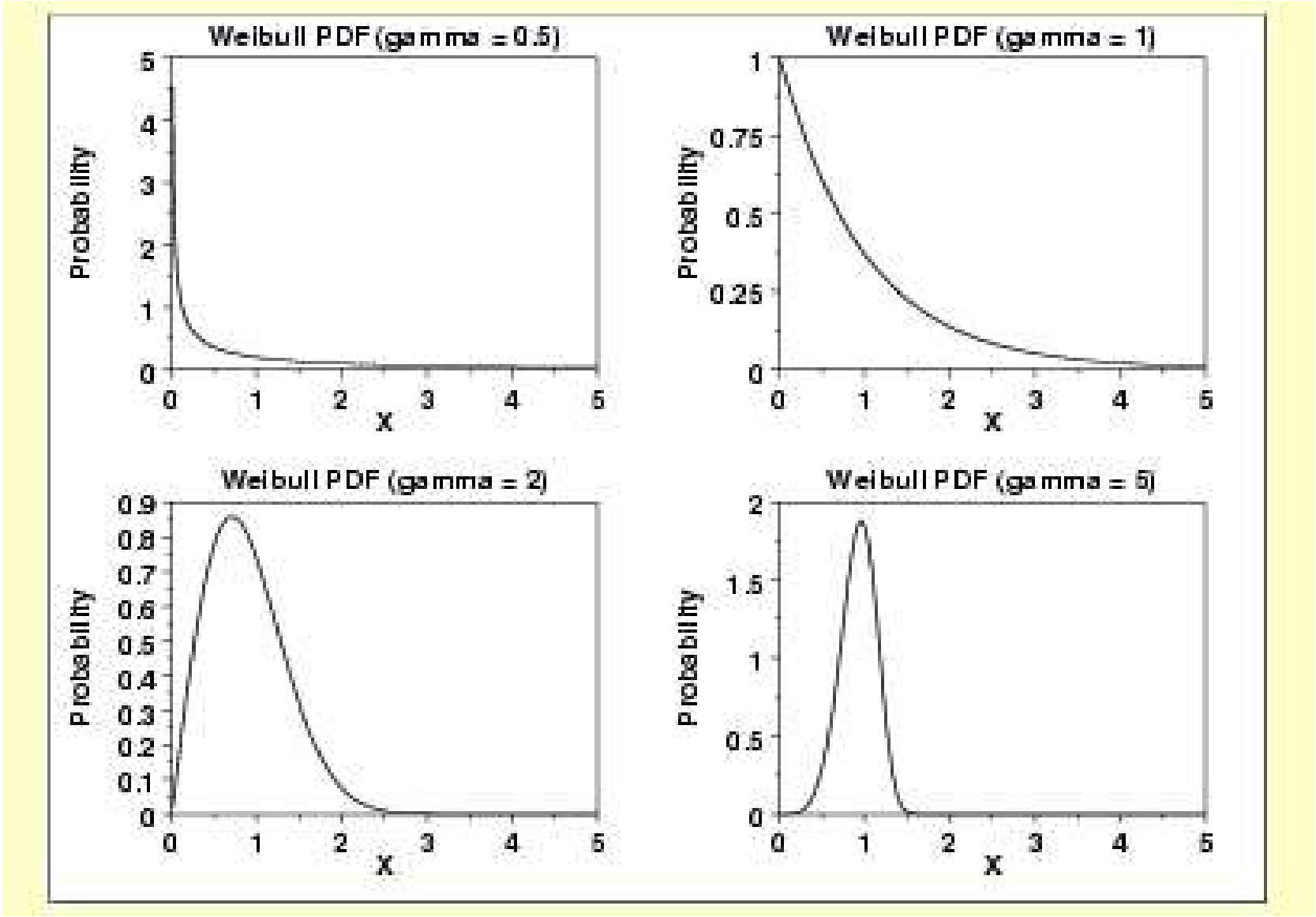
GAMMA-FORDELING ($\kappa = a$, $1/\lambda = B$ i bokas terminologi)



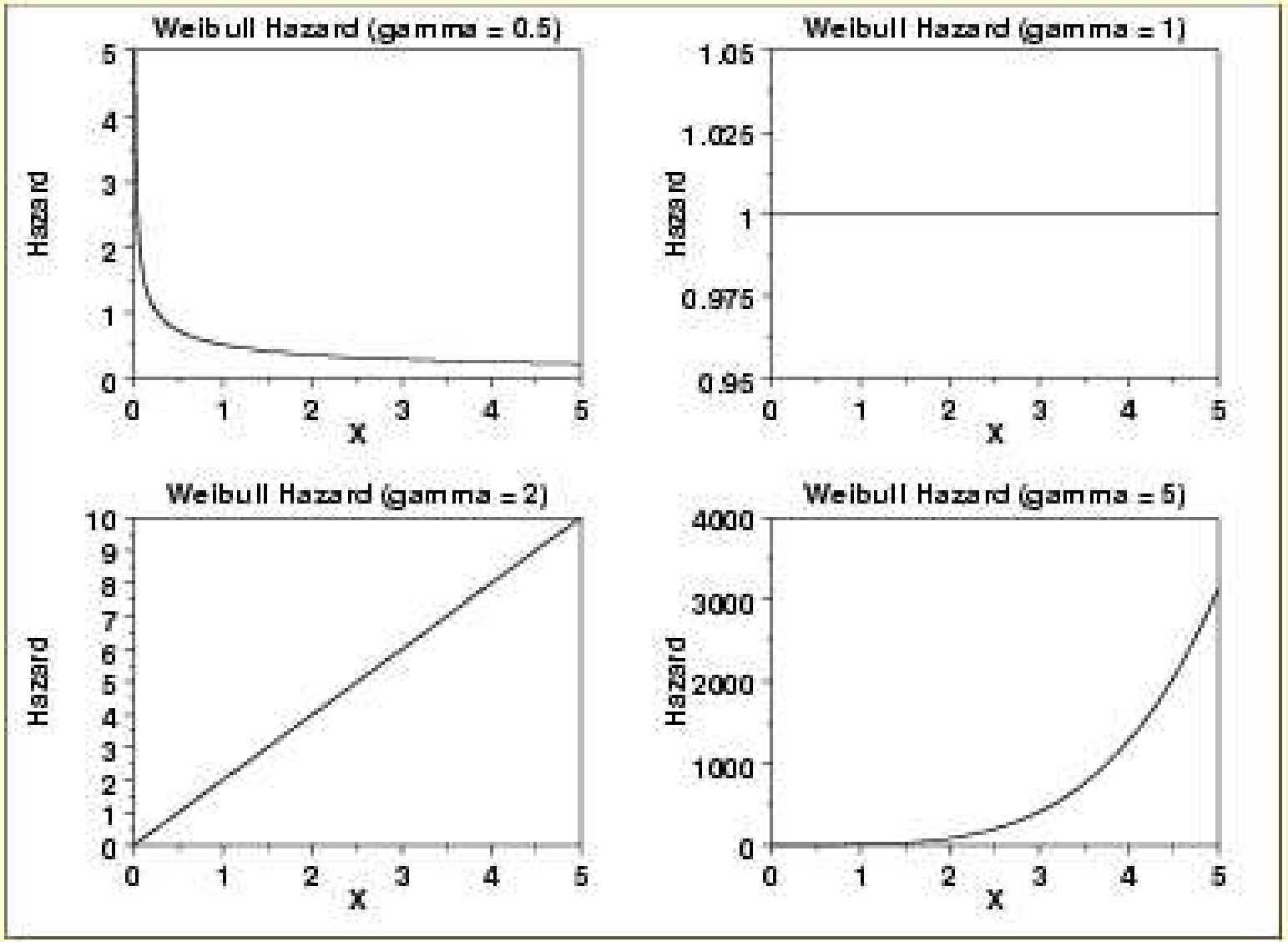
GAMMA-FORDELING ($\kappa = \gamma$, $\lambda = 1$ i bokas terminologi)



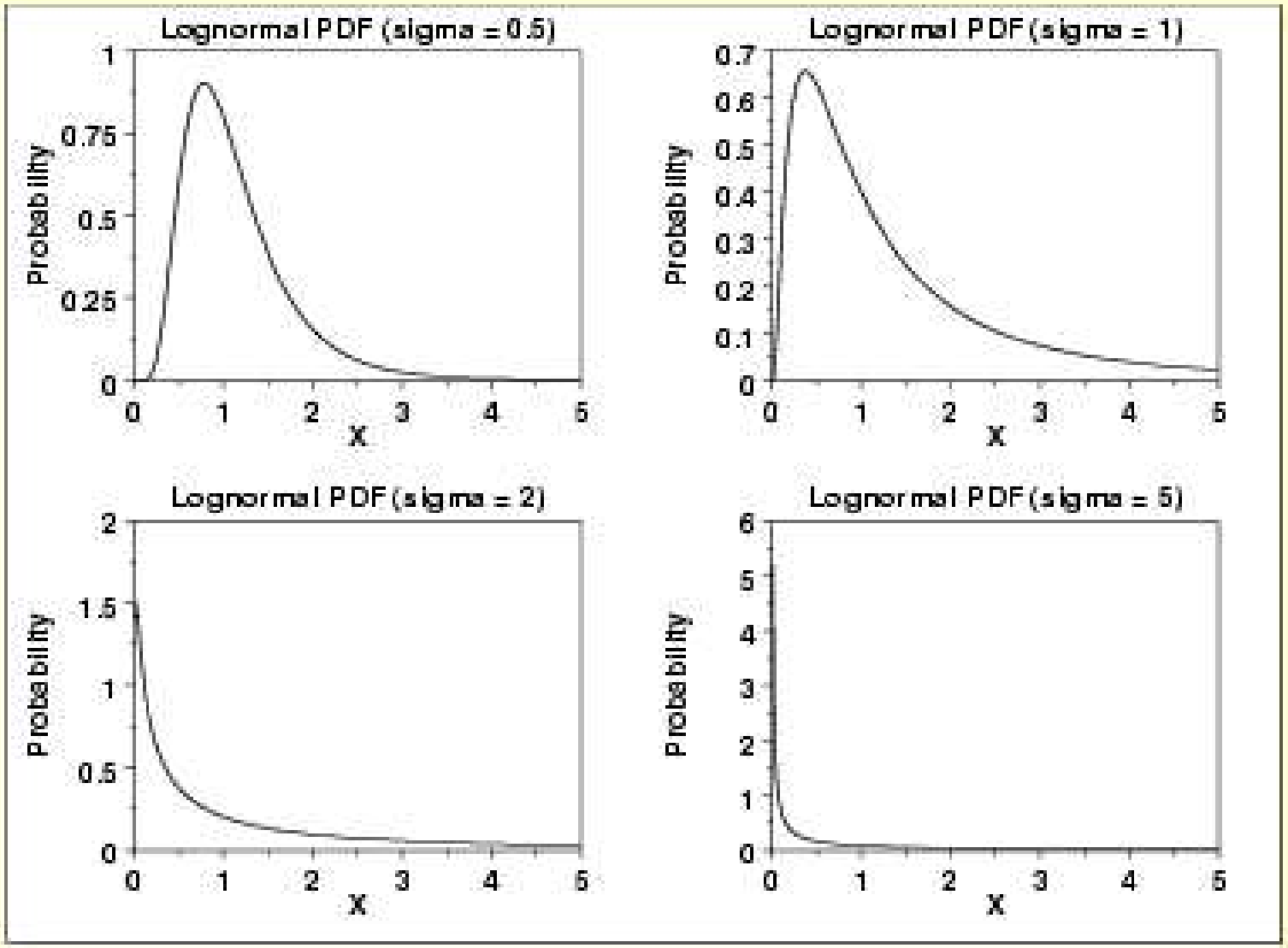
WEIBULL-FORDELING ($\alpha = \gamma$, $\lambda = 1$ i bokas terminologi)



WEIBULL-FORDELING ($\alpha = \gamma$, $\lambda = 1$ i bokas terminologi)



LOGNORMAL FORDELING ($\tau = \sigma$, $\nu = 0$ i bokas terminologi)



LOGNORMAL FORDELING ($\tau = \sigma$, $\nu = 0$ i bokas terminologi)