11. Apply the NBU test to the data of Table 11.2. Compare your result to the result obtained using the test based on $\mathcal{E}$.

Table 11.2 Intervals in Hours between Failures of the Air-Conditioning System of Plane 8044

i	1	2	3	4	5	6	7	8	9	10	11	12
X_i	487	18	100	7	98	5	85	91	43	230	3	130

Source: F. Proschan (1963).

Let $T = \sum_{i \neq j \neq k} \psi(X_{(i)}, X_{(j)} + X_{(k)}) = 188$.

H_0: F follows exponential distribution

Under H_0, $E(T) = \frac{n(n-1)(n-2)}{8} = 165$.

$$Var(T) = \frac{2}{3} n(n-1)(n-2) \left[\frac{5}{2592}(n-3)(n-4) + (n-3)\left(\frac{7}{432}\right) + \frac{1}{48} \right]$$

$$\approx 605$$

$$T^* = \frac{T - E(T)}{\sqrt{Var(T)}} \xrightarrow{d} N(0,1)$$

$T^* \approx 0.94$, $\hat{p} = 1 - \Phi(T^*) \approx 0.18 > 0.05$

$\Rightarrow$ fail to reject the null.

23. Describe a situation in which it might be expected that the mean residual life function would be initially increasing and then later decreasing.

At birth, animals usually face a relatively high risk of mortality (e.g. infection, predictors). However, if it survive through its infancy, the risk of mortality decreases due to stronger body and immunity, then the residual life increases compared to when in infancy. And finally residual life decreases due to aging

34. The data in Table 11.18 are from Hollander, McKeague, and Yang (1997) and concern 432 manuscripts submitted for publication to the Theory and Methods Section of the *Journal of the American Statistical Association* in the period January 1, 1994–December 13, 1994. Of interest is the distribution of the time (in days) to first review. When the data were studied on December 13, 1994, 158 papers were still awaiting the first review. Thus, there are 158 censored times and 274 uncensored times. In Table 11.18, the variable X_i = minimum (T_i, C_i), where T_i is the time to first review and C_i is the time to censorship, and the indicator variable δ_i is 1 if the ith observation is uncensored and 0 if it is censored. Compute the Kaplan–Meier estimate of the survival function.

35. For the review times data of Table 11.18, compute asymptotic 95% confidence bands for the survival function.

36. For the review times data of Table 11.18, compute an asymptotic 95% confidence interval for the probability that the time to first review will exceed 150 days.

Table 11.18 The Times to First Review of 1994 JASA Theory and Methods Papers

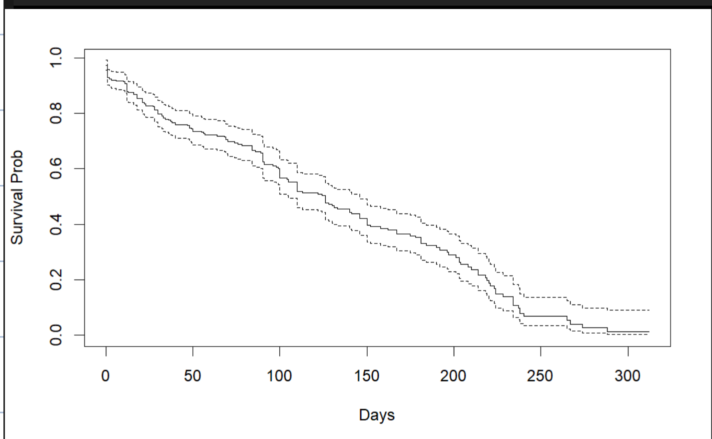
X_i	δ_i	X_i	δ_i	X_i	δ_i	X_i	δ_i	X_i	δ_i	X_i	δ_i	X_i	δ_i	X_i	δ_i	X_i	δ_i	X_i	δ_i	X_i	δ_i
214	1	201	1	28	1	252	0	118	1	187	0	28	1	28	1	76	1	56	0	28	0
184	1	274	1	287	0	96	1	33	1	152	1	21	1	118	0	18	1	21	1	27	0
150	1	265	1	195	1	175	1	69	1	46	1	1	1	40	1	88	0	55	0	27	0
70	1	120	1	86	1	54	1	133	1	103	1	0	1	6	1	85	0	55	0	25	0
16	1	141	1	137	1	167	1	126	1	37	1	144	0	91	1	85	0	54	0	25	0
141	1	48	1	74	1	150	1	84	1	170	1	144	0	34	1	85	0	18	1	22	0
210	1	204	1	71	1	219	1	197	1	64	1	140	0	21	1	20	1	54	0	22	0
132	1	312	0	140	1	86	1	85	1	182	0	14	1	1	1	83	0	53	0	21	0
30	1	220	1	22	1	1	1	15	1	180	0	0	1	111	0	82	0	50	0	21	0
204	1	188	1	120	1	111	1	206	1	176	0	27	1	111	0	81	0	50	0	15	0
84	1	84	1	176	1	128	1	125	1	175	0	23	1	1	1	81	0	1	1	15	0
36	1	84	1	181	1	178	1	57	1	64	1	126	1	48	1	11	1	15	1	15	0
38	1	215	1	155	1	40	1	181	1	42	1	139	0	110	0	77	0	50	0	1	1
69	1	33	1	74	1	131	1	215	0	175	0	55	1	47	1	77	0	47	0	1	1
33	1	55	1	29	1	20	1	3	1	149	1	137	0	68	1	70	1	47	0	14	0
49	1	140	1	100	1	220	1	13	1	158	1	114	1	74	1	74	0	46	0	12	0
203	1	147	1	195	1	84	1	175	1	169	0	56	1	98	1	71	0	16	1	12	0
203	1	41	1	127	1	32	1	37	1	169	0	124	1	105	0	23	1	43	0	12	0
218	1	94	1	34	1	95	1	182	1	22	0	121	1	104	0	28	1	43	0	8	0
267	1	292	1	177	1	188	1	210	0	168	0	1	1	104	0	70	0	18	1	8	0
99	1	131	1	150	1	115	1	92	1	157	1	27	1	103	0	44	1	43	0	8	0
21	1	221	1	265	0	238	0	208	0	89	1	130	0	90	1	69	0	42	0	8	0
78	1	39	1	174	1	1	1	30	1	165	1	130	0	98	0	68	0	42	0	7	0
150	1	3	1	104	1	187	1	28	1	14	1	130	0	98	0	67	0	40	0	7	0
237	1	16	1	203	1	125	1	168	1	161	0	127	0	98	0	64	1	0	1	7	0
91	1	129	1	109	1	110	1	202	0	161	0	100	1	97	0	30	1	12	1	7	0
21	1	210	1	217	1	32	1	114	1	159	0	126	0	96	1	41	1	39	0	6	0
224	1	240	1	238	1	32	1	105	1	91	1	126	0	97	0	62	0	35	0	5	0
126	1	141	1	210	1	228	1	196	0	146	1	28	1	18	1	61	0	35	0	5	0
167	1	231	1	22	1	80	1	195	0	159	0	125	0	96	0	20	1	35	0	4	0
105	1	119	1	148	1	64	1	114	1	134	1	125	0	92	0	57	0	30	1	1	0
146	1	291	0	142	1	231	0	75	1	13	1	125	0	91	0	57	0	35	0	1	0
50	1	199	1	126	1	64	1	194	0	159	0	95	1	91	0	57	0	34	0		
28	1	67	1	220	1	228	0	143	1	18	1	95	1	91	0	57	0	34	0		
288	1	263	1	145	1	18	1	106	1	155	0	123	0	31	1	57	0	34	0		
37	1	155	1	21	1	55	1	128	1	154	0	123	0	27	1	57	0	33	0		
18	1	189	1	256	0	154	1	200	0	124	1	123	0	83	1	42	1	33	0		
113	1	0	1	253	0	139	1	129	1	73	1	109	1	33	1	57	0	29	1		
22	1	209	1	22	1	91	1	138	1	51	1	119	0	11	1	57	0	28	0		
234	1	223	1	80	1	196	1	152	1	21	1	6	1	88	0	57	1	27	0		

Source: M. Hollander, I. W. McKeague, and J. Yang (1997).

````
```{r}
review_times <- pooled_data[seq(1, length(pooled_data), by = 2)]
censorship <- pooled_data[seq(2, length(pooled_data), by = 2)]

KME <- survfit(Surv(review_times, censorship) ~ 1)

plot(KME, conf.int = T, xlab = "Days", ylab = "Survival Prob")
```
````




```
Call: survfit(formula = Surv(review_times, censorship) ~ 1)

 time n.risk n.event survival std.err lower 95% CI upper 95% CI
  150     72     143    0.398  0.0338        0.337         0.47
```