BACHELOR OF ELECTRICAL ENGINEERING EXAMINATION, 2018

(4^{th} Year, 2nd Semester,)

RELIABILITY ENGINEERING

Time: Three Hours Full Marks: 100

(50 marks for each part)

Use a separate Answer-script for each Part

PART – I

Answer any three questions

(Two marks are reserved for neatness and well organized answers)

1. For the system shown in Fig. 1, the main feeders of section 1, 2 and 3 have failure rate of 0.2 failures/ yr and the lateral distributions have a failure rate of 0.3 failures/ yr. Other reliability parameters are given in Table-1.The number of customers and average load connected to load points A, B and C are 800, 9000 MW, 800, 1500 MW and 700, 2000 MW respectively. Calculate the failure rate, outage time, unavailability of each load point and also the load and energy oriented indices. 16

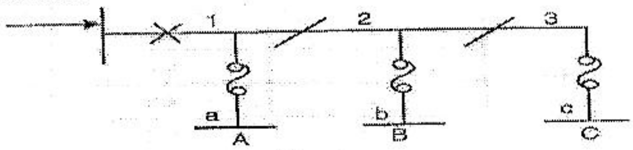

Fig. 1

Table - 1

Component	r (hrs)	s (hrs)
Section		
1	1.5	0. 20
2	2.0	0.30
3	2.5	0.30
Distributor		
a	2.0	0.20
b	3.0	0.20
c	1.5	0.30

2. a) *Define the following terms:*
i) Active failure ii) Passive failure and iii) Stuck condition of breaker 6

b) For the system shown in Fig. 2, compute the average repair time, annual outage duration and failure rate of load point L1 and L2 with the following condition.
   i) isolation of failed component not possible
   ii) isolation of failed component is possible

Considering the failure rate of 0.2 failures /yr, repair time of 60 hours and switching time of 1.5 hours for each transformer. 10

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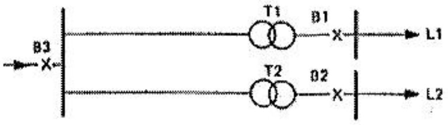

Fig. 2

3.a) A system contains four 70 MW units and one100 MW unit each having F.O.R. = 0.03. Construct the capacity outage probability table rounded off to 75 MW steps. 8

b) Explain with the help of suitable example why 'loss of largest unit method' is preferred to 'percentage reserve method' while computing risks in two almost similar systems. 8

4. a) A generating system contains three 25 MW generating units each with 4% F.O.R. and one 30 MW unit with 5% F.O.R. If the peak load for a 100 day period is 75 MW, what is the LOLE for this period? Assume that the appropriate load characteristic is a straight line from the 100% to the 60% load points. Variation of load from 100% to 60% takes place in 100 days. 10

b) Briefly discuss the method of recursion with suitable example. 6

5. a) If failure rate is constant for a system, then prove that $Q(t) = \lambda t - \frac{(\lambda t)^2}{2!} + \frac{(\lambda t)^3}{3!} \dots\dots\dots$ 5

b) A system contains 5 × 100 MW units with the following parameters: failure rate = 0.02 failures/day and repair rate = 0.48 repairs/day. Draw the state space diagram. Compute the capacity outage probability table including rate of departure & frequency. 11

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BACHELOR OF ENGINEERING IN ELECTRICAL ENGINEERING EXAMINATION,2018
(4TH YEAR 2ND SEMESTER)

RELIABILITY ENGINEERING

Full Marks 100

Time: Three hours **(50 marks for each part)**

Use a separate Answer-Script for each part

No. of Questions	PART – II	Marks
	Answer any ***TWO*** questions	
1. (a)	**For the reliability analysis, a sample of 200 s-identical analog multiplier modules were simultaneously placed for *life testing*. The test was stopped just when 20 modules failed. The times at which the failures occurred are : 742, 773, 786, 801, 812, 839, 866, 882, 903, 941, 952, 966, 990, 1003, 1120, 1251, 1273, 1311, 1341, and 1352 hours. Determine the maximum likelihood estimate (MLE) of the failure rate of the multipliers. Calculate the two-sided 90 % confidence interval for the *mean-time-to-failure* (MTTF) of the modules. Also obtain the 90% two-sided confidence interval for the reliability of a module at 900 hours, and furthermore, that of a design life of the module on the basis of a reliability of 85%. *Assume exponential life distribution.* Use the Chi-square table attached. Use linear interpolation wherever necessary. Derive the expressions used for MLE and confidence-interval estimation.**	15
(b)	**Lifetime of a certain type of motor follows a Rayleigh distribution, the probability density function being** $f(t)=1.57\times10^{-2}t\exp\left(\frac{-1.57\times10^{-2}t^2}{2}\right)$**; where t is in years. The manufacturer replaces free all motors that fail while under guarantee. If the manufacturer is willing to replace only 3% of the motors that fail, how long a guarantee should he/she offer? What is the average life of this type of motors? If a motor survives for 12 years, what is its probability of surviving a further period of 3 years? Derive the relevant expressions.**	10
2. (a)	**If *R(t)* is the system reliability without maintenance, t_0 is the time interval between consecutive preventive maintenances and *M* is the number of complete preventive**	12

No. of Questions	PART – II	Marks
	maintenance intervals survived by the system, derive the expression for the probability of survival of the system up to an instant t , taking into consideration the effect of preventive maintenances. *State clearly the assumptions made (if any).* Also show that preventive maintenance does not improve the system reliability for constant failure rate model. What will be the reliability function taking into account the preventive maintenance, if the failure-time has a Weibull distribution?	
(b)	An industrial fan has a failure rate of 0.05 f/week. Evaluate the system reliability for an operating period of 30 weeks & the MTTF, when no spares are available. Derive the expression for the probability density function of the time-to-failure of the complete system, when two spares are carried as immediate replacements. Also obtain the above mentioned reliability and the MTTF of the complete system, taking into account the spares. The first replacement has a failure rate of 0.07 f/week and the second has a failure rate of 0.08 f/week.	13
3. (a)	The time-to-failure of a continuously operated electrical system has a probability density function $$f(t)=t\exp\left(-t\right)u\left(t\right)$$ where t is in months. The system starts under a new condition at t=0, and after every renewal it can be treated as a new system. The duration of the down-state of the system can be considered as negligibly small in comparison with that of the up-state. Determine the expected number of cumulated failures up to 14 months and also the repair rate at t = 24 months. Derive the expressions used.	13
(b)	In the event of a fault, the *time-to-repair* of an alternator is found to have a Weibull distribution with a shaping parameter of 0.5 and scaling parameter of 10 hours. Obtain the *maintainability* of the generator at 12 hours from the instant of occurrence of the fault, the mean-time-to-repair (MTTR), and also the steady-state *availability*, if the MTTF is 800 hours.	12

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No. of Questions	PART – II	Marks
4.	**Write short notes on *any two* of the following.**	
(a)	**Accelerated life testing of electronic components at enhanced humidity, at elevated temperature, and at escalated current.**	**12 ½ + 12 ½**
(b)	**Evaluation of reliability of majority-vote or m-out-of-n engineering systems.**	
(c)	**Lognormal distribution and its application in the reliability assessment of engineering items.**	
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PART – II

CHI-SQUARE TABLE

$$\chi^2_{q,K}$$

K\ q	0.05	0.10	0.20	0.40	0.60	0.80	0.90	0.95	0.975
1	0.0039	0.0158	0.0642	0.275	0.708	1.642	2.706	3.841	5.024
2	0.103	0.211	0.446	1.022	1.833	3.219	4.605	5.991	7.378
3	0.352	0.584	1.005	1.869	2.946	4.642	6.251	7.815	9.348
4	0.711	1.064	1.649	2.753	4.045	5.989	7.779	9.488	11.143
5	1.145	1.610	2.343	3.655	5.132	7.289	9.236	11.070	12.833
6	1.635	2.204	3.070	4.570	6.211	8.558	10.645	12.592	14.449
7	2.167	2.833	3.822	5.493	7.283	9.803	12.017	14.067	16.013
8	2.733	3.490	4.594	6.423	8.351	11.030	13.362	15.507	17.535
9	3.325	4.168	5.380	7.357	9.414	12.242	14.684	16.919	19.023
10	3.940	4.865	6.179	8.295	10.473	13.442	15.987	18.307	20.483
11	4.575	5.578	6.989	9.237	11.530	14.631	17.275	19.675	21.920
12	5.226	6.304	7.807	10.182	12.584	15.812	18.549	21.026	23.337
13	5.892	7.042	8.634	11.129	13.636	16.985	19.812	22.362	24.736
14	6.571	7.790	9.467	12.078	14.685	18.151	21.064	23.685	26.119
15	7.261	8.547	10.307	13.030	15.733	19.311	22.307	24.996	27.488
16	7.962	9.312	11.152	13.983	16.780	20.465	23.542	26.296	28.845
17	8.672	10.085	12.002	14.937	17.824	21.615	24.769	27.587	30.191
18	9.390	10.865	12.857	15.893	18.868	22.760	25.989	28.869	31.526
19	10.117	11.651	13.716	16.850	19.910	23.900	27.204	30.144	32.852
20	10.851	12.443	14.578	17.809	20.951	25.038	28.412	31.410	34.170
22	12.338	14.041	16.314	19.729	23.031	27.301	30.813	33.924	36.781
24	13.848	15.659	18.062	21.652	25.106	29.553	33.196	36.415	39.364
26	15.379	17.292	19.820	23.579	27.179	31.795	35.563	38.885	41.923
28	16.928	18.939	21.588	25.509	29.249	34.027	37.916	41.337	44.461
30	18.493	20.599	23.364	27.442	31.316	36.250	40.256	43.773	46.979
40	26.509	29.051	32.345	37.134	41.622	47.269	51.805	55.758	59.342
60	43.188	46.459	50.641	56.620	62.135	68.972	74.397	79.082	83.298
80	60.391	64.278	69.207	76.188	82.566	90.405	96.578	101.879	106.629
100	77.929	82.358	87.945	95.808	102.946	111.667	118.498	124.342	129.561
x	-1.645	-1.282	-0.841	-0.253	0.253	0.841	1.282	1.645	1.960

***Note*:**

If **X is a χ^2 random variable with K degrees of freedom,**

$$\Pr\left(X \le \chi^2_{q,K}\right) = q$$