57:022 Principles of Design II
Midterm Exam - Spring 1996

Choose 5 out of 6 parts

Part:	I	II	III	IV	V	VI	Total
Possible Pts:	15	15	15	15	15	15	75
Your score:	_____	_____	_____	_____	_____	_____	_____

PART I

Along highway I-80 in Iowa, the probability that each passing car stops to pick up a hitchhiker is p=2%, i.e, an average of one in fifty drivers will stop; different drivers, of course, make their decisions whether to stop or not independently of each other.

___ 1. Consider a stochastic process in which $X_n=1$ if car n stops to pick up the hitchhiker, and $X_n=0$ otherwise. Then $\{X_n: n=1,2,3,...\}$ is a

a. Markov process	c. Exponential process	e. Binomial process
b. Bernouilli process	d. Poisson process	f. *None of the above*

___ 2. $P\{X_n=1\}$ =

a. 0.98	c. 0.02	e. 0.025
b. 0.2	d. 0.50	f. *None of the above*

___ 3. If 20 cars pass the hitchhiker, the probability that *none* of them stop is

a. $(0.98)^{19}(0.02)$	c. $(0.02)^{19}(0.98)$	e. $(0.98)^{20}$
b. $(20)(0.02)$	d. $(0.02)^{20}$	f. *None of the above*

___ 4. Given that a hitchhiker has counted 20 cars passing him without stopping, what is the probability that he will be picked up by the 30^{th} car *or before?*

a. $1-(0.02)^{30}$	c. $(0.98)^{30}$	e. $(0.98)^{10}$
b. $1-(0.98)^{10}$	d. $1-(0.02)^{10}$	f. *None of the above*

___ 5. If 20 cars pass the hitchhiker, the probability that *exactly two* of them stop is

a. $\binom{20}{2}(0.98)^{18}(0.02)^2$	c. $1-\binom{20}{2}(0.02)^{18}(0.98)^2$	e. $(0.98)^{18}(0.02)^2$
b. $1-\binom{20}{2}(0.98)^{18}(0.02)^2$	d. $\binom{20}{2}(0.02)^{18}(0.98)^2$	f. *None of the above*

Suppose that the arrivals of the cars form a Poisson process, at the average rate of 25 per minute. Define "success" for the hitchhiker to occur at time t provided that *both* an arrival occurs at t *and* that car stops to pick him up. Let T_1 be the time (in seconds) of the first "success", i.e., the time that he finally gets a ride, when he begins his wait at time $T_1=0$.

___ 6. The arrival rate of "successes" is

a. 2/minute	c. 0.02/minute	e. 1/minute
b. 0.5/minute	d. 50/minute	f. *None of the above*

___ 7. The random variable T_1 has what distribution?

a. Pascal	c. Geometric	e. Exponential
b. Poisson	d. Erlang	f. *None of the above*

___ 8. What is $E(T_1)$, the expected (mean) value of T_1?

a. 4 minutes	c. 2 minutes	e. 1 minute
b. $^1/_2$ minute	d. $^1/_4$ minute	f. *None of the above*

___ 9. What's the probability that his waiting time is less than or equal to 4 min. $(P\{T_1 \leq 4\}$?

a. e^{-1}	c. $1 - e^{-1}$	e. $1 - e^{1}$

b. $1 - e^{-2}$ d. e^{-2} f. *None of the above*

___ 10. What is the probability that he must wait *exactly* 4 minutes for a ride ($P\{T_1 = 4\}$?

a. $1 - e^{-1}$ c. e^{-1} e. 0.0

b. $1 - e^{-2}$ d. e^{-2} f. *None of the above*

___ 11. Suppose that after 1 minute (during which 18 cars have passed by) he is still there waiting for a ride. What is the *conditional* expected value of T_1 (expected *total* waiting time, i.e., since time 0, given that he has already waited 1 minute)?

a. 1 minute   c. 3 minutes   e. 2.5 minutes

b. 2 minutes   d. 4 minutes   f. *None of the above*

PART II

An electronic device is made up of a large number of components. Every component is essential, so that the device will fail when the first component fails. The lifetime of each component is random, but its probability distribution is unknown. A test of the device is performed, in which fifty units of the device are operated simultaneously, and the time of the first five failures is noted, namely 142, 202, 249, 289, and 325 hours. Letting R be the fraction of the devices surviving, the following table was computed:

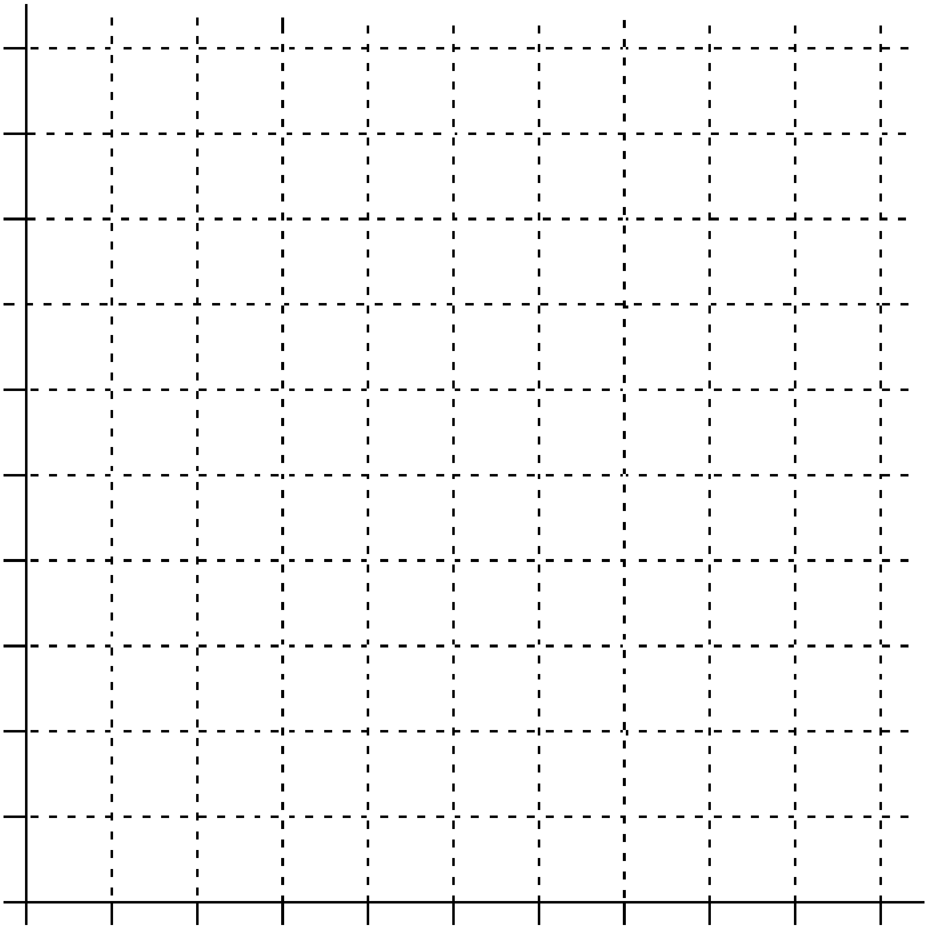
t	R	ln t	ln ln t	ln R	ln (1/R)	ln ln (1/R)
142	0.98	4.956	1.601	-0.0202	0.0202	-3.902
202	0.96	5.308	1.669	-0.0408	0.0408	-3.198
249	0.94	5.517	1.708	-0.0618	0.0618	-2.783
289	0.92	5.666	1.735	-0.0834	0.0834	-2.484
325	0.90	5.784	1.755	-0.1054	0.1054	-2.250

Choose answers for the following questions from the list below.

ANSWERS (if numerical answer, choose nearest value!)

a. 0.1	b. 0.2	c. 0.3
d. 0.4	e. 0.5	f. 0.6
g. 0.7	h. 0.8	i. 0.9
j. 1	k. 2	l. 3
m. 100	n. 200	o. 300
p. 800	q. 900	r. 1000
s. constant	t. increasing	u. decreasing
v. Poisson	w. Weibull	x. Exponential
y. Gamma	z. Gumbel	aa. Normal
bb. R	cc. ln R	dd. ln ln R
ee. ln (1/R)	ff. ln ln (1/R)	gg. t
hh. ln t	ii. ln ln t	jj. *None of the above*

1. What probability distribution would you suggest to model the unit's lifetime? _____
2. In order to (theoretically) obtain a straight line, what is plotted on the vertical axis? ___
3. What should be plotted on the horizontal axis? _____
4. Plot the appropriate transformed data below, and (very roughly) sketch a line through the points.



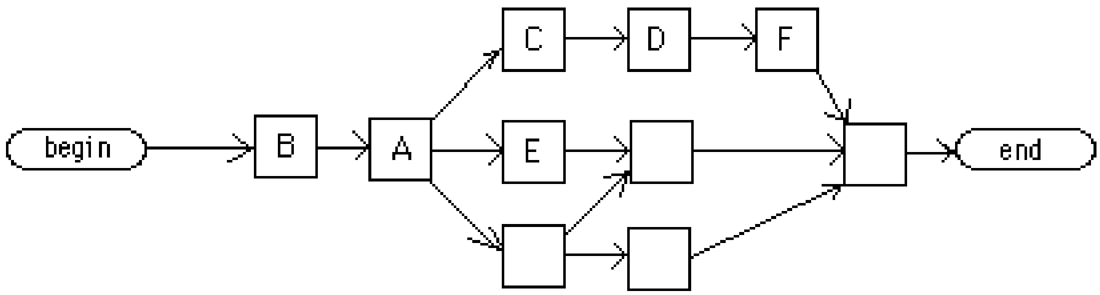
5. Estimate (very roughly... only 1 or 2 significant digits needed!) the parameters of the probability distribution which you specified in (1.) _____ & _____
6. For the distribution with the parameters you specified in (5), is the failure rate increasing or decreasing? _____
7. What is the probability that a unit will survive less than 600 hours? _____
8. What is the probability that a unit will survive more than 1200 hours? _____

ggggg PART III ggggg

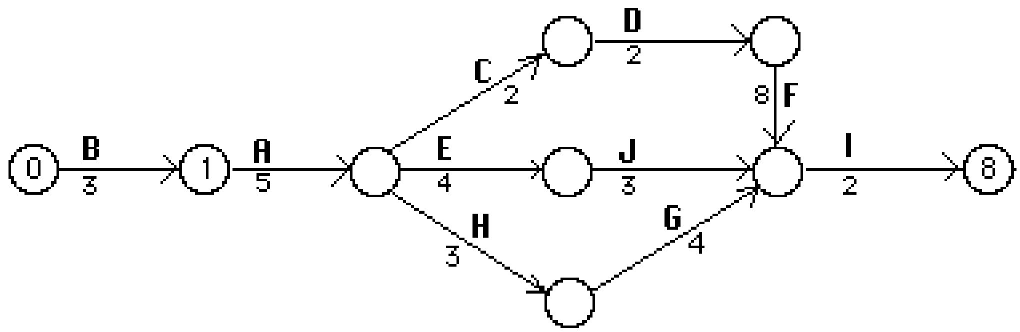
Consider the project:

Activity	Description	Predecessor Activities	Duration (days) Mean	Std Dev
A	Walls & ceiling	B	5	2
B	Foundation	none	4	1
C	Roof timbers	A	2	1
D	Roof sheathing	C	2	1
E	Electrical wiring	A	4	2
F	Roof shingles	D	2	1
G	Exterior siding	H	4	1
H	Windows	A	4	1
I	Paint	F,G,J	3	1
J	Inside wall board	E,H	3	1

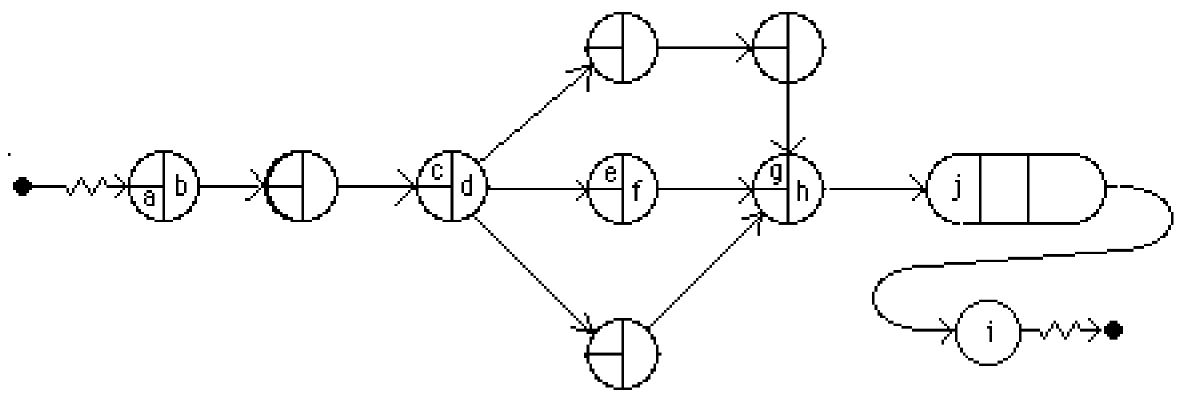
1. Complete the AON network by labeling the nodes:



2. Complete the AOA & the corresponding SLAM networks below by inserting any "dummy" activities which are necessary, and labeling the nodes.

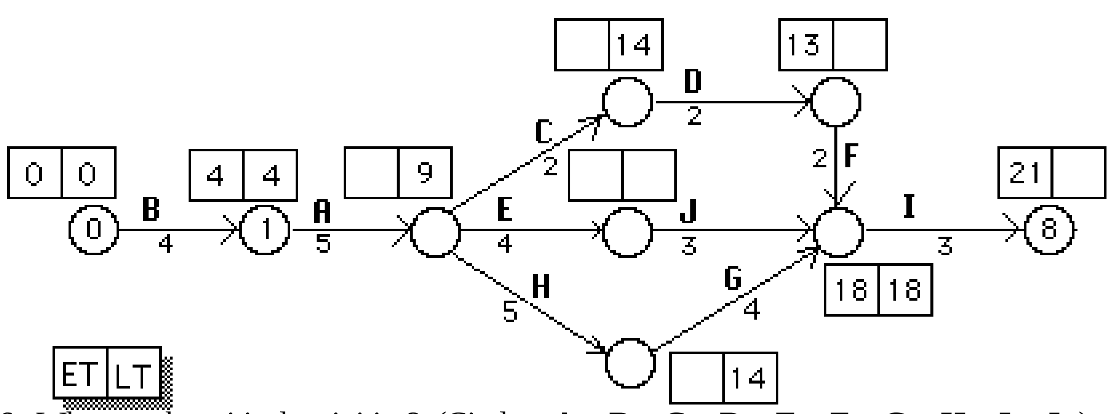


3. Give numerical values (0, 1, 2, 3, 4, or ∞) of "a" - "i" on the SLAM network below.
a ___ b ___ c ___ d ___ e ___ f ___ g ___ h ___ i ___



4. "j" on the SLAM network above should indicate which type of statistic?
Circle: LAST INT(1) BETWEEN FIRST

5. Complete the ETs (earliest times) & LTs (latest times) in the network below, using the expected activity durations, as indicated. *Don't forget any "dummy" activities which you entered above!*



6. What are the critical activities? (Circle: **A B C D E F G H I J**)

7. What is the "total slack" or "total float" in activity D? ______

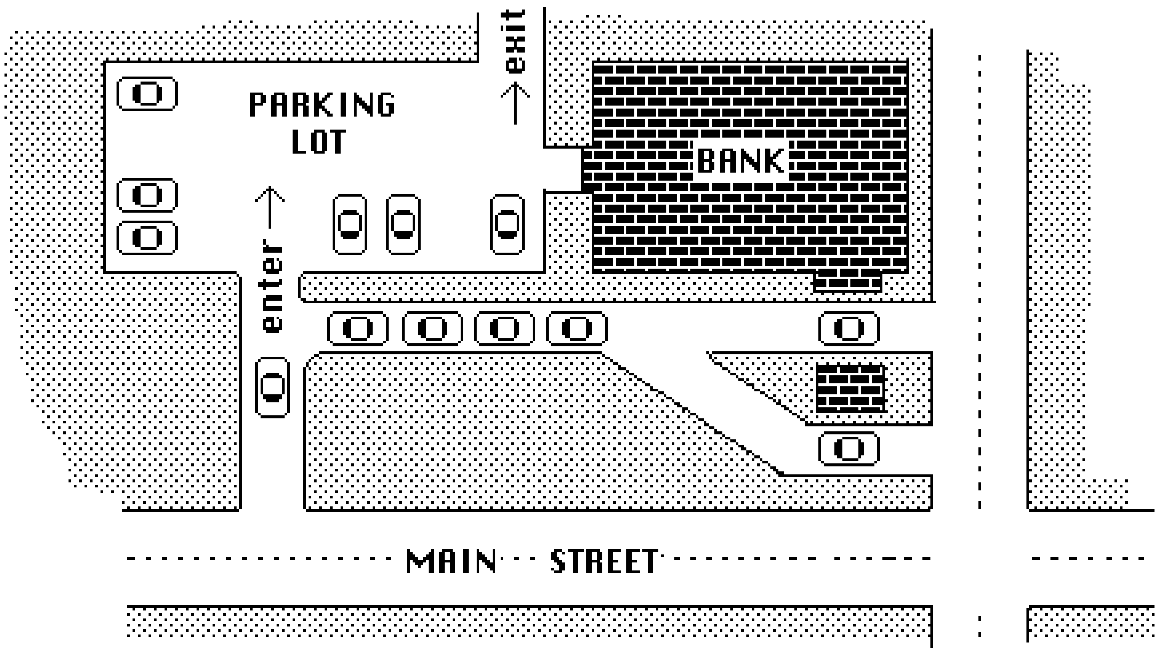
PART IV

Consider a bank with both drive-up windows and inside tellers (see diagram below), having the following features:

- There are 2 drive-up teller windows, and 3 indoor tellers
- Cars enter from the street according to a Poisson process, at the average rate of 2/minute
- 20% of the customers arriving in the cars wish to do their banking with the indoor tellers, and 80% prefer the drive-up tellers
- Those wishing to do their banking inside park in a lot, and when finished, leave by another exit.
- Assume that the parking lot always has sufficient space for anyone wishing to park for banking inside.
- There is room for 4 cars in the single waiting line which "feeds" both drive-up windows.
- Whenever the waiting line of cars for the drive-up tellers is filled, all arriving cars must use the parking lot (if not filled) and do their banking inside.
- The time that a customer spends at the drive-up window is uniformly distributed between 30 seconds and 2 minutes, while the time that a customer spends at an inside teller window is normally distributed with mean 3 minutes and standard deviation 1 minute.

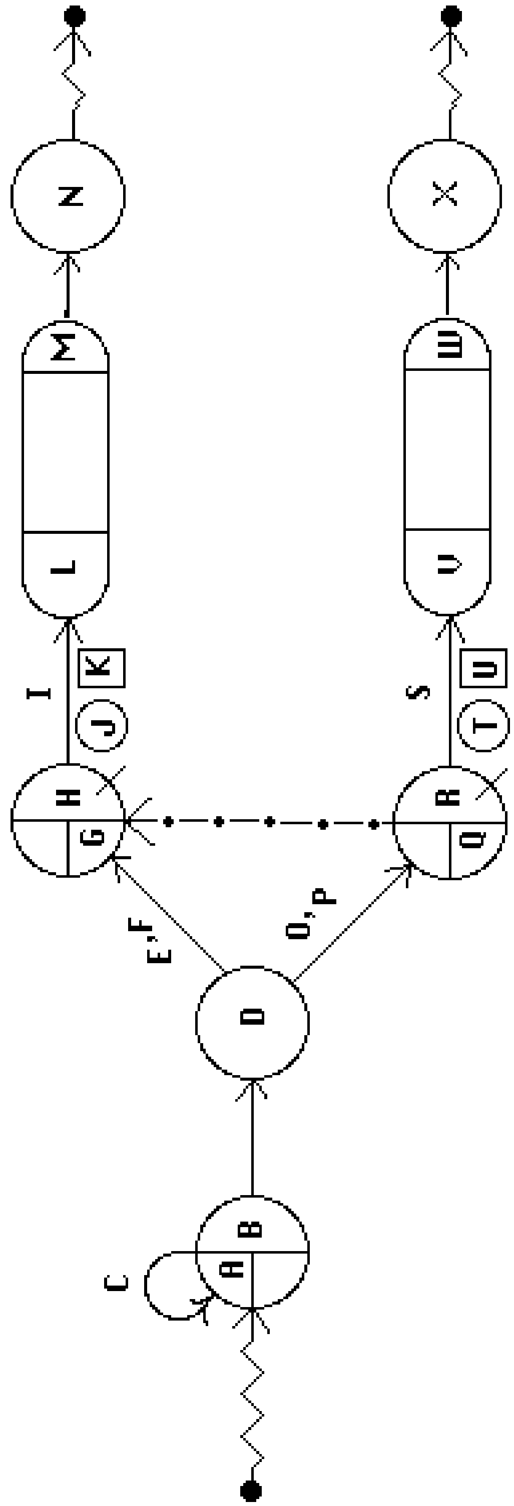
A simulation of an 8-hour day is to be performed. Statistics of particular interest include:

- the average time in the system spent by customers using the drive-up window
- the average time in the system spent by customers banking inside
- the average number of cars waiting for the drive-up window
- the maximum number of cars in the parking lot



Based upon the description of the system above, write the correct values of each of the parameters A through X for the network below. **The possible values are given in the following list:** (Some answers may be used several times, or perhaps not at all!)

0	0.2	UNFRM(0.5,2)
1	0.8	INTVL(1)
2	∞	EXPON(0.5)
3		EXPON(2)
4		RNORM(3,1)



Values		Values	
A.	________	M.	________
B.	________	N.	________
C.	________	O.	________
D.	________	P.	________
E.	________	Q.	________
F.	________	R.	________
G.	________	S.	________
H.	________	T.	________
I.	________	U.	________
J.	________	V.	________
K.	________	W.	________
L.	________	X.	________

ggggg PART V ggggg

Below is the output for the simulation model of the bank in PART IV. Based on this output, and information given in PART IV, answer the following questions. If not enough information is given, specify *"Insufficient Info"*.

1. What was the maximum number of cars in the parking lot during the day? ______

2. How many cars were served by the tellers *inside* the bank during the day? _______
3. If you are a teller in one of the drive-up windows, what fraction of the day would you expect to be busy? _________
4. What is the average time spent in the system by a customer who banks inside? __________
5. What is the maximum time that any customer spent at the bank during the day? __________

S L A M   I I   S U M M A R Y   R E P O R T

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
DRIVEIN_TIME	0.245E+01	0.102E+01	0.416E+00	0.504E+00	0.545E+01	694
INSIDE_TIME	0.564E+01	0.355E+01	0.629E+00	0.000E+00	0.172E+02	348

FILE STATISTICS

FILE NUMBER	LABEL/TYPE		AVERAGE LENGTH	STANDARD DEVIATION	MAXIMUM LENGTH	CURRENT LENGTH	AVERAGE WAIT TIME
1	Q1	QUEUE	1.741	1.473	4	3	1.195
2	Q2	QUEUE	1.987	3.214	16	4	2.687
3		CALENDAR	4.947	1.299	7	6	0.581

SERVICE ACTIVITY STATISTICS

ACT NUM	ACT LABEL OR START NODE		SER CAP	AVERAGE UTIL	STD DEV	CUR UTIL	AVERAGE BLOCK	MAX IDL TME/SER	MAX BSY TME/SER	ENT CNT
1	Q1	QUEUE	2	1.813	0.47	2	0.00	2.00	2.00	694
2	Q2	QUEUE	3	2.134	1.09	3	0.00	3.00	3.00	348

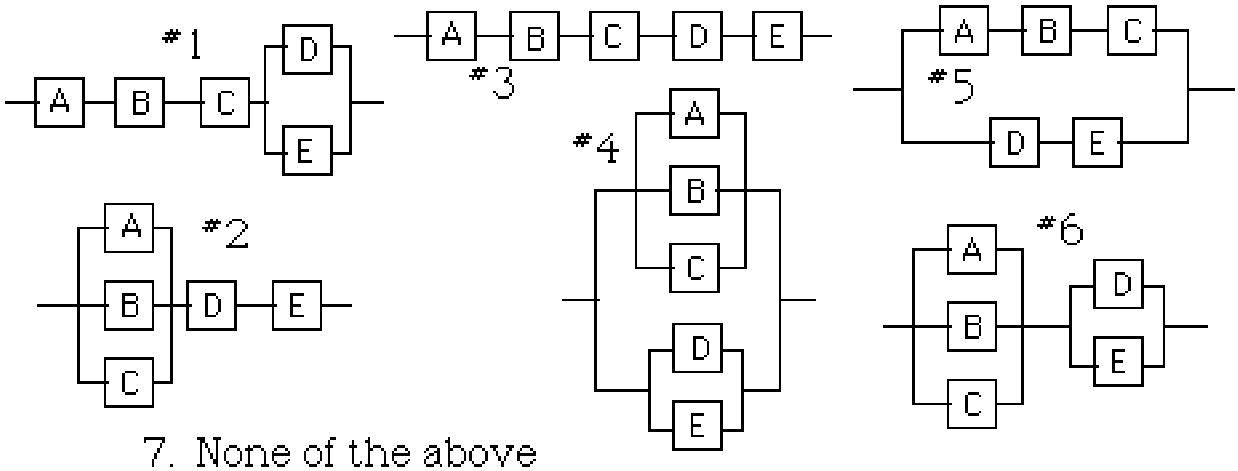
PART VI

A system consists of five components (A,B,C,D, &E). The probability that each component *fails during the first year* of operation is 10% for A, B, and C, and 20% for D and E. For each alternative of (a) through (e), indicate:

- the number of the reliability diagram below which represents the system.
- the computation of the 1-year reliability (i.e., survival probability)
- the SLAM network which would simulate the system lifetime

Diagram	Reliability	SLAM network	
___	___	___	a. The system can function if all of A, B, and C function *or* if both D and E function.
___	___	___	b. The system requires all of A, B, & C, and at least one of D & E.
___	___	___	c. The system requires that D & E both function, and at least one of A, B, & C function.
___	___	___	d. The system requires at least one of A ,B, &C, and at least one of D & E .

Diagrams:

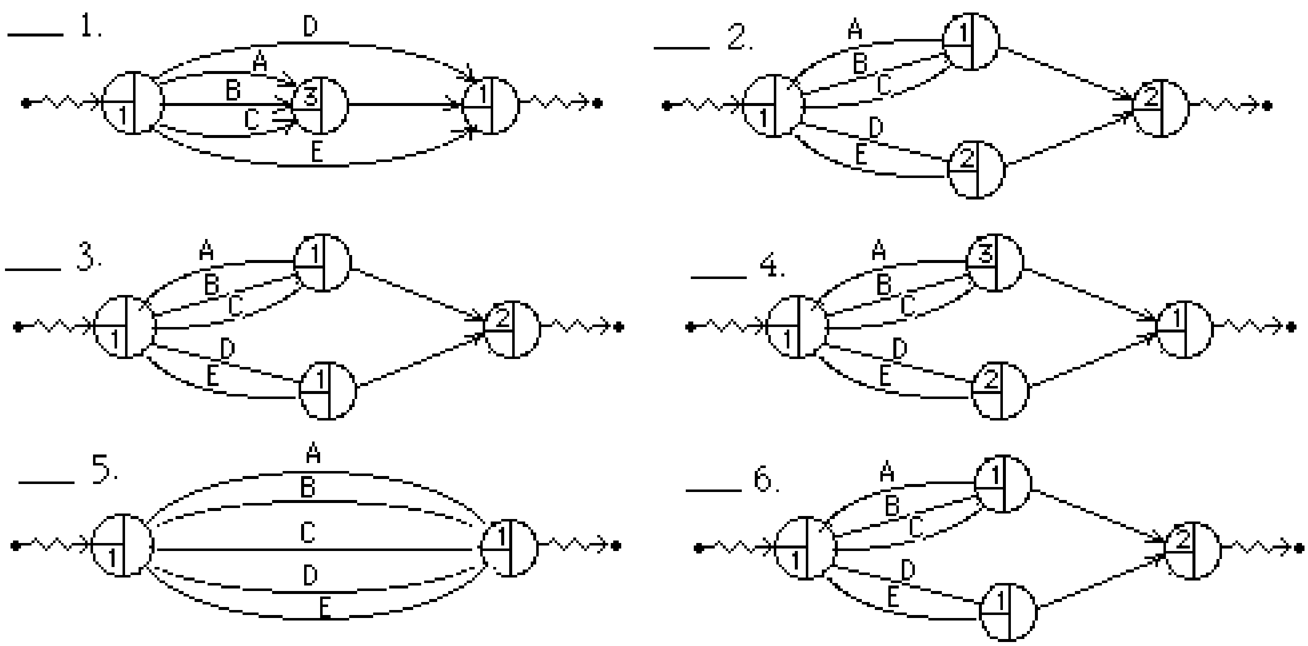


7. None of the above

Reliabilities:

1. $[1-0.1^3]\,[1-0.2^2]$
2. $1 - (0.1)^3(0.2)^2$
3. $1-[1-0.1^3]\,[1-0.2^2]$
4. $1- [1-0.9^3]\,[1-0.8^2]$
5. $0.9^3[1-0.2^2]$
6. $[1-0.1^3]\,(0.8)^2$
7. *None of the above*

SLAM networks:



7. None of the above