57:022 Principles of Design II
Midterm Exam - Spring 1992

Write your answers on the answer sheet!

PART I

The city engineer of West Walla Walla, New Jersey, has determined that during the spring rainy season, ...

- the number of inches of rain received during any storm is exponentially distributed with mean 4 inches
- the capacity of the city's storm sewer system is exceeded if a storm deposits more than 8 inches of rain on the city
- the occurrence of storms forms a Poisson process, with an average of one storm every 4 days

Select your answer to each question from the list below, and indicate by the appropriate letter (a through v):

___ 1. What is the probability that any one storm will cause the capacity of the storm sewer system to be exceeded?

In the questions below, let your answer to (1) be represented by "p".

___ 2. If at least eight storms occur during the rainy season, what is the probability that exactly 2 storms will cause the capacity of the sewer system to be exceeded.

___ 3. If ten storms do occur, what is the probability that the capacity of the sewer system will be exceeded for the *first* time by the *third* storm?

___ 4. What is the probability that there are exactly 2 storms during an 8-day period?

___ 5. What is the probability that a storm occurs during the next 2 days, given that the last storm occurred 4 days ago?

___ 6. What is the probability that the *maximum* storm deposit during a rainy season with exactly eight storms will exceed 8 inches?

___ 7. The *maximum* storm deposit during an entire rainy season has approximately a probability distribution with what name?

___ 8. The *sum* of all the storm rain deposits during a rainy season has approximately a probability distribution with what name?

ANSWERS:

a. $1 - e^{-2}$	b. e^{-2}	c. $1 - e^{-4}$
d. e^{-4}	e. $1 - e^{-1/2}$	f. $2e^{-2}$
g. $p(1-p)^2$	h. $p^8(1-p)^2$	i. $\binom{8}{2} p^6(1-p)^2$
j. $\binom{8}{2} p^2(1-p)^6$	k. $p^6(1-p)^2$	l. $1 - (1-e^{-2})^8$
m. $(1-e^{-2})^8$	n. $1-e^{-8}$	o. $\frac{2^4}{4!} e^{-2}$
p. $\frac{4^2}{4!} e^{-4}$	q. Normal	r. Gumbel
s. Exponential	t. Weibull	u. Poisson
v. Binomial		

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

1. What probability distribution should be used to model the unit's lifetime?

2. In order to (theoretically) obtain a straight line, what should be plotted on the horizontal axis?

3. What should be plotted on the vertical axis?

4. Plot the appropriate transformed data on the answer sheet and (roughly) sketch a line through the points.

5. Estimate (roughly... only 1 significant digit needed!) the parameters of the probability distribution which you specified in (1.) *(2 answers required!)*

6. For the distribution with the parameters you specified in (4), is the failure rate increasing or decreasing?

7. What is the probability that a unit will survive less than 600 hours?

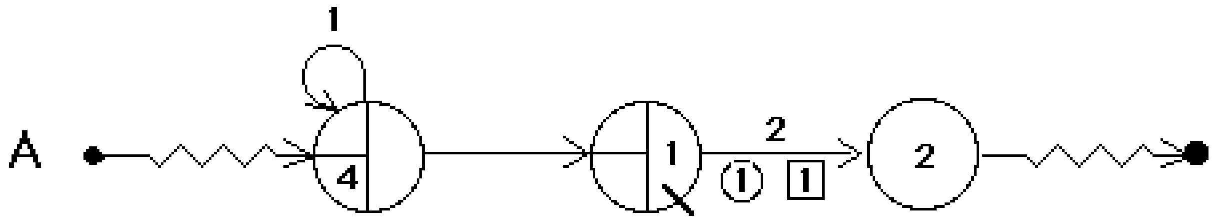
8. What is the probability that a unit will survive more than 1300 hours? _____

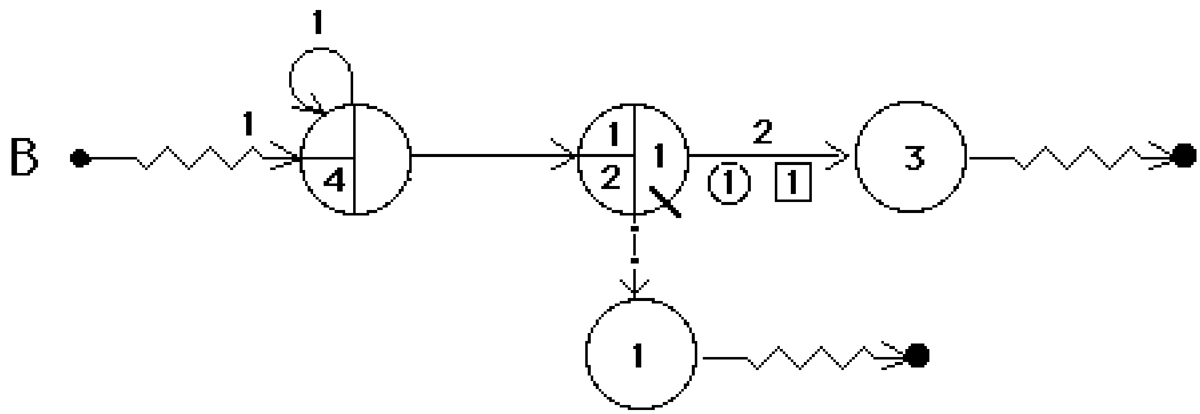
ANSWERS (Choose nearest numerical value!)

a. 1	b. 2	c. 3
d. 0.1	e. 0.2	f. 0.3
g. 0.4	h. 0.5	i. 0.6
j. 0.7	k. 0.8	l. 0.9
m. 100	n. 200	o. 300
p. 800	q. 900	r. 1000
s. constant	t. increasing	u. decreasing
v. Gamma	w. Gumbel	x. Exponential
y. Weibull	z. Poisson	aa. Normal
bb. t	cc. ln t	dd. ln ln t
ee. R	ff. ln R	gg. ln ln R
hh. ln (1/R)	ii. ln ln (1/R)	

PART III

For each SLAM network below, find the requested information:





Network ID	# in system initially	time first entity leaves	time simulation ends	# of entities leaving system
A	1)________	2)________	3)________	4)________
B	5)________	6)________	7)________	8)________
C	9)________	10)________	11)________	12)________

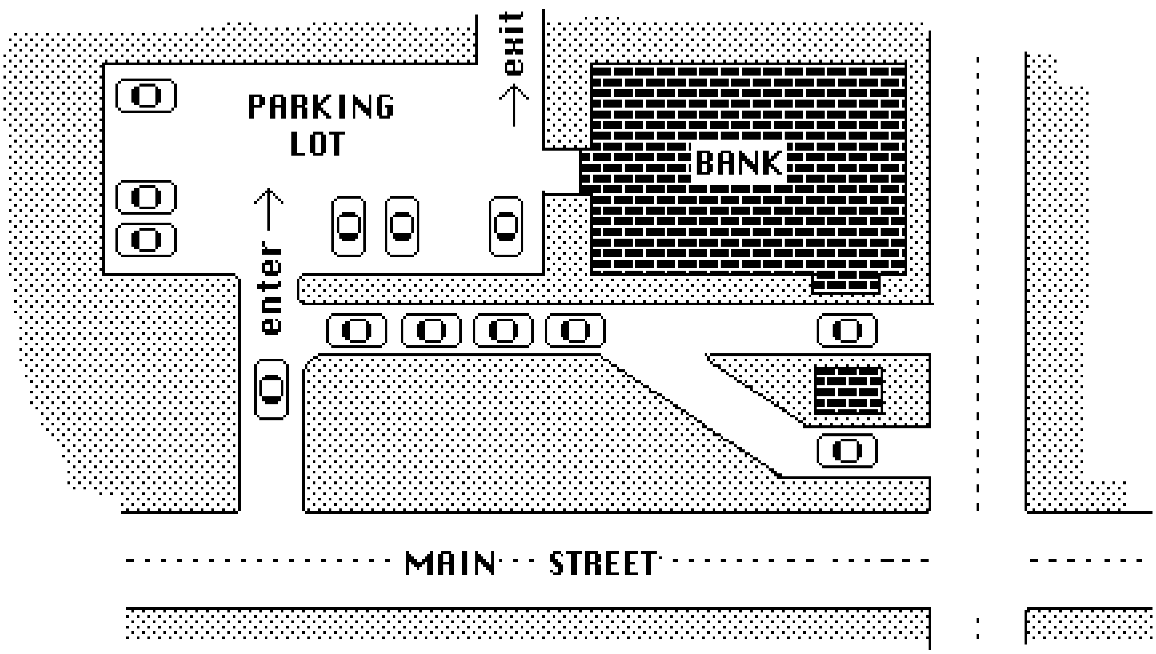
PART IV

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.

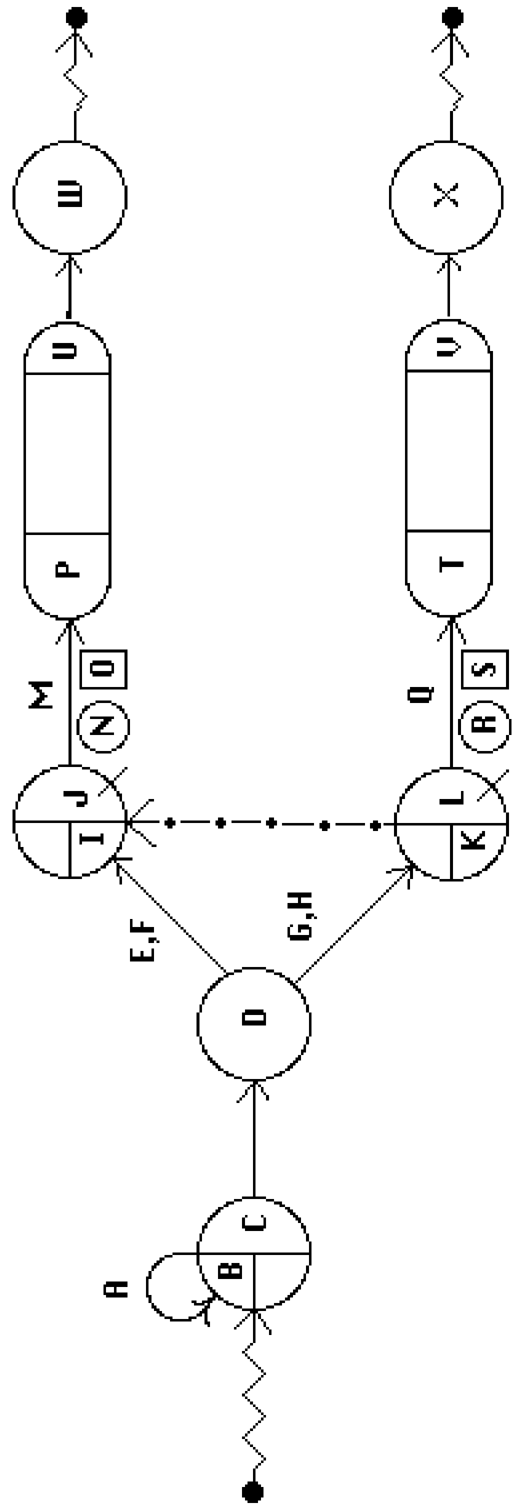
A simulation of an 8-hour day is to be performed. Statistics of particular interest include:

- 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)


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

PART V

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:

1. How many cars did the tellers at the drive-up window serve during the day? ______
2. What was the maximum number of cars in the parking lot during the day? _______
3. What is the average time spent in the system by a car using the drive-up window? _________
4. If you are a teller in one of the drive-up windows, what fraction of the day would you expect to be idle? __________

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

57:022 Principles of Design II   Name ________________________
Midterm Exam - March 9, 1992
Answer Sheet

Detach this answer sheet and hand in. In Parts I and II, write the corresponding letter from the possible answers at the end of the problem; in Part IV, write the answer from the list of possible answers at the end of the problem; in Parts III and V, you must write the numerical value.

PART ONE	PART TWO	PART THREE	PART FOUR	PART FIVE
1. ______	1. _______	1. _______	A. _________	1. _______
2. ______	2. _______	2. _______	B. _________	2. _______
3. ______	3. _______	3. _______	C. _________	3. _______
4. ______	4. see below	4. _______	D. _________	4. _______
5. ______	5. _______	5. _______	E. _________	
6. ______	6. _______	6. _______	F. _________	
7. ______	7. _______	7. _______	G. _________	
8. ______	8. _______	8. _______	H. _________	
		9. _______	I. _________	
		10. ______	J. _________	
		11. ______	K. _________	
		12. ______	L. _________	
			M. _________	
			N. _________	
			O. _________	
			P. _________	
			Q. _________	
			R. _________	
			S. _________	
			T. _________	
			U. _________	
			V. _________	
			W. _________	

PART TWO #4: