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

1. *Write the* ***number*** *corresponding to the correct probability distribution in each blank below. Note that some distributions may apply in more than one case, while others not at all!*

_____ a. the number of cars passing through an intersection during a 1-minute green light.
_____ b. the number of left-handed students in a class of 20.
_____ c. the strength of a 10-foot steel chain
_____ d. the time until the arrival of the third car at an intersection during a red light
_____ e. the total weight of a group of persons on an elevator, when loaded to its capacity of 18 persons
_____ f. the weight of the heaviest person on an elevator, when loaded to its capacity of 18 persons
_____ g. the time you must wait for a bus after arriving at the bus stop
_____ h. the lifetime of an electronic device with several dozen components which might fail (each necessary for the device to function)
_____ i. the result of tossing a single coin
_____ j. number of defective items found when testing a batch of 12.
_____ k. the distance between two flaws in a telephone cable.
_____ l. the number of items produced in order to obtain 5 acceptable items, if each is tested before producing the next
_____m. the magnitude of the highest rate of flow into the Coralville Reservoir next year
_____n. the completion time of a project with random task durations

Probability distributions:

1. Bernouilli
2. Geometric
3. Binomial
4. Exponential
5. Poisson
6. Pascal (negative binomial)
7. Erlang (Gamma) with k>1
8. Normal
9. Gumbel
10. Uniform
11. Weibull
12. Chi-square
13. Beta
14. Triangular

2. **Indicate "+" if True and "O" if False:**

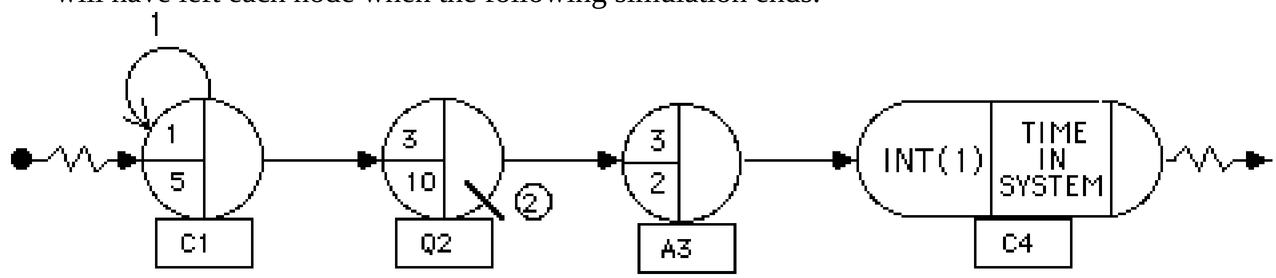
___a. If a component's lifetime has exponential distribution, its failure rate ("hazard rate") is decreasing.
___b. The "Rejection" technique may be used to generate time between arrivals in a Poisson process.
___c. In a Poisson arrival process, the time between arrivals has the Poisson distribution.
___d. If 2 components of a system have a series configuration with respect to system reliability, then both are required to function in order for the system to function.
___e. If 2 components of a system have a series configuration with respect to system reliability, then the system lifetime is the maximum of the component lifetimes.
___f. If 2 components of a system have a series configuration with respect to system reliability, then the second component replaces the first when it fails, and the system then fails when the second component fails.
___g. PERT assumes that each activity's duration has a Normal distribution.
___h. PERT assumes that the project duration has a Normal distribution.
___i. The Erlang distribution is a special case of an exponential distribution.
___j. The chi-square distribution is the distribution of the sum of normally-distributed random variables.
___k. For a finite-capacity queue (M/M/1/N), a steady state exists only if the arrival rate is less than the service rate.
___l. In an M/M/1 queueing system, ρ represents the probability that the server is busy.

___m. In an M/M/1 queueing system, π_0 represents the probability that the server is idle.
___n. The gamma function $\Gamma(n) = n!$ for positive integer values of n.
___o. In an M/M/2 queueing system, at most 2 customers may be in the system at any time.
___p. In an M/M/1/N queueing system, N represents the capacity of the waiting line.
___q. In a Poisson arrival process, the number of arrivals during an hour has the Poisson distribution.
___r. "Dummy" activities are unnecessary in the "Activity-on-Node" representation of a project.
___s. The "Mid-Square" technique may be used to generate uniformly-distributed random numbers.
___t. The exponential distribution is a special case of a Weibull distribution.
___u. The exponential distribution is a special case of an Erlang distribution.
___v. If we...
(i) test 100 lightbulbs, recording the failure time of each,
(ii) prepare a histogram indicating number of failures on six consecutive days (where the last failure occurred on the sixth day),
(iii) use the mean and standard deviation of the failure times to estimate the parameter of the Weibull distribution,
then we would assume 3 degrees of freedom when performing the Chi-Square goodness of fit test.
___w. If we plot the lifetimes of the 100 lightbulbs in (v) on Weibull probability paper, and the lifetimes do in fact have a Weibull distribution, the result will be (approximately) a straight line with slope equal to the "shape" parameter.
___x. Estimating the Weibull parameters by plotting the failure times on Weibull probability paper as in (w) requires that the test continue until all 100 lightbulbs have failed.
___y. In an M/M/1 queueing system, with arrival rate 3/minute and service time averaging 15 seconds, we would expect the server to be busy more than 60% of the time.
___z. In an M/M/1 queueing system, with an average of 20 seconds between arrivals and an average of 2 customers in the system, we would expect the average time spent by a customer in the system to be at least 1 minute.

3. For each of the following statements about SLAM, **indicate "+" if True and "O" if False:**
___a. In SLAM, an assembly node is a special type of select node.
___b. An activity following a queue node must be a service activity.
___c. An AWAIT node is a special type of a queue node.
___d. The activity preceding a queue node with blocking must be a service activity.
___e. When an entity arrives at a terminate node, the simulation ends.
___f. A SLAM model of a project employs the "Activity-on-Arrow" rather than "Activity-on-Node" representation of the project.
___g. At an AWAIT node, entities may wait for either a gate or a resource.
___h. A service activity cannot be pre-empted.
___i. Queue nodes cannot be on both sides of a single SELECT node.
___j. If 2 service activities follow a SELECT node, then 2 queue nodes must precede it.
___k. The activity preceding a queue node with balking must be a service activity.
___l. Entities may balk when arriving at an AWAIT node with limited space to wait.
___m. Entities may wait at a QUEUE node for a GATE to open.
___n. A queue node with two identical servers may also be modeled as an AWAIT node followed by a FREE node, with 2 units of resource.
___o. When two entities are waiting for a gate to open, and the first of the two is allowed to leave when the gate opens, the second entity must wait for the gate to open again.
___p. If, on two successive days, you run the same simulation model (i.e., with the same input file) in which some activities have random durations, you should expect to obtain slightly different statistics.
___q. An accumulate node is used to accumulate statistics in successive runs of a simulation model.

___r. When an entity arrives at a CLOSE node to close a gate, then any entities which follow it may not pass through the node.
___s. Between two nodes, at most one activity is allowed.
___t. An assembly node is a special case of a SELECT node.
___u. On a COLCT node, INT(1) means that you wish statistics collected on the interarrival times of entities at this node.
___v. A SLAM network requires at least one CREATE node.
___w. An entity's attribute, for example, ATRIB(1), may be used to specify the duration of an activity.
___x. An entity may depart a node on only one branch.
___y. Two queue nodes must use different file numbers.
___z. A GOON node is used to eject unruly customers from a queue.

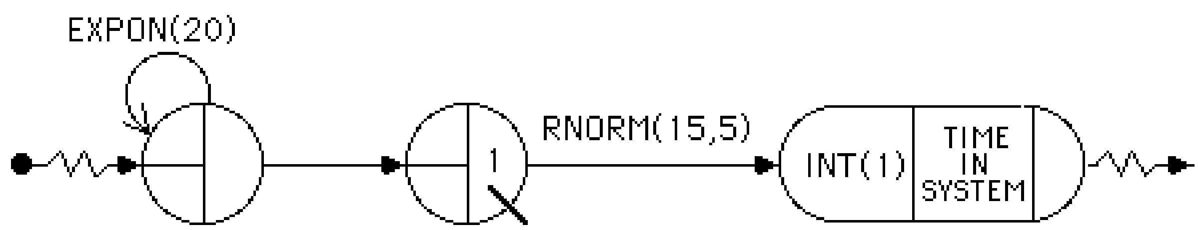
4. State the number of entities that will have arrived at each node and the number of entities that will have left each node when the following simulation ends.



node	# of entities arriving	# of entities departing
C1	_______	_______
Q2	_______	_______
A3	_______	_______
C4	_______	_______

5. Below is a SLAM network model of a barber shop with a single barber. Customers arrive an averge of every 20 minutes, according to a Poisson process. Modify it so that:
   a. There are 2 barbers (identical twins!)
   b. The waiting room has four seats. If the waiting room is full, any arriving customer will leave, but an average of 50% of these will return sometime during the next 30 minutes (uniformly distributed) and try again to enter.
   c. Customers stop arriving after 8 hours (480 minutes), but customers already in the shop are served before the shop closes.
   d. Statistics on the time between (initial) arrival and departure of customers are collected.

Indicate the changes directly on this network diagram.



6. Select **two** of the **three** systems below and draw SLAM networks which model them. (If a duration is not specified for an activity, omit the duration from the diagram.)

a. Gravel Loading: The system consists of 1 bulldozer, 2 loaders (which differ in loading times, which are exponentially distributed with means 3 and 4 minutes), and 3 identical trucks. The bulldozer creates 2 piles of gravel; the loader then transfers them to a truck, which hauls the gravel away (N(5,1) distribution), dumps it (N(2,1) distribution), and returns (N(4,1) distribution). (When both loaders are idle, the one who has waited the longest since his last load will do the operation.) Following a loading operation, a loader operator rests 5 minutes.

b. An operator is assigned to service three automatic machines in a factory. This consists of unloading the job which is completed, and reloading the next job. Each of these two tasks requires an amount of time normally distributed, with mean 5 minutes and standard deviation 1 minute. The time required for a machine to process a job has exponential distribution with mean 1 hour. Every hour, the operator is allowed to take a 5-minute break. (If he is servicing a machine when break time comes, he stops what he's doing and returns to finish the machine after his break.) We wish to simulate a 24-hour day.

c. A processing center in a manufacturing system has insufficient jobs to warrant a full-time operator. When 3 jobs await processing, an operator arrives to process them, and continues working until no further jobs require processing. Job arrival is a Poisson process, with arrival rate 1/hour. Time to process a job has Normal distribution with mean 15 minutes and standard deviation 5 minutes. We need statistics on the length of time that a job spends at this processing center, and the time between arrivals of the operator, i.e., time between successive initiation of processing.