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# 57:022 Principles of Design II
# Quizzes Spring '94

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## <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #1** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

Vehicles arrive at a toll booth on the freeway at the average rate of 6/minute in a completely random fashion. The vehicles are counted and arrival times are recorded, beginning at 12:00 noon. Ninety percent of the vehicles are cars, while the remainder are trucks, buses, etc.

*Write the alphabetic letter (A-I) corresponding to the name of the probability distribution which each of the following random variables has. Warning: some distributions may apply in more than one case, while others not at all!*

___ 1. time of arrival of first vehicle
___ 2. time of arrival of vehicle #3
___ 3. time between arrivals of vehicle #2 and vehicle #3
___ 4. number of vehicles arriving during the first minute
___ 5. number of vehicles arriving during the first 3 minutes
___ 6. vehicle# of the first vehicle which is *not* a car.
___ 7. the number of cars among the first 10 vehicles to arrive
___ 8. the number of non-cars among the first 10 vehicles to arrive
___ 9. the vehicle# of the second vehicle which is *not* a car.
___ 10. an indicator for vehicle #n which is 1 if a car, 0 otherwise.

*Probability distributions:*

A. Bernouilli
B. Exponential
C. Binomial
D. Geometric
E. Poisson
F. Normal
G. k-Erlang (k>1)
H. Pascal
I. *None of the above*

*Write the alphabetic letter (J-V) corresponding to the numerical value of the following quantities. Warning: some answers may apply in more than one case, while others not at all!*

___ 11. P{*exactly* 6 vehicles arrive during the first minute}
___ 12. P{two of the first 6 vehicles are cars}
___ 13. P{the first vehicle arrives during the first $^1/_6$ minute}
___ 14. P{the sixth vehicle arrives during the first minute}
___ 15. P{the first *non-* car is vehicle #6}
___ 16. P{the second *non-* car is vehicle #6}
___ 17. P{vehicle #6 is *not* a car}
___ 18. P{vehicle #6 is a car}
___ 19. P{two of the first 6 vehicles are *not* cars}
___ 20. P{*at least* 6 vehicles arrive during the first minute}

*Numerical values:*

J. $6e^{-6}$
K. $1 - \sum_{x=0}^{5} \frac{6^x}{x!} e^{-6}$
L. $(0.9^5)(0.1)$
M. $\binom{6}{2} 0.1^4\ 0.9^2$
N. 0.1
O. $\frac{6^6}{6!} e^{-6}$
P. $1 - e^{-1}$
Q. $\binom{5}{1}(0.9^4)(0.1^2)$
R. 0.9
S. $\sum_{x=0}^{6} \frac{6^x}{x!} e^{-6}$
T. $e^{-1}$
U. $\binom{6}{2} 0.1^2\ 0.9^4$
V. *None of the above*

*Solutions:*

| | |
|---|---|
| <u>Exponential</u> | 1. time of arrival of first vehicle |
| <u>k-Erlang (k>1)</u> | 2. time of arrival of vehicle #3 |
| <u>Exponential</u> | 3. time between arrivals of vehicle #2 and vehicle #3 |
| <u>Poisson</u> | 4. number of vehicles arriving during the first minute |
| <u>Poisson</u> | 5. number of vehicles arriving during the first 3 minutes |
| <u>Geometric</u> | 6. vehicle# of the first vehicle which is *not* a car. |
| <u>Binomial</u> | 7. the number of cars among the first 10 vehicles to arrive |
| <u>Binomial</u> | 8. the number of non-cars among the first 10 vehicles to arrive |
| <u>Pascal</u> | 9. the vehicle# of the second vehicle which is *not* a car. |
| <u>Bernouilli</u> | 10. an indicator for vehicle #n which is 1 if a car, 0 otherwise. |

| | |
|---|---|
| $\frac{6^6}{6!} e^{-6}$ | 11. P{*exactly* 6 vehicles arrive during the first minute} |
| $\binom{6}{2} 0.1^4\ 0.9^2$ | 12. P{two of the first 6 vehicles are cars} |
| $1 - e^{-1}$ | 13. P{the first vehicle arrives during the first $^1/_6$ minute} |
| $1 - \sum_{x=0}^{5} \frac{6^x}{x!} e^{-6}$ | 14. P{the sixth vehicle arrives during the first minute} |
| $(0.9^5)(0.1)$ | 15. P{the first *non-* car is vehicle #6} |
| $\binom{5}{1} (0.9^4)(0.1^2)$ | 16. P{the second *non-* car is vehicle #6} |
| 0.1 | 17. P{vehicle #6 is *not* a car} |
| 0.9 | 18. P{vehicle #6 is a car} |
| $\binom{6}{2} 0.1^2\ 0.9^4$ | 19. P{two of the first 6 vehicles are *not* cars} |
| $1 - \sum_{x=0}^{5} \frac{6^x}{x!} e^{-6}$ | 20. P{*at least* 6 vehicles arrive during the first minute} |

## <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #2** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

We wish to simulate the vehicles arriving at a toll booth on the freeway at the average rate of 5/minute (i.e., one every 12 seconds) in a completely random fashion. The vehicles are counted and arrival times are recorded, beginning at 12:00 noon. Ninety percent of the vehicles are cars, while the remainder are trucks, buses, etc.

*Write the alphabetic letter corresponding to the name of the probability distribution which each of the following random variables has. Warning: some distributions may apply in more than one case, while others not at all!*

___ 1. probability dist'n of the time of arrival of first vehicle
___ 2. probability dist'n of the number of vehicles arriving during the first minute
___ 3. probability dist'n of the time between arrival of first and second vehicles
___ 4. probability dist'n of the vehicle# of the first vehicle which is *not* a car.
___ 5. probability dist'n of the number of cars among the first 20 vehicles to arrive

| | | |
|---|---|---|
| A. Binomial | B. Erlang | C. Poisson |
| D. Geometric | E. Exponential | F. Pascal |
| G. Bernouilli | H. Normal | I. *None of the above* |

To generate numbers $R_i$, i=1,2,..., uniformly distributed in the interval [0,1], we will use the "mid-square" method with seed $R_o$= 1234. We then will use the *inverse transformation* method to generate the interarrival times $T_i$. *In each case below, write the alphabetic letter corresponding to the correct number. Note: in some cases, there may be more than one correct answer.*

___ 6. The first uniformly distributed random number $R_1$ is ....?
___ 7. The first simulated vehicle arrives at time ....?
___ 8. If F is the cumulative dist'n function (CDF) of the interarrival time, F(0.1479) = $P\{T_i \leq 0.1479\}$=....?
___ 9. The second uniformly distributed random number $R_2$ is ....?
___ 10. The second simulated vehicle arrives how long (in minutes) after the simulation begins?

| | | |
|---|---|---|
| J. 0.1479 | K. 0.2255 | L. 27321529 |
| M. 0.3215 | N. 2756 | O. 1.1558 |
| P. 0.5227 | Q. 0.1375 | R. 01522756 |
| S. 0.2732 | T. 0.1529 | U. 0.1297 |
| V. 0.8442 | W. 0.3566 | X. 0.2269 |
| Y. *None of the above* | | |

Miscellaneous facts, *some* of which you might find useful:

$(1234)^2$= 01522756 $(0152)^2$=00032104 $(5227)^2$ = 27321529

0.1479+0.0776=0.2255 $(1479)^2$= 02187441 0.1297+0.2269=0.3566

0.5227+0.3215=0.8442 0.4773+0.6785=1.1558 $1-e^{-0.1479}$= 0.1375

$$\frac{-\ln(1-0.3215)}{5} = 0.0776 \qquad \frac{-\ln(1-0.5227)}{5} = 0.1479 \qquad \frac{-\ln(0.1523)}{5} = 0.3764$$

$$\frac{-\ln(0.3215)}{5} = 0.2269 \qquad \frac{-\ln(0.5227)}{5} = 0.1297 \qquad f(t) = \lambda\, e^{-\lambda t}$$

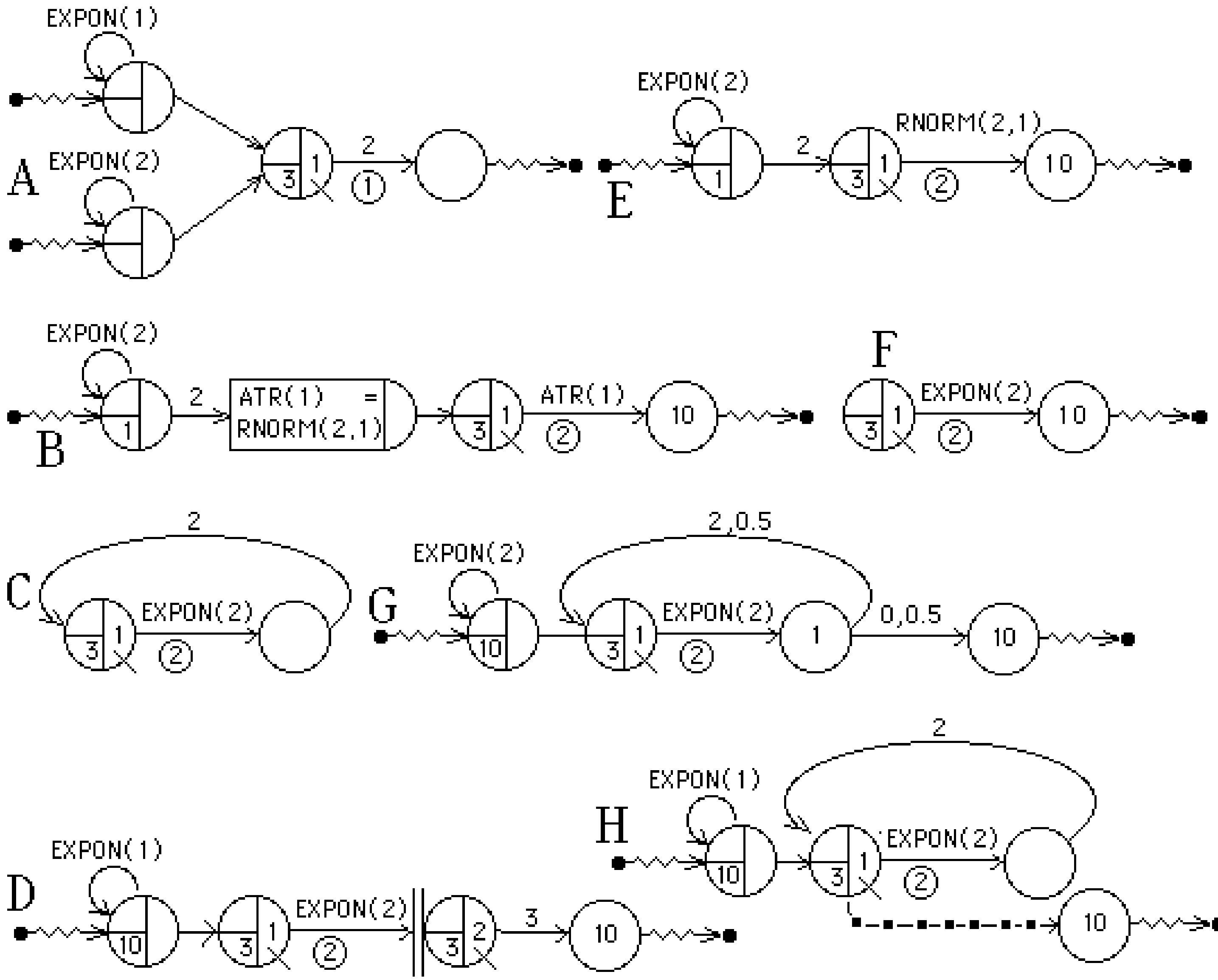
$$\frac{-\ln(1-0.2756)}{5} = 0.0645 \qquad \frac{-\ln(0.2756)}{5} = 0.2578 \qquad F(t) = 1 - e^{-\lambda t}$$

*Solutions:*

| | |
|---|---|
| *Exponential* | 1. probability dist'n of the time of arrival of first vehicle |
| *Poisson* | 2. probability dist'n of the number of vehicles arriving during the first minute |
| *Exponential* | 3. probability dist'n of the time between arrival of first and second vehicles |
| *Geometric* | 4. probability dist'n of the vehicle# of the first vehicle which is *not* a car. |
| *Binomial* | 5. probability dist'n of the number of cars among the first 20 vehicles to arrive |

6. The first uniformly distributed random number $R_1$ is 0.5227
7. The first simulated vehicle arrives at time 0.1479 or 0.1297 (depending upon whether you use 1-R or R in the inverse transformation formula).
8. If F is the cumulative dist'n function (CDF) of the interarrival time, F(0.1479) = $P\{T_i \leq 0.1479\} = 1-e^{-5(0.1479)}$ = 0.5226 (not among the answers listed).
9. The second uniformly distributed random number $R_2$ is 0.3215
10. The second simulated vehicle arrives how long (in minutes) after the simulation begins? Either 0.2255 or 0.3566 (again, depending upon your formula).

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #3** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>



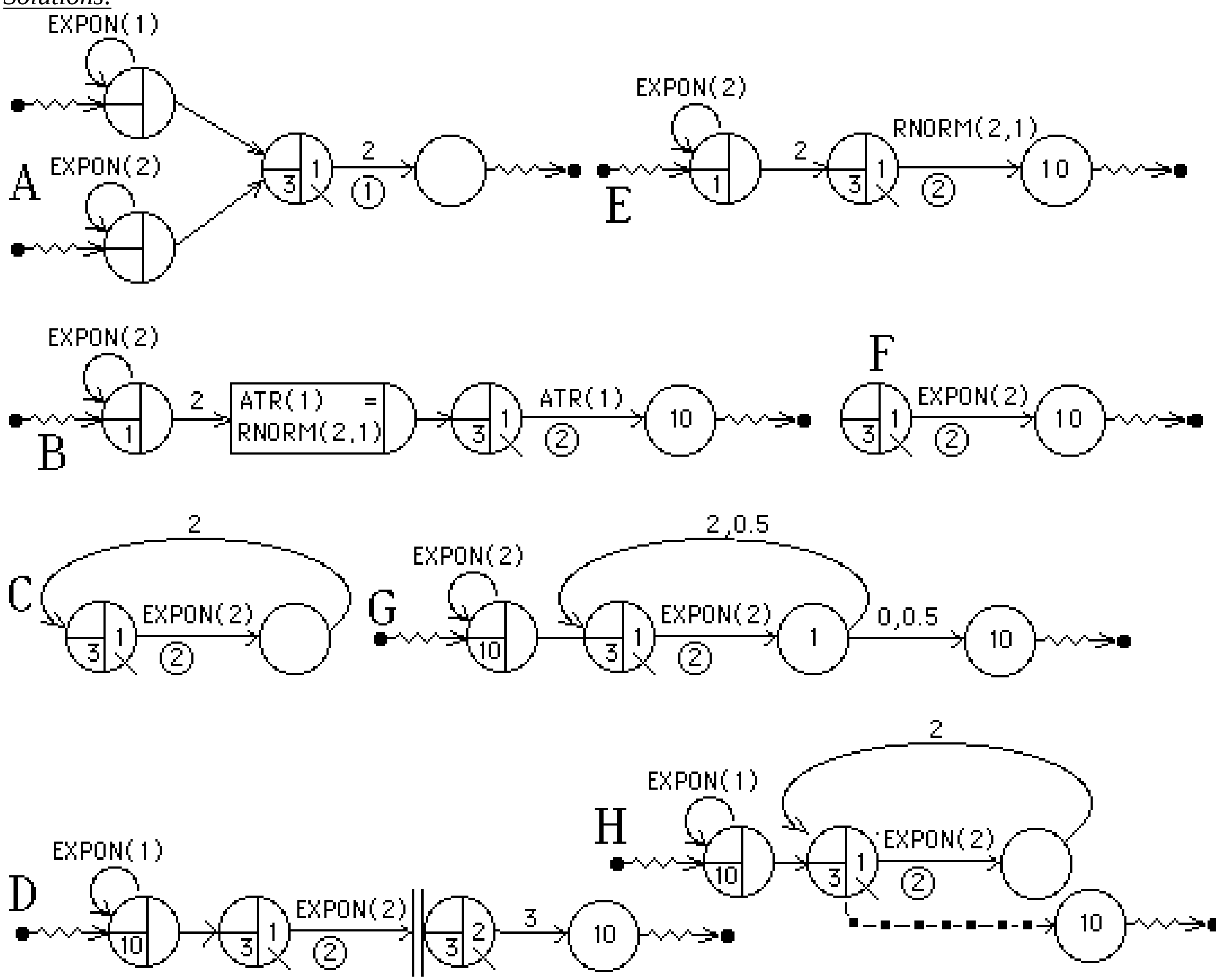

Write the Letter (A-H) of <u>at least one</u> network for each of the following characteristics. Write **I** if none.

____ 1. Exactly five entities will exit the system.
____ 2. There are a total of 3 servers in the system
____ 3. Time between entities entering the system is constant.
____ 4. Some entities may be served more than once.
____ 5. The total service time for each entity is constant.
____ 6. The simulation will terminate when 10 entities have left the system.
____ 7. Not all entities follow the same path through the network.
____ 8. Total time in the system is at least 2 time units.
____ 9. A server may be idle even though entities wait in its queue.
____ 10. The simulation will terminate only when the time limit (on the INITIALIZE control statement) has expired.
____ 11. The queue(s) have unlimited capacity.
____ 12. An entity may be destroyed when it attempts to enter a queue filled to capacity.

Write "+" for "TRUE" and "O" for "FALSE":
____ 13. An entity may leave a SLAM node by at most one activity.

____ 14. A service activity can follow only a "Queue" node.
____ 15. A "Queue" node must be followed by a service activity.
____ 16. If not a service activity, more than one entity may be in the activity simultaneously.
____ 17. Time spent by an entity in a network must be either in a queue or an activity.
____ 18. An attribute is a value associated with a service activity.
____ 19. When an entity "balks", it refuses to enter a filled queue until space becomes available.
____ 20. "Blocking" at the entrance of a queue can happen only if the activity entering the queue is a service activity.

*Solutions:*




*Note that the order of the characteristics and the labels on the networks differ on the different versions of the quiz!*

Write the Letter (A-H) of <u>at least one</u> network for each of the following characteristics. Write **I** if none.

_I_________ 1. Exactly five entities will exit the system.
_D_________ 2. There are a total of 3 servers in the system
_I_ _______ 3. Time between entities entering the system is constant.
C,G,H____ 4. Some entities may be served more than once.

_A______ 5. The total service time for each entity is constant.
_D,H,G___ 6. The simulation will terminate when 10 entities have left the system.
_G,H_____ 7. Not all entities follow the same path through the network.
A,B,C,D,E 8. Total time in the system is at least 2 time units.
__D______ 9. A server may be idle even though entities wait in its queue.
_A,C_____ 10. The simulation will terminate only when the time limit (on the INITIALIZE control statement) has expired.
_I________ 11. The queue(s) have unlimited capacity.
A,B,D,E,G 12. An entity may be destroyed when it attempts to enter a queue filled to capacity.

Write "+" for "TRUE" and "O" for "FALSE":
_O_ 13. An entity may leave a SLAM node by at most one activity.
_+_ 14. A service activity can follow only a "Queue" node.
_+_ 15. A "Queue" node must be followed by a service activity.
_+_ 16. If not a service activity, more than one entity may be in the activity simultaneously.
_+_ 17. Time spent by an entity in a network must be either in a queue or an activity.
_O_ 18. An attribute is a value associated with a service activity.
_O_ 19. When an entity "balks", it refuses to enter a filled queue until space becomes available.
_+_ 20. "Blocking" at the entrance of a queue can happen only if the activity entering the queue is a service activity.

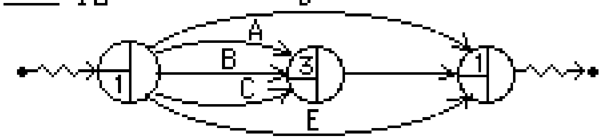
<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #4** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

Statements 1-11 below refer to exercise #1 of today's homework assignment (HW#4).*Indicate "+" for true, "o" for false:*

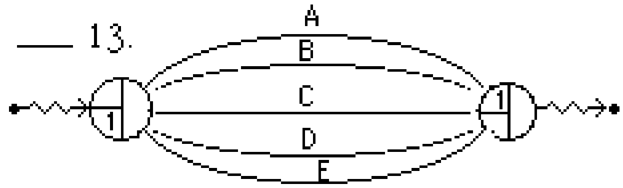
___ 1. The Cricket Graph program fits a line through data points which minimizes the sum of the squares of the errors, i.e., the vertical distance between each data point and the line.
___ 2. The method used in this exercise to estimate the Weibull parameters u & k does not require that the devices be tested until all have failed.
___ 3. We assumed in this exercise that the number of failures at time t , $N_f(t)$, has a Weibull distribution.
___ 4. The Weibull CDF, i.e., F(t), gives, for each device, the probability that it has survived until time t.
___ 5. The Weibull distribution is usually appropriate for the minimum of a large number of nonnegative random variables.
___ 6. According to the results of this homework exercise, the failure rate of the devices is decreasing rather than increasing.
___ 7. If the assumption of Weibull distribution were correct, a plot of the data points ($t_i$ vs. $R(t_i)$, where $t_i$ is the $i^{th}$ failure time and $R(t_i)$ is the fraction of survivors at this time) should lie approximately on a straight line.
___ 8. A positive value of k indicates an increasing failure rate, and negative k indicates a decreasing failure rate.
___ 9. Given a coefficient of variation for the Weibull distribution (i.e., the ratio $\sigma/\mu$), the parameter u can be determined.
___ 10. $\Gamma(n) = n!$ if n is an integer.
___ 11. The slope of the straight line fit by Cricket Graph will be the estimate of the "shape" parameter k.

*For each SLAM network 12-15 below, write the letter (a-f) of the system for which it simulates the system lifetime. Assume A, B, C, etc. in the SLAM network represent the lifetime distributions of devices A, B, C, etc.*

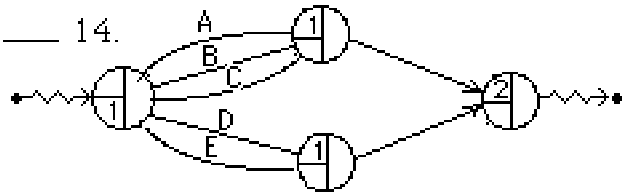
___ 12



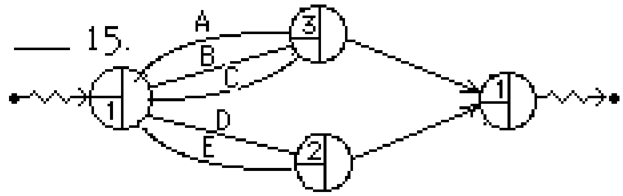

___ 13.



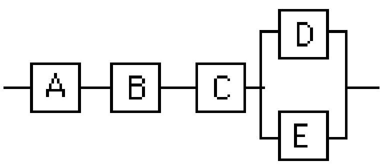

___ 14.



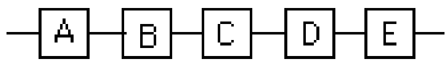

___ 15.



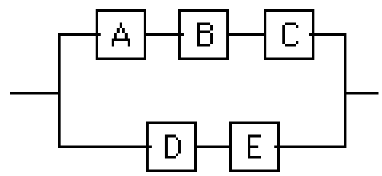

**a.**



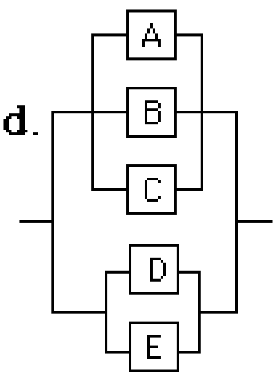

**c.**



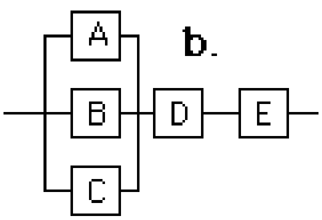

**e.**



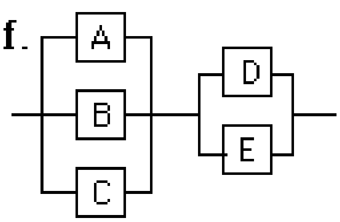

**d.**




**b.**




**f.**




*Solutions:*

True 1. The Cricket Graph program fits a line through data points which minimizes the sum of the squares of the errors, i.e., the vertical distance between each data point and the line.

True 2. The method used in this exercise to estimate the Weibull parameters u & k does not require that the devices be tested until all have failed.

False 3. We assumed in this exercise that the number of failures at time t , $N_f(t)$, has a Weibull distribution. *(The lifetime of the device is assumed to have a Weibull distribution.)*

False 4. The Weibull CDF, i.e., F(t), gives, for each device, the probability that it has survived until time t. *(The CDF gives the probability that the device has failed at time t or before.)*

True 5. The Weibull distribution is usually appropriate for the minimum of a large number of nonnegative random variables.

True 6. According to the results of this homework exercise, the failure rate of the devices is decreasing rather than increasing.

False 7. If the assumption of Weibull distribution were correct, a plot of the data points ($t_i$ vs. $R(t_i)$, where $t_i$ is the $i^{th}$ failure time and $R(t_i)$ is the fraction of survivors at this time) should lie approximately on a straight line. *(The variables should be transformed so as to obtain $x_i = \ln t_i$ and $y_i = \ln [\ln (1/R(t_i)) ]$. The points (x, y) should then fall approximately on a straight line.)*

False 8. A positive value of k indicates an increasing failure rate, and negative k indicates a decreasing failure rate. *(The parameter k will always be positive. A value greater than 1* *indicates an increasing failure rate, and a value less than 1 indicates a decreasing failure rate.)*

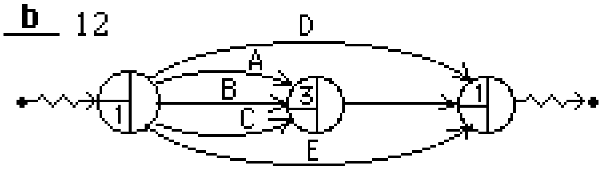
<u>False</u> 9. Given a coefficient of variation for the Weibull distribution (i.e., the ratio $\sigma/\mu$), the parameter u can be determined. *(The coefficient of variation determines k, the shape parameter, but is independent of u.)*

<u>False</u> 10. $\Gamma(n) = n!$ if n is an integer. *(G(n) = (n-1)! )*

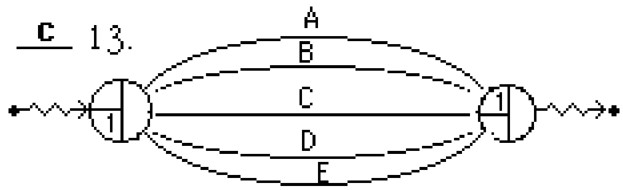
<u>True</u> 11. The slope of the straight line fit by Cricket Graph will be the estimate of the "shape" parameter k.

*For each SLAM network 12-15 below, write the letter (a-f) of the system for which it simulates the system lifetime. Assume A, B, C, etc. in the SLAM network represent the lifetime distributions of devices A, B, C, etc.*

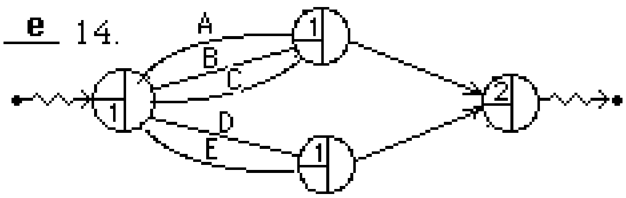
<u>**b**</u> 12



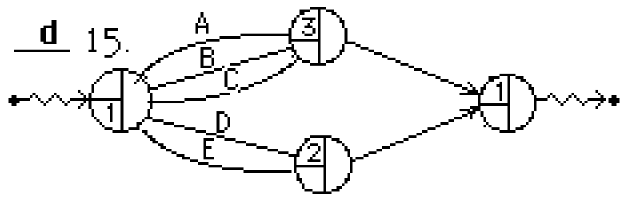

<u>**c**</u> 13.



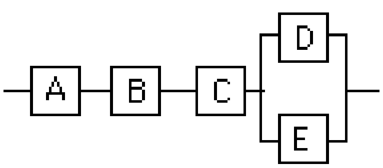

<u>**e**</u> 14.



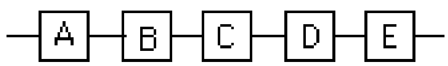

<u>**d**</u> 15.



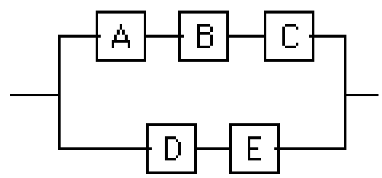

**a.**



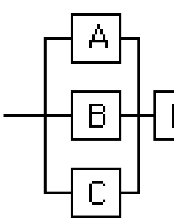

**c.**



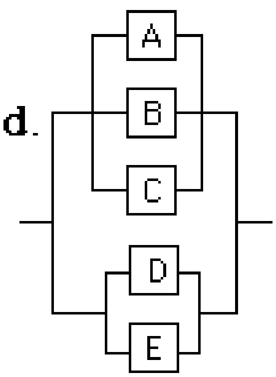

**e.**



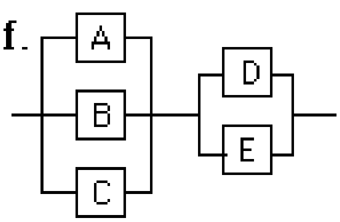

**b.**




**d.**



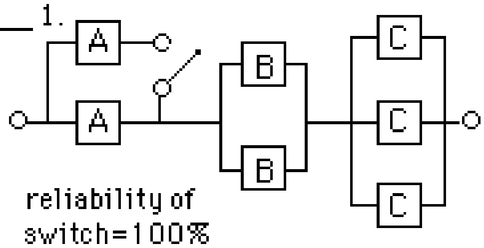

**f.**



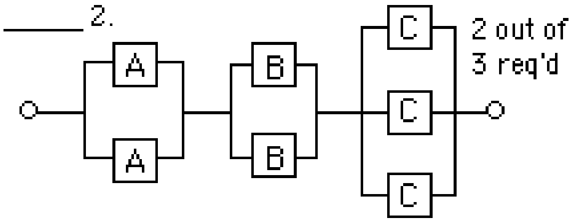

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #5** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

*For each SLAM network 1-4 below, write the letter (A-H) of the system for which it simulates the system lifetime. The switch in the diagram indicates that the back-up copy of A is switched into the system (possibly with less than 100% reliability) when the first copy of A fails. Assume that A, B, C, etc. in the SLAM network represent the lifetime distributions of devices A, B, C, etc.*

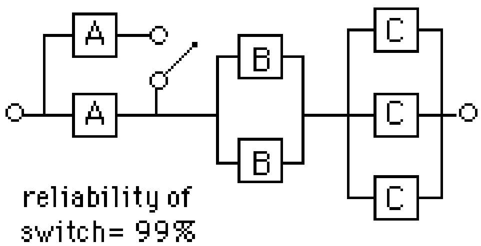
_____ 1.


A
A
B
B
C
C
C
reliability of
switch=100%

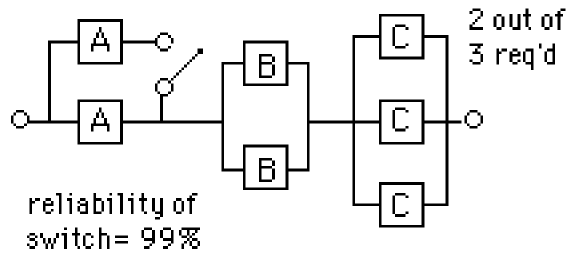
_____ 2.

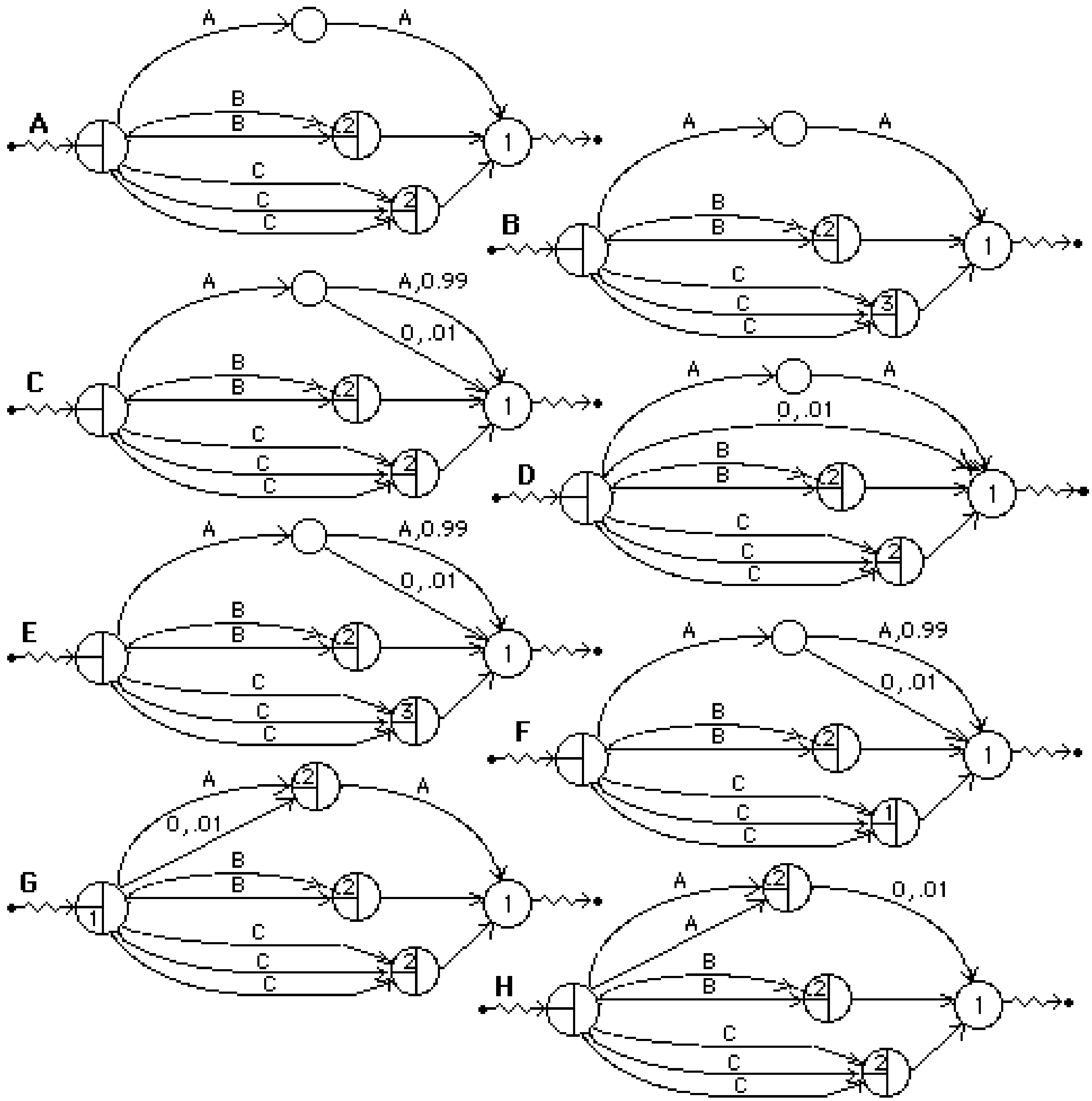

A
A
B
B
C
C
C
2 out of
3 req'd

_____ 3.


A
A
B
B
C
C
C
reliability of
switch= 99%

_____ 4.


A
A
B
B
C
C
C
2 out of
3 req'd
reliability of
switch= 99%




*For each system described below, indicate the appropriate SLAM network setment (I through P) which might best model it. If no network segment shown could be used, indicate "Q".*

____ 5. Customers select the check-out lane at the grocery store which has the shortest queue.

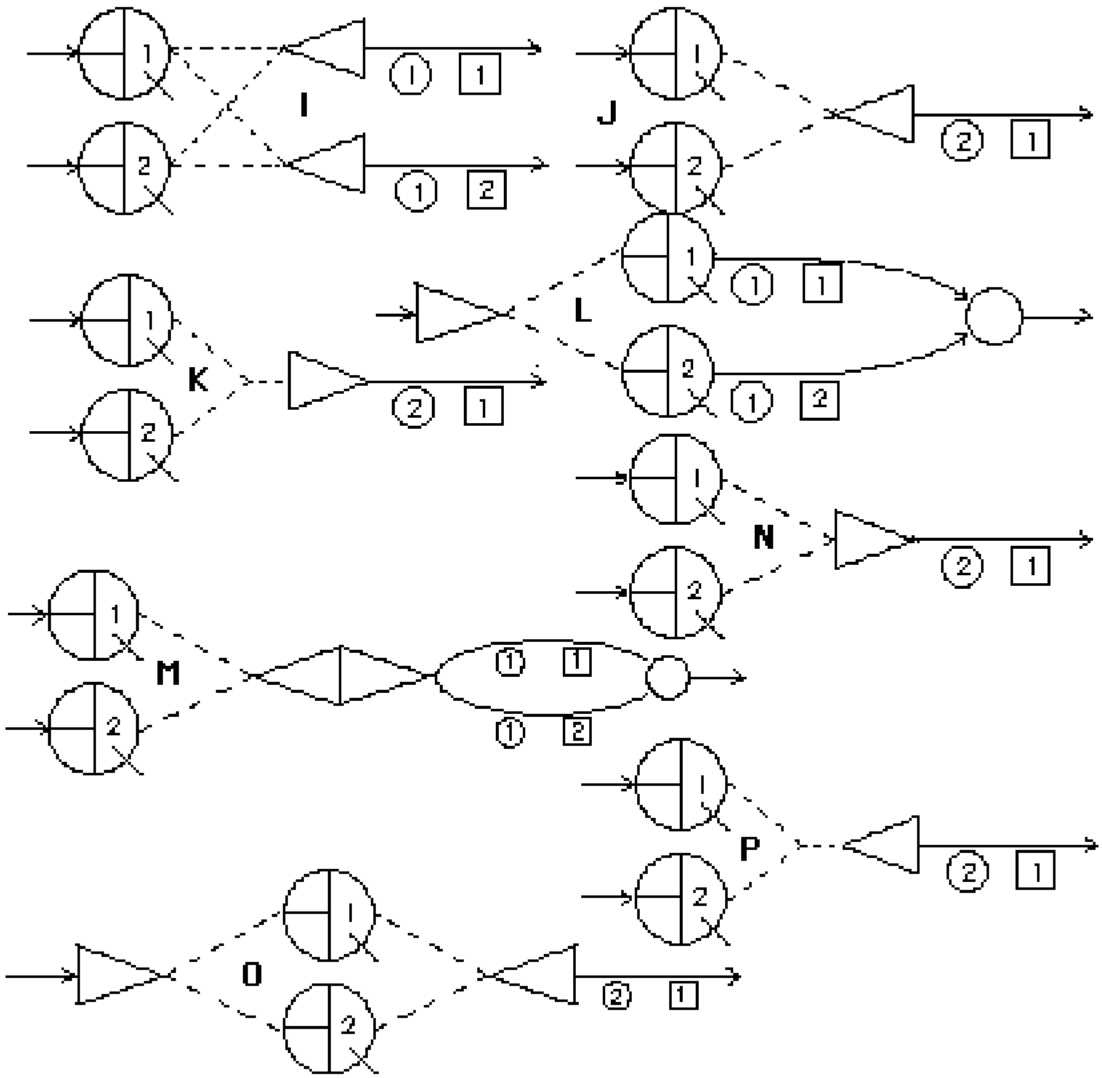
____ 6. Two (identical) servers select their next job from the longer of two queues.

____ 7. Widgets and boxes arrive on two conveyors at the final station on an assembly line. Two (identical) workers have the task of selecting a widget and a box, packing it, and sealing the box.

____ 8. Two workers, who differ in the speed with which they work, select their next job from queue #1 if any wait there, and queue #2 otherwise.

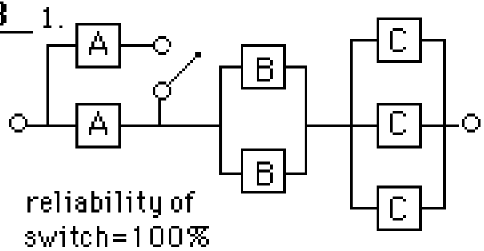
____ 9. Arriving customers select the waiting area (of two available) with the lesser number of people already waiting. Two non-identical clerks serve the person who has waited the longest.

____ 10. Customers arrive at two queues to wait for service by either of two clerks. If both clerks are idle, customers prefer clerk #1. If a clerk finishes serving a customer and both queues have persons waiting, he selects the customer at the head of the longest queue.

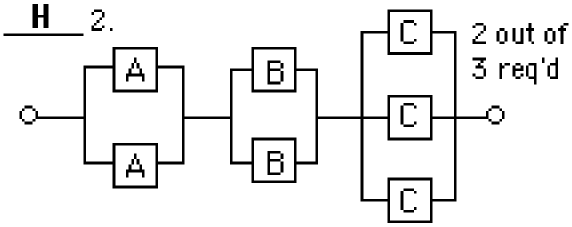



*Solutions:*

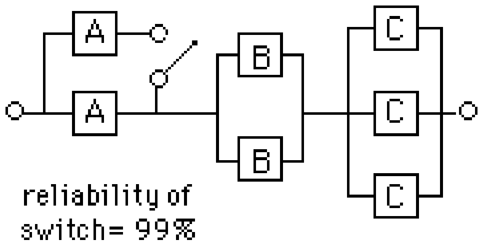
B 1.


A
A
B
B
C
C
C
reliability of
switch=100%

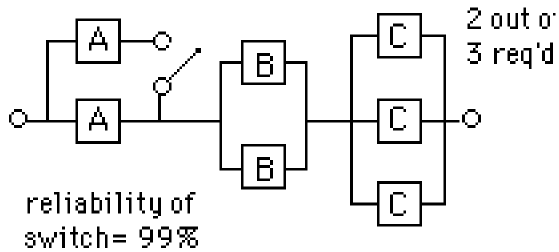
H 2.

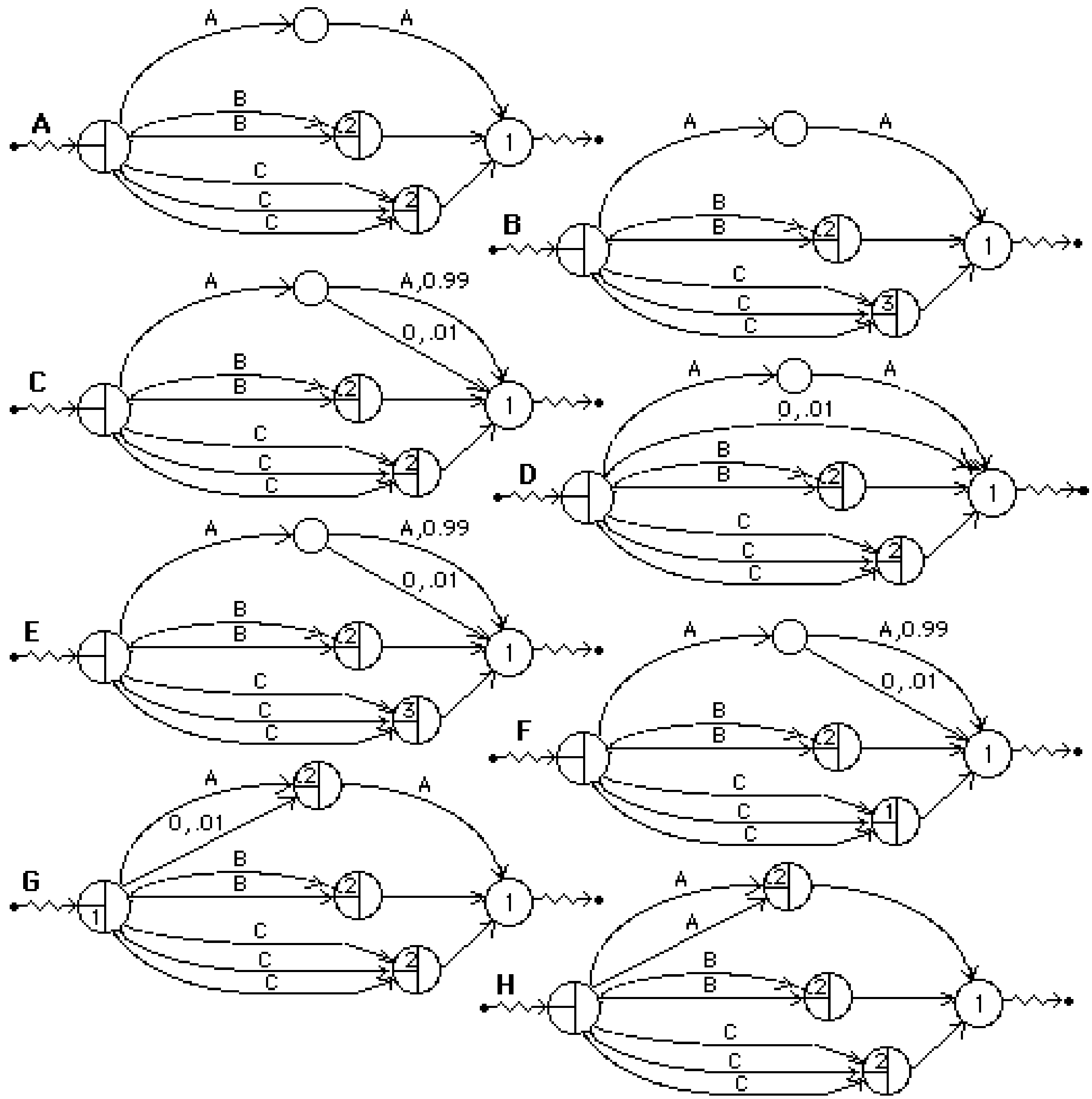

A
A
B
B
C
C
C
2 out of
3 req'd

E 3.


A
A
B
B
C
C
C
reliability of
switch= 99%

C 4.


A
A
B
B
C
C
C
2 out of
3 req'd
reliability of
switch= 99%




*For each system described below, indicate the appropriate SLAM network setment (I through P) which might best model it. If no network segment shown could be used, indicate "Q".*

_L__ 5. Customers select the check-out lane at the grocery store which has the shortest queue.

_J__ 6. Two (identical) servers select their next job from the longer of two queues.

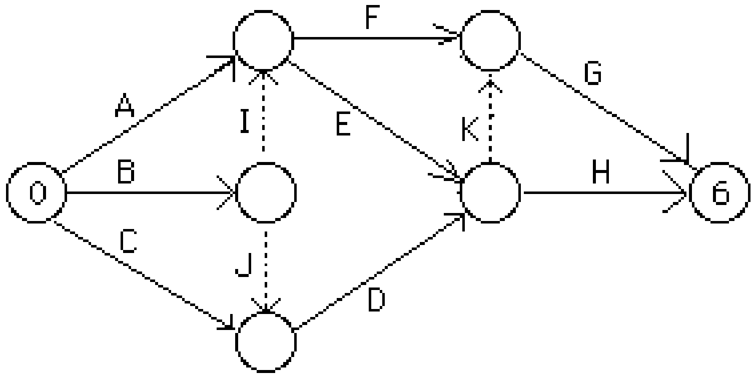
_P__ 7. Widgets and boxes arrive on two conveyors at the final station on an assembly line. Two (identical) workers have the task of selecting a widget and a box, packing it, and sealing the box.

_I__ 8. Two workers, who differ in the speed with which they work, select their next job from queue #1 if any wait there, and queue #2 otherwise.

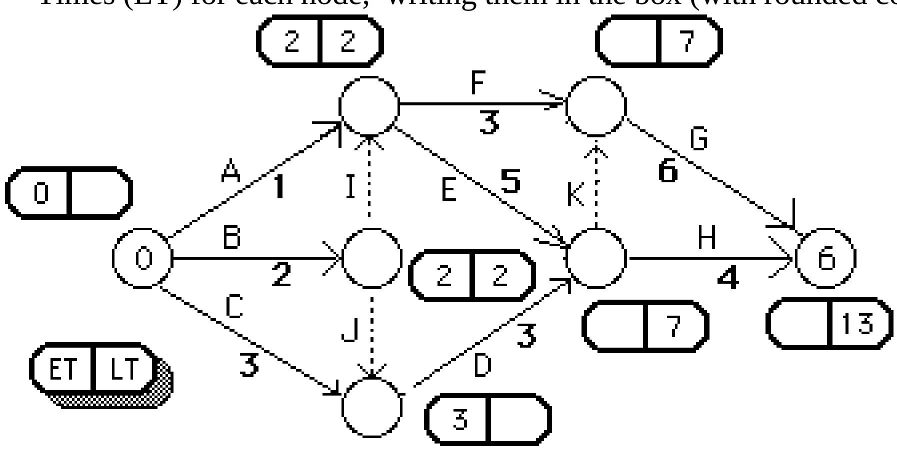
_L_ 9. Arriving customers select the waiting area (of two available) with the lesser number of people already waiting. Two non-identical clerks serve the person who has waited the longest.

_M_ 10. Customers arrive at two queues to wait for service by either of two clerks. If both clerks are idle, customers prefer clerk #1. If a clerk finishes serving a customer and both queues have persons waiting, he selects the customer at the head of the longest queue.

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #6** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>




a. Complete the labeling of the nodes on the A-O-A project network above.
b. The activity durations are given below on the arrows. Finish computing the Early Times (ET) and Late Times (LT) for each node, writing them in the box (with rounded corners) beside each node.

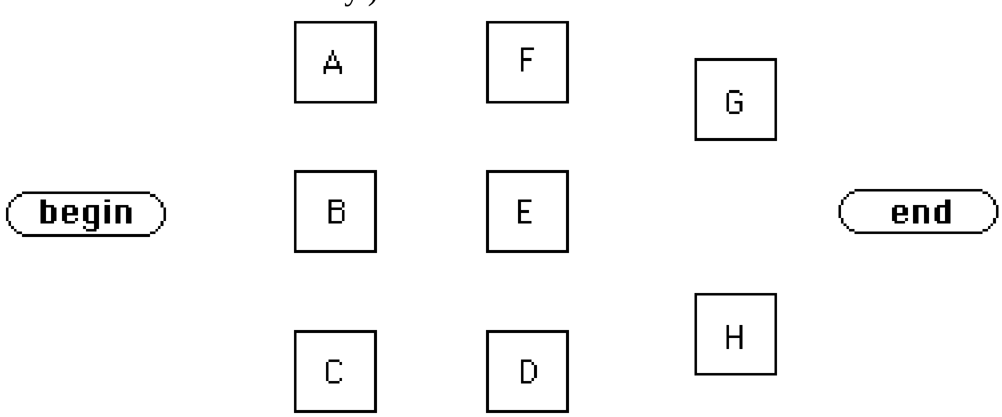



d. Find the slack ("total float") for activity D. _________

e. Which activities are critical? (circle: A B C D E F G H I J K )

f. What is the earliest completion time for the project? ___________

g. Complete the A-O-N (activity-on-node) network below for this same project. (Add any "dummy" activities which are necessary.)



<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #7** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

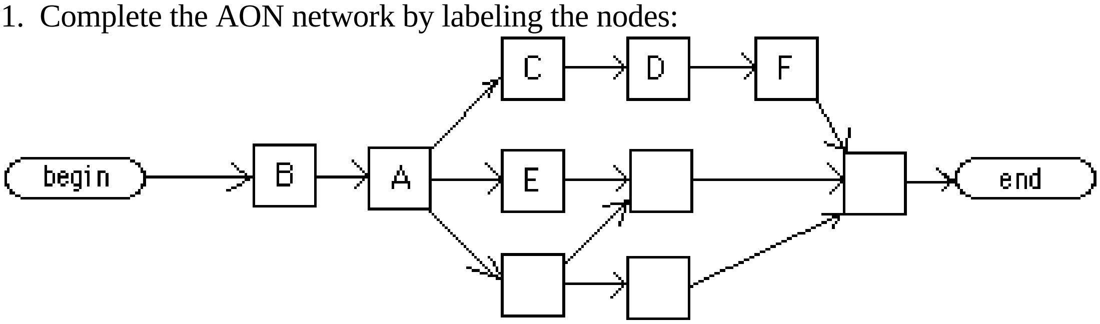
**I. Indicate "+" if True and "O" if False:**

___a. PERT assumes that each activity's duration has a Normal distribution.
___b. PERT assumes that the project duration has a Normal distribution.
___c. If an average of 100 random project completion times is desired, the terminate node should stop the simulation after 100 entities have arrived.
___d. Except perhaps for "begin" and "end" activities, "dummy" activities are unnecessary in the "Activity-on-Node" representation of a project.
___e. A SLAM model of a project employs the "Activity-on-Arrow" rather than "Activity-on-Node" representation of the project.
___f. If, on two successive days, you run the same simulation model (i.e., with exactly the same input file) in which some activities have random durations, you should expect to obtain slightly different statistics.
___g. An accumulate node is used to accumulate statistics in successive runs of a simulation model.
___h. CPM is an abbreviation for "critical path method".
___i. PERT is an abbreviation for "project evaluation & review technique".
___j. PERT assumes that the project duration has a beta distribution.
___k. Both the triangular and beta distributions for an activity are uniquely specified given minimum & maximum durations and a most likely duration.
___l. The sum of normally-distributed random variables has the chi-square distribution.

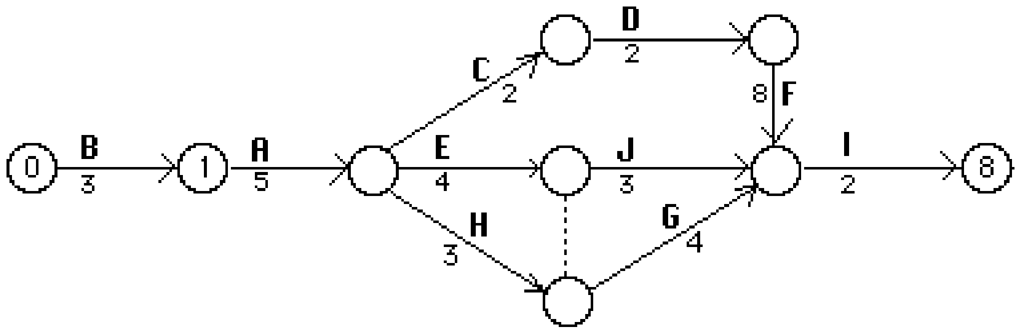
**II. Consider the construction project:**

| Activity | Description | Predecessor Activities | Duration (days) Mean | Std Dev |
|---|---|---|---|---|
| A | Walls & ceiling | B | 5 | 2 |
| B | Foundation | none | 3 | 1 |
| C | Roof timbers | A | 2 | 1 |
| D | Roof sheathing | C | 2 | 1 |
| E | Electrical wiring | A | 4 | 2 |
| F | Roof shingles | D | 8 | 2 |
| G | Exterior siding | H | 4 | 1 |
| H | Windows | A | 3 | 1 |
| I | Paint | F,G,J | 2 | 1 |
| J | Inside wall board | E,H | 3 | 1 |

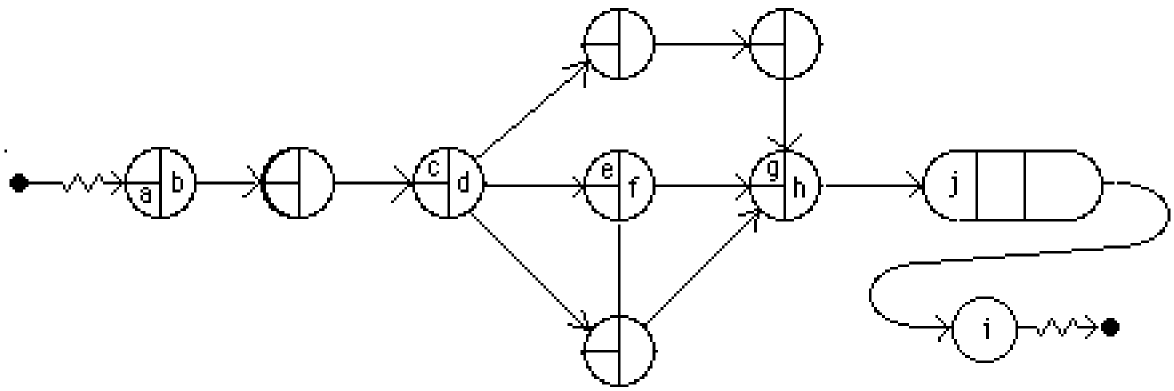
1. Complete the AON network by labeling the nodes:




2. Asssign a direction to the "dummy" activity in the AOA network below and complete labelling the nodes:

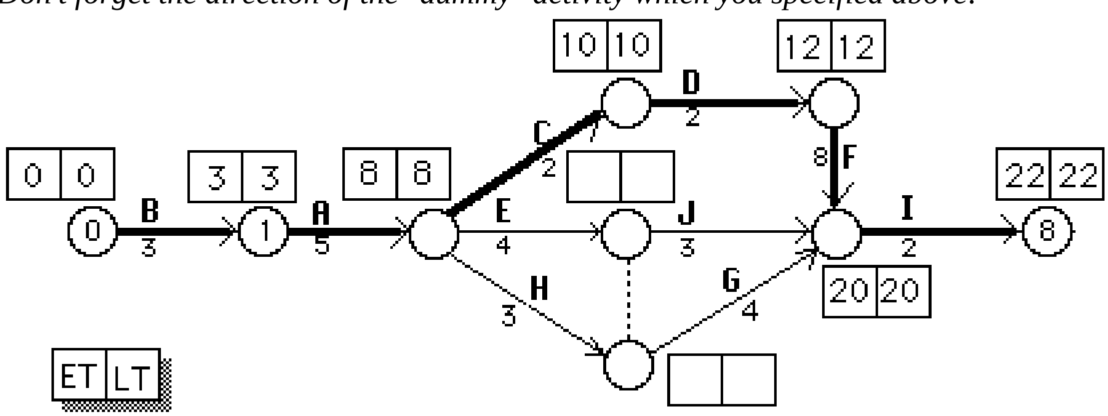



3. Give numerical values (0, 1, 2, 3, 4, or ∞ ) of "a" - "i" on the SLAM network below, if the project is to be simulated *four* times. If the default value is appropriate, you may leave blank.
   a ___ b ___ c ___ d ___ e ___ f ___ g ___ h ___ i ___




4. "j" on the SLAM network above should indicate which type of statistic? ______
   i. LAST ii. INT(1) iii. BETWEEN iv. FIRST

5. In the project network below, each activity is assumed to require its expected duration. Complete the two missing pairs of ETs (earliest times) & LTs (latest times) in the network below. *Don't forget the direction of the "dummy" activity which you specified above!*




6. The critical path is shown in bold above. What is
   ... the expected completion time of the project, according to PERT? ______
   ... the standard deviation of the project completion time, according to PERT? _______

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #8** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

For each of the following statements about SLAM, **indicate "+" if True and "O" if False:**

___a. An ASSEMBLY node is a special case of a SELECT node.

___b. 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.
___c. An AWAIT node is a special type of a queue node.
___d. A SLAM network requires at least one CREATE node.
___e. The activity preceding a queue node with blocking must be a service activity.
___f. When an entity arrives at a terminate node, the simulation is immediately terminated.
___g. In SLAM, an assembly node is a special type of select node.
___h. A SLAM network requires at least one CREATE node.
___i. At an AWAIT node, entities may wait for either a gate or a resource.
___j. A SLAM network requires at least one TERMINATE node.
___k. A service activity cannot be pre-empted.
___l. Two AWAIT nodes must use different file numbers.
___m. The activity preceding a queue node with balking must be a service activity.
___n. Entities may balk when arriving at an AWAIT node with limited space to wait.
___o. Entities may wait at a QUEUE node for a GATE to open.
___p. When two entities are waiting for a gate to open, and the gate then opens, both entities simultaneously proceed to the next node.
___q. An activity following a queue node must be a service activity.
___r. A GOON node in a SLAM network is used to eject unruly customers from a queue.
___s. INT(1) means that you wish statistics collected on the interarrival times of entities at this node.
___t. When an entity arrives at a CLOSE node to close a gate, then any entities which follow it may not pass through that node until the gate is opened again.
___u. An entity at an AWAIT node waiting for a gate must next open the gate (by means of an OPEN node) before proceeding.
___v . In a system with 2 servers and two queues, such as 2 check-out lanes at a grocery store, where the arriving customer chooses the shorter queue but can freely switch at any time from one queue to the other if it becomes shorter, the SLAM model should have a SELECT node to select the queue.
___w. To model a vehicle trying to enter a busy street, an assembly node can be used to "assemble" a vehicle and an arriving "opportunity".
___x . When an entity is assigned a unit of resource at an AWAIT node, that unit of resource is not available to other entities until that same entity frees the unit of resource at a FREE node.
___y . In SLAM, branching from a node can be conditional upon the number of entities in an activity elsewhere in the network.
___z . In SLAM, if an entity trying to enter a queue balks because the queue is filled to capacity but tries again to enter the queue, you should send the entity through an activity with duration greater than zero before returning it to try entering the queue again.

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #9** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

For each of the following statements about SLAM, **indicate "+" if True and "O" if False.** Score = # attempted - 2(# wrong), so that expected score if purely guessing should be zero.

___a. In the homework exercise (#2) involving the machine repairman, the machines were modeled as entities and the repairman as a "resource".
___b. In the SLAM model of the assembly line in project #2, there were five "gates", one preceding each of the five assembly stations.
___c. A resource which is assigned to an entity must be freed before it can be reassigned to another entity.
___d. A resource which is assigned to an entity can only be freed again by that same entity.
___e. A SLAM network requires at least one CREATE node.
___f. When an entity arrives at a terminate node, the simulation is immediately terminated.

___g. In the SLAM model of the assembly line in project #2, a worker at a station might continue working on a unit if he has not finished during the cycle time but no unit arrives from the upstream station.
___h. When an entity's use of a resource is pre-empted, the entity is destroyed unless you specify otherwise.
___i. In the SLAM model of the assembly line in project #2, the larger the cycle time the more the overtime required to complete the pre-empted units.
___j. To model a vehicle trying to enter a busy street, an assembly node can be used to "assemble" a vehicle and an arriving "opportunity".
___k. When an entity arrives at a CLOSE node to close a gate, then any entities which follow it may not pass through that node until the gate is opened again.
___l. When an entity's use of a resource is pre-empted, that entity will wait to be re-assigned the resource unless you specify otherwise.
___m. Entities may wait at a QUEUE node for a GATE to open.
___n. When an entity's use of a resource is pre-empted, the remaining time for which the resource is needed by that entity can be assigned to an attribute of that entity.
___o. In the SLAM model of the assembly line in project #2, the "time between creations" was constant and equal to the cycle time.
___p. The "1" in INT(1) on a COLCT node means that you wish statistics collected on the difference between TNOW and attribute #1 of entities arriving at this node.
___q. The activity preceding a queue node with blocking must be a service activity.
___r. An entity may be assigned more than one unit of a resource at the same AWAIT node.
___s. An unlimited number of entities may be in the same (regular) activity simultaneously.
___t. A SLAM network requires at least one CREATE node.
___u. At an AWAIT node, entities may wait for either a gate to be opened or a resource to be assigned.
___v When two entities are waiting at the same AWAIT node for a gate to open, and the gate then opens, both entities are allowed to proceed to the next node.
___w. An entity at an AWAIT node waiting for a gate must next open the gate (by means of an OPEN node) before proceeding.
___x. In the homework exercise (#1) involving the LaCrosse lock on the Mississippi River, the lock was modeled in SLAM as a "gate".
___y. Entities may balk when arriving at either a QUEUE node or an AWAIT node with limited capacity.
___z. XX(1) refers to attribute #1 of an entity.

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #10** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #11** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•> **Quiz #12** <•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>

*Match Problem.* Suppose that there are 27 matches originally on the table, and you are challenged by your dinner partner to play this game. Each player must pick up either 1, 2, 3, or 4 matches, with the player who picks up the last match pays for dinner.

Define F(i) to be the minimal cost to you (either 1 or 0) if it is your turn to pick up matches, and i matches remain on the table. Thus, F(1) = 1, F(2) = 0 (since you can pick up one match, forcing your opponent to pick up the last match), etc.

_____ 1. What is the value of F(3)?

_____ 2. What is the value of F(4)?

_____ 3. What is the value of F(6)?

_____ 4. What is the value of F(27)?

*Auto Replacement Problem.* Suppose that a new car costs $15,000 and that the annual operating cost and resale value of the car are as shown in the table below:

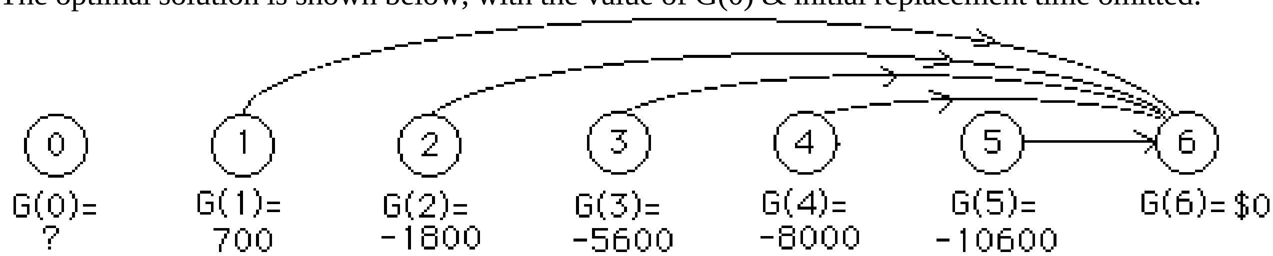
| Age of Car (years) | Resale Value | Operating Cost |
|---|---|---|
| 1 | $11000 | $400 (year 1) |
| 2 | $9000 | $600 (year 2) |
| 3 | $7500 | $900 (year 3) |
| 4 | $5000 | $1200 (year 4) |
| 5 | $4000 | $1600 (year 5) |
| 6 | $3000 | $2200 (year 6) |

(The operating cost specified above is for the year which is ending.) If I have a new car now (time 0, and this initial car is assumed to be "free", i.e. a "sunk" cost), I wish to determine a replacement policy that minimizes my net cost of owning and operating a car for the next six years.

Define G(t) = minimum cost of owning and operating car(s) through the end of the sixth year, **given that I have a new car at the end of year t.**

(As in the example solved in class, this includes the cost of the replacement car if I trade in my current car before the end of the sixth year, but does not include the cost of the car which is new at the beginning of this period.)

The optimal solution is shown below, with the value of G(0) & initial replacement time omitted:



___ 5. The value of G(5), i.e., the cost for the final year if I have a new car at the end of year 5, is

a. 0 c. 2200 e. 11000-2200 = 8800
b. 400 d. 400-11000 = -10600 f. *NOTA*

___ 6. If I have a new car at the end of year 4 and <u>replace it after one year</u>, my cost for the remainder of the six-year period is

a. 0 c. 2200 e. 11000-2200 = 8800
b. 400 d. 400-11000 = -10600 f. *NOTA*

___ 7. If I have a new car at the end of year 4 and <u>keep it until the end of the sixth year</u>, my cost for that period is

a. 600 c. 1000-9000=-8000 e. 9000-600 = 8400
b. 1000 d. 600-3000 = -2400 f. *NOTA*

___ 8. <u>If</u> I have a new car at the end of year 2, how old will it be when I should replace it?

a. 1 year old c. 3 years old e. 5 years old
b. 2 years old d. 4 years old f. 6 years old

___ 9. If I have a new car at the end of year 0 (beginning of year 1) and replace it at the end of the <u>first</u> year, my total cost for the six-year period is

a. 400 c. 15000-11000=4000 e. 9000-600 = 8400
b. 400+700=1100 d. 400+15000-11000 = 4400 f. *NOTA*

___ 10. If I have a new car at the end of year 0 (beginning of year 1) and replace it at the end of the <u>second</u> year, my total cost for the six-year period is

a. 600 c. 400+600-9000-1800=-6200 e. 400+600-1800=-800
b. 400+600=1000 d. 400+600+15000-9000=7000 f. *NOTA*

<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>-<•>