

Operations Management

Midterm 2

8/6/2011

Duration 2h30m

Good Luck!

Remember the following tips:

- Budget your time. Skim through the exam before starting.
- Show all your work to allow us to give you partial credit if appropriate.
- Answer groups in separate pages and please write down your name in all pages.

Group 1 (40 points)

a) (10 pts) The following table shows the time it took to produce each of the initial four surf boards of a series of 25. How much time do you expect to take to complete the 24th unit?

Surf boards	A	B	C	D
Production Time (in days)	2,0	1,8	1,69	1,62

b) (10 pts) Briefly describe the so-called 'bullwhip effect' in a supply chain and identify its 5 main causes.

c) (10 pts) What are the main differences and implications of having a finite population vs. a infinite population in a waiting line model?

d) Classify the following sentences as True (T), False (F), or Undetermined (U). Briefly explain your choice (2 lines maximum). Most of grade refers to the explanation.

d1) (5pts) A company that does statistical control of the production process is not taking into account its immediate customer needs.

d2) (5pts) In a service with an average utilization rate lower than 5%. A queue should never form over time.

Group 2 (40 points)

The BeachBar is located in the Tavira island. During the summer this bar is always crowded with tourists. Due to the high level of complaints caused by the waiting time in line, the owner of this bar is considering some restructuring. He knows that every time a client arrives and the line has more than 2 people, the client gives up and leaves to the competitor bar.

It is known that on average arrive 70 people per hour at the beach and 27% of those people use the BeachBar. The system of the bar is prepayment, meaning that, clients have to pass through two different phases (always in a single line). First they pay and second they receive their order in a second desk. In each of these phases there are just one service desk. The average service time on stage 1 is 2 minutes and the service rate of stage 2 is 25 people per hour.

a) (10 pts) In which stage do clients wait longer? How many people are waiting in each stage?

b) (10 pts) How many desks would be necessary in each stage if the owner of the BeachBar does not want to lose any client to competitors?

Having in mind competitors strategy, the owner of the BeachBar has decided to analyze the incurred costs if he aggregates all the service process in only one stage. Consider that service rate is 8 people per hour. He asks to his colleague to calculate the number of workers that the bar should have (assume one worker per desk).

c) (10 pts) If the goal of this new strategy is decrease the waiting time in line to no more than 5 minutes, how many workers should be hired? How long clients stay in the service area?

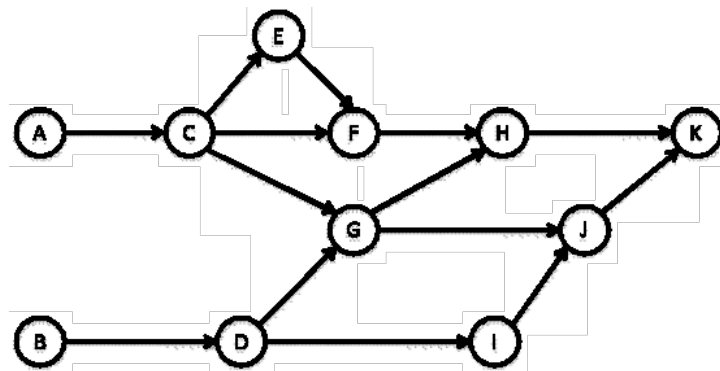
d) (10 pts) It is known that 10% of clients that are more than 9 minutes in the service area will not return to BeachBar. The cost associated with future losses is 6€/hour per client. Taking into account this what strategy would be better (between b) and c))?

Group 3 (35 points)

Dragonfly's RC is a main manufacturer of remote controlled helicopters, producing different models, to target different segments of clients. The professional down-scale replicas of Apache and Huey real helicopters, are sold mainly to helicopter pilot wannabes, and used to perform first stage flight training and improve sense and responsiveness before jumping into a real helicopter. Their mid-range own concept models are usually sold to RC helicopter's hobbyists, and their low-range electrical models are sold as kids toys.

You have been hired as an external consultant to balance the assembly line where their own-concept models, which have an average demand of 1350 per week, are produced, the plant manager provided you the following information concerning the different tasks needed to be performed, its duration and precedence relations:

Task	Time (seconds)
A	52
B	31
C	66
D	61
E	40
F	30
G	64
H	52
I	38
J	22
K	43



The line operates five days per week, with one daily shift of seven and a half hours.

- (7 pts) How many mid-range models must be produced per hour, to fulfill demand?
- (7 pts) What is the desired cycle time (in seconds)?
- (7 pts) Calculate the theoretical number of workstations needed.
- (7 pts) Balance the production line.
- (7 pts) Calculate the efficiency for this line.

Group 4 (30 points)

Rubber Cover Inc. is a tires shop located at Spain Square. Their main activity is to replace old tires and calibrate the new ones. Replacing the tires in the only available elevator is the first task where the old tires are taken off the car and the new ones are installed. The second task to be performed is to calibrate the new tires using a special machine for it. Every morning Chris, the general manager, is the first to arrive and his job is to prepare the activity for the day. This Wednesday morning he has seven cars to change tires and the time in minutes needed for each one is described on the table below (the time needed for each car depends on the size of the car and the size of the tires). Remember that due to space restrictions when they start one of the tasks in a particular car they have to finish it before starting with another car.

Car	A	B	C	D	E	F	G
Replace	23	29	19	21	24	25	26
Calibrate	20	22	22	23	18	24	27

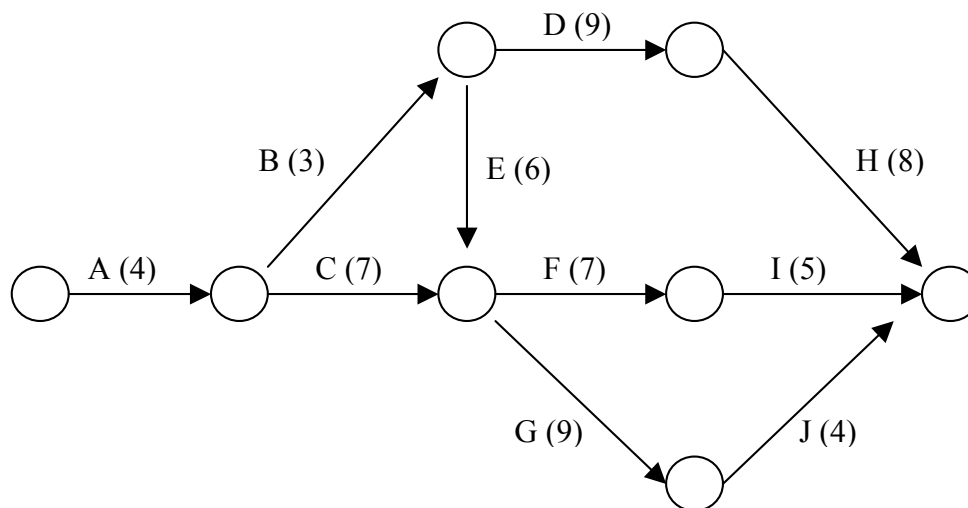
- (10 pts) Use Johnson's Rule to create a shop schedule for Rubber Cover Inc. (i.e. sequence these seven cars).
- (10 pts) Using the result from part (a), determine the completion time for each of the seven jobs (starting at zero). Construct a Gantt chart of the recommended schedule.
- (10 pts) Assuming that all the cars were ready to be worked on at time = 0 (beginning of the day), calculate the average flow-time for the sequence of jobs you determined in part (a).

Group 5 (25 points)

Following the acquisition of SLB by Moscardense, you prepared the activity-on-arc diagram for an incredibly important and urgent project (the full demolition of SLB's stadium), as illustrated by the diagram (the figures in parentheses are the activity durations in days).

Unfortunately, as happens so often lately, your boss did not find a gap in his busy schedule to get things started in time... Now the required completion date is getting closer and closer and he asks you to look for a way to reduce the duration of the project to 22 days.

Is that possible? How much will be the cost? From the project team you get the following information:



Activity	Crash Cost (per day shortened)	Possible Crash (days)
A	\$2400	2
B	\$1800	2
C	\$2200	4
D	N/a	-
E	\$900	1
F	N/a	-
G	\$2000	5
H	\$1900	2
I	N/a	-
J	\$1500	3

Show how it might be possible to complete the project in the required time and determine the total cost of crashing the schedule to 22 days. Determine the new critical path(s) for the crashed project.

Group 6 (30 points)

Carolina Timber is one of the major suppliers of timber for the furniture industry. They cut the timber in various lengths for different purposes. The following table shows measures of length (in feet) of the telephone poles taken at five different times during each day over ten days (the data collected each day constitutes one sample)

Sample	1	2	3	4	5	X-bar	R
1	30,2	30,8	30,6	30,5	30,7	30,56	0,6
2	30,9	30,7	30,8	30,9	30,8	30,82	0,2
3	30,5	30,9	31,1	31	30,9	30,88	0,6
4	30,5	30,8	30,9	31	30,8	30,8	0,5
5	31,1	30,7	30,6	30,9	31,2	30,9	0,6
6	30,7	30,8	30,9	31	31,1	30,9	0,4
7	30,5	31,1	30,7	30,8	30,7	30,76	0,6
8	30,8	30,5	30,6	30,4	30,6	30,58	0,4
9	30,4	30,5	30,7	30,9	30,7	30,64	0,5
10	30,5	30,9	30,9	30,7	31,1	30,82	0,6
Total						307,66	5

- a) (15 pts) Is the process in control?
- b) (15 pts) If specifications for telephone poles are $30.75 \pm .15$ feet, is this process producing telephone poles that fit the specs?

Operations Management

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solutions

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c) (10 pts) What are the main differences and implications of having a finite population vs. a infinite population in a waiting line model?

d) Classify the following sentences as True (T), False (F), or Undetermined (U). Briefly explain your choice (2 lines maximum). Most of grade refers to the explanation.

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a) (10 pts) In which stage do clients wait longer? How many people are waiting in each stage?

$$Wq1 = 3,45 \text{ min}; wq2 = 7,6 \text{ min} // Lq1 = 1,09; Lq = 2,4$$

b) (10 pts) How many desks would be necessary in each stage if the owner of the BeachBar does not want to lose any client to competitors?

Having in mind competitors strategy, the owner of the BeachBar has decided to analyze the incurred costs if he aggregates all the service process in only one stage. Consider that service rate is 8 people per hour. He asks to his colleague to calculate the number of workers that the bar should have (assume one worker per desk).

$$S(\text{phase1}) = 1 \text{ (equal)}; S(\text{phase}) = 2$$

c) (10 pts) If the goal of this new strategy is decrease the waiting time in line to no more than 5 minutes, how many workers should be hired? How long clients stay in the service area?

$$S=4; \text{ ws} = 8,74 \text{ min}$$

d) (10 pts) It is known that 10% of clients that are more than 9 minutes in the service area will not return to BeachBar. The cost associated with future losses is 6€/hour per client. Taking into account this what strategy would be better (between b) and c))?

$$\text{Costs b)} = 11,4\text{€}$$

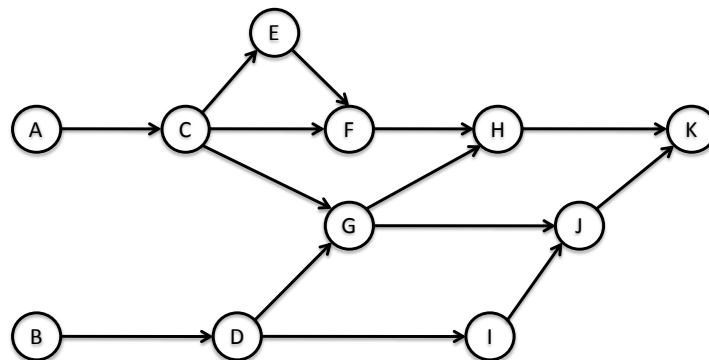
$$\text{Costs c)} = 0 \text{ (ws is lower)}$$

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Task	Time (seconds)
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C	66
D	61
E	40
F	30
G	64
H	52
I	38
J	22
K	43



The line operates five days per week, with one daily shift of seven and a half hours.

a) (7 pts) How many mid-range models must be produced per hour, to fulfill demand?

$$\text{demand} = 1350 \text{ per week}$$

$$\text{operation time} = 5 \text{ days per week} \times 7,5 \text{ hours per day} = 37,5 \text{ hours per week}$$

$$\text{production rate} = \frac{1350 \text{ per week}}{37,5 \text{ hours per week}} = 36 \text{ per hour}$$

b) (7 pts) What is the desired cycle time (in seconds)?

$$\text{cycle time} = \frac{1}{\text{production rate}} = \frac{1}{36 \text{ per hour}} = \frac{1}{0,6 \text{ per minute}} = 100 \text{ seconds}$$

c) (7 pts) Calculate the theoretical number of workstations needed.

$$N = \frac{\text{total task time}}{\text{cycle time}} = \frac{52 + 31 + 66 + 61 + 40 + 30 + 64 + 52 + 38 + 22 + 43}{100}$$

$$N = \frac{499}{100} = 4,99$$

$$N = 5$$

d) (7 pts) Balance the production line.

Station	Candidates	choice	Cumulative time (sec)	Remaining time (sec)	Idle time (sec)
1	A; B	A	52	100-52=48	-
	B; C	B	52+31=83	48-31=17	17
2	C; D	C	66	100-66=34	34
3	D; E	D	61	100-61=39	-
	E; G; I	I	61+38=99	39-38=1	1
4	E; G	G	64	100-64=36	-
	E; J	J	64+22=86	36-22=14	14
5	E	E	40	100-40=60	-
	F	F	40+30=70	60-30=30	30
6	H	H	52	100-52=48	-
	K	K	52+43=95	48-43=5	5

e) (7 pts) Calculate the efficiency for this line.

$$\text{balance delay} = \frac{\text{idle time}}{\text{time available in line}} \times 100\%$$

$$\text{balance delay} = \frac{17 + 34 + 1 + 14 + 30 + 5}{100 \times 6} \times 100\%$$

$$\text{balance delay} = \frac{101}{600} \times 100\% = 16,83\%$$

$$\text{efficiency} = 100\% - \text{balance delay}$$

$$\text{efficiency} = 100\% - 16,83\% = 83,17\%$$

Group 4 (30 points)

Rubber Cover Inc. is a tires shop located at Spain Square. Their main activity is to replace old tires and calibrate the new ones. Replacing the tires in the only available elevator is the first task where the old tires are taken off the car and the new ones are installed. The second task to be performed is to calibrate the new tires using a special machine for it. Every morning Chris, the general manager, is the first to arrive and his job is to prepare the activity for the day. This Wednesday morning he has seven cars to change tires and the time in minutes needed for each one is described on the table below (the time needed for each car depends on the size of the car and the size of the tires). Remember that due to space restrictions when they start one of the tasks in a particular car they have to finish it before starting with another car.

Car	A	B	C	D	E	F	G
Replace	23	29	19	21	24	25	26
Calibrate	20	22	22	23	18	24	27

- a. (10 pts) Use Johnson's Rule to create a shop schedule for Rubber Cover Inc. (i.e. sequence these seven cars).

(min.)		Replace	Calibrate
2°	C	19	22
4°	D	21	23
7°	G	26	27
6°	F	25	24
5°	B	29	22
3°	A	23	20
1°	E	24	18

- b. (10 pts) Using the result from part (a), determine the completion time for each of the seven jobs (starting at zero). Construct a Gantt chart of the recommended schedule.

	Replace		Calibrate		Replace		Calibrate	
	Replace	Calibrate	Start	End	Start	End	Start	End
C	19	22	0	19	19	41		
D	21	23	19	40	41	64		
G	26	27	40	66	66	93		
F	25	24	66	91	93	117		
B	29	22	91	120	120	142		
A	23	20	120	143	143	163		
E	24	18	143	167	167	185		

Replace Calibrate	C	D	G	F	B	A	E			
	C		D	G		F	B	A	E	
0	20	40	60	80	100	120	140	160	180	200

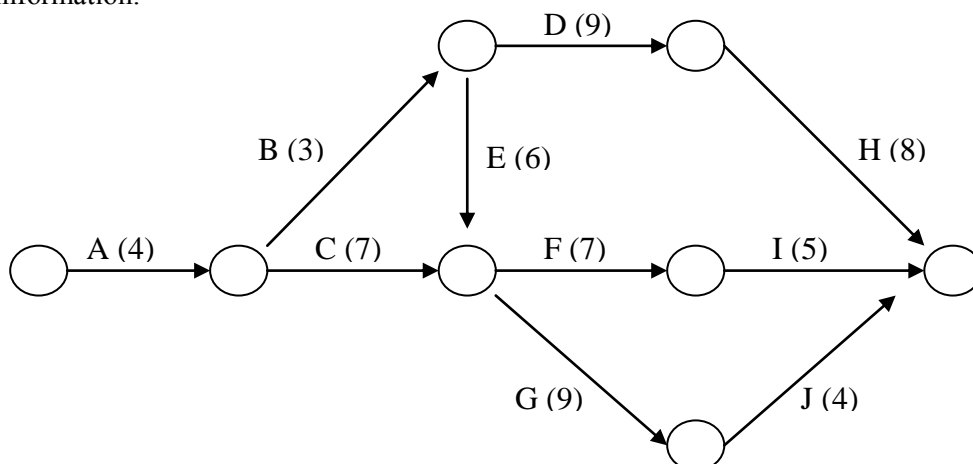
- c. (10 pts) Assuming that all the cars were ready to be worked on at time = 0 (beginning of the day), calculate the average flow-time for the sequence of jobs you determined in part (a).
 $(41 + 64 + 93 + 117 + 142 + 163 + 185) / 7 = 115 \text{ min.}$

Group 5 (25 points)

Following the acquisition of SLB by Moscardidense, you prepared the activity-on-arc diagram for an incredibly important and urgent project (the full demolition of SLB's stadium), as illustrated by the diagram (the figures in parentheses are the activity durations in days).

Unfortunately, as happens so often lately, your boss did not find a gap in his busy schedule to get things started in time... Now the required completion date is getting closer and closer and he asks you to look for a way to reduce the duration of the project to 22 days.

Is that possible? How much will be the cost? From the project team you get the following information:



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G	\$2000	5
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J	\$1500	3

Show how it might be possible to complete the project in the required time and determine the total cost of crashing the schedule to 22 days. Determine the new critical path(s) for the crashed project.

Optimal:

Step 1 - List all paths through the network and their lengths before crashing.

Step 2 – Crash E one week

Step 3 – Crash J one week

Step 4 – Crash B one week

Step 5 – Crash A one week

Path	1 st	2 nd (-1E)	3 rd (-1J)	4 th (-1B)	5 th (-1A)
A-B-D-H	24	24	24	23	22
A-B-E-F-I	25	24	24	23	22
A-B-E-G-J	26 (critical)	25	24	23	22
A-C-F-I	23	23	23	23	22
A-C-G-J	24	24	23	23	22

Total cost = \$900 (E) + \$1.500 (J) + \$1.800 (B) + \$2.400 (A) = \$6.600

Group 6 (30 points)

Carolina Timber is one of the major suppliers of timber for the furniture industry. They cut the timber in various lengths for different purposes. The following table shows measures of length (in feet) of the telephone poles taken at five different times during each day over ten days (the data collected each day constitutes one sample)

Sample	1	2	3	4	5	X-bar	R
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3	30,5	30,9	31,1	31	30,9	30,88	0,6
4	30,5	30,8	30,9	31	30,8	30,8	0,5
5	31,1	30,7	30,6	30,9	31,2	30,9	0,6
6	30,7	30,8	30,9	31	31,1	30,9	0,4
7	30,5	31,1	30,7	30,8	30,7	30,76	0,6
8	30,8	30,5	30,6	30,4	30,6	30,58	0,4
9	30,4	30,5	30,7	30,9	30,7	30,64	0,5
10	30,5	30,9	30,9	30,7	31,1	30,82	0,6
Total						307,66	5

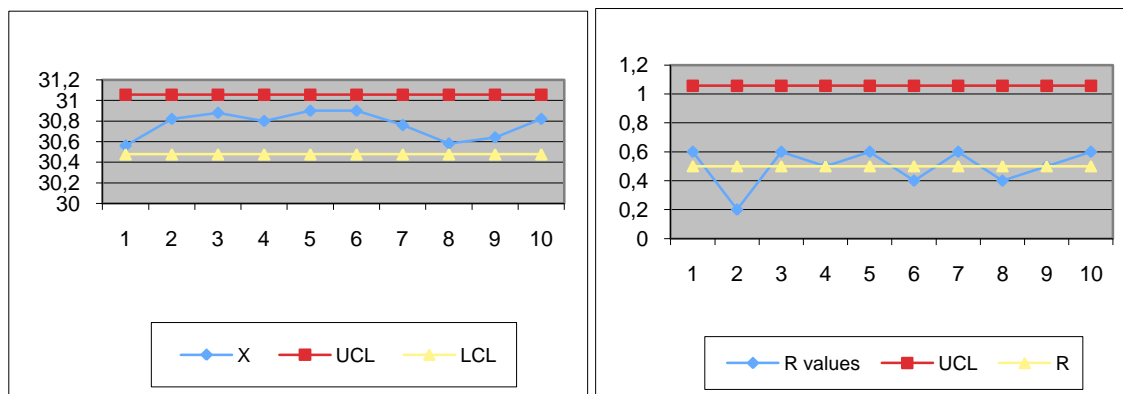
a) (15 pts) Is the process in control?

Mean \bar{X} = $307.66/10 = 30.766$, mean \bar{R} = $5.00/10 = 0.5$

From table A5 in the Appendix ($n=5$), $A_2 = .577$, $D_3 = 0$, $D_4 = 2.114$
 $A_2\bar{R} = (.577)(.5) = .2885$ $D_3\bar{R} = (0)(.5) = 0$ $D_4\bar{R} = (2.114)(.5) = 1.057$

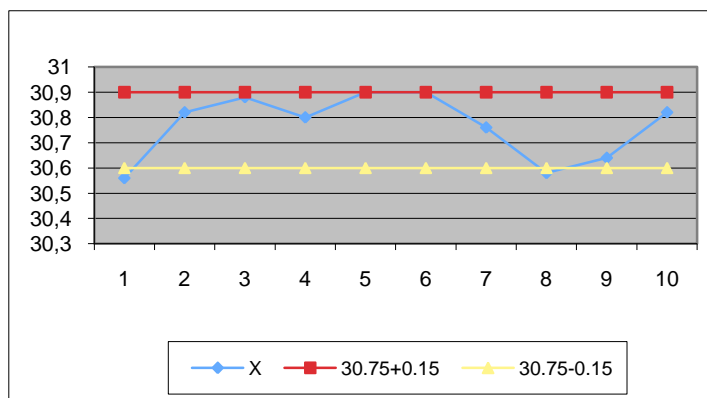
X Chart: $UCL = 30.766 + 0.2885 = 31.055$
 $LCL = 30.766 - 0.2885 = 30.478$

R Chart : $UCL = 1.057$ $LCL = 0$



b) (15 pts) If specifications for telephone poles are $30.75 \pm .15$ feet, is this process producing telephone poles that fit the specs?

No, the poles produced on the first and eight days are out of specs.



MMS table: Lq

		Number of Servers (s)									
		1	2	3	4	5	6	7	8	9	10
Utilization (ρ)	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,08	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,10	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,12	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,14	0,02	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,16	0,03	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,18	0,04	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,20	0,05	0,02	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,22	0,06	0,02	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	0,24	0,08	0,03	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,00
	0,26	0,09	0,04	0,02	0,01	0,00	0,00	0,00	0,00	0,00	0,00
	0,28	0,11	0,05	0,02	0,01	0,01	0,00	0,00	0,00	0,00	0,00
	0,30	0,13	0,06	0,03	0,02	0,01	0,00	0,00	0,00	0,00	0,00
	0,32	0,15	0,07	0,04	0,02	0,01	0,01	0,00	0,00	0,00	0,00
	0,34	0,18	0,09	0,05	0,03	0,02	0,01	0,01	0,00	0,00	0,00
	0,36	0,20	0,11	0,06	0,04	0,02	0,01	0,01	0,01	0,00	0,00
	0,38	0,23	0,13	0,08	0,05	0,03	0,02	0,01	0,01	0,01	0,00
	0,40	0,27	0,15	0,09	0,06	0,04	0,03	0,02	0,01	0,01	0,01
	0,42	0,30	0,18	0,11	0,08	0,05	0,04	0,02	0,02	0,01	0,01
	0,44	0,35	0,21	0,14	0,09	0,07	0,05	0,03	0,02	0,02	0,01
	0,46	0,39	0,25	0,17	0,12	0,08	0,06	0,04	0,03	0,02	0,02
	0,48	0,44	0,29	0,20	0,14	0,10	0,08	0,06	0,04	0,03	0,03
	0,50	0,50	0,33	0,24	0,17	0,13	0,10	0,08	0,06	0,05	0,04
	0,52	0,56	0,39	0,28	0,21	0,16	0,13	0,10	0,08	0,06	0,05
	0,54	0,63	0,44	0,33	0,25	0,20	0,16	0,12	0,10	0,08	0,07
	0,56	0,71	0,51	0,39	0,30	0,24	0,19	0,16	0,13	0,11	0,09
	0,58	0,80	0,59	0,46	0,36	0,29	0,24	0,20	0,17	0,14	0,12
	0,60	0,90	0,68	0,53	0,43	0,35	0,29	0,25	0,21	0,18	0,15
	0,62	1,01	0,77	0,62	0,51	0,43	0,36	0,31	0,26	0,23	0,20
	0,64	1,14	0,89	0,72	0,61	0,51	0,44	0,38	0,33	0,29	0,25
	0,66	1,28	1,02	0,84	0,72	0,62	0,53	0,47	0,41	0,36	0,32
	0,68	1,45	1,17	0,98	0,85	0,74	0,65	0,57	0,51	0,46	0,41
	0,70	1,63	1,35	1,15	1,00	0,88	0,78	0,70	0,63	0,57	0,52
	0,72	1,85	1,55	1,34	1,18	1,06	0,95	0,86	0,78	0,71	0,65
	0,74	2,11	1,79	1,57	1,40	1,26	1,15	1,05	0,96	0,89	0,82
	0,76	2,41	2,08	1,85	1,67	1,52	1,39	1,29	1,19	1,11	1,03
	0,78	2,77	2,42	2,18	1,99	1,83	1,70	1,58	1,47	1,38	1,30
	0,80	3,20	2,84	2,59	2,39	2,22	2,07	1,94	1,83	1,73	1,64
	0,82	3,74	3,37	3,10	2,88	2,70	2,55	2,41	2,29	2,18	2,07
	0,84	4,41	4,03	3,75	3,52	3,33	3,16	3,01	2,88	2,76	2,65
	0,86	5,28	4,89	4,59	4,35	4,15	3,97	3,81	3,67	3,54	3,42
	0,88	6,45	6,04	5,73	5,48	5,27	5,08	4,91	4,75	4,61	4,48
	0,90	8,10	7,67	7,35	7,09	6,86	6,66	6,48	6,31	6,16	6,02