SIMULATION EXERCISES

1. A telesales person has the historical sales record shown below. If the phone is answered by the lady of the house, there is a 15% chance of making a sale. If the sales person convinces the lady to purchase 1 or more subscriptions, the relative frequency distribution for the number of subscriptions ordered is as follows:-

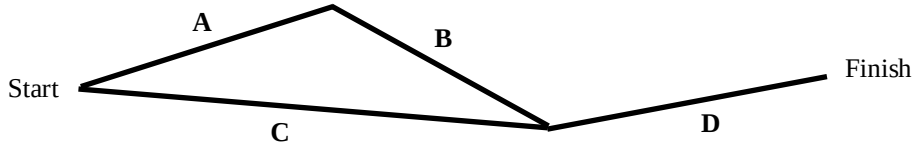
No. of Subscriptions	Relative Frequency
1	0.60
2	0.30
3	0.10

On the other hand if the man of the house answers the phone, the salesperson's chance of making a sale is 25%. In addition the relative frequency distribution for the number of subscriptions ordered is as follows:-

No. of Subscriptions	Relative Frequency
1	0.10
2	0.40
3	0.30
4	0.20

The salesperson has found that no one answers the phone on 30% of the calls he makes. However, when the phone is answered 80% are women and 20% are men. The salesperson's profit is £2.00 of each subscription sold. Using the random number table provided starting at the top line 96, 64, 53 and working across, perform the simulation of 25 calls as suggested by the full decision tree (see below) i.e. generating a simulated outcome at each chance node.

2. A project has four activities A, B, C & D that must be completed as shown in the network below (e.g. D cannot start until B and C are completed). The probability distribution for the time required to complete each of the activities is shown in the table below.



Activity	**Activity Time** *Weeks*	**Probability**
A	1	0.2
	2	0.4
	3	0.4
B	3	0.20
	4	0.45
	5	0.20
	6	0.15
C	5	0.3
	6	0.3
	7	0.3
	8	0.1
D	4	0.1
	5	0.8
	6	0.1

i) Simulate 10 completions of the project using the random number table provided starting with the top line 96, 64, 53 etc.

ii) Draw a sketch to summarise the resulting project completion times.

iii) Describe briefly the relative benefits and drawbacks of simulation in contrast to analytical (mathematical) methods in tackling this problem.

3. A major pharmaceutical company is considering the revenue generation potential of its portfolio of drugs currently going through the research and development process. The furthest advanced drug, *Preparation X*, is undergoing efficacy and safety trials on humans under controlled medical conditions. This phase will be complete in one month from now and the company's experts estimate that there is a 70% chance that *Preparation X* will pass. If it passes, the next set of trials involves efficacy and safety trials under actual conditions of use. Historically, drugs reaching this phase have a 90% chance of passing, and this phase takes from nine months to one year with a uniform probability of any of these times. The next step for successful drugs is a formal application to the licensing authorities. This typically takes between six and nine months with a uniform probability of any of these times. One receipt of the application, the licensing authorities perform an evaluation based on the pre-clinical and clinical data. All drugs of this type receive licences, but this can take from 15 to 21 months, with 18 months being a typical period. From previous experience and knowledge of the product, the company's experts have sketched a probability distribution of how long they expect to wait for the licence:

Waiting Period (months)	**Probability**
15	5%
16	10%
17	20%
18	30%
19	20%
20	10%
21	5%

On receiving the licence *Preparation X* will reach the market after one month. A further uncertainty is the level of competition. Company experts assess the likelihood of different numbers of direct competitors to *Preparation X* to be: no competitors 20%, one competitor 40%, two competitors 30%, three competitors 10%. The total market is expected to be worth £10 million per year, and the working assumption is that all competing products will have equal market shares.

Simulate 15 sets of possible outcomes of the drug's journey to market and use your results to calculate a 95% confidence interval for the expected total revenue which will have been generated by this new drug in five years from now. (Ignore adjustments such as net present value, NPV.)

Remember the 95% confidence interval is: $\mu \approx \overline{X} \pm 1.96 \times \frac{s}{\sqrt{n}}$

If the company wishes to conduct a risk analysis to compare the prospects of each potential product in its R&D portfolio, describe briefly how this type of simulation approach might be used.

4. The personnel manager of a large organisation wishes to interview all employees at a particular site, and is wondering how best to schedule the interviews. She schedules 50 interviews over a two-day period to occur at 15 minute intervals, and gets her secretary to keep careful records of interview times and arrival patterns.

The results were as follows:-

Duration of interview (minutes)	**Number of interviews**
13	4
14	7
15	11
16	15
17	9
18	3
19	1

Only 20 interviewees arrived on time. 10 were one minute early, 6 were two minutes early, 8 were one minute late and 6 were two minutes late.

a) Discuss briefly the appropriateness or otherwise of applying conventional queuing theory to this single server situation.

(10% of this question)

b) Use these data as the basis of a simulation to determine whether a 15-minute interview schedule is adequate. You may assume that if both the interviewer and an interviewee are available the interview will start even if this is before the scheduled start time. (Simulate over a 3½ hour interview session and use the random numbers provided starting with the top row, i.e. 96 64 53 5 91 3 61 etc.)

(60% of this question)

c) Describe briefly how you would go about using this type of analysis to provide the manager with a recommended policy, and what issues should be considered.

(30% of this question)

RANDOM NUMBER TABLE

96	64	53	5	91
32	76	39	72	15
64	8	72	98	64
46	87	59	62	95
35	47	4	48	62

3	61	4	21	36
56	24	40	37	13
35	16	91	11	19
67	41	37	96	87
86	9	60	50	47

84	63	67	23	49
79	99	82	3	35
85	8	85	20	12
7	67	33	3	85
51	59	80	85	63

90	11	18	91	92
58	31	82	22	22
53	70	90	25	37
57	84	71	7	16
50	31	56	74	41

86	17	18	35	25
57	30	3	6	38
3	18	66	41	58
80	10	13	21	40
46	39	53	29	43

24	23	42	31	32
9	91	62	93	71
75	19	4	93	96
51	13	9	87	39
71	79	75	31	31

24	65	84	97	49
31	68	1	72	52
80	48	87	38	78
76	86	99	29	32
25	63	92	75	21

14	65	80	32	92
29	44	69	87	51
77	23	57	45	0
41	58	76	14	20
0	6	56	98	92

56	35	89	45	20
65	30	29	51	29
32	55	79	27	25
11	42	44	55	66
60	20	32	16	8

65	24	66	82	3
63	53	3	96	86
99	73	67	29	12
1	91	39	37	12
2	12	2	78	17

34	61	23	7	51
9	61	49	55	28
56	44	24	54	58
82	92	6	31	48
92	86	52	22	4

35	23	30	6	97
30	67	26	40	16
64	91	78	10	32
18	53	16	22	24
74	10	71	80	74

34	24	49	92	5
90	81	0	63	16
84	26	92	12	97
71	87	31	18	2
9	99	24	64	89

33	44	33	6	58
27	90	18	78	67
11	59	35	50	74
21	57	68	80	12
85	90	95	22	11

94	5	16	54	33
92	34	55	60	40
96	51	27	70	32
7	41	86	18	15
35	81	89	33	95

14	16	76	92	64
18	30	60	63	75
67	6	56	0	87
43	2	95	10	82
28	73	6	98	43

53	89	77	30	13
61	91	96	0	33
88	36	87	51	1
91	54	57	68	77
25	78	11	30	16

35	36	0	33	2
4	84	62	69	18
20	58	64	87	88
17	91	88	43	45
26	92	13	93	19

87	54	92	46	79
65	43	54	91	72
79	26	27	95	81
34	87	69	94	13
36	6	36	15	73

2	75	24	71	49
47	65	77	36	81
44	1	99	97	22
74	36	19	61	52
19	27	69	36	54

46	38	56	19	74
12	65	99	16	7
78	91	45	3	73
1	48	1	60	26
36	66	73	69	23

77	64	20	94	42
2	15	94	1	46
31	50	11	71	60
97	77	57	61	17
31	1	10	26	48

91	65	87	92	68
6	44	73	55	4
88	26	55	35	88
41	90	87	65	24
73	19	25	75	21

58	32	81	27	6
76	5	84	39	93
51	4	13	81	94
65	84	96	57	90
1	4	65	74	63

42	75	67	12	21
71	10	90	69	74
84	99	47	21	42
33	74	46	51	78
77	68	92	39	39

63	28	54	22	85
26	66	66	6	57
50	18	32	34	97
66	94	31	63	36
6	97	44	48	5

90	94	27	96	83
98	95	48	59	18
2	5	43	96	31
12	3	70	38	29
30	74	86	17	18

38	17	52	39	95
59	79	87	57	66
44	50	3	36	58
74	81	31	79	51
33	34	99	95	29

72	10	91	66	83
72	32	50	14	63
36	65	74	64	39
20	40	72	97	64
79	90	48	95	97

2	36	53	47	34
84	16	40	14	58
84	44	84	7	4
32	24	67	82	5
60	64	70	93	4

64	95	46	63	5
21	50	6	9	95
6	20	22	83	94
26	85	52	20	10
87	27	51	48	48

98	61	43	90	69
54	20	92	68	56
80	67	76	39	70
59	58	29	7	93
70	48	80	78	4