THE UNIVERSITY OF MELBOURNE

Semester / Year: Semester 1 2020

Faculty / Dept: Management and Marketing

Subject Code: MGMT90141

Subject Name: Business Analysis and Decision Making

Writing Time: 3 hrs

Number of Pages (including this page): 13

Instructions to Students:

Write down your stream onto the front page of the answer sheet(s), e.g., Angelito Mon 9am, etc.

This examination contributes 50% to the final subject mark.
This examination paper includes 2 sections.

Section 1: Contains 1 compulsory question. You are required to answer this question. This section accounts for 25 marks.

Section 2: Contains 4 selective questions. You are required to answer 3 questions. This section accounts for 75 marks.

Examination answers must be submitted in PDF file via Canvas.

SECTION 1 (compulsory)

Question 1

Established by HJ Wittner in 1912, "Wittner" is one of the oldest and most famous Australian shoe brands and is known for high quality and luxury men and women leather shoes. For the autumn/winter season of 2020, Wittner has developed new designs for high heels and flat women boots. The two major operations needed to make the boots are sewing and polishing the leather. For each pair of high heel boots, sewing takes 1 hour, polishing takes 1.5 hours and 8 ounces of leather is required. For each pair of flat boots, sewing takes 0.5 hour, polishing takes 0.8 hour and 5 ounces of leather is required. The estimated profit per each pair of high heel boots and flat boots sold are $200 and $150 respectively.

Due to the Coronavirus pandemic, Wittner is behind schedule to prepare the shoes for the upcoming season across all their stores in Australia and therefore the management is deciding about whether they should have overtime sewing and polishing operations. For one of their stores in Melbourne Central, they have estimated that each hour of overtime for sewing will cost $10 and each hour of overtime for polishing will cost $30. The overtime cannot exceed 100 hours for this store. The available time for sewing and polishing are 300 hours and 120 hours, respectively. The amount of leather available is 1200 ounces. To meet customer demand for this store, Wittner has forecasted the minimum demand for high heel boots and flat boots are 60 and 50 pairs, respectively.

Wittner is aiming at **maximising its profit** from selling high heel and flat boots in their Melbourne Central store. Below is how Wittner's business analyst has solved the LP problem:

Variable Cells

Variable	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
# High Heels	60	0	?	46.6	Infinite
# Flats	144	0	?	Infinite	29.125
# Hours Overtime/Sewing	0	-10	?	10	Infinite
# Hours Overtime/Polishing	85.2	0	?	30	157.5

Constraints

Constraint	Final Value	Shadow Price	RHS Value	Allowable Increase	Allowable Decrease
Sewing Time	?	0	?	Infinite	168
Polishing Time	?	30	?	85.2	14.8
Leather Availability	?	25.2	?	92.5	470
Overtime Availability	?	0	?	Infinite	14.8
Minimum High Heels	?	-46.6	?	58.75	60
Minimum Flats	?	0	?	94	Infinite

(i) Formulate the linear programming (LP) model for Wittner.

(7 marks)

(ii) For the optimal solution, what is the cost of overtime?

(3 marks)

(iii) For the optimal solution, if Wittner decides to increase overtime for either sewing or polishing, which one should it choose? Why?

(3 marks)

(iv) For the optimal solution, if Wittner decides to increase the price of high heels by $40 (considering that all costs remain the same), how will the optimal solution and profit change?

(3 marks)

(v) Without changing the optimal solution, what is the lower bound (the minimum value) for profit?

(3 marks)

(vi) Wittner's new forecasts show the minimum demand for high heels might increase by 20%. If they take this increase into account, how much will their profit change?

(3 marks)

(vii) How will the profit change if Wittner reduces the available polishing time by 20 hours and the LP problem is still solvable?

(3 marks)

END OF SECTION 1

SECTION 2 (answer three out of four questions)

Question 2

(i) Hervis Car Rental in Austin, Texas, has 70 high-performance Shelby-H Mustangs in its rental fleet. These cars will be in greater demand than usual during the last weekend in July when the Central Texas Mustang Club holds its annual rally in Austin. At times like this, Hervis uses a revenue management system to determine the optimal number of reservations to have available for the Shelby-H cars.

Hervis has agreed to have at least 50% of its Shelby-H Mustangs available for rally attendees at a special rate. Although many of the rally attendees will request a Saturday and Sunday two-day package, some attendees may select a Saturday-only or a Sunday-only reservation. Customers not attending the rally may also request a Saturday and Sunday two-day package or make a Saturday-only or Sunday-only reservation. Thus, six types of reservations are possible. The cost for each type of reservation is shown here.

	Two-Day Package	Saturday-Only	Sunday-Only
Rally	$145	$95	$85
Regular	$170	$105	$95

The maximum anticipated demand for each type of reservation is as follows:

	Two-Day Package	Saturday-Only	Sunday-Only
Rally	25	15	20
Regular	15	25	30

Hervis Car Rental would like to determine how many Shelby-H Mustangs to make available for each type of reservation to maximise total revenue. Formulate an IP model for this revenue management application.

(14 marks)

(ii) David Brown has up to $100,000 AUD that he can invest, and he wishes to invest in the possible 12 mutual fund alternatives with the following restrictions:

For diversification, no more than $40,000 AUD can be invested in any one fund. If a fund is chosen for investment, then at least $20,000 AUD will be invested in it. No more than one of the funds can be in pure Growth funds, and at least one pure Stock fund must be selected. The total amount invested in pure Growth funds must be at least as much as the amount invested in pure Corporate Bonds and pure Government Bonds. And lastly, if David invests in any of the pure Growth funds, then he must also invest in at least one other combined type of fund alternative.

FUND ALTERNATIVES	TYPE	EXPECTED ANNUAL RETURN (%)
1	Growth	6.25
2	Growth	6.35
3	Growth & Corporate Bonds	7.55
4	Corporate Bonds	7.05
5	Corporate Bonds	8.55
6	Income	4.75
7	Income	5.55
8	Income & Stock	6.75
9	Stock	6.40
10	Stock	6.65
11	Stock & Government Bonds	6.45
12	Government Bonds	5.75

Using the following expected annual returns, formulate a mixed integer linear programming (MILP) model that will determine the investment strategy that will maximise expected annual return for David. You do not need to solve the model.

(11 marks)

Question 3

(i) Transportation, transshipment, and location-allocation problems are widely studied and applied in real-world situations. They are similar in nature. Identify both the commonalities and differences of these three optimisation problems.

(5 marks)

(ii) The distribution system for an automobile manufacturing company in the United Kingdom consists of three suppliers, two manufacturers, two warehouses, and three retailers. Supplier capacities and shipping costs per unit (in dollars) from each supplier to each manufacturer are as follows:

	Manufacturer		
Supplier	Birmingham	Liverpool	Capacity
Aberdeen	16	15	14,000
Bath	17	15	15,000
Coventry	16	17	16,000

The shipping costs per unit (in dollars) from each manufacturer to each warehouse are:

	Warehouse	
Manufacturer	Manchester	Newcastle
Birmingham	10	11
Liverpool	12	11

Customer demand and shipping costs per unit (in dollars) from each warehouse to each retailer are:

	Retailer		
Warehouse	Nottingham	Portsmouth	Sheffield
Manchester	8	7	9
Newcastle	9	6	8
Demand	10,000	25,000	10,000

Shipping costs per unit (in dollars) from each retailer to another are:

	Retailer		
Retailer	Nottingham	Portsmouth	Sheffield
Nottingham	-	1	3
Portsmouth	1	-	2
Sheffield	2	1	-

Construct a transportation table for the above four-echelon transshipment problem. Then, formulate the LP model for the problem using the approach discussed in this subject. (Hints: use S1, S2, and S3 to denote the suppliers, use M4 and M5 to denote the manufacturers, use W6 and W7 to represent warehouses, and use R8, R9, and R10 to represent the retailers.)

(12 marks)

(iii) CX Airlines wants to design a hub system in the United States. Each hub is used for connecting flights to and from cities within 1,000 miles of the hub. CX runs flights among the following cities: Atlanta, Boston, Chicago, Denver, Houston, Los Angeles, New Orleans, New York, Pittsburgh, Salt Lake City, San Francisco, and Seattle. The company wants to determine the smallest number of hubs it needs to cover all these cities, where a city is covered if it is within 1,000 miles of at least one hub. The table below lists which cities are within 1,000 miles of other cities. Formulate an integer programming model to find the minimum number of hub locations that can cover all cities.

Potential Hub Locations	**Cities Within 1,000 Miles**
Atlanta (AT)	AT, CH, HO, NO, NY, PI
Boston (BO)	BO, NY, PI
Chicago (CH)	AT, CH, NY, NO, PI
Denver (DE)	DE, SL
Houston (HO)	AT, HO, NO
Los Angeles (LA)	LA, SL, SF
New Orleans (NO)	AT, CH, HO, NO
New York (NY)	AT, BO, CH, NY, PI
Pittsburgh (PI)	AT, BO, CH, NY, PI
Salt Lake City (SL)	DE, LA, SL, SF, SE
San Francisco (SF)	LA, SL, SF, SE
Seattle (SE)	SL, SF, SE

(8 marks)

Question 4

Joe Whitmer is the CEO of a successful textbook publishing company called Radical Knowledge. Radical Knowledge offers print textbooks, digital textbooks, instructor supplements, online reference databases, test preparation materials, career assessment tools, materials for specific academic disciplines and custom solutions. Recently, Joe Whitmer received a ten-chapter manuscript for a new textbook that will be used by Australian higher education students. The editor of the higher education division at Radical Knowledge is familiar with the manuscript. He forecasts that if the textbook is successful, a profit of $750,000 will be realised. However, if the company decides to publish the textbook and it is unsuccessful, a loss of $250,000 will occur. Let s_1 = the textbook is successful, and s_2 = the textbook is unsuccessful.

Joe Whitmer ultimately has two choices, to accept the manuscript and publish the textbook or to reject it completely. Joe Whitmer hopes to maximise profits for Radical Knowledge and if he chooses to reject the manuscript, there will be no profit/loss incurred.

(i) Apply the Optimistic and Conservative approaches separately to recommend a decision strategy to Joe Whitmer. You must show all necessary workings.

(2 marks)

Joe Whitmer estimates a 0.65 probability that the textbook will be successful.

(ii) Draw a decision tree and recommend a decision to Joe Whitmer. Clearly show your calculations and provide justification for your decision strategy.

(4 marks)

Before making the decision to accept or reject the manuscript, Joe Whitmer is considering doing an in-house marketing research assessment by sending the manuscript for further review to the marketing department. The marketing team will review the ten-chapter manuscript and indicate the overall chances of a favourable outcome in the market. A review process provides either a favourable (F) or unfavourable (U) evaluation of the manuscript. Some of the relevant conditional probabilities are as follows:

$$P(F|s_1) = 0.90, P(F|s_2) = 0.25$$

(iii) Apply Bayes' Theorem to compute the posterior probabilities for Joe Whitmer, for both the Favourable and Unfavourable review cases.

(4 marks)

(iv) What is Joe Whitmer's optimal decision strategy? Draw the decision tree with clear labels, show all the necessary calculations and provide justifications for your decision strategy to Joe Whitmer.

(10 marks)

(v) Construct a risk profile for the optimal decision strategy from part (iv).

(2 marks)

(vi) Calculate the expected value of sample information and interpret this value. An external marketing company is now offering a service to conduct a manuscript marketing research assessment for $10,000. Would you advise Joe Whitmer to use this external marketing company instead of the Radical Knowledge's in-house services for the marketing research assessment and why?

(3 marks)

Question 5

5.1. Multiple Regression

You did a survey for Uniqlo's Highpoint and Emporium stores involving 20 customers and want to empirically test whether marketing elements (store location and item price) and consumer characteristics (sex, age and annual income) have to do with their intent to purchase the item they were shown (Table 1). Purchase intent is expressed as: 1 Highly unlikely to buy; 2 Unlikely to buy; 3 Undecided; 4 Likely to buy; and 5 Highly likely to buy. Using 95% confidence level, you have generated a correlation matrix and a summary output from Excel using 0 for Male, 1 for Female; and 1 for Emporium, 2 for Highpoint (Table 2).

Table 1. Uniqlo Survey

Customer	Store location	Price ($)	Sex	Age	Annual income ($)	Purchase Intent
1	Emporium	65.99	Male	32	55,986	2
2	Highpoint	139.99	Male	18	56,876	2
3	Emporium	14.99	Female	32	87,014	5
4	Emporium	15	Male	29	71,196	4
5	Emporium	69.99	Male	20	51,216	1
6	Highpoint	39.99	Female	30	60,077	3
7	Emporium	19.99	Female	26	86,578	5
8	Highpoint	15	Female	24	73,456	4
9	Highpoint	89.99	Female	31	54,309	2
10	Highpoint	79.99	Male	29	69,807	3
11	Emporium	14.99	Male	34	85,486	5
12	Emporium	18.99	Male	29	84,568	5
13	Emporium	99.99	Male	24	50,978	1
14	Highpoint	129.99	Female	26	64,578	2
15	Highpoint	65.99	Male	33	33,124	3
16	Emporium	89.99	Female	30	34,342	2
17	Highpoint	15.99	Male	18	63,679	4
18	Highpoint	129.99	Female	30	49,193	2
19	Highpoint	169.99	Female	20	37,589	1
20	Emporium	14.99	Male	23	43,682	4

Table 2. Excel Data Analysis results

	Store location	*Price ($)*	*Sex*	*Age*	*Annual income ($)*	*Purchase Intent*		
Store location	1							
Price ($)	0.463782267	1						
Sex	0.301511345	0.23533014	1					
Age	-0.20290196	-0.25707591	0.140708	1				
Annual income ($)	-0.264026708	-0.586883704	0.00574	0.19821	1			
Purchase Intent	-0.2901905	-0.838909501	-0.07291	0.301761	0.746719817	1		
SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.90646548							
R Square	0.821679666							
Adjusted R Square	0.757993832							
Standard Error	0.695709951							
Observations	20							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	5	31.22382729	6.244765	12.90208	7.91645E-05			
Residual	14	6.776172708	0.484012					
Total	19	38						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.230346792	1.402170535	0.877459	0.395046	-1.777009907	4.23770349	-1.77700991	4.23770349
Store location	0.336446748	0.364717436	0.922486	0.3719	-0.445794354	1.118687851	-0.44579435	1.118687851
Price ($)	-0.018794271	0.004444565	-4.2286	0.000842	-0.028326915	-0.009261627	-0.02832691	-0.00926163
Sex	0.093312501	0.345669807	0.269947	0.791139	-0.6480755	0.834700501	-0.6480755	0.834700501
Age	0.021517137	0.033841791	0.635816	0.535153	-0.051066285	0.094100559	-0.05106629	0.094100559
Annual income ($)	3.07731E-05	1.16867E-05	2.633184	0.019664	5.70773E-06	5.58385E-05	5.70773E-06	5.58385E-05

(i) Develop an estimated regression equation that can be used to predict purchase intent given marketing elements and consumer characteristics.

(2 marks)

(ii) Disregarding all other variables, how much *Purchase Intent* rating change do you expect when the price of an item shown jumps by $60?

(2 marks)

(iii) In one sentence, what conclusion can you draw from the *Adjusted R square*?

(2 marks)

(iv) Disregarding all other variables, how would you interpret the *p-value* for the Annual Income variable particularly when a customer's annual income is higher by $40,000 than another customer?

(3 marks)

(v) What is the likelihood of a female person aged 35 with an annual income of $45,000 and shops at Highpoint to buy an item which costs $100?

(3 marks)

(vi) Interpret in one sentence the coefficient for the *Sex* variable (regardless of whether *Sex* is significant or not).

(2 marks)

(vii) Show/Calculate if there is any difference in purchase intent if a customer shops in Emporium instead of Highpoint (regardless of whether *Store Location* is significant or not).

(3 marks)

(viii) Do you suspect multicollinearity between any marketing elements and consumer characteristics? Which ones? If Yes or No, explain in one sentence why.

(2 marks)

5.2. Normal Probability Distribution

(ix) Using the Uniqlo data above, the average income and standard deviation of the male customers surveyed are $60,600 and $16,301, respectively. Assuming incomes are normally distributed, calculate the probability that their income is between $50,000 and $70,000.

(3 marks)

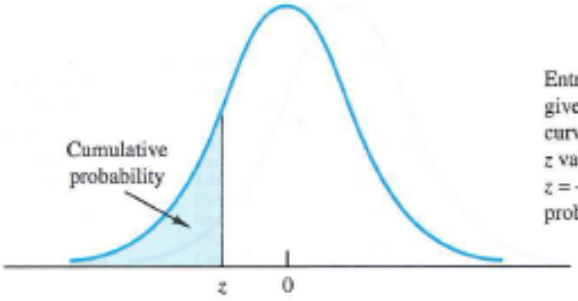
(x) How high does a male customer's income have to be to put it in the top 5%?

(3 marks)

END OF SECTION 2

Appendix 1

CUMULATIVE PROBABILITIES FOR THE STANDARD NORMAL DISTRIBUTION

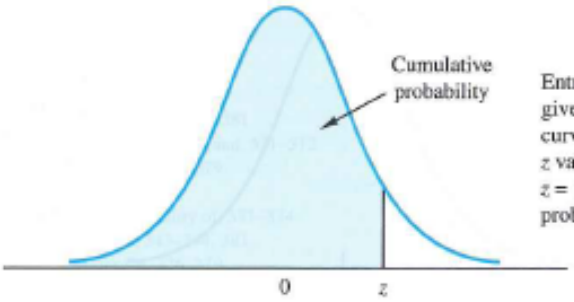


Entries in this table give the area under the curve to the left of the z value. For example, for $z = -.85$, the cumulative probability is .1977.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
−2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
−1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
−.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
−.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
−.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
−.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
−.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
−.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
−.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
−.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
−.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
−.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

Appendix 2

CUMULATIVE PROBABILITIES FOR THE STANDARD NORMAL DISTRIBUTION



Entries in the table give the area under the curve to the left of the z value. For example, for $z = 1.25$, the cumulative probability is .8944.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9913
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9986	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990

END OF EXAMINATION PAPER