THE UNIVERSITY OF MELBOURNE

Student ID _____

Semester / Year: xxx

Faculty / Dept: Management and Marketing

Subject Code: MGMT90141

Subject Name: Business Analysis and Decision Making

Writing Time: 2 hrs

Reading Time: 15 minutes

Open Book Status: No

Number of Pages (including this page): 9

Authorised Materials: Calculator

Instructions to Students:

Write down your stream onto the front page of the answer booklet(s), e.g., Tue2pm, 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.

Instructions to Invigilators:
Student may keep the paper: No
Student may annotate the paper during reading time: Yes
Paper to be held by Library: No

Extra Materials Required (please supply):
Graph paper: No Multiple Choice form: No

SECTION 1 (compulsory)

Question 1

Digital Controls, Inc. (DCI), manufactures two models of a radar gun used by police to monitor the speed of automobiles. Model A is more accurate than model B. For the next week, the company has orders for 100 units of model A and 150 units of model B. Although DCI purchases all the electronic components used in both models, the plastic cases for both models are manufactured at a DCI plant in Newark, New Jersey. Each model A case requires 4 minutes of injection-molding time and 6 minutes of assembly time. Each model B case requires 3 minutes of injection-molding time and 8 minutes of assembly time. For next week, the Newark plant has 600 minutes of injection-molding time available and 1080 minutes of assembly time available. The manufacturing cost is $10 per case for model A and $6 per case for model B. Depending upon demand and the time available at the Newark plant, DCI occasionally purchases cases for one or both models from an outside supplier in order to fill customer orders that could not be filled otherwise. The purchase cost is $14 for each model A case and $9 for each model B case. Management wants to develop a minimum cost plan that will determine how many cases of each model should be produced at the Newark plant and how many cases of each model should be purchased. (*Hint:* Let x_{11} be the number of cases of model A manufactured; x_{12} be the number of cases of model A purchased; x_{21} be the number of cases of model B manufactured; x_{22} be the number of cases of model B purchased.)

The sensitivity analysis report is shown as below.

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B9	Model A Manufactured	100	0	10	1.75	1E+30
C9	Model A Purchased	0	1.75	14	1E+30	1.75
B10	Model B Manufactured	60	0	6	3	2.333333333
C10	Model B Purchased	90	0	9	2.333333333	3

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
B16	Demand for model A LHS	100	12.25	100	11.42857143	100
B17	Demand for model B LHS	150	9	150	1E+30	90
B18	Injection molding time LHS	?	0	600	1E+30	20
B19	Assembly time LHS	?	-0.375	1080	53.33333333	480

(i) Formulate the linear programming (LP) model for the DCI. (7 marks)

(ii) For the optimal solution, how much injection-molding time is spent? (3 marks)

(iii) For the optimal solution, how much assembly time is spent? (3 marks)

(iv) Would the solution change if the injection-molding time available were only 580 minutes instead of 600 minutes? (4 marks)

(v) What would the optimal solution be if the purchase cost for each model B case were increased from $9 to $10? (4 marks)

(vi) How much would total cost increase or decrease if the assembly time available were 1100 minutes instead of 1080 minutes? (4 marks)

SECTION 2 (answer three out of four questions)

Question 2

(i) Tucker, Inc., produces high-quality suits and sport coats for men. Each suit requires 1.2 hours of cutting time and 0.7 hours of sewing time, uses 6 yards of material, and provides a profit contribution of $190. Each sport coat requires 0.8 hours of cutting time and 0.6 hours of sewing time, uses 4 yards of material, and provides a profit contribution of $150. For the coming week, 200 hours of cutting time, 180 hours of sewing time, and 1200 yards of fabric are available. Additional cutting and sewing time can be obtained by scheduling overtime for these operations. Each hour of overtime for the cutting operation increases the hourly cost by $15, and each hour of overtime for the sewing operation increases the hourly cost by $10. A maximum of 100 hours of overtime can be scheduled. Marketing requirements specify a minimum production of 100 suits and 75 sport coats.

Formulate the LP model to determine the number of suits and sport coats to be produced and the number of hours of overtime for both cutting and sewing operations to be scheduled such that the total profit is maximized.

(10 marks)

(ii) The Grand Strand Oil Company produces regular and premium gasoline for independent service stations. The Grand Strand refinery manufactures the gasoline products by blending 3 petroleum components. The gasolines are sold at different prices, and the petroleum components have different costs. Data available show that regular gasoline can be sold for $2.9 per gallon and premium gasoline for $3 per gallon. For the current production planning period, Grand Strand can obtain the 3 petroleum components at the cost per gallon and in the quantities as follows:

Petroleum component	Cost/gallon	Maximum available
1	$2.5	5,000 gallons
2	$2.6	10,000 gallons
3	$2.84	10,000 gallons

Product specifications, as shown in the following table, for the regular and premium gasolines restrict the amounts of each component that can be used in each gasoline product. Current commitments to distributors require Grand Strand to product at least 10,000 gallons of regular gasoline.

Product	Specifications
Regular gasoline	At most 30% component 1
	At least 40% component 2
	At most 20% component 3
Premium gasoline	At least 25% component 1
	At most 45% component 2
	At least 30% component 3

Formulate the LP model to determine the amount of gallons of components 1, 2, and 3 should Grand Strand mix or blend into regular and premium gasoline to reach the maximum profits.

(15 marks)

Question 3

(i) Epsilon Airlines services predominately the eastern and south-eastern United States. The vast majority of Epsilon's customers make reservations through Epsilon's website, but a small percentage of customers make reservations via phone. Epsilon employs call-center personnel to handle these reservations along with any problems with the website reservation system and for the rebooking of flights for customers if their plans change or their travel is disrupted. Having too many employees on hand is a waste of money, but having too few results in very poor customer service and the potential loss of customers. Epsilon analysts have estimated the minimum number of call-center employees needed by day of week for the upcoming vacation season. These estimates are as follows:

Day	Minimum number of employees needed
Monday	75
Tuesday	50
Wednesday	45
Thursday	60
Friday	90
Saturday	75
Sunday	45

The call-center employees work five consecutive days and then have two consecutive days off. An employee may start any day of the week. Each call-center employee receives the same salary. Assume that the schedule cycles and ignore start-up and stopping of the schedule. Formulate the LP model that will minimize the total number of call-center employees needed to meet the minimum requirements. (10 marks)

(ii) The distribution system for the Herman Company consists of three plants, two warehouses, and four customers. Plant capacities and shipping costs per unit (in $) from each plant to each warehouse are as follows:

	Warehouse		
Plant	1	2	Capacity
1	4	7	400
2	8	5	600
3	5	6	300

Customer demand and shipping costs per unit (in $) from each warehouse to each customer are as follows:

	Customer			
Warehouse	1	2	3	4
1	6	4	8	4
2	3	6	7	7
Demand	300	300	300	400

Suppose that shipments between the two warehouses are permitted at $2 per unit and that direct shipments can be made from Plant 3 to Customer 4 at a cost of $7 per unit. Construct a transportation table for the transshipment problem. Then, formulate the LP model for the problem. (Hints: use P1, P2, and P3 to denote the plants, use W4 and W5 to denote the warehouses, and use C6, C7, C8, and C9 to denote the customers.) (15 marks)

Question 4

To save on expenses, Rona and Jerry agreed to form a carpool for traveling to and from work. Rona preferred to use the somewhat longer but more consistent Queen City Avenue. Although Jerry preferred the quicker expressway, he agreed with Rona that they should take Queen City Avenue if the expressway had a traffic jam. The following payoff table provides the one-way time estimate in minutes for traveling to or from work. Based on their experience with traffic problems, Rona and Jerry agreed on a 0.15 probability that the expressway would be jammed.

	State of nature	
Decision alternative	Expressway Open	Expressway Jammed
Queen City Avenue	30	30
Expressway	25	45

(i) Determine the optimal decision for Rona and Jerry if they wish to minimize the travel time.

(2 marks)

(ii) What is the expected value of perfect information? (2 marks)

In addition, they agreed that weather seemed to affect the traffic conditions on the expressway. Let C = clear; O = overcast; R = rain. The following conditional probabilities apply.

$$P(C \mid s_1) = 0.8 \qquad P(O \mid s_1) = 0.2 \qquad P(R \mid s_1) = 0.0$$
$$P(C \mid s_2) = 0.1 \qquad P(O \mid s_2) = 0.3 \qquad P(R \mid s_2) = 0.6$$

(iii) Apply the Bayes' Theorem to compute joint probabilities and posterior probabilities.

(6 marks)

(iv) Draw a decision tree for this problem. (5 marks)

(v) What is the optimal decision strategy, and what is the expected travel time? (10 marks)

Question 5

Television viewing reached a new high when the Nielsen Company reported a mean daily viewing time of 8.35 hours per household. Use a normal probability distribution with a standard deviation of 2.5 hours to answer the following questions about daily television viewing per household.

(i) What is the probability that a household views television between 5 and 10 hours a day? (6 marks)

(ii) How many hours of television viewing must a household have in order to be in the top 3% of all television viewing households? (4 marks)

(iii) What is the probability that a household views television more than 3 hours a day? (3 marks)

Elliptical trainers are becoming one of the more popular exercise machines. Their smooth and steady low-impact motion makes them a preferred choice for individuals with knee and ankle problems. But selecting the right trainer can be a difficult process. Price and quality are two important factors in any purchase decision. Consumer Reports conducted extensive tests to develop an overall rating based on ease of use, ergonomics, construction, and exercise range. The following data show the price and rating for eight elliptical trainers tested.

Brand and Model	Price ($)	Rating
1	3700	87
2	2500	84
3	2800	82
4	1900	74
5	1000	73
6	800	69
7	1700	68
8	600	55

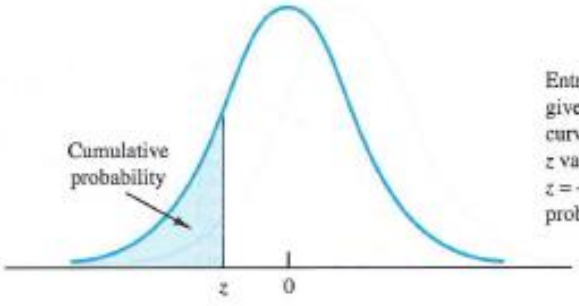
(iv) Develop an estimated regression equation that can be used to predict the rating for an elliptical trainer. (7 marks)

(v) Use the estimated regression equation to predict the rating for an elliptical trainer with a price of $1500. (1 mark)

(vi) Given that SSE = 173.88. Compute the coefficient of determination r^2 and the sample correlation coefficient r_{xy}. (4 marks)

Appendix 1

CUMULATIVE PROBABILITIES FOR THE STANDARD NORMAL DISTRIBUTION

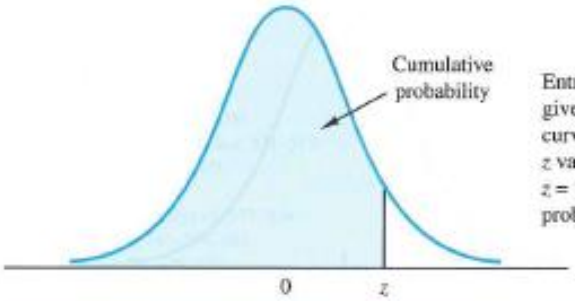


Entries in this table give the area under the curve to the left of the z value. For example, for $z = -.85$, the cumulative probability is .1977.

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

Appendix 3

1. Expected value, $EV(d_i) = \sum_{j=1}^{N} P(s_j)V_{ij}$

2. Expected value with perfect information (for maximization problems),
$$EVwPI = \sum_{j=1}^{N} P(s_j) \max_i V_{ij}$$

3. Expected value without perfect information (for maximization problems),
$$EVwoPI = \max_i [EV(d_i)] = \max_i \left[\sum_{j=1}^{N} P(s_j)V_{ij} \right]$$

4. Expected value of perfect information, $EVPI = |EVwPI - EVwoPI|$

5. Sample variance, $s^2 = \frac{\sum(x_i - \bar{x})^2}{n-1}$

6. Sample standard deviation, $s = \sqrt{s^2}$

7. Conversion from normal distribution to standard normal distribution, $z = \frac{x-\mu}{\sigma}$

8. Estimated linear regression equation, $\hat{y} = b_0 + b_1 x$

9. Slope, $b_1 = \frac{\sum_i^n (x_i - \bar{x})(y_i - \bar{y})}{\sum_i^n (x_i - \bar{x})^2}$

10. *Y*-intercept of the regression line, $b_0 = \bar{y} - b_1 \bar{x}$

11. Sum of squares due to error, SSE = $\sum(y_i - \hat{y}_i)^2$

12. Total sum of squares, SST = $\sum(y_i - \bar{y})^2$

13. Sum of squares due to regression, SSR = $\sum(\hat{y}_i - \bar{y})^2$ OR SSR = SST – SSE

14. Coefficient of determination, $r^2 = \frac{\text{SSR}}{\text{SST}}$

15. Sample correlation coefficient, $r_{xy} = (\text{sign of } b_1)\sqrt{r^2}$

END OF EXAMINATION PAPER