UNIVERSITI KUALA LUMPUR
KAMPUS CAWANGAN MALAYSIAN SPANISH INSTITUTE

FINAL EXAMINATION

OCTOBER 2025 SEMESTER

COURSE CODE	:	SFB36403 (V1)
COURSE TITLE	:	OPERATION RESEARCH
PROGRAMME NAME	:	BACHELOR OF ENGINEERING TECHNOLOGY (HONS) IN MANUFACTURING (AUTOMOTIVE)
DATE	:	31 JANUARY 2026
TIME	:	2:00PM - 5:00PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consist of ONE sections.
4. Section A consist of five questions. Answer FOUR (4) questions only.
5. Please write your answer on the answer booklet provided.
6. Please answer all questions in English only.
7. Refer to the attached Formula/ Appendies. ☑ *Tick if applicable*

THERE ARE 10 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 100 marks)

Answer FOUR (4) questions.

Please use the answer booklet provided.

Question 1

SpeedGear Auto Components Sdn. Bhd. manufactures a high-precision Gear Housing Assembly (Model GH-24) for a major automotive OEM. Due to rising competition, the OEM has requested SpeedGear to reduce 10% of the selling price next year. Before making a decision, management wants to analyze the cost–volume–profit situation. Annual fixed manufacturing and overhead costs are RM 120,000. The selling price is RM 650 per unit, and the variable cost per unit is RM 350. In the current year, the company expects to sell 1,500 desks

(a) Determine the monthly break-even volume for SpeedGear Auto Components Sdn. Bhd.

(8 marks)

(b) Graphically illustrate the break-even analysis for SpeedGear Auto Components Sdn. Bhd.

(4 marks)

(c) Determine the profit per year for SpeedGear Auto Components Sdn. Bhd.

(5 marks)

(d) If the selling price is reduced by 10%, what effect will the change have on the break-even volume?

(8 marks)

Question 2

RapidTune Auto Service Centre operates a single service bay for engine diagnostics. Customers arrive at an average of 20 per hour, and service times follow an exponential distribution with an average of two minutes, but this duration is not determined by any probability distribution, and the standard deviation is four minutes.
The manager wants to evaluate customer waiting time and queue performance. Based on this situation, calculate the numerical values of the preceding operating characteristics:
Refer Appendix Attachment - appendix 1a .

(a) Define a suitable queuing system for this situation.

(3 marks)

(b) Define the arrival rate and service rate.

(4 marks)

(c) Calculate the probability of no customer in the queuing system.

(3 marks)

(d) Calculate the average number of customers in the queuing system.

(3 marks)

(e) Calculate the average number of customers in waiting lines.

(3 marks)

(f) Calculate the average time a customer spends in the total queuing system.

(3 marks)

(g) Calculate the average time a customer spends in the waiting line.

(3 marks)

(h) Calculate the probability that the machine is busy.

(3 marks)

Question 3

Velocity AutoParts Sdn. Bhd. manufactures two critical components for electric vehicles: Battery Cooling Plates (BCP) and Motor Mount Brackets (MMB). Production of these parts requires two key resources: carbon-fibre composite sheets and precision machining hours. Due to supplier delays and machine maintenance schedules, both resources are limited for the upcoming week.

The following information is available:

1. The company has 18 kg of carbon-fibre composite and 20 hours of precision machining.
2. Producing one BCP requires 2 kg of carbon-fibre composites and 2 hours of precision machining.
3. Producing one MMB requires 3 kg of carbon-fibre composites and 2 hours of precision machining.
4. Due to existing customer contracts, there are no more than 4 BCPs that must be produced.
5. Each BCP yields a profit of RM400, while each MMB yields a profit of RM300.

The Operations Director wants to determine the most profitable production plan for the week while respecting material availability, machining capacity, and customer requirements.

(a) Summarize all the information by using a single table.

(4 marks)

(b) Formulate a linear programming model for this problem.

(6 marks)

(c) Use the graphical method to solve this model.

(15 marks)

Question 4

ElectroCore Devices Sdn. Bhd. produces high-performance microcontroller boards for consumer electronics brands. The company operates three manufacturing plants located in Penang, Johor, and Melaka. The finished boards must be delivered to two regional distribution hubs before reaching OEM customers. The number of microcontroller boards for the three plants during the next quarter is 1000, 1500, and 1200 boards. The quarterly microcontroller board demand at the two distribution centers is 2300 and 1400 boards.

Due to rising fuel costs and limited logistics budget, management requires an optimal transportation plan that minimizes monthly shipping costs. The transportation costs per board on the different routes are given in the table below.
Refer Below - Table1 : Shipping cost (RM) .

Table 1: Shipping cost (RM)

From	To	
	Hub H1 (Central Hub – Selangor)	Hub H2 (East Hub – Kuantan)
Plant P1 (Penang)	80	215
Plant P2 (Johor)	100	108
Plant P3 (Melaka)	102	68

(a) Formulate this problem as a transportation linear programming problem

(10 marks)

(b) Solve the problem of the transportation route to minimize the costs.

(12 marks)

(c) Discuss the obtained results from question (b).

(3 marks)

Question 5

PrecisionDrive Components Sdn. Bhd. has secured a contract to design a next-generation fuel injector module for a hybrid engine system. The company must complete the design project within a strict deadline to meet the prototype testing window set by the automotive OEM.

As the Project Planning Engineer, you are tasked to use the Critical Path Method (CPM) to analyze the project schedule based on the following activity data.

Refer Below - Table2 : The required activities, predecessors, and duration of completion of each activity. .

Refer Appendix Attachment - appendix 1 .

Table 2: The required activities, predecessors, and duration of completion of each activity.

Activity	Description	Predecessor	Duration (month)
A	Product design	none	5
B	Market research	none	1
C	Production analysis	A	2
D	Product model	A	3
E	Sales brochure	A	2
F	Cost analysis	C	3
G	Product testing	D	4
H	Sales training	B,E	2
I	Pricing	H	1
J	Project report	F,G,I	1

(a) Evaluate the project network and determine the expected activity time based on the critical path.

(16 marks)

(b) Construct a project Gantt chart

(5 marks)

(c) Due to the uncertain situation, process G was delayed 1 month. Discuss the impact of your project management planning.

(4 marks)

END OF EXAMINATION PAPER

APPENDIX

Appendix for Section A Question 2 : appendix 1a

1. Single Server Queuing System

Po = $(1-\lambda/\mu)$

Pn = $(\frac{\lambda}{\mu})^n$.Po

L = $\lambda / (\mu - \lambda)$

Lq = $\lambda^2 / \mu (\mu - \lambda)$

W = $1 / (\mu - \lambda)$

Wq = $\lambda / \mu (\mu - \lambda)$

U = λ/μ

2. Undefined and Constants Service Time

Po = $1 - \lambda / \mu$

Lq = $\frac{\lambda^2\sigma^2+(\frac{\lambda}{\mu})^2}{2(1-\frac{\lambda}{\mu})}$

L = Lq + (λ/μ)

Wq = Lq / λ

W = Wq + $(1/\mu)$

3. Finite Queuing Line

Po = $\frac{1-\lambda/\mu}{1-(\frac{\lambda}{\mu})^{M+1}}$

Pn = (Po)$(\frac{\lambda}{\mu})^n$; for n ≤ M

L = $\frac{(\frac{\lambda}{\mu})}{1-\lambda/\mu} - \frac{(M+1)(\frac{\lambda}{\mu})^{M+1}}{1-(\frac{\lambda}{\mu})^{M+1}}$

Lq = $L - \frac{\lambda\,(1-PM)}{\mu}$

W = $\frac{L}{\lambda(1-PM)}$

Wq = W – $1/\mu$

Appendix for Section A Question 2 : appendix 1b

4. Finite Calling Population

Po = $1 / \left(\sum_{n=0}^{N} \frac{N!}{(N-n)!} \left(\frac{\lambda}{\mu}\right)^n\right)$; where N = population size

Pn = $\frac{N!}{(N-n)!} \left(\frac{\lambda}{\mu}\right)^n . Po$; where n = 1,2,...,N

Lq = $N - \left(\frac{(\lambda+\mu)}{\lambda}\right)(1-Po)$

L = $Lq + (1 - Po)$

Wq = $\frac{Lq}{(N-L)\lambda}$

W = $Wq + (1/\mu)$

5. Multiple Server Waiting Line

Po = $1 / \left[\left[\sum_{n=0}^{n=c-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n\right] + \frac{1}{c!} \left(\frac{\lambda}{\mu}\right)^c \left(\frac{c\mu}{c\mu-\lambda}\right)\right]$

Pn = $\frac{1}{c!c^{n-c}} . \left(\frac{\lambda}{\mu}\right)^n . Po$, for n > c; Pn = $\frac{1}{n} \left(\frac{\lambda}{\mu}\right)^n .Po$ for n ≤ c

L = $\frac{\lambda \ \mu \ \left(\frac{\lambda}{\mu}\right)^c}{(c-1)!(c\mu-\lambda)^2} . Po + (\lambda/\mu)$

W = L / λ

Lq = $L - (\lambda/\mu)$

Wq = $W - (1/\mu)$ = Lq / λ

Pw = $\frac{1}{c!} \left(\frac{\lambda}{\mu}\right)^c . \frac{c\mu}{c\mu-\lambda} . Po$

Depreciation = (Purchase value – Salvage value) / n

Profit or Loss = Revenue – Total Cost

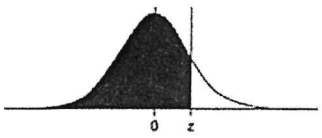
TE = $(a+4m+b) / 6$

V = $[(b-a) / 6]^2$

Z_{value} = $(D-S) / \sqrt{V}$

Appendix for Section A Question 5 : appendix 1

STANDARD NORMAL PROBABILITY TABLE



The table shows the area to the left of a z-score:

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-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
-0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
-0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
-0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
-0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
-0.5	.3085	.3050	.3015	.2s981	.2946	.2912	.2877	.2843	.2810	.2776
-0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
-0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
-0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
-0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.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	.5099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319