UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	UTILISATION OF ELECTRICAL ENERGY
COURSE CODE	:	BEF 33203
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) Utility company is essentially need to plan the electricity demand in advance for a distribution system:

(i) Define the load factor.

(1 mark)

(ii) Explain the diversity factor.

(1 mark)

(b) A medium voltage industrial consumer having the monthly electrical power consumptions data for April 2017 as shown in **Table Q1(b)(1)**.

Table Q1(b)(2) specifies the corresponds tariff rate (Tariff E2s – TNB) used to calculate the electrical bill on this premise. Assume the load factor is 70%.

(i) Calculate the monthly maximum load demand of this consumer.

(5 marks)

(ii) Analyse the average power factor and the total penalty charge due to the poor power factor.

(12 marks)

(iii) Evaluate the total monthly bill charge for this consumer.

(5 marks)

(iv) Conclude what happen to the utility bill if the power factor is less than 0.85.

(1 mark)

Q2 (a) (i) Describe the important of *X/R* ratio consideration in low voltage short circuit studies.

(1 mark)

(ii) Explain **one (1)** cause of the occurrence for the largest asymmetrical fault current.

(2 marks)

(b) A lecture hall has been installed with 60 fluorescent lamps, each with 40 Watts capacity output power (inclusive ballast consumption) using a 35 m length of 1.5 mm^2 cable. Single phase 240 V_{rms} voltage and the average power factor for this lighting system is at 0.95 lagging is used from the public low distribution system. Consider the voltage drop standard (17th Edition of IEE Wiring Regulations) such as specified in **Table Q2(b)** is generated. By referring to **Appendix A**:

(i) Calculate the voltage drop for this installation.

(5 marks)

(ii) Analyse the new cable size and voltage drop percentage to ensure voltage drop is lower than the allowable value of 3%.

(13 marks)

(c) A three phase 65 HP motor code letter K (locked-rotor kVA/ HP ratio ranging from 8.0 – 9.0) for induction motor is to be started using three- phase 415 V_{rms} supply voltage, that is taken from the panel distribution board using a 30 m length, 35 mm^2 three-core cable.

(i) Evaluate the percentage of voltage drop in the cable during the motor starting with the locked-rotor power factor is at 0.40 lagging by referring to **Appendix A**.

(3 marks)

(ii) Conclude what happen to the low voltage distribution system if the voltage drop is lower than 5%.

(1 mark)

Q3 (a) Modern loads and equipment are typically sensitive to power quality variations. Explain this statement in brief.

(1 mark)

(b) **Figure Q3(b)** depicts a simple 230 V single-phase wiring. Give respond to the following problems by referring to **Appendix B** and **Appendix C**:

(i) Determine the proper rating for the circuit breaker and cable. Justify the selection made.

(4 marks)

(ii) Demonstrate the minimum overload current in percentage of the lumped load so as to trip the circuit breaker.

(2 marks)

(c) A simplified electrical installation for a medium size industry in Parit Raja is depicted in **Figure Q3(c)**. The loads descriptions are given in **Table Q3(c)**.

(i) Analyse the total kVAr that to be supplied by Power Factor Corrector 1 (PFC 1) in order to improve the power factor of the pump system to 0.95 PF lagging.

(4 marks)

(ii) Point out the total kVAr that to be supplied by Power Factor Corrector 2 (PFC 2) in order to improve the overall power factor of the 415 V system to 0.98 PF lagging.

(8 marks)

(iii) Design the proper capacitance values for PFC 2 if the capacitors are to be arranged in both Delta (Δ) and Wye (Y) connections.

(5 marks)

(iv) Criticise your findings in **Q3(c)(iii)** in terms of costing.

(1 mark)

Q4 (a) Define the terms of Direct Contact and Indirect Contact used in electric shock. Give an example in each case.

(4 marks)

(b) Consider a production area in an electronic industry, 45 m × 25 m with the luminaires mounted at 4 m from the floor. The targeted lighting level is 1000 Lux on the working surface (assume height of desk is 0.7 m) and 200 W high pressure sodium luminaires (assume efficacy is 90 lumens/ watt) are to be used.

(i) Analyse the lighting specifications required for this application. The specifications should include the lumens produced by the light source, the targeted lumens on the working surface, and the total number of luminaires (*N*) required. Assume Maintenance Factor (MF) and Utilisation Factor (UF) are 0.8 and 0.65, respectively.

(7 marks)

(ii) The ballast circuit of the luminaire consumes additional 5% power and the industrial tariff for the entire factory is given as 22.2 sen/ kWh. Determine the total monthly electricity cost in Ringgit Malaysia (RM) for these luminaires if they are to be operated 21 hours per day. Assume 30 days per month.

(4 marks)

(iii) Investigate appropriate lighting configuration for this installation with respect to the specifications as obtained in **Q4(b)(i)**. The space to height ratio (SHR) for this configuration must not more than 0.95. Distinguish the spacing between the row, between the rows and the wall, between the columns and between the column and the wall.

(6 marks)

(iv) Construct the configuration drawing by showing all the spacing as obtained in **Q4(b)(iii)**.

(3 marks)

(v) Evaluate the space to height ratio (SHR).

(1 mark)

– END OF QUESTIONS –

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Table Q1(b)(1)

Time (Hour)	Electricity Consumption per month (kWh)	Reactive Power Consumption per month (kVArh)
0800 – 1200	45,155	75,400
1200 – 1600	48,650	60,800
1600 – 2000	70,655	78,900
2000 – 2200	48,780	55,600
2200 – 0500	27,540	40,600
0500 – 0800	59,750	65,050

Table Q1(b)(2)

(a) Tariff E2s (Special Industrial Tariff)	**Unit**	**Rates**
For each kilowatt of maximum demand per month	RM/kW	26.50
For all kWh during peak hour	Sen/kWh	28.5
For all kWh during off peak hour	Sen/kWh	15.1
The minimum monthly charge is RM600.00 Off-peak hours (10.00 p.m. to 8.00 a.m.) every day		
(b) Power Factor Penalty Rate		
Below 0.85 and up to 0.75 lagging	1.5% of the bill for that month for each one-hundredth (0.01).	
Below 0.75 lagging, in addition to the charge payable under sub-paragraph (a) above,	A supplementary charge of 3% of the bill for that month for each one-hundredth (0.01).	

Table Q2(b)

Tariff E2s – TNB		
Type of Supply	**Lighting**	**Other uses**
(i) Low voltage installation supplied directly from a public low voltage distribution system	3%	5%
(ii) Low voltage installation supplied from private LV supply	6%	8%

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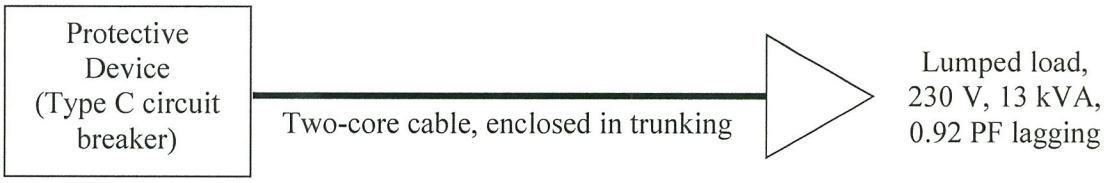

Figure Q3(b)

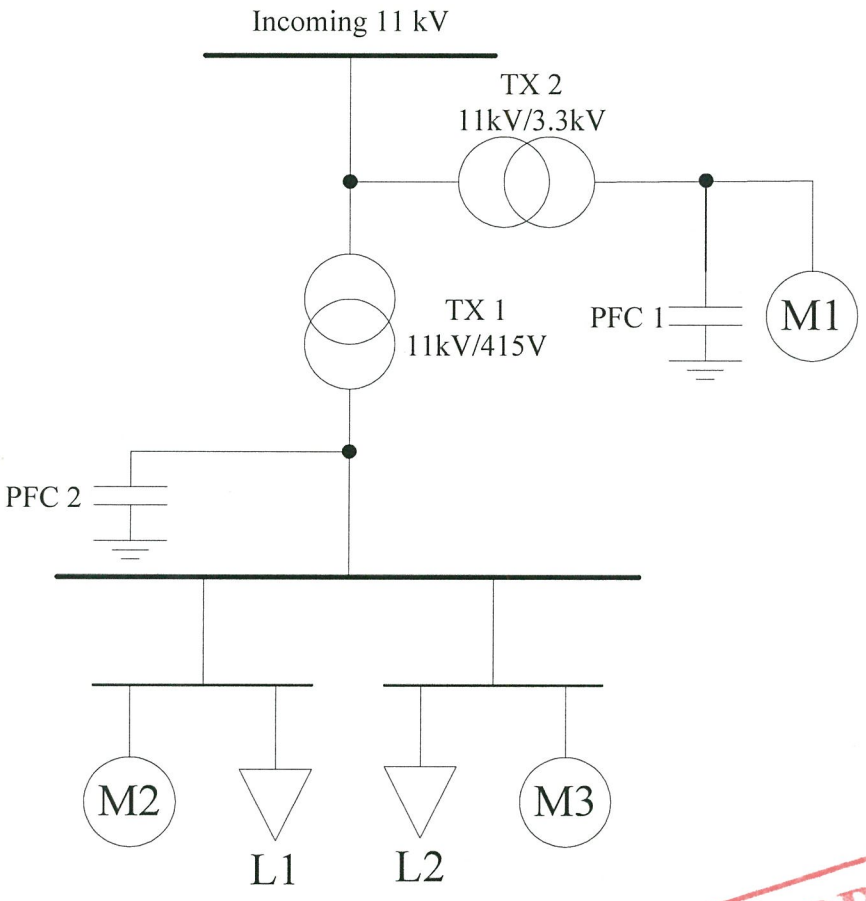

Figure Q3(c)

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Table Q3(c)

Symbol	Descriptions
M1	500 HP electric pump with 80% efficiency and operating at 0.68 PF lagging.
M2	Consists of 5 units of small 3-phase induction motor. Each one is rated at 5 HP with 70% efficiency and operating at 0.8 PF lagging.
M3	Consists of 50 units of small single-phase induction motor. Each one is rated at 0.5 HP with 88% efficiency and operating at 0.75 PF lagging.
L1	Lumped load rated at 25 kVA and operating at 0.92 PF lagging.
L2	Lumped load rated at 15 kVAr and operating at 0.75 PF lagging.

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Appendix A

Tabulated Table of Voltage Drop in mV/A/m
(Source: IEE Wiring Regulations (17th Edition, BS7671: 2008, Appendix 4, Table 4D2B)

VOLTAGE DROP (per ampere per metre) Conductor operating temperature: 70°

Conductor cross-sectional area	Two-core cable, d.c.	Two-core cable, single phase a.c.			Three- or four-core cable, three-phase a.c.		
1	2	3			4		
(mm^2)	(mV/A/m)	(mV/A/m)			(mV/A/m)		
1	44	44			38		
1.5	29	29			25		
2.5	18	18			15		
4	11	11			9.5		
6	7.3	7.3			6.4		
10	4.4	4.4			3.8		
16	2.8	2.8			2.4		
		r	x	z	r	x	z
25	1.75	1.75	0.170	1.75	1.50	0.145	1.50
35	1.25	1.25	0.165	1.25	1.10	0.145	1.10
50	0.93	0.93	0.165	0.94	0.80	0.140	0.81
70	0.63	0.63	0.160	0.65	0.55	0.140	0.57
95	0.46	0.47	0.155	0.50	0.41	0.135	0.43
120	0.36	0.38	0.155	0.41	0.33	0.135	0.35
150	0.29	0.30	0.155	0.34	0.26	0.130	0.29
185	0.23	0.25	0.150	0.29	0.21	0.130	0.25
240	0.180	0.190	0.150	0.24	0.165	0.130	0.21
300	0.145	0.155	0.145	0.21	0.135	0.130	0.185
400	0.105	0.115	0.145	0.185	0.100	0.125	0.160

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Appendix B

Protective Devices
(Source: IEE Wiring Regulations (17th Edition, BS7671: 2008)

Table 41.3 (b) Type C circuit-breakers to BS EN 60898 with U_0 of 230 V

Rating, I_n (amperes)	6	10	16	20	25	32	40	50	63	80	100	125

Table 41.4 (a) General purpose fuses to BS 88-2.2 and BS 88-6 with U_0 of 230 V

Rating (amperes)	6	10	16	20	25	32	40	50	63	80	100	125	160	200

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Appendix C

TABLE 4D2A – Multicore 70 °C thermoplastic insulated and thermoplastic sheathed cables, Non-armoured (COPPER CONDUCTORS)

Ambient temperature: 30 °C
CURRENT-CARRYING CAPACITY (amperes): Conductor operating temperature: 70 °C

Conductor cross-sectional area	Reference Method A (enlosed in conduit in thermally insulating wall etc.)		Reference Method B (enclosed in conduit on a wall or in trunking etc.)		Reference Method C (clipped directly)		Reference Method E (in free air or on a perforated cable tray etc, horizontal or vertical)	
	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.
1	2	3	4	5	6	7	8	9
(mm^2)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
1	11	10	13	11.5	15	13.5	17	14.5
1.5	14	13	16.5	15	19.5	17.5	22	18.5
2.5	18.5	17.5	23	20	27	24	30	25
4	25	23	30	27	36	32	40	34
6	32	29	38	34	46	41	51	43
10	43	39	52	46	63	57	70	60
16	57	52	69	62	85	76	94	80
25	75	68	90	80	112	96	119	101
35	92	83	111	99	138	119	148	126
50	110	99	133	118	168	144	180	153
70	139	125	168	149	213	184	232	196
95	167	150	201	179	258	223	282	238
120	192	172	232	206	299	259	328	276
150	219	196	258	225	344	299	379	319
185	248	223	294	255	392	341	434	364
240	291	261	344	297	461	403	514	430
300	334	298	394	339	530	464	593	497
400	-	-	470	402	634	557	715	597

* with or without a protective conductor