UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2012/2013

COURSE NAME	:	UTILISATION OF ELECTRICAL ENERGY
COURSE CODE	:	BEX 42803/ BEF 33203/ BEE 4213
PROGRAMME	:	BEE/ BEF
EXAMINATION DATE	:	JANUARY 2013
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) A wiring diagram is a simplified conventional pictorial representation of an electrical circuit. Describe in brief the information that is included in an electrical drawing.

(4 marks)

(b) A 100MW power station delivers 100 MW for 2 hours, 50 MW for 8 hours and it is shut down for the rest of each day. It is also shut down for maintenance for 60 days each year. Calculate its annual load factor.

(4 marks)

(c) A generating station supplies the following loads:

15,000 kW, 12,000 kW, 8,500 kW, 6,000 kW and 450 kW. The station has a maximum demand of 22,000 kW. The annual load factor of the station is 48%. Calculate:

(i) The number of unit supplied annually

(2 marks)

(ii) The diversity factor

(2 marks)

(iii) The demand factor

(2 marks)

(d) A generating station has the following daily load cycle:

Time (hours)	0 – 6	6 – 10	10 – 12	12 – 16	16 – 20	20 – 24
Load (MW)	20	25	30	25	35	20

Draw the load curve and determine:

(i) The maximum demand

(ii) The units generated per day

(iii) The average load

(iv) The load factor

(7 marks)

(e) Given the following data of a power station:

- Annual maximum demand on station 100 MW
- Maximum demand of different types of loads supplied 40 MW, 30 MW, 25 MW and 20 MW
- Average load factor of the station 50%
- Capacity of the station – two units of 50 MW each and one unit of 25 MW

Analyse:

(i) The number of units supplied annually

(2 marks)

(ii) The diversity factor

(2 marks)

Q2 (a) Explain why the X/R ratio is important in low voltage short circuit studies.

(4 marks)

(b) 60 fluorescent lamps with 40 W each (inclusive ballast consumption) is installed using 1.5 mm^2 cable with the total length of 35 meters in a lecture hall. Assume the average power factor for this lighting system is 0.95 lagging. It is supplied from a 240 V public low voltage distribution system following the voltage drop standard (17th Edition of IEE Wiring Regulations) as follows:

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%

Analyse the voltage drop for this installation. Propose a new cable size and recalculate the new voltage drop percentage if necessary.

(13 marks)

(c) A 65 HP, 415 V, code letter K (locked-rotor kVA/HP is given as 8.0 – 9.0) induction motor is to be started with full voltage supplied from a 415 V panelboard. Assume the locked-rotor power factor is 0.40 lagging. The motor is wired using a 35 mm^2 cable with the total length of 30 m from the panelboard. Calculate the percentage voltage drop in the cable during the motor starting.

(8 marks)

Q3 (a) Explain two (2) major effects of harmonics to industrial power systems.

(4 marks)

(b) A three-phase 415 V commercial installation having the total loading of (88 + j47.5) kVA with the total system impedance of 5%.

(i) Analyse the total reactive power to be supplied by a capacitor bank in order to improve the overall power factor of the system to unity power factor.

(1 mark)

(ii) If a total reactive power of 72.5 kVAr is accidentally injected into the system, evaluate the percentage of voltage rise for this system due to the severe over-correct event.

(4 marks)

(c) A 50 Hz, 415 V small-scale industrial plant having a total system impedance (Z_{sys}) of $0.003 + j2\pi f(30\mu H)$ Ohms. The power system supplies a 500 kVA harmonic-producing load that has the harmonic spectrum as given in Table Q3(c).

(i) Compute the value of the reactive power for the power factor correction capacitors that might cause parallel resonant frequency at 5^{th} order harmonic.

(3 marks)

(ii) Analyse the root of the sum of the squares (RSS) and the total harmonic distortion (THD) of the bus voltage without the power factor correction connected.

(5 marks)

(iii) Compare the root of the sum of the squares (RSS) and the total harmonic distortion (THD) of the bus voltage with the power factor correction connected.

(8 marks)

Q4 (a) Describe two (2) causes of Transient Overvoltages at Industrial Frequency (TOVIF).

(4 marks)

(b) A single phase motor circuit is protected by a 63A circuit breaker. A fault occurs and causes a current of 98 A to flow through the earth continuity path. Due to the poor contact of lock nut and bush connecting a steel conduit to a metal box, the resistance of this conduit connection alone is 0.5 Ω. Regulation D22 regarding the basic earthing requirements is given in Table Q4(b).

(i) Analyse whether the protective device will be damaged.

(ii) Calculate the amount of heat produced at the metal box.

(iii) Rate the degree of risk, if any, of a fire developing.

(4 marks)

(c) A circular exhibition hall measuring at 10 meters in diameter is to be illuminated to a level of 350 Lux. Utilisation and maintenance factors are to be taken as 0.65 and 0.85, respectively. Estimate the power required to illuminate the hall if:

(i) Using energy-saving T5 fluorescent lamp, having an efficacy of 64 lm/ W.

(3 marks)

(ii) Using LED lighting, having an efficacy of 85 lm/ W.

(3 marks)

(d) A car park is measuring at 48 m by 28 m. Illumination is to be provided by 2 X 36 W luminaires having an efficacy of 62 lm/W and a spacing-height ratio of 1.0. The luminaires are suspended 4m above the working surface. The utilisation factor is 0.7 and the light loss factor is 0.5.

(i) Recommend the number of luminaires required.

(8 marks)

(ii) Analyse the general level of illumination produced in Lux.

(3 marks)

– END OF QUESTIONS –

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TABLE Q3(c)

Frequency (Hz)	Harmonic Order	Line Current Magnitude (A)
250	5	65
350	7	40
550	11	25

TABLE Q4(b)

Regulation D22 (Basic Earthing Requirements)
States that earth leakage protection may be provided by means of fuses or excess current circuit breakers if the earth fault current available to operate the protective device and so make the faulty circuit dead exceeds: 1. 3 times the current rating of any semi enclosed fuse or any cartridge fuse having a fusing factor exceeding 1.5, used to protect the circuit, or 2. 2.4 times the rating of any cartridge fuse having a fusing factor not exceeding 1.5, used to protect the circuit, or 3. 1.5 times the tripping current of any excess current circuit breaker used to protect the circuit.

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Appendix A

Alternating-Current Resistance and Reactance for 600-Volt Cables, 3-Phase, 75°C (167°F) – Three Single Conductors in Conduit

Size (AWG or kcmil)	Ohms to Neutral per Kilometer / Ohms to Neutral per 1000 Feet														Size (AWG or kcmil)
	X_L (Reactance) for All Wires		Alternating-Current Resistance for Uncoated Copper Wires			Alternating-Current Resistance for Aluminum Wires			Effective Z at 0.85 PF for Uncoated Copper Wires			Effective Z at 0.85 PF for Aluminum Wires			
	PVC, Aluminum Conduits	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	PVC Conduit	Aluminum Conduit	Steel Conduit	
14	0.190 0.058	0.240 0.073	10.2 3.1	10.2 3.1	10.2 3.1	- -	- -	- -	8.9 2.7	8.9 2.7	8.9 2.7	- -	- -	- -	14
12	0.177 0.054	0.223 0.068	6.6 2.0	6.6 2.0	6.6 2.0	10.5 3.2	10.5 3.2	10.5 3.2	5.6 1.7	5.6 1.7	5.6 1.7	9.2 2.8	9.2 2.8	9.2 2.8	12
10	0.164 0.050	0.207 0.063	3.9 1.2	3.9 1.2	3.9 1.2	6.6 2.0	6.6 2.0	6.6 2.0	3.6 1.1	3.6 1.1	3.6 1.1	5.9 1.8	5.9 1.8	5.9 1.8	10
8	0.171 0.052	0.213 0.065	2.56 0.78	2.56 0.78	2.56 0.78	4.3 1.3	4.3 1.3	4.3 1.3	2.26 0.69	2.26 0.69	2.30 0.70	3.6 1.1	3.6 1.1	3.6 1.1	8
6	0.167 0.051	0.210 0.064	1.61 0.49	1.61 0.49	1.61 0.49	2.66 0.81	2.66 0.81	2.66 0.81	1.44 0.44	1.48 0.45	1.48 0.45	2.33 0.71	2.36 0.72	2.36 0.72	6
4	0.157 0.048	0.197 0.060	1.02 0.31	1.02 0.31	1.02 0.31	1.67 0.51	1.67 0.51	1.67 0.51	0.95 0.29	0.95 0.29	0.98 0.30	1.51 0.46	1.51 0.46	1.51 0.46	4
3	0.154 0.047	0.194 0.059	0.82 0.25	0.82 0.25	0.82 0.25	1.31 0.40	1.35 0.41	1.31 0.40	0.75 0.23	0.79 0.24	0.79 0.24	1.21 0.37	1.21 0.37	1.21 0.37	3
2	0.148 0.045	0.187 0.057	0.62 0.19	0.66 0.20	0.66 0.20	1.05 0.32	1.05 0.32	1.05 0.32	0.62 0.19	0.62 0.19	0.66 0.20	0.98 0.30	0.98 0.30	0.98 0.30	2
1	0.151 0.046	0.187 0.057	0.49 0.15	0.52 0.16	0.52 0.16	0.82 0.25	0.85 0.26	0.82 0.25	0.52 0.16	0.52 0.16	0.52 0.16	0.79 0.24	0.79 0.24	0.82 0.25	1
1/0	0.144 0.044	0.180 0.055	0.39 0.12	0.43 0.13	0.39 0.12	0.66 0.20	0.69 0.21	0.66 0.20	0.43 0.13	0.43 0.13	0.43 0.13	0.62 0.19	0.66 0.20	0.66 0.20	1/0
2/0	0.141 0.043	0.177 0.054	0.33 0.10	0.33 0.10	0.33 0.10	0.52 0.16	0.52 0.16	0.52 0.16	0.36 0.11	0.36 0.11	0.36 0.11	0.52 0.16	0.52 0.16	0.52 0.16	2/0
3/0	0.138 0.042	0.171 0.052	0.253 0.077	0.269 0.082	0.259 0.079	0.43 0.13	0.43 0.13	0.43 0.13	0.289 0.088	0.302 0.092	0.308 0.094	0.43 0.13	0.43 0.13	0.46 0.14	3/0
4/0	0.135 0.041	0.167 0.051	0.203 0.062	0.220 0.067	0.207 0.063	0.33 0.10	0.36 0.11	0.33 0.10	0.243 0.074	0.256 0.078	0.262 0.080	0.36 0.11	0.36 0.11	0.36 0.11	4/0
250	0.135 0.041	0.171 0.052	0.171 0.052	0.187 0.057	0.177 0.054	0.279 0.085	0.295 0.090	0.282 0.086	0.217 0.066	0.230 0.070	0.240 0.073	0.308 0.094	0.322 0.098	0.33 0.10	250
300	0.135 0.041	0.167 0.051	0.144 0.044	0.161 0.049	0.148 0.045	0.233 0.071	0.249 0.076	0.236 0.072	0.194 0.059	0.207 0.063	0.213 0.065	0.269 0.082	0.282 0.086	0.289 0.088	300
350	0.131 0.040	0.164 0.050	0.125 0.038	0.141 0.043	0.128 0.039	0.200 0.061	0.217 0.066	0.207 0.063	0.174 0.053	0.190 0.058	0.197 0.060	0.240 0.073	0.253 0.077	0.262 0.080	350
400	0.131 0.040	0.161 0.049	0.108 0.033	0.125 0.038	0.115 0.035	0.177 0.054	0.194 0.059	0.180 0.055	0.161 0.049	0.174 0.053	0.184 0.056	0.217 0.066	0.233 0.071	0.240 0.073	400
500	0.128 0.039	0.157 0.048	0.089 0.027	0.105 0.032	0.095 0.029	0.141 0.043	0.157 0.048	0.148 0.045	0.141 0.043	0.157 0.048	0.164 0.050	0.187 0.057	0.200 0.061	0.210 0.064	500
600	0.128 0.039	0.157 0.048	0.075 0.023	0.092 0.028	0.082 0.025	0.118 0.036	0.135 0.041	0.125 0.038	0.131 0.040	0.144 0.044	0.154 0.047	0.167 0.051	0.180 0.055	0.190 0.058	600

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Appendix B

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 C

Table of Asymmetrical Current Factors

System X/R Ratio	Instantaneous Peak Factor	Half-Cycle Factor	Time of Peak tp (ms)
0.0	1.4142	1.000	4.2
0.1	1.4142	1.000	4.4
0.2	1.4142	1.000	4.7
0.3	1.4149	1.000	4.9
0.4	1.4181	1.000	5.2
0.5	1.4250	1.000	5.4
0.6	1.4362	1.000	5.5
0.7	1.4511	1.000	5.7
0.8	1.4692	1.001	5.8
0.9	1.4897	1.002	5.9
1.0	1.5122	1.002	6.1
2.0	1.7560	1.042	6.8
3.0	1.9495	1.115	7.1
4.0	2.0892	1.191	7.4
5.0	2.1924	1.263	7.5
6.0	2.2708	1.304	7.6
7.0	2.3323	1.347	7.7
8.0	2.3817	1.381	7.8
9.0	2.4222	1.412	7.8
10.0	2.4561	1.438	7.9
20.0	2.6256	1.570	8.1
30.0	2.6890	1.618	8.2
40.0	2.7224	1.643	8.2
50.0	2.7427	1.662	8.2
100.0	2.7848	1.697	8.3
infinity	2.8284	1.732	8.3