The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Bachelor of Technology Honors in Engineering
ECX3232– Electrical Power
Final Examination -2016/2017
Duration: Three hours   Closed book

00120

Date: 29th November 2017 _____ Time: 09.30-12.30hrs

This paper contains eight (8) questions. Answer any 5 questions. All questions carry equal marks.

Q1

a) What are the merits and demerits of coal power plant when compared with natural gas power plant?

[4 Marks]

b) List the sources of renewable energy that can be used for off-grid electricity generation.   [3 Marks]

c) A load variation throughout a day of a certain consumer metered at 400/230 V nominal, 50 Hz, ac system is shown in Table Q1.

Table Q1

Time (hrs)	0000-0700	0700-1300	1300-1800	1800-2400
Total Load (kW)	30	42	44	30
Load Description	Lighting load only	Lighting load +	Lighting load +	Lighting load only
		12 kW induction motor load operating at 0.85 p.f	14 kW induction motor load operating at 0.9 p.f	

   i.   Draw the daily load curve for this consumer and determine the load factor.   [3 Marks]
   ii. What is the maximum demand?   [2 Marks]
   iii. What is the applicable tariff rate of this consumer?   [1 Marks]
   iv. Calculate the monthly electricity bill of this consumer.   [4 Marks]
   v.   Determine the size of the capacitance/phase needed to be installed between 0700-1300 hrs to improve the power factor to unity. Assume that capacitors are star connected.   [3 Marks]

   Note: A month consists of 30 days. Tariff rates offered from the utility is given in page 6.

Q2

a) What is the condition to be satisfied for maximum efficiency of transformer?   [2 Marks]

b) When performing a short circuit test for a transformer, LV windings are usually short circuited. What would be the reason?   [3 Marks]

c) Consider a 20 kVA, 2000/200 V, 50 Hz single-phase distribution transformer supplying full-load current at 0.85 power factor lagging. The open circuit (O/C) and short circuit (S/C) test results are as follows:

O/C Test: 200V, 4 A, 120 W

S/C Test: 60V, 10 A, 300 W

Determine:

i. the equivalent circuit parameters referred to HV and LV side [8 Marks]
ii. full load voltage regulation at 0.85 power factor [3 Marks]
iii. efficiency of transformer at full load at 0.85 power factor lagging [2 Marks]
iv. maximum efficiency of the transformer at above p. f. [2 Marks]

Q3

a) Explain the "armature reaction" in a DC motor, indicating few remedies to its adverse effects
[4 Marks]

b) Draw speed-torque characteristics of DC series motor. Comments on its starting torque and operation at no-load [4 Marks]

c) A 230 V DC series motor drives a load, the torque of which varies as the square of the speed. The motor takes a current of 16 A, when the speed is 600 rpm. Calculate the speed and current when the motor field winding is shunted by a divertor of the same resistance as that of field winding. Clearly state any assumptions make during calculations. [12 Marks]

Q4

a) Figure Q4-a shows torque-speed characteristic of several types of DC motors. Identify each type of motor represented by curves a, b, c and d respectively.
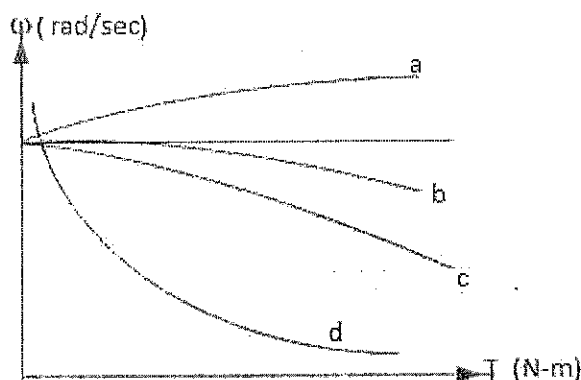

Figure Q4-a [4 Marks]

b) A 400 V DC Shunt motor while running at 1500 rpm takes an armature current of 30 A and delivers an output of 15 hp. The load torque varies as the square of speed. Calculate the value of the resistance to be connected in series with the armature for reducing the motor speed to 1300 rpm. Assume that the armature resistance of the motor is 0.4 Ω. [16 Marks]

Q5

a) Explain the working principle of a three phase induction motor. Why does an induction motor never run on synchronous speed? [6 Marks]

b) A 400 V, 4 pole, 50 Hz, three-phase star-connected induction motor has the following impedances per phase as referred to stator side:

$R_1 = 0.6$ $R_2' = 0.3$

$X_1 = 1.1$ $X_2' = 0.5$ $X_m = 25$

Mechanical losses are 1000W and stator core loss is 500 W.
For a given slip of 3%, calculate;

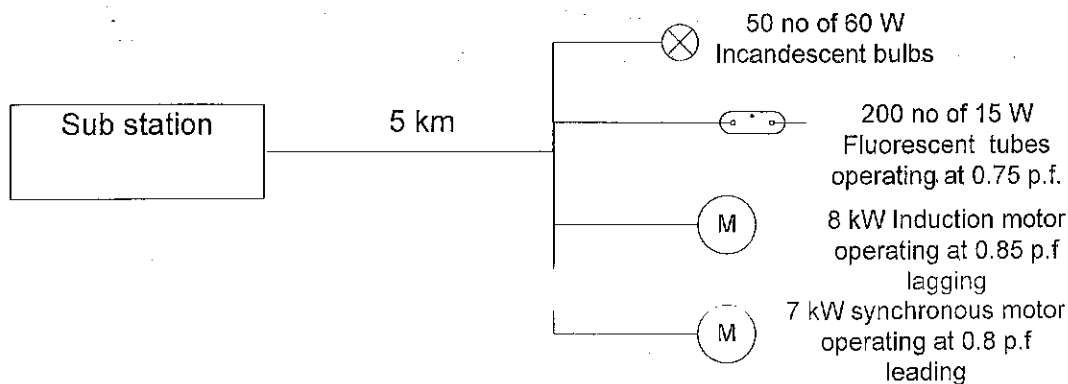|		
i.	Speed of the motor	[2 Mark s]
ii.	Stator line current and its power factor	[4 Marks]
iii.	Air gap power	[4 Marks]
iv.	Output power	[2 Marks]
v.	The overall machine efficiency	[2 Marks]

Q6

a) What are the advantages of ring main distribution system over radial system in electricity distribution network? [4 Marks]

b) Figure Q6-b explains the steps of typical electricity transmission and distribution system in Sri Lanka. Identify the voltage levels used in each step.

Generation   Transmission   Distribution

Generation   Transformer ups the voltage   Electricity transmitted nationwide at high voltage   Transformer reduces the voltage   Electricity transmitted locally at low voltage

Figure Q6-b [6 Marks]
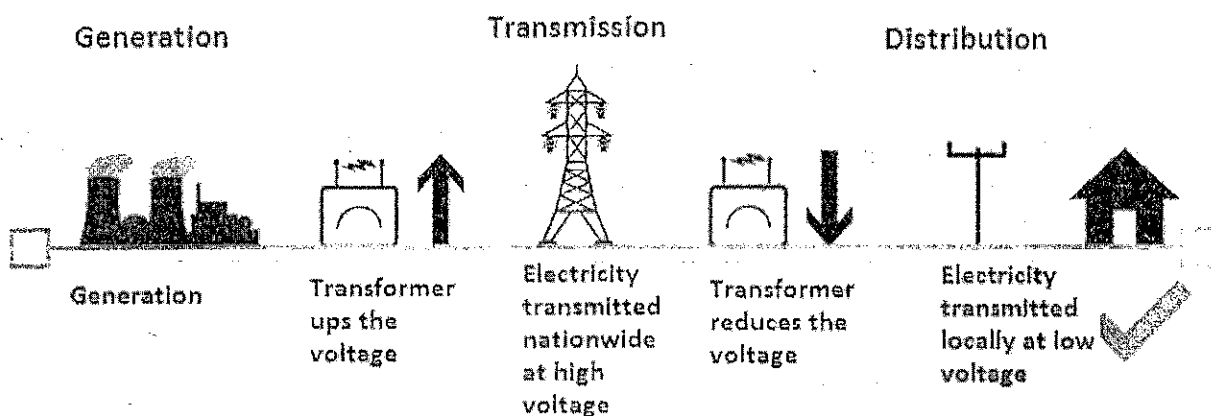
c) A 50 Hz, single phase distribution line has several loads 5 km away from the substation as shown in figure Q6-c. The transmission line has impedance of $1+ j\ 5\ \Omega$ per km. In order to maintain 400 V at the load end , Calculate

   i.   Current flowing in the distribution line
   ii. Substation voltage
   iii. Active and reactive power dissipated in the line
   iv. Active and reactive power delivered by the substation

Sub station	5 km

50 no of 60 W Incandescent bulbs

200 no of 15 W Fluorescent tubes operating at 0.75 p.f.

8 kW Induction motor operating at 0.85 p.f lagging

7 kW synchronous motor operating at 0.8 p.f leading

Figure Q6-c [10 Marks]

Q7

a) What is the purpose of following equipment used in domestic/industrial electrical installations?

- Semi-enclosed Fuse
- Receptacle
- MCB
- RCCB
- Ground wire
- Surge arrestor   [5 Marks]

b) Figure Q7-b shows the time/current zones of effects of 50 Hz current on the human body. Briefly describe the four zones of shock severity. You may use appropriate examples.
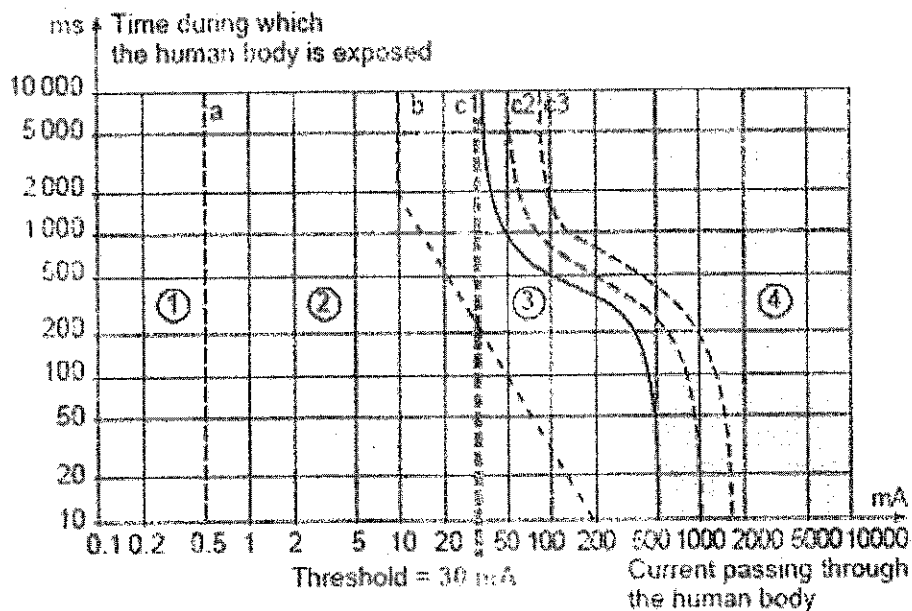

Figure Q7-b   [5 Marks]

c) What are the areas of fundamental requirement for safety as specified by the IEE wiring regulation? Briefly explain the regulations related to safety.(you have to explain at least five regulations related to this)   [5 Marks]

d) Peak electricity demand in Sri Lanka is around 2300 MW which is occurred at night time period as per the daily records in CEB (Ceylon Electricity Board). Briefly discuss the methods to reduce the peak demand.   [5 Marks]

Q8

a) What are the loads that produces harmonics in electrical power system? Explain the potential effects of harmonics in electrical distribution system.   [5 Marks]

b) Figure Q8-b shows the arrangement of a laboratory experiment and readings are given for connected motor load. Determine apparent power, power factor and reactive power of the load.

wattmeter   ammeter

240 V
RMS
60 Hz
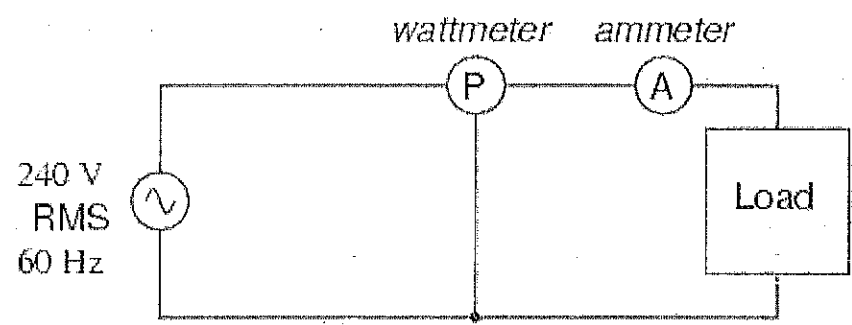
Load

Wattmeter reading = 1.5 kW
Ammeter reading = 9.6   A RMS

Figure Q8-b   [5 Marks]

c. Power factor of above motor load is corrected by using a capacitor as shown in Figure Q8-c. Determine the size of the capacitor needed to improve the power factor to unity.
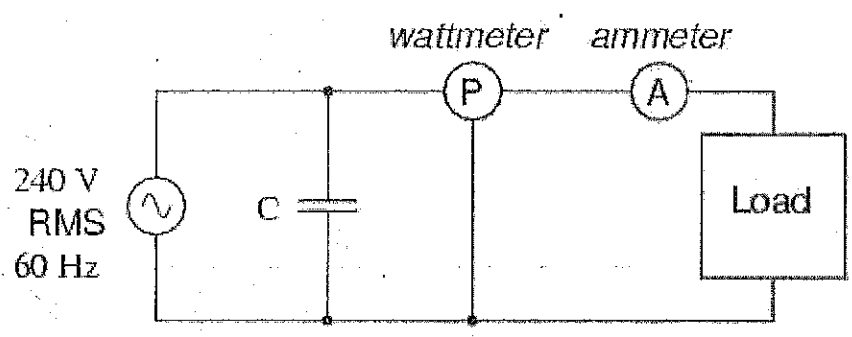

wattmeter   ammeter

240 V
RMS
60 Hz

C

Load

Figure Q8-c   [5 Marks]

d. An e.m.f represented by the equation $e = 150 \sin 314\, t + 50 \sin 942\, t$ is applied to a capacitor having a capacitance 20 μF. What would be the r.m.s value of the charging current? .   [5 Marks]

Tariff rates offered from the utility for Q#1

Customer Category I- 1

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand is less than or equal to 42 kVA.

Customer Category I- 2

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand exceeds 42 kVA.

Customer Category I-3

This rate shall apply to supplies at each individual point of supply delivered and metered at 11,000 Volt nominal and above

Customer Category	Energy charge (Rs/kWh)			Fixed Charge (Rs/ month)	Maximum Demand Charge per month (Rs/kVA)	Fuel adjustment charge (% of Energy Charge)
	Peak 1830-2230 hrs	Off-Peak 2230-0530 hrs	Day 0530-1830 hrs			
Industry						
I-1	Consumption per month (kWh) <301 - 10.80 Consumption per month (kWh) >301 - 12.20			600		15
I-2	20.50	6.85	11.00	3,000	1,100	15
I-2	23.50	5.90	10.25	3,000	1,100	15

Note: Fuel adjustments charge is applied only on monthly energy charge. It is not applied on monthly fixed charge and monthly demand charge