# UNIVERSITY OF GHANA

### BACHELOR OF SCIENCE IN ENGINEERING
### SECOND SEMESTER EXAMINATIONS: 2014/2015

### FAEN 106: APPLIED ELECTRICITY (3 Credits)

**INSTRUCTION:** *Answer any five (5) Questions of your choice*

**TIME ALLOWED:** *THREE (3) HOURS*

**Q1.** **(a)** Using waveform diagrams, briefly explain what AC and DC sources are. List four characteristics that make DC voltage and current sources different from AC voltage and current sources. [6 marks]

**(b)** Assume the voltage waveform monitored from the socket in the Level 100 lecture hall is described by the expression:

$v(t) = 220\cos(50t + 10)$.

Find the period and phase, RMS voltage, and the value of the instantaneous voltage at time $t = 50\mu s$. [5 marks]

**(c)** A microwave and refrigerator in the room of a student are connected in parallel and supplied by 220V from the socket. Suppose the total current delivered by the voltage source is 35A and the power that is dissipated by the microwave is 2000W. Sketch the circuit arrangement and find:

**(i)** the resistance of each appliance. [5 marks]

**(ii)** the amount of energy in kWh consumed if the university charged the student an amount of GHC 65.50 for the month of April. Assume the service charge per kWh is GHC 6.50 and the charge per kWh (unit) is GHC 0.15 [4 marks]

**Q2.** **(a)** What is electric shock? Assume a person picks up a bare power line which is not energized from the ground and shortly afterwards, current is introduced gradually in the line. Briefly explain the circumstances that may cause the person to stop breathing or have cardiac arrest. [4 marks]

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**(b)** Suppose a person received severe electric shock and was subjected to a current of 35mA for 10s after touching a refrigerator. Find the number of electrons that passed through the person? [4 marks]

**(c)** List four (4) factors that could possibly enhance electric shock. [2 marks]

**(d)** The diagram in figure 1 below shows a bird on an electric power line. Explain the reason why the bird will not be subjected to electric shock though it is standing on the line. Explain a scenario under which the bird can be electrocuted. [4 marks]

**(e)** Suppose a person standing on the ground touches the power line at the same point as the bird. Do you think the person will receive severe or any form of electric shock? Explain your answer. [2 marks]

**(e)** Explain two (2) scenarios from the diagram under which a person touching the power line will not be subjected to any electric shock. [4 marks]
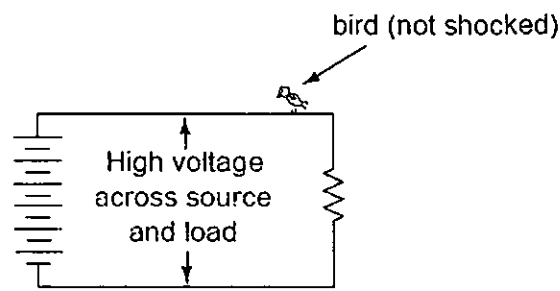
bird (not shocked)



Figure 1

**Q3.** **(a)** What is power factor? Give three (3) reasons why electric power utilities prefer to operate at unity power factor or close to unity. [4 marks]

**(b)** State two (2) major causes of low power factor in electrical systems and give two (2) reasons why power factor correction is necessary. [4 marks]

**(c)** Assume a single phase 4kW machine in the school of engineering building is supplied at a power factor of 0.76 from a 430V three-phase 50Hz voltage supply. Sketch the circuit diagram and find:

**(i)** the amount of current drawn by the machine and its resistance. [3 marks]

**(ii)** the reactive power and inductance of the machine. [4 marks]

**(iii)** the shunt capacitance required to be connected across the voltage supply to raise the power factor from 0.76 to 0.95 with the load remaining the same. Sketch the resulting circuit diagram with the capacitance. [5 marks]

**Q4.** **(a)** Give three (3) reasons why electric power utilities such as the Volta River

Authority (VRA) would prefer to transmit power from Takoradi at much higher voltages such as 161kV rather than lower voltage such as 430V. [6 marks]

(b) Give two (2) advantages that three-phase power distribution systems may have over single-phase power distribution systems. [2 marks]

(c) Suppose a food processing plant is to be located 5km away from the nearest three-phase 11kV, 50Hz voltage source of Electricity Company of Ghana (ECG). The resistance and reactance of the transmission line from the supply source are $0.5\Omega/km$ and $0.3\Omega/km$ respectively. Assume the load at the plant is 2MW and operates at a power factor of 0.95. If the sending-end voltage from the ECG source is 11kV, sketch the circuit line diagram find :

(i) the phase voltage at the source and the current in the transmission line. [4 marks]

(ii) the phase and line voltage received at the food processing plant. [4 marks]

(iii) the power loss in the transmission line. [2 marks]

(v) the efficiency of the transmission line. [2 marks]

Q5. (a) Give four sources in Ghana (2 conventional and 2 non-conventional) that could be used to generate electricity. [4 marks]

(b) List four (4) electric power companies in Ghana and briefly explain the role of each company in the supply of electricity to consumers. [4 marks]

(c) Briefly explain the electricity generation process from a thermal plant such as the VRA Takoradi plant. Use a block diagram to support your answer. [4 marks]

(d) A small lake covering an area of 200sqkm is supposed to be used to generate electricity. The head of water is 60m and the average flow rate is estimated at $30m^3/s$. If the efficiency of the penstock, turbine, and generator to be used in the generation are 100%, 70% and 60% respectively, find the total power (in KW) that can be produced from the lake. [3 marks]

(ii) What is the rating of each generator if the plant is to be equipped with three (3) generators? [2 marks]

(iii) Find the number of days it will take to sustain the level of power produced if the water level is allowed to drop by 5cm. [3 marks]

Q6. (a) Do you agree to the statement that transformers are among the most efficient electrical machines with ability to transfer over 99.5% of its input to output? Give reasons for your answer. [3 marks]

(b) List four (4) components that make up the transformer unit and four (4) ways by which transformers can be classified. [4 marks]

(c) With the support of a circuit diagram briefly explain how transformers are able to transform power from one level of voltages and currents to another. [3 marks]

(d) You have been tasked to design a power supply circuit for a pulse monitoring device using 220V/5V step-down transformer. If the primary has 2000 turns with a current of 3A, find:

(i) the rating of the transformer and the number of turns in the secondary. [3 marks]

(ii) the current in the secondary windings. [3 marks]

(iii) the copper loss in the secondary if the resistance and reactance of the winding are $0.16\Omega$ and $0.7\Omega$, respectively. [2 marks]

(iv) the efficiency of the transformer if the iron loss is 5W. [2 marks]

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