Student ID: ..... Student Signature: .....

UNIVERSITY OF GHANA

BSC ENGINEERING/SECOND SEMESTER EXAMINATIONS: 2016/2017

SCHOOL OF ENGINEERING SCIENCES

FAEN 106: APPLIED ELECTRICITY (3 CREDITS)

INSTRUCTIONS:

ANSWER ALL QUESTIONS IN SECTIONS A AND B AND THREE (3) QUESTIONS FROM SECTION C

SECTIONS A AND B ARE TO BE ANSWERED ON THE QUESTION SHEET

SECTION C SHOULD BE ANSWERED IN THE ANSWER BOOKLET PROVIDED

TIME ALLOWED: THREE (3) HOURS

SECTION A [20 MARKS]

Circle your choice of answer on the question paper.

1. In Ghana, power is transmitted at a linear frequency of 50 Hz which is equivalent to an angular frequency of
   a) 314 s^{-1}
   b) 50 s^{-1}
   c) 314 rad s^{-1}
   d) 50 rad s^{-1}
2. Electric current is simply the *rate of flow* of electric charge. Hence its unit could also be
   a) C/s
   b) J/s
   c) J/C
   d) A/s
3. To determine the *average value* of a symmetrical periodic waveform such as a sine wave, one can integrate the wave equation from:
   a) 0 to 2π
   b) $-\pi$ to π
   c) $-\pi/2$ to $3\pi/2$
   d) $-\pi$ to 0
4. The power dissipated in a 1.5-kΩ pure resistor when a voltage $v = 200 \sin \omega t$ volts is applied across it is:
   a) 300 kW
   b) 26.67 W
   c) 8.89 W
   d) 13.33 W

5. In a RLC AC circuit, *heat dissipation* occurs through
   a) Both the resistor and capacitor
   b) Both the resistor and inductor
   c) All three circuit elements
   d) Only the resistor
6. In the derivation of the root mean square (RMS) value of a sine wave, we use the mean of the squares of the values (currents or voltages) because
   a) Over one cycle the average value is zero
   b) Over one cycle, the average value is too large
   c) Over one cycle, the average value is too small
   d) Over one cycle, the average value is constant.
7. A transformer is the main reason for the use of AC for electricity transmission. This is because
   a) It has a very high efficiency and requires little or no maintenance over a long time
   b) It is a very portable device
   c) It is a purely resistive circuit
   d) None of the above
8. The wiring in houses and buildings is arranged so all electric devices are in *parallel*. In this way if you disconnect one device,
   a) The current to the others is not interrupted
   b) The current to the others is interrupted
   c) The whole circuit becomes open
   d) A short circuit is created.
9. The effective resistance of an electric circuit that has a resistor R Ω in series with 10 resistors connected in parallel each also of resistance R Ω is:
   a) 10R Ω
   b) 11R Ω
   c) 0.1R Ω
   d) 1.1R Ω
10. Assuming your ECG bill for the month of September 2016 was GH₵ 135. What is the quantity of electricity consumed for the month if ECG charges 30 pesewas/unit and the service charge is also GH₵ 15?
    a) 500 units
    b) 150 units
    c) 120 units
    d) 400 units
11. A three-phase delta connected load has 30 A of current flowing through each phase winding. How much current is flowing through each of the lines supplying power to the load?
    a) $30\sqrt{2}$ A
    b) $30\sqrt{3}$ A
    c) $30/\sqrt{3}$ A
    d) 30 A
12. A three-phase delta connected load receives power from a supply of 560 V. How much voltage is dropped across each phase?
    a) $560\sqrt{3}$ V
    b) $560/\sqrt{3}$ V
    c) 560 V
    d) $560\sqrt{2}$ V

13. A three-phase wye-connected load has a phase current of 25 A. How much current is flowing through the lines supplying the load?
    a) $25/\sqrt{3}$ A
    b) $25\sqrt{3}$ A
    c) 25 A
    d) $25\sqrt{2}$ A
14. A three-phase resistive load has a phase voltage of 240 V and a phase current of 18 A. What is the *total energy* consumed by this three-phase load in 10 h?
    a) 74.82 kWh
    b) 129.6 kWh
    c) 129600 kWh
    d) 43.2 kWh
15. An alternating current completes 4 cycles in 5 ms. What is its frequency?
    a) 20 Hz
    b) 125 Hz
    c) 800 Hz
    d) 0.02 Hz
16. In a simple *series* DC circuit, the following properties uniquely identify such a circuit.
    a) Same voltage drops across each series component but different currents
    b) Each series component has the same value of current and voltage
    c) Current is the same through each component but voltage drops are different
    d) Voltage drops are the same as the source emf for each series component
17. For a simple DC circuit in which components are all connected in *parallel*:
    a) Current through each component is the same
    b) Voltage across each component is the same as the source emf
    c) Both the current and voltage values are the same for each component
    d) None of the above
18. The impedance (Z) of a coil of resistance 4 Ω and reactance 3 Ω is:
    a) 7 Ω
    b) 25 Ω
    c) 5 Ω
    d) 1 Ω
19. In electrical measurements, the unit of *conductance* is the:
    a) Ohm
    b) Mho
    c) Farad
    d) Coulomb
20. Electric companies use a larger unit of electrical energy; the *kWh*, which is equivalent to:
    a) 36 MJ
    b) 0.36 MJ
    c) 3.6 MJ
    d) 360 MJ

SECTION B [20 MARKS]

Answer all questions in this section on the question paper by filling in the blanks.

1. In a three-phase generator, the windings (phases) are ..... degrees out of phase with each other.
2. In a single-phase power transmission, the power falls to zero ..... times during each cycle.
3. In Ghana, the *peak value* of the *rms* voltage of 240 *V* that reaches our homes is .....
4. For a purely resistive three-phase circuit, the power of the circuit is ..... $V_L * I_L$ using the parameters of line voltage and line current.
5. From **Fig. SECBQ5**, Kirchhoff's Current Law (KCL), indicates that I_2 = ...

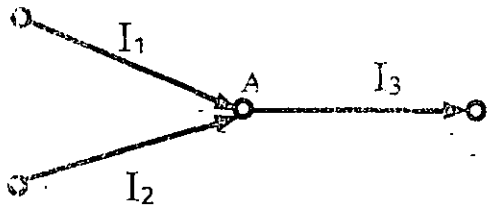

Fig. SECBQ5

6. According to KVL, in **Fig. SECBQ6**, V_{R1} = ...

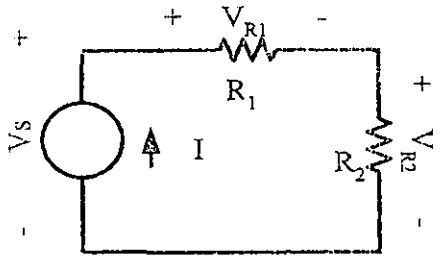

Fig. SECBQ6

7. In a circuit, an *ammeter* is connected in ..... with the circuit components.
8. In a circuit, a *voltmeter* is connected in..... across the component whose p.d. it is to measure.
9. An Ohmmeter is used to measure the value of .....
10. The value of the resistance of a certain resistor from a certain manufacturer is rated 4.7 kΩ ± 5 %. The figure ± 5 % is called the .....
11. A transformer works by the Principle of Magnetic .....
12. The transformer experiences two main kinds of losses; these are ..... and .....
13. The *effective value* of voltage or current in an AC circuit is commonly known as the ..... value.
14. The units of the *resistivity* of a wire is .....
15. A piece of wire of diameter 4mm and length 10 mm and resistance 20 Ω has resistivity .....
16. A three-phase circuit uses either ..... wires or ....., wires.
17. The *peak current* in a 1.8-kΩ resistor connected to a 120-V rms ac source is .....
18. An open circuit has an ..... resistance.

19. In a *capacitive* circuit, current .....voltage.
20. In an *inductive* circuit, current ..... voltage.

SECTION C [60 MARKS]

Answer only three (3) questions from this section.
Each question carries 20 marks.

Q1.

a) A single-phase network consists of three parallel branches, the currents in the respective branches being represented by:

$$i_1 = 20 \sin 314t \text{ amperes;}$$

$$i_2 = 30 \sin (314t - \pi/4) \text{ amperes;}$$

$$i_3 = 18 \sin (314t + \pi/2) \text{ amperes.}$$

The supply voltage for the network is also represented by 200 sin314t volts.

Calculate:

i. The **total current** in a form similar to the branch currents; [3 marks]
ii. The **impedance, resistance,** and **reactance** of the network; [3 marks]
iii. The circuit ***r.m.s.*** current and ***r.m.s.*** voltage in **polar form**; [2 marks]
iv. The **apparent power** supplied by the sources in **polar form**; [2 marks]
v. The **apparent power** supplied by the sources in **rectangular** (complex) **form**; [2 marks]
vi. The **active power** absorbed and the **power factor** of the source. [2 marks]

b) An alternating voltage v has a periodic time of 20 ms and a maximum value of 200 V. When time t = 0, $v = -75$ volts. Deduce a *sinusoidal expression* for v. If this alternating voltage feeds a $50\angle 8^0\ \Omega$ impedance load, deduce a *sinusoidal expression* for the current, i, that is also generated. [6 marks]

Q2.

a) Use a *delta-star conversion* to find the current *I* in the unbalanced bridge circuit in **Fig. Q2a** if the source voltage is *150 V*. Hence determine the *rate of heat dissipation* from the *9-Ω resistor* and also from the *entire circuit* into the surrounding environment.

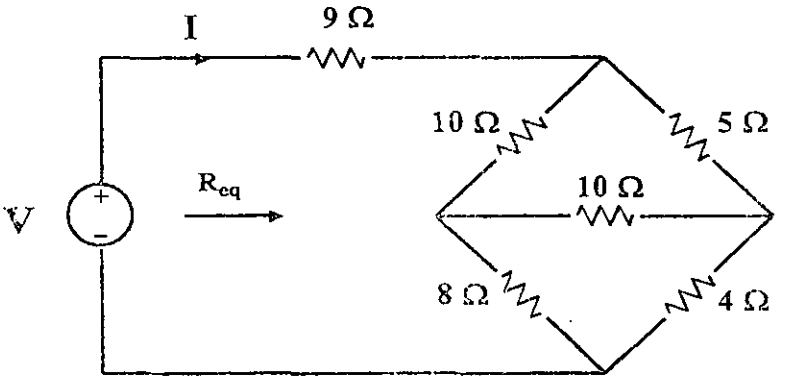

Fig. Q2a

[10 marks]

b) Determine the equivalent resistance, R_T, of the circuit of **Fig. Q2b**.

[6 marks]

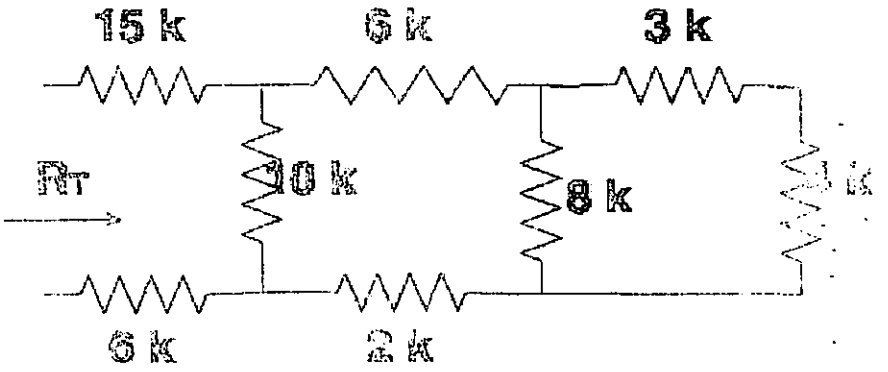

Fig. Q2b

Note the resistance values are in **kΩ**.

c) Two resistors when connected in series to a 110-V line use one fourth the power that is used when they are connected in parallel. If one resistor is 1.6 kΩ, what is the resistance of the other? [4 marks]

Q3.

a) A transformer is a magnetic circuit. Explain why this is so. [2 marks]
b) A transformer has a turns ratio of 2:7. Explain this to a layman. [2 marks]
c) State two (2) advantages and two (2) disadvantages of an auto-transformer. [4 marks]
d) A transformer has 800 primary turns and 2000 secondary turns. If the primary voltage is 160 V, determine the secondary voltage assuming an ideal transformer. [2 marks]
e) An ideal transformer connected to a 250 V mains, supplies a 25 V, 200 W lamp. Calculate the transformer turns ratio and the current taken from the supply. [4 marks]
f) A model-train transformer plugs into 120 V ac and draws 0.65 A while supplying 15 A to the train. Calculate:
   (i) the turns ratio of the transformer; [2 marks]
   (ii) the voltage present across the tracks; and [2 marks]
   (iii) the power transformed. [2 marks]

Q4.

a) What is meant by three-phase (3-Φ) electric power? [2 marks]
b) State *three advantages* of 3-Φ AC power over single-phase AC power. [3 marks]
c) Three loads, each of resistance 50 Ω are connected in *star* to a 400 *V*, 3-phase supply. Determine:
   i. The phase voltage; [1 mark]
   ii. The phase current; and [1 mark]
   iii. The line current. [1 mark]
d) Three identical coils, each of resistance 10 Ω and inductance 42 mH are connected to a 415 V, 50 Hz, 3-Φ supply for ***365 days***. Determine the *total energy* dissipated (kWh) when the coils are connected:
   i. in star; and [3 marks]
   ii. in delta. [3 marks]
e) Purely resistive loads of 24 kW, 18 kW and 12 kW are connected between the neutral and the red, yellow and blue phases *respectively* of a 3-Φ, *four-wire* system. The line voltage is 415 *V*. Calculate:
   i. The current in each line conductor (i.e., I_R, I_Y and I_B); and [3 marks]
   ii. The current in the neutral conductor. [3 marks]

Q5.

a) A motor takes a current of 10 A when supplied from a 250 V ac supply. Assuming a power factor of 0.75 lagging find the power consumed. Find also the cost of running the motor for *10 weeks* continuously if 1 kWh of electricity costs 7.20 GHp. [5 marks]

b) If four identical lamps are connected in parallel and the combined resistance is 100 Ω, find the resistance of one lamp. [2 marks]

c) The instantaneous voltage in an AC circuit at any time t seconds is given by:

$$v = 100 \sin (50\pi t - 0.523) \text{ V}.$$

Find:

i. the peak-to-peak voltage, the periodic time, the frequency and the phase angle; [2 marks]
ii. the voltage when t = 0; [1 mark]
iii. the voltage when t = 8 ms; [1 mark]
iv. the time in the first cycle when the voltage is - 40 V; and [2 marks]
v. the first time when the voltage is a maximum. [2 marks]

d) A load takes 50 kW at a power factor of 0.8 lagging. Calculate the *apparent power* and the *reactive power*. Determine the *capacitance* required to reduce the reactive power to *half of its original value* if the load is operating from a 250-V, 50-Hz supply. [5 marks]