FEDERAL UNIVERSITY OF TECHNOGY, OWERRI
SCHOOL OF SCIENCE
DEPARTMENT OF PHYSICS

2013/2014 HARMATTAN SEMESTER EXAMINATION TIME:3 HOURS

PHY 201: APPLIED ELECTRICITY 1

ANSWER ALL QUESTIONS

Surname		Reg. No.	
Other names		Department	

(1) Define potential difference between two points in a circuit. ____________________

(2) A battery pushed 240 coulombs through a circuit in 30s. calculate the current in the circuit ________

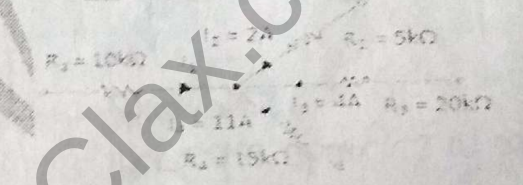
(3) Copper wires in houses typically have a diameter of about 2.5mm. How long a wire would have a 2.0Ω resistance? (Conductivity σ for Cu = $5.95\times 10^{7}(\Omega m)^{-1}$)____________

(4) What are the four colour bands of a resistor with resistance $(82\pm 8.2)k\Omega$ ____________?

(5) An electric heater draws a steady 12A on a 120V line. How much does it cost per 30 days if it operates 2.0h per day and the electric company charges ₦10.00k per kWh ____________

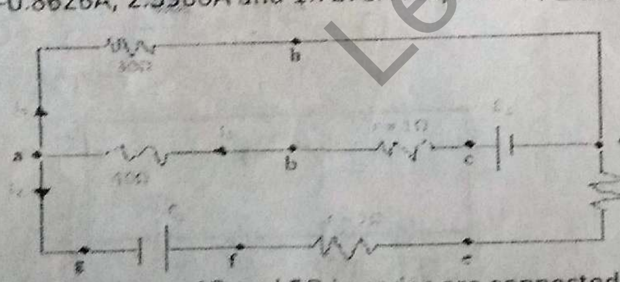
(6) Two coils which are close together have a mutual inductance of 230mH. If the emf in coil 1 is 100V, what is the rate of change of the current in coil 2 ____________

(7) Calculate the potential difference across R_1 in the circuit segment below ____________



(8) In a circuit loop containing resistance R, if the resistance is traversed in the direction of the current I, the potential drop is ____________

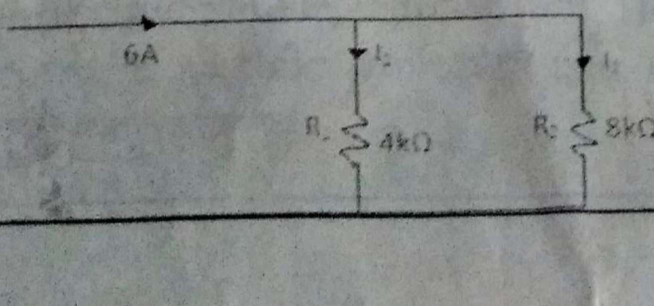
(9) Using loops ahdcba and ahdefga on the circuit below, determine the values of $\mathcal{E}_1$ and $\mathcal{E}_2$ if I_1, I_2 and I_3 are -0.8626A, 2.5960A and 1.7278A respectively ____________



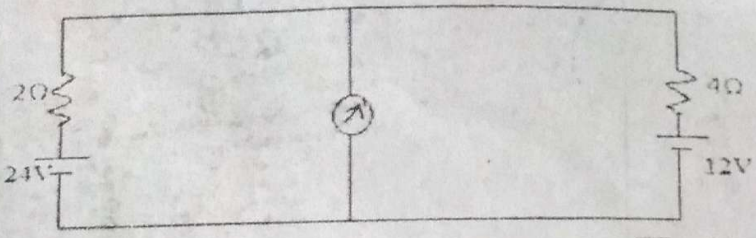
(10) Two resistors 4Ω and 5Ω in series are connected to a battery of emf 4V and internal resistance 1.0Ω. Find the current in the circuit ____________

(11) Three resistors R_1=100Ω, R_2=40Ω and R_3=60Ω are connected in series across a voltage source of 20V. What is the voltage drop across R_3 ____________

(12) Calculate I_2 from the figure below ____________



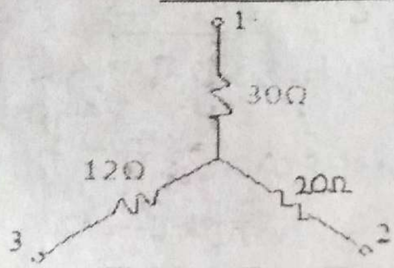
(13) Using the superposition theorem, find the current through the 2Ω resistor in the circuit below ______



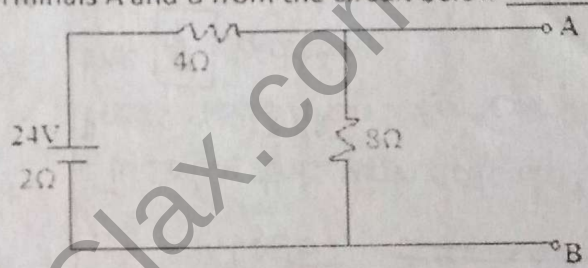
(14) When maximum power transfer is achieved, efficiency is ______

(15) In Thevenin's theorem, a dc network can be replaced by an equivalent circuit consisting of ______

(16) The three resistances 30Ω, 20Ω and 12Ω are star-connected as shown below. Convert the star connection to delta connection ______



(17) Deduce the Norton's equivalent between terminals A and B from the circuit below ______



(18) A resistive load, R_L draws the maximum power from a 24V, 4Ω voltage source. The value of this maximum power is ______

(19) Define the root mean square (rms) value of an alternating quantity ______

(20) The average value of an alternating voltage is 20V. Calculate the root mean square (rms) value of the voltage ______

(21) If the equation of an alternating voltage is given by $e = 50\sin 2\omega t$, what is the frequency ______

(22) What is the equation of a 50Hz current sine wave having an rms value of 60A ______

(23) State the difference between a leading and a lagging alternating quantity ______

(24) An alternating current is given by the expression $i(t) = 30\sin(157t+\pi/3)$, calculate the period ______

(25) An ac voltage of 50Hz frequency has a peak value of 100V. Find the average value of the voltage ______

(26) A 30μF capacitor is connected across a 400V, 50Hz supply, calculate the reactance of the capacitor ______

(27) State the condition for series resonance ______

(28) An RLC circuit consists of a resistance of 100Ω, an inductance of 1000mH and a capacitance of 100μF. If a voltage of 100V is applied across the combination, find the resonance frequency ______

(29) A resistance of 50Ω, an inductance of 0.15H and a capacitance of 100μF are connected in parallel across a 100V, 50Hz supply. Calculate the current in each branch ______

(30) A current $I = 1.8\cos 377t$ flows in a series LR circuit in which L = 3.85mH and R = 1.35kΩ. What is the average power dissipation ______

(31) When is the complex expression for impedance Z capacitive ______

(32) In a given R-L circuit, R = 35Ω and L = 1H. Find the current flowing through the series circuit at 50Hz when the voltage $V = 110 < 30^\circ$ volts is applied across the circuit ______

(33) An alternating voltage (8 +j6)V is applied to a series ac circuit and the current flowing is (2 + j5)A. Find the impedance ______

(34) If an alternating current is given as $37.74 < -32^\circ$, calculate the power factor ______

(35) Two impedances given by $Z_1 = (10 + j5)$ and $Z_2 = (8 + j6)$ are joined in parallel and across a voltage of $V = (200 + j0)$ volts. Calculate the phase of the total current ______

2013/2014 EXAM SOLUTIONS

1) The potential difference between two points in a circuit is the difference in potential energy per unit charge between the two points.

2 Given $Q = 240C, t = 30s$

$I = \frac{Q}{t} = \frac{240}{30} = \underline{8A}$

3 $\rho = \frac{RA}{L}$; $L = \frac{RA}{\rho}$

$R = 2\Omega, d = 2.5mm = 0.0025m, \rho = \frac{1}{\sigma} = \frac{1}{5.94\times10^7}$

$\therefore A = \frac{\pi d^2}{4} = \frac{\pi(0.0025)^2}{4} = 4.91\times10^{-6}m^2$

$\therefore L = \frac{2\times4.91\times10^{-6}}{(5.95\times10^7)^{-1}} = \underline{584.14m}$

4 $(82\pm8.2)K\Omega = (82\pm8.2)\times10^3\Omega$

1st digit − 8 = Grey

2nd digit − 2 = Red

Multiplier − $\times10^3$ = Orange

* Notice that 8.2 is 10% of 82, Therefore tolerance of 10% = Silver

Thus the four colours are Grey, Red, Orange, Silver

5 $I = 12A, V = 120V$;

$P = IV = 12\times120 = 1440W$

Since the heater operates at 2hrs per day for 30 days, therefore it operates for a total of

2 rs × 30days = 60hrs

Thus the total cost is

1.44kw × 60hr × ₦10/kWh = ₦864

6 $V = L\frac{di}{dt}$; $\frac{di}{dt} = \frac{V}{L}$

but $V = 100V, L = 230mH = 230\times10^{-3}H$

$\frac{dI}{dt} = \frac{100}{230\times10^{-3}} = \underline{434.78A/s}$

7) From KCL, $I_4 = I_1 + I_2 + I_3$

but $I_1 = I_4 - (I_2 + I_3)$

$= 11 - (2+4) = 5A$

$V_1 = I_1R_1 = 5\times10K\Omega = \underline{50KV}$

8) $-IR$

9) From loop ahdcba,

$-30I_1 + \mathcal{E}_2 - I_3 - 40I_3 = 0$

$\mathcal{E}_2 = 30I_1 + 41I_3$

$\mathcal{E}_2 = 30(-0.8626) + 41(1.7278) = \underline{44.9618V}$

from loop ahdefga,

$-30I_1 + 20I_2 + I_2 - \mathcal{E}_1 = 0$

$\mathcal{E}_1 = -30I_1 + 21I_2$

$\mathcal{E}_1 = -30(-0.8626) + 21(2.5960) = \underline{80.4V}$

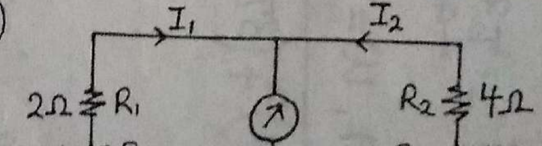
10) $E = (R+r)I$

$I = \frac{E}{R+r} = \frac{4}{(4+5)+1} = \frac{4}{10} = \underline{0.4A}$

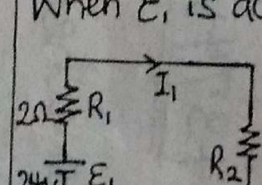
11) $V_3 = \frac{VR_3}{V_1+V_2+V_3} = \frac{20\times60}{100+40+60} = \underline{6V}$ (VDR)

12) $I_2 = \frac{IR_1}{R_1+R_2} = \frac{6\times4}{4+8} = \underline{2A}$ (CDR)

13)



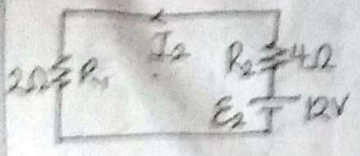
When $\mathcal{E}_1$ is acting alone



$I_1 = \frac{\mathcal{E}_1}{R_1+R_2} = \frac{24}{2+4}$

$I_1 = 4A$

When $\mathcal{E}_2$ is acting alone,



$I_2 = \frac{E_2}{R_1+R_2} = \frac{12}{2+4}$

$I_2 = 2A$

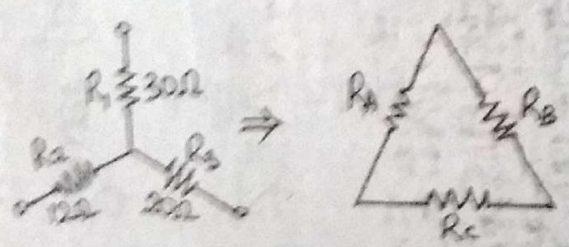
Superposing the current through R_1 is

$I_1 - I_2 = 4-2 = \underline{2A}$

$\eta = \frac{\text{Load power}}{\text{total power}} = \frac{P_L}{P_T}$

... a voltage source V_{TH} in series with a resistor R_{TH}

6



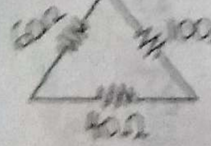
$R_A = \frac{R_1R_2+R_2R_3+R_3R_1}{R_3} = \frac{(30)(12)+(12)(20)+(20)(30)}{20}$

$R_A = \underline{60Ω}$

$R_B = \frac{R_1R_2+R_2R_3+R_3R_1}{R_2} = \frac{1200}{12} = 100Ω$

$R_C = \frac{R_1R_2+R_2R_3+R_3R_1}{R_1} = \frac{1200}{30} = 40Ω$

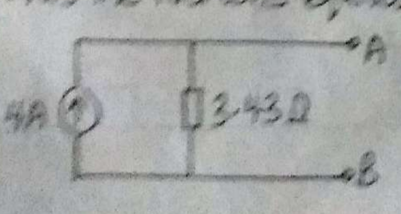
Thus the delta connection is shown



17 $\frac{E}{R_1} = \frac{24}{4+2} = \frac{24}{6} = 4A$

$(4+2)||8 = \frac{6\times8}{6+8} = \frac{48}{14} = 3.43Ω$

Thus the Norton's equivalent circuit is



18) $P_{Lmax} = \frac{E^2}{4R_L} = \frac{24^2}{4\times4} = \underline{36W}$

19) $I_{rms} = \frac{I_m}{\sqrt{2}}$ and $V_{rms} = \frac{V_m}{\sqrt{2}}$ where I_m and V_m are maximum currents and voltage respectively.

20) $V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{20}{\sqrt{2}} = \underline{14.14V}$

21) $\omega = 2\pi f$

$f = \frac{\omega}{2\pi}$

22) $I_{rms} = \frac{I_m}{\sqrt{2}}$, Given $I_{rms} = 60A$

$I_m = \sqrt{2} I_{rms} = 60\sqrt{2} = 84.85A$

$\omega = 2\pi f = 2\pi \times 50 = 100\pi$

The equation of a current sine wave

$I = I_m \sin\omega t$

$\therefore I_m = \underline{84.85\sin 100\pi t}$

23) The leading alternative quantity reaches the maximum value before the lagging alternating quantity.

24) $T = \frac{2\pi}{\omega} = \frac{2\pi}{157} = \underline{0.04s}$

25) $E_{av} = 0.637E_m = 0.637\times100 = \underline{63.7V}$

26) $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi\times30\times10^{-6}\times50}$

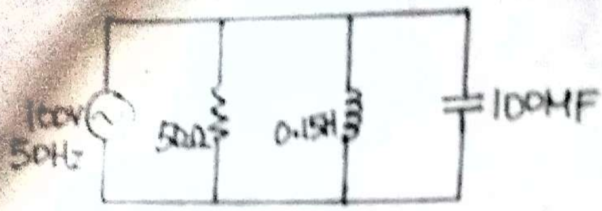
$X_C = \underline{106.1Ω}$

27) For series resonance, $X_C = X_L$

28) $f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{1000\times10^{-3}\times100\times10^{-6}}}$

$f_0 = 15.92Hz$

29)



All the branches have the same voltage because they are in parallel

Current across resistor $I_R = \frac{V}{R} = \frac{100}{50} = 2A$

Current across inductor $I_L = \frac{V}{X_L} = \frac{V}{2\pi f L}$

$$I_L = \frac{100}{2\pi \times 50 \times 0.15} = 2.12A$$

Current across capacitor $I_c = \frac{V}{X_c} = \frac{V}{\left(\frac{1}{2\pi f C}\right)}$

$$I_c = \frac{100}{\left(\frac{1}{2\pi \times 50 \times 100 \times 10^{-6}}\right)} = 3.142$$

$I_c = 3.142A$

30) $P_{av} = I_{av}V = I_{av}^2 Z = I_{av}^2\sqrt{R^2+X_L^2}$

$P_{av} = I_{av}^2\sqrt{R^2+(2\pi f L)^2} = I_{av}^2\sqrt{R^2+(\omega L)^2}$

From the question, $w = 377$, $I_{av} = 1.8$

$\therefore P_{av} = 1.8^2\sqrt{(1.35\times10^3)^2+(377\times3.85\times10^{-3})^2}$

$P_{av} = 4374W$

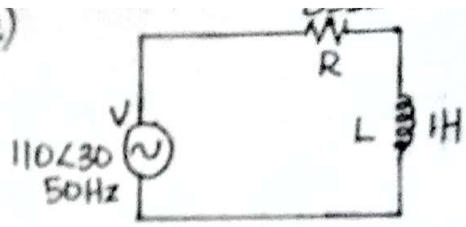
31) This is when $R = jX_L = 0$

because $Z = R + j(X_L - X_c)$

Substituting $R = jX_L = 0$

$Z = -jX_c$ which is purely capacitive

32)



Recall $e = E_m \sin(\omega t + \phi) = \frac{E_m}{\sqrt{2}}\angle\phi$

$\therefore 110\angle30° = (\sqrt{2})110\sin(2\pi f t + 30)$

$110\angle30° = 155.6\sin(100\pi t + 30)$

$V = IZ$; $I = \frac{V}{Z}$

$Z = \sqrt{R^2+(2\pi f L)^2} = \sqrt{35^2+(2\pi\times50\times1)^2}$

$Z = 316.1\Omega$

$\therefore I = \frac{V_m}{Z} = \frac{155.6}{316.1} = 0.49A$

33) $Z = \frac{V}{I} = \frac{8+j6}{2+j5} = 1.58 - j0.96$

34) Power factor $= \cos\phi = \cos(-32)$

$\therefore$ Power factor $= 0.85$

35) $Z_1 \| Z_2 = \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{(10+j5)(8+j6)}{10+j5+8+j6}$

$Z_{12} = Z_1 \| Z_2 = 4.5 + j2.81$

$I = \frac{V}{Z_{12}} = \frac{200}{4.5+j2.81} = (32-j20)A$

Converting I to polar form,

$(32-j20)A = 37.7\angle-32°$

Thus the phase $\phi = -32°$