MAY/JUNE 2005
Question & Model Answer
IN BASIC ELECTRICITY 194

Question 1

1(a) Define the following terms:

(i) Work

(ii) Potential difference

(iii) Power

(b) A forklift raises 300kg of load through a distance of 12m in 15sec. Determine

(i) The force required to lift the load

(ii) The work done by the forklift

(iii) The power dissipated by the forklift in KW.

Take $g = 10m/S^2$

Solution:

1(a)(i) Work is said to be done when a force moves through a distance in the direction of the force. Work is measured in joules(J) or Newton-metres (Nm) and it is symbolized by letter W or E.

(ii) Potential difference (p.d) is defined as the voltage measured across a circuit when an electric current is flowing or in a closed circuit. It is also called on-load voltage or closed circuit voltage. Potential difference can also be defined as the voltage measured between two points when an electric current is flowing. p.d is denoted by the symbol V and it is measured in volts.

(iii) The term power is defined as the ratio at which work is said to be done. But, electric power is the rate at which any device or appliance consume electric current in a closed (d.c) circuit. It is represented by P and measured in watts(W)

a(b)(i) The force required to lift the load of 300kg

Force, $F = ma$ where $a = g$

$= mg$

= 300 x 10

= <u>3,000N</u>

(ii) Work done by the forklift in 15secs

work done, W = Force x Distance

= f x s

= 3,000 x 12

= <u>36,000J</u>

(iii) The power dissipated by the fork lift in kw

Power, P = $\frac{\text{work done}}{\text{time taken}} = \frac{W}{t}$

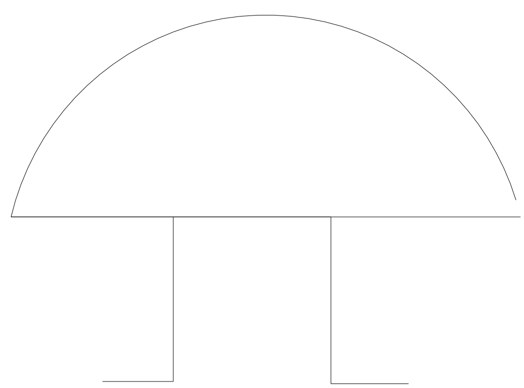
= $\frac{36,000}{15}$ = 2400w

= <u>2.4kw</u>

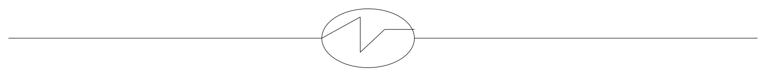
QUESTION 2: Draw the B.S. symbols of the follow:-

SOLUTION

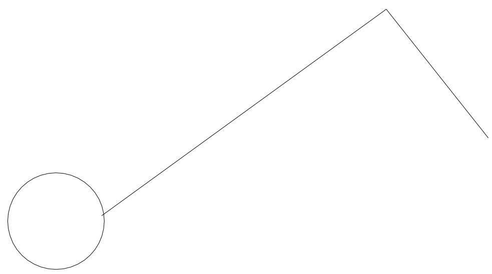
2(i) Electric bell



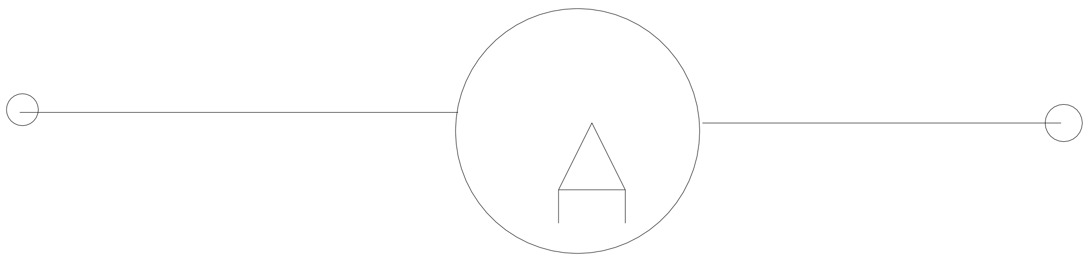
ii Discharge Lamp



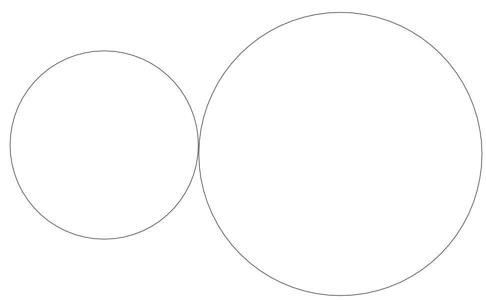
iii One way switch



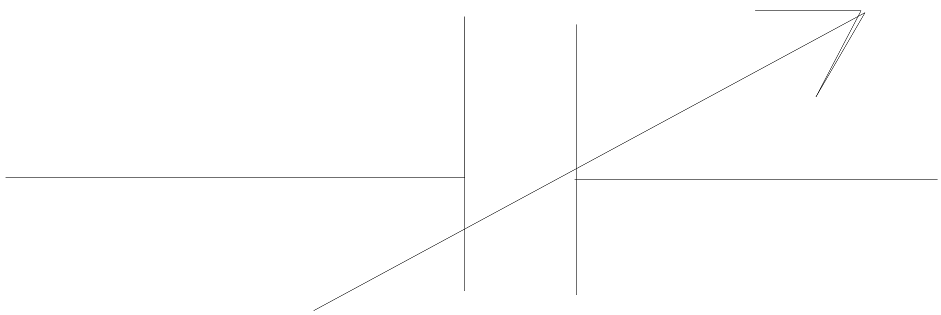
iv Ammeter



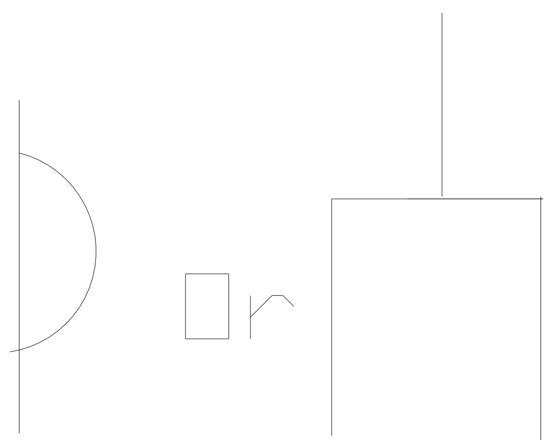
v Electric fan



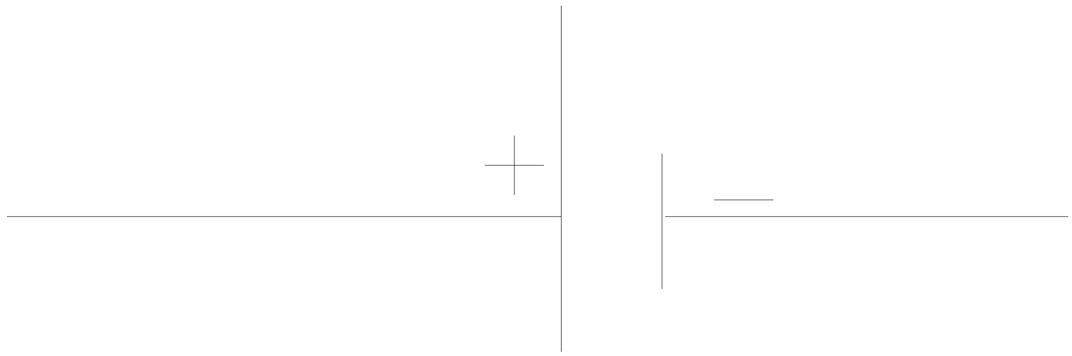
vi Variable capacitor



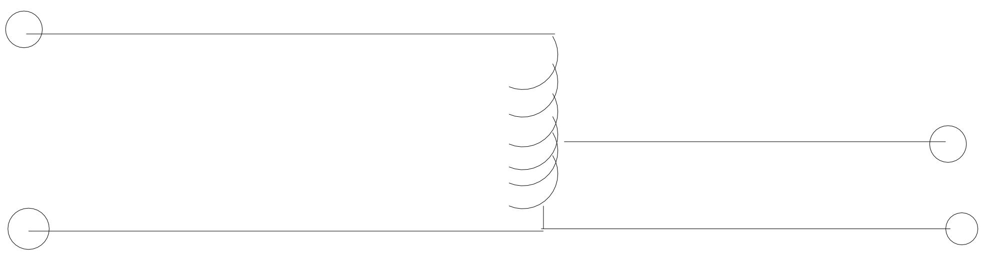
vii Socket



ix Cell



x Auto-transformer



QUESTION 3: (a)(i) Define Capacitance

(ii) State THREE factors that determine the capacitance of a capacitor.

(b) Three capacitors of values 4µf, 8uf and 12µf respectively are connected in series across 10V d.c source. Determine:

(i) The total capacitance

(ii) The total charge stored by the capacitance

(iii) The energy stored in the circuit

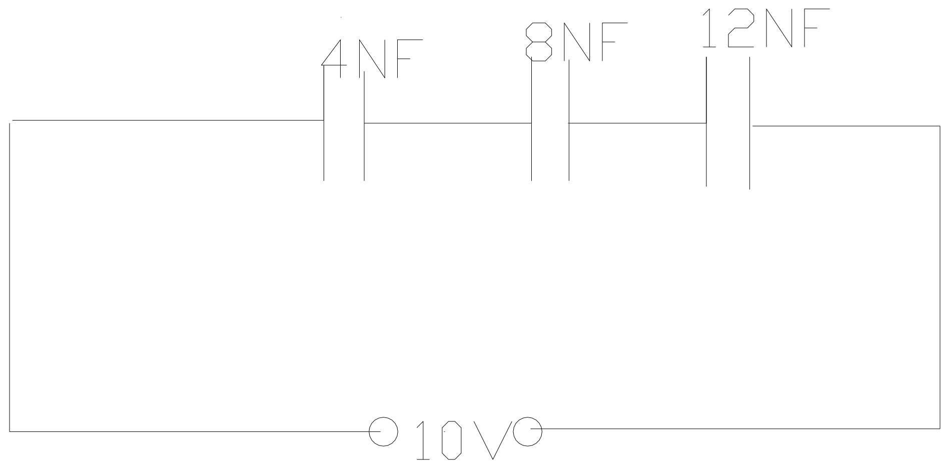
SOLUTION:

3.(a)(i) Capacitance is the property of an isolated conductor or sets of conductors and insulator to store electric charge. It is the ability of a capacitor to store electric charges, it can also be defined as the ratio of the amount of electricity (charge) to the potential difference produced between the plates. It is symbolized by letter C and it is measured in farad (F). Capacitance, C = Q/v.

(ii) Three factors on which the capacitance depends are;

- The effective surface area of overlap of the two parallel plates. If the area is small, the capacitance value will be small ie C α A.
- The distance between the plates. The greater the distance between the plates, the smaller the value of the capacitance is $C\ \alpha\ \frac{1}{d}$
- The presence of a dialectic material. The capacitance a capacitor increases as the presence of the dialectic, ε increases i.e C α ε

(b)



(i) The total capacitance of the groups

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C} = \frac{1}{4} + \frac{1}{8} + \frac{1}{12}$$

$$\frac{1}{C} = \frac{6 + 3 + 2}{24} = \frac{11}{24}$$

$$\Rightarrow C = \frac{24}{11} = 2.1\ 8\mu F$$

$\therefore C = 2.18\mu F$

(ii) The total charge, Q Stored by the capacitor

$$Q = CV$$
$$= 2.18\mu F \times 10v$$
$$= 21.8\mu C$$
$$Q = 21.8\mu C$$

(iii) The energy stored in the circuit

$$\text{Energy = work done} = \frac{1Q^2}{2C} = \frac{1(21.8\mu C)^2}{2(2.18\mu)F}$$

$$W = \frac{1(21.8)^2}{4.36}$$

$$\therefore W = \underline{\underline{109.0J}}$$

Question 4(a) List the factors which determine the resistance of a wire-wound resistor.

(b) Determine the range of resistance of a resistor which has the following colour-codes; Blue, black, Red and Silver.

(c) Two resistors of values 8Ω and 12Ω are connected in parallel across a 240V battery. Determine.

(i) The total resistance

(ii) The total current

(iii) The energy power consumed in the 12Ω resistor.

Solution:

4.(a) Factors which determine the resistance of a wire-wound resistor are:

- The nature or type of the material used I resistively
- The temperature of the resistor
- The length of the wire and
- The cross-sectional area of the wire

(b) The range of resistance of a resistor which has the following colour-codes; Blue, Black, Red and Silver.

Blue	Black	Red	Silver
6	0	10^2	10%

ie 6000 of ±10%

$\Rightarrow$ 6000 of (+10%)

= 6000 + (6000 x 0.1)

= 6000 + 600

= 6600Ω

Similarly, 6000 of (-10%)

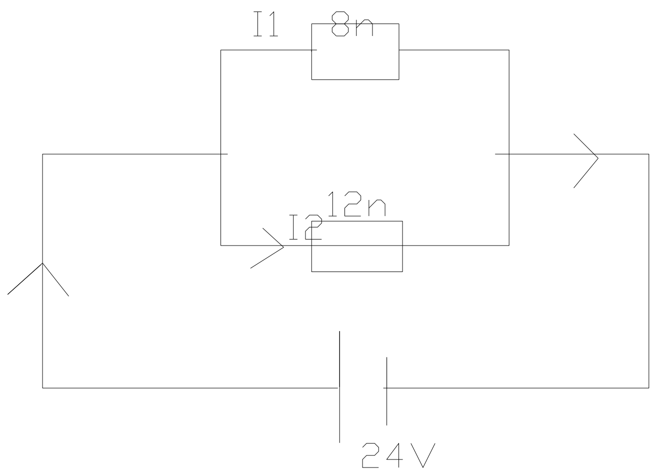
= 6000 – (6000 x0.1)

= 600 - 600

= 5400Ω

∴ The range of resistor with the above colour codes is between 6600 and 5400Ω

(C)



(i) Total Resistance, R_T

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_T} = \frac{1}{8} + \frac{1}{12}$$

$$\frac{1}{R_T} = \frac{2+3}{24} = \frac{5}{a24}$$

$$R_T = \frac{24}{5} = 4.8$$

∴ $R_T = 4.8\Omega$

(ii) Total current I_T

$$I_T = \frac{V}{}$$

$= R_T$

$= \frac{240}{4.8}$ 50A

∴

∴ $I_T = \underline{50A}$

(iii) Power consumed in the 12Ω resistor is

$I_T = \frac{V}{P_2} = \frac{240}{12} = 20A$

Hence Energy/Power $= IV$ or I^2R

$= 20 \times 240$

$P = 4800W$

$P = \underline{4.8KW}$

Question 5

(a) Define the following in relation to alternating current circuits and give their units and symbols:

(i) Resistance

(ii) Reactance

(iii) Impedance

(b) Two dissimilar components namely; and inductor of 0.1 Henry and a capacitor of 53MF are connected in series across a 250V, 50Hz supply.

Calculate:

(i) the inductive reactance

(ii) the capacitive reactance

(iii) the resonance frequency of the circuit

Solution

5(a)(i) Resistance is defined as the opposition which the components or materials in a pure resistive circuit offers to the flow of an alternating current. Such resistance is represented by the letter R and it is measured in ohms (Ω).

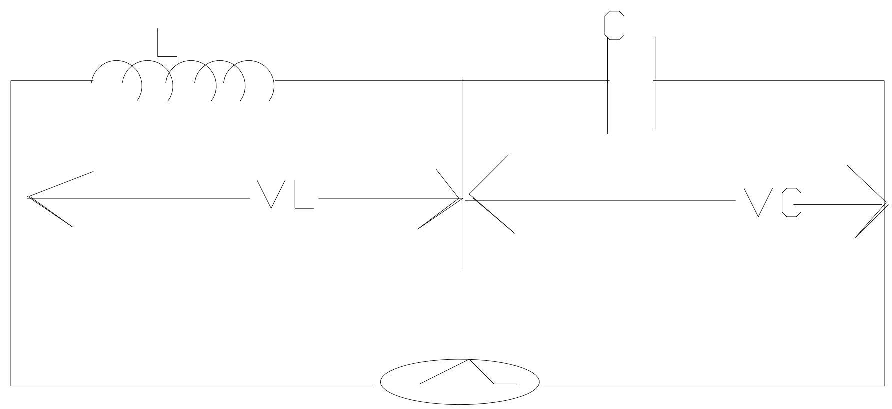
(ii) Reactance as used in an A.C. circuit is of two kinds, namely inductive and capacitive reactances. Inductive reactance is the opposition to an alternating current due to the presence of an inductor in the circuit. It is given as X_L and can be obtained from the reaction, $X_L = 2 \Lambda Fl$. The unit is ohms (Ω).

Capacitive reactance is the opposition to an alternating current due to the presence of a capacitor in the circuit. It is given as X_c and can be obtained from the relation, $X_c = \frac{1}{2\Lambda fc}$. The unit is also ohms (Ω).

(iii) Impedance as used in relation to alternating current is the effective opposition offered by the presence of an inductor (inductance coil), a capacitor and a resistor in an A.C. circuit. The impedance is represented as Z and can be obtained from the relations.

$$Z = \sqrt{R^2 + X^2_L} \quad \text{or} \sqrt{R^2 + X^2_c} \quad \text{or} \sqrt{R^2 + (X_L - X_c)^2}$$

The unit of Z is ohms (Ω).



(i) Inductive Reactance, $X_L = 2\Lambda fL$

$X_L = 2\Lambda fL$

$= 2 \times 3.142 \times 50 \times 0.1$

$= 31.42\Omega$

$\therefore X_L = \underline{31.42\Omega}$

(ii) The capacitive reactance, $X_c = \frac{1}{2\Lambda fc}$

$$X_c = \frac{1}{2 \times 3.142 \times 50 \times 53 \times 10^{-6} F}$$

$$= \frac{1 \times 10^6}{2X3.142X50X53}$$

$$= \frac{1000000}{166652.6} = 60.1$$

$$\therefore X_c = 60.1\Omega \,/\, 6.01x10^{-2}\Omega$$

(iii) The resonance frequency of the circuit

At resonance, $X_L = X_c$

$$\Rightarrow 2\Lambda fL = \frac{1}{2\Lambda fc}$$

$$4 f_o^2\Lambda^2LC = 1$$

$$f_o^2 = \frac{1}{4\Lambda^2LC}$$

$$= \frac{1}{4X(3.142)^2x0.1x53x10^{-6}}$$

$$\frac{10^6}{209.3} = 4777.8$$

$$f_o = \sqrt{4777.8}$$

$$\therefore f_o = 2.19 \times 10^{-3}H_Z$$

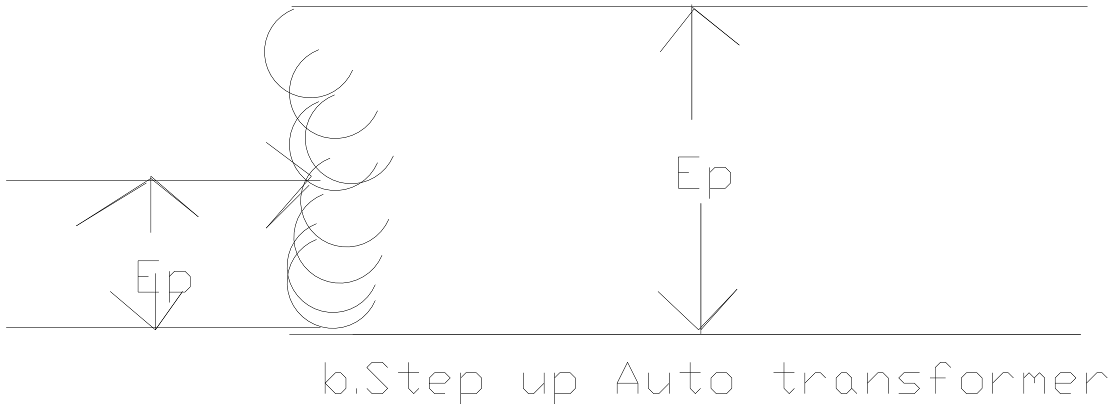
Question 6

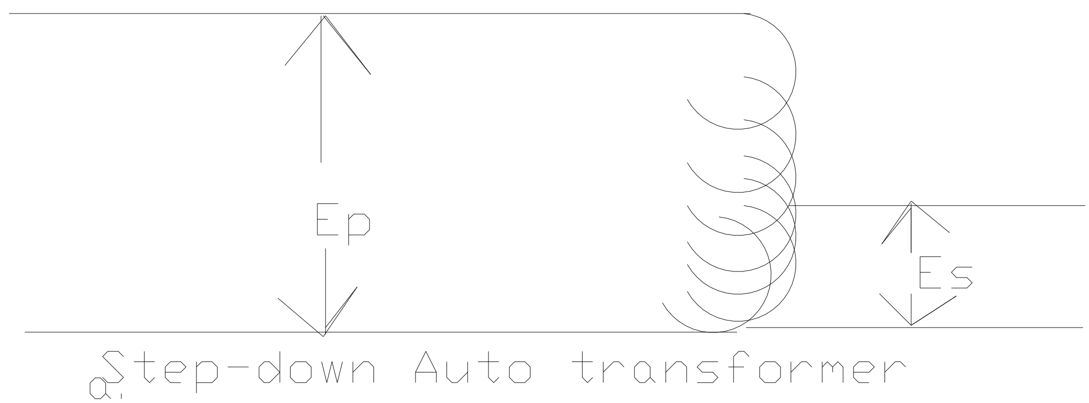
(a) With aid of a labeled diagram, describe the construction of an auto transformer

(b) A single phase auto transformer is supplied at 240V, 50Hz, the supply being connected between the common terminal and tapping at 720turns. Calculate the number of turns required to given an output of 260volts.

Solution

6(a) The auto-transformer is of two types; the step-down and step-up auto-transformers. In the auto-transformer, there is only one winding which has one or more tapping points. This winding serves as both primary and secondary, the basic connections for step-down and set-up auto-transformer are as shown in the diagrams below.





The auto-transformer is less expensive than a double-wound transformer but its use in limited because of the danger inherent in the direct electrical connections which exist between the input and output terminals. Auto-transformers are often employed in ac motor starters to reduce the pressure applied to the motor during the starting period.

b.

N_p = 720turns, Ns =?

E_p = 240V Es = 260v

But $\frac{Es}{Ep} = \frac{Ns}{Np}$

$\Rightarrow Ns = \frac{Es \times Np}{Ep} = \frac{260 \times 720}{240} = \frac{187200}{240} = 780$

Ns = 780turns

Question 7

(a) State TWO magnetic laws of attraction and repulsion.

(b) With diagrams, show the hysterises loop of:

(i) a hard magnetic material

(ii) a soft magnetic material

(C) A coil has self inductance of 25 Henry, when the current that flows through the circuit changes from 0.4 amperes to 0.2A in one minute. Determine the e.m.f. induced in the coil.

Solution

7(a) The two magnetic laws of attraction and repulsion state that

(ii) Magnets of dissimilar poles attract each other while

(iii) Magnets of like poles repel each other.

(b) The hysterises of loops

(i) Soft magnetic material (ii) Hard magnetic material

(c) Emf induced, Emf = $\frac{\text{Inductance (L) x rate of change of current}}{\text{Time needed for change in flux}}$

$Emf = \frac{25\ (0.4 - 0.2A)}{1x60s}$

$= \frac{25x0.2}{60} = \frac{5.0}{60}$

Emf = 0.083v