Solution

PHYSICS

Class 12 - Physics

Section A

1. **(a)** more than dc value
Explanation:
The output of a rectifier consists of an AC component called ripple and a DC component. The ratio of the AC and DC components will be greater than one for a half-wave rectifier, while it will be less than one for a full-wave rectifier.

2.
(b) Cu, Ag and Au
Explanation:
Cu, Ag and Au are the good conductors of electricity.

3.
(d) 40 cm
Explanation:
$L = f_o + f_e = 44$ and $|m| = \frac{f_o}{f_e} = 10$
This gives $f_o = 40\text{cm}$

4. **(a)** 20 cm
Explanation:
$\tau = q_m \times 2l \times B\sin\theta$
$\therefore$ 2l = $\frac{\tau}{q_m \times B\sin\theta}$
= $\frac{80\times10^{-7}}{2\times4\times10^{-5}\times\sin30^\circ}$ = 0.20 m = 20 cm

5.
(c) $\frac{C_1}{C_2}$
Explanation:
As C_1 and C_2 are connected in parallel, so the potential V=$\frac{Q}{C_1+C_2}$ will be same for both capacitors. thus, Q_1 = $\frac{QC_1}{C_1+C_2}$ and Q_2 = $\frac{QC_2}{C_1+C_2}$
$\therefore \frac{Q_1}{Q_2} = \frac{C_1}{C_2}$

6.
(c) The rate of heating
Explanation:
Since, the current remains constant, the rate of heating will not increase.

7.
(c) 0.5 A
Explanation:
$\varepsilon = -\frac{d\phi}{dt} = -100t$
I(at = 2s) $= \frac{|\varepsilon|}{R}$
$= \frac{100\times2}{400}$ = 0.5 A

8.
(c) due to spin and orbital motions of electrons both
Explanation:

due to spin and orbital motions of electrons both

9.

(b) distance between slit and screen

Explanation:

Angular width of central maximum,

$\theta_0 = \frac{\beta_0}{D} = \frac{2D\lambda}{a}\frac{1}{D} = \frac{2\lambda}{a}$

Clearly, θ_0 does not depend on the distance D between the slit and screen.

10.

(d) both on only on the system of units and only on medium between charges

Explanation:

both on only on the system of units and only on medium between charges.

11.

(c) C and A

Explanation:

In both figures (A) and (C), p-side is at higher potential than the n-side.

12.

(b) 3 cm

Explanation:

Apparent depth = (Real depth) / (refractive index)

Now, Height raised = real depth - apparent depth

= real depth(1 - $\frac{apparent\ depth}{real\ depth}$)

= real depth(1 - $\frac{1}{refractive\ index}$)

= d$\left(1 - \frac{1}{\mu}\right) = 12\left(1 - \frac{1}{\frac{4}{3}}\right) = 12\left(1 - \frac{3}{4}\right) = \frac{12}{4} = 3cm$

13. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation:

Both A and R are true and R is the correct explanation of A.

14. **(a)** Assertion and reason both are correct statements and reason is correct explanation for assertion.

Explanation:

Assertion and reason both are correct statements and reason is correct explanation for assertion.

15.

(b) Both A and R are true but R is not the correct explanation of A.

Explanation:

When the intensity of light emerging from two slits is equal, the intensity at minima, $I_{\text{min.}} = \left(\sqrt{I_a} - \sqrt{I_b}\right)^2$ = 0, or absolute dark. It provides better contrast.

16. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation:

Both A and R are true and R is the correct explanation of A.

Section B

17. Let $E_0 = \frac{V_0}{d}$ be the electric field between the plates when there is no dielectric and the potential difference is V_0. If the dielectric is now inserted, the electric field in the dielectric will be $E_0 = \frac{KV_0}{d}$.(having thickness 3/4 d) The potential difference when dielectric is introduced ,will then be

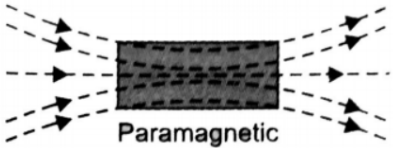
V = $E_0\left(\frac{1}{4}d\right) + \frac{E_0}{K}\left(\frac{3}{4}d\right)$

$= E_0 d\left(\frac{1}{4}+\frac{3}{4K}\right) = V_0\frac{K+3}{4K}$

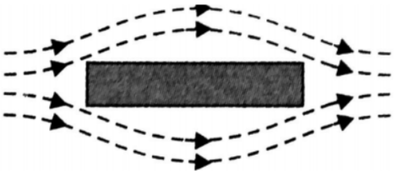
The potential difference decreases by the factor $\frac{(K+3)}{4K}$ while the free charge Q_0 on the plates remains unchanged. The capacitance thus increases

$C = \frac{Q_0}{V} = \frac{4K}{K+3}\frac{Q_0}{V_0} = \frac{4K}{K+3}C_0$

18. Inside a paramagnetic bar, field concentrates slightly in the bar, figure.



Inside a Diamagnetic bar, magnetic field lines are repelled or expelled and the field inside the material is reduced. This is shown in the figure.



19. When p-type semiconductor is chipped with n-type semiconductor, e-from the n-side diffuse towards p-side and holes from p-side diffuse towards n-side leaving behind a layer of immobile +ve ions on n-side and immobile -ve ions on p-side leading to formation of depletion layer.
20. The nucleus of a hydrogen atom is a proton (mass $1.67 \times 10^{-27} kg$) which has only about one-fourth of the mass of an alpha particle $\left(6.64 \times 10^{-27} kg\right)$. Because the alpha particle is more massive, it won't bounce back in even a head on collision with a proton. It is like a bowling ball colliding with a ping pong ball at rest. Thus, there would be no large angle scattering in this case. In Rutherford's experiment, by contrast, there was large angle scattering because a gold nucleus is more massive than an alpha particle. The analogy there is a ping pong ball hitting a bowling ball at rest.
21. Current sensitivity of a galvanometer is the deflection produced per unit flow of current while voltage sensitivity is the deflection produced per unit applied potential difference.

Current sensitivity, $I_s = \frac{\alpha}{I} = \frac{NBA}{k}$

Voltage sensitivity,$V_s = \frac{\alpha}{V} = \frac{\alpha}{IR} = \frac{NBA}{kR}$

If the current sensitivity is increased by increasing the number of turns N, the resistance R will also increase. So, the voltage sensitivity might not increase on increasing the current sensitivity.

OR

here $m = 9\times10^{-31}$kg and $B = 6 \times 10^{-4}$ T

$r = \frac{mv}{(qB)} = \frac{9\times10^{-31}\ kg \times 3\times10^{7}\ ms^{-1}}{(1.6\times10^{-19}\ C \times 6\times10^{-4}\ T)}$

$= 28 \times 10^{-2}$ m = 28 cm

$\nu = \frac{v}{(2\pi r)} = 17 \times 10^{6}\ s^{-1} = 17 \times 10^{6}$ Hz =17 MHz.

$E = (\frac{1}{2})mv^2 = (\frac{1}{2})\, 9 \times 10^{-31}\ kg \times 9 \times 10^{14}\ m^2/s^2 = 40.5 \times 10^{-17}$ J

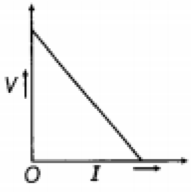
$\approx 4 \times 10^{-16}$ J = 2.5 keV.

Section C

22. Internal resistance usually means the electrical resistance inside batteries and power supplies that can limit the potential difference that can be supplied to an external load.

We know that, V = E - Ir

The plot between V and I is a straight line of positive intercept and negative slope as shown in figure below.



The value of potential difference corresponding to zero current gives emf of the cell.

Maximum current is drawn when terminal voltage is zero, so

V = E - Ir

$\Rightarrow 0=E-I_{\max} r \Rightarrow r=\frac{E}{I_{\max}}$

Internal resistances within power supplies are normally constant and independent of use unless the power supply gets hot as a result of short circuits or low resistance loads. In that case, the internal resistance is likely to increase slightly.

23. In a p-n-junction diode, the loss of electrons from the n-region and the gain of electrons by the p-region causes a difference of potential across the junction of the two regions. This potential tends to prevent the movement of electrons from the n region to the p region. Hence a potential barrier is created across the junction.
    a. In forward bias, the barrier potential is reduced.
    b. In reserve bias. the barrier potential increases.

24. i. From de-Broglie equation,

$\lambda=\frac{h}{p}=\frac{h}{\sqrt{2 m K}}$

As, $p=\sqrt{2 m K}$ and K = qV

$\Rightarrow \quad \lambda=\frac{h}{\sqrt{2 m q V}}$ ....(i)

$\lambda \propto \frac{1}{\sqrt{m q}}$

Ratio of wavelengths of electron and proton,

$\frac{\lambda_e}{\lambda_p}=\sqrt{\left(\frac{m_p}{m_e}\right)\left(\frac{q_p}{q_e}\right)}$

Ratio of mass of proton and electron,

$\frac{m_p}{m_e}=1836$ (constant)

$\frac{q_p}{q_e}=1$ (Both electron and proton have same charge)

$\Rightarrow \quad \frac{\lambda_e}{\lambda_p}=\sqrt{1836 \times 1}$

$\lambda_e \approx 42.8 \lambda_p$ nearly

Electron have greater wavelength associated with it than that of proton.

ii. $\because \quad \lambda=\frac{h}{p}$ (de-Broglie equation)

$\Rightarrow \quad p=\frac{h}{\lambda} \Rightarrow p \propto \frac{1}{\lambda} \Rightarrow \frac{p_e}{p_p}=\frac{\lambda_p}{\lambda_e}$

Now,

$\frac{\lambda_p}{\lambda_e}=\frac{1}{42.8} \Rightarrow \quad \frac{p_e}{p_p}=\frac{\lambda_p}{\lambda_e}=\frac{1}{42.8}$

Momentum of proton is nearly 42.8 times to that of momentum of electron. Thus, electron will have less momentum.

25. i. The characteristic property of nuclear force that explains the constancy of binding energy per nucleon is the saturation or short range nature of nuclear forces.

In heavy nuclei, nuclear size > a range of nuclear force.

ii. Using the formula for the radius of the nucleon, we have

R = $\mathrm{R}_0 \mathrm{A}^{\frac{1}{3}}$

Let, m be the mass of a nucleon,

therefore,

density, $\rho=\frac{\mathrm{mA}}{\frac{4}{3} \pi\left(\mathrm{R}_0 \mathrm{A}^{1/3}\right)^3}=\frac{\mathrm{mA}}{\frac{4}{3} \pi \mathrm{R}_0^3 \mathrm{A}}=\frac{\mathrm{m}}{\frac{4}{3} \pi \mathrm{R}_0^3}$

Thus, we can see that density is constant and independent of mass number A.

26. $\frac{m v_0^2}{r_n}=\frac{1}{4 \pi \epsilon_0} \frac{Z e^2}{r_n^2}$

$m v_0^2=\frac{1}{4 \pi \epsilon_0} \frac{Z e^2}{r_n}$ ...(i)

according to Bohr's Postulate

$\mathrm{m} v_0 r_n=\frac{n h}{2 \pi}$

$\therefore \mathrm{m}^2 v_0^2 r_n^2=\frac{n^2 h^2}{2 \pi}$ ...(ii)

Dividing equation (ii) by equation (i)

$r_n=\frac{\epsilon_0 h^2}{\pi m z e^2} \times \mathrm{n}^2$

According to de-Brogle electron in its circular orbit must be seen as particel wave.

Therfore, $2 \pi r_n=\mathrm{n} \lambda$

Since, de-Brogle wave length $(\lambda)=\frac{h}{p}$

Therefore, $2 \pi r_n=\frac{n h}{m v_0}$

$mv_0r_n = \frac{nh}{2\pi}$

This equation is the basis of explaining the discrete orbits and every level of H-atom, theis de-Broglie hypothesis explains the stability of H-atom.

27. i. Coherent sources: Two sources are said to be coherent in nature if they emit light of same frequency and of a stable path difference. The essential condition, which must be satisfied for the sources to be coherent are:
    a. The two light waves should be of same wavelength.
    b. The two sources must be very close to each other.
    c. The two light waves should either be with same phase or should have a constant phase difference.
    d. The two sources should preferably have the same amplitude.
    e. The sources should emit light waves continuously.

    ii. Two sources of emitting light waves of same frequency or wavelength and of a stable phase difference are required to see interference pattern, and we can obtain such nature of light waves from coherent source.
    So, we require coherent sources to produce the interference of light.

28. i. In the one revolution, change of area,
    $dA = \pi l^2$
    $\therefore$ Change of magnetic flux in one revolution of the rod,
    $d\phi_B = \vec{B} \cdot d\vec{A} = BdA\cos 0^\circ = B\pi l^2$
    (Given, magnetic field intensity, $\vec{B}$ is parallel to change in area, $d\vec{A}$)
    If period of revolution is T,
    a. Induced emf (e) = {tex}\frac {d\phi}{dt} = \frac {Bπl^2}{T} = Bπl^2 \nu{/tex} ($\because \nu = \frac{1}{T}$)
    b. Induced current in the rod,
    $I = \frac{e}{R} = \frac{\pi\nu Bl^2}{R}$
    (Given R = resistance of the rod)

    ii. Magnitude of force acting on the rod,
    $|\vec{F}| = |I(\vec{l} \times \vec{B})| = BIlsin90^0 = \frac{\pi\nu B^2 l^3}{R}$
    The external force required to rotate the rod opposes the Lorentz force acting on the rod, i.e external force acts in the direction opposite to the Lorentz force.

    iii. Power required to rotate the rod,
    $P = \vec{F}.\vec{v} = Fvcos0^0 = \frac{\pi\nu B^2 l^3 v}{R}$

OR

As the current was already flowing through the solenoid so it behaves like a magnet and let S pole is upper side a flux in-ring is constant. So there is no induced current in ring.

When current is switched off, magnetic flux decrease so induced current produced in the ring in such a way so that it can increase the flux. So the North pole is produced in the ring in the lower side and attracted by a solenoid. So, downward and solenoid are fixed rings will not be able to move downward.

Section D

29. **Read the text carefully and answer the questions:**

All the known radiations from a big family of electromagnetic waves which stretch over a large range of wavelengths. Electromagnetic wave include radio waves, microwaves, visible light waves, infrared rays, UV rays, X-rays and gamma rays. The orderly distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum.

(i) **(d)** infrared waves
Explanation:
Infrared rays can be converted into electric energy as in solar cell.

(ii) **(c)** radiowaves
Explanation:
Radiowaves have longest wavelength.

(iii) **(d)** cathode rays
Explanation:
Cathode rays are invisible fast moving streams of electrons emitted by the cathode of a discharge tube which is maintained at a pressure of about 0.01 mm of mercury.

OR

(c) microwave, infrared, ultraviolet, gamma rays

Explanation:

$\lambda_{\text{micro}} > \lambda_{\text{infra}} > \lambda_{\text{ultra}} > \lambda_{\text{gamma}}$

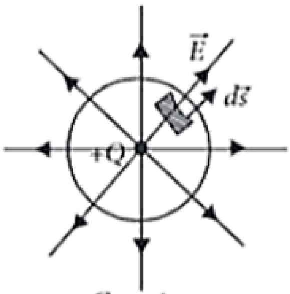
(iv) **(d)** γ-rays

Explanation:

γ-rays have minimum wavelength.

30. **Read the text carefully and answer the questions:**

Gauss's law and Coulomb's law, although expressed in different forms, are equivalent ways of describing the relation between charge and electric field in static conditions. Gauss's law is $\varepsilon_0\phi = q_{\text{end}}$, when q_{end} is the net charge inside an imaginary closed surface called Gaussian surface. $\phi = \oint \vec{E} \cdot d\vec{A}$ gives the electric flux through the Gaussian surface. The two equations hold only when the net charge is in vacuum or air.



Gaussian spherical surfaces

(i) **(c)** $\oint \vec{E} \cdot d\vec{s} = 0$ if charge is outside, $\oint \vec{E} \cdot d\vec{s} = \frac{q}{\varepsilon_0}$ if charge is inside

Explanation:

If there is only one type of charge in the universe then it will produce electric field somehow. Hence Gauss's law is valid.

(ii) **(c)** Vector

Explanation:

Vector

(iii) **(c)** 6×10^5

Explanation:

According to Gauss's theorem,

Electric flux through the sphere = $\frac{q}{\varepsilon_0}$

$\therefore$ Electric flux through the hemisphere = $\frac{1}{2}\frac{q}{\varepsilon_0}$

= $\frac{10\times10^{-6}}{2\times8.854\times10^{-12}}$ = 0.56×10^6 N m^2 C^{-1}

$\approx 0.6 \times 10^6$ Nm^2 C^{-1} = 6×10^5 N m^2 C^{-1}

(iv) **(b)** ϕ

Explanation:

As flux is the total number of lines passing through the surface, for a given charge, it is always the charge enclosed $\frac{Q}{\varepsilon_0}$. If area is doubled, the flux remains the same.

OR

(c) zero

Explanation:

As net charge on a dipole is (-q + q) = 0

Thus, when a gaussian surface encloses a dipole, as per Gauss's theorem, electric flux through the surface.

Section E

31. i. The working of an optical fibre is based on the phenomena of total internal reflection.

Given, refractive index of the glass fibre with respect to air,

$\mu_2 = {}^{a}\mu_g$ = 1.68

Refractive index of the outer coating material with respect to air,

$\mu_1 = {}^a\mu_{outer} = 1.44$

Let the critical angle be i_c

So, $\mu = \frac{\mu_2}{\mu_1} = \frac{1}{\sin i_c}$

$\Rightarrow \sin i_c = \frac{\mu_1}{\mu_2} = \frac{1.44}{1.68} = 0.8571$

$\Rightarrow i_c = \sin^{-1}(0.8571) \approx 59^\circ$

The total internal reflection will take place when the angle of incidence i will be greater than the critical angle i_c, i.e. $i > i_c = 59^\circ$ or when angle of refraction, $r < r_{max}$

where, $r_{max} = 90^\circ - i_c = 90^\circ - 59^\circ = 31^\circ$

So, ${}^a\mu_g = \frac{\sin i_{\max}}{\sin r_{\max}} = 1.68$

or, $\sin i_{max} = 1.68 \sin 31^\circ = 1.68 \times 0.5150 = 0.8652$

or $i_{max} = \sin^{-1}(0.8652) = 60^\circ$

Thus, all the rays which are incident in the range $0 < i < 60^\circ$, will suffer total internal reflection in the pipe (but $i \neq 0$).

ii. If the outer covering of the pipe is not present, then,

Refractive index of the outer pipe, μ_1 = Refractive index of air = 1

For the angle of incidence i = 90°, we can write Snell's law at the air−pipe interface as:

$\frac{\sin\ i}{\sin\ r} = \mu$

where, i = angle of incidence, r = angle of refraction,

$\frac{\sin\ i}{\sin\ r} = 1.68$

$\sin r = \frac{\sin 90}{1.68} = \frac{1}{1.68} = 0.59$

$\Rightarrow r = 36.5^\circ$

Now, $i' = 90^\circ - r$

$\Rightarrow i' = 90^\circ - 36.5^\circ$

$\Rightarrow i' = 53.5^\circ$

Since i' > r, all incident rays will suffer total internal reflection.

OR

i. a. Two independent monochromatic sources of light cannot produce sustained interference because:

i. If the sources are not coherent, they cannot emit waves continuously.

ii. Independent sources, emit the waves, which don't have the same phase or a constant phase difference. Therefore these sources will not be coherent and therefore would not produce a sustained interference pattern.

b. given $y_1 = a\cos\omega t$,

$y_2 = a\cos(\omega t + \phi)$,

by superposition principle, resultant displacement, $y = y_1 + y_2$,

or $y = a\cos\omega t + a\cos(\omega t + \phi)$

or $y = 2a\cos(\frac{\phi}{2}).\cos(\omega t + \frac{\phi}{2})$,

or $y = A\cos(\omega t + \frac{\phi}{2})$,

it is an equation of simple harmonic plane progressive wave, whose amplitude is A,

here $A = 2a\cos(\frac{\phi}{2})$,

now intensity is proportional to square of amplitude , therefore

$I = KA^2 = 4Ka^2\cos^2(\frac{\phi}{2})$,

where K is proportionality constant.

ii. A path difference of λ, corresponds to a phase difference of 2π

$\therefore$ The intensity, $K = 4a^2 \Rightarrow a^2 = \frac{K}{4}$

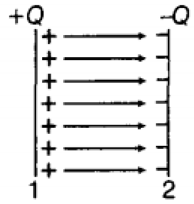
A path difference of $\frac{\lambda}{3}$, corresponds to a phase difference of $\frac{2\pi}{3}$

$\therefore$ Intensity = $4a^2\cos^2\frac{\phi}{2}$

$= 4 \times a^2 \times \cos^2\frac{2\pi/3}{2}$

$= 4 \times \frac{K}{4} \times \left(\frac{1}{2}\right)^2 = \frac{K}{4}$

32. i. Let the total charge on the plates of the below capacitor is +Q and -Q respectively.



∴The potential difference between the plates of the above capacitor of capacitance C for an infinitesimal charge q is q/C.

∴ Potential of condenser = q/C

Small amount of work done in giving an additional charge dq to the condenser,

$dW = \frac{q}{C} \times dq$

∴Total work done in giving a charge Q to the condenser,

$W = \int_{q=0}^{q=Q} \frac{q}{C} dq = \frac{1}{C}\left[\frac{q^2}{2}\right]_{q=0}^{q=Q} \Rightarrow W = \frac{1}{C}\frac{Q^2}{2}$

As, an electrostatic force is conservative, this work is stored in the form of potential energy (U) of the condenser.

$U = W = \frac{1}{2}\frac{Q^2}{C}$

$\because \quad Q = CV \Rightarrow U = \frac{1}{2}\frac{(CV)^2}{C} = \frac{1}{2}CV^2$

$\because \quad CV = Q \Rightarrow U = \frac{1}{2}QV$

Hence, $U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$

Energy density (u) is defined as the total energy per unit volume of the condenser.

i.e., $u = \frac{\text{Total energy } (U)}{\text{Volume } (V)} = \frac{\frac{1}{2}CV^2}{Ad}$

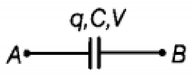
Using, $C = \frac{\varepsilon_0 A}{d}$ and V = Ed (Where V is the potential difference and E is the Electric field existing between the plates)

We get, $u = \frac{1}{2}\left(\frac{\varepsilon_0 A}{d}\right)\left(\frac{E^2 d^2}{Ad}\right) = \frac{1}{2}\varepsilon_0 E^2$

Here, Energy density between plates of capacitors is directly proportional to electric field that exists between the plates of capacitor.

ii. Initial condition :

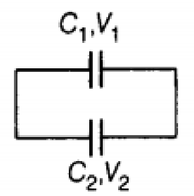
If we consider a charged capacitor of capacitance C with potential difference V, then its charge would be given, q = CV



and energy stored in it is given by

$U_1 = \frac{1}{2}CV^2$ .....(i)

When this charged capacitor is connected to uncharged capacitor,



Let the common potential be V_1, the charge flow from first capacitor to the other capacitor unless both the capacitor attains the common potential.

$\Rightarrow Q_1 = CV_1$ and $Q_2 = CV_2$

Applying conservation of charge,

$Q = Q_1 + Q_2 \Rightarrow CV = CV_1 + CV_2$

$\Rightarrow V = V_1 + V_2 \Rightarrow V_1 = \frac{V}{2}$ [hence voltage will be equally divided between the capacitors]

Total energy stored in both the capacitor is

$U_2 = \frac{1}{2}CV_1^2 + \frac{1}{2}CV_1^2 \Rightarrow U_2 = \frac{1}{2}C\left(\frac{V}{2}\right)^2 + \frac{1}{2}C\left(\frac{V}{2}\right)^2$

$U_2 = \frac{2CV^2}{8} = \frac{1}{4}CV^2$

From Eqs. (i) and (ii), we get, $U_2 < U_1$

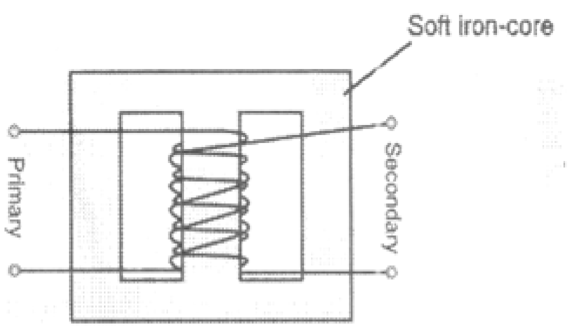
It means that energy stored in the combination is less than that stored initially in the single capacitor. It is due to the fact that when the charge is transferred from one capacitor to another capacitor energy is wasted in transferring the charge.

OR

a. Since the work done depends on the final arrangement of the charges, and not on how they are put together, we calculate work needed for one way of putting the charges at A, B, C and D. Suppose, first the charge +q is brought to A, and then the charges –q, +q, and -q are brought to B, C, and D, respectively. The total work needed can be calculated in steps:
   i. Work needed to bring charge +q to A when no charge is present elsewhere: this is zero.
   ii. Work needed to bring –q to B when +q is at A. This is given by (charge at B) $\times$ (electrostatic potential at B due to charge +q at A)
   $= -q \times \left(\frac{q}{4\pi\varepsilon_0 d}\right) = -\frac{q^2}{4\pi\varepsilon_0 d}$
   iii. Work needed to bring charge +q to C when +q is at A and -q is at B. This is given by (charge at C) $\times$ (potential at C due to charges at A and B
   $= +q\left(\frac{+q}{4\pi\varepsilon_0 d\sqrt{2}} + \frac{-q}{4\pi\varepsilon_0 d}\right)$
   $= \frac{-q^2}{4\pi\varepsilon_0 d}\left(1 - \frac{1}{\sqrt{2}}\right)$
   iv. Work needed to bring -q to D when +q at A, -q at B, and +q at C. This is given by (charge at D) $\times$ (potential at D due to charges at A, B, and C)
   $= -q\left(\frac{+q}{4\pi\varepsilon_0 d} + \frac{-q}{4\pi\varepsilon_0 d\sqrt{2}} + \frac{q}{4\pi\varepsilon_0 d}\right)$
   $= \frac{-q^2}{4\pi\varepsilon_0 d}\left(2 - \frac{1}{\sqrt{2}}\right)$
   Add the work done in steps (i), (ii), (iii), and (iv). The total work required is
   $= \frac{-q^2}{4\pi\varepsilon_0 d}\left\{(0) + (1) + \left(1 - \frac{1}{\sqrt{2}}\right) + \left(2 - \frac{1}{\sqrt{2}}\right)\right\}$
   $= \frac{-q^2}{4\pi\varepsilon_0 d}(4 - \sqrt{2})$
   The work done depends only on the arrangement of the charges, and not how they are assembled. By definition, this is the total electrostatic energy of the charges.

b. The extra work necessary to bring a charge q_0 to point E when the four charges are at A, B, C, and D is q_0 $\times$ (electrostatic potential at E due to the charges at A, B, C, and D). The electrostatic potential at E is clearly zero since potential due to A and C is cancelled by that due to B and D. Hence, no work is required to bring any charge to point E. Also, it can be said that the work done over a closed surface is zero. (charges are opposite in corners so work done during one cycle cancel out by another cycle) hence work done is zero.

33. i.

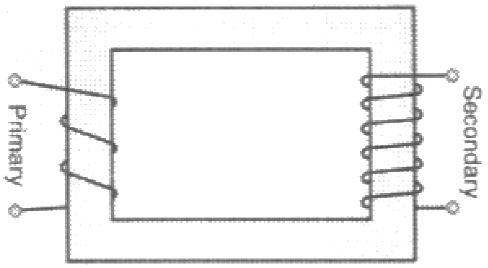


Working principle:
Step-down transformer is made up of two or more coil wound on the iron core of the transformer. It works on the principle of magnetic induction between the coils. Whenever current in one coil changes an emf gets induced in the neighboring coil (Principle of mutual induction)
Voltage across secondary
$V_s = e_s = -N_s \frac{d\phi}{dt}$
Voltage across primary
$V_p = e_p = -N_p \frac{d\phi}{dt}$
$\frac{V_s}{V_p} = \frac{N_s}{N_p}$ (here, $N_s > N_p$)
In an ideal transformer
Power Input - Power output

$I_p V_p = I_s V_s$

$\therefore \frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$

ii.



Input power, $P_i = I_i \times V_i = 15 \times 100 = 1500$ W

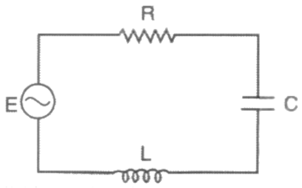
Power output, $P_0 = P_i \times \frac{90}{100} = 1350$ W

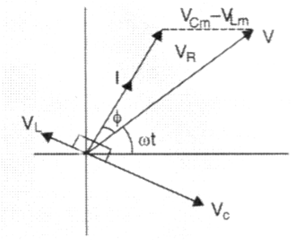
$\Rightarrow I_0 V = 1350$ W

Output voltage, $V_0 = \frac{1350}{3}$ V = 450 V

OR

i. In a series LCR circuit shown,





the voltage V_R and current I, are in the same phase, the voltage V_L will lead the current by angle 90° while the voltage V_C will lag behind the current by angle 90°. From the phasor relation, voltages $V_L + V_R + V_C = V$, as V_C and V_L are along the same line and in opposite directions, so they will combine in single phasor ($V_C + V_L$) having magnitude $|V_{Cm} - V_{Lm}|$. Since voltage V is shown as the hypotenuse of a right-angled triangle with sides as V_R and ($V_C + V_L$), so the Pythagoras Theorem results as :

$V_m^2 = V_R^2 + (V_{Cm} - V_{Lm})^2$

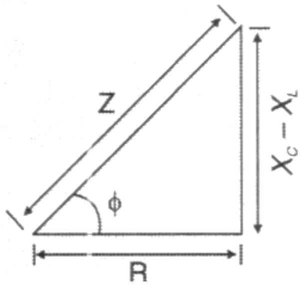
$V_m^2 = (I_m R)^2 + (I_m X_C - I_m X_L)^2$

$V_m^2 = I_m{}^2(R^2 + (X_C - X_L)^2)$

Now current in tire circuit :

$I_m = \frac{V_m}{\sqrt{\left(R^2 + (X_C - X_L)^2\right.}}$

$I_m = \frac{V_m}{Z}$ as $Z = \sqrt{\left[R^2 + (X_C - X_L)^2\right]}$

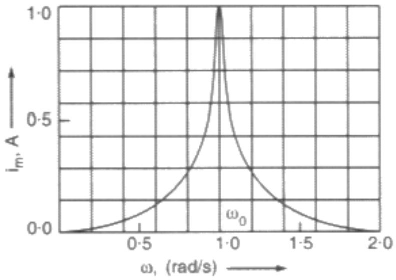


As phasor 1 is always parallel to phasor V_R, the phase angle ϕ is the angle between V_R and V and can be determined from the figure.

$\tan\phi = \frac{V_{Cm} - V_{Lm}}{V_{Rm}}$

$\tan\phi = \frac{X_C - X_L}{R}$

ii.



The capacitance of a capacitor in the tuning circuit is varied such that the resonant frequency of the circuit becomes nearly equal to the frequency of the radio signal to be received. When this happens, the amplitude of the current becomes maximum in the receiving circuit.