Nagaland Board
Class XII
Physics
Sample Paper 1 – Solution

1. (i)
When a charged rod is brought near the disc of a negatively charged gold leaf electroscope, it is observed that the divergence of leaves decreases and the rod is positively charged because the electrons move from leaves to the disc with the result that negative charge on leaves decreases.

2. (iii)
Kirchhoff's second law is applicable to closed circuits only as we form the equations using the loop and sign convention.

3. (ii)
Magnetic declination is defined as the angle between the geographic meridian and the magnetic meridian of the earth.

4. (iii)
When magnet is moved towards the coil, the magnetic lines of force entering the coil increase as a result magnetic field increases. Due to change in magnetic field, a current will setup which is confirmed by the galvanometer deflection.

5. (ii)
The emitter junction is forward biased and collector junction is reversed biased and the base region of a transistor provides an interaction between the emitter and collector of transistor and this region is made thin to reduce the recombination of holes and electrons in this region, so that there is appreciable collector current.

6. The mass of electron is small and a small increase in energy of the electron makes the electrons move with a very high speed. As a result of it, the electrons go quickly out of step with oscillating electric field.

7. Foucault currents also called Eddy currents are the induced currents when the magnetic flux linked with a conductor changes with time.

$$i = \frac{\text{induced emf}}{\text{resistance}}$$

$$i = \frac{(-d\phi / dt)}{R}$$

8. Overlapping interference pattern of different colours will form and the central bright fringe will be white.

9. When the impact parameter is minimum, the alpha particles rebound back.

10. No. We cannot have resonance in RL or RC circuit as presence of L and C in the circuit is necessary for resonance.

11. Area vector $\vec{S}$ in y-z plane points along outward along positive x-direction.

$\vec{S} = 20\,\hat{i}$

Hence the flux is:

$\phi_E = \vec{E}.\vec{S} = (6\hat{i} + 3\hat{j} + 4\hat{k}).20\,\hat{i}$

= 120 units

12. Let R_1 and R_2 be the resistances of the coils.

$R_1 + R_2 = 18$ (i) series connection

$R_1 R_2 / (R_1 + R_2) = 4$ (ii) parallel connection

Multiplying (i) and (ii) we have $R_1 R_2 = 18 \times 4 = 72$

Now $(R_1 - R_2)^2 = (R_1 + R_2)^2 - 4 R1 R2 = 18^2 - 4 (72) = 36$

$R_1 - R_2 = \pm 6$ (iii)

Solving equations (i) and (iii), we get

$R_1 = 12\,\Omega$ or $6\,\Omega$; $R_2 = 6\,\Omega$ or $12\,\Omega$.

13. If a lens has different radii of curvature, it forms an image of an object placed on its axis. If we reverse the lens the position of the image of the object will not change.

We can deduce this using the lens makers' formula which is as follows:

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Or

The images formed by total internal reflection are brighter than those formed by mirrors or lenses because, in total internal reflection 100% of incident light is reflected back into the same medium without any loss of intensity, while in reflection from mirrors and lenses there is always some loss of intensity.

14.

$$\tau = MB\sin\theta$$

$$M = \frac{\tau}{B\sin\theta}$$

$$M = \frac{0.055}{0.35 \times 0.5}$$

$$M = 0.31\, JT^{-1}$$

15. Ratio of electrons orbit radius to nuclear radius

= $(10^{-10} / 10^{-15}) = 10^5$ m

The radius of sun is R = 7 X 10^8 m

If we consider radius of earth orbits in same ratio the expected radius of earth orbit would be 7 X 10^8 X 10^5 = 7 X 10^{13} m.

It means the expected radius of earth's orbit is about 500 times the actual radius which is 1.5 X 10^{11} m.

Or

The speed of the electromagnetic waves (whether its infra red rays or gamma rays) remains same no matter in which ever medium they travel.

Hence the ratio of the speeds of infra red rays and gamma rays in vacuum is 1:1.

16.

$$T = \frac{1}{\nu} = \frac{\lambda}{c}$$

$$T = \frac{5550 \times 10^{-10}}{3 \times 10^8}$$

$$T = 1.85 \times 10^{-15}\ \text{seconds}$$

Or

A potentiometer is sensitive if it is capable of measuring the small potential differences and it shows significant change in balancing length for a small change in the potential difference being measured.

Sensitivity of potentiometer means the smallest potential difference that can be measured by using it. This can be achieved by decreasing the potential gradient by increasing the length of the wire or reducing the current in the potentiometer using rheostat.

17. Here, m = 3.2g = 3.2×10^{-3} kg

$E = 10^{10}\ NC^{-1}$

Let n be the number of electrons removed from the coin. Then the charge on the coin is,

q = +n e

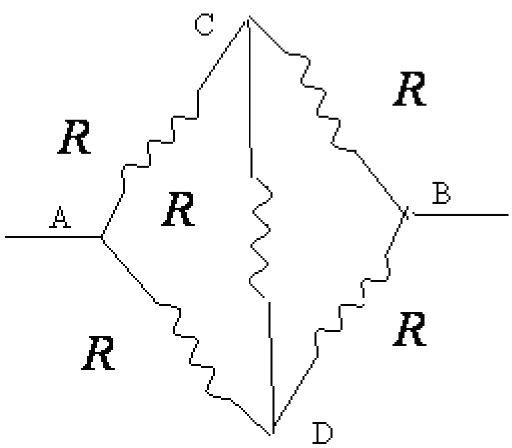
When the coin just floats,

Upward force of electric field = weight of the coin

n q E = mg

$$n = \frac{mg}{qE} = \frac{3.2 \times 10^{-3} \times 9.8}{1.6 \times 10^{-19} \times 10^{10}} = 1.96 \times 10^{7} \text{ electrons}$$

18. The network shown in the figure can be redrawn as shown in the figure below.



It is a balanced Wheatstone bridge. Therefore, point C and D are at the same potential. Since no current flows in the branch CD, this branch is ineffective in determining the equivalent resistance between terminal A and B and can be removed.

The branch ABC (= R+R= 2R) is in parallel with the branch ADB (= R+R= 2R)

$$R_{AB} = \frac{2R \text{ X } 2R}{2R + 2R} = R$$

19. We know when inductances are connected in parallel, then

$$\frac{1}{L_p}=\frac{1}{L_1}+\frac{1}{L_2}$$

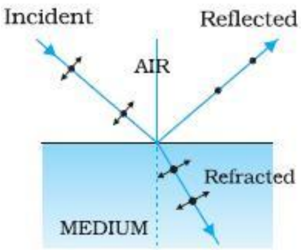
$$\frac{1}{L_p}=\frac{1}{3}+\frac{1}{7}$$

$1 / L_p = 10 / 21$

$L_p = 2.1$ H

$L_{total} = 6 + 5 + 2.1 = 13.1$ H

20. In unpolarised light, the vibrations are symmetric about the direction of propagation.For an unpolarised wave the displacement will be randomly changing with time though it will always be perpendicular to the direction of propagation.



When unpolarised light is incident on the boundary between two transparent media, the reflected light is polarised with its electric vector perpendicular to the plane of incidence when the refracted and reflected rays make a right angle with each other.

Thus when reflected wave is perpendicular to the refracted wave, the reflected wave is a totally polarised wave. The angle of incidence in this case is called Brewster's angle and is denoted by i_B. We can see that i_B is related to the refractive index of the denser medium.

Since we have $i_B + r = \pi/2$, we get from Snell's law

$$\mu = \frac{\sin i_B}{\sin r} = \frac{\sin i_B}{\sin \pi/2 - i_B} = \frac{\sin i_B}{\cos i_B} = \tan i_B$$

Or

If ordinary unpolarised light of intensity I_o' is incident on first Polaroid (A,say),

Intensity of light transmitted from first polaroid is $I_o=I_o'/2$

Given angle between transmission axes of two polaroids A and B is initially 90º.

According to Malus law, intensity of light transmitted from second polaroid (B, say) is

$I = I_o \cos^2\theta = I = I_o \cos^2 90^\circ = 0$

When one more polaroid (C say) is placed between A and B making an angle of 45º with the transmission axis of either of polaroids, then intensity of light transmitted from A is

$$I_A = \frac{I_0'}{2} = I_0$$

Intensity of light transmitted from C is

$$I_c = I_0 \cos^2 45^\circ = \frac{I_0}{2}$$

Intensity of light transmitted from polaroid B is

$$I_B = I_c \cos^2 45^\circ = \frac{I_0}{2} \times \frac{1}{2} = \frac{I_o}{4}$$

This mean that the intensity becomes one-fourth of intensity of light that is transmitted from first polaroid.

On further rotating the polaroid C such that if angle between their transmisson axes increases, the intensity decreases and if angle decreases, the intensity increases.

21. In a pure inductive circuit

$I = I_0 \sin\omega t$

$V = V_0 \sin(\omega t + 90^0)$

$V = V_0 \cos\omega t$

V leads by $\pi/2$

Hence,

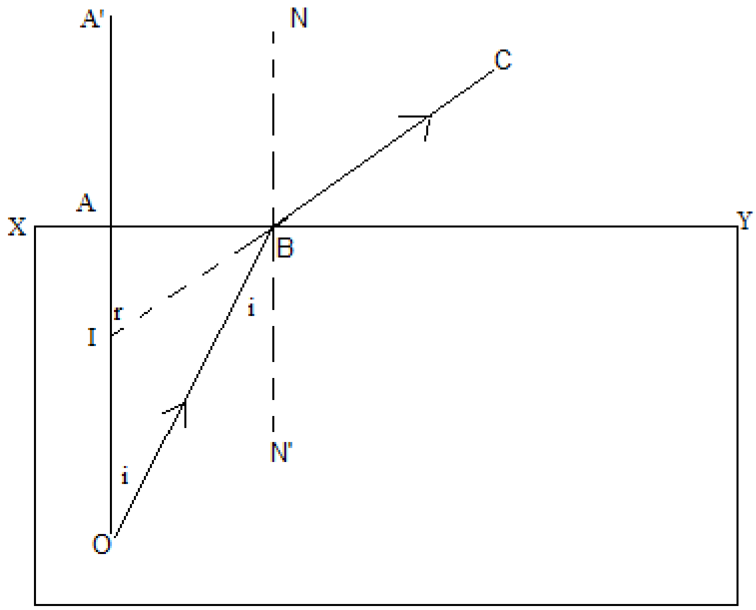
$$\text{Power}, P = \frac{1}{T}\int_0^T VIdt$$

$$P = \frac{1}{T}\int_0^T V_0 I_0 \sin\omega t \cos\omega t\, dt$$

$$P = \frac{V_0 I_0}{2T}\int_0^T \sin 2\omega t\, dt$$

$P = 0$

22.



In figure, OA passes straight along OAA'. Another ray of light from O incident at angle i on XY along OB deviates away from normal. It gets refracted at angle r along BC. When we produce back BC meets OA at I. Hence it's the virtual image of O. Hence AI is the apparent depth and AO is the real depth.

$\angle$ AOB = $\angle$ OBN' = i

$\angle$ AIB = $\angle$ NBC = r

In Δ OAB, sin i = AB / OB

In Δ IAB, sin r = AB / IB

Light is travelling from denser to rarer medium, so

μ_w^a = Sin r / sin i = (AB / IB) x (OB / AB) = OB / IB

μ_w^a = OA / IA = real depth / apparent depth = x / y

y = x / μ_w^a = x / 4/3 = (¾) x

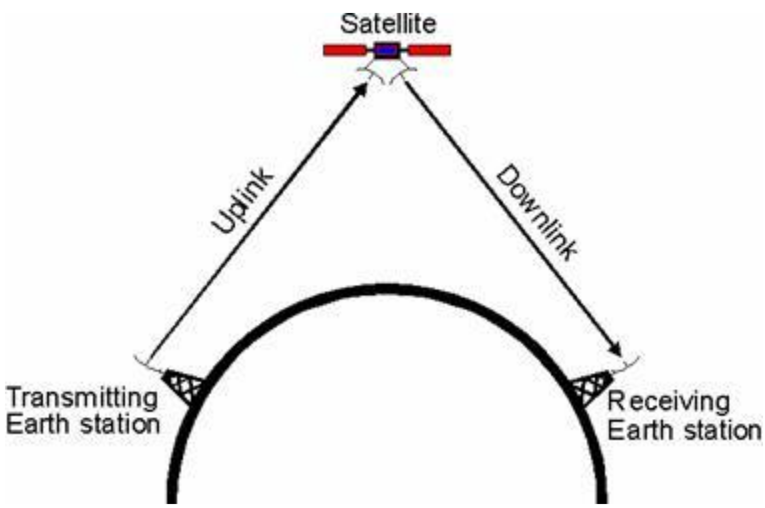
Hence apparent depth is ¾ of the real depth

Or

The communication of signal between transmitter and receiver with the help of satellite is called satellite communication.

Working: A satellite receives the signals from earth (which is beamed by transmitter), processes the signals and transmits them back to earth. The signal beamed by the satellite is received back on a distant location on earth, from which the original information signal is extracted by the process called demodulation.

The frequency at which satellite receives the signal is called uplink frequency while the frequency at which satellite returns the signal towards earth is called as downlink frequency. The downlink frequency and uplink frequencies are different so that there is no interference between these two signals.



23.

(a) In Young's double slit experiment, the distance of the nth fringe from the central fringe is given by;

$X_n = (2n - 1)\,\lambda D/2d$

Where n= 1,2,3…..

For second dark fringe, n=2

$X_2 = (2x\ 2-1)\,(\lambda D/2d) = 3(\lambda D/d)$

Here $\lambda = 6000 \times 10^{-10}$m; D = 0.800m; d=0.200x 10^{-3}m

$$X = \frac{3 \times 6000 \times 10^{-10} \times 0.800}{2 \times 0.200 \times 10^{-3}} = 0.360 \times 10^{-2}\text{m}$$

(b) The distance of nth bright fringe from the central fringe is given by;
$x_n = n(\lambda D/d)$

For second bright fringe, n=2

Therefore

$$x_2 = 2(\lambda D/d) = \frac{2 \times 6000 \times 10^{-10} \times 0.800}{0.200 \times 10^{-3}} = 0.480 \times 10^{-2} m$$

Or

The information or message signal is called "base band signal". In general, it spreads over a range of frequencies called the signal 'bandwidth'.

(i) The frequency range of voice of human speech is from 300 Hz to 3100Hz at the maximum end. Hence the bandwidth of 3100-300= 2800 Hz is considered adequate for speech transmission.

(ii) Different musical instruments produce high frequencies covering the entire range of audible frequencies from 20 Hz to 20 KHz. Hence, a bandwidth of about 20 KHz is required.
Video signals require about 4.2 MHz of bandwidth. As TV signals contain both video as well as voice, hence a signal band width of 4.5 MHz is required. But to avoid interference among telecast by different TV stations, a TV channel is usually allotted 6 MHz of bandwidth for transmission

24. Because of the emitter current the voltage drop across the 1kΩ resistor connected to the emitter is 1 V.
[1 mA x 1 kΩ = (1/1000) A x 1000 Ω = 1 V].
The voltage drop across the base-emitter junction of the silicon transistor is 0.7 V.
Therefore, the base voltage under no signal (quiescent) condition is 1 V + 0.7 V = 1.7 V.

25. The big difference really wouldn't be the charge. The scattering of a negative particle really doesn't look that much different from the scattering of a positive particle. The big difference would be the mass. Alpha particles are much, much bigger and hence tend to carry much, much more energy than electrons. So while the alpha particle shrugs off the electrons in the gold foil, the electron is more likely to get scattered by them. The experiment wouldn't be nearly as clean.

26. The photocurrent does not depend on the frequency of incident radiation, hence the photocurrent remains unchanged. The maximum kinetic energy increases with increase of frequency, given by

$E_K = h\nu - W$

If frequency is doubled, $E_K' = 2h\nu - W$

$$\frac{E_K'}{E_K} = \frac{2h\nu - W}{h\nu - W}$$

$$= \frac{2h\nu - 2W + W}{h\nu - W}$$

$$= 2 + \frac{W}{h\nu - W} > 2$$

i.e., maximum kinetic energy will increase to slightly more than double value.

27.

For a convex lens, we have u = −15 cm and f = 10 cm.

The mirror formula is

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\frac{1}{v} = \frac{1}{10} + \frac{1}{15}$$

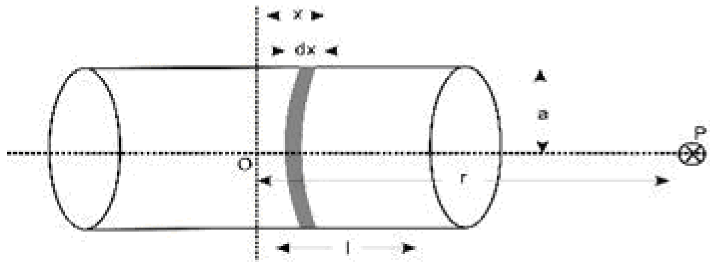
v = 6 cm

The image is smaller in size, virtual and erect. The position of the image is at 6 cm to the right of the mirror.

The final image is formed at the position of the object itself when an object lies at the centre of curvature, but the image will be real and inverted in nature. So, the concave mirror should be placed at 20 cm from the pole.

28. The magnetic field lines for a bar magnet and a solenoid resembles each other. Thus a bar magnet may be considered as a large number of circulating circuits in analogy with a solenoid.

Consider the figure shown below:



The magnitude of the field at point P due to the circular element is,

$$dB = \frac{\mu_0 n dx I a^2}{2[(r-x)^2 + a^2]^{3/2}}$$

The magnitude of total field is obtained by integrating from x = - l to x = +l, thus,

$$B = \frac{\mu_0 n I a^2}{2}\int_{-l}^{+l}\frac{dx}{[(r-x)^2 + a^2]^{3/2}}$$

Considering the far axial field of solenoid i.e. r>> a and >> l, then

$$[(r-x)^2 + a^2]^{3/2} \approx r^3$$

$$\therefore B = \frac{\mu_0 n I a^2}{2r^2}\int_{-l}^{+l} dx$$

$$= \frac{\mu_0 n I a^2 2l}{2r^3}$$

Since magnetic moment of solenoid = n (2l) I (πa^2)

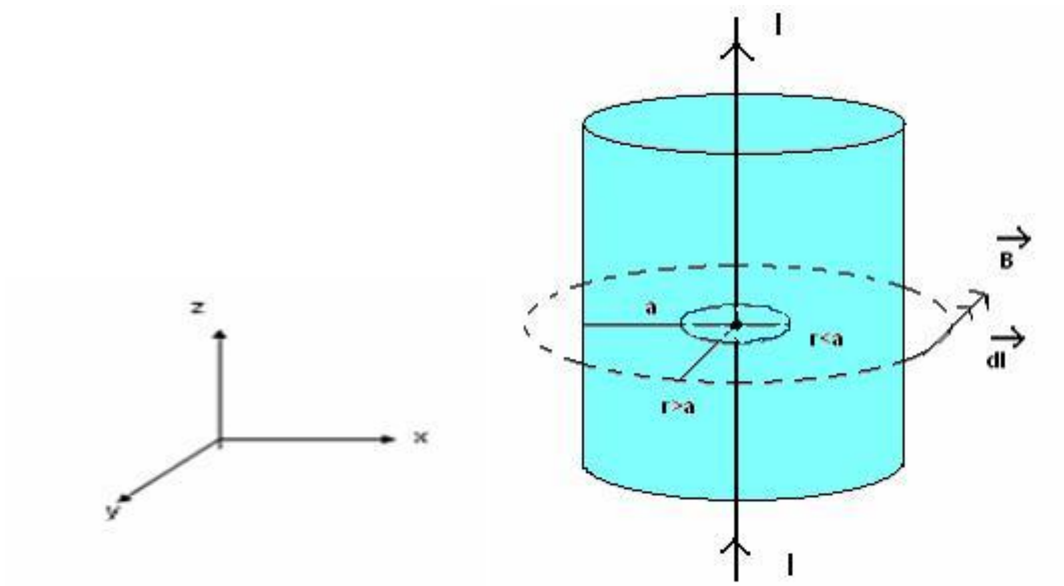
$$\therefore B = \frac{\mu_0 2m}{2\pi r^3}$$

This is also the far axial magnetic field of a bar magnet. Thus, a bar magnet and a solenoid produce similar magnetic field.

Or

Since the current distribution possesses cylindrical symmetry, therefore the magnetic field it generates also possesses cylindrical symmetry. The magnetic field circulates in the x-y plane in an anti-clockwise direction.

Let us first calculate the magnitude of magnetic field outside the wire and apply Ampere's circuital law to a circular Amperian loop in the x-y plane where the loop is centered at the centre of the wire, and is of radius r>a, where "a" is the radius of the cylindrical wire.



As the magnetic field lines form closed circle, so the magnetic field is tangential to the loop everywhere, and is in the same direction as dl taken in the counter clock wise direction. Thus, the angle between the magnetic field and dl is zero everywhere on the loop.

Also, the magnitude of magnetic field is constant. So the situation is same as that for an infinitely thin wire.

From Ampere's law,

$$\oint \vec{B}.d\vec{l} = \oint \frac{\mu_0}{2\pi r} dl = \frac{\mu_0}{2\pi r} \oint dl$$

We have, $B = \frac{\mu_0 I}{2\pi r}$ for r>a.

(Since $\oint dl = 2\pi r$, is the circumference of the circle)

That is, $B \alpha \frac{1}{r}$

Let us now apply Ampere's circuital law to a circular Amperian loop which is of radius r < a. The current I_e enclosed by the loop of radius r < a is

$$I_e = \frac{I}{\pi a^2} \pi r^2 = \frac{I r^2}{a^2}$$

From Ampere's law,

$$\oint \vec{B}.d\vec{l} = \mu_0 \mu_r I_e$$

$$2\pi r B = \mu_0 \mu_r I_e = \mu_0 \mu_r \frac{Ir^2}{a^2}$$

$$B = \frac{\mu_0 \mu_r Ir}{2\pi a^2}, \text{that is } B \alpha r$$

29. Interference is the phenomena in which the redistribution of light energy in a medium takes place due to superposition of light waves from two coherent sources.

The interference may be of two types:-

1. Constructive interference
2. Destructive interference

We are given with the values,

$\Delta D = - 5 \times 10^{-2}$ m.

$\Delta \beta = - 3 \times 10^{-5}$ m

$d = 10^{-3}$m

To find out, wavelength (λ) =?

We have the relation,

$\Delta \beta = \Delta D. \lambda / d$

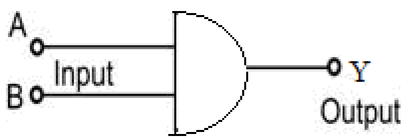
Hence wavelength (λ) can be given by

$\lambda = d. \Delta \beta / \Delta D = 10^{-3} \times (- 3 \times 10^{-5}) / (-5 \times 10^{-2})$

$\lambda = 6 \times 10^{-7}$ m.

Or

The logic symbol of AND is shown in fig.

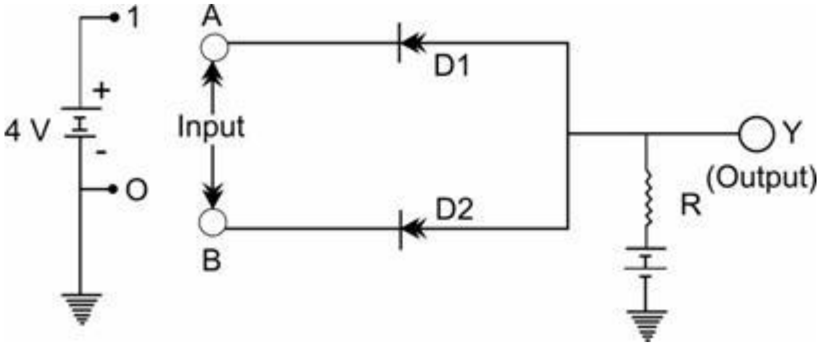


The truth table of AND gate is given below:-

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Realization of an AND gate:

To realize an AND gate having two inputs A and B, we complete the electrical circuit as shown below in fig. using two diodes D_1 and D_2.



Operation:

(i) When A = 0, B = 0, both diodes conduct and offer low(almost zero) resistance. Hence, whole voltage drop is across the resistor R and the net output voltage level at Y will be zero.

(ii) When A = 1, B = 0, diode D_1 does not conduct but D_2 conducts and provides a low resistive path. As a result, output voltage level at Y is still zero.

(iii) When A = 0, B = 1, diode D_1 conducts and provides a low resistance path but D_2 does not conduct. Output voltage level at Y is even now zero.

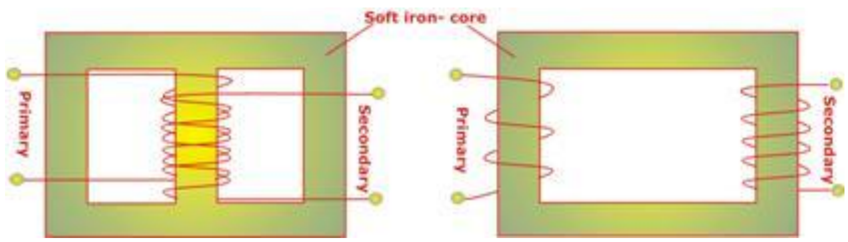
(iv) When A = B = 1, none of the two diodes conduct and there would be no drop in voltage across resistance R. Hence, voltage of Y will be 4V i.e., Y will be at voltage level 1.

Thus, output level is 1 only when both inputs A and B are at 1 level, which is the condition of AND gate.

30.

(i)Principle underlying tehw orking of transformer: The principle is Mutual Inductance. When a changing source of voltage is introduced across a coil (which is physically coupled to another coil), the changing current through it induces an EMF across the second coil.

A transformer consists of two sets of coils, insulated from each other. They are wound on a soft-iron core, either one on top of the other, or on separate limbs of the core.



One of the coils is called the *primary coil*, and has N_p turns. The other coil, the *secondary coil*, has N_p turns. The relative numbers depend on whether the voltage needs to be stepped up or stepped down.

By definition, the voltage to be *transformed* is introduced across the *primary* coil. When the alternating voltage is applied across the primary, the resulting alternating current through it produces a changing magnetic field, whose flux through the secondary coil changes.

From Faraday's law, this changing flux induces an EMF across the secondary, whose magnitude depends on the amount of coupling of the two coils, numerically measured as mutual inductance. The more this coupling or association of the two coils, the more is mutual inductance, and therefore the induced EMF.

If Φ is the flux through each turn of the core, then through *N* turns around the core, the total flux is $N\Phi$.

So, the EMF induced in the secondary coil is $E_S = -N_S \frac{d\Phi}{dt}$

Similarly, there will also be an EMF induced in the *primary* coil itself, due to self inductance, given by

$$E_P = -N_P \frac{d\Phi}{dt}$$

If the voltage applied across the primary is V_P, then if its resistance is *R*, the current through it will be $I_P = \frac{V_P - E_P}{R}$.

However, assuming negligible resistance, since we cannot have an infinite current through the coil, then

$E_P \simeq V_P$

If the secondary is an open circuit, no current is drawn from it then, voltage across it will be

$$V_S = E_S = -N_S \frac{d\Phi}{dt}$$

From equations, it is clear that

$$\frac{V_s}{V_P} = \frac{N_S}{N_P}$$

If the transformer is 100% efficient, that is, all the input power is transferred to the secondary without any leakage or losses, then

$$I_P V_P = I_S V_S$$

This implies that

$$\frac{I_P}{I_S} = \frac{V_s}{V_P} = \frac{N_S}{N_P}$$

It is clear from that if $N_S > N_P$, the voltage will be stepped up, and if $N_S < N_P$ it will be stepped down.

However, in a step down transformer, there will be a greater current in the secondary as compared to the primary and vice-versa.

(ii)The possible sources of power losses in practical transformers can be (1) Flux Leakage: Not all flux of the primary can be associated with the secondary. There is always some flux which due to lack of absolute coupling, can leak. To avoid this, the coils are wound over each other again and again.

(2) Resistance of windings: The transformer coil wires cannot have absolutely zero resistance, so some Joule loss is inevitable.

(3) Core eddy currents: Since the core is a very good conductor itself, currents are induced in it due to changing magnetic fields, called eddy currents. These also result in losses.

(4) Hysteresis: Some part of energy is frozen into the core permanently in the form of a residual magnetic field due to its ferromagnetic character.

(iii) No, it doesnot violate the energy conservation. When low voltage is converted to high volatge , the current is lowered, thereby conserving the total energy dissipated across the primary and secondary coil.

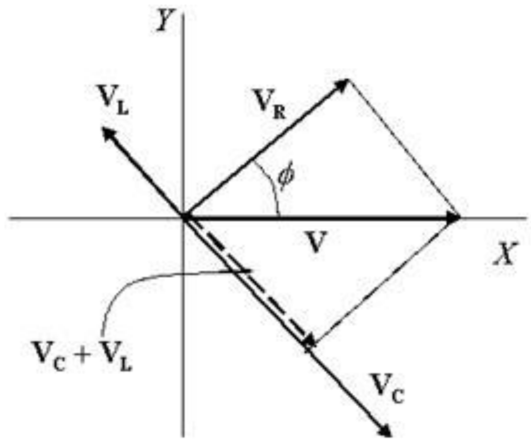
Or

In the phasor diagram, since at $t=0$, the external source of EMF is $V=V_0$ (peak value), which is the *x* component of the phasor $\mathbf{V}$, this vector will be along the *X* axis. The current phasor $\mathbf{I}$ will be at an angle ϕ relative to this.

So, since $\mathbf{V_R}=R\mathbf{I}$, it will be parallel to this current phasor, at angle ϕ relative to $\mathbf{V}$.

Similarly, looking at equations, it is evident that $\mathbf{V_L}$ will make an angle $+\frac{\pi}{2}$ and $\mathbf{V_C}$ will make angle $-\frac{\pi}{2}$ relative to $\mathbf{V_R}$.

This also implies that $\mathbf{V_L}$ and $\mathbf{V_C}$ will lie in *opposite* directions, as the following figure shows.



It is obvious from the figure that the vector $\mathbf{V_R}$ is perpendicular to the vector $\mathbf{V_C}+\mathbf{V_L}$, and *also*, of course, $\mathbf{V}=\mathbf{V_R}+(\mathbf{V_L}+\mathbf{V_C})$

Taking the dot product

$\mathbf{V}\bullet\mathbf{V}$ gives

$$V_0^2=(V_R)_0^{\;2}+(\mathbf{V_C}+\mathbf{V_L})\bullet(\mathbf{V_C}+\mathbf{V_L})$$
$$=(V_R)_0^{\;2}+[(V_L)_0-(V_C)_0]^2$$
$$=[R^2+(X_C-X_L)^2]I_0^2$$

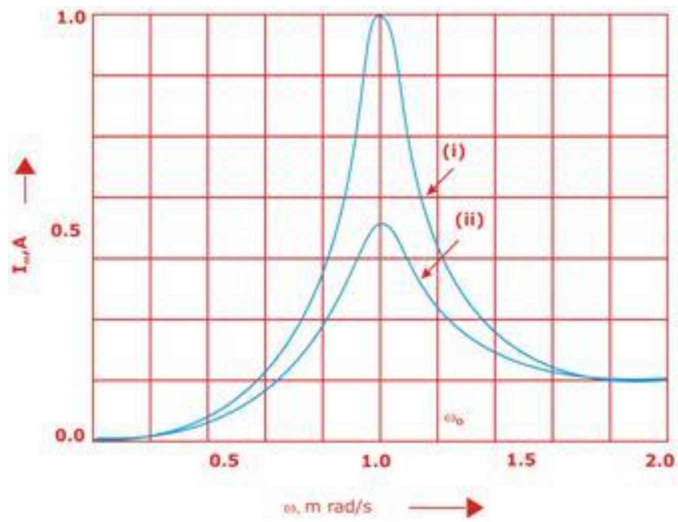
From this, we immediately get

$$I_0 = \frac{V_0}{Z}; \quad Z = \sqrt{R^2 + (X_C - X_L)^2}$$

The factor Z is the analog of resistance in a purely resistive circuit, and is called *Impedance*.

The phase is immediately found from the simple phasor picture $\tan\phi = \frac{X_C - X_L}{R}$

(ii)The current as a function of source frequency is plotted below:



(iii)Whenever one needs a selection mechanism to select a particular frequency out of a range of frequencies, such resonating circuits are useful.

For instance, the tuner in a radio is precisely such a circuit, whose L and C can be varied. Varying these components varies the resonant frequency. As soon as the resonant frequency matches a particular external signal (radio signal) frequency, there is a sharp response, and the device picks up that signal.

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