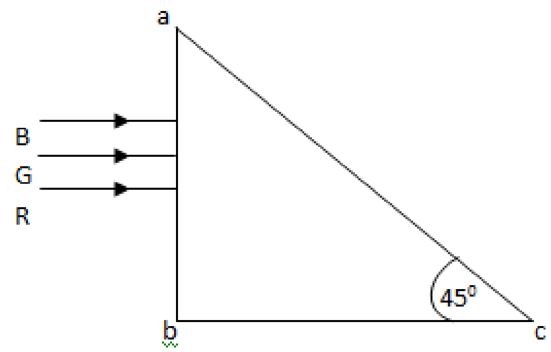
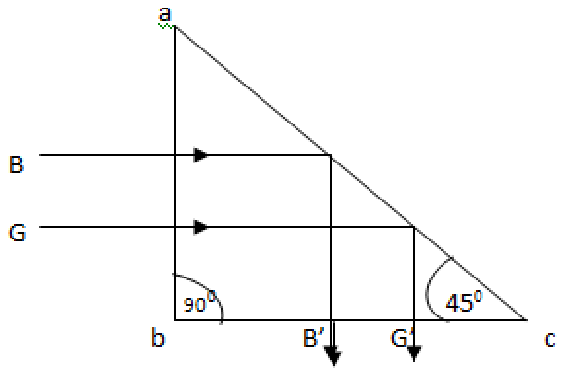
Q27. Three light rays red (R), green (G) and blue (B) are incident on a right angled prism 'abc' at face 'ab'. The refractive indices of the material of the prism for red, green and blue wavelengths are 1.39, 1.44 and 1.47 respectively. Out of the three which colour ray will emerge out of face 'ac'? Justify your answer. Trace the path of these rays after passing through face 'ab'.



Answer:
The red light ray (R) will emerge out of face. The path of green (G) and blue (B) light rays will be as



$\mu = A + \frac{B}{\lambda^2}$, we know wave length of Red (R) is maximum; hence refractive index of this prism for red will be minimum. Also we have $\mu_1 sini = \mu_2 sinr$, and critical angle for red is maximum hence except red colour Green and Blue light rays will incident at ac surface more than the critical angle hence blue and green will suffer total internal reflection where as Red will emerge out for ac face.

Q28. (a) Derive an expression for the average power consumed in a series LCR circuit connected to a.c. source in which the phase difference between the voltage and the current in the circuit is ϕ .
(b) Define the quality factor in an a.c. circuit. Why should the quality factor have high value in receiving circuits? Name the factors on which it depends.

Answer

(a) **To find power consumed in LCR circuit :**

Given E = alternating emf applied to an LCR circuit $= E_0 \sin \omega t \;\; \ldots\ldots\ldots(1)$

If alternating current developed lags behind the applied emf by a phase angle ϕ then

$$I = I_0 \sin(\omega t - \phi) \ldots\ldots(2)$$

Total work done over a complete cycle is

$$W = \int_0^T EI\,dt$$

$= \int_0^T E_0 \sin \omega t \; I_0 \sin(\omega t - \phi)\,dt$

$= E_0 I_0 \int_0^T \sin \omega t \; \sin(\omega t - \phi)\,dt$

$= \frac{E_0 I_0}{2} \int_0^T 2 \sin \omega t \; \sin(\omega t - \phi)\,dt$

$= \frac{E_0 I_0}{2} \int_0^T [\cos(\omega t - \omega t + \phi) - \cos(\omega t + \omega t - \phi)]$

$$[\because 2 \sin A \sin B = \cos(A - B) - \cos(A + B)]$$

$= \frac{E_0 I_0}{2} \int_0^T [\cos \phi - \cos(2\omega t - \phi)]\,dt$

$= \frac{E_0 I_0}{2} \left[t \cos \phi - \frac{\sin(2\omega t - \phi)}{2\omega}\right]_0^T$

$= \frac{E_0 I_0}{2} [T \cos \phi]$

$\therefore$ Average power in LCR circuit over a complete cycle is

$P = \frac{\omega}{T} = \frac{E_0 I_0}{2} \cos \phi = \frac{E_0}{\sqrt{2}} . \frac{I_0}{\sqrt{2}} . \cos \phi$

$\therefore \; P = E_v \, I_v . \cos \phi$

(b) **Quality factor in an a.c. :**

The Q-factor of a resonant LCR circuit is defined as ratio of the voltage drop across inductor or capacitor to the applied voltage.

$\therefore Q = \frac{\text{Voltage across L or C}}{\text{applied voltage}}$

Since $V_L = I\,X_L$ and $V = IR$

$\therefore Q = \frac{I\,X_L}{IR} = \frac{\omega_0 L}{R}$

Hence at high frequencies, the Q-factor $\frac{\omega_0 L}{R}$ is quite large.

∴ The voltage drop across the inductor will be quite large as compared to the applied voltage.

Also $Q = \frac{1}{\sqrt{LC}} \cdot \frac{L}{R} \quad \left[\because \omega_0 = \frac{1}{\sqrt{LC}}\right]$

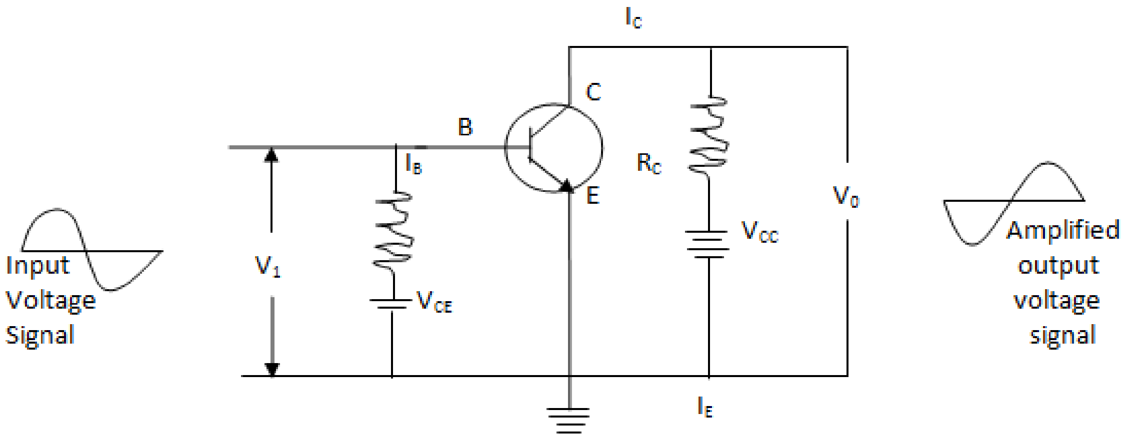
$\therefore Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

The Q-factor of LCR-series circuit depends on L, C and R.

Q29. Explain, with the help of a circuit diagram, the working of n-p-n transistor as a common emitter amplifier.

Answer:

Transistor as an Amplifier - Common Emitter (C E) configuration: The circuit diagram of a common emitter amplifier using n-p-n transistor is given below.



The input (base-emitter) circuit is forward biased and the output (Collector-emitter) circuit is reversed biased. When no a.c. signal is applied, the potential difference V_{CC} between the collector and emitter is given by

$V_{CC} = V_{CE} + I_C R_C$

When an a.c. signal is fed to the input circuit, the forward bias increases during the positive half cycle of the input. This results in increase in I_C and decrease in V_{CC}. Thus during positive half cycle of the input, the collector becomes less positive.

During the negative half cycle of the input, the forward bias is decreased resulting in decrease in I_E and hence I_C. Thus V_{CC} would increase making the collector more positive.

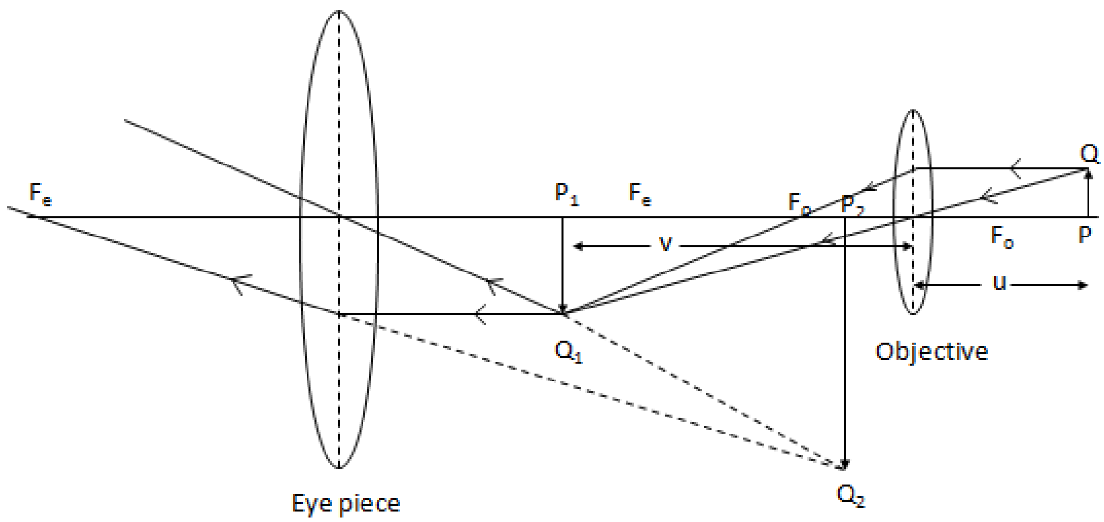
Hence in a common-emitter amplifier, the output voltage is 180^0 out of phase with the input voltage.

(i) Input signal voltage $V_i = I_B R_B$
(ii) Output signal voltage $V_o = I_C R_C$
(iii) Voltage gain (Av)of the amplifier is the ratio of output voltage to the input voltage.

$$Av = \frac{V_o}{V_i} = \frac{I_C\,R_C}{I_B\,R_B} = \beta\left(\frac{R_C}{R_B}\right) \quad \because \; \beta = \frac{I_C}{I_B}$$

Q30. Draw the labeled ray diagram for the formation of image by a compound microscope.
Derive the expression for the total magnification of a compound microscope. Explain why both the objective and the eyepiece of a compound microscope must have short focal lengths.

Answer
It consists of objective and eye piece. The objective is a convex lens of small aperture and small focal length. The aperture of the eye piece lens is slightly greater and the focal length is also small.



Ray diagram : PQ is an object kept in front of objective ($f_o <$ u $< 2\,f_o$), P_1Q_1 is the image formed by objective this image serves as object for eye piece, since P_1Q_1 lies between the focus and optical center of eye piece hence an extended image P_2Q_2 is formed by eye piece. Thus P_2Q_2 is the final image of PQ produced by the compound microscope.

Magnifying power= Height of final image/ Height of original image= P_2Q_2 / PQ = (P_1Q_1/PQ)X(P_2Q_2/ P_1Q_1)
From the above figure = P_1Q_1/PQ = Magnifying power of objective =M_o
P_2Q_2/ P_1Q_1=Magnifying power of eye piece= M_e

Magnifying power of compound microscope :

$$M = M_o \times M_e$$

For normal vision

$$M_n = \frac{v}{u}\frac{D}{f_e}$$

For distinct vision

$$M_d = \frac{v}{u}\left(1 + \frac{D}{f_e}\right)$$

For large magnifying power, f_0 and f_e both have to be small. Also f_0 is taken to be smaller than f_e so that the field of view may be increased.