MODEL SET-4

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

Question Nos. 1 to 11 are of short answer type. Each question carries 2 marks. **11 × 2 = 22**

SHORT QUESTIONS

1. Write two properties of electric field lines ?

Ans.—Following are the two properties of electric field lines—

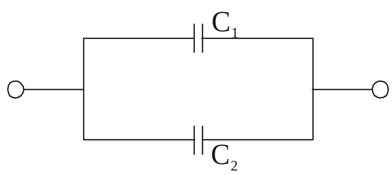
(1) Two electric field lines do not cross each other,

(2) The electric field lines begin from positive charge and terminated on negative charge.

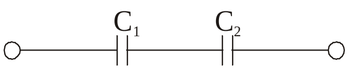
2. Two condensers have capacitances C_1 and C_2 . Show their parallel combination and series combination circuits.

Ans.—Paralle combination :

$$\boxed{C = C_1 + C_2}$$



Series combination :



3. Write Lenz's law of electromagnetic induction.

Ans.—Lenz's law of electromagnetic in direction :

It states that—"The direction of included e.m.f. or current is such thta it opposes the cause which produces it."

Its expression is as follows :

$$\boxed{\in = -N\frac{d\phi B}{dt}}$$ It gives the direction of induced e.m.f.

Here, –ve sign shows that induced e.m.f. opposes the change in magnetic flux. It was explained by Lenz.

4. Write any two properties of X-rays.

Ans.—Two properties of X-rays are as follows—

(1) They are not deflected by electric or magnetic field.

(2) They travel with the speed of light as electromagnetic wave.

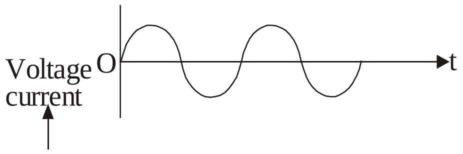
5. Write any two N-type and P-type semiconductors.

Ans.—Following are the difference between n-type and p-type semiconductor—

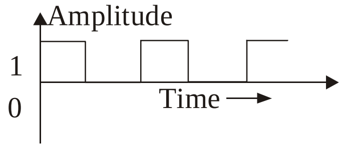
	n-type semiconductors		p-type semiconductors
1.	When pentavalent impurity atoms like As, sb etc. are added in the instrinsic semiconductor, we get n-type semiconductor.	1.	When trivalent impurity atoms like gallium, indium etc. are added in the intrisic semi-conductor, we get p-type semiconductors.
2.	The majority carriers in the n-type semi-conductor are electrons and minority carriers are holes.	2.	The majority carriers in p-type semiconductor are holes and minority carriers are electrons.
3.	$n_e >> n_h$	3.	$m_h >> n_e$

6. What do you mean by analog and digital signal ?

Ans.—Analog signal—It is an electrical wavelform continously changing in magnetude with time.



Digital signal—It is a discountinuous and discrete signal having only binary variations 1 and 0 with time.



7. Define current density. Write its SI unit and dimension.

Ans.—Current density—Current density of a conductor is defined as the amount of current passing per unit area of the conductor held to the flow of chares :

It can be expressed as—

$\boxed{J = \frac{I}{A}}$ It is a vector quantity.

The S.I. unit of current density is ampere/ metre^2 (Am^{-2})
The dimension of current density is $[M^oL^{-2}T^oA]$

8. State Kirchoff's two laws of electrical network.

Ans.—Kirchhoff's first law—It states that—
"The algebraic sum of all the currents meeting at a junction in a closed electrical circuit is zero."

$$\boxed{\sum I = 0}$$

It is also called junction law. It is based on the law of conservation of charges. Actually it is Kirchhoff's current law.

Kirchhoff's second law—It states that—
"The algebraic sum of all voltage that is, the potential difference across all elements and e.m.f. of all sources in any closed electrical circuit is zero.

$\boxed{\sum E + \sum \Delta V = 0}$ or, $\boxed{\Delta V = 0}$

It is also called loop law and Kirchhoff's voltage law.
It is based on the law of conservation of energy.

9. State two properties of nuclear force.

Ans.—Two properties of nuclear forces are as follows :
(1) It is mainly an attractive force.
(2) It is strong fundamental force in nature.

10. What is the dl-Brogie wavelength associated with an electron, accelearated through a potential difference of 100 volt.

Ans.—As we know that,

$$\lambda = \frac{12.27}{\sqrt{V}} A^o, \text{ for electron}$$

$$= \frac{12.27}{\sqrt{100}}$$

$$= \frac{12.27}{10}$$

$$\boxed{\lambda = 1.22 A^\circ}$$

11. An astronomical telescope having a magnifying power of 8 consists of two thin lenses 45 cm. apart. Find the focal length of the lenses.

Ans.—We have,

$$M.P. = \frac{f_o}{f_e}$$

$$8 = \frac{f_o}{f_e}$$

$\therefore \quad f_o = 8 f_e$

$f_o = 8 \times 5$

$$\boxed{fo = 40\text{c.m.}}$$

Length of the telescope,

$L = f_o + f_e$

45 cm = 8 fe + fe

45 c.m. = 9fe

$$\therefore \quad fe = \frac{45\text{cm}}{9}$$

$$\boxed{fe = 5\text{c.m.}}$$

SECTION-II (NON-OBJECTIVE TYPE QUESTIONS)

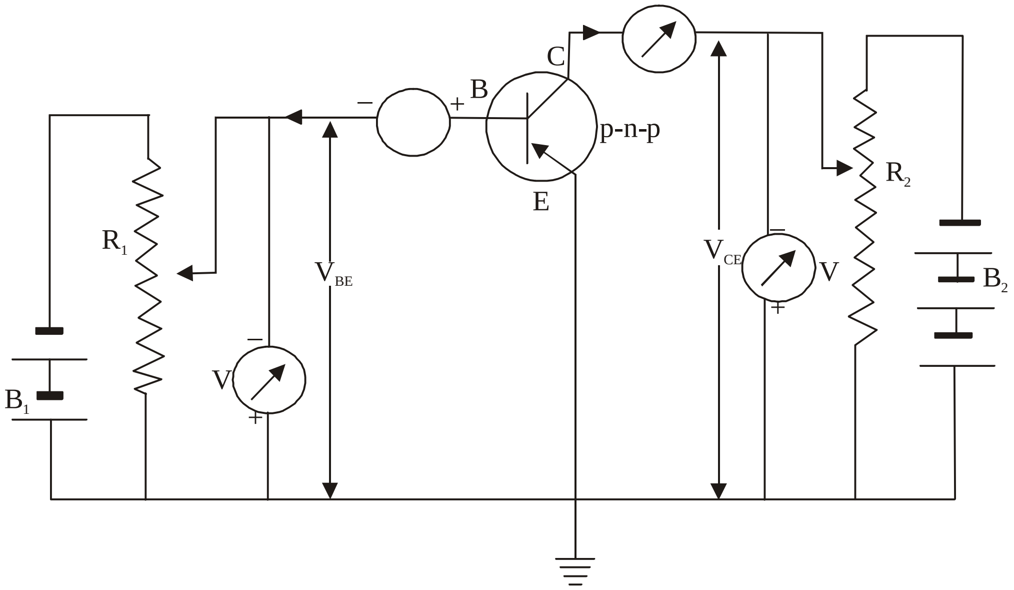
Question Nos. 12 to 15 are of long answer type. Answer must be explantory and in your own language. Each question carries 5 marks. **4 × 5 = 20**

LONG QUESTIONS

12. Discuss common transistor biasing in the case of p-n-p transistor. Discuss its characteristics curve and current amplification factor ?

Ans.—The variation of base current I_b (input) with base emitter voltage (V_{BE}) at constant collector emitter voltage (V_{CE}) is called input characteristic.

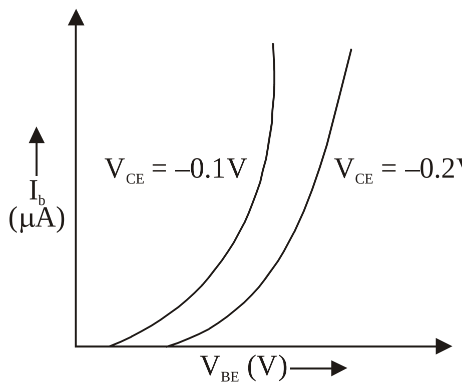
Circuit diagram to study the common-emitter characteristics of a transistor is shown.



Conclusion—

(i) The input characteristics are similar to forward bias characteristics of a junction diode.

(ii) For a given value of emitter-base voltage (V_{BE}), the base current decrease with the increase in collector emitter voltage.



Output Characteristics of Common Emitter Transistor

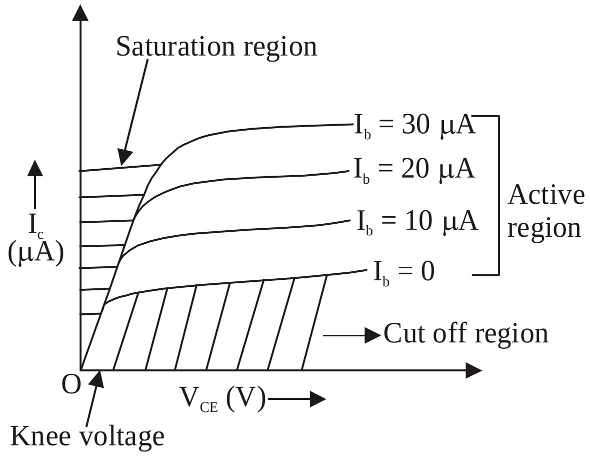
The variation of the collector current I_C (output) with collector-emitter voltage (V_{CE}) at constant base current (I_b) is called output characteristic.

(i) Keep the base current (Ib) fixed (say, 10 μA).

(ii) Now change the collector-emitter voltage (V_{CE}) using variable resistance R_2 and note the corresponding values of collector current. (I_C)

(iii) The graph between the various values of V_{CE} and I_C is plotted which is the output characteristic of the transistor.

(iv) A set of such curves can be plotted at different fixed values of base current (say 20μ A, 30 μA, 40 μA).



Conclusion—

(i) For a given value of base current, collector current increases rapidly with the collector-emitter voltage in the begining but at high value of V_{CE} , collector current becomes constant.

(ii) For a given value of V_{CE} , the collector current (I_C) is higher for high value of base current (I_b).

Output resistance (r_o) is defined as the ratio of small change in V_{CE} (i.e. ΔV_{CE}) to the small change in collector current (ΔI_C) at constant base current.

i.e. $$r_o = \frac{\Delta V_{CE}}{\Delta I_C} / I_b = \text{constant}$$

This is also know as a.c. resistance (i.e. effective resistance in the output for an a.c. input signal).

$$\text{D.C.resistance} = \frac{V_{CE}}{I_C}$$

Output characteristics of a transistor in common-emitter configuration are divided into three regions :

(i) active region, (ii) cut off region and (iii) saturation region

Active region—Active region lies above I_B = 0 as shown in figure. In this region, collector junction in reverse biased and emitter junction in forward biased for a given value of IB, collector current increases as / VCE / increases. A transistor is operated in active region if it is used as an amplifier.\

Cut off region—Cut off region lies below IB = 0. The collecotor current has finite value under this condition. In order to cut off the transistor, the emitter junction has to made slightly reverse biased in addition to IB = 0.

Saturation region—Saturation region lies close to zero voltage axis where all the curves coincide. In this region, collector current is independent of the base current.

Current Amplification factor (β) :

(i) d.c. current gain (βdc)—

It is defined as the ratio of the collector current (I_e) to the base current (I_B). That is $\beta dc = \frac{I_C}{I_B}$

Since $I_C > I_B$, so βdc is greater than 1. The value of βdc lies between 20 and 200.

(ii) Small signal current gain (βac)—

It is defined as the ratio of small change in collector current (ΔI_C) to the small change in base-current (ΔI_B) at constant collector-emitter voltage (V_{CE}).

That is, $\beta ac = \frac{\Delta I_C}{\Delta I_B} / V_{CE} = \text{constant}$

13. Define and deduce the general expression of mutual inductance. In the case of solenoid, prove that, $M_{12} = M_{21} = M$?

Ans.—Mutual Induction—Mutual induction of two coil can be defined as the magnetic flux linked to the secondary coil due to the flow of induced current in primary coil.

Mathematically, it can be written as,

$\phi_S \propto I_P$ ...(1)

$\boxed{\phi_s = MIP}$ ...(2)

Where, M is a proportionally constant which is called mutual inductance.

$\therefore \boxed{M = \frac{\phi_S}{I_P}}$ ...(3)

Hence, mutual induction of two coils is the ratio of magnetic flux changes in secondary coil to the induced current produced in primary coil.

If IP = 1A ...(4)

$\boxed{M = \phi_S}$ ...(5)

Mutual inductance of two coils is numerically equal to change in magnetic flux in secondary coil provided induced current produced in primary coil is 1A.

According to Faraday's second law

$$\varepsilon_s = \frac{-d\phi s}{dt} \quad ...(6)$$

Using eq^n (2)

$$\varepsilon_s = \frac{-d}{dt}(MIP)$$

$$\varepsilon_s = M \cdot \left(\frac{dIP}{dt}\right)$$

$$M = \frac{\varepsilon s}{\left(\frac{-dIP}{dt}\right)} \quad ...(7)$$

Hence, mutual inductance of two coils is the ratio of induced emf produced in secondary coil to the rate of lose of induced current produced in primary coil with respect to time

If $\frac{-dIP}{dt} = 1AS^{-1}$ ...(8)

$\boxed{M = \varepsilon s}$ ...(9)

Therefore, mutual inductance of two coils is numerically equal to induced emf produced in secondary coil provided rate of loss of induced current produced in secondary coil with respect to time is $1AS^{-1}$.

S.I. unit of inductance, $L = \frac{\phi}{I} = \frac{\text{weber}}{\text{ampere}} = \text{WbA}^{-1}$

$\boxed{1\text{henry} = 1\text{weber}/1\text{ampere}}$

Solenoid—Prove that $M_{12} = M_{21} = M$

N-turns coil wrapped around soft iron core is called solenoid two solenoid S_1 and S_2 are placed co-axially as shown in next page. The magnetic field of solenoid S_1 can be expressed as,

$B_1 = \mu o n_1 I_1$ …(1)

Magnetic field of solenoid S_2,

$B_2 = \mu o n_2 I_2$ …(2)

For solenoid S_1, N, is the toal number of turns, n_1 is the total number of turns per unit lenght and the since they are placed co-axially.

$\therefore\ l_1 = l_2 = l$ …(3)

For solenoid S_2, N_2 is the total number of turns, n_2 is the total no. of turns per unit lenght.

$B_1 = \mu o n_1 I_1$ …(1)

Magnetic field of solenoid S_2

$B_2 = \mu o n_2 I_2$ …(2)

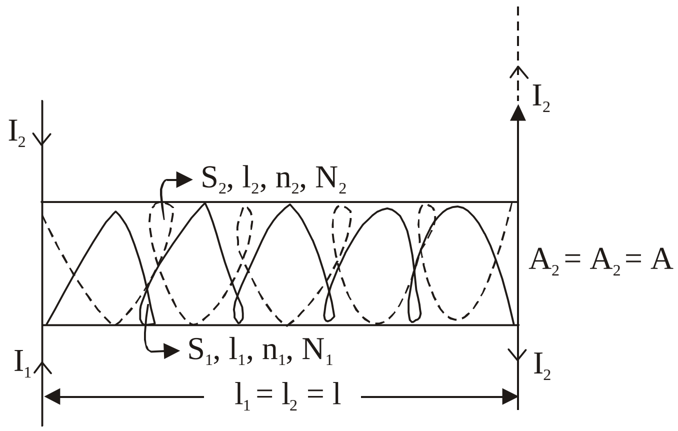
$l_1 = l_2\ l$(say) …(3)

$$\left.\begin{aligned} n_1 &= \frac{N_1}{l_1} = \frac{N_1}{l} \\ n_2 &= \frac{N_2}{l_2} = \frac{N_2}{l} \end{aligned}\right\} \quad \ldots(4)$$

Using in eq^n (1) & (2)

$$B_1 = \frac{\mu o N_1 I_1}{l} \quad \ldots(5)$$

$$B_2 = \frac{\mu o N_2 I_2}{l} \quad \ldots(6)$$



$\phi 1 = N_1 B_2 A_1$ …(7)

$\therefore\ A_1 = A_2 = A$ (say) …(8)

Using eq^n (6)

$$\phi_1 = \frac{N_1 \mu o N_2 I_2}{l} \cdot A_1$$

$$\boxed{\phi_1 = \frac{\mu o N_1 N_2 A \cdot I_2}{l}} \quad \ldots(9)$$

Similarly, $\phi_2 = N_2 B_1 A_2$

$\phi_2\ N_2\ B_1 A$ …(10)

Using eq^n (5)

$$\phi_2 = \frac{\mu o N_2 N_1 I_1 \cdot A}{l}$$

$$\boxed{\phi_2 = \frac{\mu o N_1 N_2 A \cdot I_2}{l}} \quad \ldots(11)$$

By def^n of mutual inductance, for primary coil

$$\phi \ \alpha \ I_2 \quad \ldots(12)$$

$$\boxed{\phi_1 = M_2, I_2} \quad \ldots(13)$$

Eqating eq^n (9) and (13)

$$M_2 I_2 = \frac{\mu o N_1 N_2 A_2}{l}$$

$$\therefore \boxed{M_{21} = \frac{\mu o N_1 N_2 A}{l}} \quad \ldots(14)$$

By def^n of mutual inductance for secondary coil.

$$\phi_2 \propto I_1 \quad \ldots(15)$$

$$\boxed{\phi_2 = M_{12} I_1} \quad \ldots(16)$$

Equating eq^n (16) & (11)

$$M_{12} I_1 = \frac{\mu o N_2 N_1 A I_1}{l}$$

$$\boxed{M_{12} = \frac{\mu o N_1 N_2 A}{l}}$$

From eqn (14) & (17)

$$\boxed{M_{12} = M_{21} = M}$$

Conclusion—Mutual inductance of primary coil is numericlly equl to mutual inductance of secondary coil with respect to primary coil which is simply called mutual inductance of two coil.

14. What do you mean by Wheatstone bridge. Discuss its balanced condition ?

Ans.—Wheatstone bridge—It is an arrangement of four resistance connected with galvanometer in the form of a bridge. It is used to find unknown resistance accurately.

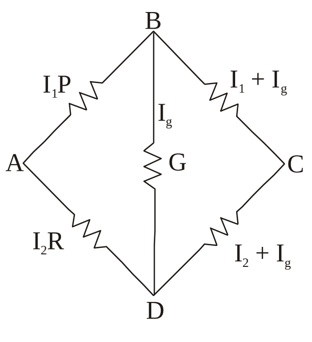
Principle—If no electric current passed through galvanometer for balanced bridge, $I_g = O$

$$\frac{P}{Q} = \frac{R}{5}$$

Working theory—There are three resistance P, Q and R are but S is unknown. With the help of known resistance unknown resistance can be determined R is known resistance.

If no electric current passed through galvanometer the bridge is said to be balanced.

Construction—



In loop ABDA

$$I_1p - I_gG + I_2 R = O \quad \ldots(3)$$

For balanced bridge. $I_g = O$

$\therefore \quad I_1p + I_2R = O$

$I_1p = I_2R$

$$\frac{I_1}{I_2} = \frac{R}{P} \quad \ldots(4)$$

In loop BCB

$$-(I_1 - I_g)Q + (I_2 + I_g)\, s + I_gG = O \quad \ldots(5)$$

For balanced bridge, $I_g = O$

$\therefore \quad I_1Q + I_2S = O$

$I_1Q = I_2S$

$$\frac{I_1}{I_2} = \frac{S}{Q} \quad \ldots(6)$$

Equating eq^n (4) & (6)

$$\frac{R}{P} = \frac{S}{Q}$$

$\therefore \quad PS = RS$

$$\frac{P}{Q} = \frac{R}{S} \text{ or } \frac{R}{S} = \frac{P}{Q} \quad \ldots(7)$$

Equation (7) is the required condition for a balanced wheatstone bridge.

Advantages—

(i) It works on deflection method therefore is reading is very accurate.

(ii) In the help of known resistance unknown resistance can be determined in the order of high accuracy.

Disadvantage—

It gives very accurate measurement only when all the resistance are nearly equal.

It is extreamly difficult to select unknown resistance is the order of known resistance.

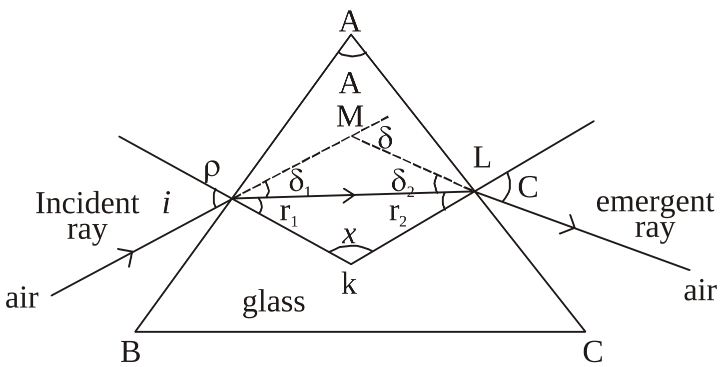
15. Deduce Prism equation and find the expression for minimum deviation produced by a prism ?

Ans.—Prism equation OR Prism formula OR Refraction through prism—

In a prism there are two refracted surface AB and AC.

Case-I—When a ray of light passes from rare to denser medium it bends towards the normal.

Case-II—When a ray of light passes from denser to rarer medium it bends away from the normal.



In ΔPML :—

$\delta = \delta_1 + \delta_2$ ...(1)

$i = \delta_1 + r_1$

$\therefore \quad \delta_1 = i - r_2$ ...(2)

$e = e - r_2$ ...(3)

Using in eq^n (1)

$\delta = i - r_1 + e - r_2$

$$\boxed{\delta = (i+e) - (r_1 + r_2)} \quad ...(4)$$

In ΔPLK :—

$r_1 + r_2 + x = 180^o$

$x = 180^o - (r_1 + r_2)$ ...(5)

In quadiralateral ALKP :—

$\angle PAL + \angle ALK + \angle LKP + \angle KPA = 360^o$ ...(6)

$A + 90^o + x + 90^o = 360^o$

$A + x = 360^o - 180^o$

$A + x = 180^o$ ...(7)

Using eq^n (5)

$A + 180^o - (r_1 + r_2) = 180^o$

$A - (r_1 + r_2) = 0$

$$\therefore \quad \boxed{(r_1 + r_2) = A} \quad ...(8)$$

Eqn (8) is called 1st eqn of prism.

Hence angle of prism is the sum total of angle of refraction through both the surface.

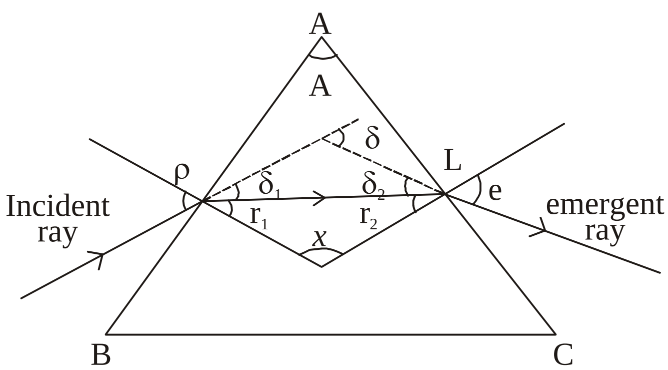
Using eq^n (8) in (4)

$\delta = (i + e) - A$

$$\therefore \quad \boxed{(i+e) = (\delta + A)} \quad ...(9)$$

Eq^n (9) is called 2nd eqn of prism. It starts that the sum total of angle of incidence & angle of emergence is equal to sum angle of deviation and angle of prism.

Case-III Minimum deviation produced by a prism—



Deviation produced by a prism is the angle b/w extended line of incident ray and emergent ray.

For min^m deviation produced by prism,

if $\delta = \delta m$ ...(1)

then $i = e$ ...(2)

$r_1 = r_2 = r$ (say) ...(3)

A/C to prism's first relation

$r_1 = r_2 = A$ ...(4)

r + r = A

2r = A

$\therefore \quad r = \left(\frac{A}{2}\right)$ …(5)

A/C to prism's second relation,

i + e = δ + A …(6)

i + i = δm + A

2i = δm + A

$\therefore \quad i = \left(\frac{\delta m + A}{2}\right)$ …(7)

A/C to snell's law,

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

Using eq^n (7) & (5)

$$\boxed{\frac{\sin\left(\frac{\delta m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = n}$$ …(9)

Eqn (9) is the general expression for minimum deviation produced by a prism.