ISSN: 2349-9141

Available online at http://www.ijirr.com

International Journal of Information Research and Review
Vol. 2, Issue, 04, pp. 611-613, April, 2015

OPEN ACCESS JOURNAL

Full Length Research Paper

NEW APPROACH FOR TOTAL INTERNAL REFLECTION IN PRISM

[*,1]Subhadip Dey, [2]Sabyasachi Mukhopadhyay and [3]Ritwik Barman

[*,1]Bidhan Chandra KrishiViswavidyalaya, Mohanpur, Nadia, West Bengal
[2]Department of Physical Science, IISER, Kolkata
[3]IISER, Kolkata

***Corresponding Author**

Received 9th April 2015; Accepted 30th April 2015

Abstract

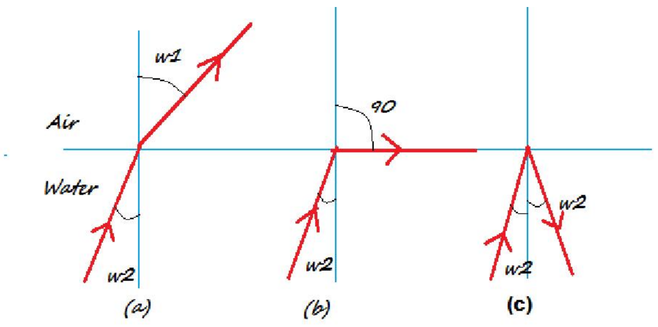
A new formula for determining the incident angle for which the light will be totally reflected from the prism is obtained here. That is, it can be estimated for what conditions we will get total reflection from any isosceles prism. There are some limitations in diversion angle of the prism in this formula, but more or less this formula is applicable for all type of isosceles prisms.

Keywords: Geometrical optics, Optics, Total reflection in prism.

To cite this paper: *Subhadip Dey, Sabyasachi Mukhopadhyay and Ritwik Barman. 2015. New Approach for total Internal reflection in Prism. International Journal of Information Research and Review. Vol. 2, Issue, 04, pp. 611-613.*

INTRODUCTION

When light is incident upon a medium of lesser index of refraction the ray is bent away from the normal, so the exit angle is greater than the incident angle. Such reflection is commonly called "internal reflection". The exit angle will then approach 90° for some critical incident angle θ_c, and for incident angles greater than the critical angle there will be total internal reflection, (Francis Jenkins and Harvey *et al.,* 1981)

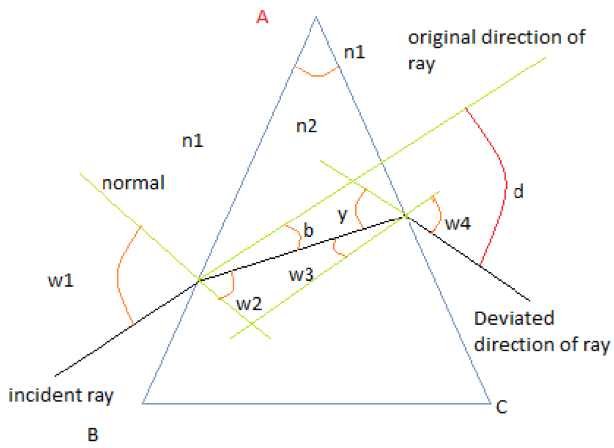


(a)Refraction; (b) Critical Angle; (c) Total internal reflection

In prism two surfaces are inclined at an angle α.

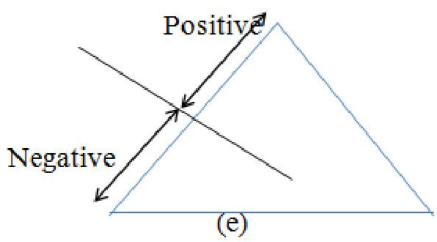
Its refraction at the second surface as well as first surface follows Snell's law (Francis Jenkins and Harvey, 1981), so mathematically it can be expressed as:-

$$\frac{\sin w_1}{\sin w_2} = \frac{n_2}{n_1} = \frac{\sin w_4}{\sin w_3}$$



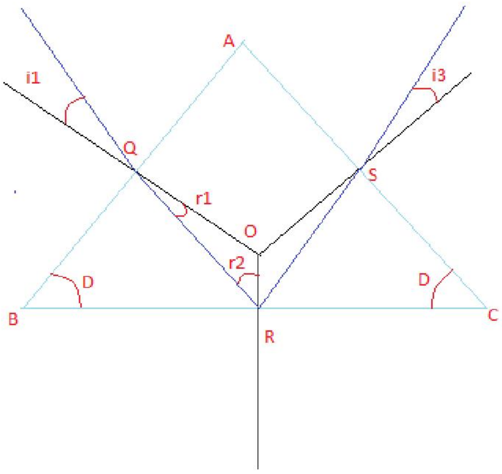
(d) Fig. Refraction in prism

The angle of deviation in first surface $=\theta 1 - \theta 2$ and the angle of deviation in second surface= $(\theta 4 - \theta 3)$. Now let divide the one surface of the prism in two halves from middle. Consider the upper half as positive and lower half as negative portion.



Now let consider the ray of light falls on the "Positive" side of the prism in one surface. And let consider that the light falls on the base of the prism at an angle greater than critical angle. So "Total reflection" will take place from the base of the prism. And it will be diverted toward the second surface of the prism. So, by this way total reflection of light in any isosceles prism can be obtained.

Theory



(f)

Now, $\angle ABC$ AND $\angle ACB$ are same. A ray of light falls on Q in the considered positive side of the prism. Let, the incident angle is i_1 and refractive angle is r_1. The two surfaces are inclined at an angle A.

$$\frac{\sin i_1}{\sin r_1} = \mu$$

$$\therefore \sin r_1 = \frac{\sin i_1}{\mu}$$

Now, D= $(r_1 + r_2)$

$i_1 = i_3$

$\Delta QOR \equiv \Delta SOR$

$\therefore QR = RS$

Now, $RS \parallel AB$ and QR $cuts$ $these$ two

$\therefore \angle QRS = \angle RQB$

$\therefore 2r_2 = 90° - r_1$

$\therefore 2r_2 + r_1 = 90°$

$\therefore 2(D - r_1) + r_1 = 90°$

$\therefore 2D - 90° = r_1$

$\therefore \sin r_1 = \sin(2D - 90°)$

$\therefore \frac{\sin i_1}{\mu} = \sin(2D - 90°)$

$\therefore \sin i_1 = \mu \sin(2D - 90°)$

$\therefore i_1 = \sin^{-1}[\mu \sin(2D - 90°)]$

$= \sin^{-1}[\mu \sin(180° - A - 90°)]$

$= \sin^{-1}[\mu \cos A]$

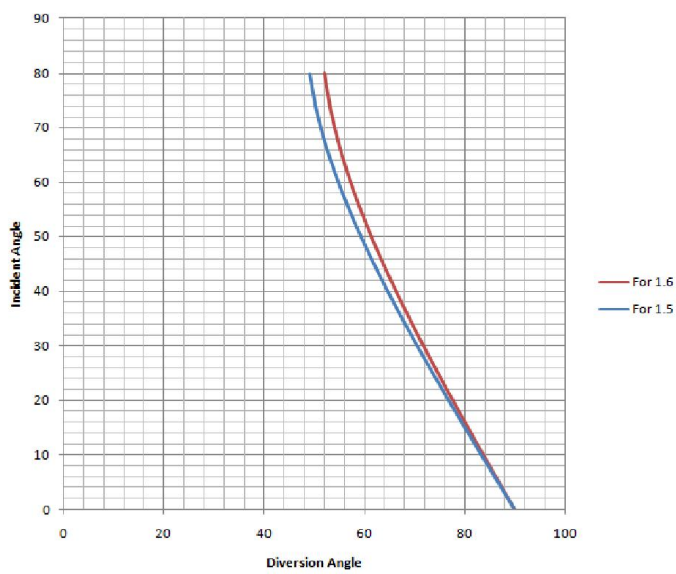
This formula is only valid for $90° \leq A \leq 48.2°$ [For $\mu = 1.5$]

CHART (For $\mu = 1.5$)

Diversion angle	Incident angle required
90	0
89	1.495614747
88	3.000812883
87	4.502652628
86	6.006221904
85	7.512113165
84	9.020932841
83	10.53330523
82	12.04987666
81	13.57132003
80	15.0983398
79	16.63167744
78	18.1721177
77	19.7204955
76	21.27770397
75	22.84470354
74	24.4225326
73	26.01231988
72	27.61529904
71	29.23282605
70	30.86639993
69	32.51768785
68	34.18855568
67	35.88110567
66	37.59772325
65	39.341136
64	41.11448873
63	42.9214406
62	44.76629254
61	46.65415748
60	48.59119242
59	50.58492187
58	52.64470107
57	54.78240029
56	57.01345417
55	59.35854597
54	61.84646872
53	64.51935398
52	67.44321131
51	70.73235022
50	74.6198192
49	79.76675454

Table 1. Diversion Angle vs. Incident Angle

Graphical Representation



(g) Fig. Graph plotted between Diversion Angle and Incident Angle for $\mu = 1.5$ and $\mu = 1.6$

Conclusion

Thus by this formula the incident angles for which the ray of light will get totally reflected from the prism can be measured easily with some limitation. This formula will be helpful for any isosceles prism. This formula may be involved in future works.

REFERENCES

Francis A. Jenkins and Harvey E. 1981. White *Fundamentals Of Optics* (Singapore: McGraw-Hill Book Company) Vol 2, Ch 2, Sec 2.1, p 24

Francis A. Jenkins and Harvey E. 1981. White *Fundamentals Of Optics* (Singapore: McGraw-Hill Book Company) Vol 2, Ch 1, Sec 1.6, p 11

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