Opticks : $b or, A treatise of the reflections, refractions, inflections and colours of light

Isaac Newton

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OPTICKS:

OR, A

TREATISE

OF THE

Reflections, _Refractions_, _Inflections_ and _Colours_

OF

LIGHT.

The FOURTH EDITION, _corrected_.

By Sir _ISAAC NEWTON_, Knt.

LONDON:

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TITLE PAGE OF THE 1730 EDITION

SIR ISAAC NEWTON'S ADVERTISEMENTS

Advertisement I

Part of the ensuing Discourse about Light was written at the Desire of some Gentlemen of the Royal-Society, _in the Year 1675, and then sent to their Secretary, and read at their Meetings, and the rest was added about twelve Years after to complete the Theory; except the third Book, and the last Proposition of the Second, which were since put together out of scatter'd Papers. To avoid being engaged in Disputes about these Matters, I have hitherto delayed the printing, and should still have delayed it, had not the Importunity of Friends prevailed upon me. If any other Papers writ on this Subject are got out of my Hands they are imperfect, and were perhaps written before I had tried all the Experiments here set down, and fully satisfied my self about the Laws of Refractions and Composition of Colours. I have here publish'd what I think proper to come abroad, wishing that it may not be translated into another Language without my Consent._

The Crowns of Colours, which sometimes appear about the Sun and Moon, I have endeavoured to give an Account of; but for want of sufficient Observations leave that Matter to be farther examined. The Subject of the Third Book I have also left imperfect, not having tried all the Experiments which I intended when I was about these Matters, nor repeated some of those which I did try, until I had satisfied my self about all their Circumstances. To communicate what I have tried, and leave the rest to others for farther Enquiry, is all my Design in publishing these Papers.

In a Letter written to Mr. Leibnitz _in the year 1679, and published by Dr._ Wallis, _I mention'd a Method by which I had found some general Theorems about squaring Curvilinear Figures, or comparing them with the Conic Sections, or other the simplest Figures with which they may be compared. And some Years ago I lent out a

Manuscript containing such Theorems, and having since met with some Things copied out of it, I have on this Occasion made it publick, prefixing to it an_ Introduction, _and subjoining a_ Scholium _concerning that Method. And I have joined with it another small Tract concerning the Curvilinear Figures of the Second Kind, which was also written many Years ago, and made known to some Friends, who have solicited the making it publick._

_I. N._

April 1, 1704.

Advertisement II

In this Second Edition of these Opticks I have omitted the Mathematical Tracts publish'd at the End of the former Edition, as not belonging to the Subject. And at the End of the Third Book I have added some Questions. And to shew that I do not take Gravity for an essential Property of Bodies, I have added one Question concerning its Cause, chusing to propose it by way of a Question, because I am not yet satisfied about it for want of Experiments.

_I. N._

July 16, 1717.

Advertisement to this Fourth Edition

This new Edition of Sir Isaac Newton's Opticks _is carefully printed from the Third Edition, as it was corrected by the Author's own Hand, and left before his Death with the Bookseller. Since Sir_ Isaac's Lectiones Opticæ, _which he publickly read in the University of_ Cambridge _in the Years 1669, 1670, and 1671, are lately printed,

it has been thought proper to make at the bottom of the Pages several Citations from thence, where may be found the Demonstrations, which the Author omitted in these_ Opticks.

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Transcriber's Note: There are several greek letters used in the descriptions of the illustrations. They are signified by [Greek: letter]. Square roots are noted by the letters sqrt before the equation.

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THE FIRST BOOK OF OPTICKS

PART I.

My Design in this Book is not to explain the Properties of Light by Hypotheses, but to propose and prove them by Reason and Experiments: In order to which I shall premise the following Definitions and Axioms.

DEFINITIONS

DEFIN. I.

By the Rays of Light I understand its least Parts, and those as well Successive in the same Lines, as Contemporary in several Lines. For it is manifest that Light consists of Parts, both Successive and Contemporary; because in the same place you may stop that which

comes one moment, and let pass that which comes presently after; and in the same time you may stop it in any one place, and let it pass in any other. For that part of Light which is stopp'd cannot be the same with that which is let pass. The least Light or part of Light, which may be stopp'd alone without the rest of the Light, or propagated alone, or do or suffer any thing alone, which the rest of the Light doth not or suffers not, I call a Ray of Light.

DEFIN. II.

Refrangibility of the Rays of Light, is their Disposition to be refracted or turned out of their Way in passing out of one transparent Body or Medium into another. And a greater or less Refrangibility of Rays, is their Disposition to be turned more or less out of their Way in like Incidences on the same Medium. Mathematicians usually consider the Rays of Light to be Lines reaching from the luminous Body to the Body illuminated, and the refraction of those Rays to be the bending or breaking of those lines in their passing out of one Medium into another. And thus may Rays and Refractions be considered, if Light be propagated in an instant. But by an Argument taken from the Æquations of the times of the Eclipses of _Jupiter's Satellites_, it seems that Light is propagated in time, spending in its passage from the Sun to us about seven Minutes of time: And therefore I have chosen to define Rays and Refractions in such general terms as may agree to Light in both cases.

DEFIN. III.

_Reflexibility of Rays, is their Disposition to be reflected or turned

back into the same Medium from any other Medium upon whose Surface they fall. And Rays are more or less reflexible, which are turned back more or less easily._ As if Light pass out of a Glass into Air, and by being inclined more and more to the common Surface of the Glass and Air, begins at length to be totally reflected by that Surface; those sorts of Rays which at like Incidences are reflected most copiously, or by inclining the Rays begin soonest to be totally reflected, are most reflexible.

DEFIN. IV.

The Angle of Incidence is that Angle, which the Line described by the incident Ray contains with the Perpendicular to the reflecting or refracting Surface at the Point of Incidence.

DEFIN. V.

The Angle of Reflexion or Refraction, is the Angle which the line described by the reflected or refracted Ray containeth with the Perpendicular to the reflecting or refracting Surface at the Point of Incidence.

DEFIN. VI.

The Sines of Incidence, Reflexion, and Refraction, are the Sines of the Angles of Incidence, Reflexion, and Refraction.

DEFIN. VII

The Light whose Rays are all alike Refrangible, I call Simple, Homogeneal and Similar; and that whose Rays are some more Refrangible than others, I call Compound, Heterogeneal and Dissimilar. The former Light I call Homogeneal, not because I would affirm it so in all respects, but because the Rays which agree in Refrangibility, agree at least in all those their other Properties which I consider in the following Discourse.

DEFIN. VIII.

The Colours of Homogeneal Lights, I call Primary, Homogeneal and Simple; and those of Heterogeneal Lights, Heterogeneal and Compound. For these are always compounded of the colours of Homogeneal Lights; as will appear in the following Discourse.

AXIOMS.

AX. I.

The Angles of Reflexion and Refraction, lie in one and the same Plane with the Angle of Incidence.

AX. II.

The Angle of Reflexion is equal to the Angle of Incidence.

AX. III.

_If the refracted Ray be returned directly back to the Point of

Incidence, it shall be refracted into the Line before described by the incident Ray._

AX. IV.

Refraction out of the rarer Medium into the denser, is made towards the Perpendicular; that is, so that the Angle of Refraction be less than the Angle of Incidence.

AX. V.

The Sine of Incidence is either accurately or very nearly in a given Ratio to the Sine of Refraction.

Whence if that Proportion be known in any one Inclination of the incident Ray, 'tis known in all the Inclinations, and thereby the Refraction in all cases of Incidence on the same refracting Body may be determined. Thus if the Refraction be made out of Air into Water, the Sine of Incidence of the red Light is to the Sine of its Refraction as 4 to 3. If out of Air into Glass, the Sines are as 17 to 11. In Light of other Colours the Sines have other Proportions: but the difference is so little that it need seldom be considered.

Suppose therefore, that RS [in _Fig._ 1.] represents the Surface of stagnating Water, and that C is the point of Incidence in which any Ray coming in the Air from A in the Line AC is reflected or refracted, and I would know whither this Ray shall go after Reflexion or Refraction: I erect upon the Surface of the Water from the point of Incidence the Perpendicular CP and produce it downwards to Q, and conclude by the first Axiom, that the Ray after Reflexion and Refraction, shall be found somewhere in the Plane of the Angle of

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