locity with which the wind meets the ſail, and the obli­quity of its ſtroke. We ſhall adopt the constructions founded on the common doctrine, that the impulſe is as the square of the fine of the inclination, becauſe they arc simple; whereas, if we were to introduce the values of the oblique impulſes, ſuch as they have been obſerved in the excellent experiments of the Academy of Paris, the conſtructions would be complicated in the extreme, and we could hardly draw any conſequences which would be intelligible to any but expert mathe­maticians. The concluſions will be erroneous, not in kind but in quantity only; and we ſhall point out the neceſſary corrections, ſo that the final reſults will be found not very different from real obſervation.

If a ſhip were a round cylindrical body like a flat tub, floating on its bottom, and fitted with a mast and ſail in the centre, ſhe would always ſail in a direction perpendicular to the yard. This is evident. But ſhe is an oblong body, and may be compared to a cheſt, whoſe length greatly exceeds its breadth. She is ſo ſhaped, that a moderate force will puſh her through the water with the head or ſtern foremoſt; but it re­quires a very great force to puſh her ſidewiſe with the fame velocity. A fine failing ſhip of war will require about 12 times as much force to puſh her ſidewiſe as to puſh her head foremoſt. In this respect therefore ſhe will very much resemble a cheſt whoſe length is 12 times its breadth; and whatever be the proportion of these reſiſtances in different ſhips, we may always subſtitute a box which ſhall have the ſame reſiſtances headwiſe and ſidewiſe.

Let EFGH (fig. 1.) be the horizontal ſection of ſuch a box, and AB its middle line, and C its centre. In whatever direction this box may chance to move, the direction of the whole reſiſtance on its two ſides will paſs through C. For as the whole ſtream has one incli­nation to the side EF, the equivalent of the equal im­pulſes on every part will be in a line perpendicular to the middle of EF. For the ſame reaſon, it will be in a line perpendicular to the middle of FG. Theſe per­pendiculars muſt croſs in C. Suppoſe a maſt erected at C, and YC y to be a yard hoiſted on it carrying a ſail. Let the yard be firſt conceived as braced right athwart at right angles to the keel, as repreſented by Y'y'. Then, whatever be the direction of the wind abaft this ſail, it will impel the veſſel in the direction CB. But if the ſail has the oblique poſition Yy, the impulſe will be in the direction CD perpendicular to CY, and will both puſh the veſſel ahead and ſidewiſe: For the impulſe CD is equivalent to the two impulſes CK and CI (the ſides of a rectangle of which CD is the diagonal). The force CI puſhes the veſſel ahead, and CK puſhes her ſidewiſe. She muſt therefore take ſome intermediate direction *ab,* ſuch that the reſiſtance of the water to the plane FG is to its reſiſtance to the plane EF as CI to CK.

The angle *b*CB between the real courſe and the di­rection of the head is called the Leeway; and in the courſe of this diſſertation we ſhall expreſs it by the ſymbol *X.* It evidently depends on the ſhape of the veſſel and on the poſition of the yard. An accurate knowledge of the quantity of leeway, correſponding to different circumſtances of obliquity of impulſe, extent of ſurface, &c. is of the utmoſt importance in the practice

of navigation; and even an approximation is valuable. The ſubject is ſo very difficult that this muſt content us for the preſent.

Let V be the velocity of the ſhip in the direction C*b,* and let the ſurfaces FG and FE be called A' and B'. Then the reſiſtance to the lateral motion is *m*V2 × B' × sine2, *b*CB, and that to the direct motion is mV2 × A' × sine2, bCK, or mV2 × A' × coſ.2 bCB. Therefore these reſiſtances are in the proportion of B' × ſine2, V to A' × coſ.2, x (repreſenting the angle of leeway *b*CB by the ſymbol x).

Therefore we have CI : CK, or CI : ID= A'.

coſ.2x : B' ∙ sine2x, = A':B' ∙ sine^2x/cos.^2x = A : B ∙ tan­gent2 x*.*

Let the angle YCB, to which the yard is braced up, be called the Trim of the sails, and expreſſed by the ſymbol *b.* This is the complement of the angle DCI. Now CI : ID = rad.: tan. DCI, = 1 : tan, DCI, = I : cotan. *b.* Therefore we have finally 1 : co­tan, *b = A :* B' ∙ tan.2 x, and A' ∙ cotan. *b* = B' ∙ tangent2x, and tan.2x = A/B cot. *b.* This equation evi­dently aſcertains the mutual relation between the trim of the sails and the leeway in every case where we can tell the proportion between the reſiſtances to the direct and broadſide motions of the ſhip, and where this pro­portion does not change by the obliquity of the courſe. Thus, ſuppoſe the yard braced up to an angle of 30⁰ with the keel. Then cotan. 30⁰ = 1,732 very nearly. Suppoſe also that the reſiſtance ſidewiſe is 12 times greater than the reſiſtance headwiſe. This gives A' = I and B' = 12. Therefore 1,732 = 12 × tangent2x, and tangent2 x = 1,732/12 = 0,14434, and tan. x = 0,3799, and x *=* 20o 48', very nearly two points of leeway.

This computation, or rather the equation which gives room for it, ſuppoſes the reſiſtances proportional to the ſquares of the sines of incidence. The experiments of the Academy of Paris, of which an abſtract is given in the article *RESISTANCE of Fluids,* show that this ſuppoſition is not far from the truth when the angle of in­cidence is great. In this preſent case the angle of in­cidence on the front FG is about 70⁰, and the experi­ments juſt now mentioned ſhow that the real reſiſtances exceed the theoretical ones only 1/180 But the angle of incidence on EF is only 20⁰ 48'. Experiment ſhows that in this inclination the reſiſtance is almoſt quadruple of the theoretical reſiſtances. Therefore the lateral reſiſtance is assumed much too ſmall in the pre­ſent inſtance. Therefore a much ſmaller leeway will ſuffice for producing a lateral reſiſtance which will ba­lance the lateral impulſe CK, ariſing from the obliquity of the ſail, viz. 30⁰. The matter of fact is, that a pret­ty good ſailing ſhip, with her ſails braced to this angle at a medium, will not make above five or six degrees leeway in ſmooth water and eaſy weather; and yet in this ſituation the hull and rigging preſent a very great ſurface to the wind, in the most improper poſitions, ſo as to have a very great effect in increaſing her leeway. And if we compute the reſiſtances for this leeway of six degrees by the actual experiments of the French Academy on that angle, we ſhall find the result not far