In all theſe numbers we have the tangent of wCD double of the tangent of DCF.

But this is really doing but little for the ſeaman. The apparent direction of the wind is unknown to him till the ſhip is sailing with uniform velocity; and he is ſtill uninformed as to the leeway. It is, however, of fervice to him to know, for inſtance, that when the angle of the vanes and yards is 56 degrees, the yard ſhould be Braced up to 37⁰ 30', &c.

But here occurs a new difficulty. By the conſtruction of a ſquare-rigged ſhip it is impoſſible to give the yards that inclination to the keel which the calculation requires. Few ſhips can have their yards braced up to 37⁰ 30'; and yet this is required in order to have an incidence of 56⁰, and to hold a courſe 94⁰ 25' from the apparent direction of the wind, that is, with the wind apparently 4⁰ 25' abaft the beam. A good ſailing ſhip in this poſition may acquire a velocity even exceeding that of the wind. Let us ſuppoſe it only one half of this velocity. We ſhall find that the angle WCw is in this caſe about 29⁰, and the ſhip is nearly going 123⁰from the wind, with the wind almoſt perpendicular to the sail; therefore this utmoſt bracing up of the sails is only giving them the poſition ſuited to a wind broad on the quarter. It is impoſſible therefore to comply with the demand of the mathematician, and the ſeaman muſt be contented to employ a leſs favourable diſpoſition of his ſails in all caſes where his courſe does not lie at leaſt eleven points from the wind.

Let us see whether this reſtriction, ariſing from neceſſity, leaves any thing in our choice, and makes one courſe preferable to another. We ſee that there are a prodigious number of courtes, and theſe the moſt uſual and the moſt important, which *we* muſt hold with one trim of the ſails; in particular, ſailing with the wind on the beam, and all cates of plying to windward, muſt be performed with this unfavourable trim of the ſails. We are certain that the ſmaller we make the angle of in­cidence, real or apparent, the ſmaller will be the veloci­ty of the ſhip; but it may happen that we ſhall gain more to windward, or get ſooner away from a lee-coaſt, or any object of danger, by ſailing ſlowly on one courſe than by ſailing quickly on another

We have ſeen that while the trim of the ſails remains the ſame, the leeway and the angle of the yard and courſe remains the ſame, and that the velocity of the ſhip is as the sine of the angle of real incidence, that is, as the ſine of the angle of the ſail and the real direction of the wind.

Let the ſhip AB (fig. 8.) hold the courſe CF, with the wind blowing in the direction WC, and having her yards DCD braced up to the ſmalleſt angle BCD which the rigging can admit. Let CF be to CE as the velocity of the ſhip to the velocity of the wind; join FE and draw C*w* parallel to EF; it is evident that FE is the relative motion of the wind, and wCD is the relative incidence on the ſail. Draw FO parallel to the yard DC, and deſcribe a circle through the points COF; then we ſay that if the ſhip, with the ſame wind and the ſame trim of the ſame drawing ſails, be made to ſail on any other courte Cf, her velocity along CF is to the velocity along C*f* as CF is to C*f*; or, in other words, the ſhip will employ the ſame time in going from C to any point of the circumference CFO.

Join *fO*. Then, becauſe the angles CFO, *cfO* are on

the ſame chord CO, they are equal, and fO is parallel to *d*C*d,* the new poſition of the yard correſponding to the new poſition of the keel *a b,* making the angle *dCb* = DCB. Alſo, by the nature of the circle, the line CF is to *Cf* as the ſine of the angle COF to the ſine of the angle COf, that is (on account of the parallels CD, OF and C*d,* Of), as the ſine of WCD to the ſine of *WCd.* But when the trim of the ſails remains the ſame, the velocity of the ſhip is as the ſine of the angle of the ſail with the direction of the wind; there­fore CF is to Cfas the velocity on CF to that on *Cſ,* and the propoſition is demonstrated.

Let it now be required to determine the beſt courſe for avoiding a rock R lying in the direction CR, or for withdrawing as faſt as poſſible from a line of coaſt PQ. Draw CM through R, or parallel to PQ, and let *m* be the middle of the arch CmM. It is plain that *m* is the moſt remote from CM of any point of the arch *Cm*M, and therefore the ſhip will recede farther from the coaſt PQ in any given time by holding the courſe C*m* than by any other courſe.

This courſe is eaſily determined; for the arch C*m*M = 360⁰ — (arch CO + arch OM), and the arch CO is the meaſure of twice the angle CFO, or twice the angle DCB, or twice *b + x,* and the arch OM meaſures twice the angle ECM.

Thus, ſuppoſe the ſharpeſt poſſible trim of the ſails to be 35⁰, and the observed angle ECM to be 70⁰; then CO + OM is 700 + 1400 or 210⁰. This being taken from 360⁰, leaves 150⁰, of which the half Mm is 75⁰, and the angle MC*m* is 37⁰ 30'. This added to ECM makes EC*m* 107⁰ 30', leaving WCm = 72⁰ 30', and the ſhip muſt hold a courſe making an angle of 72⁰ 30**'** with the real direction of the wind, and WCD will be 37⁰ 30'.

This ſuppoſes no leeway. But if we know that under all the ſail which the ſhip can carry with ſafety and ad­vantage ſhe makes 5 degrees of leeway, the angle DCm of the ſail and courſe, or *b + x,* is 40⁰. Then CO + OM = 220⁰, which being taken from 360⁰ leaves 140⁰, of which the half is 70⁰, = M*m,* and the angle MC*m =* 35⁰ and EC*m =* 105⁰, and WC m *= 75*⁰ and the ſhip muſt lie with her head 70⁰ from the wind, making *5* degrees of leeway, and the angle WCD is 35⁰.

The general rule for the poſition of the ſhip is, *that the line on shipboard which bisects the angle* b + x *may also bisect the angle* WCM, or make the angle between the courſe and the line from which we wiſh to withdraw equal to the angle between the ſail and the real direction of the wind.

It is plain that this problem includes that of plying to windward. We have only to ſuppoſe ECM to be 90⁰; then, taking our example in the ſame ſhip, with the ſame trim and the ſame leeway, we have *b +* x = 40⁰. This taken from 90⁰leaves 50⁰and WCn = 90 — 25 = 65, and the ſhip’s head muſt lie 60⁰ from the wind, and the yard muſt be 25⁰ from it.

It muſt be obſerved here, that it is not always eligi­ble to ſelect the courſe which will remove the ſhip faſteſt from the given line CM; it may be more prudent to remove from it more ſecurely though more ſlowly. In ſuch cates the procedure is very ſimple, *viz.* to ſhape the courſe as near the wind as is poſſible.

The reader will alſo eaſily tee that the propriety of theſe practices is confined to thoſe courtes only where the practicable trim of the ſails is not ſuſſiciently ſharp.