ions ; then make the coefficient of *x* equal to 0, also the co­efficient of *a* equal to 0. This will give two equations, which will determine *a* and *x,* and from this we get *b=p—a—x.*

Should it be required, in the third place, to find the best course and trim of the sails for getting away from a given line of coast CM (fig. 6.), the process perfectly resembles this last, which is in fact getting away from a line of coast which makes a right angle with the wind. Therefore, in place of the angle WCF, we must substitute the angle WCM±WCF. Call this angle *e.* We must make v∙cos. (*e*±*a*±*b*±*x*) a maximum. The analytical process is the same as the former, only *e* is here a constant quantity.

These are the three principal problems which can be solved by means of the knowledge that we have obtained of the motion of the ship when impelled by an oblique sail, and therefore making leeway ; and they may be considered as an abstract of this part of M. Bouguer,s work. We have only pointed out the process for this solution, and have even omitted some things taken notice of by M. Bezout in his very elegant compendium. Our reasons will appear as we go on. The learned reader will readily see the ex­treme difficulty of the subject, and the immense calculations which are necessary even in the simplest cases, and will grant that it is out of the power of any but an expert ana­lyst to derive any use from them ; but the mathematician can calculate tables for the use of the practical scaman Thus he can calculate the best position of the sails for ad­vancing in a course 90° from the wind, and the velocity in that course; then for 85,, 80°, 75°, &c. M. Bouguer has given a table of this kind ; but to avoid the immense diffi­culty of the process, he has adapted it to the apparent direc­tion of the wind. We have inserted a few of his numbers, suited to such cases as can be of service, namely, when all the sails draw, or none stand in the way of others. Column 1st is the apparent angle of the wind and course ; column 2d is the corresponding angle of the sails and keel ; and column 3d is the apparent angle of the sails and wind.

|  |  |  |
| --- | --- | --- |
| 1  *w* CF | 2  DCB | 3  wCD |
| 103°53' | 42°30' | 61°23' |
| 99 13 | 40 — | 59 13 |
| 94 25 | 37 30 | 56 55 |
| 89 28 | 35 — | 54 28 |
| 84 23 | 32 30 | 51 53 |
| 79 06 | 30 — | 49 06 |
| 73 39 | 27 30 | 46 09 |
| 68 — | 25 — | 43 — |

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 service 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 37°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.@@1 Few ships can have their yards braced up to 37° 30'; and yet this is required in order to have an incidence of 56°, and to hold a course 94° 25' from the apparent direction of the wind, that is, with the wind apparently 4° 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 WC*w* is in this case about 29°, and the ship is nearly

going 123° from 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 courses, 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 cases 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 *w*CD

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 course *Cf,* her velocity along CF is to the velocity along *Cf* as CF is to *Cf;* 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 cord CO, they are equal, and *fO* is parallel to *dCd,* the new position of the yard corresponding to the new position of the keel *ab,* making the angle dC6=DCB. Also, by the nature of the circle, the line CF is to *Cf* as the sine of the angle CFO to the sine of the angle COf; that is (on account of the parallels CD, OF and Cd, *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 Cf the velocity on CF to that on *Cf,* 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 C *m* M. It is plain that *m* is the most remote

@@@, There are few of the modem men-of-war which cannot have their yards braced up to 27°. instead of 37° **30'·** We may assume that most ships will admit of their yards being braced up to 30° ; so that the angle of incidence would be 49° 06', and the course 79° 06'.