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Slender planing surfaces

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This thesis concerns the steady motion of a slender planing craft on a free surface and the effect this motion has on the shape of the free surface. The equations governing the flow are linearised under the assumption that the boat is not only flat, but also slender. That is, the length is much greater than the beam, which, in turn, is much greater than the draft. The solution of the problem leads to an integral equation relating the pressure distribution under the hull to the stream function. From this, an integral expression for the displacement of the free surface due to the planing motion of the hull is derived. Since an explicit functional form can not be found, a numerical technique for calculating the free-surface elevation is outlined and results are presented for a low-aspect-ratio wedge. The behaviour of the free surface in the far field (that is, at distances which are large compared with the boat length) is investigated, and parametric equations for the contours of the surface are derived.

The problem is solved again, this time with the effect of gravity neglected, and expressions for the free-surface elevation are obtained. As a result, it is found that the shape of the planing hull and the extent to which it is wetted are related by an integral equation. Thus, if the shape, defined by the hull slope in the direction of motion and the section shape, is given, then the extent to which it is wetted must be determined as part of the solution of the problem. Conversely, if the waterplane shape is assumed known, then the complete shape can not be fixed in advance. In the general case, it is not possible to solve the direct problem of finding the extent of the wetted region for a given hull analytically. Instead, the inverse problem of fixing the waterplane shape

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and finding the hull shape which produced it must be solved. However, in the particular case when the hull slope in the direction of motion is laterally uniform, analytic results, which directly relate the hull slope, section shape, and waterplane shape, are obtained.

Two other hull geometries are given particular attention - a hull with a chine and a hull with an arrowhead-shaped waterplane. In the first problem, it is shown that a vertical chine may be used to prescribe the waterplane shape in the same way that a transom stern may be used to fix the wetted length. The "arrowhead" problem is more complicated than those previously considered, because the velocity potential aft of the trailing edge is initially unknown. An integral equation for determining this function is derived, but no attempt is made to solve it. Under the assumption that the velocity potential is known, expressions for the free-surface elevation are found, which indicate once again the close relationship between hull shape and wetted area.

Lastly, the problem in which the hull is laterally asymmetric is considered. In the first instance, the hull is slightly yawed and in the second, it is yawed sufficiently for one of the leading edges to become a trailing edge. As in the "arrowhead" problem, the second case involves an unknown velocity potential in the region aft of the trailing edge, which must be found before the free-surface elevation can be completely determined. In both cases, as in the symmetric problem, it is shown that, if the wetted area is prescribed, then the hull shape is necessarily partly determined by the solution and conversely. The lift force, rolling moment, and pitching moment are calculated for a slightly-yawed hull.