PROBLEMS IN SHIP THEORY

by

Prof. Dr. - Ing. G. Weinblum
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OUTLINE

Introductory Remarks;

I. Water Support; Classes of Ships.
II. Static Stability.
III. Resistance (Powering, Part I).
IV. Propulsion (Powering, Part II).
V. Maneuverability.
VI. Behavior in a Seaway.
VII. Vibration Problems.
INTRODUCTORY REMARKS.

We shall speak primarily about ships. However, most results or at least methods apply as well to other technical bodies moving in water or at its surface. Such bodies are submarines, torpedoes, paravanes, planing vessels, hydrofoils etc. One difficulty in promoting and applying scientific methods in our field stems from the fact that shipbuilding is one of the oldest trades. The most important theorem in ship theory — Archimedes' law — has been found more than two thousand years ago, but ten thousands of years before ships have been successfully built without any theoretical knowledge. From our present point of view this compares unfavourably with conditions in the fields of aircraft, electrical engineering, and chemistry which are essentially products of modern research, while ship theory represents the application of science to a classical field of technical work. We shall, however, try to show that the number of technical scientific problems in this field is large, that they are important from the point of view of practice, fruitful and many of them astonishingly difficult, even more difficult than in the sister science of aerodynamics, essentially due to the presence of the free water surface and to the complicated shape of the ship.

A survey can be made from two principles (leaving aside the historical approach):

I. We may start in a general way from rational mechanics, especially hydromechanics and theory of elasticity, and try to select problems pertaining to the ship.

II. We may state the general properties which constitute a ship from the point of view of rational mechanics, formulate the corresponding scientific problems and show what has been done and should be done to solve them.

Obviously the latter procedure appeals to the scientific engineer; it is more direct and evident and we shall follow it here.

Incidentally, it can, however, narrow the outlook and lead to repetitions. That is by no means detrimental from the
present point of view since it indicates the need for inte-
gration of the field of research as aimed at by the project
"Ship hydrodynamics" at this University.

The concept ship theory is used in two senses:
1) a broader one embracing the application of all parts of
eral mechanics to technical ship problems. 2) More com-
monly, however, a narrower definition is accepted following
which to ship theory belong those problems only in which the
ship can be considered as a rigid body.

The second definition has its merits and weak spots. The
simplified mechanical model of a rigid body is useful in
several respects; in many cases extraneous forces acting
on the ship can be calculated with reasonable accuracy fol-
lowing this scheme which means that matters of strength and
elasticity are excluded from ship theory and are considered
as an independent and equally important branch of ship science.

We shall use here this narrower concept because it allows us
to concentrate primarily on hydrodynamics. It is obvious,
however, that the separation made fails not only in principle,
but also in practice; e. g. the theory of ship vibrations
does not fit the artificial scheme at all.

A strong impetus towards developing ship theory results
from the present trend to increase the ship speed, especially
the sustained speed in a seaway; obviously the simple static
and hydrostatic concepts on which a large part of ship theory
rested earlier are crumbling under this impact.

Of the three methods of research, theory, model-testing, and
fullscale investigations in the present brief review emphasis
will be laid on the first one; but full credit will be given
to model experimenting which almost for a century till today
has represented a characteristic feature of our discipline.

It has been pointed out by von Karman that technical hydro-
mechanics and other similar branches have developed roughly
by the following pattern:
1. Approach by empirical and arbitrary ad hoc hypotheses. Therefrom
results the use of formulas with "variable constants" of
which the Admiralty formulas are famous examples.
2. The application of laws of similitude (model testing);
in 3. The creation of consistent theories.
Problems of marine engineering expect those connected with propulsion remain outside of the present talk; rather we shall suppose that marine engineers are able to supply us with anything we want from them. It must be acknowledged, however, that when technical progress in the ship business is discussed, generally, the lion's share goes to marine engineering.

There are two branches of applied hydrodynamics from which ship theory has learned a lot: Aerodynamics and hydraulics. The importance of aerodynamics for our problems is well known, less well known is that hydraulic engineers have contributed valuable ideas and information in the fields of wave motions, shallow water effect, wave reflection, etc.

The main properties which constitute a ship from the point of view of ship theory can be summarized approximately as follows:

I. Buoyancy and lift or more generally water support. Problems referring to volume, space, deck space, etc. can be subsumed under this heading.
II. Transverse and longitudinal static stability.
III. Resistance
IV. Propulsion
V. Maneuverability.
VI. Seaworthiness.
VII. Vibrations.

We leave out by definition the large field of strength.

I. Buoyancy:
Archimedes' law reduces the buoyancy problem to simple geometrical calculations. Certainly there is no need to dwell upon these matters. We may mention an interesting sideline of investigation—the representation of the hull form by algebraic expressions. There are some immediate practical reasons for studies in this direction, like a possible reduction of work on the mold loft; more important, however, is the desire to fix properly