Marina system
Centre for Naval Architecture

Course Description

SD2710 Initial Ship Design

Spring Term 2012

Version 1.0

Centre for Naval Architecture

INTRODUCTION

This course is an introduction to *Naval architecture* and *Initial ship design*. You will be faced with the task of analysing and developing marine technology systems. During the intensive introductory weeks of the course, you will assimilate the basics of shipping and the subjects of hydrostatics, stability, propulsion resistance, power requirements and propulsion. You will analyse and model the propeller. You will then incorporate this into your task of planning and designing a merchant ship that will solve a transport scenario. This could be to transport iron ore from Narvik to the USA, or kiwi fruit from New Zeeland to the countries around the Baltic Sea. Many aspects stand in opposition to each other, such as providing a slim hull with low propulsion resistance, which is good, but at the same time can entail poor transverse stability. Shipdesign work is therefore an iterative process in which the ship's geometry and dimensions, load capacity and speed are weighed up against the transport task in question and different side conditions. To solve your assignment, you will develop a design tool with which you can easily alter speed, length, breadth, and so on, and automatically update the connections that depend on these. Based on the results obtained from your design tool, you create the principal dimensions of the vessel and select hull shape. After that, stability and power requirements must be examined and after any necessary corrections, you choose a propeller for the vessel, partly with the help of your own propeller model!

In addition to *Propeller Modelling*, *Initial ship design* and the *In-depth study*, the course contains general introductions to *Shipping*.

The Course Description contains detailed information on the various modules of the course, formal requirements and schedule, according to the Table of Contents below. The course is organised such that you are personally expected to plan your work well, to follow the timetabled teaching and to keep the deadlines specified under the heading *Examination* in the *Formal Requirements section*.

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Formal Requirements

Teachers

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Course Home page

www.msy.se

Course material

The course binder in Swedish and English costs 500 SEK and is purchased at the first lecture or at the Aeronautical and Vehicle Engineering student office. (3rd floor, Teknikringen 8).

Swedish

The course material consists of *Sjöfartens bok*, *Fartygs stabilitet* by Mikael Huss as well as Naval Architecture's own compendium. The e-books included in the English course literature are recommended as a complement

English

The course material consists of English versions of the Naval Architecture compendium, and access via the Main Library (KTHB) (http://innopac.lib.kth.se/) to the e-books *Basic Ship Theory* by Rawson & Tupper, *Ship Design for Efficiency and Economy* by Schneekluth & Bertram and *Practical Ship Design* by Watson.

Learning Outcomes

Bear in mind that the learning outcomes constitute the results we are striving for. They can be achieved to different degrees and to different levels of success, but passing the course will mean that all outcomes have been accomplished to a reasonable level. Through your work, you will learn a great deal, and you will feel increasingly confident in your ability in relation to the objectives of the course. The various steps in the examination (see following page) are your main opportunity to show that you have acquired these skills. During the course, you will therefore check against the course objectives that your reports and presentations show that you are approaching or fully meet these objectives.

After completing the course, you will be able to:

1. give an account of the various existing shipping markets and for each of these markets describe: what characterises the ships; the main goods/freight flow paths; global scope; etc.
2. give an account of the various players in shipping and describe their respective roles,
3. give an account of the environmental advantages of shipping compared with other forms of transport, and describe the main shipping-related environmental problems and measures for tackling them.
4. describe the basics of blade element theory for analysis of a ship's propeller, and the relevant fluid mechanics contained in the theory.
5. give an account of the strengths and limitations of blade element theory when analysing a ship's propeller,

6. implement blade element theory in a calculation program for analysis of ships' propellers,
7. dimension and analyse a ship's propeller with the help of blade element theory,
8. tackle an engineer's problem which is perhaps not fully specified by making reasonable assumptions and estimates, and choosing a suitable method for solving it,
9. make motivated assumptions and estimates about a vessel's shape and dimensions for analysis of load capacity, stability properties and power requirements in an initial design phase and evaluate how the result is affected by the accuracy of the assumptions made,
10. interpret a body plan and a general arrangement plan
11. give an account of various factors contributing to a vessel's propulsion resistance and estimate these for a given vessel using semi-empirical methods,
12. use model test data to estimate the propulsion resistance of the corresponding full-scale vessel, motivate why Froude's model law is used in model experiments with surface piercing vessels,
13. give an account of how a ship's geometry and the location of its centre of gravity affect its stability,
14. make a rough manual estimate of the initial stability of a ship,
15. with the help of computer tools determine and interpret the GZ curve of a ship,
16. carry out a heeling test,
17. apply international and national regulatory frameworks for assessment of a ship's seaworthiness,
18. use propeller characteristics to select ships' propellers based on the ship's power requirements and the design coefficients of the hull,
19. carry out an independent engineering investigation,
20. present project assignments in reports written in English (and Swedish) so that the entire chain from problem formulation via method of solution to result is communicated to the reader,
21. orally present technical assignments
22. practise technical communication in swedish and english

COURSE STRUCTURE

SD2710 award 8 ECTS credits. Of the 220 working hours that the course credits are equivalent to, approximately one-third is timetabled. The timetabled hours are used for, among other things, various types of examination (See below). Lectures, teacher-led problem solving, supervision and a lab session are also given during timetabled hours. The remaining 140 hours are at your disposal for working on project assignments and course literature. The course structure is strongly geared to problem-based learning and presupposes that you plan your work well, follow the timetabled teaching and keep the deadlines specified below.

EXAMINATION

Examinations are given regularly throughout the course, and in these you present your projects in several stages, demonstrate your ability to apply the content of the course literature in the practical problem solving and show how you are developing in the direction of the course objectives. The examinations are in the form of oral presentations, written tests, feedback from students and teachers on report drafts, and as a number of reports. The reports must follow the report template (NB: there is a special template for the final report), which can be downloaded from the course home page. Reports are submitted as stapled, hard copy (paper) versions directly to the teacher or left in the course mailbox outside Room 420 on the 4th floor, Teknikringen 8. Moreover, the report is to be uploaded to *Bilda (pdf* or *Word 2003*). The checklist from the course home page must be filled in and attached to the report on submission.

Your final grade is calculated on the basis of how many points you have accumulated during the course. You are awarded points partly for attendance and active participation in a number of important classroom sessions, partly based on an assessment of the content of your reports in relation to the formulation of the project assignments and course objectives. The reports are assessed both on their technical content and on language and structure. Points for attendance are awarded when the design report has been approved. Deadlines for the various point-awarding modules of the course, and criteria for how attendance and content points are distributed are specified in the table below. Points awarded for attendance are either full points or no points. Other modules are assessed using 0, 3, 4 or 5, and the points are distributed accordingly (as 0/5, 3/5, 4/5, or 5/5 times "the maximum number of points for content"). The points forming the basis of the grade constitute the total accumulated sum of points multiplied by 1.5, divided by the number of ECTS credits for the course. Grading-based points of 51 or more give grade A, 46-50 points give grade B, 41-45 points give grade C, 36-40 points give grade D and 31-35 points give grade E. Note that a precondition for receiving points is that you have kept the respective deadline! Note also that your attendance and your active participation in the point-awarding activities give you valuable feedback that helps you to achieve better results when working with the reports.

NB! Points for attendance are awarded when the final report for the design report has received a Pass.

DEADLINE	MODULE	MAX POINTS, ATTEND.	MAX POINTS, CONTENT	EXAMINED COURSE OBJECTIVES
	Shipping	SD2710	SD2710	
Wed 25/1 time 13-16	- Guest lecture: Reefer transport	5		
Fri 22/1 time 13-15	- Peer-review av essay draft +written test	5		22
Mon 30/1 at 8 oclock	- Essay, submission		40	1-3
	Propeller modelling			
Week 6-7 (book time)	- Oral presentation	5	20	4-7
Fri 10/2 time 13-16	- Peer-review of report draft	5		22
Mon 13/2 at 10 oclock	- Report, submission		40	4-7
	Initial ship design			
Mon 23/1 time 8-11	- Lab inGIH-badet (public baths)	5		12 & 16
Mon 20/2 time 9-12	- Review 1	5		21-22
Fri 24/2 time 13-16	-guest lecture.: International regulations	5		
Mon 27/2 time 9-11	- Written test+Review 2 (book time)	5		21-22
Ons 7/3 time 13	- Submission prel. report			
Fri 9/3 time 15-17	- Report feedback	10		22
Fri 16/3 time 16	- Submission of report		100	8-20
	Exam			
Mon 12/3 time 9-13	-Exam		70	11-14 & 18
Total points:		50	270	
Grade points=	1.5·(Total points)/(No. ECTS cr. for course)	Max SD2710: 1.5(50+270)/8=60		

Examples for calculating "Grading points" (We consider): you complete all the parts of the course and receive 2 times 5 = 10 Attendance points and you hand in your report which is assessed as a 4, which gives you 4/5 times 40 = 32 content points. Shipping thus gives you 1.5(10+32)/8 = 7.875 grading points.

As a guideline for the assessment, the criteria given below are applied. These basic principles may also help you to evaluate your own performance and to understand better how your work has been assessed. There is, of course, no clinically objective assessment system. The examiner also uses his/her experience in assessing the separate parts of the course and adds in an overall picture of your performance to the final grade, but the point system and grading criteria are the course leaders' way of helping you, as clearly and transparently as possible, to form a clear picture of what is assessed in the written work that you produce.

The table below shows the essential grading criteria applied in examinations.

SCORE	GRADING CRITERIA FOR WRITTEN WORK (REPORTS, HAND-IN ASSIGNMENTS, ETC.)
5 (Pass with distinction)	*An excellent solution where all parts of the assignment have been completed with hardly any errors and with clear independent analysing discussion and conclusions. (...tydligt självständigt analyserande diskussion och slutsater)* The aim and task (report, hand-in assignment, etc) are clearly formulated, including all necessary input data. Method and approach are made clear and continuously motivated throughout the text. Results and conclusions are clearly presented and linked back to the aim of the work and discussed. Clear traceability in calculations and reasoning. Independent reasoning and discussions are carried out on the results, consequences of the assumptions, choice of methods and any alternative methods or approaches.
4 (Pass with credit)	*A well structured and easy to follow solution where almost all parts of the assignment have been completed with few errors.* The aim and task (report, hand-in assignment, etc) are clearly formulated, including all necessary input data. Method and approach are made clear and continuously motivated throughout the text. Results and conclusions are clearly presented and linked back to the aim of the work and discussed. Clear traceability in calculations and reasoning.
3 (Pass)	*A fair attempt to solve the task and to present the work and results. All results and conclusions are reasonable.* The aim and task (report, hand-in assignment, etc) are reasonably formulated, including necessary input data. Method and approach are reasonably clear and continuously motivated throughout the text. Results and conclusions are presented and linked back to the aim of the work and discussed. Fair traceability in calculations and reasoning.
0 (Fail)	*A bad or unserious attempt to solve the task.* The aim and/or task (report, hand-in assignment, etc) are inadequately formulated. Method and approach are not clear. Motivation inadequate or missing. Only parts of the assignment have been completed. Results and links back to the aim of the work are missing or unclear. **In case results or conclusions are obviously against common sense the work is graded fail no matter other qualities.**

In the final assessment of your course grade, the KTH grading criteria matrix is also used. See http://www.nada.kth.se/utbildning/grukth/exjobb/betyg/rektorsbeslut/

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SHIPPING

Your task is to work with the selected texts in the course binder *On seaborne transportation* according to the reading instructions below. The aim is for you to assimilate knowledge so that you understand and can give an account of important concepts and contexts in the field of shipping. In concrete terms, this means that you must be able to (objectives 1-3):

1. Give an account of the various shipping markets in existence, in other words, the different types ofcargo transported by sea, and for each market describe: what characterises the ships; approximately how extensive the global transport work is; principal freight flow paths; and significant Swedish aspects,
2. Give an account of the various players in shipping (shipyards, shipping lines, cargo shipping agencies, harbours, IMO, EU, national authorities, classification societies, etc.)and describe theri respective roles,
3. Give an account of the environmental advantages of shipping compared with other types of transport, and describe the principal shipping-related environmental problems and the measures measures for tackling them.

<u>N.B. Note that the assignment needs to be addressed in parallel with the lectures and lab sessions on resistance, propulsion and stability. Start reading the texts from the first week of the course!</u>

EXAMINATION

The examination consists of two parts:
1) Essay: Write a text of 1500-2000 words to show that you fulfil the objectives as given above. Note that you must use your own wording, in other words, not write a summary of the source material. However, the text may be illustrated to advantage using pictures and diagrams from the texts and other sources, and enhanced with your own points of view and conclusions. Peer review on Friday 27/1. Final submission Monday 30/1, time: 10:00.

<u>2) Written test:</u> On Friday 27/1, a written test is given in which you must answer a number of questions dealing with important concepts and contexts in the texts you have read.

READING INSTRUCTIONS

The Maritime Engineering Reference Book (Molland, editor 2008), Chapter 2 *Marine Vehicle types*
p 45-60 Sections 2.1-2.2.8

Swedish Shipping (Solberg, editor 2010), Chapter 5 *The green wave*
p 35-43

Shipgaz no 5 2010: *High time to queue up for ballast water treatment gear*
p16-18

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Master thesis (Melén-Eriksson 2005): *Trends in overseas Transport system for refrigerated cargoes and reefer ship concept study*
p 4-10 section 2.1

The Maritime Engineering Reference Book (Molland, editor 2008), Chapter 11 *Marine safety*
p 786-791 Sections 11.1-11.1.6
p 794-796 Sections 11.2-11.2.2.2
p 797-799 Sections 11.2.2.4-11.2.3
p 800-805 Sections 11.2.4.1-11.3.2

From the IMO Website (2011-01-04), *On IMO,..*
p 3-5 *Brief History of IMO*

<u>N.B. Revise before the guest lectures! For 25/1: section 2.1 *Trends in overseas...*, pages 4-10, and for 24/2 revise the sections Regulatory authorities Chapter 11 pages 794-96, 797-99 and 800-805.</u>

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PROPELLER STUDY –BLADE ELEMENT THEORY

During the lectures, you have been given an introduction to how a propeller works, how it works together with the hull, how it is described in terms of propeller characteristics and how it can be selected in the planning stage with the help of semi-empirical methods. In this part of the course, the propeller and fluid mechanics are described in more depth and you will be given the task of analysing the propeller by menas of Blade Element Theory.

After this module, the student must be able to (objectives 4-7):

4. describe the basics of Blade Element Theory for analysis of a ship's propeller and the fluid mechanics pertaining to it,
5. give an account of the strengths and limitations of Blade Element Theory when analysing a ship's propeller,
6. implement Blade Element Theory in a calculation program for analysis of ships' propellers,
7. dimension and analyse a ship's propeller with the help of Blade Element Theory.

EXAMINATION

The examination for this module consists in the student carrying out a number of assignments specified in the booklet *Propeller analysis* (Kuttenkeuler 2011). The assignments deal with methodology, and are presented in front of the computer along with the teacher. One assignment deals with application of methodology in the analysis of a specific propeller. This assignment is presented in a report that is submitted on the date of the examination. The report and the oral presentation are assessed as two separate parts.

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INITIAL SHIP DESIGN

Your task is to design a vessel that solves a certain transport scenario under a number of side conditions.One transport scenario might be, for example, to transport 70 trucks between the large Swedish lake Vänern and the Ruhr District in Germany once a week. The side conditions include international regulatory frameworks, and restrictions on the ship's dimensions in relation to harbours, bridge heights and locks. The work is to be carried out in two phases. In phase 1, you analyse the transport work and decide the main dimensions and speed for your vessel. In phase 2, you use Matlab and planning and design tools *Quicklines* and *Hydrostatics* to create a hull geometry, analyse floating condition and transverse stability. You determine propulsion resistance and propeller arrangement using the methods in the booklet *Ship Resistance and Power Requirement* and using your own propeller program.

Read through all of these instructions carefully. On page 14, you will find clear directions for how and when you are to report your work. The transport scenarios and side conditions are presented on pages 19 and 15 respectively. Guidance on how you should carry out the work is given on pages 16, 17 and 18.

The learning outcomes of this module are that after completing the work you will be able to (objectives 8-20):

8. tackle an engineer's problem which is perhaps not fully specified by making reasonable assumptions and estimates, and choosing a suitable method for solving it,
9. make motivated assumptions and estimates about a vessel's shape and dimensions for analysis of load capacity, stability properties and power requirements in an initial design phase and evaluate how the result is affected by the accuracy of the assumptions made,
10. interpret a body plan and a general arrangement plan
11. give an account of various factors contributing to a vessel's propulsion resistance and estimate these for a given vessel using semi-empirical methods,
12. use model test data to estimate the propulsion resistance of the corresponding full-scale vessel, motivate why Froude's model law is used in model experiments with surface piercing vessels,
13. give an account of how a ship's geometry and the location of its centre of gravity affect its stability,
14. make a rough manual estimate of the initial stability of a ship,
15. with the help of computer tools determine and interpret the GZ curve of a ship,
16. carry out a heeling test,
17. apply international and national regulatory frameworks for assessment of a ship's seaworthiness,
18. use propeller characteristics to select ships' propellers based on the ship's power requirements and the design coefficients of the hull,
19. carry out an independent engineering investigation,
20. present project assignments in reports written in English (and Swedish) so that the entire chain from problem formulation via method of solution to result is communicated to the reader.

EXAMINATION

The work is to be finally presented in a technical report for which you are able to assume reasponsibility in all respects. Along the way to this final stage, you will report how work is progressing (see below). In this stage, you address your coursemates and teachers to receive comments on your work, to gain support for your ideas and to be given the go-ahead to continue. In this study situation, the presentations constitute the examination. In working life, they would be natural features of the work process. Feel free to cooperate with other students. Perhaps someone else has chosen the same transport scenario as you? Note, however, that each student reports individually and you must therefore have full insight into and understanding of all parts of the project! The examination is your chance to show that you have fulfilled the course objectives. Look at the course objectives, ask yourself if you have reached them and also if your work shows that you have done so.

Project review 1 (Mon 20/2 time: 9:00-12:00)

In the review session, you work in small groups. You will present your results from project phase 1 (See *Instructions and Guidance—Phase 1*, page 16) on a *Giant Post-it* note. You will also give an oral report of the basis for your decisions, with motivations and references. You will give feedback on the projects of your coursemates and get their views on your work. You will also be discussing your ideas and views on each other's work collectively with a teacher.

Project review 2 + Written test (weeks 9-10)

You are now in the middle of the technical investigation and have worked with the Matlab script *QuickLines* och *Hydrostatics* (See *Instructions and Guidance—Phase 2*, page 17). In this session, you report your work individually to a teacher. You will present your results and explain how you have tackled the issues of stability, resistance and propulsor in your project, how you intend to proceed and what problems you are facing. Document your work carefully. Bear in mind the final report and the fact that it will be much easier to obtain supervision if your questions are placed in a structured context. You must book a time for your project review, which takes about 20 minutes and summarise it on a *Giant Post-it*. During the timetabled hours, (Mon. 27/2, time: 9-11), you will undergo a written test which covers the course material according to the reading instructions for phases 1 & 2.

Submission of preliminary report (Wed.7/3 time:13:00)

The report must now be virtually complete. You should feel that you have done the job and reported on your approach, your motivated decisions, where you have got your information from and your results, in a clear and satisfactory manner. Remember, of course, that the language, figures, tables and references will also do their job in communicating between you and your readers. Go through the course objectives and make sure you have fulfilled them through your report! Use the report template and do not forget the compulsory appendix, *General arrangement plan and main data*. Also go through the checklist. You will hand in three copies of the report for review by two students and one teacher. You will also receive two reports from other students for you to review.

Report feedback (Fri 9/3 time15:00-17:00)

Since report-writing is part of the course and we place demands on the quality of the report, we want you to receive feedback that you are able to incorporate into the final report version. In groups (approx. 4-5 students and one teacher), the students' reports are discussed. The students must be able to present their own projects orally, ask questions and give constructive criticism on the 2-3 student reports they have read before the seminar.

Report submission (Fri 16/3 time: 16:00)

The report must now be completely finished, including changes resulting from feedback. Go through the Naval Architecture checklist (available on the course home page) and the course objectives before you submit the report.

THE DESIGN ASSIGNMENT

Choose a transport scenario (see page 19) and design vessels that can carry out the scenario with respect to the side conditions below. Follow *Instructions and guidance* on the following pages, use the report template (from the course home page) and note that the Appendix *General arrangement plan and main data* in the template are compulsory in this assignment.

SIDE CONDITIONS:

- The ship must be of the displacement type, that is, Froude number Fn<0.4.
- Economy and the environment: Choose an economically appropriate speed in relation to the cargo type that your vessel is to carry. Choose economically sensible/reasonable ship's dimensions Here there are typical conflicts between ship's length, where propulsion resistance and therefore fuel costs decrease with increased length, and building costs, which increase with length. Avoid overdimensioning, i.e., dimension the vessel so that it solves its task but no more.
- Physical limitations must be taken into account, e.g. draught in harbours, quay length, dimension of locks, height of bridges and power lines, etc.
- Freeboard in accordance with *International Convention on Load Lines*; see the Swedish Maritime Administration's code SJÖFS 2006:1 Regulation 28-40. See www.sjofartsverket.se, or Watson p. 308-12.
- Intact stability according to IMO Resolution A.749 1993; see Huss 2007 p.93-95 och Appendix 1 (the latter reproduces the Swedish Maritime Administration's code SJÖFS 2006:1, Appendix 4, Regulation 3:1) or Rawson & Tupper pp.113-115 and 130.
- The ship's lightweight is approximated according to Watson or Rapo; see Milchert 2001 section 4.1-4.5 or Watson section 4.1-2 and 4.4-4.6.
- The ship's course stability is analysed according to Clarke; see Milchert 2001 page 12:6 or the downloadable figure on the course home page. Most often we want the ship to be course-stable in order for it not to wind its way forward and require constant compensation from the rudder. If the course stability is too great, however, the ship is hard to turn. It is worth noting that tank vessels and bulk carriers are often somewhat course-unstable. Therefore, course stability is not an absolute requirement for your ship!
- Both loaded and unloaded (possibly with ballast) vessel conditions are to be investigated.
- The propeller arrangement must be dimensioned with a reasonable propeller rpm.
- The ship must be divided into watertight compartments in accordance with *SOLAS* as formulated in *DNV Rules for Classification of Ships* (Part 3 Chapter 1 Section 3: A100-A300 for ships longer than 100 metres; Part 3 Chapter 2 Section 3: A100-A300 for ships shorter than 100 metres), which can be downloaded from the course home page under msy.se.
- The work you carry out in this course module corresponds to the first stage in the design of a ship. Here, your focus is on analysing the ship's load capacity (and the accompanying analysis of intact stability), speed and power requirement. You must, however, be aware (and this could well be mentioned in your report) that there are many other important aspects dealt with later in the design process. Examples of such aspects are the ship's seakeeping abilities, manoeuvrability, hull design, installation of machine systems and cargo handling systems, and how the vessel is to be divided into watertight compartments in order to meet the regulations for damage stability.

INSTRUCTIONS AND GUIDANCE –PHASE 1

Determine main dimensions, load capacity and speed. The ship design is presented on a *Giant Post-it* note during *Review 1* with a simple *general arrangemenet plan* (GA) and in terms of:

Length, overall	L_{OA}	Displacement	Δ
Length,betw perpendiculars	L_{pp}	Deadweight	DW
Breadth, max	b	Lightweight	LW
Draught	T	Ballast weight, loaded ship	BW_L
Freeboard	F	Ballast weight, empty ship	BW_T
Height to weather deck	D	Centre of gravity, vertical	KG
Height overall	H	Longitudinal centre of gravity,	LCG
Block coefficient	C_B	Metacentric height	GM_0
Cruising speed	V		

The result is to be motivated as a rough estimate (that is, by means of calculations) with respect to:

- ability to solve the given transport work (route, travel time, speed, frequency of crossings, number of vessels, load capacity for each vessel, time for loading and unloading, etc.),
- transverse stability, by showing that the metacentric height $GM_0>0$,
- course stability,

and by reasoning with respect to

- resistance, power requirements and propulsion.

Suggested procedure: Determine route and estimate the distance. Determine the mass and dimensions of the cargo. Choose a suitable type of vessel. To determine the size, shape and speed of the ship requires an iterative procedure in which the main dimensions, hull shape (block coefficient), load capacity and speed are weighed up against the transport scenario and side conditions in question.
It would be appropriate to make use of *Matlab* so that you can alter speed, length, breadth, etc., and automatically update the connections depending on these.Consider whether the transport work is best solved with several ships travelling at low speed or with one high-speed craft. There may be limitations in harbours and locks that force you to divide up the transport among several ships, or demands placed on frequency of crossings.

Outline the arrangement plans in three views which show the division of the ship into cargo space, engine space, etc. Make assumptions about how much of the ship's inner volume can be utilised for cargo and how much will be occupied by engine room, double bottom, forepeak, etc. Determine how the cargo is distributed in different tanks or on different decks. Determine the resulting load capacity. Estimate the ship's lightweight and possible ballast weight and theri respective centres of gravity. Calculate the draught with and without load. Determine the position of the ship's centre of gravity and make an estimation of the stability. Estimate the time required for loading, unloading and bunkering and calculate the total travel time. Repeat the prodecure and alter the ship's dimensions and speed until you achieve a satisfactory design.

Reading instructions

- *Introduction to Naval Architecture* (Rosén 2011): Read the whole booklet.
- *Basic Ship Theory* (Rawson & Tupper 1998): Read pages 7-14, 52-61, 73-76, 91-99 and 122-124 carefully.
    - *Fartygs stabilitet* (Huss 2008): Read pages 11-24 and 27-35carefully.
- *Ship resistance and powering* (Garme 2011): Read pages 3-19 och 28-36 extensively.
- *Practical Ship Design* (Watson 1998): read 4.1-2 and 4.4-4.6 and in chapter 3 pages 55, 58-65 and figures 3.1-3.5. (for estimation of lightweight and centre of gavity)
- *Ship Design for Efficiency & Economy (Shneekluth & Bertram 1998): pages 149-54, 166-68, 173-75 and 178* (for estimation of lightweight and centre of gavity)

- *Handledning i Fartygsprojektering* (Milchert 2001): Read 4.1-4.5 and 17 (as support for the arrangement plans). The figures in section 17 give some idea of how large a part of the ship is occupied by engine room, forepeak, etc. Use the figures on p. 5-8, section 9 to estimate how much the hull structure (beams in decks, sides, double bottom and double hull) encroach on the load volume. Use fig. On p. 6 in section12 to assess course stability.

- *Internet*: For information about: restrictions on ship dimensions in harbours, locks, under bridges, etc; the characteristics of your cargo; existing vessels that carry out similar transport. You will find a number of useful links on the course home page. A suitable tool for determining route and distance is *Google Earth* (http://earth.google.com/).

INSTRUCTIONS AND GUIDANCE– PHASE 2

Refine the design with geometry description, hydostatic data, stability analysis, estimation of power requirement and choice of propeller. This means presenting the geometry with body plan, a simplified trim and stability book, updating of quantities from Phase 1 and the following new quantitites:

Centre of buoyancy, vertical		*KB*
Longitudinal centre of buoyancy		*LCB*
GZ curve		$GZ(\phi)$
Propulsion resistance as function of speed		$R(U)$
Effective power and shaft power as function of speed		$P_E(U)$ & $P_S(U)$
Engine power		
Propeller	- diameter	*D*
	- no. of blades	*Z*
	- rpm	*n*
	- pitch ratio	*P/D*
	- blade area ratio	A_E/A_0

Present data for both fully loaded and for unloaded (possibly with ballast) ships. Show that the ship(s) can solve the transport problem and that the side conditions are fulfilled.So far, you should have come as far as *Review 2*. On this occasion, too, *Giant Post-its* are one way of summarising GA and main data!

Procedure: Use the *Matlab*-script *QuickLines* (download from course home page) in order to:

- Create a hull geometry that dorresponds to the results from Phase 1.
- Drw a body plan.

Use the program *Hydrostatics*, with the hull geometry from *QuickLines*, in order to:

- Analyse floating conditions (hydrostatics) och transverse stability. Modify the geometry (back to *QuickLines*) or the mass distribution if necessary so that the ship floats on an even keel and meets the stability criteria.
- Estimate the propulsion resistance, power requirement and necessary engine power.
- Choose propeller or propellers.

You will explain how to interpret the stability properties from the GZ curve and how the ship's geometry and position of centre of gravity affect the quantity. The reader of your report must be able not only to see that your ship fulfils a regulatory framework/set of rules, but also to understand the problem of hydrostatic stability and how it relates to the concepts you have used to show that the stability is adequate. Also discuss the significance of "too good" stability.

You will give an account of the internal relationship of the various resistance components from low to high speed and in particular which component dominates at cruising speed and why. Evaluate the uncertainties inthe prediction in relation to the cruising speed you have chosen and the risks these constitute for the whole ship project.

Reading instructions

- *Basic Ship Theory* (Rawson & Tupper 1998): Read 7-14, 52-66, 73-76, 91-104, 112-115, 122-124 and 127-135 carefully.
    - *Fartygs stabilitet* (Huss 2007): Read pages 11-24, 27-40, 44-58, 80-81, 93-95 and 160-162 carefully.
- *Ship resistance and powering* (Garme 2011): Read pages 3-19 och 28-53 carefully.
- *Practical Ship Design* (Watson 1998): Check in the compendium for questions that are relevant to you particularly chapters 9, 12.9, 15.1-6 and 16.
    - *Handledning i Fartygsprojektering* (Milchert 2001): chapters 7, 10 and 11.

CHOOSE ONE OF THE FOLLOWING TRANSPORT SCENARIOS:

1. Trucks between Lake Vänern and the Ruhr District

The European motorways are approaching gridlock as a result of traffic overload. In combination with rising fuel prices and the imore and more obvious threat from transport-related pollution, transport with trucks and articulated trucks is increasingly being called into question. One alternative under discussion is to transfer some of the transport to vessels on the major rivers and canals. As part of this discussion, your task is to design one or more vessels that can transport 70 trailers a week in both directions between suitable harbours in Lake Vänern to equally suitable ones in the Ruhr District.

2. Oil from the Persian Gulf to Sweden

Sweden imports approx. 1.4 million tonnes of oil per month. Of this, 150,000 tonnes go to the refinery in Nynäshamn. Your taks is to design one or more ships that solve this entire transport problem. The oil is to be transported from suitable harbours in the Persian Gulf.

3. Private cars between Gothenburg and Shanghai.

Gothenburg's harbour ships out approx. 330,000 private cars annually. As part of an investigation on the possibility of opening a shipping line for transport of private cars between Gothenburg and Shanghai for import/export of 5000 cars/month in both directions, your task is to design suitable vessels.

4. Containers between Rotterdam and Singapore

In Singapore, which is the world's largest container harbour, 24 million containers (TEU) are loaded and unloaded annually. In Europe's largest container harbour, Rotterdam, the yearly loading and unloading volume is 10 million. Your task is to design a container ship that can transport 12,000 containers (TEUs) between these harbours. The ship must be able to do the round trip including loading and unloading in 40 days.

5. Kiwi fruit from New Zeeland to the Baltic Sea

Although New Zeeland is on the other side of the globe, we can buy fresh fruit from there in Sweden. Your task is to design a ship that transports 5000 tonnes of kiwi fruit, apples and other fresh fruit from New Zeeland to the countries around the Baltic Sea. The ship is to divide its cargo equally among Stockholm, Helsinki, Saint Petersburg, Tallinn and Riga. The transport time should be shorter than 4 weeks

6. Oil from Venezuela to the USA

"Venezuela's controversial president Hugo Chavez knows how to be a thorn in the flesh of the United States. He is now offering poor US citizens heating oil at reduced prices so that they can make it through a cold winter." (From Swedish national newspaper *DN* 2005-11-24). As part of this project, Hugo Chavez has turned to you for help in designing one or more ships that can transport 120,000 tonnes of crude oil per month from Puerto La Cruz to Seattle in the USA.

7. Product tankers for petrol transport from the Swedish west coast to Estonia

Further develop the quick design from the introductory lecture. Deliver 570, 000 m^3 petrol/yr from the Preemraff refinery in Brofjorden to Tallinn.

8. Iron ore from Narvik to the US East Coast

The main product of the Swedish mining company LKAB is refined iron ore, also known as pellets.. Most of the production is transported by rail from Kiruna to Narvik in Norway, from which it is shipped out to the rest of the world. Your task is to design one or more ships that can deliver 400,000 tonnes of pellets every month from Narvik to suitasble harbours on the East Coast of the United States.

9. Iron ore from Luleå to Gdansk

If the trains do not go to Narvik, they go to Luleå, on the Swedish coast. Further develop the 20-minute design from the introductory lecture. Design ships that deliver 30,000 tonnes of iron pelletsa week from Luleå to Gdansk.

10. Trailers between Nynäshamn and Gdansk

In an investigation on the possibility of opening a transport route directly between Nynäshamn and Gdansk, you are given the task of designing suitable vessels. In the plans sketched, 100 trailers will arrive at and depart from each harbour every 24 hours. (Traffic started on the route during 2007!)

11. A small Ro-Pax-vessel for traffic between the Baltic islands of Öland and Gotland

Further develop the design from the introductory lecture. Two crossings per day between Klintehamn (Gotland) and Grankullavik (Öland) with space for 20 private cars, 5 trucks and 150 passengers. (In the summer of 2007 traffic started between Grankullavik and Visby, Gotland!)

12. Banana trade route Colombia-Hamburg

The Swedish-Danish-Japanese NYKCool would like to see reasonable ships that can freight 3500 pallets of bananas a week from Turbo in Colombia to Hamburg. In Turbo, ships are usually loaded in a roadstead.

13. Car freight world-wide Asia-Europe-North America-Asia

The car transport shipping company Wallenius needs ships for the following transport. Private cars are loaded in Yokohama and Masan, approx. 3000 cars per harbour. In Europe, they are unloaded in Bristol,Zeebrugge and Bremerhaven. After that, they continue to North America after loading in Bremerhaven, Zeebrugge och Southampton, 2000 cars in each harbour. In North America, unloading in Halifax, Baltimore and Port Hueneme. From Port Hueneme ballast leg to Yokohama. The ship should cover the route approx. 4 times a year.

14. Citrus fruits from Mediterranean harbours to Stockholm

Sweden imports approx. 80 000 tonnes of oranges and 10 000 tonnes of lemons a year. A significant amount of this is produced around the Mediterranean. Design a ship that loads fruit in Valencia, Syracuse and Haifa. The ship will transport 4000 tonnes of fruit per month to Stockholm for forwarding to wholesalers in Svealand (central Sweden) and södra Norrland (north Sweden).

15. Cruises Miami-Alexandria

Design a modern cruising ship for 1400 passengers going to Miami-Bahamas-Bermuda-Madeira-Malaga-Korsika-Rome-Alexandria. The shipowner conceives the voyage, including two overnight stays in Alexandria before the return flight to Miami, as taking 21 full days.

16. Liquid natural gas from the “Snow White” field to Cove point (USA)

From the “Snow White” field in the Barents Sea, natural gas is transported to Melköya off the coast of Hammerfest in Norway. From there, 2.4 billion cubic metres of natural gas will be delivered annually to the terminal in Cove point, Maryland, on the East Coast of the USA. Design suitable ships for accomplishing the transport.

17. Wheat from the USA to Japan

The USA is one of the largest exporters of wheat in the world. A large part of the exported production is bought by Japan. Design ships that transport 1 million tonnes of wheat a year from Huston, Texas ti Yokohama, Japan’s largest import harbour.

18. Paper products from Sundsvall to Lübeck or Gothenburg

Paper destined for Germany, Switzerland and Austria is often shipped to Lübeck from paper mills in Sweden and Finland. Paper destined for other parts of the world use Gothenburg as a reloading harbour. Thepapermaking group, Stora Enso, which works with the freight forwarder SECU (Stora Enso Cargo Unit) have recently contracted Transatlantic's new ships for transport between Uleåborg och Kemi in the Gulf of Bothnia (northern end of the Baltic Sea) and Kotka in the Gulf of Finland, to Lübeckand Gothenburg. Modo and SCA ship paper from the Swedish side to these harbours for forwarding. Design ships for paper products (newspaper, magazine paper, office papaer, etc.) for transport from Sundsvall. The ships must be able to ply the route Sundsvall-Lübeck or Sundsvall-Göteborg. The flow of goods from Sundsvall is calculated to be 1 million tonnes/year.

19. Product tankers

From a press release from Nynäs (refinery) 2007-03-29:
Nynäs is expanding its global operations in response to the increasing demand for the company's products, particularly environment-friendly process oil for the tyre industry. Demand for this product is great since the EU has decided to forbid the aromatic extracts that are used in tyres today and that have a negative effect on people and the environment. Nynäs is now assessing different ways of increasing production in our own refineries and in partner refineries throughout the world. In Nynäshamn, Nynäs has at present permission to produce 530,000 tonnes of special oils and the application concerns an increase to 1.2 million tonnes. The expansion is at the planning stage, and applying for a new environmental permit is an important first step. No decisions have been made on investments, but various alternatives are presently being considered at Nynäs.

A part of Nynäs's production increase could possibly go to the industries in the Baltic Sea area. Design a product tanker that travels between Nynäshamn and approx. 10 different harbours round the Baltic, where each harbour is visited once a month. In total, the ship will deliver 300,000 tonnes/year. One conceivable client is the tyre manufacturer Nokian with factories in Nokia and St. Petersburg. Therefore, design the ship with Rauma and St. Petersburg as unloading harbours and treat the other legs in a more routine manner.

20. Gotland traffic fuled by gas

Design a Ro-Pax vessel for 1500 passengers and 160m ro-ro cargo. Propulsion is to be with gas as fuel, preferably natural gas, but with the possibility of using biogas to the extent this is possible. Bunkering takes place in Nynäshamn. The ship will be berthed in Nynäshamn over night and the smallest acceptable bunkering capacity must be sufficient for three round-trip crossings Nynäshamn-Visby. The ship must be able to fit into the present timetable with departure from Nynäshamn at 11:05 and 21:05 and from Visby at 07:05 and 16:45.
Read about the planned guest terminal in Nynäshamn:
http://www.aga.se/international/web/lg/se/likelgagase.nsf/0/6C4AB57C88C9B320C1257288004B5636

21. Trucks between Oxelösund (Sweden) and Turku (Finland)

Further develop the scenario from the introductory lecture: Shortcut between southern Sweden and Finland. Transport is needed for approx. 250 articulated trucks and trailers every week between Oxelösund and Turku in both directions. Solve the transport problem with a reasonable timetable.

22. Short Sea Shipping: Container traffic Oxelösund-Hamburg-Bremerhaven

Further develop the scenario from the introductory lecture. Use Oxelösund as importation and exportation harbour for transports to and from the area round Lake Mälaren (Sweden) and Hamburg and Bremerhaven as corresponding points for local goods flow to/from northern Europe or after reloading to/from the whole world. Design ships that do a round trip in a week and can accommodate a load of 800 containers.

23. Bauxite from Brazil to a smelting plant in Norway

Sør-Norge Aluminium AS has the capacity to produce (2010) 165, 000 tonnes of aluminium a year.This requires about 660, 000 tonnes of bauxite. Design ships for suitable transport of bauxite from Porto Trombetas in Brazil to the smelting plant in Norway, in the outer part of the Hardanger Fjord between Haugesund and Bergen.

24. Timber export from Sweden to Great Britain

Every year, about 3 million cubic metres of sawn timber is exported to Great Britain. Desing ships that transport 500,000 cubic metres of timber from Gävle to Hull.

25. Round timber from Canada to China

Canada is one of the world's largest exporters of forestry products. Unbarked logs are known as round timber or roundwood and they areexported as raw material to countries such as China. Design ships that take 1 million cubic metres of round timber in a smooth flow from Port Metro in Vancouver to the harbours Tianjin and Qingdao in China.

Centre for Naval Architecture

TIMETABLE

PERIOD 3 (INITIAL SHIP DESIGN SD2710 AND NAVAL ARCHITECTURE SD1710)

Week 3 *Introduction*				
Mon	16 jan	8-10		
		10-12		
Tue	17 jan	8-9	E33	Introduction KG+IS
		9-11	E32	Initial ship design KG+IS
Wed	18 jan	13-15	L41	SD1710/2710 Stability. KG
		15-17	L41	SD1710/2710 Resistance. KG
Thu				
Fri	20 jan	13-15	L43	SD1710/2710 Stability. KG OBS: Read Rawson & Tupper: 91-104, 122-124 & 130-135 (*Fartygs stabilitet* s27-40)
		15-17	L43	SD1710/2710 Before the lab session. OBS: Read Rawson & Tupper: 101, & 130-135 and *Ship resistance and powering* 51-53 (*Fartygs stabilitet* s40 & 80-81)

Week 4 *Shipping, guestlecture and lab session*				
Mon	23 jan	8-11	GIH-badet	SD1710/SD2710 Resistance & stability lab sesion
		11-12		
Tue	24 jan	8-10		
		10-12	E53	SD1710/2710 Resistance and powering, KG OBS! Read *Ship Resistance and powering*: page 37-50
Wed	25 jan	13-16	E33	SD1710/2710 Guest lecture by Brita Melén Eriksson and Ralph Mohlin from NYKCool on the global transport of refrigerated cargo and reefer ships. Before the lecture: Read Wikipedia on Reefer_ship (*Sjöfartens bok* s54-56)
		16-17		
				SD1710/2701 Lab session follow-up and review of results according to lab instructions. KG/IS
Thu				
Fri	27 jan	13-15	L41	SD1710/2701 EXAMINATION: Peer-review on shipping essay and written test. KG
		15-17		

Week 5 *Propeller modelling och marine propulsion*				
Mon	30 jan	8-10		
		10-12	L42	SD1710/2710 EXAMINATION: Submision of the shipping essay at 10.15 in the lecture room. Lab session follow-up and review of results according to lab instructions. KG
Tue	31 jan	8-10		
		10-12	E51	SD1710/2710 Intro propeller modelling JK
Wed	1 feb	13-15	E51	SD1710/2710
		15-17		
Thu				
Fri	3 feb	13-17	V33	SD1710/2710 Propeller modelling JK

Week 6 *Propeller modelling*				
Mon	6 feb	8-12		
Tue	7 feb	8-10		
		10-12	L22	SD1710/2710 Propeller modelling JK
Wed	8 feb	13-16	D33	SD1710/2710 Propeller modelling JK
		16-17		
Thu				
Fri	10 feb	13-16	E51	SD1710/2710 EXAMINATION: Peer-review session on the propeller modelling report/summing-up/workshop JK
		16-17		

Week 7 *Initial ship design*				
Mon	13 feb	8-10		
		10-12	Q15	SD1710/2710 EXAMINATION: Submission of the propeller modelling report at 10.15 in the lecture room. Ship design and ship stability, AR OBS! Read: Rawson & Tupper: 91-94, 112-115, 112-124 & 127-130 *(Fartygs stabilitet* s29-31, 47-58 & 93-95)
Tue	14 feb	8-10		
		10-12	Q22	SD1710/2710 Ship design and ship stability, AR OBS! Read: Rawson & Tupper: 91-94, 112-115, 112-124 & 127-130 *(Fartygs stabilitet* s29-31, 47-58 & 93-95)
Wed	15 feb	13-15	E34	SD1710/2710 Initial ship design, *Quicklines* & *Hydrostatics* KG
		15-17		
Thu				
Fri	17 feb	13-15	L32	SD1710/2710 Initial ship design, Ship dimensions, resistance & propulsion KG
		15-17		

Week 8 *Initial ship design, Review 1and guest lecture*				
Mon	20 feb	8-9		
		9-12	L41/42	SD1710/2710 EXAMINATION: *Review 1*. KG/IS
Tue	21 feb	8-10		
		10-12		
Wed	22 feb	13-15	L44	SD1710/2710 Ship resistance, KG OBS! Read: Ship resistance and powering: p3-4, 10-13 and 28-36
		15-17		
Thu				
Fri	24 feb	13-16	E51	SD1710/2710 Guest lecture, Erik Eklund from Transportstyrelsen *On rules and regulations for international shipping* Before the lecture: Read *On IMO, SOLAS…* in your course binder (*Sjöfartens bok*: s118-126)
		16-17		

Week 9 *Initial ship design and Review 2(book time with Karl)*				
Mon	27 feb	8-9		
		9-11	L42	SD1710/2710 EXAMINATION: Written test on resistance, propulsion and stability (according to reading instructions for phase 1 & 2)
Tue	28 feb	8-10		
		10-12		
Wed	29 feb	13-15		
		15-17		
Thu				
Fri	2 mar	13-15		
		15-17		

Week 10 *Initial design report*				
Mon	5 mar	8-10		
		10-12		
Tue	6 mar	8-10		
		10-12		
Wed	7 mar	13-15	Room 420	SD2710 EXAMINATION: At. 13 hand in report draft to *peer review,* time for reading course mate's reports.
		15-17		SD2710 time for reading course mate's reports.
Thu				
Fri	9 mar	13-15		SD2710 time for reading course mate's reports.
		15-17	Room 521, Room 420	SD2710 EXAMINATION: Report feedback sessions KG

Week 11 *Initial design report and written exam*				
Mon	12 mar	9-13	V34	SD2710 EXAMINATION: Written exam KG
Tue	13 mar			
Wed	14 mar			
Thu	15 mar			
Fri	16 mar	16	Room 420	SD2710 EXAMINATION: Report submission

Week 23 *Re-exam*				
Fri	8 june	8-13	L41	SD2710 EXAMINATION: written re-exam KG