Student # _____

Ph.D. Qualifiers Examination in

ENGINEERING DESIGN

Spring 2009

Instructions

The study guide states that to be successful on this exam, you must demonstrate that you know:

- How to formulate a problem,
- How to sketch and understand engineering drawings (projections),
- How to obtain order of magnitude results (approximate analysis),
- What next steps you would take to get to a more in-depth solution,
- How to identify failure criteria and assess failure,
- How and when to perform optimization, and
- How to implement component design.

You should show analytical insight through design solutions that exhibit the level of maturity and understanding expected of Master's level students. Remember that there is not a single correct solution, but we are interested in seeing your thought process.

This design examination is open-ended to some extent, allowing you to demonstrate your creativity, resourcefulness, and mastery of various aspects of design. The design problem statement may lack certain details, much as problems in industry or academe. As such, you may need to make some reasonable assumptions and suggestions in order to develop potential designs. Be certain to clearly identify any assumptions you feel you need to make in order for a certain design feature or concept to be a reasonable solution. You are expected to address what is known about the design problem, but also what is not known and make suitable design decisions and conclusions.

The exam evaluators have no preconceived notion/ideas of the best solutions. Thus, you will be graded on your process of thinking and approach to open design problems.

Be sure to pace yourself to finish in the time allotted. Consider spending about 15 minutes maximum on Part 1, 40 minutes on part 2, and 65 minutes on part 3.

Good luck!

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Problem Statement

Modern SUVs are popular and often used to transport canoes from home to a body of water (river, lake, etc). However, it is difficult to load and secure the canoe onto the top of a vehicle without scratching, denting, or damaging either the canoe or the SUV. Design a system for loading and securing the canoe to the top of the SUV. It is desired that the canoe be loaded from the side of the vehicle.

You are expected to consider the design of your mechanism(s) and structures to fulfill this need.

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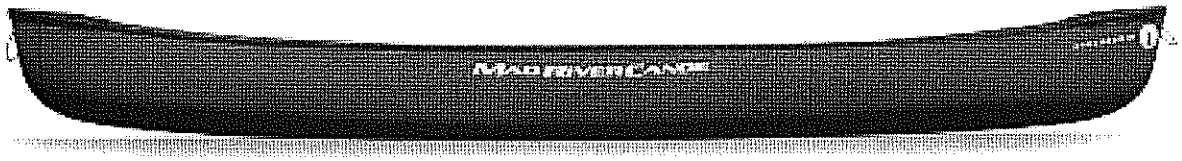
Canoe specifications



Length	16' 3"/ 496 cm
Width @ 4" waterline	34" / 86 cm
Maximum	36" / 91 cm
Center Depth	15" / 38 cm
Bow Depth	22" / 56 cm
Stern Depth	21" / 53 cm
Bow Rocker	2.25" / 6 cm
Stern Rocker	2.125" / 5.5 cm
Average Weight	82 lbs / 38 kg
Max Capacity 6" Freeboard	1100 lbs / 499 kg

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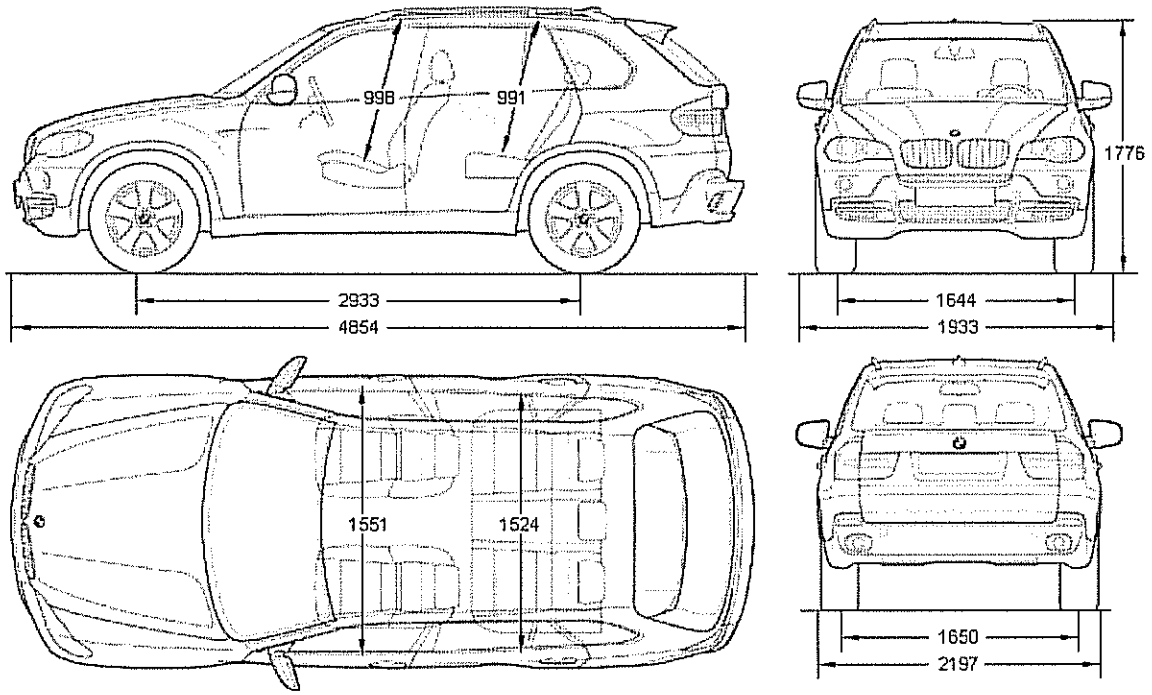
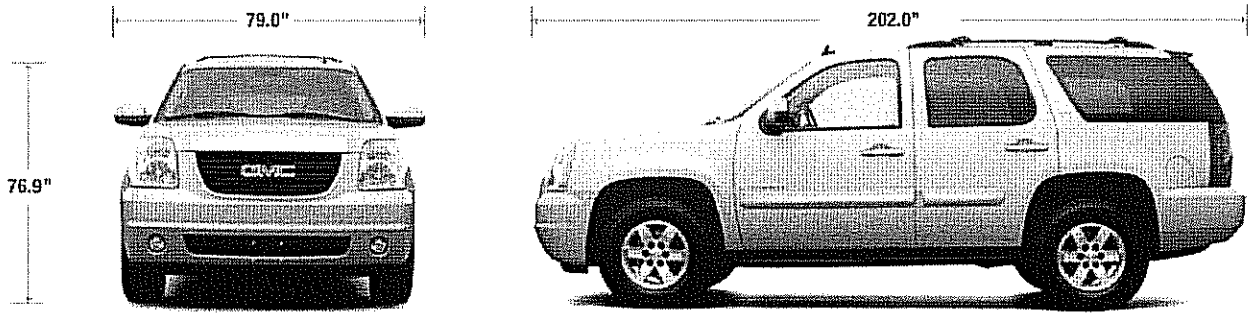
SUV specifications for example vehicles



Dimensions in mms

DIMENSIONS



Dimensions in inches

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Stage 1: Problem Formulation

Part 1.1: In lieu of spending time formulating the problem, we ask you to consider the following requirements:

1. *The system must be actuated with human power*
2. *The system must interface with the SUV*
3. *The system must secure the canoe to the roof of the SUV*
4. *The system must fulfill the functionality for different types of SUVs*
5. *The system must not require modification to the canoe*
6. *The system must not damage the SUV or canoe*
7. *The system must be stable*
8. *The system must load the canoe from the side of the vehicle*
9. *The system should be esthetically pleasing*
10. *The system should take a minimum of space when loading*
11. *The system may allow the loading of two canoes*

Part 1.2: *Determine* the functions of the system.

Stage 2: Analysis, Evaluation, and Failure Mode Identification

Part 2.1: *Identify* critical failure modes of the proposed solution. Examine the effects of these failure modes and discuss approaches for addressing these.

Part 2.2: *Formulate* an analysis plan for the conceptual design solutions. Determine what analysis (e.g., computational, experimental, physical prototyping) is required to improve upon the design and generate a viable solution.

Stage 3: Critical Component Design and Generalization

Part 3.1: *Select* the most critical component, assembly or interface in the existing solution. Explain why you feel this is the most critical element.

Part 3.2: *Implement* a detailed solution for the selected element. Provide specific details to progress from conceptual design to detailed design specifications, including analysis steps, manufacturing plan, critical interfaces, etc.