GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1996

COMPUTER AIDED ENGINEERING

EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

-- **Please sign your name on the back of this page** --

Given

Equations for Bezier curves are

$$b(u) = \sum_{j=0}^{n} B_{i,n}(u)\vec{P}$$

$$B_{i,n}(u) = \binom{n}{i} u^i (1-u)^{n-i}$$

where: **P** are the control vertices that define the Bezier curve.

Questions

a) Given the equation for a Bezier curve above, derive the equation of a **general** Bezier surface. Using this Bezier surface equation, derive the equation for a **bicubic** Bezier surface.

b) Using a sketch or two, model the bracket that joins the top-tube and seat-tube with bicubic Bezier surfaces. Note that the ends of the bracket are cylindrical in shape to match the cylindrical tubes. Please highlight any assumptions that you make in your modeling.

c) Explain what continuity requirements are needed in your model. Also explain how you met these continuity requirements. Pay particular attention to any unusual patches or adjacencies in your model.

d) Pick another type of surface (4th order Bezier, bicubic NURBS, etc.) that would be suitable to model the bracket. Describe how you would model the bracket using this other surface type. What are the pros and cons of these surface types?

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DESIGN

EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

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Ph.D. Qualifying Examination in Design

Spring 1996

George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology

Written Examination:

Attempt all parts of the question. Be sure to list and justify all of your assumptions explicitly. Read the entire exam first.

There are a large number of semi-articulated tractor-trailers ("semis") that use the extensive interstate highway system in and around Atlanta (see attached drawing). Due to excessive speed, these trucks sometimes flip onto their sides when negotiating the interchanges on to and off of the interstate system. This situation will only worsen now that the speed limits have been raised to 65 on urban interstates and 70 on rural interstates.

Overturned semis cause delays by blocking the roads, and must be righted and removed in a minimal amount of time, as they add to the already horrendous traffic jams currently on Atlanta's roads.

A popular remedy is to take two tow trucks and pull the trailer up-right. This is accomplished by wrapping the cables around the trailer and pulling. This can damage the trailer by crushing it, and doesn't always work.

Your job is to develop an alternative means of righting the trailer (ignore the tractor for now) with minimal further damage to the trailer and in minimal time.

Specifications for a typical trailer are on the attached drawing and below.

The final design must be capable of being carried by a standard tow truck, must be operable by a crew of four, and must only require the power available from a tow truck (120 v electricity, hydraulic and pneumatic power), as well as the tow cable and hook. But, you cannot use the cable and hook as they are used now (wrapped around the trailer).

a) First, develop an initial set of specifications for the device. Discuss how these relate to the problem statement.

b) Quickly break the system down into subsystems (long descriptions are not necessary, only ones that are detailed enough for us to understand what they are). Identify the CRITICAL subsystem and develop between three and six candidate designs for it.

c) Of these three to six candidate designs, pick the three which appear most promising to you and present a brief (less than one page) feasibility and/or performance evaluation of each. From these, select the "best" design. You must explicitly indicate your evaluation method and criteria, as well as the weightings of each criterion.

d) Choose one of the three candidates and perform a more detailed feasibility study. Present a model and a function structure of the candidate design. Determine design specifications for the components, including those based on performance requirements.

e) Based on your feasibility study, present an overall evaluation of the candidate design chosen for part c. (I.e., compare your design to the specifications that you developed in part a.)

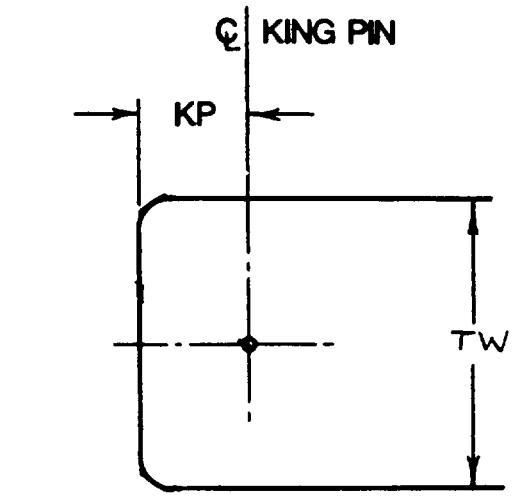
f) Assume that you had generated 20 concepts for your subsystem. In the context of this assumption, critically evaluate the design process as described by parts a-e above. What are some of the root assumptions for the successful application of the method? What are some of the flaws in the above process? How would you overcome these flaws? (Don't limit yourself to these questions.)

(N.B. If you do not do an adequate job on the written exam, you may be asked to discuss it on the oral.)

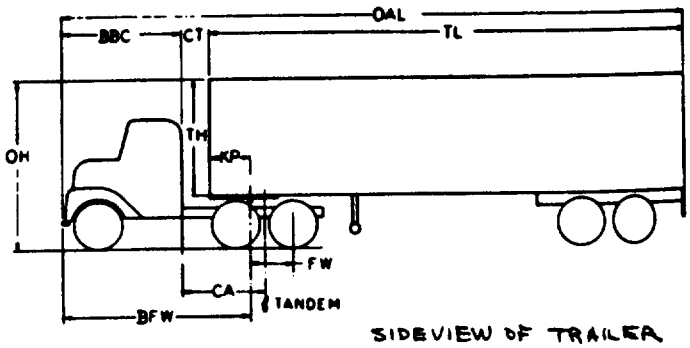
On the attached drawing:

OAL (overall length) = 55 feet
TL (trailer length) = 45 feet
KP (king pin center) = 3 feet
OH (overall height) = 14 feet
TH (trailer height) = 10 feet
TW (trailer width) = 8 feet

The trailer weight is 25 tons (50,000 lbs) fully loaded and 5 tons (10,000 lbs) empty.



TOP VIEW OF TRAILER FRONT END



SIDEVIEW OF TRAILER