GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

**Ph.D. Qualifiers Exam - Spring Quarter 1995**

DESIGN
EXAM AREA

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

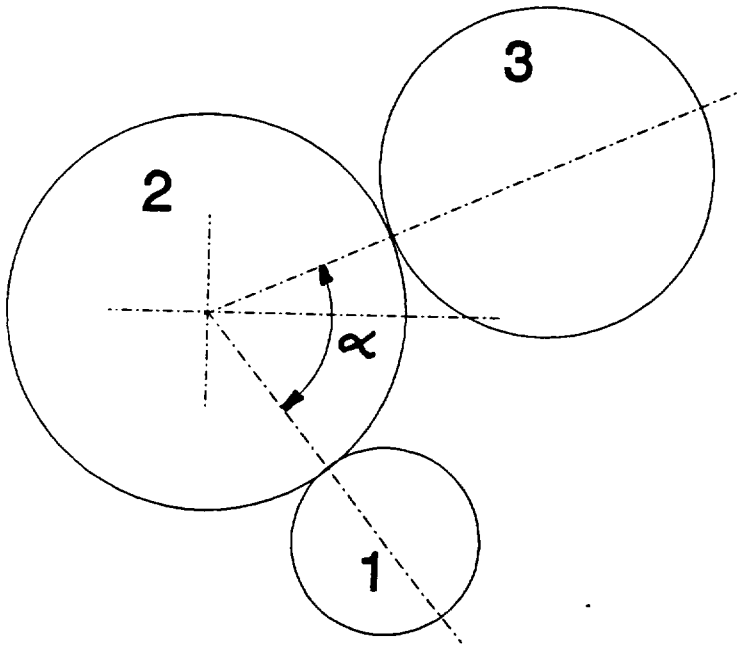
**-- Please sign your name on the back of this page --**

**PhD Design Qualifying Exam**
**Spring Quarter 1995**

**#1**

Pinion 1 is transmitting 20 hp to gear 3 through idler 2. Pinion 1 has a diameter of 2 in and is rotating at 10,000 rpm. Idler 2 has a diameter of 4 in, and a pressure angle of 20°. Idler 2 is located at the center of its supporting shaft.

a. Determine the reactions at the bearings of the idler supporting shaft as a function of the span angle, $\alpha$.
b. Determine the angle $\alpha$ at which the reactions at the bearings are minimized.



**Design Qualifier, Spring 1995** #2

## QUESTION: PITCHING MACHINE DESIGN PROBLEM

Please read through the entire problem before starting on part (a). Credit will be given for completeness and believability. If you run out of time, indicate how you would proceed.

Due to the long delay in starting the season, the Braves' baseball team desperately needs batting practice. You have been hired as a consultant to design and produce an automated pitching machine. Based on the following problem statement, answer the questions below:

> "Given a start signal, propel baseballs at varying intervals (8 to 14 seconds apart) and at various speeds (80 to 95 mph)."

a) (20%) Partition the pitching machine system into subsystems. Describe the interfaces between subsystems in terms of energy, material, and information flows.

b) (40%) For each subsystem, generate a representative set of concepts that can fulfill the requirements of the subsystem. Provide sketches and brief descriptions. From these subsystem concepts, generate a representative set of system concepts, sketch them and describe their operation briefly. Are there any interface conflicts between subsystems?

c) (40%) Perform a selection Decision Support Problem on the system concepts from part (b). Identify evaluation attributes and define scales for them. For example, you may want to consider pitch accuracy, pitch timing, pitch speed, cost, and safety. Rate the concepts against the attributes using a table. Define several different scenarios and justify (pick a relative importance for each attribute, sum of importances = 1. One set of relative importances is one scenario.) Compute merit function values for each concept and rank them from best to worst. Are your results meaningful? Explain.

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#3

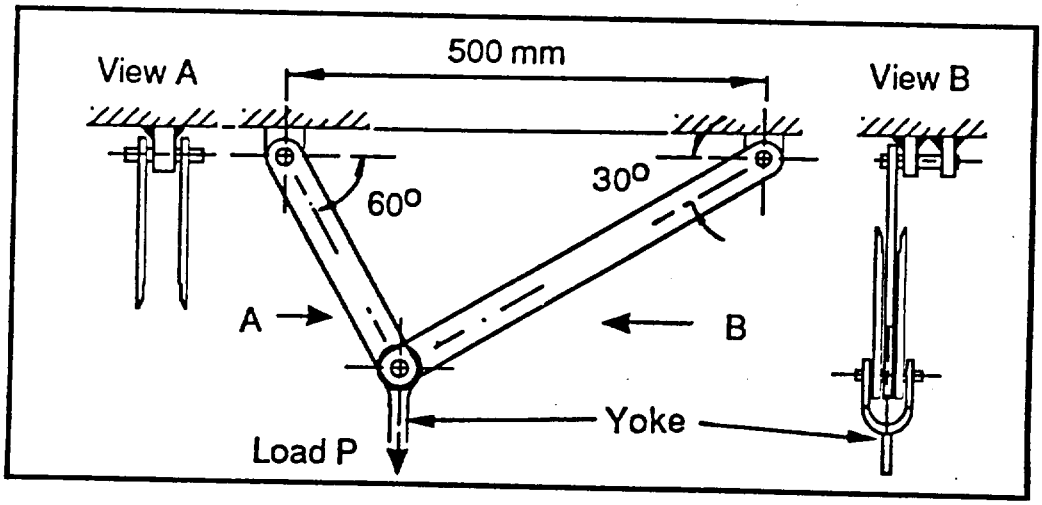
Figure shows a structure constructed from 10 mm x 20 mm mild steel and 10 mm diameter pins.

(a) List all the possible modes of failure for the structure under the action of the load P.
(b) Determine the load P at failure of the structure.
(c) Suggest ways of modifying the structure to improve the effectiveness of the use of materials.

The following material properties apply:

Mild steel structure: $S_u = 350\ MPa;$ $S_y = 240\ MPa$
Pins: $S_s = 200\ MPa;$ $S_b = 205\ MPa$

$S_b$ is the allowable bearing stress (average contact pressure).




* FIGURE IS NOT NECESSARILY DRAWN TO SCALE