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THE GEORGE W. WOODRUFF SCHOOL OF MECHANICAL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY

DESIGN QUALIFIER

SPRING 2011

WRITTEN EXAMINATION

We are interested in learning what you know and your ability to reason in the formulation and solution of design problems.

If you find any part of this exam confusing, please state your assumptions and rephrase the question and proceed.

Please read the entire exam first.

Questions 1, 2a and 2b carry equal points.

Allocate your time carefully so that you cover all three parts that you are being examined on in these two questions, namely Methodology and Analysis.

ORAL EXAMINATION

Please arrive a half an hour before the scheduled time for the oral exam. During this period we will give you a question to think about. The scope of the oral exam is as follows:

- * provide an opportunity for you to state how design fits into your research activities;
- * probe your understanding on the question that we posed to you in the preceding half hour.

QUESTION 1. – DESIGN METHODOLOGY

BACKGROUND AND MOTIVATION

Many jobs require employees to sit at their computers all day and type. Unfortunately, this type of position requires a lot of repetitive body movement, including clicking a mouse. These repetitive motions can cause several injuries, including carpal tunnel syndrome and, in extreme cases, arthritis. Fortunately, by using ergonomic keyboard accessories, including an ergonomic mouse, some of these injuries can be avoided. There are several health benefits to using an ergonomic mouse. The most immediate benefit is that the user will feel much more comfortable when using their workstation and will most likely be more productive as a result. Another benefit of using an ergonomic mouse is that the user will be less likely to incur injuries due to strain from unnatural repeated movements. A third benefit is that users will be less likely to incur serious injuries such as carpal tunnel syndrome or arthritis as a result of repeated mouse clicking.

Ergonomic Mouse Design



DESIGN PROBLEM

The function of an ergonomic mouse is to ease repetitive motion and strain. Ergonomic mice are designed in such a way that the hand is able to control the computer's on-screen cursor in a way that motions are more natural and less strenuous. There are many different types of ergonomic mouse designs. The fundamental principle is a "handshake" design, which allows the user to keep his hand straight (like he was giving a handshake) while accessing the buttons of the right side. Four existing products in the market are shown in the above figure, including HandShoe, Ortho, Logitech and 3M brands.

TASK

Assume that you are in charge of a design team responsible for developing a new ergonomic mouse design for your company. Your boss wants you to start from benchmarking with your competitors and to document your design process thoroughly. You are advised to follow the general guidelines of design methodology and turn in a report documenting main deliverables.

DELIVERABLES (YOU ARE REQUIRED TO ELABORATED THESE ISSUES)

- 1.1 *Requirement Analysis:* To clarify the design task, you need to identify the customer needs to be met by your design. Develop a list of functional requirements for your design in solution neutral terms. Prioritize the importance of design criteria? **(2 pt.)**

- 1.2 *Conceptual Design:* Compose appropriate function structure diagrams that characterize the overall function and its decomposition into sub-functions. Transform the function structure into working principles of your design solution(s), to the module levels. **(2 pt.)**

- 1.3 *Design Evaluation:* Formulate a structured, systematic procedure for evaluating your design concept(s) and benchmarking with existing HandShoe, Ortho, Logitech and 3M designs. You may use one of the popular methods, such as Pugh Selection Matrix, QFD, or multi-attribute decision making, etc. **(2 pt.)**

- 1.4 *Embodiment:* What are the major issues that you should deal with at the embodiment design stage? Outline what types of engineering analysis that may be needed in order to justify the technical feasibility of your design. **(1 pt.)**

- 1.5 *Product Costing:* How would you estimate the cost of your design? Please outline a systematic procedure. If considering mass production of your design, what are the critical issues for managing product cost of your design? **(2 pt.)**

- 1.6 *Pricing:* How would you estimate the market size (i.e., product demand) for your product? What are the tradeoffs underlying the pricing decisions for selling your product? **(1 pt.)**

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QUESTION 2b.

2b.1

A spur pinion of 3 in. pitch diameter drives a 9 in. gear. The pinion shaft has 600 in-lb of torque applied, and the pressure angle is 20° . Determine (a) the tangential force F_t , (b) the separating or radial force F_r , and (c) the gear torque $M_{t(gear)}$. **(6 pt.)**

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2b.2

A 35 in. long cantilever spring is composed of 8 graduated leaves and one extra full length leaf. The leaves are $1\frac{3}{4}$ in. wide. A load of 500 lb at the end of the spring causes a deflection of 3 in. Determine the thickness t of the leaves. **(4 pt.)**