ID Number _____

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

DESIGN QUALIFIER

FALL 2009

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 question or part of this exam confusing, please state your assumptions and rephrase the question and proceed.

Please read the entire exam first.

Questions 1 and 2 carry equal points. Both have multiple parts.

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

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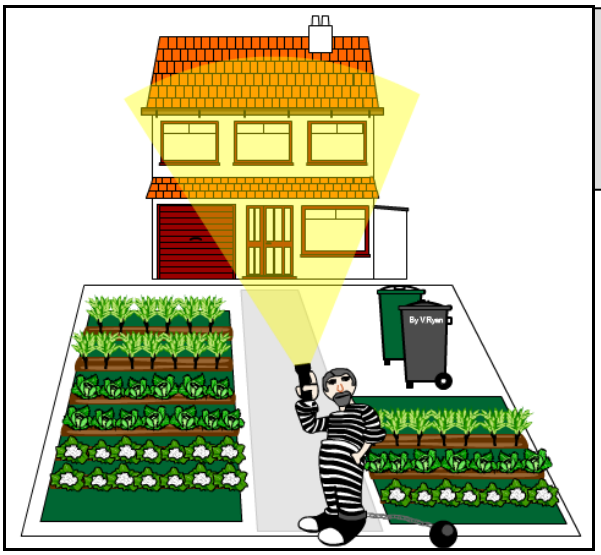
QUESTION 1- METHOD AND REALIZABILITY



New Home Security Device to be Designed by GA Tech PhD Students

BACKGROUND AND MOTIVATION

A number of houses and dorm rooms have been broken into around the Georgia Tech Atlanta campus. It has been noticed that the number of strangers walking around campus has increased lately and home owners and residents are becoming more and more concerned about the security of their homes. Georgia Tech Police have advised people to make their homes look as if they are occupied when they go away for work, classes, or nights out. This may deter a potential thief from breaking into either the house or apartment. A Georgia Tech Neighborhood Watch scheme has also been introduced recently and this has helped people to feel more secure. However, even though neighbors will keep an eye on your home if you decide to go out and leave your house or apartment empty, they cannot watch twenty four hours a day. Often even the police ignore alarms when they are activated because of the high number of false alarms.

DESIGN PROBLEM

Recently, *FoolTheCrooks Inc.*, an Atlanta-based company specializing on home security systems, has given a $100,000 grant to Georgia Tech for their PhD students to design a family of security devices for single-family homes and apartment complexes that will make houses and apartments around campus look occupied when, in fact, they are empty. Police statistics clearly show that homes are much more likely to be broken into when they are empty. Consequently, if a home looks occupied it is likely to be safe.

The device to be designed will be mobile so that it can be moved from room to room, easy to set up and control and also cheap to make. It must not be powered by mains voltage and in this way will be completely safe to be left 'on' for a long time and will not be affected by power cuts. It will be activated by anyone approaching the home from the front or back. It must deter even professional crooks from taking an interest in the home and even convince people in the street that the home is occupied.

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Task

Assume that you are in charge of the design student team responsible for developing the home security device as described above.

- Identify the customer requirements to be met by your design.
- What might be an appropriate underlying working principle to realize this type of device?
- What function structure may provide the most flexibility for designing a family of home security devices for the above mentioned purpose?
- What are the key components of such home security devices?

Deliverables

Method

1.1 *Clarify the Task:* State the overall function of your system in solution neutral terms. What are the most important drivers/design criteria? Define a design requirements list.

1.2 *Conceptual Design:* State and implement the steps (including functional diagrams/decomposition) for transforming the overall function that you have identified for your product family into an appropriate number of alternative design solutions. Ensure that you have identified the important sub functions. Sketch and describe the workings of these alternatives.

1.3 *Selection:* Suggest a structured approach to selecting one of the alternatives for further development.

Realizability

1.4 *Embodiment:* Further develop the alternative that you have selected.

1.5 *Costing:* How would you estimate the cost of your design? You may critically evaluate the design in terms of manufacturability, initial cost, maintenance cost, reliability, manipulation performance, energy consumption, and other criteria that you feel are important to consider in this phase of design.

1.6 *Pricing:* Based on the preceding analysis, how would you estimate the market size for such a system and set the price for selling/operating such a system? Be brief.

1.7 *Return on investment:* In addition to costing and pricing, estimate if offering such home security devices for a rental fee per month would be a viable business idea. Justify.

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QUESTIONS IIA. Short Answer. Please write a complete descriptive answer in the space provided.

1. What happens to the applied torque when the screw and the nut are well lubricated? (0.5 pt.)

2. In a bolted connection, does the bolt or the members typically carry a greater portion of the externally applied load? Give an estimate of the percentage each one carries. (1 pt.)

3. What is Presetting? List two advantages of Presetting (1.25 pt.)

4. Is the Spring Rate of a helical extension spring linear for the whole range of loading? Explain. (0.75 pt.)

5. Why is the deflection in a torsion spring (when friction is present between the coils) greater than the deflection in the same torsion spring (when there is no friction between the coils)? (0.75 pt.)

6. What type of stresses act on torsion springs? Why do those type of stresses act on torsion spring? (1 pt.)

7. Explain the meaning of Basic Load Rating, C. (0.5pt.)

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8. List two primary reasons why bearings fail. (0.5 pt.)

9. What are two differences between Shield and Seal in roller bearings? (0.5 pt.)

10. Discuss the effect of Interference on gear teeth. (0.5 pt)

11. What is a Conjugate action; and name two profiles that can produce Conjugate Actions? (1.5pts)

12. What is the characteristic of an Idler Gear? (0.5 pt)

13. What is the major difference between a Reverted and Non-Reverted Geartrain? (0.75 pt)

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IIB Component Design Analysis

In Figure 1, a spring loaded pressure relief valve is shown which opens if the pressure exceeds the safety limit. The area of the disk on which the pressure acts is 950 mm^2. The dimensions for the spring are wire diameter d = 5 mm, mean coil diameter D = 25 mm, total number of coils N_{total} = 12, free length Lf = 80 mm. The spring is made of A228 music wire with a modulus of rigidity G=79.3 Gpa. The modulus of elasticity E for carbon steel is 207 GPa. The modulus of elasticity E for cast iron is 100 GPa. Useful equations: $k = d^4 G / (8D^3Na)$

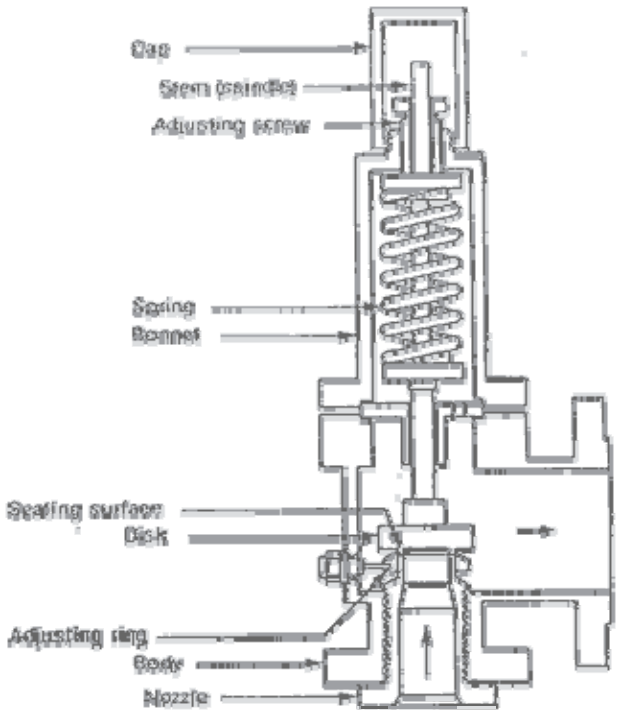

Figure 1 – Spring Loaded Pressure Relief Valve

a) At what pressure will all coils of the relief valve spring be touching? (4 points)

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In Figure 2, an epicyclical (or planetary) gear system is given.

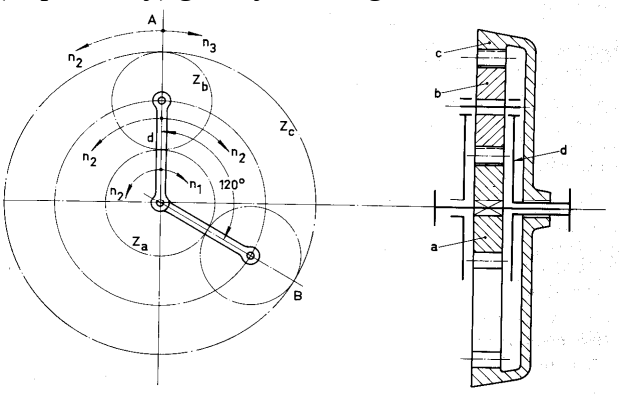

Figure 2 - Epicyclical Gear System

b) How many teeth (Zc) has the internal ring gear c of the system in Figure 2, if the number of teeth on gear wheel a (sun wheel), Za = 25, and the number of teeth on gear wheel b (planet wheel), Zb = 20? (3 points)

c) Assuming that the total load on a roller bearing use in this gear system is 1000 N and the bearing's basic load rating is 30000 N, what is the L_{10} life of the bearing? What would the L_{10} life be is a ball bearing was used with the same basic load rating and the same load conditions? (3 points)