ID Number _____

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

DESIGN QUALIFIER

SPRING 2014

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 I, IIA and IIB 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.

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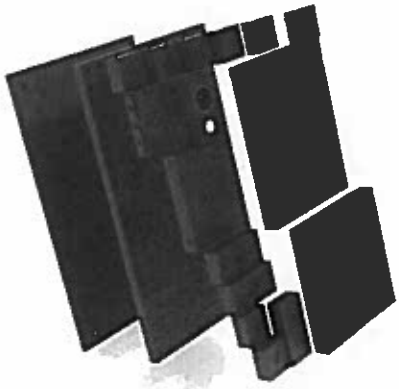
QUESTION I. - DESIGN METHODOLOGY

DESIGN PROBLEM

Smartphones are amazing devices on so many levels but their effective lifecycle leaves much to be desired. They are great when first launched but after six months or a year when newer models are available, many are ready to trade up to the latest and greatest. For what, a slightly faster processor or more memory? What about all of the other components in your dated smartphone that are still perfectly fine and current? Unfortunately you'll be buying back most of those parts in the new phone while the outgoing handset gets traded in or perhaps even tossed in the recycling bin. But does it really have to play out like that?



TASK

Assume that you are in charge of a design team responsible for developing a concept for a product platform of next generation highly customizable smartphones that allow users to upgrade any key component (module) as new releases or variants become available. This not only saves customers a lot of money but also benefits the environment. 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 a systematic design methodology and turn in a report documenting the main deliverables as follows.

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). Hint: You may use one of the formal methods on a quantitative basis (No intuition-based approach please - subjective score-based methods are not acceptable), such as analytic procedures of multi-attribute decision making, etc. **(2 pt.)**

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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. To implement mass customization of your products, 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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IIA: Machine Design Analysis (10 pts)

Mobile boom cranes are very important machines that perform difficult construction tasks such as construction 100m tall wind turbines. An example of such a crane from US patent 6,568,547 is shown in Figure 1. The tall boom (3) can range between 20-180m. To keep the crane from tipping forward when it lifts up a heavy payload, counterweights (11 and 21) are suspended from the mast (5) at the back of the machine. Given the cranes massive height and large carrying capacity, the design of the boom is very important, both for performance and safety.

a) The crane can tip over both the forward and rearward edges of the crawler tracks (1). You can assume that the when the crane is in the configuration shown in the figure that the boom and mast balance each other out, so that we can just focus on the effects of the payload and the counterweight. Assume the boom is 50m long, the payload weights 200 metric tons, and it is located 5m in front of the tracks. Further assume that the tracks are 8 m long. The counterweight weighs 100 metric tons and is located 7m rearward of the back of the tracks. Will the crane tip over? If so, in which direction (forward or backward)? (2pts).

b) If the payload weight was increased, what weight would cause the crane to tip over forward? (1 pts)

c) Assume the boom is at an angle of 75 degrees elevated above the horizontal plane. What is the compressive load it must support with the 200 ton payload? (2 pts)

d) The boom is constructed from a rectangular steel lattice. You can assume that the cross beams form 45 degree angles with the outer bars. Sketch one planar segment near the middle of the lattice boom and calculate which bar has the most compressive force applied to it (3 pts)

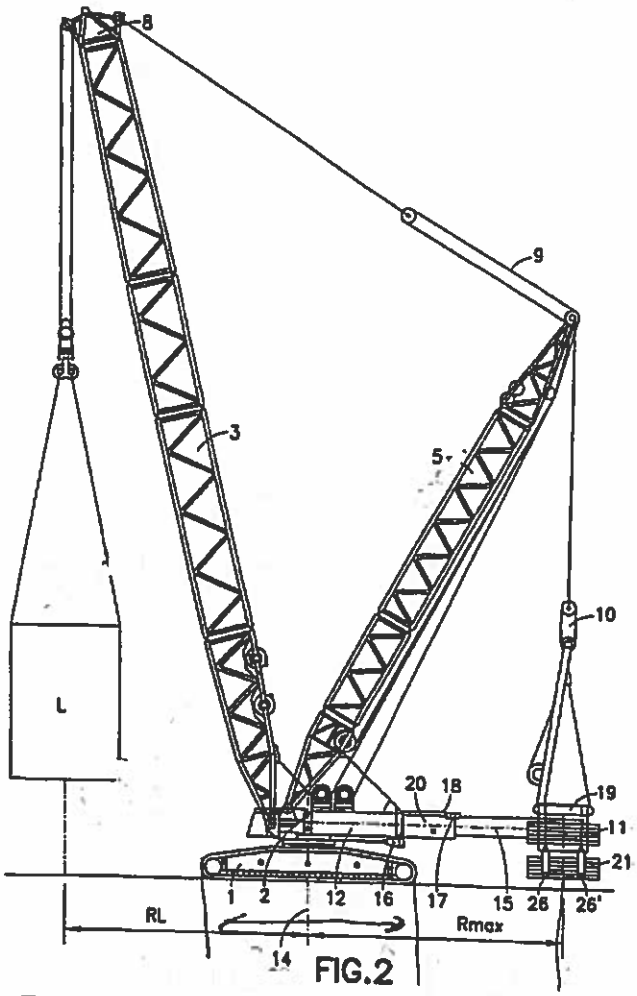

Figure 2: Mobile Crane shown in Figure 1 of US patent 6,568,547.

e) The base of the boom narrows down to a single large bar that is attached to a bearing so the boom can pivot and change its angle. For the values given above, what is the bending moment at the base of the boom when it is locked in place? (2 pts)

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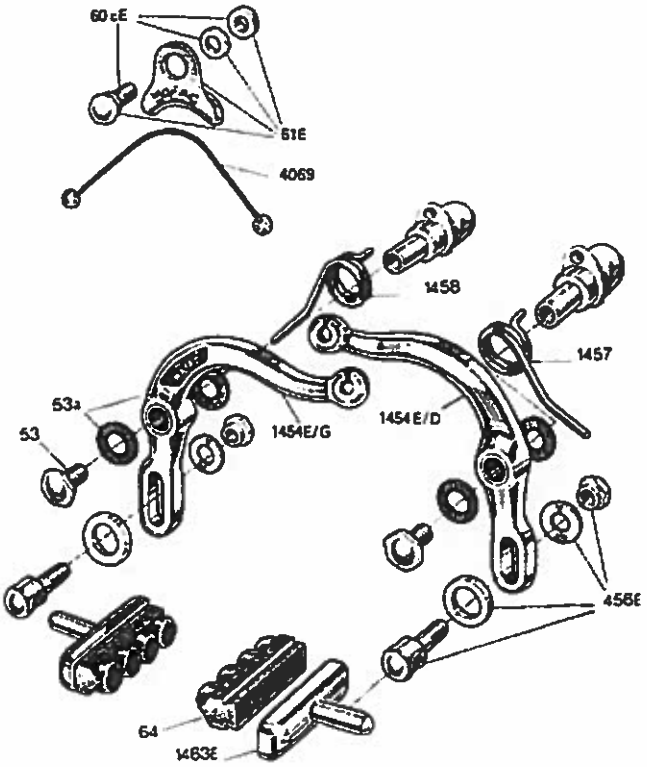
IIB: COMPONENT DESIGN - Short Answer Questions (10 Points)

Please write a complete descriptive answer in the space provided.



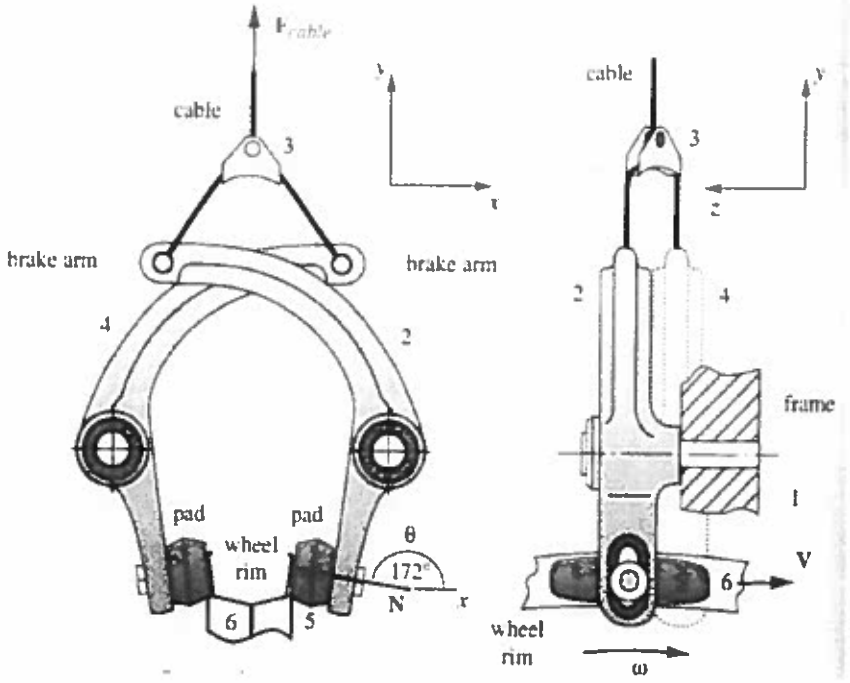


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Figure 1 –Bicycle Brake

1. In Figure 1, an isometric as well as a schematic multiview of a bicycle brake is shown. Referring to Figure 1, describe the most likely failure points (excluding brake pads) and explain your reasoning. **(2 pt.)**

2. What type of springs are the ones labeled 1457 and 1458 in Figure 1 and what is the principal stress? **(1 pt.)**

3. Why do we use lock washers? (0.5 pt.)

4 What are the commonalities and differences between a brake and a clutch? (1 pt.)

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5. What is the main difference between a conventional gear train and an epicyclical gear train? (1 pt.)

6. Comparing spur gears, helical gears and worm gears, which gears are typically the noisiest and why? (1 pt.)

7. In case of failure, why is it typically preferable to have compression springs fail over extension springs? (1 pt.)

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In Figure 2, a drawing of a typical four-cylinder internal combustion (IC) engine is given. The four pistons drive a crankshaft through the connecting rods. In Figure 3, a picture of a typical connecting rod is given. In Figure 4, a detailed drawing is given of one of the connecting rod connection to the crankshaft.

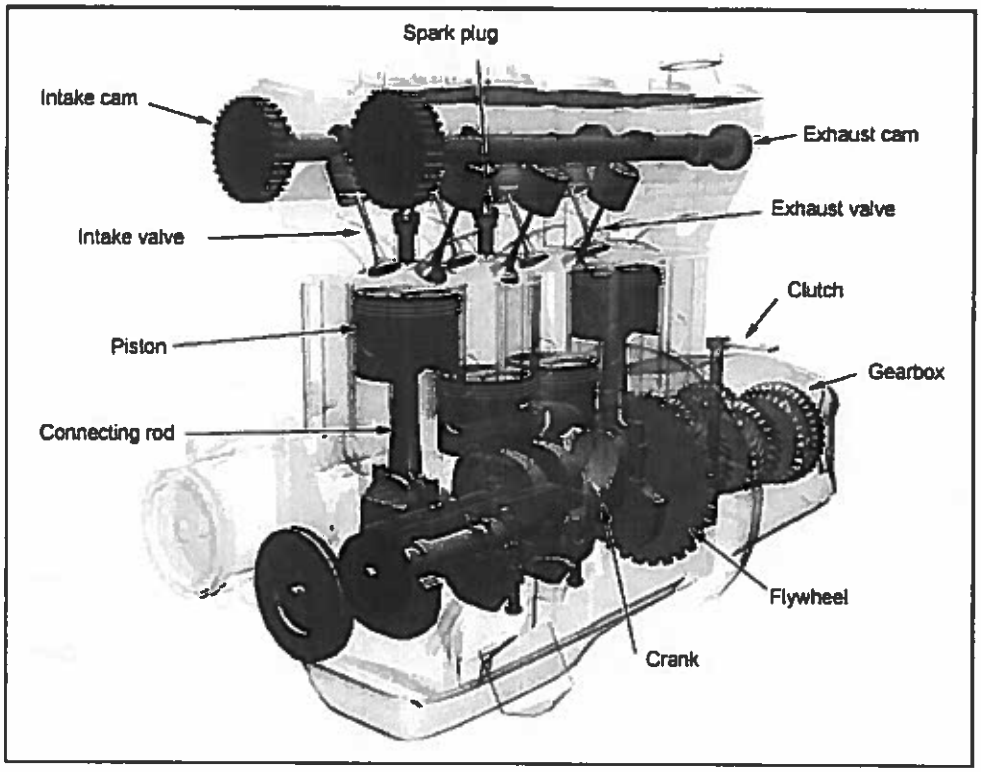

Figure 2 – Typical Four Cylinder Internal Combustion Engine.

8. What is another important function of lubrication (such as oil or grease) other than reducing friction in bearings? (1 pt.)

9. What are some (more than one) advantages and disadvantages of using journal bearings for the crankshaft (crank) in Figure 2? (1 pt)

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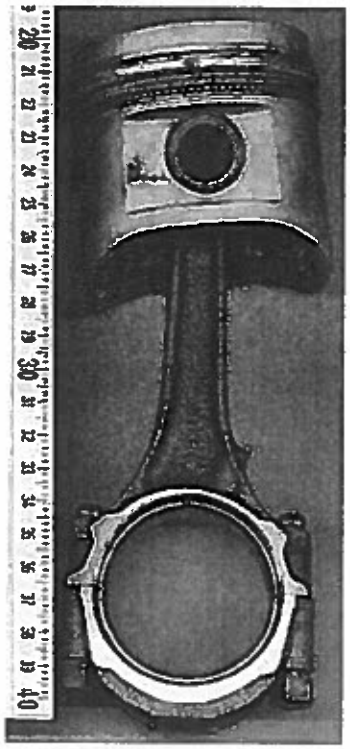

Figure 2 – A Connecting Rod

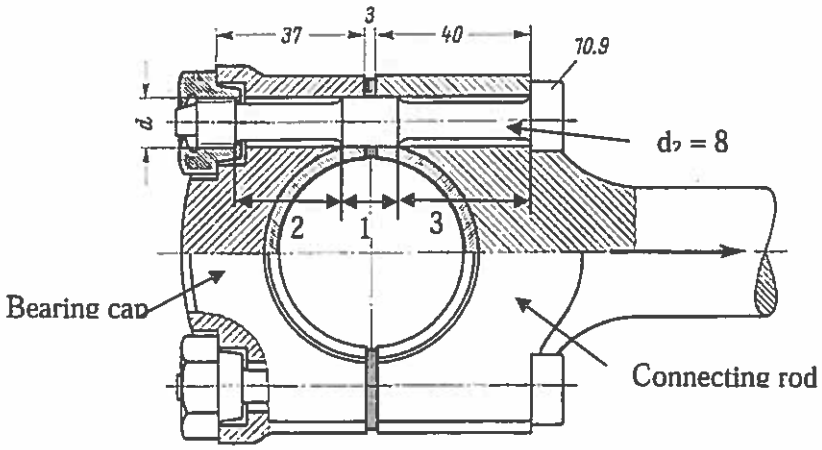

Figure 3 – Connecting Rod Drawing

As you see in Figure 3, two bolts connect the bearing cap to the connecting rod.

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10. The shape of the nuts used in Figure 4 is different than regular nuts that you typically see. Can you explain what the purpose (or intended purpose) of these special nuts is? (1 pt)

11. Why would you not recommend reusing the nuts for the connecting rod after, say, an engine overhaul has taken place? (0.5 pt)