

Name: \_\_\_\_\_ Student #: \_\_\_\_\_

University of Toronto  
Faculty of Applied Science and Engineering  
APS112 and APS113 Engineering Strategies and Practice II

Quiz #2 April 13, 2012

This is a 50-minute closed-book quiz. No aids are permitted except for a translation-only dictionary. The quiz has a total of 25 questions. There are 18 multiple choice questions and 7 written answer questions. There are a total of 33 marks with 18 marks for the multiple choice questions and 15 marks for the written questions.

Your question paper, with your name and student number filled in **on each page**, must be returned with the multiple choice answer sheet slipped inside.

Good Luck!

Written Answer Mark Breakdown

Question	Possible Marks	Marks
19	3	
20	3	
21	1	
22	1	
23	2	
24	2	
25	3	

**Multiple Choice Questions (1 mark each; total of 18 marks)**

For multiple choice questions, you must use the multiple choice answer sheet provided. Follow the directions on the sheet carefully to ensure that you receive marks for the correct answer. **You should mark only the single, most correct answer for each question.** Always mark the answer in the spot corresponding to the question number. Use a pencil. Erase any errors completely. There is no deduction for wrong answers.

1. Which of the following statements is **TRUE**?
  - a) A risk and a hazard mean essentially the same thing.
  - b) A safe design must have all hazards completely eliminated.
  - c) Safety is best considered once key design decisions are made, since you must know what hazards you are dealing with.
  - d) Society's tolerance for risk is decreasing over time.
  - e) Society will tolerate more risk when many people are simultaneously exposed to a hazard.
  
2. Which of the following items is **NOT** considered to be intellectual property that can be formally protected?
  - a) A musical composition.
  - b) A book.
  - c) A newly discovered law of nature.
  - d) A new and non-obvious device for measuring pressure in a tire.
  - e) A unique symbol or image associated with a particular company.
  
3. A manufacturer of expensive electronic LED light bulbs decides to implement a quantitative reliability engineering program. He is planning to:
  - a) Measure the failure rate under standard testing conditions so that he can make estimates of the distribution of failure rates in service and can estimate his warranty costs.
  - b) Increase the lifetime of the electronics by choosing higher quality components.
  - c) Extend the warranty coverage so that consumers can be certain of a minimum useful service life.
  - d) Survey the customers to ensure that the bulbs are providing the type of light required by consumers.
  - e) Include a redundant system to enhance the reliability of the product.

4. The **MAIN** reason that the rope and washer water pump (i.e. elephant pump) is a good choice for the developing world is because it is: (More than one answer is correct. You need to choose the most important answer.)
- a) Inexpensive to make
  - b) Made from non-toxic materials
  - c) Easy to maintain with local materials
  - d) Protected by patent and therefore profitable for the manufacturer
  - e) More efficient (i.e. uses less energy)
5. A thermostat regulates the circulation of coolant in an engine that would overheat without the coolant. It was designed to be a failsafe component. This means that it:
- a) Has been designed to applicable codes so that if it does fail, there is no liability for the designer.
  - b) Has been over-designed so that the probability of failure is less than 0.5% over the design lifetime of the engine.
  - c) Will fail open so that the coolant will still be circulating after failure.
  - d) Fails in a controlled way so that it can be repaired after failure.
  - e) A failure mode analysis has been conducted on the product.

**Questions 6 through 8 follow from the statement:**

A pump manufacturer is introducing a new piston pump for chemical plants, and is hoping to sell many units to plant maintenance engineers as replacements for the originals.

6. Which of the following would **NOT** be important?
- a) The industrial design.
  - b) Design for manufacturing.
  - c) Design for assembly.
  - d) Design for reliability.
  - e) None of the above. a) to d) are all important.
7. The manufacturing facility is to be located in China with a mostly manual assembly. Which of the following is most **TRUE**?
- a) All the screws in the pump should be accessed with a single tool for ease of assembly and repair.
  - b) All parts should be custom designed for optimal functionality.
  - c) Pump should be designed for easy upgrade to automated assembly.
  - d) Assembly instructions should be language independent (graphic-based).
  - e) Pump should ship with a set of replacement parts.

8. The manufacturer has protected their Intellectual Property because they have:
- a) Filed a global Utility Patent on the pump design.
  - b) Filed a Design Patent on the unique functionality of the pump.
  - c) Publically disclosed the design documents of the pump.
  - d) Filed for a Trademark on the pump design.
  - e) None of the above. a) to d) would not provide any IP protection.

9. In a F.A.S.T. diagram for a travel mug (See Figure 1), what is likely the basic function?
- a) Provide lid to keep liquid from splashing
  - b) Keep user from burning self
  - c) Contain liquid in cylinder
  - d) Provide handle
  - e) Insulate liquid

10. In a F.A.S.T. for the travel mug (See Figure 1) what is a provided function?
- a) Hot liquid
  - b) Orientation of mug when drinking
  - c) A circular recess in the car to hold the mug
  - d) \$1.79 for the coffee
  - e) None of the above



Figure 1 - Travel Coffee Mug

11. A House of Quality is:
- a) A list of safety and reliability objectives for a design.
  - b) The main section of the Ontario Building Code.
  - c) A statistical method of quantitatively measuring product quality.
  - d) A representation of the relationships, values, and tradeoffs of design elements.
  - e) Any home built by UofT civil engineers.
12. Which is **NOT** a method of risk management (as presented in lectures)?
- a) Reduce
  - b) Eliminate
  - c) Postpone
  - d) Insure
  - e) Pass on

13. Which of the following is **FALSE**?

- a) The extremes of project monitoring are doing none of it and micromanaging (and both should be avoided).
- b) The 4 hour house (in lecture video) is fast tracked.
- c) Project Closure includes self-evaluation of performance during the project.
- d) Direct costs would include the cost of parts for a project.
- e) Using someone else's iClicker is an academic offence.

14. Which of the following are the “engineering mantra” and also indicate the tradeoffs if a project is in trouble as discussed in the Project Management lectures?

- a) Works – On time – On budget
- b) Labour – Management – Parts
- c) Direct Costs – Indirect Costs – Overhead
- d) Loans – Shareholder Input – Profit
- e) Purchase quantity – Inventory – Spoilage

15. Which of the following is **NOT** a way of evaluating the validity of a research source?

- a) Number of hits
- b) Bias
- c) Expertise
- d) Purpose
- e) Intended audience

**Questions 16 through 18 are regarding Case Study #1.**

### **Case Study #1**

From a materials' point of view, the Boeing 787 Dreamliner represents an enormous advance in aircraft design and manufacturing. Its use of structural composites is more comprehensive than any other previous commercial aircraft. Its immediate predecessor, the Boeing 777 is 9% composites by weight, compared to 50% for the Boeing 787. The epoxy/carbon fiber matrices in the new aircraft are intended to reduce weight, allowing fuel savings and extended flying range. [1]

Introducing the new technology created three key challenges:

- Having 50% of the primary structure of the aircraft – including the fuselage and wing – made of composites represented a manufacturing challenge. [2] No one ever attempted to mass produce very large carbon-reinforced plastic structures, which are thermoset materials with significantly slower processing times than thermoplastics,
- The critical tooling for such large sections was only in the development stage and, therefore, represented a source of delay in the project development plan,

- New coatings had to be developed to deal with the crack propagation issues, which are not a factor with aluminum. [1]

On the other hand, a lot was known about composites. “When we made the decision on composites’ use in the wings, fuselage, floor beams and so on, we went down a path based on a material that we had already had a significant amount of production experience with (in the Boeing 777),” says Dr. Alan G. Miller, director of technology integration on the 787 and former chief engineer for all materials technology at Boeing. “We knew the things like dimensional stability. We knew how composites impacted the manufacturing flows. We had a lot of design allowables databases. We had a lot of confidence from our customers.” [1]

#### References

[1] D. Smock, "Boeing 787 Dreamliner Represents Composites Revolution," 6 April 2007. [Online]. Available: [http://www.designnews.com/document.asp?doc\\_id=226256&dfpPParams=ind\\_183,aid\\_226256&dfpLayout=article](http://www.designnews.com/document.asp?doc_id=226256&dfpPParams=ind_183,aid_226256&dfpLayout=article). [Accessed 10 April 2012].

[2] B. Lu & N. Wang, "The Boeing 787 Dreamliner – Designing an Aircraft for the Future," 1 January 1970. [Online]. Available: <http://www.jyi.org/features/ft.php?id=3610>. [Accessed 10 April 2012].

16. In considering the design of the Boeing 787 from multiple perspectives, which of the following statements gives the most useful information about how the design will affect stakeholder’s interests?

- a) Airlines – interested in cheaper aircraft and higher profit
- b) Passengers – interested in safety while on board the aircraft
- c) Manufacturer of composite materials – interested in contributing to society through innovation
- d) Environmental NGOs – interested in reducing emissions from aircraft
- e) Airport managers – interested in maintaining runways and not building new ones for larger aircraft

17. What is one “gap” Boeing was trying to address?

- a) Number of passengers is too low
- b) Too many aircraft at airports
- c) Cost of airfare is becoming too high
- d) Cost of fuel is becoming too high
- e) Too many old aircraft are being used

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18. Generally speaking, when Boeing committed to a materials solution for their new aircraft, they should have considered the best balance of the needs of:
- a) Society, passengers and airlines
  - b) Environment, manufacturers and users
  - c) Client, environment and society
  - d) Client, airports and research
  - e) Airlines, environment and government

**Written Answer Questions (marks as indicated; total of 15 marks)**

19. Hazards are often associated with energy release. Identify 3 **DIFFERENT** types of stored energy and for each one, give an example of a common hazard that could be found in your home. [3 marks]

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20. A successful design incorporates materials that are stiff and strong enough. Even so, several material failure modes only appear with time and might cause eventual failure. List 3 such modes. [3 marks]

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21. What is the main difference between engineering design and industrial design? [1 mark]

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22. In one sentence, explain how the existence of patent protection promotes innovation. [1 mark]

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**Questions 23 to 25 are regarding Case Study #2.**

**Case Study #2**

A simple crane is to be used to haul 2000 kg loads from the ground to the top of a 30 story apartment building. The cable is unwound from a spool at the back of the crane and must reach the ground from the top (See Figure 2).

*Note:* For steel: Failure stress  $\sim 400$  MPa, Density  $\sim 7900$  kg/m<sup>3</sup>. Stress = Force/Area.

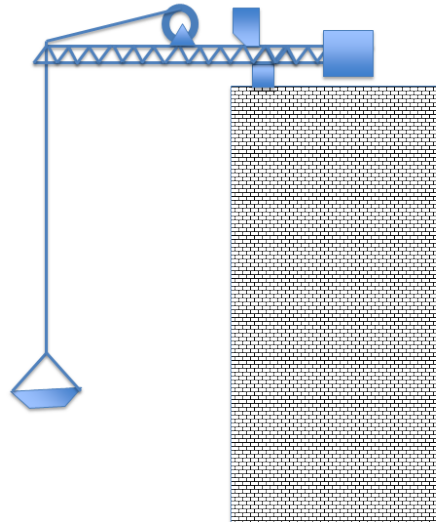


Figure 2 - Crane

23. What design for safety consideration would be used to ensure that the cable or crane did not fail (snap!) in service? [2 marks]

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24. The crane operator sits at the very top of the crane. Can the hazard (workers on ground being hit by the swinging bucket) be eliminated? How else would you keep the workers on the ground kept safe when the load is being lifted? [2 marks]

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25. Estimate how much the steel cable will weigh, so that you know how big a truck is needed to bring the cable to the building site. You must provide a specific numerical estimate using a Fermi or “Back of the Envelope” type calculation. Show the various steps used in the estimation. You must use the data for steel provided. [3 marks]

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