University of Toronto
Faculty of Applied Science and Engineering
APS111 & APS113 Engineering Strategies and Practice
Course Coordinator: Micah Stickel
Communication Coordinator: Peter Weiss
Module A Coordinator: Susan McCahan
Midterm Examination
October 29, 2015

This is a 70 minute midterm with **36** questions and 14 pages. It is a multiple choice midterm and is closed book. No aids are permitted. Read each question thoroughly and provide the answer on the answer sheet. Be sure to fill out the answer sheet clearly with no overlaps. Fill out the answer sheet using a pencil. Erase any errors completely. Provide only 1 answer per question and each correct answer is worth 1 mark. There is no deduction for wrong answers. Select the answer that best satisfies the question. You are not required to hand in the exam question booklet. You may tear off the appendix to ease the answering of questions.

1. Which of the following design projects would probably have a longer requirements phase and a much shorter solution generation phase?
    a. An innovative shampoo system that takes a different approach to hair washing
    b. A new power plant that will produce enough power to supply electricity to a city
    c. A “Back to the Future” hover board system
    d. A new wristband that monitors blood pressure in real time

2. Engineers may be involved in almost any project, but they would NOT be the lead designers in which of the following projects:
    a. The design of a new company logo or branding strategy
    b. The design of a new lightweight material for use in aircraft instruments
    c. The design of a plant that produces freshwater from salt water (i.e. a desalination plant)
    d. The design of a new internet search engine

3. Which of the following are phases in the engineering design process?
    a. Requirements development, project management, and idea generation
    b. Project management, requirements development, and solution evaluation
    c. Project management, idea generation, and solution evaluation
    d. Requirements development, idea generation and solution evaluation

4. A company, such as Unilever, tasks a group of their engineers to formulate a new deodorant product for the consumer market. This would be an example of:
    a. A request for proposal (RFP)
    b. An in-house design project
    c. A consulting project
    d. A entrepreneurial venture

5. A design space can best be described as
    a. A physical space where design engineers do their work
    b. An online space, like Google docs, where design engineers collaborate
    c. An abstract space that encompasses a design problem and its potential solutions
    d. A environment or space where the design will operate or be installed

6. Which of the following is the best definition of a design brief?
    a. A statement from the client that describes the design problem they want solved
    b. A brief document written by the design team that explains the design problem
    c. A short introduction to the “alternative design solutions” section of an engineering report
    d. An explanation of how the proposed design solution should be implemented

7. After reading a well-written problem statement, the reader should
    a. Have an understanding of the proposed design solution in detail
    b. Be able to describe the ideation process the design team followed
    c. Know all of the stakeholders that are important to the design project
    d. Have some understanding of the context for the design problem

8. After reading a well-written problem statement, the reader should
    a. Know the most important design solution ideas that are being considered
    b. Have an understanding of the essential requirements of the design problem
    c. Be able to give a detailed description of the intended users and operators for the design
    d. Have an understanding of the next steps the design team is planning

9. The “need” in a design problem is

    a. what the client wants that they do not currently have

    b. the gap between current technology and what the client needs

    c. the possible design ideas that would satisfy the client

    d. the set of information the design team needs to research

10. Suppose you are designing a new type of house paint. Two of the requirements identified for this project are:

    x: should create an opaque covering on a wall with only one coat of paint.

    y: should reduce the time it takes to paint a wall

    On a how-why tree:

    a. x should be above y; i.e. y is further down the tree

    b. y should be above x; i.e. x is further down the tree

    c. x and y are on two different branches and therefore may be at the same level

    d. x and y do not belong on a how-why tree

11. When you buy house paint you get a can of the base formulation (usually white liquid paint) and then the paint store will add pigments to create the color you want. Suppose you are designing a new type of house paint, which of the following would most likely be outside the <u>scope</u> of this project?

    a. The design of the container (e.g. can) that the paint will be packaged in

    b. The design of the color pigments for the paint that will allow it to come in many possible shades

    c. The base formulation which includes the choice of chemical materials to go into the paint

    d. The additives that give the paint shelf-life so it will not harden or change color over time

**<<More questions on next page>>**

12. Suppose you are designing a new type of house paint. One of the requirements identified for this project is: should create an opaque covering on a wall with only one coat of paint. What would be an appropriate metric for this?

    a. Measure the viscosity of the paint and compare it to other paints that are highly rated

    b. Apply a coat of the paint and measure how long it takes to fully dry

    c. Using a paint roller, apply a coat of white paint to a black wall and measure the resulting color

    d. You can assume house paint is always capable of covering a surface in one coat, so it is not necessary to have a metric for this

13. Published standards and standardized test procedures, such as those from ISO and ASTM, are best used for specifying

    a. Functions, objectives, and service environment

    b. Objectives, constraints, and metrics

    c. Functions, service environment, and metrics

    d. Functions, objectives and stakeholder interests

14. The crossing signals at intersections in Toronto now tell pedestrians how many seconds are left before the light changes. This is a relatively new technology that was added in the last few years. This is a good example of

    a. User interaction design (UI)

    b. Universal design

    c. An affordance (as re-defined by Donald Norman)

    d. Participatory design

15. Support for a claim is considered both true and valid when

    a. Whether or not there is a clear line of reasoning that leads through the evidence to the conclusion, the evidence really exists.

    b. The evidence really exists and there is a clear line of reasoning that leads through the evidence to the conclusion.

    c. Whether or not the evidence or reasoning exist, the idea is truly valuable and ought to be expressed.

    d. There is a clear line of reasoning that leads to the conclusion, whether or not the evidence really exists.

16. The ESP style guide is…

    a. like a book of writing tips about how to add style to a piece of writing like poetry or stories

    b. more about "right and wrong" than about the appropriate way to communicate in a profession or organization

    c. like a dictionary or thesaurus – it lists words alphabetically and how to use them in the right way

    d. more about the appropriate way to communicate in a profession or organization than about "right and wrong"

*Questions 17 to 19 pertain to the Team situation described in the following paragraph*

Allan, Bea and Carlos are working on a design team together. Allan is the team leader. Allan and Bea are very busy with school and other things. Carlos has a lighter load this semester so he volunteered to do more of the work when the project was getting started. This seemed like a good idea, but as the semester goes on Carlos begins to struggle with the workload. Eventually he tells the team that they will have to carry more of the load. Allan and Bea are disappointed and also unprepared. They assumed Carlos would be handling things, so they have not been paying attention to the details of the work up until now.

17. Carlos's behaviour is best described as

    a. Hitchhiking

    b. Hijacking

    c. Isolationism

    d. Enabling

18. This team was performing well together until the workload for Carlos got overwhelming. Now they are

    a. Back to the team forming phase because they have to re-write their team rules

    b. Back to the team norming phase because they have to reconfigure their working relationship

    c. Staying in the performing phase because they got to performing before this happened

    d. Moving on to the adjourning phase because they will need to break up the team before they create a new team work plan

19. If you were coaching this team through this period, which of the following strategies would be the best one to recommend to them?

    a. Have clear agendas for every team meeting so the team can move forward with decisions efficiently

    b. Allan and Bea should take Carlos out for lunch to thank him for the work he has contributed

    c. Use some time-blocking periods so Carlos can help the others pick up parts of the project and carry more of the load

    d. Allan and Bea should do all of the work for the next phase of the project to make up for their lack of work on the first phases

*Questions 20 to 36 pertain to the Case Study – Quantifying Drift Invertebrates in River and Estuary Systems located in the appendix of this booklet.*

20. Suppose you choose to use functional decomposition to generate solution ideas for this design problem. The elements of the functional decomposition could include:

    a. Isolate a water sample, count drift invertebrates, identify drift invertebrates

    b. Mass (drift invertebrates), energy (water conditions), information (type of invertebrates)

    c. Collect a water sample, filter a water sample, image (take a photo of) drift invertebrates

    d. Total cost of the equipment, accuracy of the count, size of the target item

21. Which of the following is a secondary function for this design problem?

    a. Recognize small drift invertebrates in a volume of water

    b. Operate at all levels of the water column

    c. Accurately identify drift invertebrates 95% of the time

    d. Cost should not exceed $100k

22. Which of the following is an appropriate statement to include in the service environment section of a report on this problem?

    a. The design should be able to operate in turbid conditions

    b. The total cost should not exceed $100k

    c. The Bureau of Reclamation is an agency of the U.S. federal government

    d. Ponds and streams may include particulate matter and floating debris

23. An appropriate benchmarking activity for this project could include task analysis. Which of the following is an example of this method?

    a. Observing zoologists in the field capturing and counting species in an ecosystem
    b. Identifying the working parts in equipment made for oceanographic studies of prey species
    c. Observing drift invertebrate behaviour in their primary habitats
    d. Creating prototypes of a design idea and testing it in local ponds and streams

24. Which of the following would be an appropriate objective for this design?

    a. The device must be submersible in water
    b. The total cost of the equipment should not exceed $100k
    c. The system should operate in situ for as long as possible
    d. The system should be able to detect drift invertebrates

25. Suppose your team decides that one objective of the system is to measure as accurately as possible the size of each drift invertebrate. Which of the following is an appropriate goal for this objective?

    a. Measure the size of each invertebrate to within +/-0.25mm or +/-5% of the item size
    b. Sort the drift invertebrates in a sample by size and count the number in each size range
    c. Measure the number of invertebrates in a sample with 95% accuracy or better
    d. Use an imaging technique to quantify the size of the drift invertebrates in a sample

26. Which of the following is an appropriate constraint for this design?

    a. Shall measure water velocities between 0 and 1.5 m/s
    b. Shall have a total cost that does not exceed $100k
    c. Shall operate in conditions of 100NTU turbidity
    d. Shall operate under a wide range of light conditions

**<<More questions on next page>>**

27. One of the stakeholders for this project would be the Sierra Club. What is an appropriate way to express the Sierra Club's interest?
    a. To protect and restore the quality of the natural environment
    b. To measure the health and well-being of fish habitats
    c. To operate the design in a way that minimizes disruption to the natural environment
    d. To reduce the destructive effects of humans on the environment

28. Using functional basis, the primary function of this design is best described as
    a. Separate mass and convey information
    b. Sense mass and transform information
    c. Extract energy and information
    d. Store energy and maintain information

29. Which of the following would be outside the scope of this project?
    a. Systems that should be able to operate in ocean ecosystems
    b. Systems that can measure drift invertebrate populations in flowing water
    c. Technology that is able to operate in night time conditions
    d. Systems that sort drift invertebrates by size

30. If you applied the black box method to this problem, which of the following would NOT be considered an output?
    a. Information about the number of drift invertebrates in a water sample
    b. Information about the size of drift invertebrates in a water sample
    c. Energy in the form of light needed to image the invertebrates
    d. Drift invertebrates (dead or alive)

31. Your team is generating possible solution ideas for this project. One of the team members suggests using a bubble net and filtering system similar to the way some whales, such as humpbacks, hunt and feed. This type of ideation is an example of:
    a. Morph charting
    b. Design by analogy
    c. SCAMPER
    d. Using magic solutions

32. Your team is generating possible solution ideas for this project. One team member suggests modifying the existing equipment that works in oceanographic studies for use in steam and pond environments. This type of ideation is an example of:

    a. Morph charting
    b. Design by analogy
    c. SCAMPER
    d. Using magic solutions

33. A design team is very excited to work on this project because they believe in doing whatever is possible to increase positive environmental impacts in the world, but they end up having an argument about what number to include as a goal for the cost of the design when produced in large quantities. Which of the following statements shows how bias affects this decision:

    a. Bias does not affect the decision because some may consider environmental values more important than economic values.
    b. Bias affects the decision because none of the team members have studied drift invertebrates in the past.
    c. Bias does not affect the decision because the whole team considers environmental values more important than economic values.
    d. Bias affects the decision because some may consider environmental values more important than economic values.

34. For this project, use of Wikipedia articles on zooplankton, drift invertebrates, and oceanographic study equipment are

    a. Strictly forbidden – use of Wikipedia is considered an Academic Misconduct at university.
    b. A good place to start – but you should go on to more detailed and specific sources
    c. Great because you need at least three references for every sentence in the assignment.
    d. Excellent when also combined with other sources such as Yahoo Answers and Sparknotes

**<<More questions on next page>>**

35. In the Problem Statement, one team member has written:

> This project is economically important because in the US alone, the “commercial and recreational saltwater fishing generated more than $199 billion in sales and supported 1.7 million jobs in the nation’s economy in 2011” according to an NOAA report (3).

The problem with what the student wrote is that:

a. Quotation marks should never be used in a university report.
b. Square brackets should be used rather than round for the internal citation
c. The internal citation should be outside the punctuation, not inside.
d. The name of the author and date are always in the brackets for IEEE.

36. The correct way to format a reference source in an IEEE reference list is:

a. [Online] Available: http://www.nmfs.noaa.gov/mediacenter/2013/03/07_noaa_report_finds_commercial_and_recreational.html
b. Fionna Matheson. NOAA report finds commercial and recreational saltwater fishing generated $199 billion in 2011. NOAA Fisheries Newsroom.
c. Fionna Matheson. (03-07-13) *NOAA Fisheries Newsroom.* [Online] http://www.nmfs.noaa.gov/mediacenter/2013/03/07_noaa_report_finds_commercial_and_recreational.html
d. F. Matheson. (2013, March 13) *NOAA report finds commercial and recreational saltwater fishing generated $199 billion in 2011* [Online] Available: http://www.nmfs.noaa.gov/mediacenter/2013/03/07_noaa_report_finds_commercial_and_recreational.html

*End of questions that pertain to the Case Study – Quantifying Drift Invertebrates in River and Estuary Systems located in the appendix of this booklet.*

*There are no questions beyond this point*

## Appendix A: Case Study – Quantifying Drift Invertebrates in River and Estuary Systems

**There are no questions in this appendix**. You may detach this appendix for ease of answering the questions that pertain to the Case Study.

This case study is based on an Innocentive design challenge -- Challenge ID: 9933647

Substantial parts of this text are copied from the published challenge. However, it has been modified for use as a case study in APS111.

Habitat restoration, improvement, and creation in rivers, streams, and estuaries are key elements for the recovery of salmon, trout, and other critical fish species in the North America. Millions of dollars are spent annually on activities such as manipulating flow regimes, adding structural elements such as wood or rock, reconnecting rivers with their floodplains, and restoring wetlands. A critical aspect in evaluating the effectiveness of these habitat manipulations is understanding how they influence the food resources available to critical fish species targeted for recovery and protection. Yet despite its importance, quantification of food resources has proven difficult.

The Bureau of Reclamation, in collaboration with other federal agencies (NOAA-National Marine Fisheries Service, U.S. Geological Survey, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers) is seeking a way to economically detect, count, and identify zooplankton and drift invertebrates in river and estuary systems. Problems identified that prevent the simple transfer of oceanographic techniques to rivers and streams are higher water velocities, turbidity, higher surface/depth ratio, and costs (time and money).

**Background**

Habitat restoration is considered a key element of fish recovery, and the quality of habitat and food resources available to fish often needs to be evaluated before and after restoration actions. Habitats are often designed to provide increased foraging and rearing habitats at appropriate spatial and temporal scales. Accurate food counts, such as zooplankton and drift invertebrates, are instrumental in fish habitat evaluation and restoration in our rivers and streams. Although technology has been developed for automated detection and identification of zooplankton and drift invertebrates in oceanographic settings, they have not been developed for the unique environmental conditions in rivers and estuaries. High flow rates and turbidity cause problems with automated visual systems used today. The main obstacle in estuaries is turbidity while the main obstacle in river systems is flow velocity. In addition, the horizontal nature of rivers invokes problems not encountered in deep ocean waters (e.g., sunlight effects at the surface of water and the mixing of food sources throughout the water column in rivers due to turbulence as opposed to more stratified food webs in ocean waters). We would like to identify devices/methods that can detect, count, and identify zooplankton and drift invertebrates in an economical way in rivers and estuary systems. Measurements of this type are currently time-intensive

and expensive, especially for juvenile salmon in a highly dynamic and complex system such as the Sacramento-San Joaquin Delta (California).

Traditional sampling methods involve the use of towed nets (for slow-moving water) or stationary nets (for fast-moving water) that collect organisms from the water column. Both the field collection of samples and the subsequent sorting and identification of collected invertebrates are time-intensive and expensive, and agencies lacking technical expertise must often rely on outside experts to process samples. Because of the high costs associated with these traditional methods, the spatial and temporal extent of sampling is often inadequate to characterize food availability at scales that are biologically relevant.

In the marine science community, significant advances have been made in plankton monitoring through the use of devices that capture high-resolution images of particles (>100 µm) and invertebrates. These devices produce a catalog of time-stamped images that can be processed to various taxonomic levels with image analysis software, allowing the abundance of organisms in a known volume of water to be quantified.

Analogous technologies for freshwater environments do not exist, but could be developed to continuously monitor the prey abundances and dynamics in key locations for migrating and rearing fishes. Pilot systems have been tested in the freshwater environment, but there have been problems with image capture, leading to poor image quality (blurred) and poor identification (low probability of differentiating target organisms from drift algae, detritus and other materials).

The difficulties during the pilot were likely caused by

- High water velocity
- Low water clarity (turbidity)
- Small target size (1-20 mm)

Another big difference between the marine ocean environment and the freshwater and estuarine environment is that ocean monitoring tends to be vertical (in the water column) and items on the surface are not a large percentage of the whole so they can be ignored. In a stream, items on the surface are a high percentage of the overall water column, and sunlight at the surface affects the imaging equipment considerably. It is difficult to get accurate measurements if targeted items on the surface are ignored.

**The Challenge**

A device/method is sought that could be deployed to collect data continuously (over hours, preferably days) to capture tidal and day/night variation in prey abundance in rivers and streams. By simultaneously deploying multiple units, scientists could measure important spatial and temporal variation such as depth stratification and source/sink food web dynamics.

The device/method must detect, count, and identify drift invertebrates automatically in a size range of 1 to 20 mm in a cost effective method.

Things to Avoid

1. Equipment made today for oceanographic study – although a good place to start, we are familiar with what exists and our Challenge is to go beyond what exists for our particular problems in freshwater systems.
2. A simple list of equipment without explanation of how they work in concert will not suffice as a description of the system.

Any proposed solution should meet the following specifications:

1. The device/method should be able to:
    a. Detect representative samples of drift invertebrates (1-20 mm). This should include those targeted items floating on the surface to a high degree as well as those in the water column. Representative samples of drift invertebrates in California and other localities are available at the California Department of Fish and Wildlife's Aquatic Bioassessment Laboratory digital reference collections. (http://www.dfg.ca.gov/abl/Lab/referencecollection.asp).
    b. Count the targeted items in samples (sort out debris from targeted zooplankton and invertebrates to minimize false positives)
    c. Identify the number and taxonomic family (or groups of morphologically similar families) of specimens detected (NOTE: exact identification of each species is not as critical as identification of the total amount of food available to fish).
2. This must be accomplished under the following conditions:
    a. Velocities between 0 and 1.5 meters per second.
    b. Turbidity between 0 and 100 NTUs.
    c. Function in shallow water (less than 1 m) and deep water (up to 20 meters).
    d. Function over a long period of continuous deployment (greater than24 hours but preferably many days).
    e. Operate without natural light (at night or dark spaces, provides own light source as needed).
    f. Operate under bright light conditions near the surface in the daytime.
3. If the device is submersible in water, it should be durable enough to be deployable when towed off a boat.
4. If optical, it should be able to capture images without a blur.
5. The device/method should be able to accurately count and identify available drift invertebrates (food) with 95% accuracy.
6. The device/method should be able to measure the size of each target item within 0.5 mm or 10% of item size.
7. The total cost of the equipment should be targeted to not exceed $100K when produced in larger quantities.

8. The proposed system should offer the Seeker client “freedom to practice”. There should be no third party patent art preventing the use of specific equipment and materials for their commercial application.

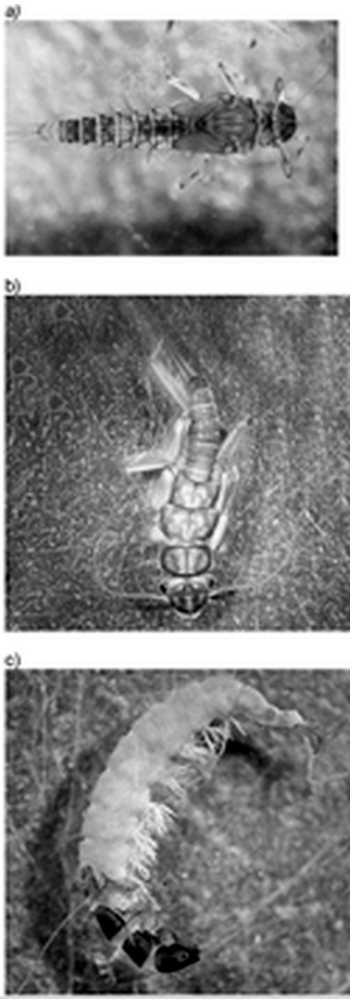
Nice to have

Include ability to measure flow entering device, such that number of food particles per volume of water is estimable.

Some examples of drift invertebrates are shown below:

These photos show some food sources available to fish in streams: a) mayfly, Ephemeroptera, family Baetidae, b) stonefly, Plecoptera, family Perlidae, and c) caddisfly, Trichoptera family Hydropsychidae.

*Photos taken from http://www.dfg.ca.gov/abl/Lab/california_referencecollection.asp*



**APS111&113 Fall 2015 Midterm Exam Answer Key**

| | | |
|---|---|---|
| 1 | b | |
| 2 | a | |
| 3 | d | |
| 4 | b | |
| 5 | c | |
| 6 | a | |
| 7 | d | |
| 8 | b | |
| 9 | b | |
| 10 | b | |
| 11 | a | |
| 12 | c | |
| 13 | b | |
| 14 | a | |
| 15 | b | |
| 16 | d | |
| 17 | d | |
| 18 | b | |
| 19 | c | |
| 20 | a | |
| 21 | b or a | "b" is more correct but we are also accepting "a" because it's close |
| 22 | d | |
| 23 | a | |
| 24 | c | |
| 25 | a | |
| 26 | c | |
| 27 | a | |
| 28 | b | |
| 29 | a | |
| 30 | c | |
| 31 | b | |
| 32 | c | |
| 33 | d | |
| 34 | b | |
| 35 | b | |
| 36 | d | |