University of Toronto
Faculty of Applied Science and Engineering
Final Examination, December 12, 2011
Duration: 2.5 hours
APS111H1 F and APS113Y1 Y - Engineering Strategies & Practice 1

Calculator Type: 4 (No electronic or mechanical devices permitted)
Exam Type: A (Closed book, no aids permitted)
Course Coordinator: J. Bazylak
Communication Coordinator: Dr. P. Weiss
Module B Coordinator: Prof. P.H. Byer

Instructions:
This is a closed book exam; no calculators or aids are permitted, except for a translation-only dictionary, i.e. direct word-to-word translations but no definitions. There are two parts of the exam: multiple-choice questions, and a writing component. Read each question carefully.

For the multiple-choice portion, provide the most correct answer to each question on the answer sheet. **Only one answer is to be given for each question**. Be sure to fill out the answer sheet clearly with no overlaps, using a pencil. Erase any errors completely. There are a total of 37 multiple-choice questions, each of which is worth about 1.6 marks, for a total of 60 marks worth 60% of the exam.

The second part of the exam is a writing component worth 40% of the exam. Answer this part in the exam booklet carefully following the instructions.

Part 1: Multiple-choice questions (60%)

1. The Conceptual Design Specification helps develop which Critical Thinking ability?
   a. Ability to commit to a solution that balances the needs of different stakeholders.
   b. Ability to translate a client statement into an engineering need.
   c. Ability to generate multiple solutions and determine criteria for choosing one.
   d. Ability to understand and express a problem from multiple perspectives.
   e. Ability to reflect on lessons learned in a project so that your process improves.

2. Creativity tools, such as SCAMPER, are used to:
   a. expand the design space
   b. narrow the design space
   c. define the design space
   d. organize the design space
   e. constrain the design space

3. Suppose you are designing a new search engine algorithm to compete with Google. In your requirements you have two primary objectives. The search engine should be:
   #1 Fast: It should take no more than a microsecond to produce a search list.
   #2 Accurate: The top listed site should be the most relevant for the user based on the search words.

   Which of the following is an appropriate metric for objective #2?
   a. The top 10 sites identified by the algorithm should contain the search words.
   b. Use a focus group to assess the user interface for usability.
   c. The algorithm should never produce irrelevant results.
   d. Use a focus group to rate the relevance of the top site identified by the algorithm in normal use.
   e. Measure the time period from search word entry to the appearance of the top site.

4. Which of the following is a "best practice" for community consultation?
   a. Consultation is useful at every step of the process
   b. Wait until late in the process to address conflicts
   c. Consultation should mainly help stakeholders understand the proposed design
   d. a and b
   e. b and c

5. The systems approach to design is characterized by:
   a. the systematic thoughts of the users
   b. the use of electronic systems
   c. consideration of the relationships and interactions between elements of a design
   d. All of the above
   e. b and c

6. Which of the following is an objective of cyclists using a public bike rental system?
   a. Separate lanes for bikes and autos
   b. Inexpensive bike rentals
   c. Rentals must cost less than $5 per day
   d. All of the above
   e. a and b

7. Which of the following should be included in an individual's area of leadership?
   a. Charisma
   b. Bias
   c. Passions
   d. Financial needs
   e. All of the above

8. Which of the following is **NOT** one of the four leadership styles covered in the course?
   a. Authoritarian
   b. Analytical
   c. Driver
   d. Amiable
   e. Expressive

9. Which of the following is correct?
   a. The humanistic view alone can clearly see the relationship between people and technology
   b. The Human-tech approach to design uses feedback
   c. Engineering design should fit human nature to accommodate technology
   d. All of the above
   e. None of the above

10. Which of the following statements is **NOT** suggested by the human-tech view?
   a. Engineers help solve social problems.
   b. Engineers should have technical excellence.
   c. If technologically feasible, we should automate as many operator tasks as possible.
   d. If a system doesn't work for people, it doesn't work.
   e. Engineers should design systems, which take advantage of people's capabilities and compensate for people's limitations.

11. Which of the following creates a legal constraint for design decisions?
   a. Professional code of ethics
   b. Regulations
   c. Government guidelines
   d. All of the above
   e. a and b

12. A company manufactures and sells a product that does **NOT** meet government safety standards, and several users are injured because of this improper design. The company would be subject to:
   a. criminal liability
   b. civil liability
   c. criminal liability and civil liability
   d. an ethical dilemma
   e. c and d

13. Which of the following has had significant social impacts?
    a. Vacuum cleaners
    b. Cell phones
    c. Roads constructed in areas where Aboriginal peoples hunt
    d. All of the above
    e. b and c

14. For the design of an automobile, which of the following is an example of a strategy in design for the environment (DfE)?
    a. Design the automobile so that it is easier to repair.
    b. Design the automobile with better air emission controls.
    c. Design the automobile with better fuel efficiency.
    d. All of the above
    e. a and c

15. Which of the following is **NOT** a principle of industrial ecology (design for sustainability)?
    a. Industries should reduce pollution to levels needed to meet legal requirements
    b. Every product should be designed so that it can be used to create other useful products at the end of its current life.
    c. Industries should make minimum use of materials and energy in products and processes.
    d. Products and processes can produce residuals, but not waste.
    e. Materials used should be the least toxic for purpose.

16. The use of recycled plastic bottles in the manufacturing of polyester clothing is an example of:
    a. Design for the environment thinking
    b. Cradle-to-Grave thinking
    c. Industrial ecology
    d. Pollution control
    e. a and c

17. Two designs are economically identical except that Design A has an initial investment of $1,000 and no salvage value. Design B has an initial investment of $3,000 and a salvage value of $2,000. Which of the following principles or concepts can be used to make a recommendation?
    a. Time value of money
    b. Strategy of least commitment
    c. Pay back period
    d. Engineering estimation
    e. External costs

Questions 18 to 21 refer to the following situation: A company manufactures plastic cups. The manufacturing facility operates 8 hours/day, 5 days/week. The company buys raw plastics from another company and then uses a machine to mold the plastic into cups. It then pays another company to transport the cups in boxes of 10,000 cups for sale around the country; each truck can carry 1000 boxes. They sell each box for $100 and generally sell between 50 and 200 truck-loads per year depending on the demand for their cups. In addition to other costs, the company pays for following:

1. Rent for the building where it manufactures the cups
2. Heat for the manufacturing building
3. Electricity for the molding machine
4. Raw plastics
5. Transportation of the cups for sale

18. Which of these costs is a fixed, ongoing cost?
    a. 1, 2 and 3
    b. 2, 3 and 4
    c. 3, 4 and 5
    d. 1 and 2
    e. 2 and 3

19. The economic objective of the company is to:
    a. Minimize costs
    b. Maximize profit or net revenues
    c. Make a profit
    d. Keep within its budget
    e. Maximize revenues

20. If the fixed costs are $2,400,000 per year, and the variable costs are $40 per box, which of the following is correct?
    a. If the company sells 50,000 boxes/year, the net revenue = $ 600,000 per year.
    b. If the company sells 50,000 boxes/year, the net revenue = $ 2,000,000 per year.
    c. a is correct and the breakeven quantity is 40,000 boxes per year.
    d. a is correct and the breakeven quantity is 50,000 boxes per year.
    e. b is correct and the breakeven quantity is 40,000 boxes per year.

21. If the price of a box of cups increases, which of the following will be correct?
    a. Fewer boxes will be sold
    b. Revenues will increase
    c. Net revenues will increase
    d. All of the above
    e. b and c

22. A sensitivity analysis can be used to:
    a. understand the effects of uncertainties about economic costs and benefits
    b. understand the concerns of the stakeholders
    c. understand the health effects of pollutants on sensitive species
    d. All of the above
    e. None of the above

23. The preferred design alternative is the one that:
    a. is the least expensive
    b. best meets the objectives of the client and users
    c. best addresses the objectives of the client, users and other stakeholders
    d. is the one that meets all regulations
    e. a and d

24. The government is considering three alternative technologies to generate electricity, and wishes to compare these technologies on the basis of their economic, environmental and social impacts. Below are the rankings of these technologies on an ordinal scale, where 1 is the best and 3 is the worst, for each of these factors:

	Technology 1	Technology 2	Technology 3
Economic impacts	1	2	3
Environmental impacts	2	1	3
Social impacts	1	3	2

What can you conclude about these designs?
    a. Technology 1 is best
    b. Technology 2 is best
    c. Technology 3 is best
    d. Technology 1 is best and Technology 3 is worst
    e. There is insufficient information to make any of the above conclusions.

Questions 25 through 37 relate to Case #1 which is described on page 13.

25. In Case #1, an example of an *explanation* is found in which of the following sentences or parts of sentences?
    a. Of particular concern to the environmental group is that the road would disturb the habitat of a special species of bird that lives in the natural area.
    b. ...since it would disturb the natural area and would increase noise and air pollution that would disturb the homeowners and decrease the value of their properties.
    c. ...it is not legally required by the *Endangered Species Act* to protect that particular species of bird.
    d. The government states that the noise at the homes from the road use would be lower than the regulated level of 50 dB...
    e. Homeowners and a local environmental NGO are understandably against route #1...

26. In Case #1, an example of an effect on a stakeholder interest is found in which of the following sentences or parts of sentences?
    a. Homeowners and a local environmental NGO are understandably against route #1...
    b. ...it is not legally required by the *Endangered Species Act* to protect that particular species of bird.
    c. ...since it would disturb the natural area and would increase noise and air pollution that would disturb the homeowners and decrease the value of their properties.
    d. The government states that the noise at the homes from the road use would be lower than the regulated level of 50 dB...
    e. None of the above

27. In the second paragraph of Case #1, the *statement* that is developed, overall, by the paragraph is found in which of the following sentences or parts of sentences?
    a. ...it is not legally required by the *Endangered Species Act* to protect that particular species of bird.
    b. ...since it would disturb the natural area and would increase noise and air pollution that would disturb the homeowners and decrease the value of their properties.
    c. Of particular concern to the environmental group is that the road would disturb the habitat of a special species of bird that lives in the natural area.
    d. Homeowners and a local environmental NGO are understandably against route #1...
    e. The government states that the noise at the homes from the road use would be lower than the regulated level of 50 dB...

28. In Case #1, an example of *evidence* is found in which of the following sentences or parts of sentences?
    a. Of particular concern to the environmental group is that the road would disturb the habitat of a special species of bird that lives in the natural area.
    b. ...it is not legally required by the *Endangered Species Act* to protect that particular species of bird.
    c. Homeowners and a local environmental NGO are understandably against route #1...
    d. The government states that the noise at the homes from the road use would be lower than the regulated level of 50 dB...
    e. ...since it would disturb the natural area and would increase noise and air pollution that would disturb the homeowners and decrease the value of their properties.

29. In Case #1, truckers prefer route #1 because:
    a. On the psychological level of the Human-tech ladder, getting somewhere directly is easier to learn than taking longer.
    b. On the organizational level of the Human-tech ladder, it enables them to meet their company's goals more easily.
    c. On the physical level of the Human-tech ladder, it is better because it reduces the time more than route #2.
    d. On the political level of the Human-tech ladder, people, rather than the system, will be blamed for not getting to the destination on time.
    e. On the team level of the Human-tech ladder, it means that the shifts for drivers can be more evenly divided.

30. In Case #1, which of the following would **NOT** be a stakeholder in the design of this road?
    a. The environmental NGO
    b. Homeowners near the proposed route
    c. Birds in the natural area
    d. Commuters
    e. None of the above

31. In Case #1, when designing the road, including its route, which of the following are objectives that should be considered?
    a. The local homeowners want to minimize any loss in their property values.
    b. The government requires that the road cost less than $100 million to build.
    c. The road design must meet the requirements of the *Endangered Species Act.*
    d. All of the above
    e. a and b

32. In Case #1, in order to reduce the level of noise at the homes, the government has decided that it will construct a noise barrier between the road and the homes. A noise barrier is an example of a design that is based on:
    a. pollution prevention
    b. pollution control
    c. design for environment
    d. design for sustainability
    e. None of the above

33. In Case #1, which of the following are social factors that would likely be affected by building the new road?
    a. Leisure time
    b. Enjoyment of property
    c. Bird watching
    d. All of the above
    e. None of the above

34. In Case #1, the government is also considering whether to use concrete or asphalt pavement materials. An economic analysis has produced the following data for Route #1:

	Initial Cost	Ongoing Cost
Concrete pavement	$60 million	$ 4 million/year
Asphalt pavement	$42 million	$ 6 million/year

    What is the payback period for the concrete pavement compared with the asphalt pavement for this route?
    a. 7 years
    b. 8 years
    c. 9 years
    d. 15 years
    e. 22 years

35. In Case #1, which of the following are likely to be environmental impacts that should be considered when designing the road?
    a. Loss of bird habitat
    b. Human health and safety
    c. Cumulative effects on air quality
    d. All of the above
    e. b and c

36. In Case #1, a life-cycle assessment of a road made of concrete pavement should include:
    a. fuel that would be needed to operate the equipment used to mine the aggregate (rocks) that is used in the pavement
    b. the pollution created during the manufacturing of the concrete
    c. the effects of the pollution created during the manufacturing of the equipment used to build the road
    d. All of the above
    e. a and b

37. In Case #1, during public consultation, a third route was proposed. The government wishes to evaluate the three routes on the basis of cost, travel time and noise. The table below shows the scores (on a scale of 0 to 10, where 10 is best) and weights (on a scale of 0 to 100) for the three objectives for the three routes:

		Scores for		
	Weights	Route #1	Route #2	Route #3
Cost	30	10	0	8
Travel time	50	10	0	8
Noise	20	0	10	8

What can you conclude about the three alternative routes?
    a. Route #1 is the best route
    b. Route #2 is the best route
    c. Route #3 is the best route
    d. Route #1 and Route #3 are equally the best routes.
    e. Route #2 is dominated by Route #3

Part 2: Long Answer Question (40%)

INSTRUCTIONS: This question requires three written answers. Use an exam booklet, and write in your name, student number, course, and date of examination on the booklet's cover page. You may use as many pages as you need for your preliminary work, but the final answers must be no more than four (4) pages single spaced or eight (8) pages double spaced. Clearly indicate the final copy to be graded by writing "Final Copy" at the start of it. Use headings, subheadings, paragraphs, and bullet lists where appropriate.

1. Based on the case given below, identify the key stakeholders and their interests. Identify functions, objectives and/or constraints that arise from their interests. Indicate how particular functions, objectives or constraints are related to human factors, economic or environmental concerns. (20%)
2. Based on the case given below, write a concise Problem Statement **in your own words**. (15%)
3. Based on the case given below, identify the Service Environment. (5%)

The Case for Developing New Technology for Desalinating Water

PC Investment (PCI) is an organization that creates partnerships between industry, government, researchers, and organizations such as the World Bank and Engineers without Borders to solve the world's wicked problems. One such problem is access to clean water for human consumption and agricultural purposes.

Background

Human population growth combined with over-use of water resources for domestic purposes, industry, and irrigation has resulted in a shortage of fresh water supply in many parts of the world. Only 0.5% of the water in the world is accessible fresh water, and this water is not equally available in all parts of the world. Twenty-six countries do not have sufficient water resources to sustain agriculture and economic development, and approximately one billion people lack access to safe drinking water. In addition, the projected 40–50% growth in human population over the next 50 years, coupled with industrialization and urbanization, will result in an increasing demand on the available water resources.

With nearly 98% of the world's available water supply being sea or brackish water (part sea, part fresh water, found near the mouths of rivers), desalination has become an important alternative source of clean water. Although in 2009, worldwide seawater desalination capacity increased by 12.4% and is projected to grow with increasing demand for clean water, only 4% of these facilities were located in Africa, where, according to UN reports, 20% of the world's population struggles for access to safe drinking water on a daily basis.

Obstacles to expanding desalination technologies around the world include:

- energy and infrastructure costs, which deter the economical production and distribution of clean water; these costs ranged, in 2009, between approximately \$0.10 and \$1.50 (US dollars) per 1 m^3,
- contamination due to microorganisms present in water coming into the plant,

- damage from salt that is not completely dissolved; this reduces the efficiency and life of water treatment plants, resulting in high costs for water pre-treatment and early replacement for the facility or parts of the facility,
- weak economies and government instability which create challenges to the establishment of costly water desalinization plants.

The Challenge: Meeting the Global Demand for Clean Water

Proposals are being sought for projects utilizing recent advances in nanotechnology, to decrease total cost of desalination by increasing energy efficiency, minimizing costs associated with water pre-treatment, and decreasing the capital costs. PCI will then become involved to find private and public funding to support these projects. Proposals must identify the location and scope of the projects.

This case study adapted from: T. Humplik, J. Lee, S.C. O'Hern, B.A. Fellman, M.A. Baig, S.F. Hassan, M.A. Atieh, F. Rahman, T. Laoui, R. Karnik and E.N. Wang "Nanostructured Materials for Water Desalination" *Nanotechnology* 22 (2011)
It also used information from Water for Children Africa (no date) "The Facts." http://waterforchildrenafrica.org/facts.html (Accessed) 11/27/2011 6:11 PM

You may remove this page in order to use it when answering questions 25 through 37.

Case Study #1: Road Design

The government is planning to build a new road to lessen the travel times for cars and trucks between two cities. Two potential routes for the road are being considered. Route #1 is a direct route that would go through a natural area next to a housing development and would reduce travel times by about 25%. Route #2 is longer in order to avoid the natural area and homes, but would only reduce travel times by 15%. Truckers and commuters, of course, prefer route #1. All other potential routes have been eliminated since they would cost more than the government budget of $100 million to build the road.

Homeowners and a local environmental NGO are understandably against route #1 since it would disturb the natural area and would increase noise and air pollution that would disturb the homeowners and decrease the value of their properties. Of particular concern to the environmental group is that the road would disturb the habitat of a special species of bird that lives in the natural area. The government states that the noise at the homes from the road use would be lower than the regulated level of 50 dB, and that while the bird might be disturbed, it is not legally required by the *Endangered Species Act* to protect that particular species of bird.

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