University of Toronto

Faculty of Applied Science and Engineering

Final Examination, December 8, 2010

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 <u>most correct answer</u> to each question on the answer card. **Only one answer is to be given for each question**. Be sure to fill out the answer form clearly with no overlaps, using a number 2 pencil. Erase any errors completely. There are a total of 44 multiple-choice questions, each of which is worth about 1.5 marks, for a total of 67 marks worth 67% of the exam.

The second part of the exam is a writing component worth 33% of the exam. Answer this part in the exam booklet carefully following the instructions.

Part 1:   Multiple-choice questions (67%)

1. Which of the following should be considered part of the "human service environment" when designing a vehicle to travel on a sidewalk?
   (a) People who may block the vehicle's path
   (b) People who may steal the vehicle
   (c) People who will operate the vehicle
   (d) a and b
   (e) a and c
   (f) b and c
   (g) All of the above

2. A design that is sustainable meets the needs of:
   (a) future generations
   (b) the current generation
   (c) the designer
   (d) a and b
   (e) a and c
   (f) b and c
   (g) All of the above

3. Sustainable development requires that designs be:
    (a) the most functional
    (b) the least expensive
    (c) the most advanced technically
    (d) the least environmentally damaging
    (e) All of the above
    (f) None of the above

4. Which of the following is a "best practice" for community consultation?
    (a) Only involve those who may cause problems with approval of the design
    (b) Include the cost and time for community consultation in your project plan
    (c) Consult primarily at the end of the design process
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

5. Which of the following is **not** correct?
    (a) Learning leadership requires experience
    (b) Leadership is a process
    (c) Leadership is the same as management
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

6. Which of the following is correct?
    (a) "Drivers" like to focus on team dynamics
    (b) "Expressives" are usually good at brainstorming
    (c) "Amiables" are often autocratic
    (d) "Analyticals" often escalate conflict
    (e) a and b
    (f) a and c
    (g) b and d

7. What is the correct order of the Human-tech ladder, from low to high?
    (a) physical, psychological, team, organizational, political
    (b) team, psychological, physical, political, organizational
    (c) physical, psychological, team, political, organizational
    (d) psychological, physical, organizational, team, political
    (e) psychological, physical, team, organizational, political
    (f) team, physical, psychological, organizational, political

8. Which of the following is consistent with the Human-tech approach to design?
   (a) Increased functionality is a priority
   (b) Design should adapt human nature to accommodate technology
   (c) Design with feedback
   (d) a and b
   (e) a and c
   (f) b and c
   (g) All of the above

9. The goal of designing for human factors is:
   (a) performance
   (b) safety
   (c) satisfaction
   (d) automation
   (e) a, b and c
   (f) b, c and d
   (g) All of the above

10. Which of the following is an issue addressed in the psychological level of the Human-tech ladder?
    (a) Budget allocations
    (b) Cause/effect relations
    (c) Responsibilities
    (d) Communications patterns
    (e) a and b
    (f) a and c
    (g) b and c

11. Which of the following is correct about preventable medical errors in the U.S.?
    (a) They are primarily due to problems at the psychological level of the Human-tech ladder
    (b) They are primarily due to problems at the physical level of the Human-tech ladder
    (c) They are primarily due to poor equipment
    (d) They are at the minimum feasible level
    (e) a and d
    (f) b and d
    (g) c and d

12. Automobile accidents are largely due to which of the following?
    (a) Vehicle mechanical failure
    (b) Roadway conditions
    (c) Driver factors
    (d) Weather conditions
    (e) None of the above

Questions 13 and 14 are based on the CBC video "Pedal Power":

13. Which of the following is **not** a characteristic of the bike system in Paris?
    (a) 100s of km of bike lanes
    (b) Bikes share separate lanes with public transit and taxis
    (c) Free, shared bikes
    (d) Significant problems with repairs and vandalism
    (e) All of the above

14. The change cyclists would most like to see is:
    (a) no requirement to wear a helmet
    (b) completely separate roadways for bikes
    (c) automobile drivers be required to pay for accidents they cause with bikes
    (d) cities provide free bikes
    (e) stricter enforcement of laws for automobile drivers
    (f) None of the above

15. From an economic perspective, the best alternative is the one that minimizes the present value of costs, if:
    (a) the benefits are the same for all alternatives
    (b) the discount rate is 0
    (c) all alternatives have the same lives
    (d) cost savings are a benefit
    (e) the payback period is less than the lives of the alternatives
    (f) all of the alternatives have the same initial costs
    (g) None of the above

16. A municipality is building a new road through a small town. Which of the following is an external cost of this project?
    (a) Health care costs due to air pollution from the automobiles travelling on the road
    (b) Lower property values near the road
    (c) Cost of snow removal
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

17. The cost of a monthly transit pass is a:
    (a) initial cost
    (b) ongoing cost
    (c) fixed cost
    (d) variable cost
    (e) a and c
    (f) b and c
    (g) b and d

Questions 18, 19 and 20 refer to the following situation: A small private water bottling company owns a building in which it pumps water from the groundwater and treats and bottles the water. It then transports the bottled water in small trucks for sale in a large city nearby. They sell the water for $1 per litre. The following are the types of costs the company incurs:

1. Cost they paid for the building
2. Employee salaries
3. Fire insurance
4. Heat and light for the building
5. Electricity for pumping the water
6. Chemicals for treating the water
7. Transportation of the bottled water

18. Which of the above costs is a variable, ongoing cost?
    (a) 1, 2 and 3
    (b) 2, 3 and 4
    (c) 3, 4 and 5
    (d) 4, 5 and 6
    (e) 5, 6 and 7
    (f) 6 and 7
    (g) 7

19. Which of the following is correct if the variable costs of production decrease and all else stays the same?
    (a) The breakeven quantity will increase
    (b) The breakeven quantity will decrease
    (c) The breakeven quantity will not change
    (d) The breakeven quantity may increase, decrease or not change, and more information is needed to determine what will happen
    (e) The breakeven quantity is not relevant to this issue

20. If the price of a bottle of water decreases, which of the following is **not** correct?
    (a) Revenues will increase
    (b) Revenues will decrease
    (c) Revenues will not change
    (d) Revenues may increase, decrease or not change, and more information is needed to determine what will happen
    (e) a, b and c

21. If the price of each of the following increases by 10%, for which would the "inelasticity of demand" principle be **least likely** to apply?
    (a) University student transit pass
    (b) Annual vehicle registration fee
    (c) Extra large cup of coffee
    (d) Tuition at the university
    (e) Tube of toothpaste

22. A City needs to choose whether to build a toll bridge or a toll tunnel for commuter traffic. The bridge will cost $2,400,000 and will have annual revenues of $200,000 and annual costs of $80,000. The tunnel will cost $3,000,000 and will have an annual revenues of $300,000 and annual costs of $100,000. What is the payback period of the bridge and which alternative is preferred on the basis of the payback periods?

    (a) 20 years and the bridge is the best alternative
    (b) 20 years and the tunnel is the best alternative
    (c) 15 years and the bridge is the best alternative
    (d) 15 years and the tunnel is the best alternative
    (e) 12 years and the bridge is the best alternative
    (f) 12 years and the tunnel is the best alternative
    (g) There is not enough information to answer this question

23. You are given the following information about two feasible designs:

	Initial costs	Annual revenues	Annual costs	Disposal costs
Design A	$6900	$1100	$600	$100
Design B	$4900	$1000	$600	$100

    r > 0% and the lives of both designs are 20 years.

    Which design is better from an economic perspective?
    (a) Design A is better than Design B
    (b) Design B is better than Design A
    (c) Design A and B are equally good
    (d) There is not enough information to answer this question

24. Contingency funds are set up to:
    (a) pay the designer
    (b) pay legal fees for incorrect designs
    (c) pay for unanticipated costs
    (d) buy gifts for workers when the work is completed
    (e) fund new projects
    (f) None of the above

25. Which of the following is an example of a strategy in design for environment (DfE) of a computer printer?
    (a) Treat the pollution from the manufacturing plant of the printer
    (b) Design a more energy efficient printer
    (c) Design a printer that is easier to disassemble
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

26. Which of the following is a principle of industrial ecology?
    (a) Industries should get most needed materials through recycling
    (b) Only natural (ecological) systems are to be used for production
    (c) Pollution should be controlled to meet legal requirements
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

27. Which of the following is **not** correct about life cycle assessment?
    (a) It uses a systems approach
    (b) It is a means of understanding a technology's environmental impact
    (c) It starts by constructing a life cycle diagram
    (d) The only thing that needs to be quantified is the input mass
    (e) It is a way to compare two technologies
    (f) All of the above
    (g) None of the above

28. A full life cycle assessment of a cell phone should include:
    (a) extraction of the natural gas needed to make the plastic for the cell phone
    (b) manufacturing of the cell phone
    (c) disposal of the cell phone battery
    (d) electricity production to recharge the batteries
    (e) b and c
    (f) b, c and d
    (g) All of the above

29. The life cycle assessment of a wind turbine that was shown in class found that most of
    the environmental impacts were the result of which of the following?
    (a) Use (operation) of the nacelle
    (b) Operation of the turbine
    (c) Transmission of the electricity
    (d) Manufacturing of the rotor
    (e) Manufacturing of the base (foundation) of the tower
    (f) Disposal of the tower
    (g) None of the above

30. Which of the following is correct?
    (a) Cumulative impacts result solely from a single decision
    (b) The outputs of a life-cycle assessment include usable products
    (c) One of the two main components of risk is uncertain costs
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

31. Which of the following is a basic element or characteristic of the systems approach?
    (a) The use of computer systems for engineering design
    (b) The systematic use of knowledge to solve problems
    (c) Consideration of the relationships and interactions between elements of a design
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

32. Which of the following is **not** a social impact that would likely result from banning waste pickers from landfills in developing countries?
    (a) More women would be unemployed
    (b) Less waste would be generated
    (c) People would become more educated
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

33. Which of the following is a type of social factor that has been significantly affected by cell phones?
    (a) Privacy
    (b) Political power
    (c) Gender inequality
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

34. Which of the following has had significant social impacts?
    (a) Hydroelectric dams
    (b) Slot machines
    (c) Trains
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

35. Which of the following is correct for the evaluation and comparison of design alternatives?
    (a) There is a need to estimate how well each alternative meets each objective in terms of quantitative metrics
    (b) All objectives of all stakeholders do not need to be considered
    (c) Metrics on an interval scale provide more information than metrics on an ordinal scale
    (d) a and b
    (e) a and c
    (f) b and c
    (g) All of the above

36. The table below shows the rankings on an ordinal scale, where 1 is best and 3 is worst, for the three objectives for three designs:

	Rankings for		
	Design A	Design B	Design C
Objective 1	1	2	3
Objective 2	1	3	2
Objective 3	2	3	1

What can you conclude about the three alternative designs?
(a) Design A is the best design
(b) Design B is the best design
(c) Design C is the best design
(d) Design B is dominated by Design A
(e) Design C is dominated by Design A
(f) a and d
(g) a and e

37. Project requirements can best be described as:
(a) an accurate, general statement describing all aspects of the problem
(b) an accurate, general statement describing the design alternatives
(c) a clear, specific description of all aspects of the problem
(d) a clear, specific description of the design alternatives
(e) a bulleted list of requirements that the solution must fulfil
(f) a clear explanation of the service environment in which the solution must operate
(g) None of the above

Questions 38 through 44 relate to Case #1 which is described on page 11.

38. In Case #1, the problem statement should include:
(a) the names of some additives that can be used to modify the properties of sugar
(b) the efficiency of microwave heating versus conductive heating
(c) the cost of natural gas at the processing plant location
(d) the other businesses owned and operated by Dolce Foods International
(e) the number of workers currently employed in the processing plant
(f) None of the above

39. In Case #1, secondary function(s) for the design would include:
(a) to add energy (heat) to the environment
(b) to melt sugar
(c) to be more environmentally friendly than the current system
(d) to retain the quality of the product Dolce is producing
(e) to meet safety standards
(f) All of the above
(g) None of the above

40. In Case #1, the scope of the project, as stated in the client statement, includes:
    (a) costing locally available energy sources (fuels, electricity, etc.)
    (b) maintaining the rate of sugar production
    (c) reducing the environmental impact of the process
    (d) developing a heating process for a variety of sugar products
    (e) a and b
    (f) c and d
    (g) All of the above

41. In Case #1, reasonable constraint(s) implied by the client statement include:
    (a) the new process design shall reduce energy costs by at least 80%
    (b) the new process design shall reduce energy costs by at least 30%
    (c) the new process design shall reduce energy costs below current levels
    (d) the new process design must reduce Greenhouse Gas production
    (e) a and d
    (f) b and d
    (g) c and d

42. In a problem statement, the major assertion states the need of the client. In Case #1, the evidence for the major assertion is found in:
    (a) Lines 13 to 16
    (b) Lines 6 to 10
    (c) Lines 1 to 5
    (d) Lines 11 to 12
    (e) None of the above

43. In Case #1, the explanation of the assertion is contained in:
    (a) Lines 1 to 5
    (b) Line 13 to 16
    (c) Lines 11 to 12
    (d) Lines 6 to 10
    (e) None of the above

44. In Case #1, the major assertion is found in:
    (a) Lines 11 to 12
    (b) Lines 1 to 5
    (c) Lines 13 to 16
    (d) Lines 6 to 10
    (e) None of the above

You may remove this page in order to use it when answering questions 38 through 44.

CASE #1 (adapted from a challenge posted on Innocentive)

1   The client, Dolce Foods International (DFI) is interested in identifying methods that would lower
2   the energy costs associated with industrial food preparation processes, specifically costs linked to
3   the melting of sugar. Food engineers at DFI estimate the current energy consumption of the
4   process as being 880 BTU per pound of the product. They note that altering the process has been
5   shown to reduce energy input by 30% [1] but set their goal at an 80% reduction. The sugars of
6   significance to this project are granular and naturally-grown. Sugar is a crystalline form of
7   carbohydrates, has a melting point of 320°F and heat capacity of 0.30 cal/g°C (1 cal = 4.18J).
8   The current method used to melt the sugar is by conductive heating via steam, under atmospheric
9   conditions. The steam is generated typically with a natural gas fired boiler.
10   Methods the client is willing to consider to reduce energy costs include:
11   1. Modifying the physical and chemical properties of the sugar which is by adding certain
12   additives to the sugar, and/or by using sugar alternatives, and/or pre-treating the sugar.
13   2. Changing the cooking method. As an example, this would involve a shift from using
14   steam generated by burning fossil fuel to utilizing electrically powered microwave ovens.
15   Another example would be the modification of the pressure under which the sugar is
16   heated.

[1] J. Al Ghurair & G.C. Singh, "Al Khaleej Sugar: An Energy Efficient Refinery," in *Sugar Industry Technologists Meeting.* Estoril, Portugal: Sugar Industry Technologies, 1999. [Online] Accessed November 25, 2010. Available:
http://www.aksugar.ae/images/PDF/AlKhaleejEnergyEfficientRefinery1999.pdf

Part 2:   Written Problem Definition (33%)

INSTRUCTIONS: This question requires two 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 – maximum two (2) pages for each question. 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, write a concise Problem Statement **in your own words. (10%)**
2) Based on the case given below, identify the **key stakeholders** and their **interests**. Identify the relationship between their interests and levels of Human Tech ladder, and/or environmental and/or economic concerns. Indicate, as well, functions, objectives and constraints that arise from the particular stakeholder interests. **(23%)**

CLIENT STATEMENT: Improving Material Handling Efficiency

Attucla Corporation is looking for creative, economical ways to safely improve the manual (non-automated) loading/unloading rate of boxes from a large truck (semi-trailer) to a staging area to a small (delivery) truck. We are looking for procedural and equipment changes to speed up the loading/unloading rate, decrease the drivers amount of work while keep them safe from injury. We would like to increase the rate of unloading the semi trailer from 400 to 800 or more cases per hour while at the same time avoid any ergonomic or safety issues.

Here are some facts about the scenario:
a. The foot print of each case is 40 cm X 53 cm. The height of the cases varies from 15 cm to 36 cm. The average weight of a case is 2.04 kg. The average stack weighs 27.22 to 36.30 kg.
b. The semi-trailers have an interior height of 2.79 m. Boxes may be stacked up to that height.
c. The small (delivery) trucks have an interior height of 2.06 m. Boxes may not be stacked higher than 2.06 m.
d. The average distance from the truck to the staging area is about 12 m.
e. The average number of cases in a semi-trailer is 1600.
f. The average unload rate is 400 cases/hour.
g. Reaching overhead to grasp a box and move it is considered an ergonomic "red zone" and should be avoided if possible. Drivers should not have to reach up over 1.78 m in height.
h. The material in the cases is not fragile and can easily withstand normal delivery handling. (i.e. they could be dropped from low heights and bounced a bit as long as they were not dropped from large heights or crushed).
i. The cases are cardboard boxes that are fan folded on top and bottom (not taped).

(This case is adapted from a challenge posted on Innocentive)

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