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University of Toronto  
Faculty of Applied Science and Engineering

APS111 Engineering Strategies and Practice  
Course Coordinator: Prof. S. McCahan

Final Examination  
December 7, 2004

This is a 2 hour and 30 minute exam. The exam is closed book and closed notes. The only permissible aids are a calculator. Answer all parts of all questions. Your answers must be well structured, clear, concise, and complete in order to obtain the maximum credit. The mark values for each question are given to help you allocate your time. Please write your answers in the booklets provided.

Please **write clearly**. We cannot give you marks if we cannot read your work.

Exam: 6 pages (5 pages of questions, 1 page figure for Question 2)

5 questions (worth a total of 150 points)

To get full credit you must **answer all parts of all questions**

**Problem 1 (42 pts)**

The Panama Canal is a major engineering artefact. Based on the reading you did for class and your discussion in tutorial, answer the following questions:

- a) Identify at least 4 stakeholders who would support construction of the canal in 1903 and/or today. Specifically identify their stake (i.e., why they care) (8 pts)
- b) Identify at least 4 stakeholders who would not support construction of the canal in 1903 and/or today. Specifically identify their stake (i.e., why they care) (8 pts)
- c) Identify at least 8 constraints for the canal and classify them into one of the four broad areas of constraints (16 pts)
- d) Considering your responses to parts a)-c), prepare a problem statement with objectives and functions that clearly define the problem that the Panama Canal was intended to solve. You may use bullet point form. (10 pts)

**Problem 2 (55 pts)**

Farbucks is an upscale coffee retailer that specializes in decaffeinated coffees. While not highly popular with undergraduate engineering students, Farbucks' products do meet a major market demand for aging Baby Boomers who are worried about their blood pressure. Farbucks has hired you to reduce their costs and improve their product's environmental image. You have prepared the product life cycle shown in the attached figure. Using that life cycle, answer the following questions.

- a) Select the most economical alternative for decaffeinating coffee beans. The two alternatives being considered are the current method Farbucks is presently using which uses dichloromethane to extract caffeine (process 1) and a new process that uses steam (process 2). Show all of your work for full credit. The following additional information is available. (20 pts)
  1. The decaffeinating facility sells 800,000 kg of decaffeinated coffee beans per year at a price of \$2.30 per kg.
  2. The decaffeinating facility buys 850,000 kg of decaffeinated coffee beans per year at a price of \$1.20 per kg.
  3. The capital cost to continue using the dichloromethane process is \$ 0.
  4. The operating cost to continue using the dichloromethane process is \$0.70 per kg beans sold.
  5. The capital cost for the new steam process is \$2,400,000 now and another \$1,425,000 spent in year 5.
  6. The operating cost for the new steam process is \$0.20 per kg beans sold.

7. Assume that  $i = 5\%$ ,  $(P|A, i, N) = \frac{(1+i)^N - 1}{i \cdot (1+i)^N}$ , and  $(P|F, i, N) = \frac{1}{(1+i)^N}$
8.  $LCC$  (for a 10-year life) = Initial Capital Costs + Capital Costs in Year 5  $\times$   $P|F$  + Annual Operating Costs  $\times$   $P|A$  – Annual Revenue  $\times$   $P|A$
- b) *Long answer question (up to 2 pages)*: Recently, OSHA has determined that dichloromethane is a possible hazard for workers. The current process using dichloromethane meets all workplace regulations, but workers are occasionally exposed to dichloromethane. If the public learns that Farbucks uses beans decaffeinated with the dichloromethane process, the demand for their coffee may decrease. In a written statement to Farbucks, examine the benefits and disadvantages of continuing to use the dichloromethane process. In particular, consider legal and ethical issues, economical issues (supply and demand as well as LCC), and possible environmental issues. (25 pts)
- c) Identify three opportunities in this life cycle where the principles of industrial ecology could be applied to reduce costs. Also identify whether the cost reduction is internal or external. (10 pts)

**Problem 3 (6 pts)**

Answer the following questions worth 1 pt each.

- i) A life cycle assessment impact analysis requires knowledge of:
- (a) psychology
  - (b) ecology
  - (c) law
  - (d) economics
  - (e) (b) and (c)
- ii) Which of the following is a tort?
- (a) a pastry
  - (b) a breach of contract
  - (c) a civil wrong
  - (d) (b) and (c)
  - (e) none of the above
- iii) Energy is measured in:
- (a) Joules
  - (b) Watts
  - (c) kilowatt-hours
  - (d) (a) and (b)
  - (e) (a) and (c)

- iv) Which of the following is not a presently a stakeholder for the Panama Canal?
- (a) New Zealand
  - (b) United States
  - (c) Canal workers
  - (d) Ship building companies
  - (e) none of the above
- v) Which of the following activities is not done by engineers?
- (a) Teaching
  - (b) Leading
  - (c) Performing
  - (d) Designing
  - (e) Constructing
- vi) Which of the following is not a stage of life cycle assessment?
- (a) Improvement analysis
  - (b) Scope and life cycle development
  - (c) Life cycle cost
  - (d) Impact analysis
  - (e) Inventory analysis

**Problem 4 (20 pts)**

Answer the following questions worth 2 pts each.

- i) Ethics are:
- (a) The formalized codes of conduct describing what society feels is the proper way to behave.
  - (b) The principles of conduct that govern the behavior of an individual or a profession.
  - (c) Guidance provided by professional organizations to help resolve dilemmas.
  - (d) (a) and (b)
  - (e) All of the above.
- ii) Which of the following are human factor levels?
- (a) Organizational
  - (b) Professional
  - (c) Team
  - (d) (a) and (b)
  - (e) (a) and (c)

- iii) Conceptual design contains the following stages:
- (a) Define problem
  - (b) Concept generation
  - (c) Gather information
  - (d) (b) and (c)
  - (e) All of the above
- iv) Which of the following is not part of Problem Definition?
- (a) Establish functions
  - (b) Clarify objectives
  - (c) Evaluate concepts
  - (d) Identify constraints
  - (e) Establish user requirements
- v) Ecology is
- (a) The study of organisms
  - (b) The study of the environment
  - (c) The study of interactions between organisms and the environment
  - (d) The study of organism population dynamics
  - (e) The management of organisms and the environment
- vi) Which of the following is true for a particular company which manufactures a product:
- (a) Increasing the sale price of the product will, necessarily, increase profit
  - (b) Decreasing the sale price of the product will, necessarily, increase profit
  - (c) Decreasing internal production costs, all else being equal, will increase profit
  - (d) Increasing internal production costs, all else being equal, will increase profit
  - (e) An increase in supply for the product will always result in an increase in profit
- vii) The second law of thermodynamics
- (a) States that energy is destroyed when used
  - (b) Predicts that the entropy of the universe decreases
  - (c) Is the reason mass can be recycled
  - (d) Is the reason energy flows from higher level use to waste thermal energy
  - (e) Explains how energy can be recycled in ecosystems

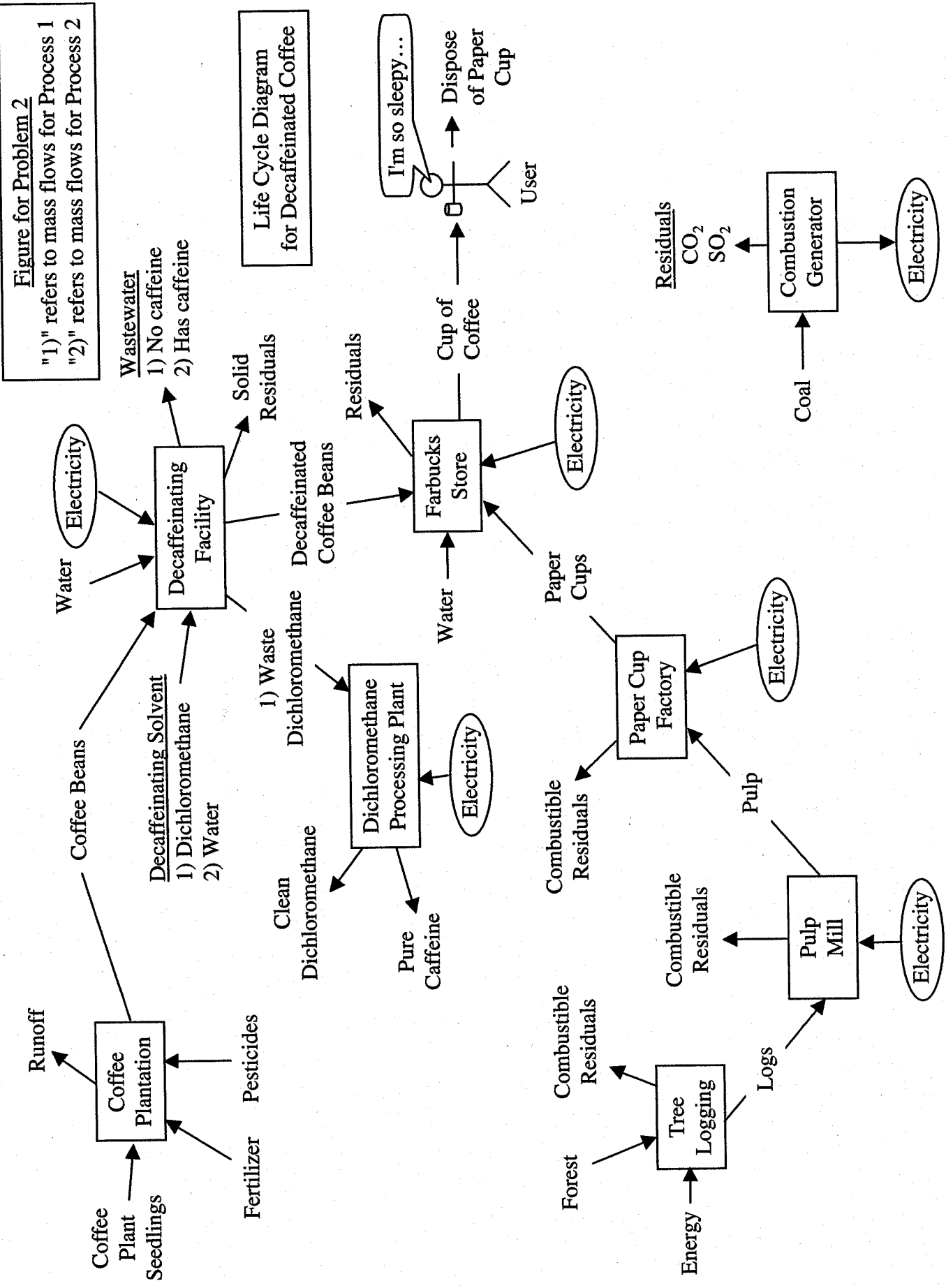
- viii) Based on industrial ecology principles
- (a) All mass used for producing products ends up as waste
  - (b) Residuals from one process can be raw materials for other products
  - (c) Products after use can be raw materials for other products
  - (d) (a) and (b)
  - (e) (b) and (c)
- ix) Pilots of B-17 planes in World War II had frequent landing gear mishaps because
- (a) The landing gear controls did not function properly
  - (b) The pilots often operated the landing gear controls incorrectly
  - (c) The designer of the cockpit located the landing gear controls behind the pilot seat
  - (d) The designer of the cockpit placed the landing gear controls next to identical flap controls
  - (e) (b) and (d)
- x) Considering human factors during the design process
- (a) Is logical because that is when user requirements are determined
  - (b) Is inefficient because design should focus on technical requirements
  - (c) Neglects the importance of stakeholders to design
  - (d) (b) and (c)
  - (e) None of the above

**Problem 5 (27 pts)**

You have spent most of your life in school and have experienced both good and bad examples of school and classroom design. Your first client after graduating from the University of Toronto is a private secondary school that wants to construct a new, state-of-the-art educational centre.

- a) Identify 4 human factors issues related to the design of a classroom. At least 2 of the 4 should come from a rung on the human tech ladder above the physical level. (10 pts)
- b) Identify 3 social impacts related to the design and construction of a school building. (6 pts)
- c) In gathering information for your design, you interview a number of staff members who will work at the new school. Several of the staff request that the new school building design include a room that has a special ventilation system to allow smoking (basically a smoking lounge for the staff). Explain why ethical issues arise from this request. Use the concepts that you have learned in Engineering Strategies and Practice in your explanation. (11 pts)

Figure for Problem 2  
 "1)" refers to mass flows for Process 1  
 "2)" refers to mass flows for Process 2



Life Cycle Diagram  
 for Decaffeinated Coffee