UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING
FINAL EXAMINATION, APRIL 2001

MIE 415S ENVIRONMENTAL ENGINEERING

Examiner: M.J. Thomson

Attempt all questions.
The value of the questions given in parentheses.
Show your work.

1. **(10%)** Compare a hydrogen fuel cell car versus a conventional car
   a) on the basis of air pollution emissions
   b) discuss a renewable energy source for each option

2. **(10%)** Energy
   a) Name 4 DFE strategies concerning energy
   b) For each give an example relating to a hybrid car.

3. **(10%)** Solid Waste
   a) Name three strategies that reduce solid waste
   b) For each give an example relating to a photocopier.

4. **(10%)** Primary and secondary water treatment seeks to improve to water quality items.
   a) What do they remove?
   b) How does they do this?
   c) What would be the environmental impact if these processes did not occur?

5. (10%) Life Cycle assessment
   a) What are the main advantages of using the EIO-LCA technique over the conventional quantitative LCA?
   b) What are the main disadvantages of using the EIO-LCA technique over the conventional quantitative LCA?

6. (15%) Gaseous emissions
   a) Name 5 DFE strategies for gaseous emissions
   b) Apply each one to the gasoline fueled car and explain why it reduces emissions

7. **(35%)** Mini-Project. The Ontario government wants to eliminate the use of coal at the Lakeshore generating station. The Toronto City government wants to find a way of disposing its municipal solid waste. They want to consider replacing the coal with municipal solid waste (i.e. incineration). They hire you to give a comprehensive evaluation of the two alternatives:
   (1) Electricity generated by a coal burning power plant.
   (2) Electricity generated by burning the garbage.

   Use the mini-project data supplied below. Be comprehensive. Be quantitative!
   a) (15%) From a life cycle assessment perspective, identify and evaluate (be quantitative) the following environmental impacts of the two options.
      i) Gaseous (air) emissions
      ii) Energy
      iii) Solid emissions

   b) (5%) Note what the specific impact on the environmental is for the:
      i) Gaseous (air) emissions
      ii) Energy
      iii) Solid emissions

   c) (10%) For each of the following air pollution emissions from the incinerator, suggest an air pollution control equipment that can be connected to the exhaust piping to reduce these emissions. Describe briefly how this technology removes the pollutant.
      i) Acid gases such as SO_2 and HCl
      ii) Fly ash (particulates)
      iii) Unburned Hydrocarbons (also called volatile organic compounds)
      iv) NOx

   d) (5%) Suggest your preferred alternative and support your conclusion.

Mini Project Data

Ontario Electricity Generation Mix

Coal	25%
Fuel Oil	1%
Natural Gas	3%
Nuclear	41%
Hydro-electric	30%

Electricity Generation Efficiency (fuel energy to electrical energy)

Coal	39%
Fuel Oil	38%
Natural Gas	38%
Nuclear	33%
Hydro	100%
Incineration	20%

Fuel data per unit energy content of Fuel

Fuel	Mass of Fuel	Exhaust Emissions					Extraction Solid Waste	Ash
		CO_2	CO	NOx	SOx	lead		
	kg/MJ	kg/MJ	kg/MJ	kg/MJ	kg/MJ	kg/MJ	kg/MJ	kg/MJ
Coal	0.034	0.10	3.0E-5	3.0E-4	3.4E-4	4.0E-11	1.5E-2	3.4E-3
Fuel Oil (in boiler)	0.022	0.095	1.0E-4	4.0E-4		0.0E+00	3.0E-4	0.0E+0
Natural Gas	0.019	0.060	2.0E-5	2.0E-4	0.0E+0	0.0E+00	2.0E-4	0.0E+0
Diesel (in engine)	0.022	0.069	1.9E-3	7.5E-4	0.0E+0	0.0E+00	3.0E-4	0.0E+0
Nuclear		5.0E-3	5.0E-6	5.0E-6	0.0E+0	0.0E+00	0.9E-3	0.0E+0
Municipal solid waste	0.077	1.0E-1	3.0E-5	2.5E-5	7.2E-6	6.0E-11		3.9E-3

Environmental impact per unit of pollutant also stated as
Environmental Load Units per kilogram pollutant (ELU/Kg)

Chromium	8.8
Lead	180
Iron	0.09
Nickel	24.3
CO	0.27
HC	1.00
NOx	0.22
CO_2	0.09
SOx	0.10