Examination:	**Recycling for the EMEC course**
Date:	**December 16, 1999**
Time:	**9.00 - 12.00**

Examination on Recycling for the EMEC course

Question 1
5 pts.

(a) One can look upon discarded substances in different ways. Give two definitions of waste, one from an environmental and one form an economic point of view.

(b) Give the priority ways of waste treatment such as it is suggested by the Dutch government.

Question 2
10 pts.

Make a schematic drawing of a car shredder including the air suction system. Using this drawing, describe the mechanism of action of the shredder together with the function of the major functional parts.

Question 3
15 pts.

a) Describe the three steps of the Life Cycle Assessment (LCA) methodology briefly

b) Explain the Eco-Indicator '95 methodology in some detail

c) Mention three shortcomings of LCA and give a clear example of each

d) Give the definition of Sustainable Development and explain in short how this is related to Design for Recycling

Question 4
20 pts.

In Europe is new legislation in preparation to organise the product responsibility of manufactures.

(a) What will be the influence of this legislation on the resource cycle?

(b) How is the automotive and electronic equipment cycle organised in the Netherlands?

(c) How can the economy of these cycles be improved, and give some examples?

Question 5
25 pts.

If you need a magnet with a very deep reach in order to pull steel parts from a mixture, which configuration is the most attractive, the multipole or the dipole? Can you support your answer on the basis of the field equations for the two configurations (see formulas given below: $\mu_0 = 4\pi 10^{-7}$ Tm/A)

Multipole magnet of polewidth ω, magnetization m:

$$B(z) = \frac{2\mu_0 m}{\pi} e^{-\pi z / w}$$

where z is the vertical distance from the bottom of the magnet block.

Dipole magnet with magnetic moment M:

$$B(z) = \frac{\mu_0 M}{2\pi z^3}$$

where z is the vertical distance to the center of the magnet.

Consider a dipole magnet made of NdFeB (magnetization 10^6 A/m) with a volume of 0.1 m^3 and a vertical orientation. How deep is the reach of the magnet for a steel part of 1 kg (steel has a density of 8000 kg/m^3 and a magnetization of 2 10^6 A/m). And how deep is the reach for a steel part of 0.1 kg.

Question 6
25 pts.

You are an entrepreneur who has attracted venture capital to buy equipment for a soil remediation facility in France. The supply of contaminated soil in France is boundless and your profit is proportional to the capacity, expressed in tonnes per hour, which you can process!

Four types of equipment are available: spirals (code: SP), fluidized bed upstream columns (code: FB), screens, and cyclones. The main function of spirals and fluidized beds is to separate the contaminants based on differences in density while the screens and cyclones are primarily used to separate particles according to size. A screen (for larger size fractions) and the hydrocyclone (for smaller size fractions) are sold as a pair (=together) only (code: SC). Please denote the number of units of each type of equipment as N_{SC}, N_{SP}, and N_{FB}.

A fluidized upstream column can clean soil with a maximum capacity of 20 tonnes per hour. The cleaning capacity of a single spiral is only 4 tonnes per hour while a set of screen and cyclone reduce the capacity of the plant by 2 tonnes per hour.

a) Give the equation for the capacity, which is to be maximized subject to constraints!

Your budget for buying equipment is f1 000 000. A unit of each type of equipment costs the following:

N_{SC} = 1: f6 000
N_{SP} = 1: f20 000
N_{FB} = 1: f80 000

b) Express in an equation how your budget is allocated (the financial constraint).

c) Which type of equipment has the most attractive capacity-to-price ratio?

You only have limited space available. The total space is 800 m^3 of which most is reserved for storage. Only 60 m^3 is available for your plant. The screen and cyclones can be placed outside the area, effectively increasing the area of your plant. Hence the space requirement of a set is negative! The area required for each unit equals:

N_{SC} = 1: Area = -2 m^2
N_{SP} = 1: Area = 2 m^2
N_{FB} = 1: Area = 5 m^2

d) Give the equation which expresses how the available area is subdivided (the space constraint).

Another consideration is that, for each FB, pre-classification of the soil with 3 sets of SC is necessary. Alternatively, a single SP can also perform this task and reduce the required number of SC's.

e) Give an equation, which relates the number of units of each type of equipment (the process constraint).

Now please put the objective function and the constraints into Excel. Solve for the number of units of each type.

f) Specify the number of units of each type of equipment, which you would tentatively purchase!