I. Collection

1. A family of four people generates solid waste at a rate of 2 lb/cap/day. Bulk density of refuse in a garbage can is approximately 200 lb/CY.
    a. If collection is once per week, how many 30-gallon garbage cans will they need?
    b. If they have a trash compactor that produces 20-lb blocks with a density of 1400 lb/CY, how many would they produce weekly and how many cans would they need?
2. Continuing #1, how many customers can a 20CY truck service if the compacted density if 500 lb/CY?
3. If a community of 5000 customers is to be collected once per week on M/T/Th and F, and a single truck can service 300 customers, including trips to the landfill, how many collection vehicles are needed?

II. Storage and Transfer

A community of 1200 homes will haul recyclable materials to a dropoff center.
The center will be open 8 hr/day, 2 day/week.
40% of the residents will participate in any given week.
75% of the participants will drop off once per week, while the others will drop off once every two weeks.

Find the average vehicle unloading rate.

III. Treatment

Estimate the amount of percolation of water through a landfill 10m deep, with a 1-m cover of sandy loam soil. The landfill is located in Ohio, where
P = 1025 mm/yr
R = 0.15
E = 660 mm/yr
Soil Field Capacity = 200 mm/m
Refuse field capacity = 300 mm/m
Soil is at field capacity when applied, incoming refuse has moisture content of 150 mm/m.

IV. Disposal

Given a contaminated groundwater system. Design a 3-foot thick barrier soil to control the influx of clean water into the contaminated aquifer. Extraction well will be pumped at a rate of 5 gpm. The perimeter barrier must be 3000 feet long. The aquifer is 30 feet thick. Inward gradient to the wells will be achieved by maintaining a 5-foot drawdown within the containment. Determine the maximum hydraulic conductivity to sustain the 5 gpm flow rate.

Sample Problem 104
Sample Problem 105
Sample Problem 107
Sample Problem 138
Sample Problem 139

V. Quantity Estimates

Consider a household that generates waste daily.

Bottles and cans represent 20% by weight; 100% of them are recycled.
Paper waste represents 32% of the total waste generated, but 20% of the paper is burned in the fireplace.
Magazines represent 5% of the waste generated and are recycled.
On any given day, 20 lbs of consumer goods are brought into the house. Seven (7) pounds of food is consumed and 5 pounds of food is stored.

a. Draw a material flow diagram
b. Calculate the amount of waste disposed of during a typical day.

Sample Problem 136

VI. Site and Haul Economics

6-1 A manufacturing process has annual operating costs of $10.9 million. Waste disposal costs $3.3 million/year.
A process upgrade will cost $23.3 million. New annual operating and waste disposal costs will be $7.1 million and $1.4 million, respectively.
Assuming no salvage value, a design life of 10 years, and a cost of capital of 12%/year, is the upgrade economically viable?

Current PW = A * PWF
Proposed PW = C + A * (PWF)

6-2. Determine the breakeven point for a hauled container system and a stationary container system compared with a transfer/haul system using trailer transport.
Given operiatng costs:
a. hauled container system – 8 CY container: $25/hr
b. Stationary containter system – 20 CY container: $40/hr
c. trailer transport – 105 cy container: $40/hr
d. transfer station operation: $2.75/cy

Solution:
Express costs in terms of production ($/CY/min)
Determine unit cost/cy for different driving times
Note that we are not considering fixed costs in this example.

VII. Energy Recovery

7-1 Note the energy content of the typical municipal solid waste given in the table below.

a. Suppose 60% of the paper and 90% of the cardboard is recycled. What is the final energy content of the waste stream?

b. Determine the final energy content for the indicated recycling rate.

c. Determine the quantity and composition of the residue resulting from combustion of MSW without recycling. Estimate the volume reduction assuming that the specific weight of the MSW in the storage pit is 375 lb/CY and the specific weight of the residue is 1000 lb/CY.

Component	Weight (lb)	Inert Residue (%)	Typical Energy Content (Btu/lb)	Total Energy Content (Btu)	b. Recycling Rate (%)	b. Weight after recycling (lb)	b.Energy Content after recycling (Btu)	c. Computed Residue weight (lb)	c. Computed Residue (%)
Food Waste	9.0	5.0	2000	18000	0			.45	1.9
Paper	34.0	6.0	7200	244800	35			2.04	8.6
Cardboard	6.0	5.0	7000	42000	30			.30	1.3
Plastic	7.0	10.0	14000	98000	30			.70	2.9
Textile	2.0	2.5	7500	15000	20			.13	0.5
Rubber	0.5	10.0	10000	5000	20			.05	0.2
Leather	0.5	10.0	7500	3750	20			.05	0.2
Yard Waste	18.5	4.5	2800	51800	15			.83	3.5
Wood	2.0	1.5	8000	16000	20			.03	0.1
Glass	8.0	98	60	480	30			7.84	33.0
Tin/steel can	6.0	98	300	1800	20			5.88	24.7
Aluminum	0.5	96	---	---	70			.48	2.0
Other metal	3.0	98	300	900	20			2.94	12.4
Dirt, Ash, etc.	3.0	70	3000	9000	0			2.04	8.6
Total	100.0			506530				23.76	100.0

ISWM, p 318

Problem 7-2
Using the data below, estimate the specific weight of typical residential waste with the given composition

A	B	C	D	E	F	G	H
Component	**% by weight**	**Specific Weight lb/CY**	**Moisture Content (%)**	**Energy Content Btu/lb**	**Volume (CY)**	**Dry Weight (lb)**	**Energy Btu**
Food Waste	15	490	70	2000			
Paper	35	150	6	7200			
Cardboard	7	85	5	7000			
Plastics	5	110	2	14000			
Textiles	3	110	10	7500			
Rubber	3	220	2	10000			
Leather	2	270	10	7500			
Yard Waste	20	170	60	2800			
Wood	10	400	20	8000			
	100						

1. Assume incoming sample weight = 100 lb

2. (F) Volume = B/C

3. Specific Weight = $\frac{\text{total wet weight}}{\text{total volume}}$

Problem 7-3
Determine the overall moisture content of the waste given above.

1. (G) Dry Weight =(1-MC) * wet weight
2. MC = (WW-DW) / WW *100%

Problem 7-4
Estimate the "as discarded" energy content for the waste on a dry basis and dry ash-free basis
Assume Ash content is 4%

1. component energy content = B * E
2. total Energy content = Sum of component energy / total weight
3. on a dry basis (1/1-MC)*total energy content

dry ash free basis (1/1-MC-ash)*total energy content

Problem 7-5
Consider a household that generates a certain amount of waste.
Bottles and cans represent 20% by weight and are recycled.
20% of the paper waste (32% of the total waste) is burned in the fireplace.
On any given day, 20 lbs of consumer goods are brought into the house.
The family consumes 7 lbs of food that day, and 5 pounds of food is stored.
Magazines are 5% of the paper wastes, and are not thrown away.
Draw a materials flow diagram and calculate the amount of solid waste disposed of during this day.

VIII. Hazardous Waste Systems

IX. Applicable Standards