

Waste Collection Exercises





Problem 1: Description

- Determine the number of hauled container trucks required to serve a shopping center producing 113 yd³ of waste per **day**. Containers are picked up daily and are 9 yd³ each and are 70% full. Use the data on the following slide.

- Use this equation:

$$Y = a + b + c(d) + e + f + g$$





Data

- Total collection time (Y): 8 hours
- Off route time (f + g): 1.6 hours
- Time to drive to and from the garage (a + e): 30 min
- Time to drive to and from disposal facility (round trip): 12 minutes
- Time to unload at the disposal facility: 11 min
- Time to pick up container: 5 min
- Time to unload container: 5 min
- Time to drive between containers: 4 min





Question

What are the number of trips to the disposal site per day required vs. the number of trips per day each truck can make?

- Note: Number of trips/day [c] required is equal to the number of containers.



Step 1: Solve for c, number of trips possible per day per truck

➤ Equation:

$$Y = a + b + c(d) + e + f + g$$

➤ b is a function of which variables?

➤ Answer is given in next slides



Step 1: Solve for c

$$Y = a + b + c(d) + e + f + g$$

$$a + e = 30 \text{ min}$$

$$b = (\text{pick up} + \text{put down}) \times c + \text{drive between time} \times (c-1)$$

$$b = 14c - 4$$

$$d = \text{drive to disposal site} + \text{time at site}$$

$$d = 11 + 12$$

$$f + g = 1.6(60)$$



Step 1: Cont'd

$$480 = 30 + 14c - 4 + 23c + 96$$

$$c = 9.7$$

$c \sim 9$ trips/day possible



Step 2: Calculate the number of containers filled per day

- The number of containers that must be delivered to the disposal site per day is equal to the number of trips required per day
- Think about the relationships among the given data to make this calculation
- Answer is given in next slide



Step 2: Calculate the number of containers filled per day

$$\frac{\text{Daily Volume}}{\text{Container Volume} \times \text{Utilization}} = \frac{113 \text{ yd}^3/\text{d}}{9 \text{ yd}^3/\text{container} \times 0.7}$$
$$= 17.9 \text{ containers/day}$$
$$= 18 \text{ trips/day}$$

But 9 trips/day are possible
So 2 trucks must be used





Problem 2: Description

Calculate the truck volume (v) and the number of trucks (N) you would recommend to serve a residential community using a manually loaded compactor on a **weekly** basis. Each location is served once each week. Use data from the following slide.





Data

- Total number of locations = 50,000 loc/week
- Waste generation per location = 20 lb/loc
- Waste specific weight = 177 lb/yd³
- Compaction ratio = 2.5
- Collection time = 1 min/location
- Total collection time = 40 hrs per week, 5 days/wk
- Disposal time (total) = 31 min/trip
- Time to and from garage (total) = 20 min/day
- Off route time = 15% of total collection time
- Number of trips/day possible = 2





Step 1: Calculate time required per week as a function of N

- Use this equation:

$$Y = a + b + c(d) + e + f + g$$

- b is a function of the number of locations each truck visits times the collection time per location
- Answer is given in next slide



Step 1: Calculate N using time per week for each truck

$$Y = a + b + c(d) + e + f + g$$

$$Y = (40)(60) \text{ min/wk} = 2400 \text{ min/wk/truck}$$

$$a + e = 5 \times 20 \text{ min/wk} = 100 \text{ min/wk/truck}$$

$$b = \text{no. loc /wk} \times \text{time/loc}$$

$$b = 50,000 \times 1 \text{ min/week/N trucks}$$

$$c = 2 \text{ trips/day} \times 5 \text{ days/week/truck}$$

$$d = 31 \text{ min/trip/truck}$$

$$f + g = 2400 \times 0.15 = 360 \text{ min/wk/truck}$$





Step 2: Solve for N

- Answer is given in next slide



Step 2: Solve for N

$$Y = a + b + c(d) + e + f + g$$

$$2400 = 100 + 2(31)(5) + 360 + 50,000/N$$

N = 31 trucks needed



Step 3: Calculate minimum truck volume required

- Truck volume is equal to volume/trip
- Calculate the required volume/trip



Step 3: Calculate minimum truck volume required

$$\text{Vol/trip} = \text{vol/wk} / \text{trips/week}$$

$$(v)(2.5) = \frac{(50,000 \text{ loc} / \text{wk})(20 \text{ lb} / \text{loc})}{(177 \text{ lb} / \text{yd}^3)(10 \text{ trips} / \text{wk} / \text{truck})(31 \text{ trucks})}$$

$$v = 7.3 \text{ yd}^3$$

$$v \sim 10 \text{ yd}^3$$





Problem 3

A community of 1000 homes stores their waste containers along alleys located in back of all of their homes. A satellite vehicle with a 2-yd^3 capacity picks up the waste once per week and delivers it to a mechanically loaded compactor truck that moves along a main artery as the satellite vehicle collects wastes. Calculate the number of trips per week the satellite vehicle makes to the compactor truck and the time per week required to collect all of the waste. How many trips does the compactor make to the disposal site?





Data

- Number of days/week = 5
- Length of work day = 8 hours
- Off route time = 15% of the day
- Time to and from garage = 15 min each
- Pickup time per location (satellite vehicle) = 0.6 min
- Average time to drive to and from compactor = 5 min
- Compactor volume = 30 yd^3
- Compaction ratio = 3
- Waste generation is $0.2 \text{ yd}^3/\text{location}$





Step 1: Calculate the number of satellite vehicle trips

- Hint: Calculate the number of locations per trip the vehicle can collect.



Step 1: Calculate the number of satellite vehicle trips

$$[\text{vol/trip}]/[\text{vol/loc}] = \text{loc/trip}$$

$$2 \text{ yd}^3/\text{trip}/0.2 \text{ yd}^3/\text{loc} = 10 \text{ loc/trip}$$

$$[\text{Number of location}]/[\text{week/loc/trip}] = \text{trips/week}$$

$$1000 \text{ loc/wk}/10 \text{ loc/trip} = 100 \text{ trips/week}$$





Step 2: Calculate the time per week to collect waste

- Use equation below, based on time per week:

$$Y = a + b + c(d) + e + f + g$$



Step2: Calculate the time per week to collect waste

$$Y = a + b + c(d) + e + f + g$$

$$a + e = 30 \text{ min/day} \times 5 \text{ days/week}$$

$$b = \text{time/loc} \times \text{loc/week}$$

$$b = (0.6)(1000) = 600 \text{ min/week}$$

$$c = 100 \text{ trips/week}$$

$$d = 5 \text{ min/trip}$$

$$Y = 150 + 600 + (5)(100) + 360$$

$$Y = 1610 \text{ min/week}$$





Step 3: Calculate the number of compactor trips

- Based on volume per week and truck capacity



Step 3: Calculate the number of compactor trips

$$\text{Trips/wk} = [\text{vol/wk}] / [(\text{vehicle vol.})(\text{compaction ratio})]$$

$$\text{Vol/wk} = [1000 \text{ loc/wk}][0.2 \text{ yd}^3/\text{loc}]$$

$$\text{Trips/wk} = [200 \text{ yd}^3/\text{wk}] / [30 \times 3 \text{ yd}^3/\text{trip}]$$

$$\text{Trips /wk} = 2.22$$

Cannot make a partial trip, so...

$$\text{Trips/wk} = 3$$





Practice Problem 1

- If “vehicle use efficiency,” n , is defined as the weekly vehicle use time in min/wk divided by the length of the work week in min/week, calculate n for a manually loaded collection system using the following information:





Practice Problem 1: Data

- Number of days per week = 5
- Average length of work day = 8 hours
- Off route time = 15% of the day
- Time to and from garage = 15 min each
- At disposal site time = 12 min/trip
- Drive to and from disposal site (total) = 45 min/trip
- Compactor volume = 30 yd³
- Number of compactors = 3
- Volume/location = 0.35 yd³
- Pick up time per location = 1 min
- Volume collected per week = 1500 yd³
- Compaction ratio = 2.5





Practice Problem 2

- How many trips per day to a landfill can a mechanically loaded commercial waste collection compactor make serving the community described in the next slide?





Practice Problem 2: Data

- Length of work day = 8 hours
- Off route time = 15% of the day
- Time to and from garage = 20 min total
- At disposal site time = 8 min/trip
- Drive to and from disposal site (total) = 25 min/trip
- Compactor volume = 20 yd³
- Pick up, unload and replacement time = 5 min
- Drive between containers = 5 min
- Compaction ratio = 2.5
- Containers are 8 yd³ each, 70% full





Practice Problem 3

A community is considering two types of recyclables pickup, commingled (with separation at a dirty MRF, or source separated. Compare the number of locations that can be served each week using the data provided on the next slide.



Variable	Commingled	Source Separated
Hours per day	8	8
Days per week	5	5
Truck volume, yd ³ /trip	30	20
Compaction Ratio	2	1
Drive to/from landfill, hr/trip (total)	0.5	0.5
At site time, min/trip	10	20
Collection time, min/location	0.5	3.6
Off route time, % of day	15	15
Time to/from garage, min (each)	10	10
Generation rate, yd ³ /loc	0.2	0.2



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