INTRODUCTION

• Trucks are hauling units.
• Trucks have high travel speeds when operating on suitable roads, provide relatively low hauling costs.
• Trucks provide a high degree of flexibility permitting modifications in the total hauling capacity of a fleet and adjustments for changing haul distances.
Most trucks may be operated over any haul road for which the surface is sufficiently firm and smooth and on which the grades are not excessively steep.
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

INTRODUCTION

Some trucks now in use are designated as off-highway trucks because their size and total load are larger than that permitted on public highways. These trucks are used for hauling materials on large project sites, where their size and costs are justified.

TRUCKS CLASSIFICATION

Trucks may be classified according to a number of factors including:

1. The size and type of engine-gasoline, diesel, butane, propane
2. The number of gears.
3. The kind of drive-two-wheel, four-wheel, six-wheel, etc.
4. The number of wheels and axles and arrangement of driving wheels.
5. The method of dumping the load-rear-clump, side-dump.
6. The class of material hauled-earth, rock, coal, ore, etc.
7. The capacity, in tons or cubic yards.
REAR-DUMP TRUCKS

Rear-dumps trucks are used when:

- The material to be hauled is free-flowing or has bulky components.
- The hauling unit must dump into restricted locations or over the edge of a bank or fill.
- Maximum maneuverability in the loading or dumping area is required.

Highway rear-dump
BOTTOM-DUMP TRUCKS

Bottom-dumps trucks are used when:

✓ The material to be hauled is free-flowing.
✓ There are unrestricted loading and dump sites.
Tractor with bottom dump trailer

Bottom dump trailer deposits a wind row of material.
Articulated Trucks

Can operate over bad ground.
These are specialized trucks for hauling a fleet of equipment from one point to another.

- General construction
- Military
- Services

Trucks to move the fleet
Special trailers for heavy loads
Tires are about 35% of a truck’s operating cost. Overload a truck and you abuse the tires.
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

TIRES
Tires are designed for a wide range of applications.

Section 20  CAT Handbook

The Terex Titan, the world’s largest truck at 350-ton was designed around the tires.

CAT is working on a 340-ton truck.
They are BIG

Safety
There are three methods of expressing the capacities of trucks and wagons:

1) by the load which it will carry, expressed gravimetrically in tons.
2) by its struck volume (cu yd).
3) by its heaped volume (cu yd).
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

CAPACITY OF DUMP TRUCKS

The **struck capacity** of a truck is the volume of material which it will haul when it is filled level to the top of the sides of the body.

The **heaped capacity** is the volume of material, which it will haul when the load is heaped above the sides.

TRUCK CAPACITY

Manufacturer's specification sheets will list both struck and heaped capacities.

- material measured straight across the top of the body.
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

TRUCK CAPACITY

- based on a 2:1 slope above hauler bodies.

Articulated Trucks

Retainer plate to increase load capacity.
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

CAPACITY OF DUMP TRUCKS

The heaped capacity will vary with the height and angle at which the material may extend above the sides.

- Wet earth or sandy clay may be hauled with a slope of about 1:1
- Dry sand or gravel may not permit a slope greater than about 3:1.

PERFORMANCE CAPABILITIES OF TRUCKS

The productive capacity of a truck or wagon depends on the size of its load and the number of trips it can make in an hour.

The size of the load can be determined from the specifications furnished by the manufacturer.
PERFORMANCE CAPABILITIES OF TRUCKS

The number of trips per hour will depend on the **weight** of the vehicle, the **horsepower** of the engine, the **haul distance**, and the condition of the haul road.

Example 1

Determine the maximum speed for the truck, whose specifications are given below, when it is hauling a load of 22 tons up a 6% grade on a haul road having a rolling resistance of 60 lb per ton:

- **Engine**: 239 fwhp
- **Capacity**:
  - Struck, 14.7 cu yd
  - Heaped, 2:1, 18.3 cu yd
- **Net Weight (empty)** = 36,860 lb
- **Payload** = 44,000 lb

**Gross Vehicle Weight** = 36,860 + 44,000 = 80,860 lb

**Total Resistance** = \( rr + gr = \frac{60}{20} + 6 = 9\% \)

**Maximum Speed** \( \approx 6.5 \) mph (from Figure 1, or Fig.10 - 9 Text)
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

BALANCING THE CAPACITIES OF BALANCING THE CAPACITIES OF
HAULING UNITS WITH EXCAVATOR SIZE

- When loading with hoes, shovels, draglines, or belt loaders, it is desirable to use haul units whose capacities balance the output of the excavator.

- Factors which will affect the production rate and the cost of handling earth:
  1. Advantages of using small trucks compared with large trucks
  2. Disadvantages of using small trucks compared with large trucks
  3. Advantages of using large trucks compared with small trucks
  4. Disadvantages of using large trucks compared with small trucks
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

USING SMALL TRUCKS COMPARED WITH LARGE TRUCKS

**Advantages:**
1) They are more flexible in maneuvering, which may be an advantage on short hauls.
2) They may have higher speeds.
3) There is less loss in production when one truck in a fleet breaks down.
4) It is easier to balance the number of trucks with the output of the excavator, which will reduce the time lost by the trucks or the excavator.

**Disadvantages:**
1) A small truck is more difficult for the excavator to load owing to the small target for depositing the bucket load.
2) More total spotting time is lost in positioning the trucks because of the larger number required.
3) More drivers are required to haul a given output of material.
4) The greater number of trucks increases the danger of units bunching at the pit, along the haul road, or at the dump,
5) The greater number of trucks required may increase the total investment in hauling equipment, with more expensive maintenance and repairs, and more parts to stock.
Using Large Trucks Compared with Small Trucks

Advantages:

1) Fewer trucks are required, which may reduce the total investment in hauling units and the cost of maintenance and repairs.
2) Fewer drivers are required.
3) The smaller number of trucks facilitates synchronizing the equipment and reduces the danger of bunching by the trucks. This is especially true for long hauls.
4) There are fewer trucks to maintain and repair and fewer parts to stock.
5) The engines ordinarily use cheaper fuels, i.e., gasoline versus diesel. But this must be based on fuel prices at the specific project location.

Disadvantages:

1) The cost of truck time at loading is greater, especially with small excavators.
2) The heavier loads may cause more damage to the haul roads thus increasing the cost of mechanical maintenance to the trucks and requiring more support equipment for maintenance of the haul road.
3) It is more difficult to balance the number of trucks with the output of the excavator.
4) Repair parts may be more difficult to obtain.
5) The largest sizes may not be permitted to haul on highways.
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

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TRUCK PRODUCTION

STEP 1: BUCKET LOADS

Number of bucket loads required to fill the truck.

\[
\text{Bucket loads} = \frac{\text{Truck capacity}}{\text{Loader Bucket capacity}}
\]

Bucket loads must be an integer number.
MATCH THE LOADER TO THE TRUCK

BUCKET CAPACITY
WEIGHT LIMIT

Check load weight against gravimetric capacity of the haul unit.

Max. gross weight = 150,000 lb
Operating weight (empty) = 68,900 lb
Therefore the max load is = 81,100 lb

Note the difference. Sideboards.
WEIGHT LIMIT

Check load weight against gravimetric capacity of the haul unit.

TRUCK PRODUCTION

**STEP 2: LOAD TIME**

LOAD TIME =

- Excavator cycle time
  - No. of bucket loads
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

STEP 2 LOAD TIME

CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

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TRUCK PRODUCTION

STEP 3: HAUL TIME

HAUL TIME

\[
= \frac{\text{HAUL DISTANCE (FT)}}{88 \times \text{HAUL SPEED}}
\]
STEP 4: RETURN TIME

RETURN TIME

\[ \text{RETURN TIME} = \frac{\text{RETURN DISTANCE (FT)}}{88 \times \text{HAUL SPEED}} \]

STEP 5: DUMP TIME

This will depend on the type of hauling unit.
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

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STEP 5: DUMP TIME

This will depend on the type of hauling unit.

• Rear dumps must be spotted before dumping. Total dump time can exceed 2 minutes.

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STEP 5: DUMP TIME

• Bottom dump units dump while moving.
STEP 5: DUMP TIME

PROJECT SPECIFIC FACTORS

• Is the dump area smooth permitting safe maneuvering to dump?

• Is the dump area crowded with support equipment?
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

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STEP 5: DUMP TIME

PROJECT SPECIFIC FACTORS

• Do loaded haul units have the right-of-away.

Grader
Roller
Water truck

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STEP 5 DUMP TIME

Turn and Dump times (min.)

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Bottom Dump</th>
<th>End Dump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favorable</td>
<td>0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Average</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Unfavorable</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

See p. 295
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

TRUCK PRODUCTION

**STEP 6: TRUCK CYCLE TIME**

**CYCLE TIME =**
- Load Time
- + Haul Time
- + Dump Time
- + Return Time
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

TRUCK PRODUCTION

STEP 7: NUMBER OF TRUCKS REQUIRED

\[
\text{TRUCKS REQUIRED} = \frac{\text{TRUCK CYCLE TIME}}{\text{LOADER CYCLE TIME}} + 1
\]

STEP 7  NUMBER OF TRUCKS REQUIRED

![Bar chart showing the number of trucks required for different levels of production. The chart indicates that the number of trucks increases as production increases.](chart.png)
STEP 7 NUMBER OF TRUCKS REQUIRED

The match point typically does not coincide with an even number of trucks.
STEP 8: EFFICIENCY

Three critical factors to consider:

• Bunching
• Operator
• Equipment availability

Bunching:

✓ With a perfect loader - hauler match the effect of bunching is a 10 to 20% loss.
✓ If there are extra haulers the effect is reduced as there is always a line of trucks waiting to be loaded.
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

STEP 8  MISMATCH & BUNCHING EFFICIENCY

TRUCK PRODUCTION

- Longer hauling distances usually results in better operator efficiency.
- Operator efficiency increases as haul distance increases to about 8,000 ft. after which it remains constant.
TRUCK PRODUCTION

Equipment Availability

When the loading tool breaks down, the production drops to zero.

STEP 9: PRODUCTION

\[
\text{PRODUCTION (LOADER)} = \frac{\text{WORKING MIN / HR}}{\text{LOADER CYC TIME (MIN)}} \times \text{BUCKET VOL}
\]

The Loader will control production if at least one extra truck is used.
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

STEP 9: PRODUCTION

PRODUCTION (TRUCK) =

\[
\frac{\text{WORKING MIN / HR}}{\text{TRK CYC TIME (MIN)}} \times \text{TRK VOL} \times \text{NO. TRKS}
\]

Trucks control production if fewer trucks are used.

Example 2 – Practical Exercise
(Truck Production)

Ten 25 ton/18 cy rear dump trucks with low pressure tires are available to haul a rock dirt/gravel mixture. The wheel loader being used has a 4.25 cy bucket.
Example 2 (cont’d)

The haul and return, over poorly maintained earth, is 3 miles. It is a down hill grade of 1.25% going to the dump area. Net truck weight is 36,860 lb. Working hour efficiency is 55 minutes.

STEP 1 BUCKET LOADS

NUMBER OF BUCKET LOADS REQUIRED TO FILL THE TRUCK.

- Truck capacity = 18 cy
- Dirt/gravel mixture

Fill Factor wheel loader (Table 8.6) 100-120%, use average 110%

Loader bucket capacity = 4.25 X 1.1
= 4.675 cy
**Example 2 (cont'd)**

**STEP 1 BUCKET LOADS**

**NUMBER OF BUCKET LOADS REQUIRED TO FILL THE TRUCK.**

\[
\text{Bucket loads} = \frac{18}{4.675} \Rightarrow 3.85
\]

Bucket loads must be an **integer** No. Therefore use either 3 or 4 bucket loads.

**CHAPTER 10. TRUCKS AND HAULING EQUIPMENT**

**Example 2 (cont'd)**

**STEP 1 BUCKET LOADS**

If 3 bucket loads:

Truck volume = \( 3 \times 4.675 \)

\( = 14 \text{ LCY} \)

If 4 bucket loads:

Truck volume = \( 18 \text{ LCY} \)

and the excess spills off.
**STEP 1 BUCKET LOADS**

Check load weight against gravimetric capacity of truck.

Dirt/gravel mixture

Table 4.3

\[ 2,600 \text{ lb/LCY} \]

---

**STEP 1 CHECK LOAD WEIGHT**

\[ 14 \text{ LCY} \times \frac{2,600}{2,000} = 18.2 \text{ tn} < 25 \text{ tn ok} \]

\[ 18 \text{ LCY} \times \frac{2,600}{2,000} = 23.4 \text{ tn} < 25 \text{ tn ok} \]
Example 2 (cont'd)

**STEP 2 LOAD TIME**

LOAD TIME =

Bucket cycle time X
No. of bucket loads

4.25 cy bucket

Table 8.9

Bucket cycle time 30 - 33 sec
use average 31.5 sec

(0.524 min)

3 bucket load:
3 X 0.525 = 1.58 min.

4 bucket load:
4 X 0.525 = 2.10 min.
Example 2 (cont'd)

STEP 3  HAUL TIME

HAUL TIME = \frac{3 \text{ miles} \times 5,280 \text{ ft/mile}}{88 \times \text{HAUL SPEED}}

Poorly maintained earth

Example 2 (cont'd)

STEP 3  HAUL TIME

- Poorly Maintained Earth Haul Road

Rolling resistance (Table 5.1)

70 - 100 lb/ton, use 85 lb/ton or 4.25%

Grade resistance load to dump:

\text{Total Resistance} = 4.25 + (-1.25\%)

\text{= 3.0\% or 60 lb/ton}
Example 2 (cont’d)

STEP 3  HAUL TIME

Net truck weight 36,860 lb or 18.43 tons

3 bucket load  18.20 tons

Gross wt. = 18.43 + 18.20 = 36.63 tons

4 bucket load  23.40 tons

Gross wt. = 18.43 + 23.40 = 41.83 tons
STEP 3  HAUL TIME

3 bucket load Gross wt. 36.63 ton
Rimpull = 60 lb/ton X 36.63 ton
= 2,200 lb

4 bucket load Gross wt. 41.83 ton
Rimpull = 60 lb/ton X 41.83 ton
= 2,510 lb
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

Example 2 (cont’d)

STEP 3  HAUL TIME

3 bucket load 35 mph
4 bucket load 22 mph

\[
\text{HAUL TIME} = \frac{3 \text{ miles} \times 5{,}280 \text{ ft/mile}}{88 \times \text{HAUL SPEED}}
\]

3 bucket,  5.143 min
4 bucket,  8.183 min

Example 2 (cont’d)

STEP 4  RETURN TIME

RETURN TIME = \frac{\text{RETURN DISTANCE (FT)}}{88 \times \text{HAUL SPEED}}

Net truck weight 36{,}860 lb
or 18.43 tons
STEP 4  RETURN TIME

- Poorly Maintained Earth Haul Road

Rolling resistance, 4.25%

Grade resistance load to dump 1.25%

Total Resistance = 4.25 + 1.25%

= 5.5% or 110 lb/ton

Rimpull = 110 lb/ton X 18.43 ton

= 2,030 lb
STEP 3  RETURN TIME

Return speed 35 mph

\[
RETURN \ TIME = \frac{3 \text{ miles} \times 5,280 \text{ ft/mile}}{88 \times 35} = 5.143 \text{ min}
\]

STEP 5  DUMP TIME

Rear Dump Trucks must be spotted before dumping,
- Total dump time averages about 2 minutes.

Use 2.0 minutes
EXAMPLE 420 ©Assakkaf

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Example 2 (cont’d)

STEP 6 TRUCK CYCLE TIME

3 bucket loads

Load time 1.580 min
+ Haul time 5.143 min
+ Dump time 2.000 min
+ Return time 5.143 min

CYCLE TIME = 13.866 min

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Example 2 (cont’d)

STEP 6 TRUCK CYCLE TIME

4 bucket loads

Load time 2.100 min
+ Haul time 8.183 min
+ Dump time 2.000 min
+ Return time 5.143 min

CYCLE TIME = 17.426 min
**STEP 7  TRUCKS REQUIRED**

**3 bucket loads**

\[
Trucks \text{ required} = \frac{13.866}{1.58} + 1
\]

Trucks required = 9.8

Must be an integer number therefore 10 trucks

**4 bucket loads**

\[
Trucks \text{ required} = \frac{17.426}{2.10} + 1
\]

Trucks required = 9.3

Must be an integer number therefore 10 trucks
STEP 8  EFFICIENCY

- Working hour efficiency is 55 minutes.

STEP 9  PRODUCTION

3 bucket loads

The loader will control production if at least one extra truck is used.

\[
\text{PRODUCTION} \ (\text{LOADER}) = \frac{55 \text{ min/ hr}}{1.58 \text{ min}} \times 14.025 \text{ LCY} = 488 \text{ LCY/ hr}
\]
CHAPTER 10. TRUCKS AND HAULING EQUIPMENT

Example 2 (cont’d)

STEP 9 PRODUCTION

4 bucket loads

The loader will control production if at least one extra truck is used.

\[
\text{PRODUCTION (LOADER)} = \frac{55 \text{ min/hr}}{2.10 \text{ min}} \times 18 \text{ LCY} = 471 \text{ LCY/hr}
\]

Example 2 (cont’d)

STEP 9 PRODUCTION

3 bucket loads 10 trucks

488 LCY/hr

4 bucket loads 10 trucks

471 LCY/hr
STEP 9 PRODUCTION

3 bucket loads

If only 8 trucks are AVAILABLE the trucks control production.

\[
\text{PRODUCTION (TRUCK) } = \frac{55 \text{ min/hr}}{13.866 \text{ min}} \times 14.025 \text{ LCY} \times 8 = 445 \text{ LCY/hr}
\]

STEP 9 PRODUCTION

4 bucket loads

If only 8 trucks are AVAILABLE the trucks control production.

\[
\text{PRODUCTION (TRUCK) } = \frac{55 \text{ min/hr}}{17.426 \text{ min}} \times 18 \text{ LCY} \times 8 = 454 \text{ LCY/hr}
\]
### Example 2 (cont'd)

#### STEP 9 PRODUCTION

<table>
<thead>
<tr>
<th></th>
<th>3 Buckets</th>
<th>4 Buckets</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Trks</td>
<td>488 LCY</td>
<td>471 LCY</td>
</tr>
<tr>
<td>9 Trks</td>
<td>488 LCY</td>
<td>471 LCY</td>
</tr>
<tr>
<td>8 Trks</td>
<td>445 LCY</td>
<td>454 LCY</td>
</tr>
</tbody>
</table>

While matching the fleet to the required production is important, doing it at a minimum $/unit of material moved is usually the goal.
HAPPY HAULING