UNITED STATES MARINE CORPS
ENGINEER EQUIPMENT INSTRUCTION COMPANY
MARINE CORPS DETACHMENT
1706E EAST 8TH STREET
FORT LEONARD WOOD MISSOURI 65473-8963

LESSON PLAN

Production Estimations

LESSON ID: EEC/EEO-B07

ENGINEER EQUIPMENT WARRANT OFFICER/CHIEF COURSE

CID: A16ACN1/A1613E1

REVISED 09/08/2014

APPROVED BY ______________________ **DATE** ____________________

(ON SLIDE #1)

INTRODUCTION **(10 Min)**

1. **GAIN ATTENTION:** I need you to build me a 6,500 foot runway with a 3 percent northern slope using material from three different locations to obtain a CBR of 25. You have the T/E of an ESB at your disposal. How long will it take you to complete this mission? Who knows that answer right now? As an Engineer Chief/Warrant Officer you can be called on at anytime to conduct an earth moving mission in any location in the world. You are expected to know your equipment and its capabilities to perform the mission. Inadequate production estimation will lead to mission failure.

(ON SLIDE #2)

2. **OVERVIEW:** Good morning/afternoon, my name is ________________. The purpose of this lesson is to teach you how to prepare estimates for horizontal construction projects utilizing heavy construction equipment deployed by the Marine Corps Table of Equipment in order to detail and brief accurate time, materials, and equipment required for completion of a construction project.

INSTRUCTOR NOTE
Introduce the learning objectives.

(ON SLIDE #3)

3. **LEARNING OBJECTIVE(S):**

INSTRUCTOR NOTE
Have students read learning objectives to themselves.

a. TERMINAL LEARNING OBJECTIVES:

(1) Provided a horizontal construction mission, resources, and references, manage/supervise horizontal construction project production and logistical requirements to develop project estimates in support of mission requirements. (1310-HORZ-2002/1349-HORZ-2002)

b. ENABLING LEARNING OBJECTIVES:

(1) Given soil types and soil classifications, with the aid of references, determine production time per the FM 5-434. (1310-HORZ-2002r) / (1349-HORZ-2002r)

(2) With the aid of references, calculate the basic production for the scraper per the FM 5-434. (1310-HORZ-2002s) / (1349-HORZ-2002s)

(3) With the aid of references, calculate the basic production for crawler tractors per the FM 5-434. (1310-HORZ-2002t) / (1349-HORZ-2002t)

(4) With the aid of references, calculate the basic production for the clearing, grubbing and stripping methods per the FM 5-434. (1310-HORZ-2002u) / (1349-HORZ-2002u)

(5) With the aid of references, calculate the basic production for the grader per the FM 5-434. (1310-HORZ-2002v) / (1349-HORZ-2002v)

(6) With the aid of references, calculate the basic production for scoop loader tractors per the FM 5-434. (1310-HORZ-2002w) / (1349-HORZ-2002w)

(7) With the aid of references, calculate the basic production for the backhoe loader per the FM 5-434. (1310-HORZ-2002x) / (1349-HORZ-2002x)

(8) With the aid of references, calculate the basic production for the clam shell per the FM 5-434. (1310-HORZ-2002y) / (1349-HORZ-2002y)

(9) With the aid of references, calculate the basic production for the compactor per the FM 5-434. (1310-HORZ-2002z) / (1349-HORZ-2002z)

(10) With the aid of references, calculate the basic production for the dump truck per the FM 5-434. (1310-HORZ-2002aa) / (1349-HORZ-2002aa)

(ON SLIDE #4)

4. **METHOD/MEDIA**: This lesson will be presented by lecture, demonstration, and practical application. I will be aided by computer generated slides, and the dry erase board.

INSTRUCTOR NOTE
Explain Instructional Rating Forms and Safety Questionnaire to students.

(ON SLIDE #5)

5. **EVALUATION**: There will be three written/performance examinations utilizing references and notes covering mathematical formulas, areas and volumes, scraper production estimations, dozer production estimations, grader production estimations, loader production estimations, backhoe production estimations, clamshell production estimations, compactor production estimations, and dump truck production estimations covered in this lesson and will be administered at specified points of training during this period of instruction.

(ON SLIDE #6-7)

6. **SAFETY/CEASE TRAINING (CT) BRIEF.** All instructors and students will use caution when walking around the equipment lot during equipment operations. Sun block should be used to avoid sunburn. Issue students bug spray if required. Encourage students to stay hydrated as temperatures can reach 100 degrees plus during the summer months. In the event of a casualty, emergency services (911) will be called and all students will move to the classroom and await further instruction.

TRANSITION: Are there any questions over what is going to be taught, how it will be taught, or how you the student will be evaluated? The first topic we will cover is the purpose of estimations and the states of soil.

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(ON SLIDE #8-12)

BODY **(55 HOURS 40 MIN)**

1. Estimations: (1 HR)

Estimating is the art of determining the size of the job, equipment and personal required to perform the assigned mission and quantities of materials needed. To be able to complete these tasks you must first have an understanding of soil states and understanding of some basic formulas.

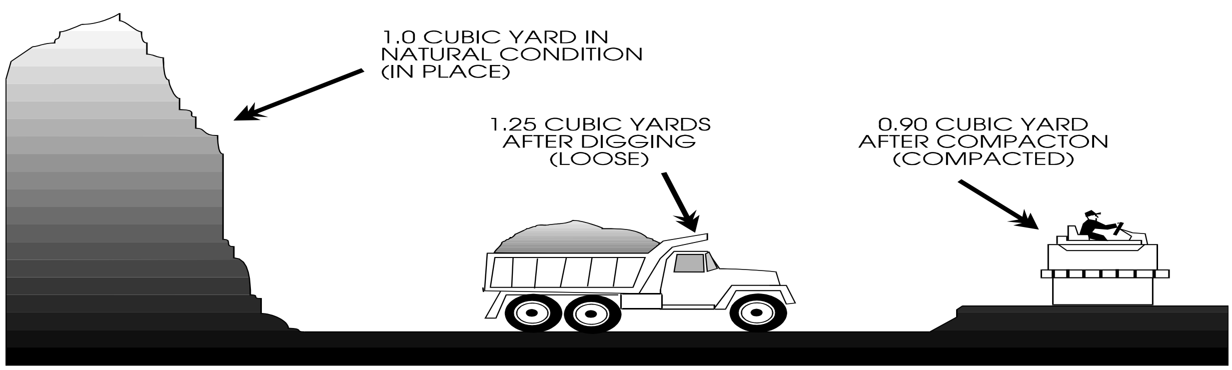
a. SOIL CONVERSION: Before we can estimate any equipment production we need to know what soil we are working with and what state it is in.

(1) Soil is found in THREE different **STATES** or **VOLUMES** 1) bank 2) loose 3) compacted. Sometimes it is necessary to convert from one volume to the other. To do this we use (TABLE# 1-1)

(a) Bank Soil Volume: is any soil that has not been disturbed from its natural state for at least ten years. This is also known as Bank Cubic Yards **(BCY)**.

(b) Loose Soil Volume: is any soil that has been disturbed. Note: soil is always in a loose volume when being hauled, worked or stockpiled. This is also known as Loose Cubic Yards **(LCY)**.

(c) Compacted Soil Volume: is any soil that has been compacted by artificial means. This is also known as Compacted Cubic Yards **(CCY)**.



EXAMPLE FOR THE VARIOUS STATES OF COMMON EARTH

(2) Now that you understand that soil is found in three basic volumes, you must also know that we can convert from bank volume, to loose volume, to compacted volume. This can be done by using table #1-1.

(3) Due to the volume change of material in different states, it is necessary to use a conversion factor to determine the correct amount of material needed for a project. These fac-

tors are in Table #1-1. The conversion chart has five columns. The first is the type of soil that is being worked with. The second column identifies the initial soil condition as being either Bank, Loose, or Compacted. Columns three through five identify the conversion factor used to convert the volume of the soil from its initial condition to another form. An asterisk indicates a soil condition, which is the same as the initial soil condition.

(ON SLIDE #13)

TABLE #1-1 SOIL CONVERSION FACTORS

SOIL	CONVERTED FROM:	BANK	LOOSE	COMPACTED
SAND OR GRAVEL	BANK LOOSE COMPACTED	* .90 1.05	1.11 * 1.17	.95 .86 *
LOAM	BANK LOOSE COMPACTED	* .80 1.11	1.25 * 1.39	.90 .72 *
CLAY	BANK LOOSE COMPACTED	* .70 1.11	1.43 * 1.59	.90 .63 *
ROCK (BLASTED)	BANK LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *
CORAL COMPARABLE TO LIMESTONE	BANK LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *

INTERIM TRANSITION: Thus far we have discussed soil conversion. Do you have any questions? Let’s move on to the demonstration.
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INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

(ON SLIDE #14,15)

EXAMPLE

If we needed to make a road that is **1500' long** with a **3" lift** of **gravel** and **24' wide,** it would be necessary to compute the volume first in compacted cubic yards and then convert it to a Loose state. This determines how much material our haul units would have to move. This is done by multiplying the volume of the compacted material by a conversion factor.

INSTRUCTOR NOTE
Ensure the students understand the conversion from inches to feet.

NOTE: When working with inches you must convert inches to feet, ie: 3" ÷ 12" = .25'

1500' (L) X .25' (H) X 24' (W) = 9000 ÷ 27 = 333.33 OR, *334 (CCY)*

334	(CCY)
X 1.17	CONVERSION FACTOR
390.78	OR **391 LCY**

NOTE: ROUND UP TO THE NEXT FULL CUBIC YARD WHEN DEALING WITH SOIL NEEDED OR TO BE REMOVED.

INTERIM TRANSITION: Thus far we have discussed soil conversion. Do you have any questions about the soil conversion demonstration? Let's move on to the practical application.

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INSTRUCTOR NOTE
Introduce the following practical application (1). Have the students do the problems 1 and 2.

PRACTICAL APPLICATION (1). (30 MIN) Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems convert basic dimensions to cubic yards.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief**: There are no safety concerns.
2. **Supervision & Guidance**: Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief**: Are there any questions or comments concerning the conversion of basic dimensions to cubic yards? In order to progress further, you must have an understanding of the conversion.

(ON SLIDE #16,17)

PROBLEM #1: Your crew is tasked to dig a trench which is 300 feet long, 9 feet wide, and 6 feet deep. The material that you are working with is earth loam, dry, and the soil has been undisturbed for more than 10 years. Using a 420E IT backhoe, how many loose cubic yards **(LCY)** of soil will you remove?

$$\frac{300' \times 9' \times 6'}{27} = 600 \text{ BCY}$$

600 BCY
1.25 CONV FACT
750 LCY

PROBLEM #2: In Problem #1 you removed ___750___ loose cubic yards of soil. However your requirement for a road you are working on is 16,600 compacted cubic yards (CCY). Will you have enough soil to do the road? If yes, how much over? If not, how much under?

750 LCY
x.72 conv fact
540 CCY

16,600 Volume Req
- 540 CCY
16,060 CCY Needed

INTERIM TRANSITION: Are there any questions or comments concerning the conversion of basic dimensions to cubic yards? Let's move on to basic production time.

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(ON SLIDE #18-20)

b. PRODUCTION TIME

Even though each item of equipment has different formulas to arrive at production times, the basic principal needs to be talked about before we can move into equipment production.

(1) CUBIC YARDS PER HOUR (CYPH) All equipment productions are based on this simple principal, Cubic Yards Per Hour (CYPH), whether it be

Loose Cubic Yards Per Hour **(LCYPH)**

Bank Cubic yards Per Hour **(BCYPH)**

Compacted Cubic Yards Per Hour **(CCYPH)**

(2) CUBIC YARDS PER DAY (CYPD) Daily production can simply be found by multiplying the total cubic yards moved per hour by the total hours worked per day.

EXAMPLE:

100 ***CYPH*** **X** 8 **HR WORK/DAY =** 800 ***CYPD***

NOTE: ROUND DOWN CYPD

(3) **TOTAL PRODUCTION DAYS:** Can be found by taking the total requirement of cubic yards needed and dividing it by the total CYPD moved.

EXAMPLE:

16,600 ÷ 800 = 20.75 OR 21
REQ CY ÷ CYPD = DAYS NEEDED TO MOVE REQ **CY**

NOTE: ROUND UP DAYS TO NEXT FULL DAY

INTERIM TRANSITION: Thus far we have discussed production time. Do you have any questions? Let’s move on to the practical application.

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INSTRUCTOR NOTE
Introduce the following practical application (2). Have the students do the problems 1 and 2.

PRACTICAL APPLICATION (2). **(30 MIN)** Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are determining basic production per hour and per day.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning the conversion of basic dimensions to cubic yards? In order to progress further, you must have an understanding of basic production.

(ON SLIDE #21-24)

WHAT HAVE YOU LEARNED?

PROBLEM #1: It has been determined that you are moving 150 LCYPH and you're working 5 hours per day, due to bad weather. The requirement to be moved is 17,000 LCY. How much material is being moved per day and how many days will it take to move the required amount of material?

150 LCYPH
x 5 hrs/day
750 LCYPD

17,000 Req LCY
÷ 750 LCYPD
22.67 or 23 days

PROBLEM #2: It has been determined that you are moving 250 LCYPH and that you're working 8 hours per day. The requirement to be moved is 18,000 LCY. How much material is being moved per day, and how many days will it take to move the required amount of material?

250 LCYPH x 8 Hrs/day 2,000 LCYPD	18,000 Req LCY ÷ 2,000 LCYPD 9 Days

(ON SLIDE #25)

TRANSISTION: Are there any questions or comments concerning basic production for hours and days?

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OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

   a. What is estimating?

   The art of determining the size, equipment, personal, and quantities needed for a project.

   b. What are the three states of soil?

   Bank, Loose, Compacted

   c. What does CCYPH mean?

   Compact Cubic Yards Per Hour (CCYPH)

(BREAK - 10 Min)

TRANSISTION: Are there any questions or comments concerning basic production for hours and days? Let's now move on to actual Scraper estimations, first starting with its basic functions and capabilities.

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(ON SLIDE #26-33)

SCRAPERS

2. **INTRODUCTION TO SCRAPERS**. (30 MINS)

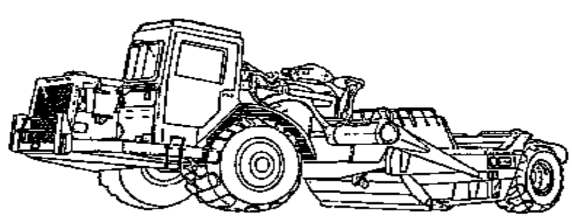
Scrapers are designed for loading, hauling, and dumping on long-haul earth moving operations. The scraper has three basic operational parts; the bowl, the apron, and the ejector. The bowl, which is equipped with a cutting edge on the front bottom, is the loading and carrying component. The apron is the front wall of the bowl, and can be raised and lowered independently of the bowl. The ejector is the rear wall of the bowl. It is moved back to load, and forward to discharge materials.

a. **USE**. In the field of heavy construction, tractor-scrapers serve the primary purpose of loading, and hauling material. The distinct advantage of the tractor-scraper, in earth moving, is the ability to load, haul, and spread in one continuous cycle. The tractor-scraper is capable of working alone for leveling operations, but is supplemented with push-tractors for cut and fill operations.

b. **CLASSIFICATION**: Tractor-scrapers are classified according to load capacity, and rated load. Capacity is measured in heaped and struck capacity. A heap load is the maximum load of the machine, and a struck load is the minimum effective load.

c. **CHARACTERISTICS:** Tractor-scrapers are wheeled vehicles characterized by a tractor and scraper. They serve as prime earth movers in cut and fill operations and in bringing elevations to rough, final grades. Since scraper bowls are of open design, they can also be loaded from above, with a shovel or a bucket. Scrapers have three types of cutting edges; straight, which is most effective for smooth grade finishing; curved, which provides better penetration than a straight edge; and the three-piece cutting edge, where the center piece (called a stinger) is held ahead of the two side pieces for better penetration. **The 621G has a rated load weight of 52,800 lbs.**

d. **OPERATION:** Scrapers are hydraulically operated and powered by a tractor. The tractor-scraper is most efficient during downhill loading. Other methods that will increase production include straddle loading, and pump loading. Straddle loading is most effective in stripper operations and will gain time on every third trip because the center strip has less resistance than a full cut. Pump loading is a technique used in sand, and gravel, where material is heaped in front of the bowl and when the pusher lugs down, the bowl is raised and lowered to create a pumping effect. All loading should be accomplished with a pusher, within (1) minute, and within (100) feet of travel. Longer loading times and distance are justified only when hauling fewer loads over long hauling distances offsets such efforts. It is important to remember that whenever soil is hauled in a haul unit, it is considered to be loose soil. Haul units, particularly scrapers, are generally said to have **TWO (2) VOLUME CAPACITIES, STRUCK AND HEAP LOADS.**



(1) Struck load : Is when the unit is loaded with soil until the material is approximately even with the top of the

side boards. The capacity of the 621G Scraper, when struck loaded is ***15.7 loose cubic yards***.

(2) Heap load. Is when the unit is loaded to its maximum capacity and the material is overflowing the side boards. The capacity of the 621G Scraper when heap loaded is ***22 loose cubic yards***.

NOTE: The 621G cannot efficiently self load to a heap capacity.

e. These terms are used as a general reference to load size. **Actual load size** will vary considerably, being somewhere between struck & heap due to variables such as soil weight, moisture content, and the manner in which the scraper is being loaded. For example, if a TRAM with a 2 1/2 cubic yard bucket were loading the 621G, the volume of the load would be some multiple of 2.5.

(ON SLIDE #34)

TRANSISTION: Are there any questions or comments concerning the introduction to the 621G Scraper?

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OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS:

a. How are scrapers classified?

According to load capacity, and rated load.

b. What are the two volume capacities?

Struck and Heap

c. What is the Scraper's rated load weight?

52,800 lbs

(BREAK – 10 Min)

TRANSITION: Now that we have covered the use, classification, characteristics and operations of the scraper, are there any questions? Let's move right into scraper production.

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(ON SLIDE #35-49)

3. PRODUCTION: (7 HRS)

There are **15** steps to determine scraper production, starting with soil weight.

a. **STEP #1: ACTUAL SOIL WEIGHT**

To determine the **actual soil weight** per cubic yard, start by taking the soil weight from (Table #2-2).

EXAMPLE:

EARTH LOAM DRY IS ___*2200 lbs*. PER CUBIC YARD

TABLE #2-2
APPROXIMATE WEIGHT OF SOIL

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL,	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

(1) Now that you know how to get your soil weight per cubic yard, Step 2 adds the weight of the moisture to the soil weight. This is called moisture content. This factor must be taken into consideration when determining the weight of the load. Notice that in Table #2-2, the approximate weights of many different types of soil are listed. For many of the soils listed, a weight is given for both wet and dry materials. For most general applications, these weights may be used to estimate the weight of the soil being worked with. However, there will

be times that a more specific weight is needed, and then the moisture content of the soil must be taken into consideration. Soil analysis personnel are trained to determine the moisture content, and the weight of this moisture must be calculated and added to the weight of the **DRY** soil. This moisture will be expressed as a percentage of the weight of the dry soil.

(2) To determine the weight of the moisture, multiply the dry weight by the percentage of the moisture content then add the result to the dry weight to determine the actual weight of the soil. If the weight of dry earth loam is 2200 lbs. per cubic yard, then 2200 lbs. is 100% of the original weight. The initial moisture content is 7% of the original weight. Therefore, the actual soil weight is 107% of the original weight. 107% converted to a decimal is 1.07. Now by multiplying the original weight of 2200 lbs. by 1.07, we will get the end result of 2354 lbs.

NOTES: ***<u>If you are given a wet soil,</u>*** **take the weight of the wet soil off of the chart.**

<u>If you are not given either wet or dry condition</u>, **take the weight of dry soil off of the chart**

<u>If you are given a wet soil and moisture content</u>, **take the weight of dry soil and multiply the moisture content.**

<u>EXAMPLE:</u>

You have Dry Earth Loam with a 7% moisture content. What is your Actual Soil Weight (ASW)?

	2200	**WEIGHT OF DRY EARTH LOAM PER CY FROM TABLE 2-2**
X	**1.07**	**100% OF SOIL WEIGHT + 7% MOISTURE**
	2,354	***ACTUAL SOIL WEIGHT*** **(ASW)**

NOTE: NEVER ROUND OFF ASW.

b. **<u>STEP #2: CUBIC YARDS OF A LOAD:</u>**

Remembering that you want to keep the weight of the load under 52,800 lbs, determine how many cubic yards can be hauled without exceeding 52,800 lbs. To do this, divide 52,800 by the actual soil weight per cubic yard.

52,800	**LBS (RATED CAPACITY)**
÷ 2,354	**LBS (ACTUAL SOIL WEIGHT)** FROM STEP# 1

22.43 **CY NO MORE THAN <u>22 CY</u>**

If the resulting figure is over 22 cubic yards, you must go with 22. It is the maximum cubic yards that the 621G can haul. If the resulting figure is less than 22, use that entire number as it appears on the adding machine in step 3.

NOTE: ROUND DOWN TO 22 IF MORE THAN THE MAXIMUM CAPACITY.

c. **STEP #3: (If Needed) BUCKETS LOADED:**

To determine the number of **buckets loaded** that is equal to or less than the figure determined in step #2. Divide that figure, in this case 22, by the size of each bucket load which for the TRAM is 2 1/2 or 2.5.

Note: if the scraper is being self loaded or push loaded go to step #5

22 **CUBIC YARDS**
÷ 2.5 **CUBIC YARDS (BUCKET SIZE FROM TABLE)**
8.80 **BUCKETS OR 8 BUCKETS LOADED**

NOTE: ROUND DOWN TO WHOLE BUCKETS LOADED.

TABLE #3-2

BUCKET SIZE

TRAM 624KR	**2 1/2 or 2.5 CY**
MC1155E	**1 3/4 or 1.75 CY**
MAC-50 CLAMSHELL	**1 ¼ OR 1.25 CY**
420E IT FRONT BUCKET	**1 ¼ or 1.25 CY**
420E IT BACKHOE BUCKET	**¼ or .25 CY**

d. **STEP #4 ACTUAL LOAD SIZE:**

To determine the volume of the load, take the answer from Step #3, 7 buckets per load, multiplied by the bucket size 2.5 for a TRAM.

8 **# OF BUCKETS**
X 2.5 **TRAM BUCKET SIZE**
20.0 ***ACTUAL LOAD SIZE*** **(ALS)** ***NOTE: NEVER ROUND OFF ALS***

e. **STEP #5 LOAD WEIGHT (LW):**

To determine the Load Weight, multiply ASW and ALS. Regardless of how much volume that you may be able to haul, you should try to keep your load weight under 52,800 pounds. Table #2-2 shows the weight of Cinders as 1200 pounds per loose cubic yard. A struck load would weigh 18,840 pounds, while the heap load would weigh 26,400 pounds. These weights would be easily hauled, but it is a different story with other materials. Take a look at Earth Loam, Wet for instance:

TABLE #2-2
APPROXIMATE WEIGHT OF SOIL

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL,	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

3,200 Weight of Earth loam WET, PER/CY
X 15.7 (LCY) Struck
50,240 LBS. STRUCK LOADED

3,200 Weight of Earth loam WET, PER/CY
X 22 (LCY) Heaped
70,400 LBS. HEAPED LOADED

(1) As you can see, the struck load weighs less than the rated capacity, but **the heaped load is over the 52,800 pound limit** by 17,600 pounds. Therefore, if you are going to be hauling this type of material, and you are self loading, you should plan on hauling a struck load. However, if you are loading the scraper with another piece of equipment, such as a scoop loader, you must determine how many loads the loader can put on the scraper and still keep the weight of the load within the acceptable weight limits.

(2) Each cubic yard weighs 2354 lbs (Step #1), and you are hauling 20 cubic yards. Therefore, the weight of your load will be 47,080 lbs.

INTERIM TRANSITION: Thus far we have discussed scraper production. Do you have any questions? Let's move on to the demonstration.

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INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE:

2354	**ASW**
X 20	**ALS**
47,080	***LOAD WEIGHT (LW)*** NOT OVER THE 52,800 LBS MAX.
LOAD WEIGHT	

NOTE: NEVER ROUND OFF LOAD WEIGHT

f. **STEP #6: SHORT TONS:**

Are found by dividing the gross weight by 2,000 lbs. (the weight of one ton)

Example:

74,946	**LBS.**	**TR. WT.**
+ 47,080	**LOAD**	**WT. (from step #5)**
122,026	**LBS.**	**GROSS WEIGHT**
÷ 2,000		**Weight of One Ton**
61.01	**ST**	***SHORT TONS (ST) (CLEAR CALCULATOR)***

Now take the Short Tons to steps 7 & 8

NOTE: NEVER ROUND OFF SHORT TONS (ST)

INTERIM TRANSITION: Are there any questions over the first six steps of scraper production? Now let's move into some practical application on these steps.

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(ON SLIDE #53)

INSTRUCTOR NOTE
Introduce the following practical application (3).

PRACTICAL APPLICATION (3). **(3 HRS)** Have the students complete the problems in the student handout.

PRACTICE: There are three problems in the student handout for the students to complete. The problems are determining the first six steps of scraper production.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning the first six steps of scraper production? In order to progress further, you must have an understanding of basic production.

(ON SLIDE #50-53)

WHAT HAVE YOU LEARNED

PROBLEM #1: If the soil analysis team told you that the Gravel being hauled by a 621G scraper had an initial moisture content of 12%, what would the **weight of each CY** be?

3000	Dry Gravel Weight
x 1.12	Moisture Content
3,360	**Actual Soil Weight (ASW)**

PROBLEM #2: When hauling this Gravel in a 621G loaded with a TRAM 624KR, what would the **load weight** be?

52,800	MAX CAP	6	BUCKETS LOADED
÷ 3,360	ASW	x 2.5	BUCKET SIZE

15.71	**CY OF LOAD**		**15.00**	**ALS**
÷ 2.50	BUCKET SIZE		x 3,360	ASW
6.28			**50,400**	**LW**
OR 6	**BUCKETS LOADED**			

PROBLEM #3: If the 621G has a load weight of 50,400 pounds, what **would your short tons be?**

50,400	LW
+ 74,946	TW
125,346	**GW**
÷ 2,000	1 TN
62.67	**SHORT TN**

(BREAK 10 MIN)

INTERIM TRANSITION: Are there any questions over the first six steps of scraper production? Let's move on to rolling resistance.

____
____
____

(ON SLIDE #55-57)

g. **STEP #7 ROLLING RESISTANCE:**

Is the resistance of movement to wheeled vehicles over a haul surface caused by irregularities in the surface such as compacting and displacement of material, caused by the flexing of tire side walls on the roadway. Rolling resistance is measured by the rim pull in pounds per short ton required to overcome resistance. This resistance effects the cycle time.

To do this multiply **SHORT TONS** (from step #6) by the **ROLLING RESISTANCE FACTOR (RRF)** found in (TABLE #4-2). The resulting answer will be your **ROLLING RESISTANCE (RR)**

TABLE #4-2
ROLLING RESISTANCE FACTORS

HARD, SMOOTH, STABILIZED ROADWAY WITHOUT PENETRATION UNDER LOAD (CONCRETE OR BLACKTOP) (WATERED, MAINTAINED)	40 LBS. A TON

FIRM, SMOOTH-ROLLING ROADWAY FLEXING SLIGHTLY UNDER LOAD 1" PENETRATION (GRAVEL TOPPED ROAD) (MAINTAINED FAIRLY REGULARY, WATERED)	65 LBS. A TON
RUTTED DIRT ROADWAY, FLEXING CONSIDERABLY UNDER LOAD 2" TO 3" PENETRATION (HARD CLAY ROAD)(LITTLE MAINTENANCE, NO WATERING)	100 LBS. A TON
RUTTED DIRT ROADWAY, NO STABILIZATION UNDER LOAD 4" TO 6" PENETRATION (SOFT CLAY ROAD) (NO MAINTENANCE, NO STABILIZATION)	150 LBS A TON
NO STABILIZATION 7" OR GRATER PENETRATION (SOFT, MUDDY, RUTTED ROADWAY, OR IN SAND) (NO MAINTENANCE)	400 LBS A TON

INTERIM TRANSITION: Thus far we have discussed rolling resistance. Do you have any questions? Let's move on to the demonstration.

____
____
____

INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: Determine the rolling resistance for a 621G scraper traveling over a **firm, smooth-rolling roadway flexing slightly under load 1" penetration.** The weight of the soil in the scraper is pounds.

61.01	**(ST)** Short Tons
X 65	**(RRF)** Rolling Resistance Factor
3965.65 OR 3966	**(RR)** Rolling Resistance

NOW TAKE RR TO STEP #9

NOTE ***ROUND OFF RULE: (ROUND UP 5 OR GREATER, ROUND DOWN 4 OR LESS.) FOR (RR).***

INTERIM TRANSITION: Are there any questions over rolling resistance? Now let's move into some practical application on these steps.

____
____
____

INSTRUCTOR NOTE

Introduce the following practical application (4).

PRACTICAL APPLICATION (4). **(2HRS)** Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are determining rolling resistance for the scraper.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning rolling resistance? In order to progress further, you must have an understanding of basic production.

(ON SLIDE #58-61)

WHAT HAVE YOU LEARNED

PROBLEM #1: Figure **Rolling Resistance** for the following situation.

Caterpillar 621G Scraper

Struck loaded- (Self Load)

Hard pan

Rutted, dirt roadway, flexing considerably under load with 2" to 3" penetration.

3,100 ASW

```
  X 15.7   ALS
 48,670   LW
```

```
  48,670   LW
 +74,946   TW
 123,616   GW
```

```
 123,616   GW
 ÷ 2,000   1 TN
   61.81   ST
```

```
   61.81   ST
  X  100   RRF
   6,181   RR
```

PROBLEM #2: Figure **Rolling Resistance** for the following situation.

Caterpillar 621G Scraper

Loaded with a TRAM (2 1/2 CY Bucket)

Trap rock

Hard, smooth, stabilized roadway without penetration

```
  52,800   MAX LOAD
 ÷ 3,500   ASW
   15.09   CY OF A LOAD
```

```
   15.09   CY OF A LOAD
  ÷  2.5   BUCKET SIZE
    6.04 OR 6 BUCKETS
```

```
       6   LW
   x 2.5   TW
   15.00   ALS
```

```
   15.00   ALS
 x 3,500   ASW
  52,500   LW
```

```
  52,500   LW
 +74,946   TW
```

127,446 GW

127,446 GW
÷ 2000 1 TN
63.72 ST

63.72 ST
X 40 RRF
2548.80 OR 2549 RR

INTERIM TRANSITION: Are there any questions over rolling resistance? Let's move on to grade resistance/grade assistance.

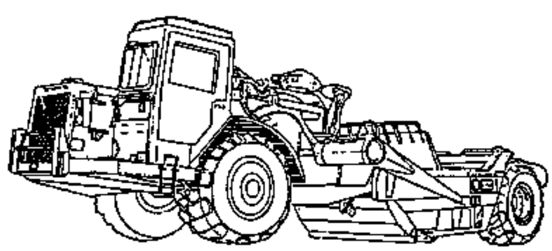
____
____
____

(ON SLIDE #62-68)

h. **STEP #8: GRADE RESISTANCE (GR) OR GRADE ASSISTANCE (GA):**

Grade Resistance or Grade Assistance is the addition, or decrease, in the amount of pounds of pull required as the result of adverse or favorable grades on haul roads. Rules of thumb generally accepted as reliable measures of the effect of grades are as follows:

(1) Each 1 percent of (uphill) grade increases the resistance by 20 pounds per short ton pull of gross vehicle weight.



The Formula:

Short Tons x 20 (constant) x % of Grade = Grade Resistance or Grade Assistance
Note: ROUND UP 5 OR GREATER, ROUND DOWN 4 OR LESS

INTERIM TRANSITION: Are there any questions over grade resistance/grade assistance? Let's move on to the next two demonstrations.

____
____
____

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: The total weight of the loaded scraper on the haul is 122,026 lbs.
Calculate the grade resistance factor for climbing a (+2) uphill grade.

61.01 X 20 X 2 = 2440.40 or +2440
Short Tons X 20 X % GRADE = *Grade Resistance (GR)*

NOTE: ***ROUND UP 5 OR GREATER ROUND DOWN 4 OR LESS (GR/GA).***

2. Each 1 percent of (downhill) grade decreases the amount of pull required by 20 pounds per short ton of gross vehicle weight.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: For the return, the tractor is empty so the total weight is 74,946 lbs.

Calculate the grade assistance factor for (-2) downhill grade.

Note: An empty scraper has a constant 37.47 for short tons.

37.47 X 20 X 2 = - 1,498.8 or -1499
Short Tons empty X constant X % GRADE = *Grade Assistance (GA)*

NOTE: ROUND UP 5 OR GREATER ROUND DOWN 4 OR LESS (GR/GA).

INTERIM TRANSITION: Are there any questions over grade assistance/resistance? Now let's move into some practical application on these steps.

____
____
____

INSTRUCTOR NOTE
Introduce the following practical application (5).

PRACTICAL APPLICATION (5). **(2HRS)** Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are determining grade assistance for the scraper.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to walk through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning grade assistance? In order to progress further, you must have an understanding of basic production.

(ON SLIDE #69-75)

WHAT HAVE YOU LEARNED

PROBLEM #1 Determine **Grade Resistance** for a 621G Scraper with the following factors.

Struck load
Sand
7% Initial moisture
3% uphill grade

	2,900	DRY SAND
x	1.07	MOISTURE
	3,103	**ASW**
	3,103	ASW

```
   x 15.7   ALS
 48,717.1   LW

 48,717.1   LW
  +74,946   TW
123,663.1   GW

123,663.1   GW
  ÷ 2,000   1 TN
    61.83   ST

    61.83   ST
  X    20   CONSTANT
  X     3   GRADE
    3,709.8 or 3710 GR
```

PROBLEM #2: Determine **Rolling and Grade Resistance** for a 621G on the haul with the following factors.

Heap load
Sandstone
Rutted, dirt roadway, no stabilization under load 4" to 6" penetration.
6% uphill grade

```
    2,200   ASW
  x    22   ALS
   48,400   LW

   48,400   LW
  +74,946   TW
  123,346   GW

  123,346   GW
  ÷ 2,000   1 TN
    61.67   ST
```

HAUL

```
    61.67   ST
  X   150   RRF
    9,250.5 or 9,251 RR

    61.67   ST
  X    20   CONSTANT
  X     6   GRADE
```

RETURN

```
    37.47   ST
  X   150   RRF
    5620.5 or 5621 RR

    37.47   ST
  X    20   CONSTANT
  X   - 6   GRADE
```

7,400.4 or 7,400 GR **-4496.4 or 4496 GA**

(BREAK 10 MIN)

INTERIM TRANSITION: Are there any questions over grade assistance/resistance? Let's move on to required pounds of pull.

____
____
____

(ON SLIDE #76-79)

i. **STEP #9: REQUIRED POUNDS OF PULL (REQPP):**

Is the total power required to move a unit. We can find our ***REQPP*** by adding ***GR*** with ***RR*** for uphill or subtracting ***GA*** from ***RR*** for downhill. **When on level terrain, your *RR* is your *REQPP*.**

EXAMPLE 1. *When traveling **uphill** a vehicle must overcome both rolling resistance and grade resistance.*

3966		**(RR)**
+ 2440		**(+GR)**
6406	=	**(REQPP)**

Using Table 5-2, you can see that the scraper will not give you enough Rim Pounds Pull (RPP) in 8th or 7th gear, but in 6th gear you have enough RPP. The *travel speed is* ***18.2 MPH***

EXAMPLE 2 *When traveling **downhill** a vehicle must overcome rolling resistance less grade Assistance.*

2436		**(RR)**
- 1499		**(-GA)**
937	**=**	**(REQPP)**

Using Table 5-2, we see that 8th gear gives you 3,694 pounds of pull, but you only need 937, so 8th gear will give you more than enough. The *travel speed is* ***32 MPH.***

EXAMPLE 3. *When traveling over **level terrain**, a vehicle must overcome rolling resistance only.*

3966 RR = (REQPP)

SUB STEP: TRAVEL SPEED: To get your travel speed you first must make a gear selection.

Gear selections for the 621G is easy now that you know how much REQPP are needed to go uphill, downhill, or on level terrain. By looking at the table below, we can use the rim pounds of pull compared to the required pounds of pull to get our gear and travel speed. For example, you used 6th gear to go up and 8th to come down.

TABLE #5-2
POWER CHARACTERISTICS OF 621G SCRAPER

AVAIL (RPP)	*33,656*	*18,569*	*15,760*	*11,703*	*8,691*	*6,495*	*4,884*	*3,694*
GEAR:	1st	2nd	3rd	4th	5th	6th	7th	8th
(TS) IN MPH	**3.2 MPH**	**5.8 MPH**	**7.5 MPH**	**10.0 MPH**	**13.6 MPH**	**18.2 MPH**	**24.2 MPH**	**32 MPH**

NOTE: If the TM doesn't have this table you can use this formula to get your (RPP) table.

$$\frac{\textbf{375 X ENGINE HP X 80\% EFFICIENCY}}{\textbf{TRAVEL SPEED IN MPH}} = \textbf{RIM POUNDS PULL (RPP)}$$

(ON SLIDE #80-91)

INTERIM TRANSITION: Are there any questions over required pounds of pull? Now let’s move into some practical application on these steps.

____
____
____

INSTRUCTOR NOTE
Introduce the following practical application (6).

PRACTICAL APPLICATION (6). (2 HRS) Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are determining travel speed.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning the travel speed? In order to progress further, you must have an understanding of basic production.

(ON SLIDE #80-85)

WHAT HAVE YOU LEARNED

PROBLEM #1: Determine **TRAVEL SPEED** with the following factors.

Caterpillar 621G Scraper

Struck load

Earth loam

10% Initial moisture

Hard, smooth roadway with
no penetration under load.

4% downhill grade

2,200	DRY EARTH LOAM
x 1.10	MOISTURE
2,420	**ASW**
2,420	ASW
x 15.7	ALS
37,994	**LW**
37,994	LW
+74,946	TW
112,940	**GW**
112,940	GW

```
   ÷ 2,000   1 TN
     56.47   ST
```

HAUL		RETURN	
56.47	ST	37.47	ST
X 40	RRF	X 40	RRF
2,258.8 or 2259 RR		**1498.8 or 1499 RR**	
56.47	ST	37.47	ST
X 20	CONSTANT	X 20	CONSTANT
X - 4	GRADE	X 4	GRADE
-4,517.6 or -4,518 GA		**2997.6 or 2998 GR**	

8TH GEAR	2,259	RR	1,499	RR	**7TH GEAR**
32 MPH	- 4,518	GA	+ 2,998	GR	**24.2 MPH**
	- 2,259	**RPP**	**4,497**	**RPP**	

PROBLEM #2: Determine TRAVEL SPEED with the following factors.

Caterpillar 621G Scraper

Struck load

Clay and gravel

3% Initial moisture

Rutted, dirt roadway, no stabilization
under load, 4" to 6" penetration.

6% uphill grade

```
     2,700   DRY EARTH LOAM
   x  1.03   MOISTURE
     2,781   ASW

     2,781   ASW
   x  15.7   ALS
  43,661.7   LW

  43,661.7   LW
   +74,946   TW
 118,607.7   GW
```

```
118,607.7  GW
÷ 2,000    1 TN
  59.30    ST
```

HAUL

```
  59.30   ST
X   150   RRF
 8,895    RR

  59.30   ST
X    20   CONSTANT
X     6   GRADE
 7,116    GR
```

RETURN

```
  37.47   ST
X   150   RRF
 5620.5 or 5621 RR

  37.47   ST
X    20   CONSTANT
X   - 6   GRADE
-4,496.4 or -4,496 GA
```

2nd GEAR
5.8 MPH

```
   8,895   RR
 + 7,116   GR
  16,011   RPP
```

```
  5,621   RR
- 4,496   GA
- 1,125   RPP
```

8TH **GEAR**
32 MPH

INTERIM TRANSITION: Are there any questions over travel speed? Let's move on to the demonstration of rolling resistance.

____
____
____

(ON SLIDE #86,87)

RETURN

The return is done by repeating steps 6-9 and using empty vehicle weight to get the short tons

INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE :

STEP #6 *SHORT TONS* ***(ST)*** *WITH EMPTY VEHICLE WEIGHT*

74,946
÷ 2,000
37.47 **(ST**, CONSTANT FOR A EMPTY 621G)

STEP #7 *ROLLING RESISTANCE* ***(RR)***

37.47 (ST)
X 65 **(RRF)** ROLLING RESISTANCE FACTOR
2,435.5 or 2,436 **(RR)**

STEP # 8 *GRADE RESISTANCE* / GRADE ASSISTANCE

37.47 (ST) X 20 X **-2** = -1,498.8 or 1,499 **(-GA)**

STEP #9 *REQUIRED POUNDS OF PULL (RPP) TRAVEL SPEED MPH.*

2,436 (RR)
-1,499 (-GA)
937 (RPP) **8TH 32 MPH**

(ON SLIDE #88-93)

j. ***STEP #10*** ***CYCLE TIME:***

Is the time required to LOAD, HAUL, SPREAD, and RETURN. This is figured by adding ***Fixed Time (Fix-T)*** *and* ***Travel Time (TT)*** *to get* ***cycle time (CT).***

(1) **Fixed Time:** is the time spent during an equipment cycle other than hauling and returning. This includes positioning, loading, unloading, turning, accelerating and decelerating all of which are fairly constant or fixed. Fixed times are determined from Table #6-2. To use Table 6-2, start with the gear you are hauling in.

TABLE #6-2
FIXED TIME

EQUIPMENT LOADING SCRAPER	**1ST GEAR HAUL 2ND GEAR HAUL 3RD GEAR HAUL**		**4TH GEAR HAUL**		**5TH GEAR HAUL 6TH GEAR HAUL 7TH GEAR HAUL 8TH GEAR HAUL**	
	STRUCK	HEAP	STRUCK	HEAP	STRUCK	HEAP

SCRAPER LOADING ITSELF	2.50	N/A	2.80	N/A	3.0	N/A
1155E	7.0	9.0	7.30	9.30	7.50	9.50
TRAM	6.0	7.0	6.30	7.30	6.50	7.50
420E w/1.25 Bucket	12.0	14.0	12.30	14.30	12.50	14.50
420E w/.25 Bucket	16.0	22.0	16.30	22.30	16.50	22.50
MAC 50 CLAMSHELL	16.0	19.0	16.30	19.30	16.50	19.50
SCRAPER PUSH LOADED	1.43	1.71	1.73	2.01	1.93	2.21

NOTE: These are average fixed times only and are based on and average operator who is familiar with the attachments and equipment operation. These times are basic starting points only. Actual fixed times can vary considerably due to varying conditions. Timing of several actual fixed cycles is necessary in order to obtain a more realistic fixed time average for the particular job being performed. **FOR CLASS ROOM PURPOSES IF THE LOAD FALLS SOMEWHERE IN BETWEEN STRUCK AND HEAP LOADS. USE THE HEAP LOAD TIME FOR THE FIXED TIME.**

(2) **Travel Time:** is the time spent on the haul road transporting material and returning empty. Travel Time depends on: (1) Size of hauling unit (2) Rolling resistance (3) Grade resistance and Distance traveled. All of which have already been figured to get your gear selection and speed to put into the cycle time formula.

(3) To figure **Cycle Time (CT)** you first must figure Travel Time (TT). To get Travel Time divide the distance in feet of the haul or return road by the sum of the travel speed (TS) in mph multiplied by 88. Do this for the haul and return. The Total Travel Time plus Fixed Time will equal **Total Cycle Time.**

NOTE: **88** is the conversion factor to change the speed in MPH to feet traveled per minute.

Example #1: A Caterpillar 621G Scraper, hauling 20.0 CY of material, travels 7500 feet to the fill area using 6th gear and returns empty by a different route of 8200 feet in 8th gear. What is the total cycle time, if a Tram is loading the 621G?

haul distance in feet

$$\frac{7500}{18.2 \text{ TS} \times 88} = 4.68 \quad \textbf{HAUL Time}$$

(HT)

(from step 9)

return distance in feet

$$\frac{8200}{\underline{32}\ \text{TS} \times 88} = \underline{2.91} \quad \textbf{RETURN Time}$$

(RT)

(from step 9)

<u>4.68</u> + <u>2.91</u> + <u>7.5</u> = <u>15.09</u> MIN.

(HT) + (RT) + Fixed Time (FT) = *CYCLE TIME* (CT)

(Table 6-2)

NOTE: NEVER ROUND OFF TIME.

(ON SLIDE #94-98)

<u>INTERIM TRANSITION</u>: Are there any questions over cycle time? Now let's move into some practical application on these steps.

INSTRUCTOR NOTE

Introduce the following practical application (7).

<u>PRACTICAL APPLICATION (7).</u> (2HRS) Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are determining cycle time for the scraper.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. Safety Brief: There are no safety concerns.

2. Supervision & Guidance: Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.

3. Debrief: Are there any questions or comments concerning the cycle time? In order to progress further, you must have an understanding of basic production.

WHAT HAVE YOU LEARNED

PROBLEM #1: Figure total **CYCLE TIME**.

Caterpillar 621G Scraper, self loaded

Haul distance - 8250'

Return distance - 7125'

Haul gear - 4th

Return gear - 8th

$$\frac{8{,}250\ HD}{10.0 \quad X \quad 88} = \textbf{9.38 HAUL TIME (HT)}$$

$$\frac{7{,}125\ RD}{32 \quad X\ 88} = \textbf{2.53 RETURN TIME (RT)}$$

9.38	**+**	**2.53**	**+**	**2.80**	**=**	**14.71**
HAUL TIME		RETURN TIME		FIXED TIME		CYCLE TIME

PROBLEM #2: Figure total **CYCLE TIME**.

Caterpillar 621G Scraper, self loaded

Haul distance - 9000'

Return distance - 9176'

Haul gear - 6th

Return gear - 8th

$$\frac{9{,}000\ HD}{18.2\ X\ 88} = \textbf{5.62 HAUL TIME (HT)}$$

$$\frac{9{,}176\ RD}{32 \quad X\ 88} = \textbf{3.26 RETURN TIME (RT)}$$

5.62 + 3.26 + 3.00 = 11.88

HAUL TIME RETURN TIME FIXED TIME CYCLE TIME

(BREAK 10 MIN)

INTERIM TRANSITION: Are there any questions over cycle time? Let's move on to Trips Per Hour.

____
____
____

(ON SLIDE #99)

k. ***STEP #11 TRIPS PER HOUR:*** *To determine Trips Per Hour (TPH) divide the working minutes per hour (normally a 60-minute work hour) by the cycle time.*

$$\frac{\textbf{MIN. WORKED PER/HR}}{\textbf{CYCLE TIME}} = \textbf{\textit{TRIPS PER HOUR (TPH)}}$$

NOTE: NEVER ROUND OFF TPH

INTERIM TRANSITION: Are there any questions before we move in to the next four demonstrations.

____
____
____

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: How many trips per hour can a 621G make during a 60-minute work hour, if it has a cycle time of 15.09 minutes?

$$\frac{\textbf{60}}{\textbf{15.09 CT}} = \textbf{3.98 TPH}$$

(ON SLIDE #100,101)

l. **STEP #12 BASIC PRODUCTION RATE (LCYPH):** *To determine the basic Production Rate, you must know the Actual Load Size (in LCY), the number of Trips per Hour, and the Efficiency Factor of the operator and equipment.*

____ TPH (from step #11)	X	____ ALS	X	____ EFFICIENCY FACTOR (from step #4)	=	____ LCYPH

NOTE: ALWAYS ROUND DOWN LCYPH

TABLE #7-2 EFFICIENCY FACTOR

TYPE UNIT	OPERATOR	DAY	NIGHT
WHEELED	EXCELLENT AVERAGE POOR	1.00 .60 .50	.67 .40 .33

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: What is the basic production rate for a 621G with an average operator, working a day shift, making 3.98 TPH, with a load of 20.0 LCY?

3.98	X	20.0	X	0.60	=	47.76 OR 47
TPH	**X**	**ALS**	**X**	**EFFICIENCY FACTOR**	**=**	**(LCYPH)**

NOTE: ROUND DOWN (LCYPH)

(ON SLIDE #102)

m. ***STEP #13* SOIL CONVERSION (SC) (IF NEEDED) :** *In some cases the basic production rate may be needed in compacted cubic yards (CCY) for a road or runway.*

____	X	____	=	____
LCYPH	**X**	***CONVERSION FACTOR***	**=**	**(____CYPH)**

NOTE: ROUND DOWN CYPH

TABLE #1-1_SOIL CONVERSION FACTORS

SOIL	CONVERTED FROM:	BANK	LOOSE	COMPACTED
SAND OR GRAVEL	BANK LOOSE COMPACTED	* .90 1.05	1.11 * 1.17	.95 .86 *

LOAM	**BANK** **LOOSE** **COMPACTED**	* .80 1.11	1.25 * 1.39	.90 .72 *
CLAY	**BANK** **LOOSE** **COMPACTED**	* .70 1.11	1.43 * 1.59	.90 .63 *
ROCK **(BLASTED)**	**BANK** **LOOSE** **COMPACTED**	* .67 .77	1.50 * 1.15	1.30 .87 *
CORAL **COMPARABLE** **TO LIMESTONE**	**BANK** **LOOSE** **COMPACTED**	* .67 .77	1.50 * 1.15	1.30 .87 *

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: What is the production rate in (CCY) for a 621G with a basic production rate of 47 LCYPH, working in Earth Loam, Dry?

47 X .72 = 33.84 OR **33** **(C CYPH)**

LCYPH X CONVERSION FACTOR = ***NOTE: ROUND DOWN (__CYPH)***

(ON SLIDE #103)

n. ***STEP #14*** ***TOTAL HOURS REQUIRED TO COMPLETE MISSION:*** *To determine the total time required to complete the mission, you must know the total volume to be moved, the basic production rate, and the number of scrapers you will use on the job.*

$$\frac{\text{VOLUME NEEDED (-CY)}}{\text{(\_CYPH)} \times \text{\# OF SCRAPERS}} = \text{TOTAL HOURS REQUIRED}$$

NOTE: NEVER ROUND OFF TIME

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: Your requirement is 19,440 CCY. You have 3 scrapers available that have a 33 CCYPH capability. How many hours will it take to complete this mission?

$$\frac{\text{19,940 CCY}}{\text{33 CCYPH x 3 SCRAPERS}} = \text{201.41 HOURS REQUIRED}$$

(ON SLIDE #104)

o. ***STEP #15*** ***TOTAL PRODUCTION (DAYS)*** *To get the production days required to complete the mission, divide total hours required by the hours worked per day, which will equal the total number of days required.*

HOURS REQUIRED ÷ HOURS WORKED A DAY = DAYS REQUIRED

NOTE: ROUND UP DAYS TO THE NEXT FULL DAY

EXAMPLE: If you are working 8 hour a days, how many days will it take if your estimation is 201.41 total hours required?

201.41 ÷ 8 = 25.18 OR 26 DAYS

(ON SLIDE #105-111)

INTERIM TRANSITION: Are there any questions over the last five steps of scraper production? Now let's move into some practical application on these steps.

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INSTRUCTOR NOTE

Introduce the following practical application (8).

PRACTICAL APPLICATION (8). **(3 HRS)** Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are determining total production days (all 15 steps).

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief**: There are no safety concerns.
2. **Supervision & Guidance**: Instructors will walk around the classroom and answer questions as they may arise. Instructor

may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. Debrief: Are there any questions or comments concerning the 15 step scraper production estimation? In order to progress further, you must have an understanding of basic production.

WHAT HAVE YOU LEARNED

PROBLEM #1: Figure total number production days with the following factors.

Three Caterpillar 621G Scrapers

Struck loaded, loam

7 hour production day

Excellent Operator

13.08 minute cycle time

Compacted volume required for job - 250,000 CY

Working 60 minutes per hour

60	MIN WORKED PER HOUR
÷ 13.08	CT
4.59	**TPH**
15.7	ALS
x 1.00	EFF FACTOR
72.06	
OR 72	**LCYPH**
x .72	CON FACTOR
51.84	
OR 51	**CCYPH**

250,000	VOL NEEDED
÷ (51 x 3)	PRODUCTION
1,633.99	**THR**
÷ 7	HRS PER DAY
233.43	
OR 234	**DAYS**

PROBLEM #2: A project requires you to build a parking lot using gravel. How many work nights, at 8 hours per night, are required to complete the project? You are working only during the hours of darkness. The job conditions are as follows. Show and label all figures and formulas.

Compacted fill required	150,000 CY
Class of earth	Gravel
Initial moisture content	14%
Average haul distance	7000 ft
Return by same route	
Grade of haul road	6% downhill
5 - 621G's/Struck loaded	
Average operators/Working 60 mins/hr.	

Rutted, dirt roadway, with no stabilization under load 4" to 6" penetration.

3000 DRY GRAVEL
x 1.14 MOISTURE
3420 ASW
x 15.7 ALS
53,694 or 52,800 LW
+ 74,946 TW
127,746 GW
÷ 2,000 1 TN
63.87 ST (HAUL)
x 150 RRF
9,580.5 or 9,581 RR (HAUL)

37.47 ST (RETURN)
x 150 RRF
5620.5 or 5621 RR (RETURN)

63.87 ST
20 CONSTANT
x - 6
-7,664.4
OR -7,664 GA

37.47 ST
20 CONSTANT
x 6
4,496.4 or 4,496 GR

```
  9,581   RR                          5,621   RR
- 7,664   GA                        + 4,496   GR
 -1,917   8TH GEAR/32 MPH             10,117   4TH GEAR/10.0 MPH
```

$$\frac{7{,}000\ \text{HD}}{32 \times 88} = \textbf{2.49 HAUL TIME (HT)}$$

$$\frac{7{,}000\ \text{RD}}{10.0 \times 88} = \textbf{7.95 RETURN TIME (RT)}$$

$$\frac{2.49}{\text{HAUL TIME}} + \frac{7.95}{\text{RETURN TIME}} + \frac{3.00}{\text{FIXED TIME}} = \frac{13.44}{\text{CYCLE TIME}}$$

```
     60   MIN/HR
÷ 13.44   CT
   4.46   TPH

   4.46   TPH
   15.7   ALS
x    .4   EF
  28.01
  OR 28   LCYPH

     28   LCYPH
x   .86   CONV FACTOR
  24.08
  OR 24   CCYPH

   150,000   VOL REQUIRED
÷ (24 x 5)   PRODUCTION
   1250.00   THR
÷        8   HRS/NIGHT
    156.25
   OR  157   NIGHTS
```

(ON SLIDE #112)

TRANSITION: Are there any questions over the last five steps of Scraper estimations? Let's move on to push loading.

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OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

a. How many steps are there in Scraper production?

15

b. When do you round off time?

NEVER

c. What does TPH mean?

Trips Per Hour (TPH)

(BREAK - 10 Min)

TRANSITION: Now that we have covered the use, classification, characteristics and operations of the scraper, are there any questions? Let's move right into scraper production.

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(ON SLIDE #113,114)

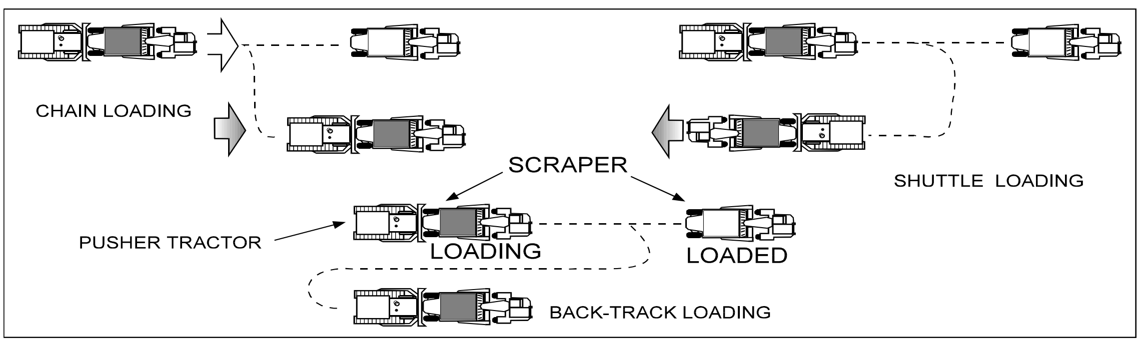
4. **PUSH LOADING (1 HR)**

a. Push loading a scraper is one of the most effective methods of loading a scraper. A self loaded Scraper may require twice the time and distance than one being assisted by a push tractor, thus effecting the cycle times and production throughout the project. The MCT is the only dozer in the Marine Corps with a reinforced blade for push loading.

b. Load time should be one minute or less. The optimum loading distance is around 90' to 125'. The optimum depth of cut for a push loaded scraper is 4 to 6 inches. The type of soil, its moisture content, laudability, operator efficiency, actual load size, and the method of equipment employment will govern these.

c. Normally the gear used during push loading is equivalent to second gear in the old D7G, for the MCT it is in RPM's and first for the 621G Scraper. The MPH listed in Table #5-2 for the scraper reflect the maximum and/or average speed in miles per hour. When push loading is employed, the maximum MPH will not be the loaded MPH reflected in the Table, therefore, for **CLASSROOM PURPOSES USE 2 MPH WHEN PUSH LOADING.**

d. There are three types of push loading. They are, Chain Loading, Shuttle Loading and Back-Track Loading. Chain Loading and Shuttle Loading is the most efficient at keeping the dozer from excess movement. Back-Track Loading is the most inefficient method of push loading. It takes more movement by the dozer, but it is still useful if the work area allows no other type of operation.



NUMBER OF PUSH TRACTORS REQUIRED

e. To get the number of Push Tractors (PT) required, we must go through 6 steps starting with load time.

(ON SLIDE #115-120)

(1) STEP #1 LOAD TIME. Load time is the time required to load the haul unit during which the dozer is in contact with the push block of the scraper. Load Time is figured by using the formula below. NOTE: USE 2 MPH FOR CLASSROOM PURPOSES.

$$\frac{\text{LENGTH OF CUT}}{\text{MPH} \times 88} = \text{LOAD TIME (LT) in min.}$$

NOTE: NEVER ROUND OFF TIME

Example:

$$\frac{\text{150' feet length of cut}}{\text{2 mph X 88 con factor}} = .85 \text{ min. LOAD TIME (LT)}$$

Note: 2 X 88 is a constant.

(2) STEP #2 BOOST TIME TRAVEL TIME. Boost time is the time expended after the scraper is loaded during which the push tractor assists the scraper in attaining momentum. (For Boost time use a constant of 0.25).

(3) STEP #3 RETURN TIME. Return time is the time required for the push tractor to return to the starting point. This portion of the cycle time will be greatly reduced by "chain" or "shuttle" loading. To get Return Time use the formula below.

LOAD TIME (LT) X 1.4 = RETURN TIME (RT)

NOTE: NEVER ROUND OFF TIME

(NOTE: 1.4 IS A CONSTANT)

Example:

.85 load time X 1.4 = 1.19 min. RETURN TIME. (RT)

(4) STEP # 4 FORMULATE CYCLE TIME.

(LOAD TIME X 1.4) + BOST TIME = PT CYCLE TIME (CT)

Example:

(LT)	(Constant)	(BT)
(.85 X 1.4) +	.25	= 1.44 min. PT CT

NOTE: NEVER ROUND OFF TIME

(5) STEP #5 NUMBER OF SCRAPERS A PUSH-TRACTOR CAN SUPPORT: This is found by dividing scraper cycle time by the push-tractor time .

$$\frac{\text{Scraper CT (min)}}{\text{push-Tractor CT (min)}} = \text{Number of scrapers a push-tractor can support}$$

(NOTE: Always round down)

Example: How many scrapers can a single push-tractor support if the scraper cycle time is 4 minutes and the push-tractor cycle time is 1.3 minutes?

$$\frac{4 \text{ min}}{1.3 \text{ min.}} = 3.1$$

Scrapers, rounded down to 3 Scrapers

(6) STEP #6 NUMBER OF PUSH TRACTORS REQUIRED: This is found by dividing the number of scrapers on the job by the number of scrapers a push tractor can support.

$$\frac{\text{Number of scrapers on job}}{\text{Number of scrapers a push-tractor can support}} = \text{Number of Push-Tractors required}$$

(NOTE: ROUND UP # OF PUSH TRACTORS REQUIRED)

Example: How many push-tractors are required on a job that has nine 621G Scrapers, if a single push-tractor can support three scrapers?

$$\frac{\text{9 scrapers}}{\text{3 scrapers per push-tractor}} = \text{3 Push- Tractors Required}$$

(ON SLIDE #121-130)

INTERIM TRANSITION: Are there any questions over the push tractor required estimations? Now let's move into some practical application on these steps.

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INSTRUCTOR NOTE

Introduce the following practical application (9).

PRACTICAL APPLICATION (9). **(2 HRS)** Have the students complete the problems in the student handout.

PRACTICE: There are three problems in the student handout for the students to complete. The problems are determining push tractors required.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. Safety Brief: There are no safety concerns.
2. Supervision & Guidance: Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. Debrief: Are there any questions or comments concerning push tractor required estimations? Now we have completed scaper production estimations.

WHAT HAVE YOU LEARNED

PROBLEM #1: Figure the number of push tractors required for (4) 621G's, with a 12.58 minute cycle time. The length of cut is 150 feet.

$\frac{150}{2 \times 88}$ = **.85 CT**

(.85 x 1.4) + .25 = **1.44 PT. CT**

$\frac{12.58}{1.44}$ = **8.74 OR 8 SCRAPERS 1 PT CAN SUPPORT**

$\frac{4 \text{ SCRAPERS ON JOB}}{8 \text{ SCRAPERS 1 PT CAN SUPPORT}}$ = **.5 OR 1 PT REQUIRED**

PROBLEM #2: Figure the number of push tractors required for (7) 621G's, with an 8.92 minute cycle time. The length of cut is 125 feet.

$\frac{125}{2 \times 88}$ = **.71 CT**

(.71 x 1.4) + .25 = **1.24 PT. CT**

$\frac{8.92}{1.24}$ = **7.19 OR 7 SCRAPERS 1 PT CAN SUPPORT**

$\frac{7 \text{ SCRAPERS ON JOB}}{7 \text{ SCRAPERS 1 PT CAN SUPPORT}}$ = **1 PT REQUIRED**

WHAT HAVE YOU LEARNED

PROBLEM #3: A project requires you to build a road using clay and gravel with an 8% moisture content. The borrow pit area allows you to push load the 621Gs with an MCT. How many days are required, at 10 hours per day, to complete the project? Also figure the total number of push tractors required. The job conditions are as follows. Show and label all figures and formulas. If you need help, raise your hand.

Compacted fill required	175,000 CY
Use clay and gravel for Soil Conversion Factor	
Initial moisture content	8%
Average haul distance	6600 ft
Return route	6600 ft
Grade of haul road	7 % Uphill
Rutted, dirt roadway, flexing considerably under load	
621G's	6
Push loaded by MCT/Struck loaded	
Average operators	working 60 min/hr.
Length of cut	80'

2,700	SOIL
x 1.08	MOISTURE
2,916	**ASW**
x 15.7	ALS
45,781.2	**LW**
+ 74,946	VW
120,727.2	**GW**
÷ 2,000	1 TN
60.36	**ST** (HAUL)
x 100	RRF
6,036	**RR (HAUL)**

37.47	ST (RETURN)
x 100	RRF
3,747	**RR (RETURN)**

60.36	ST
20	CONSTANT

37.47	ST
20	CONSTANT

x 7		x -7	
8,450.4		**- 5,245.8 or 5,246**	**GR**
OR 8,450	**GR**		

6,036	RR	3,747	RR
+ 8,450	GA	- 5,246	GR
14,486	**3rd GEAR/7.5 MPH**	**- 1,499**	**8TH GEAR/32 MPH**

$$\frac{6{,}600 \text{ HD}}{7.5 \times 88} = \textbf{10.0 HAUL TIME (HT)}$$

$$\frac{6{,}600 \text{ RD}}{32 \times 88} = \textbf{2.34 RETURN TIME (RT)}$$

10.00	+	2.34	+	1.43	=	13.77
HAUL TIME		RETURN TIME		FIXED TIME		CYCLE TIME

60	MIN/HR
÷ 13.77	CT
4.36	**TPH**

4.36	TPH
15.7	ALS
x .60	EF
41.07	
OR 41	**LCYPH**

41	LCYPH
x .63	CONV FACTOR
25.83	
OR 25	**CCYPH**

175,000	VOL REQUIRED
÷ (25 x 6)	PRODUCTION
1,166.67	**THR**
÷ 10	**HRS/NIGHT**
116.67	
OR 117	**NIGHTS**

PUSH TRACTORS REQUIRED

80 = **.45**

2 x 88

(.45 x 1.4) + .25 = **.88 PT CT**

$\frac{13.77}{.88}$ CT = **15.65 OR 15 1 PUSH TRACTOR CAN SUPPORT**

$\frac{6}{15}$ = **.4 OR 1 PT REQUIRED**

INSTRUCTOR NOTE
Hand out homework assignments 1, 1A, 1B, 1C, 1D.

(ON SLIDE #131)

TRANSITION: Are there any questions over basic scraper production?

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____

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS:

a. What is the only dozer in the Marine Corps that can be used as a push tractor?

Medium Crawler Tractor (MCT)

b. What are the three types of push loading??

Chain Loading, Shuttle Loading, Backtrack loading

c. What should the load time be?

One minute or less

(BREAK - 10 Min)

TRANSITION: Are there any questions over basic scraper production? Now let’s move into crawler tractor estimations.

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INSTRUCTOR NOTE
Hand out quiz #1. (40 MINS)

INSTRUCTOR NOTE
Administer Production Estimations Exam A (4HRS)

(ON SLIDE #132-137)

5. CRAWLER TRACTORS (2 HRS)

a. Dozers and scrapers are the most common pieces of equipment on a project. It is important to be able to properly use these prime earth movers to get maximum production, to establish production estimation rates, and to insure the prompt completion of an earth moving task.

b. **USE:** In the field of heavy construction, crawler tractors serve many purposes. They may be used as prime movers for pushing or pulling loads, as power units for winches and hoists, and as moving mounts for dozer blades. They are used primarily where it is advantageous to obtain high drawbar pull and traction. The crawler tractor is the most suitable piece of equipment for pushing or pulling loads through marshy areas.

c. **CLASSIFICATION:** Crawler tractors are classified according to weight. They are classified for easy identification as light, medium, and heavy. For example, the 1150E and the 1155 are in the light class, the MCT is in the medium class, and the D8 is in the heavy class.

d. **CHARACTERISTICS**: Crawler tractors are tractors, which are supported on the ground by track assemblies. Commonly called "bulldozers", they are the work horses of construction. Due to their versatility, they are usually the first piece of machinery on a construction job, and often the last to leave. They are used to cut haul roads, move dirt, trees, and rocks, and are used on many other jobs. A bulldozer is simply a crawler tractor with a blade mounted on the front, which is used for pushing objects or materials. Once the blade is removed and the machine is used as a towing unit, it is referred to as a tractor. Since the track sections support the weight of the machine, the crawler tractor has great traction pull. The ability to "lock" one side section of track while pulling with the other one enables the crawler tractor to pull itself out of material that would easily cause a wheeled machine to become stuck.

e. **OPERATION**: These tractors are equipped with a diesel engine rated from 85 to 202 brake horsepower, and either 4 or 6 cylinders, depending on the make and model. The all-terrain versatility of the crawler tractor is due to its' low ground bearing pressure, varying from 6 to 9 pounds per square inch, which gives it a distinct "flotation" advantage. Crawler tractors are capable of operating in muck or water as deep as the height of the track. Crawler tractors can move from jobsite to jobsite under their own power at slow speeds, however, this tends to shorten their operational life. For this reason, trailer should transport them if a long distance is involved. A paved or finished surface may also suffer extensive damage from the tracks.

(ON SLIDE #138, 139)

(1) BASIC PRODUCTION RATE: Dozer production can be estimated using the production from Table #9-3, and then adjusting the table with five (5) correction factors.

FACTOR 1 X FACTOR 2 X FACTOR 3 X FACTOR 4 X FACTOR 5 X FACTOR 6 =____________________________LCYPH

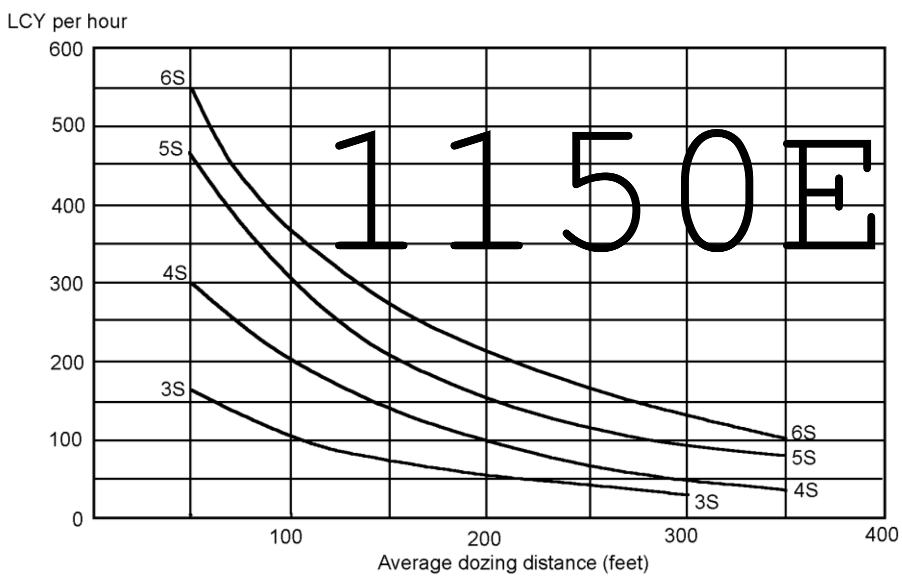
NOTE: ROUND DOWN LCYPH

NOTE: For classroom purposes, if you are not given the information for any factor, that factor will be N/A

(ON SLIDE #140-145)

(a) FACTOR #1: MAXIMUM BASIC PRODUCTION. Use (Table #9-3) to determine Maximum Basic Production. First find the average dozing distance line on the bottom of the scale, read up until you intercept the production curve for the dozer you are using, then read to the left to get the production rate in LCYPH.

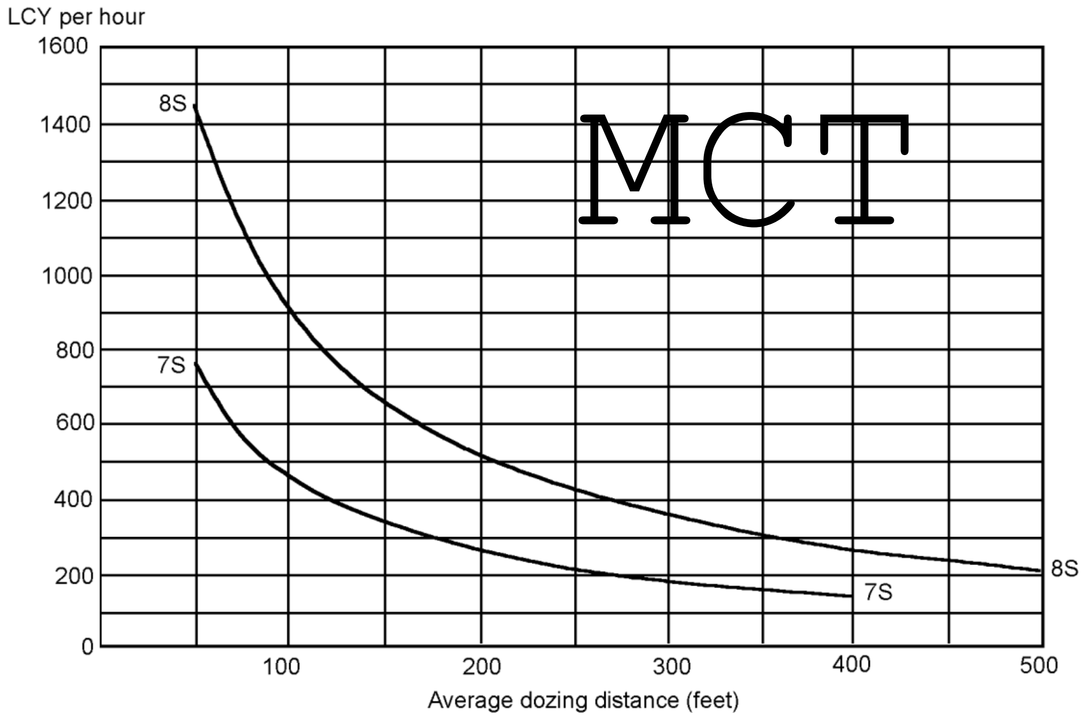
TABLE #9-3



NOTE: The "4s" represents an 1150E.

NOTE: Each LCY/hr is in increments of 50.

TABLE #9-3



NOTE: The 7S is a MCT*

NOTE: Each LCY/hr is in increments of 100.

NOTE: For classroom purposes round down to the next factor line if it falls in between.

<u>INTERIM TRANSITION</u>: Are there any questions over crawler tractors? Let's move on to some demonstrations of push tractor required estimations.

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INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

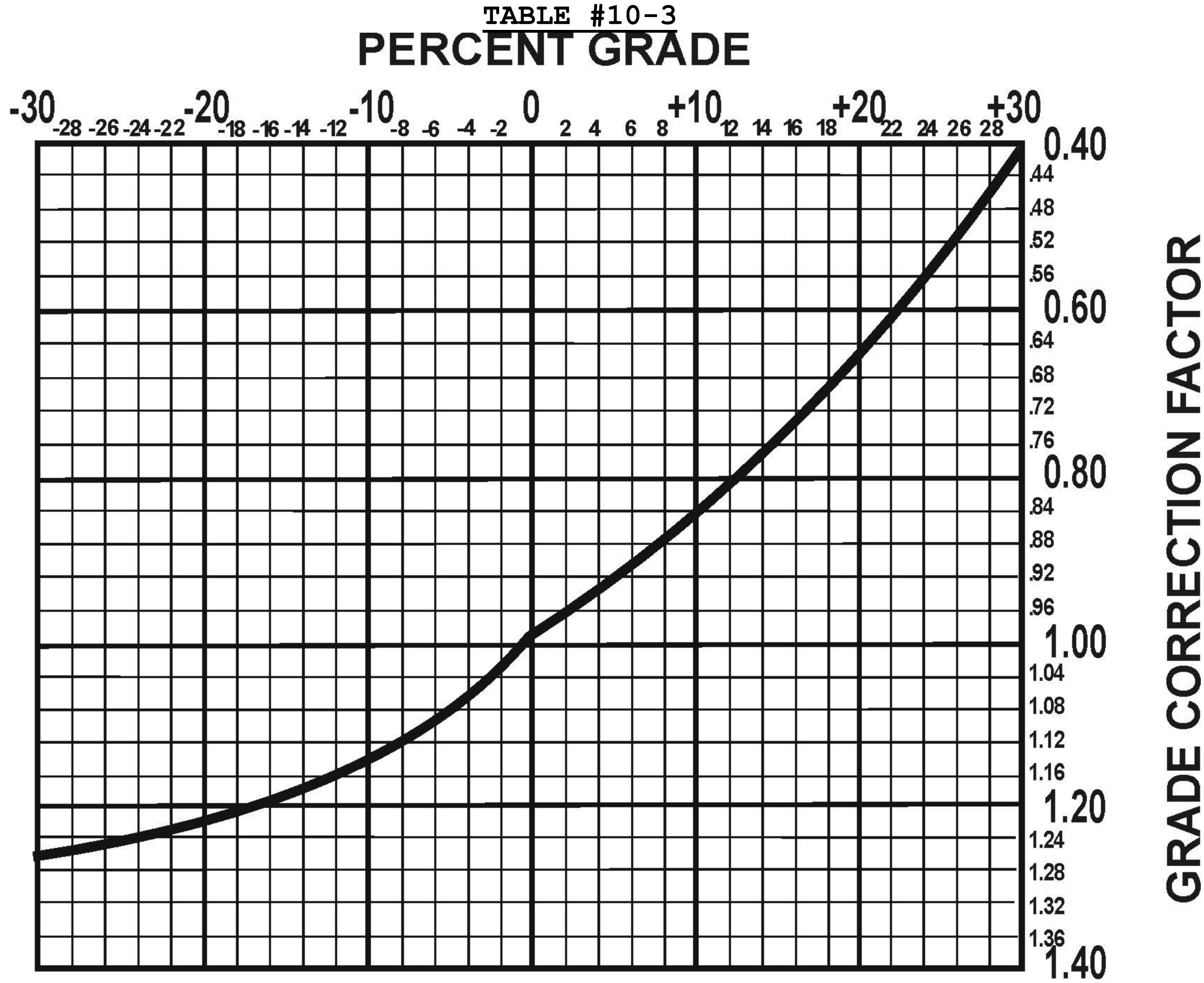
<u>EXAMPLE:</u> Determine the Maximum Basic Production for a MCT with an average dozing distance of 200 feet.

200 LCYPH

(b) FACTOR #2: GRADE CORRECTION FACTOR. Determine the **Grade Correction Factor** using (Table #10-3). Find the % of grade (-) Favorable or (+) unfavorable on the top of the scale, read down until you intercept the grade correction curve, then read to the right to determine the grade correction factor. Each vertical line on this scale represents multiple of two. Each horizontal line represents 0.04.

NOTE: For classroom purposes round down the chart, to the closest factor line if it falls in between.

TABLE #10-3



Grade correction factor

NOTE: % GRADE IS IN INCREMENTS OF 2

NOTE: FACTORS ARE IN INCREMENTS OF .04

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: Move the material up a 2% grade (+). **Grade correction factor = .96**

(ON SLIDE #146)

(c) FACTOR #3: SOIL WEIGHT CORRECTION FACTOR. Using Table #2-2 find the listed soil weight for the type soil you are working in. Add the moisture content to determine the actual soil weight for that soil. Divide 2,300 LBS/CY by the actual soil weight to find the correction factor. (2,300 LB'S is a constant, which is the weight of soil used to determine Table #9-3)

$$\frac{\textbf{2300 constant}}{\textbf{ACTUAL SOIL WEIGHT}} = \textbf{SOIL WEIGHT CORRECTION FACTOR}$$

NOTE: NEVER ROUND OFF

INSTRUCTOR NOTE
2300 is the industry standard for material unit weight per CY.

TABLE #2-2

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL,	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: What is the soil weight correction factor for clay with 5% moisture content ?

2,000	lbs. Clay
X 1.05	% of Moisture
2,100	Actual Soil Weight

2,300 Constant
2,100 Actual Soil Weight = 1.10 CORRECTION FACTOR

NOTE: NEVER ROUND OFF

(ON SLIDE #147)

(d) FACTOR #4: SOIL TYPE CORRECTION FACTOR. The dozer blade is designed to cut the material and give it a rolling effect for a production factor of 1.00. Material found in different states will effect dozer production as follows.

TABLE # 11-3
SOIL CORRECTION FACTOR

SOIL TYPE	FACTOR
LOOSE, STOCKPILE	1.20
HARD TO CUT (WITH TILT CYLINDER) HARD TO CUT (WITHOUT TILT CYLINDER)	O.80 O.70
HARD TO DRIFT (STICKS TO BLADE)	O.80
ROCK, RIPPED OR BLASTED	O.60

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: Hard packed clay is Hard to drift (sticks to blade) =

.80

(ON SLIDE #148)

(e) FACTOR #5: Determine Equipment / Operator Efficiency Correction Factor.

TABLE #7-2
EQUIPMENT OPERATOR EFFICIENCY FACTOR

TYPE UNIT	OPERATOR	DAY	NIGHT
TRACKED	EXCELLENT AVERAGE POOR	1.00 .75 .60	0.75 .56 .45

NOTE: These factors include operator efficiency and visibility (dust, rain, snow, fog and darkness) with a job efficiency of a 60-minute hour.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: Operator and equipment efficiency factors are average, working daylight = **.75**

(ON SLIDE #149)

(f) FACTOR #6: Determine the Management Technique correction factor:

TABLE # 12-3

MANAGEMENT TECHNIQUE	FACTOR
SLOT DOZING	1.20
SIDE BY SIDE DOZING	1.15

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: Slot Dozing is being Employed = **1.20**
NOTE: If management factor is not given, then it is N/A.

(ON SLIDE #150)

(2) STEP #1: Production Calculation:

FACTOR 1 X FACTOR 2 X FACTOR 3 X FACTOR 4 X FACTOR 5 X FACTOR 6 =________________________________LCYPH

NOTE: ROUND DOWN LCYPH

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: 200 LCYPH X .96 X 1.10 X .80 X .75 X 1.20 = 152.06 or 152 LCYPH

(ON SLIDE #151)

(3) STEP # 2: Soil Conversion Factor (IF REQUIRED):

Material conversion factor, if required.

TABLE #1-1 SOIL CONVERSION FACTORS

SOIL	CONVERTED FROM:	BANK	LOOSE	COMPACTED
SAND OR GRAVEL	BANK LOOSE COMPACTED	* .90 1.05	1.11 * 1.17	.95 .86 *
LOAM	BANK LOOSE COMPACTED	* .80 1.11	1.25 * 1.39	.90 .72 *
CLAY	BANK LOOSE COMPACTED	* .70 1.11	1.43 * 1.59	.90 .63 *
ROCK (BLASTED)	BANK LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *
CORAL COMPARABLE TO LIMESTONE	BANK LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: If your requirement is 4,500 compacted cubic yards and you are moving 228 loose cubic yards per hour, you must convert the loose cubic yards per hour to compacted cubic yards per hour.

152	x	.63	=	95.76 or 95 (C CYPH)
(LCYPH)	**X**	CON FACTOR (TABLE #1-1)	=	***SOIL CONVERTED (____CYPH)***

ROUND DOWN (CYPH)

(ON SLIDE #152)

(4) STEP #3: Total Hours Required:

(a) Quantity to be moved divided by the hourly production rate multiplied by the number of dozers you have employed equals the total time in hours to complete the job.

(b) The formula:

$$\frac{\textbf{Quantity to be moved (CYPH)}}{\textbf{Hr Production rate (\_\_\_CYPH) X Number of dozers}} = \textbf{THR}$$

NOTE: NEVER ROUND OFF TIME

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: How long would it take to move 4,500 CCY of clay, using 3 MCT's with a production rate of 95 CCYPH.

$$\frac{4{,}500}{95 \times 3} = 15.79 \text{ HRS}$$

(ON SLIDE #153)

(5) STEP #4: Total Production (DAYS)

(a) Total hours required divided by the number of hours worked in that day/night will give you the total production days.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE:

15.79 ÷ 8 = 1.97 OR 2 DAYS
ROUND DAYS TO NEXT FULL DAY

(ON SLIDE# 154)

(6) STEP#5: Total Number Of Dozers Required

(a) Quantity of material to be moved divided by the basic production rate per hour multiplied by the number of hours you have to complete the job. Use the formula below to formulate.

$$\frac{\textbf{Quantity to be moved}}{\textbf{Basic Production rate Per Dozer} \times \textbf{Required Completion time in hours}} = \textbf{Total \# of Dozers Required}$$

NOTE: ALWAYS ROUND UP NUMBER OF DOZERS REQUIRED

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: How many MCT's (with a production rate of 95 CCYPH) would be needed to move 4500 CCY of Loam in 5 hours?

$$\frac{\textbf{4500 CCY Required}}{\textbf{95 CCYPH x 5 Hrs}} = \textbf{9.47 or 10 MCT's}$$

(ON SLIDE #155-159)

INTERIM TRANSITION: Are there any questions over the push tractor required estimations? Now let's move into some practical application on these steps.

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INSTRUCTOR NOTE

Introduce the following practical application (10).

PRACTICAL APPLICATION (10). **(2 HRS)** Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are determining push tractors required.
PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. Safety Brief: There are no safety concerns.
2. Supervision & Guidance: Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. Debrief: Are there any questions or comments concerning push tractor required estimations? Now we have completed crawler tractor production estimations.

WHAT HAVE YOU LEARNED

PROBLEM #1: Using the following information, determine how long it will take two (2) MCT Tractors to complete the job ?

Average Dozing Distance.............150 ft
Average % of Grade..................+2%
Quantity of Soil to be Moved........1548 CCY
Material type... ....Clay with 2% Moisture Content
Material Type Factor................Hard to Drift (sticks to blade)
Operator Efficiency Factor..........Poor/Night
Blade-to-Blade Dozing is Employed
Equipment Available.................(2) MCT

SOLUTION:

300 x .96 x 1.13 x .80 x .45 x 1.15 = 134.73 or 134 LCYPH

134 x .63 = **84.42 or 84 CCYPH**

$\frac{1548}{(84 \times 2)}$ = **9.21 THR**

PROBLEM #2: Using the following information, determine how many MC1150E Tractors are required to complete this job in five (5) hours?

Average dozing distance	100 ft.
Average % of grade	+6%
Quantity of soil required	2976 LCY
Material type	Sandstone
Material type factor	Hard to Cut (with tilt cylinder)
Operator efficiency factor	Excellent/Daylight
Slot Dozing is Employed	
Equipment available	(6) MC1150E Tractors

SOLUTION:

200 x .92 x 1.05 x .80 x 1.00 x 1.20 = 185.47 or 185 LCYPH

$\frac{2976}{(185 \times 5)}$ = **3.22 or 4 Dozers Required**

TRANSITION: Are there any questions over the crawler tractor estimations? Now let's move into scoop loader estimations.

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OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

a. What is the most common piece of construction equipment on a project?

Dozers and Scrapers

b. How many factors are there to determine the basic production rate?

Six

c. If you are not given or cannot find any factors, what do you do?
Mark it as N/A and move to the next factor

(BREAK - 10 Min)

INSTRUCTOR NOTE
Hand out homework assignments 2, 2A, 2B, 2C, 2D.

TRANSITION: Are there any questions over basic crawler tractor estimations? Now let's move into scoop loaders estimations.
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(ON SLIDE #160-162)

f. Clearing and Grubbing: This consists of removing all trees, fallen timber, brush, and other vegetation from a designated area. Clearing techniques vary with the type of vegetation being cleared, soil, and moisture conditions. Table 13-3 shows average clearing rates for normal jobs.

(1) Stripping consists of removing and disposing of the top soil and vegetation, which would be objectionable as a sub grade for a road or runway.

(a) Brush and small trees: Dozers operating in first or second gear can clear brush and small trees (6" or less) at the rate of 900 to 1000 square yards per hour.

(b) Medium Trees: To remove medium trees (7 to 12 inches in diameter), the average clearing time is 2 to 9 minutes per tree.

(c) Large Trees: Removing large trees (over 12 inches in diameter) is much slower and more difficult, because the trees have large, deeply embedded root systems. Average clearing time is 5 to 20 minutes per tree.

(d) Rocks: Use a rock rake, if possible, to remove small rocks. The rake lets the soil remain while digging the rocks from the earth. When removing large partially buried rocks or boulders, tilt the dozer blade and dig the earth out from around three sides. Lower the blade enough to get under the fourth side of the rock. Lift the blade to create a lifting, rolling action as the tractor moves forward. If the dozer cannot push the rock, lift the rock upward with the blade and have someone place a log or some other object under the rock so the dozer can get another hold. If you have more than one dozer, have them work together to remove large boulders.

(ON SLIDE #163)

(2) **Production Estimates:** The two methods for estimating clearing, grubbing and stripping are: ***The Quick Method*** and ***The Tree Count Method.***

(a) *Quick Method*. Table 13-3 gives quick estimates for clearing, grubbing and stripping trees. Use these estimates only when a detailed reconnaissance and tree count are not possible.

EXAMPLE:

A road construction project requires that an area two (2) miles long and sixty (60) feet wide be cleared, grubbed and stripped. The average size of the trees on the site is six (6) inches in diameter. You have two (2) MCT tractors available to do the task. How many hours will the task take? The operator is average and the equipment will be working under daylight conditions.

(1) *Step 1: Determine area to be cleared in acres:*

First change miles to feet -----2 miles X 5,280 = 10,560'

$$\frac{\textbf{width (ft)} \quad \textbf{Length (ft)} \\ 60' \times 10560'}{43{,}560 \text{ sq ft /acre}} = 14.55 \text{ Acres}$$

NOTE: NEVER ROUND OFF ACRES

(2) *Step 2: Determine the Size and Number of Dozers Available:*

Dozer size ___MCT____ Number dozers available ______2_____

(3) *Step 3: Determine the size of trees to be cleared:*

Small trees____X____Medium trees _________Large trees _____

(ON SLIDE #164)

(4) *Step 4: Determine Production Rates (hours per acre) for Clearing,* based on dozer size and tree size (Table 13-3)

Small trees___2.50____hr/acre

TABLE #13-3 QUICK ESTIMATES FOR CLEARING

EQUIPMENT	**MAN OR EQUIPMENT (HOURS PER ACRE)**		
	SMALL TREES (6 INCHES OR LESS)	**MEDIUM TREES (7 TO 12 INCHES)**	**LARGE TREES (OVER 13 TO 30 INCHES)**
BULLDOZER: **Medium tractor** Heavy tractor (D8)	 **2.50** 1.50	 **5.00** 3.00	 **10.00** 8.00
SPADE PLOW: Medium tractor	1.33	2.20	3.90
SHEAR BLADE: Medium tractor Heavy tractor (D8)	 0.40 0.30	 0.80 0.50	 1.30 0.80
Note: These clearing rates are averages for tree counts of 50 trees per acre. Adverse conditions can reduce these rates significantly			

(5) *Step 5: Determine* ***Basic Production Rate (average hrs per acre)*** *by averaging individual production rates:* ***(IF NEEDED)***

$$\frac{\text{hr/acre(small)} + \text{hr/acre(med)} + \text{hr/acre (large)}}{\text{\# of different size trees}} = \text{basic production rate (hrs per acre)}$$

(6) *Step 6: Determine Equipment and Operator Efficiency Factor, using Table 7-2.*

Average Operator, working during daylight hours **= Efficiency factor 0.75**

TABLE # 7-2 EQUIPMENT AND OPERATOR EFFICIENCY FACTORS

TYPE OF DOZER	**OPERATOR ABILITIES**	**DAY**	**NIGHT**
TRACKED	*EXCELLENT*	1.0	0.75
	AVERAGE	0.75	0.56
	POOR	0.60	0.45

Note: These factors include operator efficiency and visibility (dust, rain, snow, fog, and darkness) with a job efficiency of a 60-minute hour.

(ON SLIDE #165, 166)

(7) *Step 7: Total hours required*

(STEP 1) (STEP 4)

$$\frac{\textbf{14.55 (acres) X Production 2.50 (hr/acre) X 1.6}}{\textbf{Efficiency 0.75 X 2 Number of dozers}} = \frac{\textbf{58.20}}{\textbf{1.50}} = \textbf{38.80 total hours}$$

(STEP 6) (STEP 2)

NOTE: NEVER ROUND OFF TIME

NOTE: If estimating clearing and grubbing only, omit 1.6 from numerator of equation. The 1.6 hours is there for disposal and stripping of vegetation.

(8) *STEP 8: Total Production (Days)*

Hours Required 38.80 ÷ 8 Hours Worked a Day = 4.85 OR 5 **DAYS**

NOTE: ROUND DAYS TO THE NEXT FULL DAY

INTERIM TRANSITION: Are there any questions over the crawler tractor estimations? Now let’s move into some practical application on these steps.

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(ON SLIDE #167, 168)

INSTRUCTOR NOTE

Introduce the following practical application (11).

PRACTICAL APPLICATION (11). **(30 MINS)** Have the students complete the problems in the student handout.

PRACTICE: There is one problem in the student handout for the students to complete. The problem is determining the quick tree count method.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning push tractor required estimations? Now we have completed crawler tractor production estimations.

WHAT HAVE YOU LEARNED?

PROBLEM: QUICK METHOD. A road construction project requires that an area five (5) miles long and eighty (80) feet wide be cleared, grubbed and stripped. The average size of the trees on the site is 10 inches in diameter. You have three (3) MCT tractors available to do the task. How many hours will the task take? The operator is average and the equipment will be working under daylight conditions.

5,280	FEET IN A MILE
x 5	MILES
26,400	**FEET**
x 80	FEET WIDE
2,112,000	**SQFT**
÷ 43,560	SQFT IN A ACRE
48.48	**ACRES**
5	PRODUCTION
x 1.6	STRIPPING
387.84	
÷ (.75 X 3)	NUMBER OF DOZERS
172.37	**THR**

(ON SLIDE #169-171)

(b) Tree-Count Method Use this method, when a detailed reconnaissance and tree count are possible, for a better production estimate.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: A road construction project requires that an area two (2) miles long and sixty (60) feet wide be cleared, grubbed and stripped. The tree count shows they are (50) trees 6″ or less in diameter, (30) trees 7″ to 12″ in diameter, and (10) trees 12″ to 30″ in diameter. You have two (2) MCT tractors available to do the task. How many hours will the task take? The operator is average and the equipment will be working under daylight conditions.

(1) Step 1: Determine area to be cleared in acres:

Width (ft) X Length (ft)

$$\frac{60' \times 10560'}{43{,}560 \text{ sq ft/acre}} = 14.55 \text{ Acres}$$

NOTE: NEVER ROUND OFF ACRES

(2) *Step 2: Determine the Size and Number of Dozers Available:*

Dozer size ___MCT___ Number dozers available ___2___

(3) ***Step 3: Determine the average number of each size of trees per acre: (use Table 14-3 as a guide.)***

____50____Small trees/acre

____30____Med trees/acre

____10____Large trees/acre

Table 14-3 Clearing time for trees and brush

TREE SIZE	MEDIUM DOZER (MCT)	HEAVY DOZER (D8)
BRUSH AND SMALL TREES (UP TO 6 INCHES)	.5 minutes per tree	.25 minutes per tree
MEDIUM TREES (7 TO 12 INCHES)	3 to 9 minutes per tree	2 to 6 minutes per tree
LARGE TREES (13 TO 30 INCHES)	5 to 20 minutes per tree	5 to 20 minutes per tree
Note: These clearing rates include removal of entire tree and stump and piling the trees in windrows. Clearing may take longer per tree than the table allows, depending on the size and location of the tree.		

INSTRUCTOR NOTE

Always use larger numbers for calculations

(4) *Step 4:* Determine **Basic Production Rate (Hrs per acre)** based on size of dozer and size of trees to be cleared (Table 14-3):

50 Small trees/acre X .50 Minutes/tree = 25 Min per acre (small trees)

30 Med trees/acre X 9 Minutes/tree = 270 Min per acre (Med trees)

10 Large trees/acre X 20 Minutes/tree = 200 Min per acre (Lg. trees)

Min per acre(Small) + **Min per acre(Med)** + **Min per acre(Large)**

$$\frac{25 \text{ min.} + 270 \text{ min.} + 200 \text{ min.}}{60\text{-min/hr}} = 8.25 \text{ HOURS PER ACRE}$$

NOTE: NEVER ROUND OFF TIME

(5) *Step 5: Determine Equipment and Operator Efficiency Factor: (Use Table 7-2,)*

Efficiency factor .75

(6) *Step 6: Total Hours Required*

$$\frac{\underset{\text{(STEP 1)}}{14.55 \text{ (acres)}} \times \text{Production } \underset{\text{(STEP 4)}}{8.25 \text{ (hr/acre)}} \times 1.6}{\underset{\text{(STEP 6)}}{\text{Efficiency } 0.75} \times \underset{\text{(STEP 2)}}{2 \text{ Number of dozers}}} = \frac{192.06}{1.50} = 128.04 \text{ TOTAL HOURS}$$

NOTE: NEVER ROUND OFF TIME

NOTE: If estimating clearing and grubbing only, omit, 1.6 from numerator of equation. The 1.6 hours is there for disposal and stripping of vegetation.

(7) *STEP 7: Total Production (DAYS)*

Hours Required 128.04 ÷ 8 Hours Worked a Day = 16.01 OR 17 DAYS

NOTE: ROUND DAYS TO NEXT FULL DAY

(ON SLIDE #172)

TRANSITION: We have just covered all the steps to determine dozer production in clearing, grubbing, and stripping operations. Are there any questions?

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____
____

1. **QUESTIONS TO THE CLASS**:

Q. What does it mean to clear and grub an area?

The removal of trees, fallen timber, brush, and other vegetation from a designated area.

Q. What are the two methods of estimating clearing, grubbing, and stripping?

The quick method and tree count method.

INSTRUCTOR NOTE
Hand out homework assignments 3, 3A, 3B, 3C, 3D, 3E.

TRANSITION: Next, we will be introduced to the grader and its production calculations.

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Take a break.
(10 MIN)

(ON SLIDE #173-177)

6. <u>INTRODUCTION TO GRADERS.</u> (1 HR)

Graders are multipurpose machines used primarily for general construction and maintenance of roads and runways. When properly used, the grader can be employed for crowning and leveling, mixing and spreading materials, ditching and bank sloping, and side-casting material.

a. **<u>USE.</u>** Graders serve as the finishers for the construction project. The grader is capable of finishing slopes and grades, blending and mixing materials, snow removal, and scarifying. Graders are used in conjunction with other earth movers when leveling, maintaining, and spreading. However, additional safety precautions should be used when equipment is performing different tasks in the same area.

b. **CLASSIFICATION.** Graders are classified as multipurpose machines. The grader can be used in a wide variety of operations from the beginning to the end of construction.

c. **CHARACTERISTICS.** Graders are wheeled vehicles characterized by a moldboard or blade and scarfier. Graders bring elevations to a final grade. The blade is used to side cast the material it encounters. The blade ends can be raised or lowered together or separately. Also, the blade can be angled and pitched for more effective operation. The scarifier is used to break up material too hard for the blade to cut. It is composed of eleven removable teeth capable of cutting to a depth of twelve inches. Graders are used for shallow cuts in medium to hard materials.

d. **OPERATION.** Graders are hydraulically operated and powered by a diesel engine. Graders are effective during leveling, ditching, and snow removal. During ditching operations, the grader can make progressive cuts to a depth of 3 feet. It is more economical to use other types of equipment to cut ditches deeper than 3 feet. Graders have a high center of gravity. The right pressure, at a critical point on the blade can cause the machine to roll over. Graders are used to create bank slopes. Well finished slopes help prevent slope failure. During the ongoing operation, the grader maintains haul roads. WORKING THE MATERIAL FROM ONE SIDE OF THE ROAD TO THE OTHER USUALLY DOES THIS. Corrugated material should be scarified prior to leveling and compacted after the grader has made the final leveling passes. During snow removal operations, the blade should be inspected hourly for excessive wear. Exercise caution and watch for hidden objects in the snow, as hitting these can cause damage the grader and injure the operator.

(ON SLIDE #178-184)

e. **GRADER PRODUCTION.**

The time required to complete a grader operation depends on the number of passes necessary and the speed maintained on each pass. In turn, this speed depends largely on the skill of the operator and the type of material being worked with.

A WORK-TIME FORMULA MAY BE USED TO PREPARE PRELIMINARY ESTIMATES OF THE *TOTAL TIME IN HOURS* REQUIRED TO COMPLETE A GRADER OPERATION.

$$\textbf{TOTAL TIME} = \frac{P \times D}{S \times E}$$

P= NUMBER OF PASSES REQUIRED
D= DISTANCE (IN MILES) TRAVELED IN EACH PASS
E= GRADER EFFICIENCY FACTOR

S= SPEED OF GRADER IN MILES PER HOUR

(1) NUMBER OF PASSES (P). The number of passes depends on the operation. Careful consideration must be made when determining the "number of passes" required. These passes must be based upon the effective grading width of the moldboard in the material worked, and/or the number of passes required for cut or fill of a given lane which will bring the surface to the desired grade.

(2) DISTANCE (D). Distance traveled in each pass is expressed in miles and is determined before construction begins. Note: if the distance has been measured in feet, you must change it into miles with this formula.

$$\frac{\textbf{DISTANCE IN FEET}}{\textbf{5280 (number of feet in 1 mile)}} = \textbf{DISTANCE IN MILES}$$

(3) EFFICIENCY FACTOR (E). The grader efficiency factor takes into account the fact that a 60 minute work hour is attained. Efficiency varies depending on supervision, operator skill, maintenance requirements and the site conditions. This formula is based on a 60 percent efficiency factor.

EFFICIENCY = 0.60 **NOTE: .60 is a constant.**

(4) SPEED (S). Speed is expressed in miles per hour. It is the most difficult factor in the formula to estimate correctly. As work progresses, conditions may require that speed estimates be increased or decreased. The work output is computed for each operation, which is performed at a different rate of speed. The sum of all the values obtained in each part is the total time required for the operation. Care must be taken to use the correct number of passes for each speed used.

TABLE #15-4
120M GRADER SPEEDS PER GEAR

	SPEED	BOTH	FORWARD	AND	REVERSE	IN MPH
GEAR	1ST	2ND	3RD	4TH	5TH	6TH
MPH	2.3	3.7	5.8	9.6	15.5	24.5

*** NOTE:** When a grader makes a number of passes covering a distance of less than 1000 feet, it normally is more efficient to back the grader the entire distance to the starting point than to turn the grader around and continue work from the far end.

When this is the case, each time that the grader backs up must be considered as a pass and is included in the formula.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE Five (5) miles of gravel road is to be leveled and re-shaped by a motorized grader with a twelve (12) foot moldboard. Six (6) passes are estimated to be required to complete leveling and reshaping. The type of material permits passes one and two (1 & 2) in second gear, passes three and four (3 & 4) in third gear, and passes five and six (5 & 6) in fifth gear.

(2nd gear passes 1 & 2)

$$\frac{2 \text{ (passes) x 5 (distance) IN MILES}}{3.7 \text{ (speed) x .60 (efficiency factor)}} = \frac{10}{2.22} = \mathbf{4.50 \text{ hrs.}}$$

(3rd gear passes 3 & 4)

$$\frac{2 \text{ (passes) x 5 (distance) IN MILES}}{5.8 \text{(speed) x .60 (efficiency factor)}} = \frac{10}{3.48} = \mathbf{2.87 \text{ hrs.}}$$

(5th gear passes 5 & 6)

$$\frac{2 \text{ (passes) x 5 (distance) IN MILES}}{15.5 \text{ (speed) x .60 (efficiency factor)}} = \frac{10}{9.3} = \mathbf{1.08 \text{ hrs.}}$$

4.50 hrs + **2.87 hrs.** + **1.08 hrs.** = **8.45 hrs. total hours**

TOTAL PRODUCTION (DAYS)

HOURS REQUIRED 8.45 ÷ 8 HOURS WORKED A DAY = 1.06 OR 2 **DAYS**

ROUND DAYS TO NEXT FULL DAY

EXAMPLE #2 A gravel road of 1,500 feet requires leveling and re-shaping. The work requires two (2) passes in second gear, and three (3) passes in third gear.

$$\frac{1500 \text{ feet}}{5280 \text{ feet per mile}} = \mathbf{.28 \text{ miles}}$$

(2nd gear passes 1 & 2)

$$\frac{2 \text{ (passes) x .28 (distance) IN MILES}}{3.7 \text{ (speed) x .60 (efficiency factor)}} = \frac{.56}{2.22} = \mathbf{.25 \text{ hrs.}}$$

(3rd gear passes 3, 4, & 5)

3 (passes) x .28 (distance) IN MILES .84

5.8 (speed) x .60 (efficiency factor) = 3.48 = **.24 hrs.**

.25 + .24 = .49 total hours

TOTAL PRODUCTION (DAYS)

HOURS REQUIRED .49 ÷ 8 HOURS WORKED A DAY = 0.06 OR 1 **DAY**

ROUND DAYS TO NEXT FULL DAY

INTERIM TRANSITION: Are there any questions over estimating for grader production? Now let's move into some practical application on these steps.

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(ON SLIDE #185-187)

INSTRUCTOR NOTE

Introduce the following practical application (12). Have the students do the problems 1 and 2.

PRACTICAL APPLICATION (12). (1HR 30 MIN) Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems cover grader production estimations.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning the conversion of basic dimensions to cubic yards? In order to progress further, you must have an understanding of the conversion.

WHAT HAVE YOU LEARNED?

PROBLEM #1: You have six (6) miles of sandy road that needs to be leveled and reshaped. Six (6) passes are estimated to be required to complete the job. The type of material permits passes (1 & 2) in first gear, passes (3 & 4) in second gear, and passes (5 & 6) in forth gear.
What is the total production time?

1 and 2

$$\frac{2 \text{ X } 6}{2.3 \text{ X } .60} = 8.70 \text{ HRS}$$

3 and 4

$$\frac{2 \text{ X } 6}{3.7 \text{ X } .60} = 5.41 \text{ HRS}$$

5 and 6

$$\frac{2 \text{ X } 6}{9.6 \text{ X } .60} = 2.08 \text{ HRS}$$

```
   8.70
   5.41
+  2.08
  -----
  16.19   THR
```

PROBLEM #2: There are 2,640 feet of a dirt road that needs to be leveled and reshaped. It is estimated that it will require six (6) passes to complete the job. The type of material permits passes (1 & 2) in first gear, passes (3 & 4) in third gear, and passes (5 & 6) in fifth gear. Figure the total production time to complete this job.

$$\frac{2,640}{5,280} = .5 \text{ MILES}$$

1 and 2

$$\frac{2 \text{ X } .5}{2.3 \text{ X } .60} = .72 \text{ HRS}$$

```
   .72
   .29
+  .11
  ----
  1.12   THR
```

3 and 4

$$\frac{2 \text{ X } .5}{5.8 \text{ X } .60} = .29 \text{ HRS}$$

5 and 6

$$\frac{2 \text{ X } .5}{15.5 \text{ X } .60} = .11 \text{ HRS}$$

INSTRUCTOR NOTE
Hand out homework assignments 4, 4A, 4B, 4C, 4D.

(ON SLIDE #188)

TRANSISTION: Are there any questions or comments concerning grader production estimations?

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OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

   a. **In the work/time formula, what does the "P" stand for?**

   Number of passes required.

   b. **If my pass is shorter than 1000 feet, what should I do?**

   Back the grader to the starting point.

(BREAK - 10 Min)

INSTRUCTOR NOTE
Hand out quiz #2. (40 MINS)

INSTRUCTOR NOTE
Administer Production Estimations Exam B (4HRS)

TRANSITION: Now that we have covered grader production estimations, are there any questions? Let's move right into scoop loader production.

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(ON SLIDE #189-196)

7. <u>SCOOP LOADERS</u> (3 HRS)

INTRODUCTION

a. Loaders are available in varied sizes and bucket capacities. Loaders have a hinged frame, which provides the steering; this steering method is referred to as articulated, and provides greater maneuverability. Articulated steering provides zero clearance for personnel at the point of articulation. Most loaders have a towing pintle for towing small trailers. Special caution should be exercised when the bucket is fully raised, because the chances of rollover or tipping are greatly increased.

b. **<u>USE:</u>** The primary use of the front-end loader is lifting and loading. It is also used for excavating, snow removal, and back filling. The loader is capable of many other operations with the proper attachments such as (forks, sweeper, snowplow, and multi-segmented bucket.) Loaders are used in and around rock quarries, when equipped with rock-type tread tires. Loaders are used in various tasks, including, stripping overburden, charging hoppers, and carrying materials.

c. **<u>CLASSIFICATION:</u>** Loaders are classified according to bucket size. The normal buckets are 2 1/2 and 5 cubic yards; however, the buckets are available in many sizes, both larger and smaller.

d. **<u>CHARACTERISTICS:</u>** Loaders are wheeled vehicles characterized by an attachment for lifting and loading. The most common scoop loader attachments are the shovel-type bucket and the forklift. The loaders hydraulic system provides the power for these attachments. The bucket is available in two types, the general purpose and the multi-segmented bucket. The general-purpose bucket is a one-piece bucket made of heavy duty all welded steel. The multi-segmented bucket is a hinged jaw bucket, commonly referred to as a clamshell. It has bolted or welded replaceable cutting edges and bolt on teeth for excavation. The two-piece bucket has many capabilities not available to the single-piece bucket. These include clamshell, dozer, and scraper operations.

e. **OPERATION:** Loaders are hydraulically operated and powered by a diesel engine. The loader is extremely versatile and capable of many different operations. When working in a stockpile, the bucket should be parallel to the ground when loading, and raised after penetration of the material. Crowding the material will prevent spilling, and maximize loading. When loading trucks from a bank or stockpile with a single loader, the "V" method should be used. This method will produce the best production, because the angle and the moving distance are kept to a minimum. A loader can dig excavations such as defilades and gun emplacements. When digging the excavation, a ramp should be constructed prior to the emplacement. This provides an area where the material can be removed from the hole. Material that is difficult to excavate should be broken up or loosened for greater effectiveness.

f. **PRODUCTION:** Scoop loaders are affected by numerous factors, which must be considered prior to their employment. Among these factors are operator skill, extent of prior loosening of the material, weight and volume of the material, slope of the operating area, height of the material, climatic conditions, and management factors.

(1) The Marine Corps currently has two scoop loaders in the system, the MC1155E, and the 624KR Tram. The front bucket on the 420DV Backhoe Loader can also be used to perform limited scoop loader operations.

(2) Scoop loader production can be estimated by using the following steps.

(ON SLIDE# 197)

(a) STEP #1: DETERMINE BASIC PRODUCTION

$$\frac{\text{BUCKET SIZE (CY) X MIN WORKED PER HOUR X 60 SEC}}{\text{LOADER CYCLE TIME (IN SECONDS)}} = \text{BASIC PRODUCTION (LCYPH)}$$

Note: Always round down LCYPH

Note: You can find the seconds you are working per hour by multiplying the minutes you are working per hour by 60.

TABLE #3-2
BUCKET SIZE

TRAM 624KR	**2 1/2 or 2.5 CY**
MC1155E	**1 3/4 or 1.75 CY**
MAC-50 CLAMSHELL	**1 ¼ OR 1.25 CY**
420E IT FRONT BUCKET	**1 ¼ or 1.25 CY**
420E IT BACKHOE BUCKET	**¼ or .25 CY**

INTERIM TRANSITION: Are there any questions over scoop loaders? Let's move on to some demonstrations of scoop loader estimations.

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INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: What is the basic production in LCYPH of a 2 1/2 cubic yard scoop loader working a 60-minute hour, with a cycle time of 35 seconds?

$$\frac{2.5 \text{ X } 3{,}600}{35} = 257.14 \text{ OR } 257 \text{ LCYPH}$$

NOTE: ALWAYS ROUND DOWN LCYPH
(ON SLIDE# 198-201)

(b) STEP #2: DETERMINE EFFICIENCY FACTOR **(Table 17-5)**

Efficiency depends on both job conditions and management conditions. To arrive at an efficiency factor, these conditions must be subjectively evaluated.

JOB FACTORS: *Job factors are the physical conditions that affect the production rate of specific jobs, other than the type of material to be handled. They include:*

* *Topography and work dimensions, including depth of cut and amount of movement required.*
* *Surface and weather conditions, including the season of the year and drainage conditions.*
* *Specifications that control handling of work or indicate the operational sequence.*
* *Equipment maintenance and repair.*

MANAGEMENT FACTORS: *Management factors are:*

* *Planning, organizing, and laying out the job; supervising and controlling the operation.*
* *Selecting, training, and directing personnel.*

TABLE # 17-5
MANAGEMENT FACTORS

JOB FACTORS	EXCELLENT	GOOD	FAIR	POOR
EXCELLENT	.84	.81	.76	.70
GOOD	.78	.75	.71	.65
FAIR	.72	.69	.65	.60
POOR	.63	.61	.57	.52

INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: If the job factor is good and the management factor is fair, the efficiency factor would be 0.71

(ON SLIDE# 202)

(c) STEP #3: DETERMINE NET PRODUCTION (LCYPH): To determine the net production in LCYPH, multiply the basic production in LCYPH by the efficiency factor.
BASIC PRODUCTION (LCYPH) X EFF FACTOR = NET PRODUCTION (LCYPH)
NOTE: ALWAYS ROUND DOWN LCYPH

INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: What is the net production in LCYPH of a scoop loader with a basic production rate of 257 LCYPH, and an efficiency factor of .71?

257 (LCYPH) x .71 = 182.47 or 182 LCYPH
NOTE: ALWAYS ROUND DOWN LCYPH

(ON SLIDE #203)

(d) STEP #4: SOIL CONVERSION (IF NEEDED): If your requirement, or quantity to be moved, is expressed in either CCY or BCY, you must use the following formula to convert your net production.

NET PRODUCTION (LCYPH) x SOIL CON FACTOR (Table # 1-1) = CONVERTED CYPH

NOTE: ROUND DOWN CYPH

TABLE #1-1 SOIL CONVERSION FACTORS

SOIL	CONVERTED FROM:	BANK	LOOSE	COMPACTED
SAND OR GRAVEL	BANK LOOSE COMPACTED	* .90 1.05	1.11 * 1.17	.95 .86 *
LOAM	BANK LOOSE COMPACTED	* .80 1.11	1.25 * 1.39	.90 .72 *
CLAY	BANK LOOSE COMPACTED	* .70 1.11	1.43 * 1.59	.90 .63 *
ROCK (BLASTED)	BANK LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *
CORAL COMPARABLE TO LIMESTONE	BANK LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: If you are loading clay, and your net production is 182 LCYPH, how many CCYPH are you loading?

182 x .63 = 114.66 OR 114 CCYPH

NOTE: ROUND DOWN CYPH

(ON SLIDE #204)

(e) STEP #5: TOTAL TIME REQUIRED (HRS)*:* To determine the total time required to complete the mission, utilize the following formula.

$$\frac{\textbf{QUANTITY TO BE MOVED}}{\textbf{HOURLY PRODUCTION RATE x \# OF SCOOP LOADERS}} = \textbf{TOTAL TIME (HRS)}$$

NOTE: NEVER ROUND OFF TIME

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: If your scoop loaders have an hourly production rate of 114 CCYPH each (after conversion), how long will it take 3 scoop loaders to move 13,250 CCY of material?

$$\frac{13{,}250}{114 \times 3} = 38.74 \text{ HRS}$$

(ON SLIDE #205)

(f) STEP #6: *TOTAL # OF DAYS REQUIRED*: To determine the total number of days that a project will take, use the following formula.

$$\frac{\textbf{\# HOURS REQUIRED}}{\textbf{\# HOURS WORKED PER DAY}} = \textbf{\# OF DAYS REQUIRED}$$

NOTE: ROUND UP TO NEXT FULL DAY

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: You have estimated that it will take you 38.74 hours to complete a project, how many days will this project take if you are working 7.5 hours per day?

$$\frac{38.74}{7.5} = 5.17 \text{ OR } 6 \text{ DAYS}$$

(ON SLIDE #206-208)

INTERIM TRANSITION: Are there any questions over the scoop loader estimations? Now let's move into some practical application on these steps.
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INSTRUCTOR NOTE

Introduce the following practical application (13).

PRACTICAL APPLICATION (11). (2HRS) Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are determining scoop loader estimations.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning scoop loader estimations? Now we have completed scoop loader production estimations.

WHAT HAVE YOU LEARNED?

PROBLEM #1: Determine the production rate in CCYPH, for a Tram 624KR with the following factors.

Cycle Time	120 seconds
Job Factor	Fair
Management Factor	Fair
Type of Material	Earth Loam, Dry

Working a 60 minute work hour

SOLUTION:

2.5	BUCKET SIZE
x 3,600	SEC/HR WORKED
9,000	
÷ 120	LOADER CYCLE TIME
75	**LCYPH**
x .65	EFF FACTOR
48.75	
OR 48	**LCYPH**
x .72	CONV FACTOR
34.56	
OR 34	**CCYPH**

PROBLEM #2: Determine the production rate in LCYPH, for an MC1155E with the following factors.

Cycle Time	90 seconds
Job Factor	Poor
Management Factor	Poor
Type of Material	Limestone

Working a 45 minute work hour

SOLUTION:

1.75	BUCKET SIZE
x 2,7000	SEC/HR WORKED
4,725	
÷ 90	LOADER CYCLE TIME
52.50	
OR 52	**LCYPH**

52	LCYPH
x .52	EFF FACTOR
27.04	
OR 27	**LCYPH**

(ON SLIDE#209-213)

INTERIM TRANSITION: Are there any questions over scoop loader estimations? Now let's move into ratio of loading units to hauling units.

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g. **Ratio of Loading Units to Hauling Units**

(1) For the cycle time to be of any value, you have to have enough loaders. There is no time computed into the cycle time for the scrapers to wait due to the loader's inability to keep up. Therefore, you have to have the proper ratio of loading units to hauling units.

(2) Utilize the formula below to figure out how many haul units (1) loader can handle with no waiting.

$$\frac{\textbf{HAUL UNIT CYCLE TIME}}{\textbf{LOAD TIME (TABLE \#18-5)}} = \textbf{\# HAUL UNITS THAT (1) LOADING UNIT CAN HANDLE WITH NO WAITING}$$

NOTE: ROUND DOWN # OF HAUL UNITS

TABLE # 18-5
LOADING TIME

LOADING EQUIPMENT	621G STRUCK LOADED	621G HEAP LOADED
1155E	6 MIN.	8 MIN.
TRAM 624KR	5 MIN.	6 MIN.
420E IT		
4 in 1 Bucket	11 MIN.	15 MIN.
GP Bucket	15 MIN.	21 MIN.
MAC-50 - Clamshell	15 MIN.	18 MIN.

Note #1: If the actual load size falls between a struck load and a heap load, use the heap load time for the load time.

Note #2: These are average fixed times only and are based on an average operator who is familiar with the attachments and equipment operation. These times are a basic starting point only. Actual fixed times can vary considerably due to varying conditions. Timing of several actual cycles is necessary in order to obtain a more realistic fixed time average for the particular job being performed.

INTERIM TRANSITION: Are there any questions over ratio of loading units to hauling units? Let's move on to some demonstrations.

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INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: How many haul units can (1) 1155E handle, if the haul units are hauling 15.7 CY of material and their cycle time is 14.5 minutes?

$$\frac{\mathbf{14.5}}{\mathbf{6}} = \mathbf{2.42 \text{ or } 2}$$

NOTE: ROUND DOWN # OF HAUL UNITS

After figuring out how many haul units (1) loading unit can handle, the next step is to determine how many loading units you will need to keep the haul units busy.

h. **Total Number of Loading Units Needed**

Use the following formula to determine the number of loading units that are required on the project.

$$\textbf{\# HAUL UNITS} \div \frac{\textbf{HAUL UNIT CYCLE TIME}}{\textbf{LOAD TIME (TABLE \#18-5)}} = \textbf{\# LOADING UNITS NEEDED}$$

NOTE: ROUND UP # LOADING UNITS

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: On your job project you have (2) 621G's being loaded by a 1155E to a struck load. If the scrapers cycle time is 14.5 minutes, how many loading units do you need to keep the scrapers busy?

$$2 \div \frac{14.5}{6} = .83 \text{ or } 1$$

NOTE: ROUND UP # LOADING UNITS

$$\frac{14.5}{6} = 2.42 \qquad \frac{2}{2.42} = .83 \text{ or } 1$$

(ON SLIDE #214-216)

INTERIM TRANSITION: Are there any questions over loading units to haul units or number of load units needed? Now let's move into some practical application on these steps.

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INSTRUCTOR NOTE

Introduce the following practical application (14).

PRACTICAL APPLICATION (14). (2 HRS 30 MIN) Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems are loader and haul unit required.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning loader and haul unit required? Now we have completed scoop loader estimations.

PROBLEM 1: How many haul units can (1) Tram 624KR handle, if the haul units are hauling 12.5 CY of material and their cycle time is 8.42 minutes?

SOLUTION:

$$\frac{8.42 \text{ HU CT}}{5 \text{ LOAD TIME}} = \textbf{1.68 OR 1 HAUL UNIT}$$

PROBLEM 2: On your job project you have (7) 621G's being loaded by MC1155E's to a struck load. If the scrapers cycle time is 33 minutes, how many loading units do you need to keep the scrapers busy?

SOLUTION:

$$7 \div \frac{33}{6} = \textbf{1.27 OR 2 LOADERS NEEDED}$$

TRANSITION: Are there any questions over loader and haul unit required? Now let's move into the dump Back Hoe.

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(ON SLIDE #217)

OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

   a. What is the primary use of front end loaders?

   Lifting and Loading

   b. How many front end loaders does the Marine Corps have?

   Three

   c. What are they?

   624KR TRAM, 420E Backhoe, and the MC1150E

(BREAK - 10 Min)

INSTRUCTOR NOTE
Hand out homework assignments 5, 5A, 5B, 5C, 5D.

TRANSITION: Are there any questions over basic scoop loader production? Now let's move into dump trucks estimations.

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(ON SLIDE #218-222)

8. BACKHOE LOADER (1HR)

a. **INTRODUCTION:** Fast-acting, variable-flow hydraulic systems and easy-to-operate controls give hydraulic excavators the high implement speed and breakout force to excavate trenches, the precision to set pipes, and the capacity to back fill. The 420E IT operates on these principals. It has the precision to work in tight places and the mobility to move quickly from job to job.

b. **Use:** The backhoe is best suited for trench excavating, since it can dig well below the unit's wheels. A large variety of booms, sticks, buckets, and attachments give excavators the versatility to excavate trenches, load trucks, clean ditches, break up old concrete, install outlet pipes, and numerous other jobs.

c. **Classification:** Horsepower classifies Backhoes and excavators. The 420E IT Backhoe Loader is rated at 88 horsepower.

Generally speaking, the greater the horsepower the greater the output.

d. **Characteristics:** The 420E IT is a fully hydraulic, rough terrain Backhoe Loader, equipped with a manually control all wheel drive able to negotiate a maximum grade of 35%. It comes equipped with a front bucket and a backhoe bucket.

e. **Operation:** Since the 420E IT is used primarily for below ground level excavation, a survey should be conducted for underground hazards, as well as surface obstacles, before starting operation. This applies particularly to populated areas with underground utilities. It is important that the machine be positioned properly on the job site to gain its greatest effectiveness. Efficient positioning of the backhoe depends on the type of work to be done. Before operating the backhoe, level the machine, lower the front bucket to the ground, and insure that the gearshift and the range shift selector levers are in the neutral positions.

g. **Production Estimates:** Backhoe and excavator production can be determined by using the following steps.

(ON SLIDE #223-226)

(1) STEP #1: BUCKET SIZE: Determine the size of the bucket that you will use to load with.

TABLE #3-2
BUCKET SIZE

TRAM 624KR	**2 1/2 or 2.5 CY**
MC1155E	**1 3/4 or 1.75 CY**
ATC CLAMSHELL	**1 ¼ OR 1.25 CY**
420E IT FRONT BUCKET	**1 ¼ or 1.25 CY**
420E IT BACKHOE BUCKET	**¼ or .25 CY**

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: You are tasked with digging a trench with the 420E IT, equipped with the general-purpose bucket.

Bucket Size = .25 Cubic yards

(2) STEP #2: CYCLES PER HOUR (CPH): To determine the cycles per hour, you must first know the following factors:

The cycle time of the 420E IT (Table 19-6)

TABLE 19-6
DEPTH OF CUT (FT)

DEGREE OF SWING	2 FEET	4 FEET	6 FEET	8 FEET	10 FEET	12 FEET	14 FEET
45 DEGREES	12 SEC	16 SEC	22 SEC	25 SEC	31 SEC	38 SEC	46 SEC
90 DEGREES	22 SEC	25 SEC	30 SEC	36 SEC	42 SEC	49 SEC	55 SEC

Note: ***These are average fixed times only and are based on an average operator who is familiar with the attachments and equipment operation. These times are a basic starting point only. Actual fixed times can vary considerably due to varying conditions. Timing of several actual cycles is necessary in order to obtain a more realistic fixed time average for the particular job being performed.***

After determining these factors, place them in the formula below.

$$\frac{\textbf{MINUTES WORKED PER HOUR} \times \textbf{60 SECONDS PER MINUTE}}{\textbf{CYCLE TIME IN SECONDS}} = \textbf{CYCLES PER HOUR}$$

NOTE: NEVER ROUND OFF CPH

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: If you are operating a 420E IT for 50 minutes per hour, and your cycle time is 36 seconds, how many cycles per hour will you operate?

$$\frac{50 \times 60}{36} = 83.33 \text{ Cycles per Hour (CPH)}$$

NOTE: NEVER ROUND OFF CPH

(3) STEP #3: EFFICIENCY FACTORS: Efficiency depends on both job conditions and management conditions. To arrive at an efficiency factor, these conditions must be subjectively evaluated.

(a) JOB FACTORS: Job factors are the physical conditions that affect the production rate of specific jobs, other than the type of material to be handled. They include:

** Topography and work dimensions, including depth of cut and amount of movement required.*
** Surface and weather conditions, including the season of the year and drainage conditions.*
** Specifications that control handling of work or indicate the operational sequence.*
** Equipment maintenance and repair.*

(b) MANAGEMENT FACTORS: Management factors are:

** Planning, organizing, and laying out the job; supervising and controlling the operation.*
** Selecting, training, and directing personnel.*

TABLE # 17-5

JOB FACTORS	MANAGEMENT FACTORS			
	EXCELLENT	GOOD	FAIR	POOR
EXCELLENT	0.84	0.81	0.76	0.70
GOOD	0.78	0.75	0.71	0.65
FAIR	0.72	0.69	0.65	0.60
POOR	0.63	0.61	0.57	0.52

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: If your job factor is good and your management factor is poor, your efficiency factor is 0.65

(4) STEP #4: NET PRODUCTION RATE (LCYPH): To determine the basic production rate (LCYPH), take the factors from steps 1 through 3, and place them in the formula below.

BUCKET SIZE x CYCLES PER HOUR x EFFICIENCY FACTOR =   LCYPH

NOTE: ROUND DOWN LCYPH

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: Determine the hourly production rate of a 420E IT equipped with the general purpose bucket, operating 50 minutes per hour, with a 36 second cycle time. Your job factor is good and the management factor is poor.

Step #1 **.25 CY**

Step #2 $$\frac{50 \times 60}{36} = 83.33 \text{ CPH}$$

Step #3 **.65**

Step #4 **.25 x 83.33 x .65 = 13.54 or 13 LCYPH**

NOTE: ROUND DOWN LCYPH

(ON SLIDE #227)

(5) STEP #5: SOIL CONVERSION (IF NEEDED): If your requirement, or quantity to be moved, is expressed in either CCY or BCY, you must use the following formula to convert your basic production rate.

LCYPH x SOIL CONVERSION FACTOR = CONVERTED CYPH

TABLE #1-1 SOIL CONVERSION FACTORS

Soil	Converted From:	Converted To:		
		Bank (in place)	Loose	Compacted
Sand or gravel	Bank (in place) Loose Compacted	* .90 1.05	1.11 * 1.17	.95 .86 *
Loam	Bank (in place) Loose Compacted	* .80 1.11	1.25 * 1.39	.90 .72 *
Clay	Bank (in place) Loose Compacted	* .70 1.11	1.43 * 1.59	.90 .63 *
Rock (blasted)	Bank (in place) Loose Compacted	* .67 .77	1.50 * 1.15	1.30 .87 *
Coral comparable to limestone	Bank (in place) Loose Compacted	* .67 .77	1.50 * 1.15	1.30 .87 *

INSTRUCTOR DEMONSTRATION (1 min)

Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: If your hourly production rate were 13 LCYPH, what would your hourly production rate in CCYPH be if you were working with wet clay?

$$13 \times .63 = 8.19 \text{ or } 8 \text{ CCYPH}$$

NOTE: ROUND DOWN CYPH

(ON SLIDE #228)

(6) STEP #6: TOTAL TIME REQUIRED (HRS): To determine the total time required to complete the mission, utilize the following formula.

$$\frac{\text{QUANTITY TO BE MOVED}}{\text{HOURLY PRODUCTION RATE} \times \text{\# OF EXCAVATORS}} = \text{TOTAL TIME (HRS)}$$

NOTE: NEVER ROUND OFF TIME

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: If you have (2) 420E IT, whose hourly production rate is 8 CCYPH (each), how many hours will it take to move 528 CCY of sand?

$$\frac{528}{8 \times 2} = 33.00 \text{ Hours}$$

NOTE: NEVER ROUND OFF TIME

(ON SLIDE #229)

(7) STEP #7: TOTAL # OF DAYS REQUIRED: To determine the total number of days that a project will take, use the following formula.

$$\frac{\text{\# HOURS REQUIRED}}{\text{\# HOURS WORKED PER DAY}} = \text{\# OF DAYS REQUIRED}$$

NOTE: ROUND UP TO NEXT FULL DAY

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example: You have estimated that a project will take 33 hours to complete, if you work 6.5 hours per day, how many days will it take to complete this project?

$$\frac{33}{6.5} = 5.08 \text{ OR } 6 \text{ DAYS}$$

NOTE: ROUND UP TO NEXT FULL DAY

INTERIM TRANSITION: Are there any questions over estimating for the backhoe? Now let's move into some practical application on these steps.

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(ON SLIDE #230-232)

INSTRUCTOR NOTE

Introduce the following practical application (15). Have the students do the problems 1 and 2.

PRACTICAL APPLICATION (15). (1HR 30 MIN) Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems cover back hoe loader estimations.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief:** There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning the conversion of basic dimensions to cubic yards? In order to progress further, you must have an understanding of the conversion.

WHAT HAVE YOU LEARNED?

PROBLEM #1: Your platoon has been tasked with digging a pipeline trench that is six feet deep, in earth loam, dry with (1) 420E IT. The swing angle the operators will be using is 45 degrees. You will be working during daylight hours for 8 hours a day with newly assigned operators rated as poor. The job factor is fair and management factor is poor since you decided to train operators with this project, and work only 30 minutes per hour. You estimate that 1250 loose cubic yards will be excavated from this trench.

How many days will it take you to complete this project?

SOLUTION:

.25	**BUCKET SIZE**
30	**MIN/HR WORKED**
x 60	**SEC/MIN**
3,000	**SEC/HR WORKED**
÷ 22	**CT**
81.82	**CPH**
.25	**BUCKET SIZE**
x .60	**EFF FAC**
12.27	
OR 12	**LCYPH**

1,250	**REQ VOLUME**
÷ 12	**PRODUCTION**
104.17	**THR**
÷ 8	**HRS/DAY**
13.02	
OR 14 DAYS	

PROBLEM #2: Your platoon has been tasked with digging 21 fighting holes. Each fighting hole contains 3.0 bank cubic yards of clay. The management factors will be excellent and the job factors will be good. You decide to use your 420E IT and best operator, who will work for 8 hours per day, and 50 minutes per hour. The cycle time will be 45 seconds.

How long will it take to complete this project?

SOLUTION:

21 x 3 = 63 BCY REQ. TO BE MOVED

50	**MIN/HR WORKED**
x 60	**SEC/MIN**
3,000	**SEC/HR WORKED**
÷ 45	**CT**
66.67	**CPH**
.25	**BUCKET SIZE**
x .78	**EFF FAC**
13	**LCYPH**
x .70	**CON FAC**
9.10	
OR 9	**BCYPH**

63	**REQ VOLUME**
÷ 9	**PRODUCTION**
7	**THR**
÷ 8	**HRS/DAY**
.88	
OR 1	**DAY**

INSTRUCTOR NOTE
Hand out homework assignments 6, 6A, 6B, 6C, 6D.

(ON SLIDE #233)

TRANSISTION: Are there any questions or comments concerning production estimations for the back hoe loader?

____
____
____

OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

a. What is the back hoe best suited for?

Trench excavation.

b. What is the size of the general purpose bucket?

1/4 or .25 CY

(BREAK – 10 Min)

TRANSITION: Now that we have covered the backhoe, are there any questions? Let's move right into clamshell production.
____
____
____

(ON SLIDE #234,235)

9. CLAMSHELL PRODUCTION (30 MINS)

a. Because of the factors, which effect operation of the clamshell, it is difficult to arrive at production rates that are dependable. These factors include; difficulty of loading the bucket in different types of soil, height of the lift, slow swing required, and the method of disposing of the load. The best method of production estimation is to observe the equipment on the job and measure the cycle time.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

b. **PRODUCTION ESTIMATION.** We will use the following example to determine the production rate and time required to complete the job. The job conditions are as follows:

Clamshell cap	1.25 CY
Job factor	Fair
Management factor	Good
Average cycle time	45 seconds
Minutes per hour worked	50 minutes (3000 seconds)
Production required	450 LCY

(ON SLIDE #236)

(1) STEP #1 CONVERT WORKING MINUTES PER HOUR TO WORKING SECONDS PER HOUR.

(50 WORKING MIN/HR x 60 SEC/MIN = 3,000 SEC/HR)

(2) STEP #2 EFFICIENCY FACTORS. This information is taken from table 17-5, Management factors.

.69

TABLE 17-5 MANAGEMENT FACTORS

	EXCELLENT	**GOOD**	**FAIR**	**POOR**
JOB FACTORS				
EXCELLENT	0.84	0.81	0.76	0.70
GOOD	0.78	0.75	0.71	0.65
FAIR	0.72	0.69	0.65	0.60
POOR	0.63	0.61	0.57	0.52

(ON SLIDE #237)

(3) STEP #3 PRODUCTION FORMULA:

$$\frac{\textbf{BUCKET SIZE X SEC/HR WORKED X EFF. FACTOR}}{\textbf{CYCLE TIME IN SECONDS}}$$

$$\frac{\textbf{1.25 X 3,000 X .69}}{\textbf{45 sec CYCLE TIME (IN SEC)}} = \underline{\textbf{57.50 OR 57}}\ \textbf{LCYPH}$$

NOTE: ROUND DOWN LCYPH

(4) STEP #4 DETERMINE SOIL CONVERSION (IF NEEDED)

LCYPH X CONVERSION FACTOR = (_______ CYPH)

TABLE # 1-1

SOIL	CONVERTED FROM:	BANK (IN PLACE)	LOOSE	COMPACT
SAND OR GRAVEL	BANK (IN PLACE) LOOSE COMPACTED	* .90 1.05	1.11 * 1.17	0.95 .86 *
LOAM	BANK (IN PLACE) LOOSE COMPACTED	* .80 1.11	1.25 * 1.39	.90 .72 *
CLAY	BANK (IN PLACE) LOOSE COMPACTED	* .70 1.11	1.43 * 1.59	.90 .63 *
ROCK (BLASTED)	BANK (IN PLACE) LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *
CORAL COMPARABLE TO LIMESTONE	BANK (IN PLACE) LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *

(5) STEP #5 DETERMINE TOTAL TIME REQUIRED TO COMPLETE JOB

QUANTITY TO BE MOVED

$$\frac{\text{450 LCY}}{\text{57 LCYPH} \times \text{\# OF CLAMSHELLS}} = \text{7.89 HRS REQUIRED}$$

(ON SLIDE #238)

(6) STEP #6 TOTAL PRODUCTION (DAYS)

7.89 ÷ 8 = .99 OR 1 DAY

HOURS REQUIRED ÷ HOURS WORKED A DAY = DAYS

ROUND DAYS TO NEXT FULL DAY

INTERIM TRANSITION: Are there any questions over estimating for the clamshell? Now let's move into some practical application on these steps.

____
____
____

(ON SLIDE #239)

INSTRUCTOR NOTE
Introduce the following practical application (16). Have the students do the one problem.

PRACTICAL APPLICATION (16). (30 MIN) Have the students complete the problem in the student handout.

PRACTICE: There is one problem in the student handout for the students to complete. The problems covers clamshell production estimations.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. Safety Brief: There are no safety concerns.
2. Supervision & Guidance: Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. Debrief: Are there any questions or comments concerning the conversion of basic dimensions to cubic yards? In order to progress further, you must have an understanding of the conversion.

WHAT HAVE YOU LEARNED?

Your platoon has been tasked to move 15,500 cubic yards of loose gravel (stockpile) to an airfield construction site. You find that the scoop loaders are tied down to a higher priority project and you will be required to use your 1.25 CY clamshell. The cycle time of the clamshell is 50 seconds. Job factors are good and management factors are fair. You are working 45 minutes per hour, and 7 hours per day. Determine how long it will take to load the gravel into haul units.

SOLUTION;

			15,500	REQ VOLUME
45	MIN/HR WORKED		÷ 47	PRODUCTION
x 60	SEC/MIN		329.79	THR
2,700	SEC/HR WORKED		÷ 7	HRS/DAY
1.25	BUCKET SIZE		47.11	

```
   ÷ .71   EFF FAC                    OR  48  DAYS
 2396.25
÷     50   CT
   47.93
  OR  47   CCYPH
```

INSTRUCTOR NOTE
Hand out homework assignments 7, 7A, 7B.

(ON SLIDE #240)

TRANSISTION: Are there any questions or comments concerning clamshell production estimations?

___
___
___

OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

   a. What is the clamshells bucket size?

   1 1/4 or 1.25 CY

   b. What piece of equipment supports the clamshell?

   MAC-50 only

(BREAK - 10 Min)

TRANSITION: Now that we have covered the clamshell production, are there any questions? Let's move right into compactor estimations.

___
___
___

(ON SLIDE #241-247)

10. Compactor (30 MINS)

a. Compaction is the process of mechanically densifying a soil by the application of a moving load. No other construction process, applied to natural soils, so drastically affects a soil's properties. Although compaction does not affect all soils alike, the advantages gained by compaction have made it a standard and essential part of the horizontal construction process.

b. **USE.** Compaction equipment is used strictly for mechanical stabilization. Compaction equipment is unique in that they are specialized for that purpose. Proper compaction is the most critical part of construction. Compaction allows the structure to meet load-bearing requirements. In roads and airfields, compaction is used from the sub-grade to the final wearing surface.

c. **CLASSIFICATION.** Compaction equipment is classified by weight, type, and method of operation. There are basically two types of compactors; towed and self-propelled. However, when classified by method of operation, there are three categories of compactors; pneumatic, vibratory, and rollers. Classification by weight uses the maximum static weight delivered to the surface.

d. **CHARACTERISTICS.** Because of the nature of compactors, it is difficult to categorize them. There are many different types, models, and functions, ranging from hand-held models used for compaction in small areas to larger models used in heavy construction. Some are diesel powered, gasoline powered, or pneumatic powered.

e. **OPERATION.** Compactors are driven, towed, or manually operated. Because of the weight and basic design of compactors, it is best to operate the power unit behind the compactor. The exception to this is with towed compactors. Extreme caution must be used when compacting on any side slopes, since once the compactor reaches the tip over point there is usually no recovery. Compactors are by nature slow, with most speeds ranging from 3 - 7 miles per hour depending on the material being compacted. Operators should be switched often to prevent boredom and fatigue.

f. **SELECTION AND TESTING OF EQUIPMENT**. Even though the Marine Corps has one type of compactor (vibratory), the military community has several to choose from. If the job you are working on needs a specific type that the corps does not have, do not forget that you may be able to temporarily loan one from another service.

g. **SELECTION FACTORS.** Soil-compacting equipment normally available to the military engineers includes sheepsfoot rollers, tamping-foot, pneumatic-tired rollers, smooth steel-wheel rollers, and vibratory types. By knowing the characteristics, capabilities, and limitations of the different types of rollers, a project officer can select the most appropriate type of compaction equipment. Table 20-8 shows the spectrum of capabilities of each type of roller and the type of compactive effort associated with each roller.

TABLE 20-8.) SELECTING COMPACTION EQUIPMENT

Spectrum of Roller Capabilities

100% Fines	**100% Sand**	**Rock**

Sheepsfoot

Tamping foot

Vibratory

Pneumatic, rubber

Smooth steel-drum

Grid roller

ROLLER TYPE	SOIL TYPE	COMPACTIVE EFFORT
Sheepsfoot	Fine-grained soils; sandy silts; clays; gravely clays	Kneading
Tamping foot (BOMAG)	All soils except pure sands and pure clays	Kneading
Vibratory	Sand/gravel; gravely and sandy soils	Vibratory (for granular-type soils)
Pneumatic	Sand/gravel; fine-grained soils; asphalt	Kneading or static (based upon tire pressure)
Steel wheel	Gravely soils; asphalt	Static
Grid roller	Rock; large grains; till	Static

NOTE: USE THIS TABLE ONLY IF TEST STRIP IS UNATTAINABLE.

(ON SLIDE #248,249)

h. **PRODUCTION**: Once you have selected the correct compaction equipment, you can now figure your production. Use the following formula to calculate compactor production in compacted cubic yards per hour:

(1) Formula:

$$\frac{16.3 \times W \times S \times L \times E}{P} = \text{CCYPH}$$

W = EFFECTIVE WIDTH OF THE ROLLER 6 FEET: The compactors drum is 7 feet wide, however to eliminate no compacted strips, each pass should overlap the preceding pass by 1 foot, thus giving the 6 foot effective width.

S = ______________________________ **Compactor speed, in mph**
(table 21-8)

L = ______________________________ **Compacted lift thickness, in inches**
(table 21-8)

E = _____________________________ **Efficiency factor**
(table 22-8)

P = ________________________________ **Number of passes required**
(table 21-8)

16.3 = Constant used in formula

(2) Production estimation starts with determining what type of soil you are working in and then looking to table 21-8 for the rest of the information you need to put in the formula.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

(a) EXAMPLE: We will use the following example to determine production. YOU ARE COMPACTING CLAY. (YOU WILL SEE CLAY ABBREVIATED AS CL ON TABLE 21-8.) THE OPERATOR IS WORKING 50 MIN/HR DURING THE DAY. THE TOTAL AMOUNT TO BE COMPACTED IS 1,500 CCY. YOU ARE WORKING 8 HOURS A DAY.

(ON SLIDE #250, 251)

(b) STEP #1: SOIL TYPE ________CL____________

(c) STEP #2: Determine compaction requirements by using Table 21-8 In this table, you should first determine type of soil you are working in, then take the speed, lift thickness and passes from the table.

TABLE 21-8 Soil classifications and compaction requirements (average)

SYMBOL	DESCRIPTION	LIFT THICKNESS COMPACTED INCHES	ROLLING SPEED (MPH/VPM)	NUMBER OF PASSES
GW	Well-graded gravels or gravel sand mixture with 5% or less fines	18 (BEST)	4 mph 1400 vpm	8
GP	Poorly graded gravels or gravel-sand mixture with little or no fines	18 (BEST)	4 mph 1400 vpm	8
GM	Silty gravel and poorly graded gravel-sand silt mixtures	12	4 mph 1100 vpm	6
GC	Clayey gravel and poorly graded gravel-sand-clay mixture	12	4 mph 700 vpm	6
SW	Well-graded sands or gravely sand mixture with 5% or less fines	18 (BEST)	4 mph 1400 vpm	8
SP	Poorly-graded sands or gravely sand mixture with 5% or less fines	18 (BEST)	4 mph 1400 vpm	8
SM	Silty sands, sand-silt mixture	12	4 mph 1100 vpm	6
SC	Clayey sands, sand-clay mixture	12	3 mph 700 vpm	7
ML	Inorganic silt of low plasticity, silty fine sands	8	3 mph 700 vpm	7
CL	Inorganic clay of low to medium plasticity, lean clays	8	3 mph 700 vpm	7
OL	Organic silt and organic silt-clay of low plasticity	*	N/A	N/A
MH	Inorganic silt micaceous or diatomaceous silty soil	*	N/A	N/A
CH	Inorganic clay of high plasticity, fatty clays	*	N/A	N/A
OH	Organic clay medium to high plasticity	*	N/A	N/A

S 3 MPH **L 8"** **P 7**

(d) STEP #3: Determine Operator/Time Factor (E). Due to the fact an operator cannot physically operate a Vibratory compactor for more than 50 minutes without a break, it is necessary to figure an efficiency factor. This is taken from the table below.

E .83

TABLE 22-8
Efficiency factors for compaction equipment

	WORKING HOURS	EFFICIENCY FACTOR
DAY OPERATIONS	50 MIN/HR 45 MIN/HR	0.83 0.75
NIGHT OPERATIONS	50 MIN/HR 45 MIN/HR	0.75 0.67

(e) STEP #4: Production Calculation. At this point, take all the information gathered and place in the formula below.

$$\frac{16.3 \times W \times S \times L \times E}{P}$$

$$\frac{16.3 \times 6' \times 3\ \text{MPH} \times 8'' \times .83}{7} = 278.31 \quad \text{OR } 278\ \textbf{CCYPH}$$

(ON SLIDE #252, 253)

(f) STEP #5: TOTAL HOURS REQUIRED

TOTAL QUANTITY TO BE COMPACTED

$$\frac{1{,}500}{278 \times 1} = 5.40 \quad \textbf{TOTAL HOURS REQUIRED}$$

CCYPH X # OF COMPACTORS

(g) STEP #6: TOTAL PRODUCTION (DAYS)

HOURS REQUIRED 5.40 ÷ 8 HOURS WORKED A DAY = .68 OR 1 DAY

ROUND DAYS TO NEXT FULL DAY

(ON SLIDE #254)

(h) RATIO OF LCYPH TO COMPACTORS (IF NEEDED). This is a logistical concern that should be asked if there is more than one compactor available.

$$\frac{\textbf{AMOUNT DELIVERED/HOUR} \times \textbf{SOIL CONVERSION}}{\textbf{CCYPH}} = \textbf{COMPACTOR REQUIRED}$$

NOTE: ALWAYS ROUND UP

TABLE #1-1 SOIL CONVERSION FACTORS

SOIL	INITIAL CONDITION	BANK(IN PLACE)	LOOSE	COMPACTED
SAND OR GRAVEL	BANK (IN PLACE) LOOSE COMPACTED	* .90 1.05	1.11 * 1.17	.95 .86 *
LOAM	BANK (IN PLACE) LOOSE COMPACTED	* .80 1.11	1.25 * 1.39	.90 .72 *
CLAY	BANK (IN PLACE) LOOSE COMPACTED	* .70 1.11	1.43 * 1.59	.90 .63 *
ROCK (BLASTED)	BANK (IN PLACE) LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *
CORAL COMPARABLE TO LIMESTONE	BANK (IN PLACE) LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *

INTERIM TRANSITION: Are there any questions over compactor estimations? Now let's move into some practical application on these steps.

____
____
____

(ON SLIDE #255-257)

INSTRUCTOR NOTE

Introduce the following practical application (17). Have the students do the problems 1 and 2.

PRACTICAL APPLICATION (17). **(30 MIN)** Have the students complete the problems in the student handout.

PRACTICE: There are two problems in the student handout for the students to complete. The problems cover production estimation for the compactor.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. Safety Brief: There are no safety concerns.
2. Supervision & Guidance: Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. Debrief: Are there any questions or comments concerning the conversion of basic dimensions to cubic yards? In order to progress further, you must have an understanding of the conversion.

WHAT HAVE YOU LEARNED ?

PROBLEM #1: Your platoon has been tasked with an airfield construction project. You have estimated that your scrapers will be delivering 600 LCYPH of fill material. The total amount to be compacted is 20,000 CY. The compaction will be performed with a self-propelled vibratory roller with a 6-foot compaction width during daylight hours. Job conditions are as follows:

TYPE OF FILL MATERIAL	SAND
OPTIMUM DEPTH OF LIFT	8 INCH (COMPACTED)
NUMBER OF PASSES REQUIRED	14
AVERAGE SPEED OF COMPACTORS	3 MPH
WORKING HOURS	45 MIN/HR
7 hrs per day	

REQUIREMENT: Determine how many compactors are required to support this fill operation.

SOLUTION:

$$\frac{16.3 \times 6 \times 3 \times 8 \times .75}{14} = \mathbf{125.74 \text{ or } 125 \text{ CCYPH}}$$

600	SOIL BEING DELIVERED
x .86	CON FAC
516	
÷ 125	CCYPH
4.13	
OR 5	**COMPACTORS REQUIRED**

PROBLEM #2: Your platoon has been tasked for a road construction project. You will have 880 LCY of fill material per hour delivered by 5-ton dump trucks. The total amount to be compacted is 10,000 CCY. The compaction will be performed with a self-propelled vibratory roller with a 6-foot compaction width during the night. Job conditions are as follows:

TYPE OF FILL MATERIAL	CLAY
OPTIMUM DEPTH OF LIFT	6 INCH (COMPACTED)
NUMBER OF PASSES REQUIRED	5
AVERAGE SPEED OF COMPACTORS	2 MPH
WORKING HOURS	50 MIN/HR

REQUIREMENT: Determine how many compactors are required to support this fill operation.

SOLUTION:

$$\frac{16.3 \times 6 \times 2 \times 6 \times .75}{5} = \mathbf{176.04 \text{ or } 176 \text{ CCYPH}}$$

880	SOIL BEING DELIVERED
x .63	CON FAC
554.40	
÷ 176	CCYPH
3.15	
OR 4	**COMPACTORS REQUIRED**

INSTRUCTOR NOTE

Hand out homework assignments 8, 8A, 8B.

(ON SLIDE #258)

TRANSISTION: Are there any questions or comments concerning production on the compactor?

____

____

____

OPPORTUNITY FOR QUESTIONS:

1. QUESTIONS FROM THE CLASS

2. <u>**QUESTIONS TO THE CLASS:**</u>

a. What type of compactor does the Marine Corps have?

Vibratory.

TRANSITION: Now that we have covered the compactor, are there any questions? Let's move right into our last production estimation formula, the dump truck.

____
____
____

(ON SLIDE #259)

11. DUMP TRUCKS (4 HRS)

(ON SLIDE #260-268)

NOTE: THE MOST COMMON HAULING EQUIPMENT USED FOR MILITARY PURPOSES ARE THE 2-1/2, 5, 7 TON (MK29-MK30), 15 TON AND 20-TON DUMP TRUCKS. THE 2 1/2 TON TRUCK IS CAPABLE OF HAULING 2 1/2 CUBIC YARDS OF MATERIAL. THE 5-TON TRUCK IS CAPABLE OF HAULING 5 CUBIC YARDS. THE 7 TON 6.5 CUBIC YARDS. THE 20-TON TRUCK, WIDELY USED IN QUARRY OPERATIONS, CARRIES 12 CUBIC YARDS. **SPECIAL ATTENTION MUST BE PAID TO THE WEIGHT OF SOIL LOADED SO AS NOT TO EXCEED THE WEIGHT LIMITATIONS OF THE VEHICLE.**

a. USE: Dump trucks are the most common hauling equipment for the engineers. Their primary purpose is to haul and deliver material. Dump trucks are also used to transport troops and equipment in support of the unit mission. The trucks are equipped with a towing hook and are a tremendous asset for moving equipment and trailers. Trucks equipped with winches are valuable for recovery operations.

b. CLASSIFICATION: Dump trucks are classified by the weight they carry in tons, by the truck volume in cubic yards, or by the heaped capacity in cubic yards. For example, a 5 ton truck is capable of carrying 5.88 cubic yards of loose dry clay weighing 1,700 pounds per loose cubic yard but is restricted to the 5 cubic yard capacity. Wet clay weighing 3200 pounds per cubic yard, for instance, would be restricted to the 5 ton capacity.

c. CHARACTERISTICS: Dump trucks are characterized by a hydraulic lift cylinder that is used to raise and lower a bed. Most trucks are capable of all wheel drive that permits operation in different terrains. The raised bed can create problems when operated around overhead utilities. The bed also becomes top heavy when fully raised, so caution should be exercised when operating on side slopes. For the safest operation, the assistant operator should dismount the truck and ground guide the operator.

d. OPERATION: Dump trucks are hydraulically operated and powered by a diesel engine. Haul at the highest safe speed (without speeding) and in the proper gear. Speeding is unsafe and hard on the equipment. When several trucks are hauling, it is essential to maintain the proper speed to prevent hauling delays or bottlenecks at the loading or dumping site. Slow trucks, as well as speeding ones, disrupt normal traffic patterns. Until the maintenance crew can repair a sluggish truck, replace it with a standby truck. Lay out traffic patterns in loading and dumping sites to minimize backing, passing, and cross traffic. Keep truck bodies clean and in good condition. Accumulations of rust, dirt, dried concrete or bituminous materials hamper dumping operations. The time spent cleaning and oiling truck bodies must be considered in computing transportation requirements. The 900 series dumps cannot raise the bed and move forward at the same time. Whereas the 800 series, and the MK29/MK30 can; allowing them to spread the loaded material. Capacities of dump trucks are expressed two ways.

(1) TONS (USE TABLE 23-9, 1-3.1 AND 1-12.1 OR CHECK DATA PLATE FOR LOAD WEIGHT.)

(2) CUBIC YARDS (USE TABLE 23-9 FOR CY OR CALL MOTOR TRANSPORT)

TABLE 23-9 TRUCK VOLUMES

TYPE OF TRUCK	LOAD CAPACITY IN POUNDS	STRUCK VOLUME IN LCY	HEAP VOLUME IN LCY
2 1/2 TON	5,000	call MT for volume	call MT for volume
5 TON	10,000	5 LCY	7.5 LCY
20 TON	40,000	call MT for volume	call MT for volume

NOTE: TABLE 23-9 INFORMATION COMES FROM TM 9 2320-260-10 AND TM 9 2320-2720-10

TABLE 1-3.1 Weights – MK29 and MK30

Item	Specification
Weight of MTVR w/Empty Dump MK29 (w/o winch)	29,938 lbs (13,592 kg)
MK30 (w/winch)	30,618 lbs (13,901 kg)
Weight of MTVR w/Full Dump Body	58,618 lbs (26,613 kg)
Weight of Payload (Permissible Capacity) Hwy	28,000 lbs (12,712 kg)
C/C	12,200 lbs (5,539 kg)
Maximum weight of Dump Body and Payload Hwy	58,618 lbs (26,613 kg)
C/C	42,818 lbs (19,439 kg)

TABLE 1-12.1 Dump Body (MK29 and MK30)

Item	Specification
Struck Payload Capacity – Paved Surface	21,060 lbs (9,561 kg)
Heaped Payload Capacity – Paved Surface	28,000 lbs (12,712 kg)
Struck or Payload Capacity – Cross Country	14,200 lbs (6,447 kg)
Recommended Personnel Capacity	16 (NOTE: Also Refer to paragraph 2-31 for warning information)

NOTE: TABLE 1-3.1 AND 1-12.1 INFORMATION COMES FROM TM 10629-10B

*****FOR CLASSROOM PURPOSES DO NOT EXCEED 10CY (20,000LBS) CAPACITY***** (OUTSIDE THE CLASSROOM, NOTE THE TYPE OF SURFACE YOU ARE TRAVELING ON, THIS WILL CHANGE THE CAPACITY)

(ON SLIDE #269)

e. PRODUCTION: Other than scrapers, dump trucks are the primary haul units for earth work in the military inventory. Primarily, dump trucks are used for hauling, dumping, spreading base course and surfacing materials, hauling other material incident to construction, and for general hauling where distance is greater than 5000 feet. There are twelve steps to calculating dump truck production, starting with soil weight.

(ON SLIDE #270)

(1) STEP #1 ACTUAL SOIL WEIGHT: To determine the actual soil weight per cubic yard, take the dry soil weight from (Table #2-2).

INTERIM TRANSITION: Are there any questions? Now I will give you several demonstrations on the first eleven steps of dump truck estimations?

____
____
____

INSTRUCTOR DEMONSTRATION (2 min)

Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE:

EARTH LOAM DRY IS _2200 lbs_. PER CUBIC YARD

TABLE #2-2
APPROXIMATE WEIGHT OF SOIL

SOIL	CONVERTED FROM:	BANK	LOOSE	COMPACTED
SAND OR GRAVEL	BANK	*	1.11	.95
	LOOSE	.90	*	.86
	COMPACTED	1.05	1.17	*
LOAM	BANK	*	1.25	.90
	LOOSE	.80	*	.72
	COMPACTED	1.11	1.39	*
CLAY	BANK	*	1.43	.90
	LOOSE	.70	*	.63
	COMPACTED	1.11	1.59	*
ROCK (BLASTED)	BANK	*	1.50	1.30
	LOOSE	.67	*	.87
	COMPACTED	.77	1.15	*
CORAL COMPARABLE TO LIMESTONE	BANK	*	1.50	1.30
	LOOSE	.67	*	.87
	COMPACTED	.77	1.15	*

(a) MOISTURE CONTENT

Initial soil weight x moisture content = actual soil weight

INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE:

2200	**LBS. WEIGHT OF DRY EARTH LOAM PER CY FROM TABLE 2-2**
X 1.07	**100% OF SOIL WEIGHT + 7% MOISTURE**
2354	**LBS. *ACTUAL SOIL WEIGHT* (ASW)**

(ON SLIDE # 271)

(2) STEP #2: CUBIC YARDS OF A LOAD: Remembering that you want to keep the weight of the load under 20,000 lbs, determine how many cubic yards can be hauled without exceeding 20,000 lbs. To do this, divide 20,000 by the listed soil weight per cubic yard.

20,000	**LBS (RATED CAPACITY)**
÷ 2,354	**ASW FROM STEP #1**
8.50	***CY OR NO MORE THAN 10 CY***

(a) *If the resulting figure is over 10 cubic yards*, you must go with 10. It is the maximum cubic yards that the MTVR series can haul. If the resulting figure is less than 10, use that figure in step 3. (***NOTE: NO MORE THAN MAX VOLUME OF TRUCK***)

(ON SLIDE # 272)

(3) STEP #3: BUCKETS LOADED: To Determine the number of buckets loaded that is equal to or less than the figure determined in step #2. Divide that figure, in this case 4.25, by the size of each bucket load which for the TRAM is 2 1/2 or 2.5.

8.50	**CUBIC YARDS**
÷ 2.5	**CUBIC YARDS (BUCKET SIZE FROM TABLE)**
3.40	**OR 3 *BUCKETS LOADED***

NOTE: ROUND DOWN TO WHOLE BUCKETS.

TABLE #3-2
BUCKET SIZE

TRAM 624KR	2 1/2 or 2.5 CY
MC1155E	1 3/4 or 1.75 CY
MAC-50 CLAMSHELL	1.25 CY
420E IT FRONT BUCKET	1 ¼ or 1.25 CY
420E IT BACKHOE BUCKET	¼ or .25 CY

(ON SLIDE # 273)

(4) STEP #4 ACTUAL LOAD SIZE OR VOLUME: To determine the volume of the load take the answer from Step #3, 1 bucket per load, and multiply by the bucket size (2.5 for a TRAM).

3 **# OF BUCKETS**
x 2.5 **TRAM BUCKET SIZE**
7.5 ***ACTUAL LOAD SIZE (ALS)***

NOTE: NEVER ROUND OFF LOAD SIZE OR VOLUME.

(ON SLIDE # 274)

(5) STEP #5 LOAD WEIGHT: Regardless of how much volume that you may be able to haul, you should try to keep your load weight under 10,000 pounds. Table #2-2 shows the weight of cinders as 1200 pounds per loose cubic yard. A struck load would weigh 6,000 pounds, while the heap load would weigh 9,000 pounds. These weights would be easily hauled, but it is a different story with other materials. Take a look at Earth Loam, Wet for instance:

TABLE #2-2

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

INSTRUCTOR DEMONSTRATION (2 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: OF OVERLOADING

3,200 Weight of Earth loam WET, PER/CY
X 10 (LCY) Struck
32,000 LBS. STRUCK LOADED

3,200 Weight of Earth loam WET, PER/CY
X 14 (LCY) Heaped
44,800 LBS. HEAPED LOADED

(a) As you can see, the struck load and the heaped load are over the 20,000-pound limit. Therefore, if you are going to be hauling this type of material, you must determine how many loads the loader can put on the dump and still keep the weight of the load within the acceptable weight limits.

(b) Each cubic yard weighs 2354 lbs (Step #1) and you are hauling 7.5 cubic yards. Therefore the weight of your load will be 17,655 lbs.

2354 **ASW (FROM STEP #1)**
x 7.5 **ALS**
17,655 ***LOAD WEIGHT (LW)***

NOTE: NOW THAT YOU KNOW THAT YOU ARE NOT OVERLOADED, YOU CAN CALCULATE YOUR CYCLE TIME.

(ON SLIDE # 275-277)

(6) STEP #6: CYCLE TIME: **To get your travel speed look at the table below, (This Table is for classroom purposes only).**

TABLE 24-9 TRAVEL SPEED

LOADED	**35 MPH**
EMPTY	**50 MPH**

The following table contains the maximum allowable speed for the MK29 and MK30. They have to be set according to the type of terrain.

TABLE 2-9 Maximum Allowable Speed

Terrain setting	Max. Allowable Speed	Driveline Lock Configuration
Highway	65 mph (105 km/h)	No Driveline lock
Cross Country	40 mph (64 km/h)	No Driveline lock
Mud/Sand/Snow	15 mph (24 km/h)	T-Case and Inter-axle
Emergency	5 mph (8 km/h)	T-Case and Inter-axle, and Rear Intra-axle

NOTE: TABLE 2-9 INFORMATION COMES FROM TM 10629-10B PAGE 2-174

(a) To figure Cycle Time (CT) you first must figure Travel Time (TT). To get Travel Time divide the sum of the Travel Speed (TS) in MPH multiplied by 88. Do this for haul and return. The Total Travel Times equal Total Cycle Time.

NOTE: **88** is the conversion factor to change the speed in MPH to feet traveled per minute.

HAUL :

Distance in feet
____
MPH TS X 88 = __________ HAUL Time (HT)

RETURN :

Distance in feet
____
MPH TS X 88 = __________ RETURN Time (RT)

______ + ______ + 2 = ______
HT + RT + 2 MIN FXT = CT

NOTE: USE 2 MIN. AS A CONSTANT FIXED TIME FOR DUMP TRUCKS IN THE CLASS ROOM.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

Example #1: A dump truck travels 7500 feet to the fill area at 35 mph and returns by a different route of 8200 feet at 50 mph. What is the total cycle time?

HAUL :

Distance in feet
7500 ft.
____
35 TS X 88 = 2.44 HAUL Time (HT)

RETURN **:**

Distance in feet

$$\frac{8200 \text{ ft}}{50 \text{ TS X } 88} = \underline{1.86} \quad \text{RETURN Time (RT)}$$

2.44	+	1.86	+	2 MIN	=	6.30
HT	+	RT	+	2 MIN FXT	=	CT

(ON SLIDE # 278)

(7) <u>STEP #7 TRIPS PER HOUR:</u> To determine Trips Per Hour (TPH) divide the working minutes per hour by the cycle time.

WORKING MIN. PER/HR
CYCLE TIME **=** ***TRIPS PER HOUR (TPH)***

NOTE: NEVER ROUND OFF TPH

> **INSTRUCTOR DEMONSTRATION (2 min)**
> Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: How many trips per hour can a dump truck make during a 60-minute work hour and a cycle time of 6.30 min/trip?

$$\frac{60 \text{ MIN. PER/HR}}{6.30 \text{ CT}} = 9.52 \text{ TPH}$$

NOTE: NEVER ROUND TPH

(ON SLIDE # 279)

(8) <u>STEP #8 PRODUCTION RATE:</u> To determine the Production Rate, you must know the size of the load, the Number Of trips Per Hour, and the Efficiency of the operator.

____	x	____	x	____________	=	____________
TPH	**X**	**ALS**	**X**	**EFFICIENCY FACTOR**	**=**	**(LCYPH)**

TABLE #7-2 EFFICIENCY FACTOR

TYPE UNIT	OPERATOR	DAY	NIGHT
TRACKED	EXCELLENT AVERAGE POOR	1.00 .75 .60	0.75 .56 .45
WHEELED	EXCELLENT AVERAGE POOR	1.00 .60 .50	.67 .40 .33

INSTRUCTOR DEMONSTRATION (1 min)

Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: What is the basic production rate of a dump truck with an average operator, working a day shift, making 9.52 TPH, with a load of 2.5 LCY?

9.52	X	7.5	X	0.60	=	42.84 OR 42
TPH	**X**	**ALS**	**X**	**EFFICIENCY FACTOR**	**=**	**(LCYPH)**

NOTE: ROUND DOWN (LCYPH)

(ON SLIDE #280)

(9) STEP #9 SOIL CONVERSION (IF NEEDED): In some cases basic production rate may be needed in compacted cubic yards (CCY) for a road or runway.

______	X	______________	=	______________
(LCYPH)	**X**	***CONVERSION FACTOR***	**=**	**(____CYPH)**

TABLE #1-1
SOIL CONVERSION FACTORS

SOIL	CONVERTED FROM	BANK(IN PLACE)	LOOSE	COMPACTED
SAND OR GRAVEL	BANK LOOSE COMPACTED	* .90 1.05	1.11 * 1.17	.95 .86 *
LOAM	BANK LOOSE COMPACTED	* .80 1.11	1.25 * 1.39	.90 .72 *
CLAY	BANK LOOSE COMPACTED	* .70 1.11	1.43 * 1.59	.90 .63 *
ROCK(BLASTED)	BANK LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *
CORAL COMPARABLE TO LIMESTONE	BANK LOOSE COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE: What is the production rate in (CCY) for a dump with a basic production rate of 14 lcy/hr, working in loam.

42 X .72 = 30.24 OR 30
LCYPH X *CONVERSION FACTOR* = (C CYPH)

NOTE: ROUND DOWN (__CYPH)

(ON SLIDE #281, 282)

(10) STEP #10 RATIO OF TRUCKS TO SCOOP LOADER

(a) The number of trucks to keep one scoop loader moving with no down time is found in the formula below (Ref FM 5-434/PG 10-4).

TCT (Tractor Cycle Time) *FROM STEP 6
LCT (Loader Cycle Time) + 1 = Trucks Req

(b) To get the Loader cycle time use the below formula.

(Bucket Cycle Time x Number of Buckets) ÷ 60 seconds = Loader Cycle Time
(Given) (From Step 3) (constant)

EXAMPLE:

$$\frac{\text{6.30 TRUCK CYCLE TIME}}{\text{1.75 LOADER CYCLE TIME}} + 1 = 3.60 + 1 = 4.60 \text{ OR 4 TRUCKS}$$

35 SEC BUCKET TIME X 3 BUCKETS ÷ 60 SEC = 1.75 LCT

(ON SLIDE #283)

(11) STEP #11 TOTAL HOURS REQUIRED TO COMPLETE MISSION: To determine the total time required to complete the mission, you must know the total volume to be moved, the basic production rate, and the number of trucks you will use on the job.

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE:

$$\frac{\text{1,900 (C CY)}}{\text{30 (C CYPH) X 4 DUMP TRUCKS}} = \text{15.83 (hr) REQUIRED}$$

NOTE: NEVER ROUND OFF TIME.

(ON SLIDE #284)

(12) STEP #12: TOTAL PRODUCTION (DAYS): To get the production days required to complete the mission, divide total time required by the hours worked per day, which will equal the total number of days required.

TOTAL HOURS REQUIRED ÷ HOURS WORKED PER DAY = TOTAL PRODUCTION DAYS

INSTRUCTOR DEMONSTRATION (1 min)
Present the below example, reference the students to the power point and white board. Ensure this is explained step by step.

EXAMPLE:

$$\frac{15.83}{8} = 1.98 \text{ OR 2 TOTAL DAYS}$$

NOTE: ROUND UP DAYS TO THE NEXT FULL DAY.

(ON SLIDE #285-289)

INTERIM TRANSITION: Are there any questions over the first eleven steps of dump truck estimations? Now let's move into some practical application on these steps.

____
____
____

INSTRUCTOR NOTE

Introduce the following practical application (18).

PRACTICAL APPLICATION (18). **(2 HRS)** Have the students complete the problems in the student handout.

PRACTICE: There is one problem in the student handout for the students to complete. The problems are dump truck production.

PROVIDE-HELP: Instructor will answer questions as they arise and assist students having difficulty.

1. **Safety Brief**: There are no safety concerns.
2. **Supervision & Guidance:** Instructors will walk around the classroom and answer questions as they may arise. Instructor may use the dry-erase board to wall through the problems. Upon completion instructors will progress to the next power point slide which contains the answers for the problems in the student handout. Clarify understanding of the material and answer any questions.
3. **Debrief:** Are there any questions or comments concerning first eleven steps of dump truck production? Now we have continue with dump truck production estimations

WHAT HAVE YOU LEARNED?

PROBLEM: A project requires you to build a road using clay with an 8% moisture content. How many days are required, at 10 hours per day, to complete the project? Also, figure the total number of 7 ton dump trucks needed. The job conditions are as follows. Show and label all figures and formulas.

COMPACTED FILL REQUIRED --------------------- 170,000 CY

CLASS OF EARTH FOR SOIL CONVERSION----------- CLAY

INITIAL MOISTURE CONTENT -------------------- 8%

AVERAGE HAUL DISTANCE ---------------------- 6600 FT

AVERAGE RETURN DISTANCE---------------------- 6600 FT

AVERAGE OPERATORS---------------------------- WORKING 60 MIN/HR

TRUCKS ARE LOADED BY TRAM WITH 2 1/2 CY BUCKET

TRAM BUCKET TIME IS 30 SECONDS

SOLUTION:

	2,000	DRY CLAY
x	1.08	MOISTURE
	2,160	**ASW**

	20,000	MAX LOAD SIZE
÷	2,160	ASW
	9.26	**CY OF THE LOAD**

	9.26	CY OF THE LOAD
÷	2.5	BUCKET SIZE
	3.70	
	OR 3	**BUCKETS LOADED**
x	2.5	ALS
	7.5	**ALS**

	2,160	ASW
x	7.5	ALS
	16,200	LW

$$\frac{6{,}600 \text{ HD}}{35 \times 88} = \mathbf{2.14 \text{ HAUL TIME (HT)}}$$

$$\frac{6{,}600 \text{ RD}}{50 \times 88} = \textbf{1.50 RETURN TIME (RT)}$$

2.14	+	**1.50**	+	**2.00**	=	**5.64**
HAUL TIME		RETURN TIME		FIXED TIME		CYCLE TIME

```
          60    MIN/HR
÷   5.64  CT
   10.64  TPH

   10.64  TPH
     7.5  ALS
x     .6  EF
   47.88
   OR 47  LCYPH

      47  LCYPH
x    .63  CONV FACTOR
   29.31
   OR 29  CCYPH

    5.64  TCT
÷   1.50  LCT
    3.76
+    1.00
     4.76
    OR 4    TRUCKS REQUIRED

   170,000   FILL REQUIRED
÷ (29 x 4)
   1465.52   THR

   1465.52
÷       10
    146.55
OR 147 DAYS REQUIRED
```

INSTRUCTOR NOTE
Hand out homework assignments 9, 9A, 9B, 9C, 9D.

TRANSITION: Now that we have completed all the steps required for dump truck estimations, are there any questions?

____

____

____

(ON SLIDE #290)

OPPORTUNITY FOR QUESTIONS:

1. **QUESTIONS FROM THE CLASS**

2. **QUESTIONS TO THE CLASS:**

a. What factors need to be considered when loading a dump truck?

Weight of the soil, condition of the traveling surface, experience of the operator, to name a few.

b. What is the loaded MAX speed?

35 MPH

c. What is the empty MAX speed?

50 MPH

(BREAK - 10 Min)

INSTRUCTOR NOTE
Hand out quiz #3. (40 MINS)

INSTRUCTOR NOTE
Administer Production Estimations Exam C (4HRS)

(ON SLIDE #291)

SUMMARY **(10 MIN)**

During this period of instruction, we have covered Production estimations for the scraper, crawler tractor, scoop loader, back hoe, clamshell, compactor, and dump truck Accurate estimations for these essential items ensures mission accomplishment, builds junior Marines confidence in leaders through successful planning to prepare estimates for horizontal construction projects utilizing heavy construction equipment deployed by the Marine Corps Table of Equipment in order to detail and brief accurate time, materials, and equipment required for completion of a construction project.

(BREAK - 10 Min)