Solution to Homework Set #4
CE 327 - Spring 2009
Assigned Mo, 4/20 Due Mo, 4/27

Problem 1

Textbook: 8.4 (condition 2 only)

Also, assume typical cycle element times as follows:

Load bucket	9 sec
Swing with Load	5 sec
Dump Load	3 sec
Return Swing	5 sec

Use Optimum height (depth) = 50% of maximum height.

***** SOLUTION *****

Optimum height = (0.50)(35) = 17.50 ft.
Total time for cycle = 9 + 5 + 3 + 5 = 22 sec
Fill factor (Table 8-7) = 100–110% → Use 105%
Ideal production per 60-min hour = (60 min / (22 sec/60 sec per min))(5yd^3)(1.05)
= 859 lcy / hr

Condition 2:

Percent optimum height = 18/17.5 * 100 = 102.86%
Height/Angle factor (Table 8-8) = 0.996
Efficiency factor = 40/60 = 0.6667
Production = (859)(0.996)(0.6667) = 570.38 lcy / hr
Cost = \$96 / 570.38 = **\$0.168 / yd^3**

Problem 2

Textbook: 9.2

$$\text{Total time} = \frac{2 \times 1{,}800\,\text{ft}}{88 \times 3.0\,\text{mph} \times 0.60} + \frac{3 \times 1{,}800\,\text{ft}}{88 \times 4.3\,\text{mph} \times 0.60}$$

$= 22.7 \text{ min} + 23.8 \text{ min} \Rightarrow 46.5 \text{ min}$

Problem 3

Textbook: 10.2

Gross vehicle weight: 70,000 lb

Grade resistance, plus 4% = 4.0%

Rolling resistance: $\frac{90\,lb/ton}{20\,lb/ton}$ = 4.5%

Total resistance = 8.5%

Required rimpull, 0.085 × 70,000 = 5,950 lb

Using Figure 10-9 go vertically up the 70,000 lb vehicle weight ordinate and intersect the sloping line indicating a total resistance of 8.5%. Then go horizontally to the right into the adjacent figure to intersect the third gear curve.

From this intersection go vertically downward to an indicated maximum speed of 12.5 mph.
An alternate procedure is to go horizontally to the left from 5,950 lb on the rimpull ordinate to intersect the curve for the third gear and again go vertically downward to a maximum speed of **12.5 mph.**

Problem 4

Textbook: 10.6

Rear-dump trucks used to haul poorly blasted rock. The performance chart shown in Fig. 10-9 is valid for these trucks.
Capacity: (1) 15 cu yd, net weight empty 44,000 lb; (2) 20 cu yd, net weight empty 50,000 lb
The shovel has a 3½ cu-yd bucket and 26 sec cycle time. The haul road from the borrow site to the fill is 4 miles up a 2%grade. Rolling resistance of the haul road is 4%.

Step 1. Number of bucket loads.
The bucket fill factor for a shovel handling poorly blasted rock is 85-100%, problem statement use 100%. The shovel bucket volume will be 3.5 lcy (3½ × 1.0). The heaped capacities of the trucks are 15 and 20 lcy.

$$\text{Balance Number of bucket loads} = \frac{15\ \text{lcy}}{3.5\ \text{lcy}}$$

Balance number of bucket loads (15 cu-yd truck) = 4.3
The actual number of bucket should be an integer number, therefore two cases should be investigated, either placing 4 or 5 bucket loads on the truck.

$$\text{Balance Number of bucket loads} = \frac{20\ \text{lcy}}{3.5\ \text{lcy}}$$

Balance number of bucket loads (20cu-yd truck) = 5.7
The actual number of bucket should be an integer number, therefore two cases should be investigated, either placing 5 or 6 bucket loads on the truck.

Step 2. Load time. Check production based on possible situations, 4, 5 or 6-bucket loads to fill the trucks.

Load time (4 buckets) $4 \times \frac{26\ \text{sec}}{60\ \text{sec per min}} = 1.73\ \text{min}$

Load volume (4 buckets) 4 × 3.5 lcy/bucket load = 14 lcy
Load weight 14 lcy × 2,600 lb per lcy = 36,400 lb

Load time (5 buckets) $5 \times \frac{26\ \text{sec}}{60\ \text{sec per min}} = 2.17\ \text{min}$

Load volume (5 buckets) 15 cu-yd trk: equals truck capacity 15 lcy, excess spills off
20 cu-yd truck: 5 × 3.5 lcy/bucket load = 17.5 lcy
Load weight, 15 cu-yd truck 15 lcy × 2,600 lb per lcy = 39,000 lb

Load weight, 20 cu-yd truck 17.5 lcy × 2,600 lb per lcy = 45,500 lb

Load time (6 buckets) $6 \times \frac{26 \text{ sec}}{60 \text{ sec per min}} = 2.60 \text{ min}$

Load volume (6 buckets) equals truck capacity 20 lcy, excess spills off.

Load weight, 20 cu-yd truck 20 lcy × 2,600 lb per lcy = 52,000 lb

Step 3. Haul time.

Rolling resistance 4%, given

Grade resistance 2%

Total resistance 6.0% (4.0% + 2%)

	15 cu-yd truck		**20 cu-yd truck**	
	4 buckets	5 buckets	5 buckets	6 buckets
Empty trk net wt	44,000 lb	44,000 lb	50,000 lb	50,000 lb
Load weight	36,400 lb	39,000 lb	45,500 lb	52,000 lb
Gross Weight	80,400 lb	83,000 lb	95,500 lb	102,000 lb
Speed (Fig. 10-9)	12.5 mph	12.5 mph	12.5 mph	12.0 mph

Haul time (12.5 mph) $\frac{4 \text{ miles} \times 5280 \text{ ft / mile}}{88 \times 12.5 \text{ mph}} = 19.2 \text{ min}$

Haul time (12.0 mph) $\frac{4 \text{ miles} \times 5280 \text{ft / mile}}{88 \times 12 \text{mph}} = 20.0 \text{ min}$

Step 4. Return time.

Rolling resistance 4%

Grade resistance -2%

Total resistance 2% [4% + (- 2%)]

(1) 15 cu yd, net weight empty 44,000 lb

(2) 20 cu yd, net weight empty 50,000 lb

Speed (Fig. 10-9) 35 mph

Return time $\frac{4 \text{ miles} \times 5280 \text{ft / mile}}{88 \times 35 \text{ mph}} = 6.86 \text{ min}$

Step 5. Dump time.

Expected dump time 1.5 min.

Step 6. Truck cycle time

	15 cu-yd truck		**20 cu-yd truck**	
	4 buckets	5 buckets	5 buckets	6 buckets
Load time	1.73 min	2.17 min	2.17 min	2.60 min
Haul time	19.20 min	19.20 min	19.20 min	20.00 min
Dump time	1.50 min	1.50 min	1.50 min	1.50 min
Return time	6.86 min	6.86 min	6.86 min	6.86 min
Truck cycle time	29.29 min	29.73 min	29.73 min	30.96 min

Step 7. Number of trucks required.

	15 cu-yd truck		20 cu-yd truck	
	4 buckets	5 buckets	5 buckets	6 buckets
Truck cycle time	29.29 min	29.73 min	29.73 min	30.96 min
Load time	1.73 min	2.17 min	2.17 min	2.60 min
Number of trucks	16.9	13.7	13.7	11.9

Step 8. Production.

	15 cu-yd truck		20 cu-yd truck	
	4 buckets	5 buckets	5 buckets	6 buckets
Truck cycle time	29.29 min	29.73 min	29.73 min	30.96 min
Load time	1.73 min	2.17 min	2.17 min	2.60 min
Number of trucks	16.9	13.7	13.7	11.9
Production 11 trks	315 lcy	333 lcy	388 lcy	426 lcy
Production 12 trks	344 lcy	363 lcy	424 lcy	461 lcy
Production 13 trks	372 lcy	394 lcy	459 lcy	461 lcy
Production 14 trks	401 lcy	415 lcy	484 lcy	461 lcy
Production 15 trks	430 lcy	415 lcy	484 lcy	461 lcy
Production 16 trks	459 lcy	415 lcy	484 lcy	461 lcy
Production 17 trks	485 lcy	415 lcy	484 lcy	461 lcy

Problem 5

Textbook: 10.7

Rear-dump trucks used to haul wet gravel. The performance chart shown in Fig. 10-9 is valid for these trucks.

Capacity: 14 cu yd, net weight empty 44,000 lb

The hoe has a 3 cu-yd bucket and 24 sec cycle time. The haul road from the pit to the plant is 2.5 miles up a 3%grade. Rolling resistance of the haul road is 3%.

Cost of hoe $97/hr, trucks $49/hr

Step 1. Number of bucket loads.

The bucket fill factor for the hoe is 105%, from the problem statement. The hoe bucket volume will be 3.15 lcy (3 × 1.05). The heaped capacity of the truck is 14 lcy.

$$\text{Balance Number of bucket loads } \frac{14 \text{ lcy}}{3.15 \text{ lcy}} = 4.4$$

The actual number of bucket should be an integer number, therefore two cases should be investigated, either placing 4 or 5 bucket loads on the truck.

Step 2. Load time. Check production based on possible situations, 4, or 5-bucket loads to fill the trucks.

Load time (4 buckets) $$4 \times \frac{24 \text{ sec}}{60 \text{ sec per min}} = 1.6 \text{ min}$$

Load volume (4 buckets) 4 × 3.15 lcy/bucket load = 12.6 lcy

Load weight Table 4-1, wet gravel 2,980 lb per lcy

Load weight 12.6 lcy × 2,980 lb per lcy = 37,548 lb

Check load weight 37,548 lb < 40,000 lb OK

Load time (5 buckets) $$5 \times \frac{24 \text{ sec}}{60 \text{ sec per min}} = 2.0 \text{ min}$$

Load volume (5 buckets) 14 cu-yd trk: equals truck capacity 14 lcy, excess spills off

Load weight, 14 lcy × 2,980 lb per lcy = 41,720 lb

Check load weight 41,720 lb > 40,000 lb; would over load the truck if 5 buckets used

Step 3. Haul time.

Rolling resistance 3%, given

Grade resistance 3%

Total resistance 6.0% (3.0% + 3%)

	14 cu-yd truck
	4 buckets
Empty trk net wt	36,860 lb
Load weight	37,548 lb
Gross Weight	74,408 lb
Speed (Fig. 10-9)	12.5 mph

Haul time (12.5 mph) $$\frac{2.5 \text{ miles} \times 5280 \text{ ft / mile}}{88 \times 12.5 \text{ mph}} = 12 \text{ min}$$

Step 4. Return time.

Rolling resistance 3%

Grade resistance -3%

Total resistance 0% [3% + (- 3%)]

Speed (Fig. 10-9) 35 mph

Return time $$\frac{2.5 \text{ miles} \times 5280 \text{ft / mile}}{88 \times 35 \text{ mph}} = 4.29 \text{ min}$$

Step 5. Dump time.

Expected dump time 1.3 min.

Step 6. Truck cycle time

	14 cu-yd truck

	4 buckets
Load time	1.60 min
Haul time	12.00 min
Dump time	1.30 min
Return time	4.29 min
Truck cycle time	19.19 min

Step 7. Number of trucks required.

	14 cu-yd truck
	4 buckets
Truck cycle time	19.19 min
Load time	1.60 min
Number of trucks	12

Step 8. Production

	14 cu-yd truck
	4 buckets
Truck cycle time	19.19 min
Load time	1.60 min
Number of trucks	12
Production 12 trks	472 lcy
Cost hoe	$97
Cost 12 trks	$588
Total cost	$685
Cost per lcy	$1.45