

**School of Engineering and Information Technology
Federation University Australia
ENMIN 5018 Surface Mining Operations and Equipment**

ASSIGNMENT 1

(Weighting 60% of total unit marks)

All questions have an equal weight

Due date: 31 December 2016

1. Summarise the steps in the development of an open pit mine.
2. Define or describe the following terms
 - a. Bench height
 - b. Working bench
 - c. Crest
 - d. Cut
 - e. Toe
 - f. Safety bench/catch bench
 - g. Bench face angle
 - h. Back break
 - i. Berms
 - j. Bench floor
 - k. Angle of repose
 - l. Bench width
3. What are the purposes of safety benches? What is the width of a safety bench?
4. What is the width of a safety bench?
5. Discuss some of the aspects that enter into bench height selection
6. Draw a sequence of five benches. Label the crest, toe, bench face angle, bench width and bank width.
7. If the bench face angle is 65° , the bench width is 20m and the bench height is 12m determine the overall slope angle for a sequence of four benches.
8. Discuss the different aspects which must be considered when selecting the ore access location.
9. What is the difference between single and double spotting of trucks? Advantages? Disadvantages?
10. Using the data for the Caterpillar 777G haul truck given overleaf, answer the following questions:
 - a. Load distribution on the front and rear tyres loaded
 - b. Payload
 - c. Turning circle
11. In the design and construction of a mine haul road, what layers are involved? Describe each one starting at the lowest layer. Describe the considerations in determining layer thickness.
12. Suggest a haulage road width for two-way traffic involving Cat 777D trucks.
13. What is meant by the California Bearing ratio? How is it determined?



MODEL	777D		777G Tier 4F****		777G Tier 4F****	
Body Type	Dual Slope		Dual Slope		X-Body	
Gross Machine Weight	163 360 kg	360,143 lb	164 654 kg	363,000 lb	164 654 kg	363,000 lb
Chassis Weight*	50 610 kg	111,575 lb	52 241 kg	115,171 lb	52 241 kg	115,171 lb
Body Weight	16 687 kg	36,788 lb	16 075 kg	35,429 lb	15 878 kg	35,005 lb
Payload without Liner	95 996 kg	212,055 lb	96 338 kg	212,389 lb	96 535 kg	212,823 lb
Standard Liner Weight	5460 kg	12,040 lb	5695 kg	12,555 lb	4686 kg	10,331 lb
Target Payload**	90 536 kg	199,597 lb	90 643 kg	199,833	91 849 kg	202,492 lb
Capacity:						
Struck (SAE)	42 m ³	54.6 yd³	42 m ³	54.6 yd³	42 m ³	54.6 yd³
Heaped (2:1) (SAE)	60.2 m ³	78.6 yd³	60.2 m ³	78.6 yd³	60.2 m ³	78.6 yd³
Distribution Empty:						
Front		47%		41.8%		41.8%
Rear		53%		58.2%		58.2%
Distribution Loaded:						
Front		33%		33%		33%
Rear		67%		67%		67%
Engine Model	3508B EUI		C32 ACERT		C32 ACERT	
Number of Cylinders	8		12		12	
Bore	170 mm	6.7"	145 mm	5.7"	145 mm	5.7"
Stroke	190 mm	7.5"	162 mm	6.4"	162 mm	6.4"
Displacement	34.5 L	2105 in³	32.1 L	1959 in³	32.1 L	1959 in³
Net Power	699 kW	938 hp	683 kW	916 hp	683 kW	916 hp
Gross Power	746 kW	1000 hp	765 kW	1025 hp	765 kW	1025 hp
Standard Tires	27.00R49		27.00R49		27.00R49	
Machine Clearance Turning Circle	28.4 m	83'0"	28.4 m	83'0"	28.4 m	83'0"
Fuel Tank Refill Capacity	1137 L	300 U.S. gal	1137 L	300 U.S. gal	1137 L	300 U.S. gal
Top Speed (Loaded)	60.4 km/h	39.9 mph	67.0 km/h	41.7 mph	67.0 km/h	41.7 mph
GENERAL DIMENSIONS (Empty):						
Height to Canopy Rock Guard Rail	5.17 m	17'0"	4.91 m	16'1"	5.17 m	17'0"
Wheelbase	4.6 m	15'0"	4.6 m	15'0"	4.6 m	15'0"
Overall Length (Operating)	10.3 m	33'8"	10.3 m	33'8"	10.54 m	34'7"
Overall Length (Shipping)	9.78 m	32'1"	9.78 m	32'1"	9.78 m	32'1"
Loading Height (Empty)	4.39 m	14'5"	4.39 m	14'5"	4.38 m	14'4"
Height at Full Dump	10.05 m	33'0"	10.05 m	33'0"	10.33 m	33'11"
Body Length (Target Length)	7.28 m	23'11"	7.28 m	23'11"	7.28 m	23'11"
Width (Operating)	6.1 m	20'0"	6.1 m	20'0"	6.55 m	21'6"
Width (Shipping)***	3.51 m	11'5"	3.51 m	11'5"	3.51 m	11'5"
Front Tire Tread	4.17 m	13'8"	4.17 m	13'8"	4.17 m	13'8"

*Weights include lubricants, coolants and 100% fuel.
 **Refer to Caterpillar's 10/10/20 Payload Policy for Off-Highway Trucks.
 ***Disassembled.
 ****Gateless Coal Bodies are available through OEM Solutions.

14. The following road cross-section dimensions apply at a particular mining operation which uses Komatsu 930 trucks:
- Safety berm width 3.5 m
 - Tuck width 7.3 m
 - Space between trucks 5.0m
 - Width of drainage ditch 2.0m
 - Overall road width 25m
 - Bench face angle 75°

Draw the section. How well does this design correspond to the rules for two-way traffic?

15. In the design of a straight haulage road segment, what major factors should be considered? What is the design rule for road width for single way traffic?

16. Define what is meant by:
 - a. Stripping ratio
 - b. Overall stripping ratio
 - c. Instantaneous stripping ratio
17. What is meant by the term push-back?
18. What is meant by the term cutoff grade?
19. What is meant by struck capacity? What is meant by heaped capacity? What controls how full the dipper is actually filled?
20. Define the following terms:
 - a. Bank weight
 - b. Loose weight
 - c. Swell
 - d. Percent swell
 - e. Swell factor
 - f. Fillability
 - g. Fill factor
21. What is the general rule of thumb concerning matching of shovel loaders and haulers?
22. What is meant by rimpull? What is meant by tractive effort?
23. Discuss the concept of rolling resistance.
24. Sometimes rolling resistance is expressed in terms of % and sometimes in terms of kg/tonne. If the rolling resistance is 60 kg/tonne, what would be the equivalent value in %?
25. What is meant by the grade resistance? What is meant by the term total resistance? If rolling resistance is 3% and the grade resistance is 8%, what is the total resistance assuming the truck is travelling up an upwards grade? What is the total resistance if the truck is travelling downhill? In each of these cases which of the performance or retarder curves would be used?
26. What is autonomous haulage?
27. A dragline is to be selected to remove overburden at a rate of 395,000 bank cubic metres per month. If the dragline is scheduled to operate 720 hours per month which an operating efficiency of 0.8, the bucket fill factor is 0.8 and its cycle time is 50 seconds, what should be the size of its bucket?
28. Define the idealised output of a power shovel
29. Draw a plan and cross-section of a dragline casting overburden from a new strip to an old strip in a coal mining stripping situation for a single seam and for a two seam operation.
30. Define the following terms:
 - a. Availability
 - b. Operational availability
 - c. Mechanical availability
 - d. Physical availability
 - e. Utilization
 - f. Working efficiency
 - g. Job efficiency

31. The total cost of ore mining at an open pit is \$ 35per tonne and that for waste is \$ 25 per tonne. If the value of the ore is \$ 110 per tonne and the company requires a 10% profit margin, what is the maximum stripping ratio?
32. Differentiate between the following:
- Scheduled hours
 - Annual hours
 - Total hours
 - Working hours
 - Shift hours
 - Operating hours
33. For a 77t truck with Gross Vehicle Weight (GVW) of 136078 kg with dual rear tyres and a tyre inflation pressure is 120 psi (or 8.43 kg/cm²). Use the equivalent single tyre loading.
- Determine the contact surface area
 - If the sub-grade material is a firm or stiff clay, then determine the minimum required distance between the wearing surface and the top of the sub-grade.
 - With the same truck specifications, design an acceptable haul road (i.e. determine different thicknesses of different layers) using CBR method. Choose your own material for different layers with proper justifications. (Use the required conversion factors)

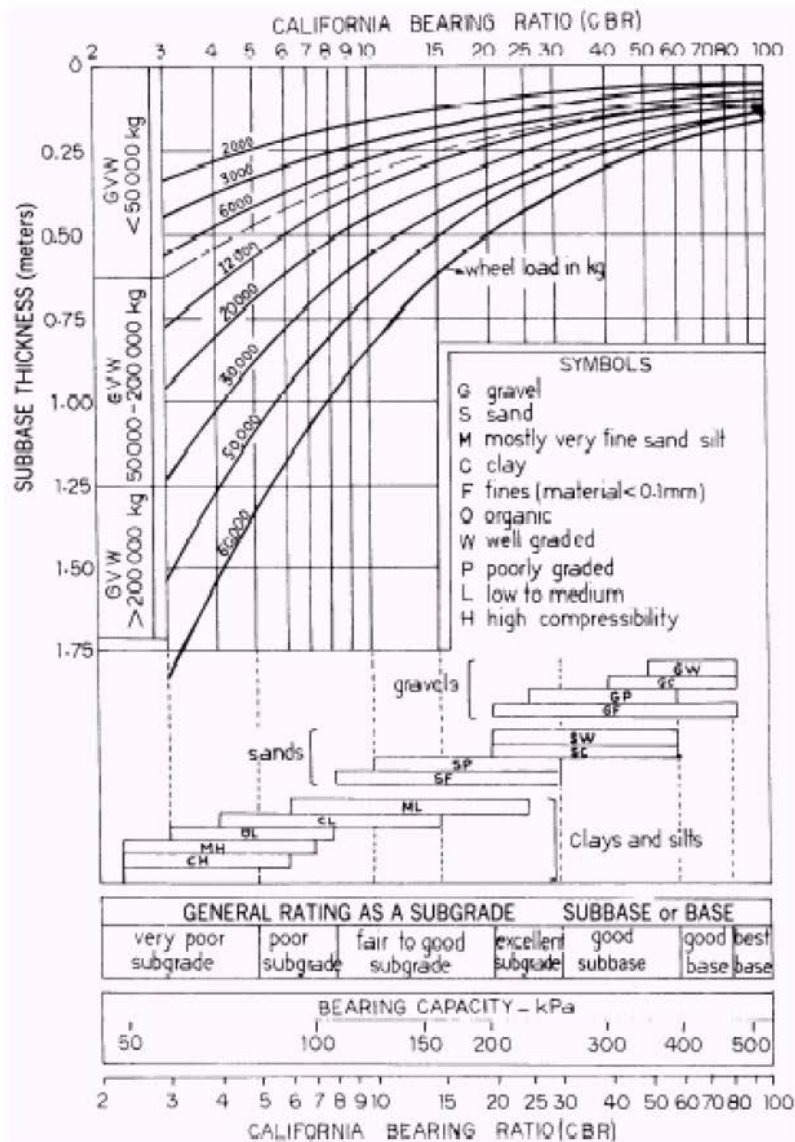


Fig. 13.4.7b. Classification and design curves for haul road construction materials, in SI units (Kaufman and Ault, 1977).

34. Dragline Output

- i. A dragline with a 2 cu yd bucket working in wet, sticky clay, with a swell factor of 20%, handles an average loose volume of 1.8 cu yd. It can complete 3 cycles per 2 minutes. Calculate ideal output, based on digging at optimum depth with a 90° angle of swing, and no delays.
- ii. Using the tables provided, calculate the probable output if the angle of swing is actually 120° and the depth of cut is 10ft.

Table 5.2: Ideal Output of Short-boom Draglines in Cubic Yards per Hour Bank Measure

Class of material	Size of bucket (cu yd)								
	3/8	1/2	3/4	1	1¼	1½	1¾	2	2½
Moist loam or light sandy clay	5.0	5.5	6.0	6.6	7.0	7.4	7.7	8.0	8.5
	70	95	130	160	195	220	245	265	305
Sand and gravel	5.0	5.5	6.0	6.6	7.0	7.4	7.7	8.0	8.5
	65	90	125	155	185	210	235	255	295
Good common earth	6.0	6.7	7.4	8.0	8.5	9.0	9.5	9.9	10.5
	55	75	105	135	165	190	210	230	265
Hard ,tough clay	7.3	8.0	8.7	9.3	10.0	10.7	11.3	11.8	12.3
	35	55	90	110	135	160	150	195	230
Wet, sticky clay	7.3	8.0	8.7	9.3	10.0	10.7	11.3	11.8	12.3
	20	30	55	75	95	110	130	145	175

Table 5.3: The Effect of the Depth of Cut and Angle of Swing on the Output of Draglines

Per cent of optimum depth	Angle of swing (deg.)							
	30	45	60	75	90	120	150	180
20	1.06	0.99	0.94	0.90	0.87	0.81	0.75	0.70
40	1.17	1.08	1.02	0.97	0.93	0.85	0.78	0.72
60	1.24	1.13	1.06	1.01	0.97	0.88	0.80	0.74
80	1.29	1.17	1.09	1.04	0.99	0.90	0.82	0.76
100	1.32	1.19	1.11	1.05	1.00	0.91	0.83	0.77
120	1.29	1.17	1.09	1.03	0.985	0.90	0.82	0.76
140	1.25	1.14	1.06	1.00	0.96	0.88	0.81	0.75
160	1.20	1.10	1.02	0.97	0.93	0.85	0.79	0.73
180	1.15	1.05	0.98	0.94	0.90	0.82	0.76	0.71
200	1.10	1.00	0.94	0.90	0.87	0.79	0.73	0.69

35. Determine the loosening costs in the following situation:

Machine D11R Tractor with No. 11 single shank ripper in coal

Rip spacing 1600mm

Ripper penetration 500mm

Rip distance 150m

Rip time 4.32 minutes

Manoeuvre time 0.35 minutes

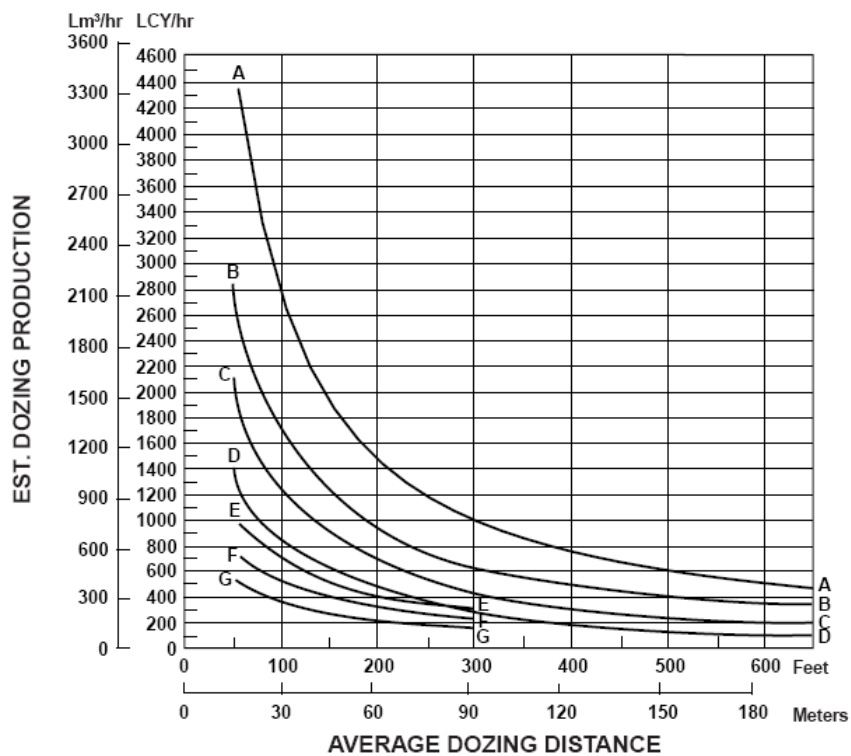
Seismic velocity 2500 m/s (assume this is a realistic value for coal, graphs available to check).

Working rate per hour \$ 120

What is the effect of the seismic velocity of rock on dozer ripping operations?

36. A Motor grader will travel at an average speed of 9 km/hr along a haul road to clear the shoulder for a distance of 17.5 km on one side. It is expected that proper clearing will require four passes, and that the machine has the usual efficiency factor of 0.6. Calculate the production expected from this grader performing this task.
37. Determine the maximum production for a Caterpillar D10T Dozer fitted with a Semi - Universal Blade using the diagram below for a dozing distance of 90m.

ESTIMATED DOZING PRODUCTION • Semi-Universal Blades • D6N through D11R



- KEY
- A — D11R-11SU
 - B — D10T-10SU
 - C — D9R/D9T-9SU
 - D — D8R/D8T-8SU
 - E — D7R Series II-7SU
 - F — D6R Series II-6SU
 - G — D6N-6SU

NOTE: This chart is based on numerous field studies made under varying Job conditions. Refer to correction factors following these charts.

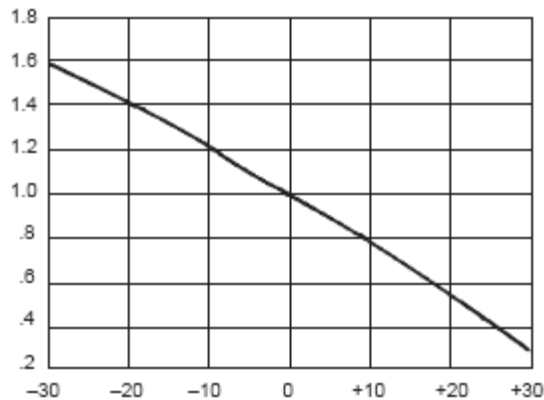
Determine the corrected production for the dozer for downhill dozing on a 2% slope, with a 50 minute working hour and an average operator as per the correction factors below.

JOB CONDITION CORRECTION FACTORS

	TRACK- TYPE TRACTOR	WHEEL- TYPE TRACTOR
OPERATOR —		
Excellent	1.00	1.00
Average	0.75	0.60
Poor	0.60	0.50
MATERIAL —		
Loose stockpile	1.20	1.20
Hard to cut; frozen —		
with tilt cylinder	0.80	0.75
without tilt cylinder	0.70	—
Hard to drift; "dead" (dry, non-cohesive material) or very sticky material	0.80	0.80
Rock, ripped or blasted	0.60-0.80	—
SLOT DOZING	1.20	1.20
SIDE BY SIDE DOZING	1.15-1.25	1.15-1.25
VISIBILITY —		
Dust, rain, snow, fog or darkness	0.80	0.70
JOB EFFICIENCY —		
50 min/hr	0.83	0.83
40 min/hr	0.67	0.67
BULLDOZER*		
Adjust based on SAE capacity relative to the base blade used in the Estimated Dozing Production graphs.		
GRADES — See following graph.		

*NOTE: Angling blades and cushion blades are not considered production dozing tools. Depending on job conditions, the A-blade and C-blade will average 50-75% of straight blade production.

% Grade vs. Dozing Factor
 (–) Downhill
 (+) Uphill



38. What is the difference between a shovel and an excavator?

39. Calculate the efficiency of a 24H Caterpillar grader maintaining a 40m wide haul road, given the following:

- road length is 5,000m
- machine takes 8 hours to complete the task
- average speed of the machine is 22km/hr

- task completion requires making 8 passes

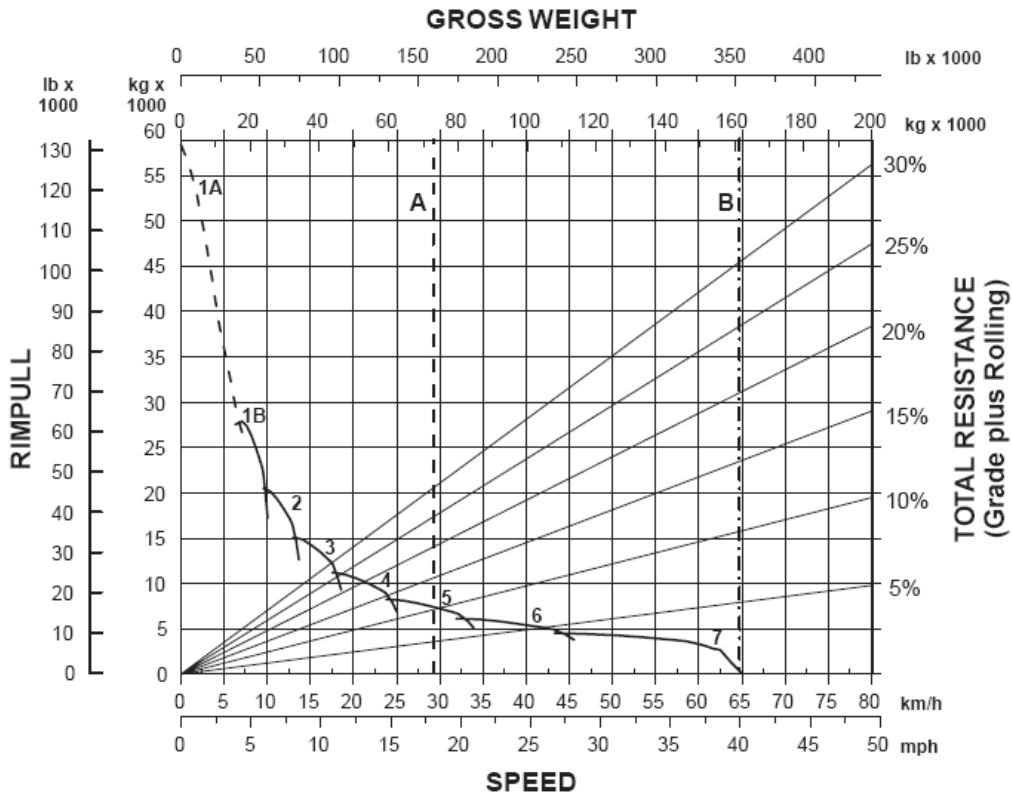
40. Given are the following data for a shovel-truck surface mine operation:

- required production/bench = 15,000 tonnes/shift
- operating period = 1 shift/day
- material = well blasted rock
- working time = 10.5 hrs/shift
- operating factor = 83%
- specific weight of rock = 2.6 t/m³
- Calculate the idealised output (m³/hr) of the shovel.

41. Describe a bucket chain excavator. What cut methods can be used with a BCE?

42. Estimate the cycle time and production of a Caterpillar 777D flat floor off highway truck operating on a level haul road of 4000m length. The road is a rutted dirt roadway with no maintenance and no stabilisation, tyre penetration is 2.5 cm. The following can be assumed;

- Loading time 1.4 min
- Manoeuvre and dump time 0.8 min
- Truck hauls 80 tonnes of ore each trip
- Job efficiency of 0.8



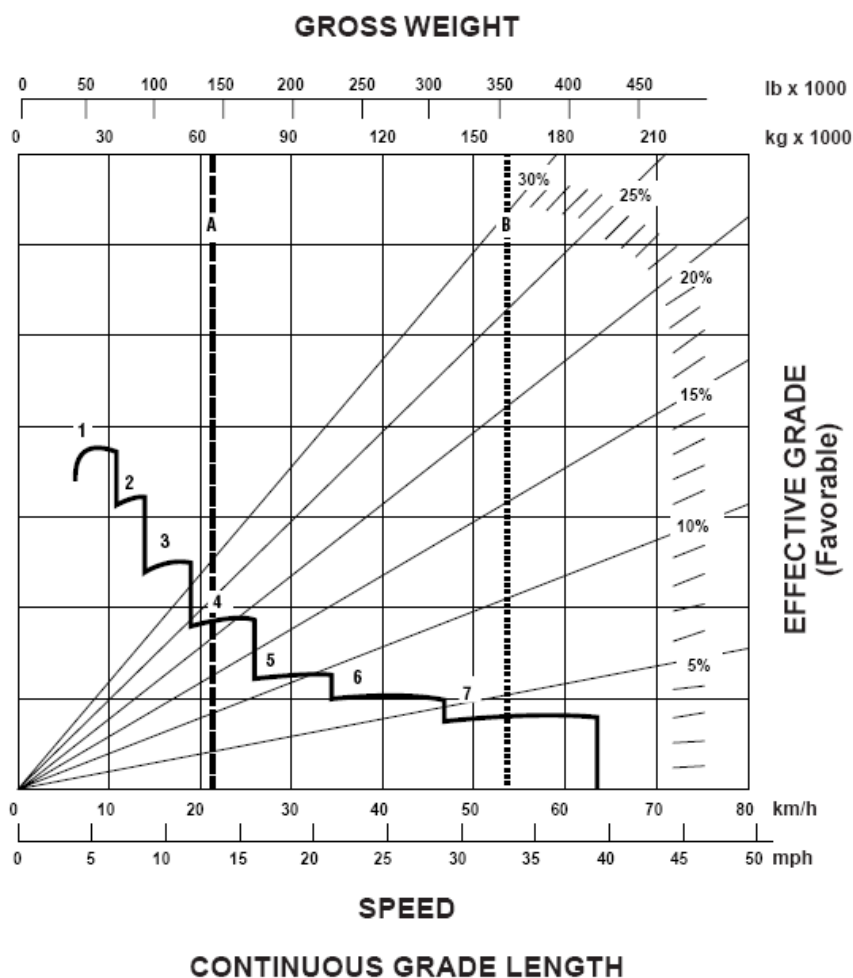
KEY

1A — 1st Gear (Torque Converter)
1B — 1st Gear
2 — 2nd Gear
3 — 3rd Gear
4 — 4th Gear
5 — 5th Gear
6 — 6th Gear
7 — 7th Gear

KEY

A* — Empty 64 359 kg (141,889 lb)
B* — Max GMW 163 293 kg (360,000 lb)

*These two reference lines (A and B) apply only to 777D.

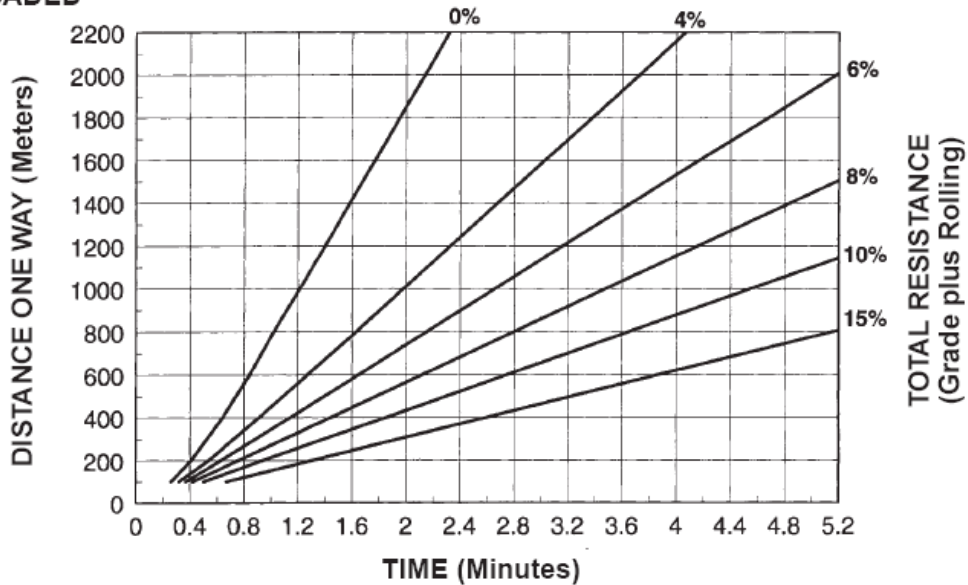


- KEY**
- 1 — 1st Gear
 - 2 — 2nd Gear
 - 3 — 3rd Gear
 - 4 — 4th Gear
 - 5 — 5th Gear
 - 6 — 6th Gear
 - 7 — 7th Gear

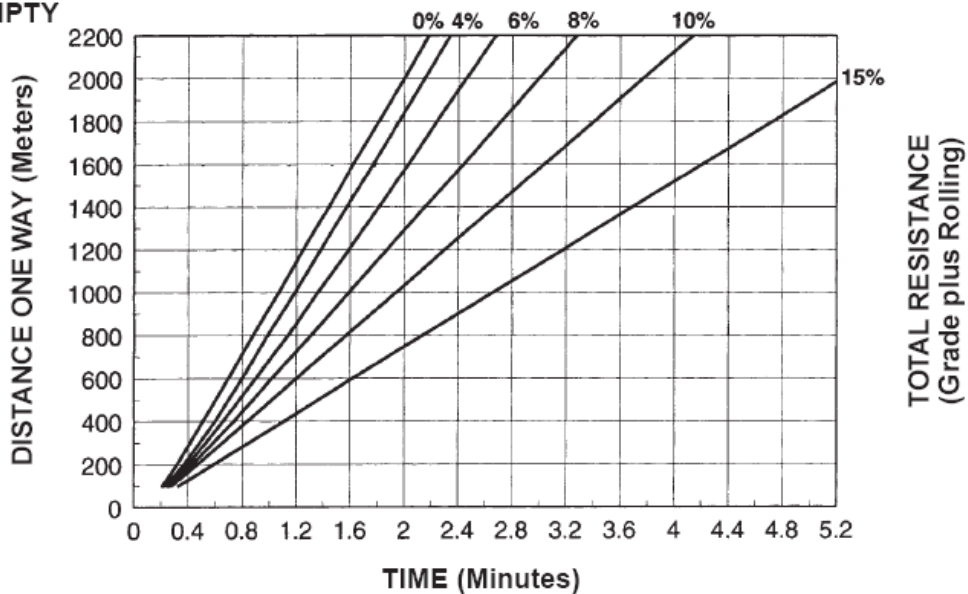
- KEY**
- A* — Empty 64 359 kg (141,889 lb)
 - B* — Max GMW 161 028 kg (355,000 lb)

*These two reference lines (A and B) apply only to 777D. Brake performance for the 776D will vary depending on trailer brake capability.

LOADED



EMPTY

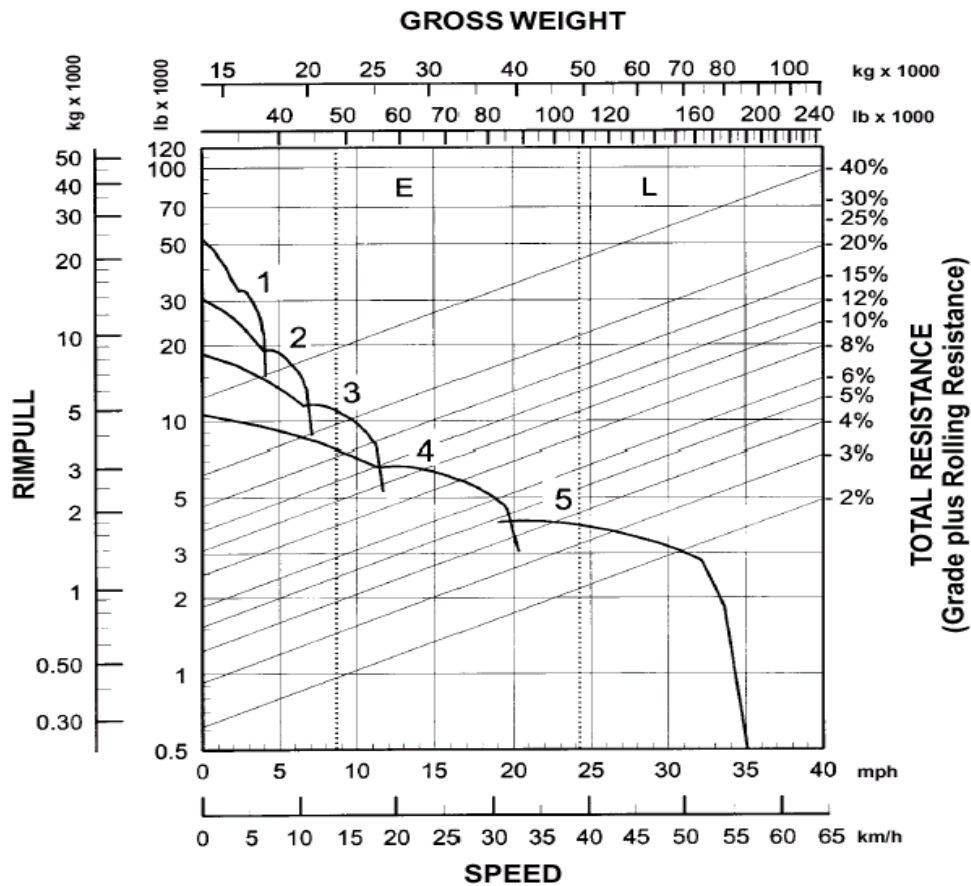


43. For the situation in question 42, determine the cycle time if road conditions were improved to a rolling resistance of 20 kg/tonne.
44. For the problem in question 42 and 43 the engineer at the site is considering the use of a shorter, 2,200m, haul road that has a slope of 6% adverse. If all other factors remain the same which haul route should be selected on the basis of shortest cycle times? What are the cycle times and hourly productions?
45. An off highway truck weighs 23 t empty and carts a payload of 35 t up a 4% grade. The RR factor is 40 kg/tonne. Calculate:
 - a) The total resistance (kg)
 - b) The effective grade (%)

46. A rubber tyred scraper unit weighing 50 t is towed by a crawler tractor weighing 40t up a 6% grade. The RR factor is 40kg/t. Calculate:
- The rolling resistance (kg)
 - The grade resistance (kg)
 - The total resistance (kg)
47. A Caterpillar D30D articulated dump truck has the rim pull curve in the figure below. (Gross weight 21.9 t empty, 49.117 t loaded). If the truck ascends a 5% grade with a rolling resistance of 40kg/t, find the following:
- Total resistance (kg)
 - The required rim pull (kg) when loaded
 - The maximum speed of the truck when loaded (km/h)

D30D Rimpull-Speed-Gradeability
● 29.5R25 Tires

Articulated Trucks



KEY
 1 — 1st Gear
 2 — 2nd Gear
 3 — 3rd Gear
 4 — 4th Gear
 5 — 5th Gear

KEY
 E — Empty 21 900 kg (48,278 lb)
 L — Loaded 49 117 kg (108,278 lb)

CAT D30D Rimpull, Speed, Gradeability (Caterpillar Performance Handbook version 31 (2000)).

48. The average speed of an 18m^3 scraper is 37 km/hr and its return speed uphill is 16 km/hr over a 1000 m haul distance and a 1000m return distance. Using a fixed time of 4 minutes, calculate the cycle time (min).

49. What are the advantages and disadvantages of in-pit crushing

50. Continuous surface miners such as the Wirtgen surface miners are used at a number of operations worldwide. Describe such a machine and detail the type of operation where such a machine has advantages over traditional surface mining techniques.

**School of Engineering and Information Technology
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ENMIN 5018 Surface Mining Operations and Equipment**

ASSIGNMENT 2

(Weighting 40% of total unit marks)

Due date: 31 December 2016

Students are to design a suitable open pit for the deposit described. The candidate should include in their answer the following:

Design a detailed surface mine excavation plan.

Detail development requirements.

Detail Production requirements including a full description of the method selected.

Number of production units required/rate of production/other scheduling.

Describe loading/haulage requirements

Equipment

Processing

Personnel

Safety

Briefly describe power & drainage requirements

As well as any other salient points as required by the mining system, for economic analysis use current market prices in A\$ for the commodity as required. Accurate costing is not an essential aspect to the project but some notional economic modelling is required to illustrate the viability of the method detailed.

State and justify all assumptions.

Gold-silver mineralisation in the deposit is hosted by an epithermal quartz vein system, which developed in a sequence of hydrothermally altered quartz-bearing andesite's of Miocene age. Gold occurs as electrum (a gold-silver alloy) and is generally very fine grained. The steeply dipping vein system extends over 1,600 metres of strike length. Pervasive oxidation centred on the larger veins extends to a depth of about 200 metres.

This ore resource has been estimated to be approximately 11.25 million tonnes at 3.3 grams per tonne gold and 26 grams per tonne silver; equivalent to approximately 1,200,000 ounces of gold and 9.6 million ounces of silver.

The final pit will have approximate dimensions of 860 metres long by 600 metres wide at the original surface by 250 metres deep. The original surface has a fairly flat topography with minimal cover of topsoil and subsoil (10m or less). Typically, the waste rock consists of a thick sequence of volcanic lavas, breccia's and tuff's of generally andesitic composition as such geomechanically these are classed as reasonably competent rocks.

Ore is delivered to the processing plant; the processing plant has a planned output of up to a maximum of 1.25 million tonnes per annum.

The climate of the area is similar to that of Ballarat.

