You have now done all the necessary inspections and tests possible and have now got the report from the third-party inspection agency. You are required to analyze the below graph and come up with solutions.

Use the given graph and indicate on the graph the method of calculating the following:

1. Calculate the decel supervision distance in the shaft and why is this important to know (2)
2. Calculate the brake delay from trip out up to effective braking (2)
3. Explain the reason why the winder did not run at constant speed. (2)
4. By indicating on the graph, show how you will derive the average deceleration rate and calculate the actual value. (3)
5. By indicating on the graph, show how you will derive the maximum deceleration rate and calculate the actual value. (3)
6. Indicate on the graph where you will pick up the difference in braking effort also which brake is doing the most work. (3)
7. How would you rectify this problem to make sure that the brake effort is equal on both brakes. (3)
8. What would the Degree of protection (DOP) be on this winder looking at the information given. (2)

Total = 20

Section A: Compulsory Questions (Answer All Questions)

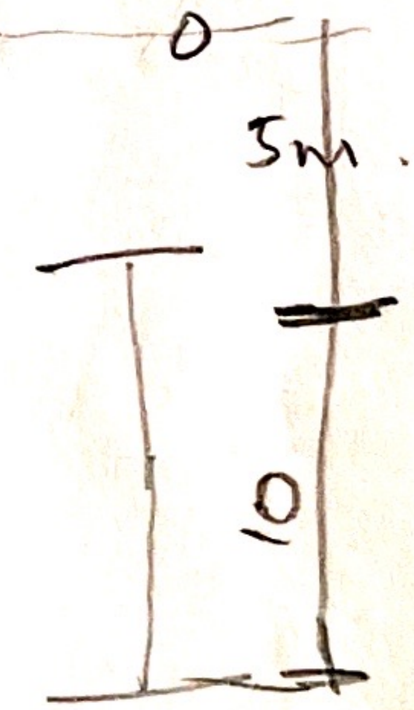
Question 1

You have been appointed as a shaft engineer at your mining group. You have been at the shaft for six months and you did some brake race skimming on your Man winder brake races. Since the skimming there were some erratic problems with the winder and the unions have complained to you that employees are unhappy with the operation of the man winder.

You are busy with the investigation to find the root cause of the problem encountered with the winder. During the investigation you picked up that the brake lining of the underlay side is wearing more quicker that the overlay side. While scrutinizing the WED log sheets, you picked up several entries that the brake wear alarms were recorded as problematic on the winder overlay side. Your foreman reported that the overlay side brake race is starting to glace. Your deceleration rates are also questionable hence you need to find the reason for anomalies.

Your winder data is as follows:

- Permitted speed of the winder: 13m/sec
- Drum diameter: 4,5m
- Rope diameter: 55 mm
- Three full drum turns on the drum
- Overrun in the headgear is 20m
- Tested distance from trip to stop: 5m
- Distance from bank to your mechanical overwind is 15m
- Normal winder speed 13m/sec
- Distance from the mechanical overwind to the crash beam: 5m
- Winder has an Electronic Speed Distance controller (ESD).
- There is a tower installed in the shaft, max speed is 7m/sec
- Conveyance is a 3-deck conveyance
- Loading capacity is 70 people per deck
- Decel zone in the shaft is 10 turns
- Winder stopped within 10 meters from the bank mark

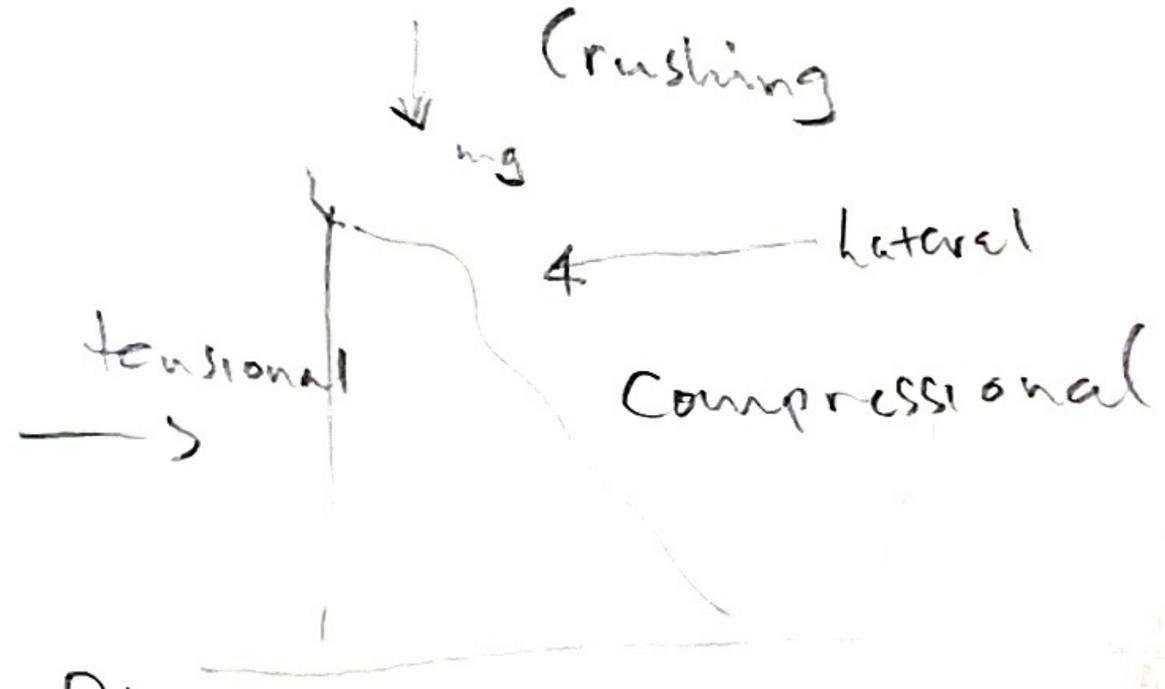


Question 2

1. You are an appointed engineer at a mine, and tailings dams form part of your areas of responsibility. Your core responsibility within the tailings dam is to ensure that there are no catastrophic dam failures. There are 3 main failure modes which have led to catastrophic dam failures in the past.

   a. Name and briefly discuss the 3 main catastrophic failure modes. (14)
   b. What are the six main activities, related to each other, which constitute the tailings management lifecycle? List them, in their correct sequence. (6)

Total = 20



tailings lifecycle

Obtain a dam design drawing from
Appoint competent people to
build the dam using material with
pre-with aggregate size,
Appoint competent people to maintain
the dam.

Monitor the rise of the dam wall
and rate of residue discharge and correct
thickness
Use a penstok to drain excess
water

Question 3

You are an appointed engineer at a Shaft of a Coal Mine. The transformer feeding your main ventilation fan failed and on trying to energize the spare transformer, it was found to be faulty. This breakdown resulted in the shaft being on stop for more than a week, with a high risk of methane build-up underground. A test report of the transformer that failed, which was conducted three months before the failure, revealed the following, amongst others:

Transformer insulating oil condition	Units of measure	Results	Comments
Water Content	mg/kg	36	Unacceptable
Breakdown Voltage (BDV)	kV	23	Unacceptable
Total Polychlorinated Biphenyl	ppm	1 (Level 1)	Acceptable
Transformer oil Temperature	Degrees Celsius	65 degrees Celsius	Acceptable

The investigations concluded that the root cause to the failure of the transformer was the un-acceptable condition of the transformer oil.

1. Elaborate on this, with specific reference to water content in the transformer oil and breakdown voltage (BDV) (9)
2. What is the minimum water content acceptable in a transformer oil? (2)

Mines and Works Plant Engineering Examination 9 November 2022

3. What is the minimum breakdown voltage acceptable? (3)
4. As the responsible engineer, what remedial steps would you take to prevent a re-occurrence of such a transformer failure? (3)
5. Why are transformers rated in KVA not in kW? (3)

Total = (20)

[Section A: Total = 60 marks]

Section B: Answer only 2 Questions

Question 4

You are an engineer on a largest installed base and high production shaft and your maximum demand is 150 MW when operating at a power factor of 0.8 lagging and your load factor currently is 40 %. You need to make sure that the power consumption of this shaft is at the optimum. During your inspection, you saw some power factor equipment installed but records show it is not operational. Most of the machines used on the shaft are large machines, NO synchronous motors have been installed. Your pump motors are rated at 4 MW and pump pressures range up to 250 Bar. Smallest machine rating is 2 MW. In your experience, what can be done to ensure that you run the shaft at optimum power for all your installations? If you rectify your installed base of power factor equipment, you can improve your power factor to .95 lagging. With some scheduling changes you can improve your load factor to 70 %. Looking at Eskom`s tariff book, the maximum demand charge is R20 per KVA, the energy charge is 63 cents per unit consumed. You need to prepare a business case to make changes to the system to further improve the electrical consumption and usage.

1. In easy understandable language and with a neat sketch define power factor? (2)
2. When looking at the information given define load factor? (2)
3. When you improve your power factor to .95 lagging, indicate the savings with a load factor of 40% per year. (4)
4. What is the negative impact of improving the power factor to unity? (4)
5. Looking at the installed base of power factor equipment, there are three methodologies to implement to the system. Describe the methodologies and mention the significance it has to the electrical power system. Which system will you recommend for your business case? (8)

Total = (20)

Question 5

You have been appointed as the production engineer on a high production shaft. Monthly call of 250 000 tons. The production section consists of 8 production levels with 4 raise lines each. You have 55 *10 ton locos running on these levels. Each level also has 2 double header locos with 20 ton hoppers making up the train. The stopes are equipped with the following winches.

Gully winches = 75 kW pillman

Face winches = 22 kW double drum

Mono rope winches = 15 kW

To achieve your targets, you need to ensure that the winch installations are up to standard. You need to implement a safety system and a guideline to ensure that all the risks are identified with the winch installations and the operation thereof.

In a short period of time several serious winch accidents occurred on the shaft. Over and above the safety system you need to make the workforce aware of the risks when working with winches underground.

1. In terms of your safety campaign and guideline, which safety measures will you implement as a minimum requirement in this process.? Explain your answer (5)
2. How would you ensure that the return pulleys are secured? Explain your answer by a neatly drawn drawing of the installation.? (5)
3. Explain the term "Death Triangle"? (3)
4. What will you include as minimum requirements for a winch signalling system? (3).
5. What will you specify as a minimum requirement for the operation of Mono rope winches? (4).

Total = (20)

Question 6

You are the engineer on a shaft where you need to install a new Refrigeration plant. Your power supply from Eskom is 132 000 / 6600-volt Yd1 20 MVA transformer. The plant is to receive power from Eskom Substation and main consumer substation that is +- 500 m away from the plant. Furthermore, your bulk air cooler unit will be placed 80 m from your Refrigeration plant. Your ground conditions are not favourable due to large patches of Dolomite. You will need to feed the 1000 kVA minisub and 2 * 250 kW pumps at the BAC. The BAC motors will be driven by two VSD`s and some ancillary equipment. It is necessary to install an overhead line from the ESKOM Substation to the Refrigeration plant and a small overhead line is to be built from the Refrigeration substation to the Bulk Air Cooler Sub Station. You also need to install a fibre cable to connect all the sub stations and equipment to ensure visibility at the remote-Control room. You can only use standard aluminium conductors. These conductors are:

1. "Hare" Conductor
2. "Fox" Conductor
3. "Lynx" Conductor
4. "Bear Conductor

Use the below table for the selection of the conductors.

Your main Overhead line must be able to supply the Refrigeration plant with +- 2000 Amps. To cater for start-up of the 2 * 3,5 MW refrigeration plants and the ancillary equipment. The system power factor is .85

Both the Eskom Consumer Substation and the Refrigeration Substation will be upgraded with new switchgear with the correct protection system installed. The bus bar rating will be 2000 Amps in the consumer Sub Station and 1250 Amp in the Refrigeration Substation.

Your design should be a standard design as used on the mine with all the necessary protection disconnection and safety devices installed.

1). Give a short description by the aid of a neat drawing on how you will lay out the overhead lines with all the protection and safety systems. (8)

2). Calculate the required conductor sizes for these overhead lines taking into consideration the volt drop calculations as well as the power calculations. (8)

3). How would you make sure that the end of the lines you will be able to earth the lines automatically for work to be performed without using the standard earth clamps. Draw and describe the connection points.(4)

Total = (20)

Aluminium Conductor Steel Reinforced - ACSR (British Standard Sizes)

Code name	Equival. copper area	Stranding and wire diameter	Diameter over steel	Overall diameter (Std.)	Aluminium area	Steel area	Total area	Mass kg/km			Ultimate tensile strength	Coefficient of linear expansion	Initial modulus of elasticity	Final modulus of elasticity	DC resistance at 20°C	Current rating	Standard drum length
	mm²	mm	mm	mm	mm²	mm²	mm²	Aluminium	Steel	Total	Newton	/C° x 10^{-6}	MPa	MPa	Ω/km	A	m
MOLE	6,45	6/1/1,50	1,50	4,50	10,60	1,77	12,37	29,20	13,90	43,10	4780	19,31	65000	80400	2,7062	87	3000
SQUIRREL	12,90	6/1/2,11	2,11	6,33	20,98	3,50	24,48	57,70	27,50	85,20	8020	19,31	54600	80400	1,3677	130	3000
GOPHER	16,30	6/1/2,36	2,36	7,08	26,25	4,37	30,62	72,20	34,40	107	9610	19,31	52700	80400	1,0933	150	3000
WEASEL	19,35	6/1/2,59	2,59	7,77	31,61	5,27	36,88	87,00	41,50	129	11450	19,31	51500	80400	0,9077	170	2500
FOX	22,58	6/1/2,79	2,79	8,37	36,68	6,11	42,80	101	48,10	149	13100	19,31	50700	80400	0,7822	190	2500
FERRET	25,81	6/1/3,00	3,00	9,00	42,41	7,07	49,48	117	55,60	173	15200	19,31	50200	80400	0,6766	210	1500
RABBIT	32,26	6/1/3,35	3,35	10,05	52,88	8,81	61,70	145	69,40	214	18500	19,31	49500	80400	0,5426	240	1500
MINK	38,71	6/1/3,66	3,66	10,98	63,13	10,52	73,65	174	82,80	257	21900	19,31	49100	80400	0,4546	260	1500
SKUNK	38,71	12/7/2,59	7,77	12,95	63,22	36,88	100,10	175	292	467	52900	15,84	71900	108000	0,4571	270	2000
BEAVER	45,16	6/1/3,99	3,99	11,97	75,02	12,50	87,53	206	98,40	304	25900	19,31	48800	80400	0,3825	290	1500
HORSE	45,16	12/7/2,79	8,37	13,95	73,36	42,80	116,16	203	338	541	60700	15,84	71000	108000	0,3939	300	2000
RACCOON	48,39	6/1/4,09	4,09	12,27	78,83	13,14	91,97	217	103	320	27200	19,31	48700	80400	0,3640	300	1500
OTTER	51,61	6/1/4,22	4,22	12,66	83,92	13,99	97,91	231	110	341	28900	19,31	48700	80400	0,3419	310	1500
CAT	58,06	6/1/4.50	4,50	13,50	95,43	15,90	111,33	263	125	388	32800	19,31	48500	80400	0,3007	340	1500
HARE	64,52	6/1/4,72	4,72	14,16	104,98	17,50	122,48	289	138	427	36000	19,31	48500	80400	0,2733	360	1500
DOG	64,52	6/4,72 +7/1,57	4,71	14,15	104,98	13,55	118,53	289	100	389	34700	19,92	48800	76400	0,2733	360	2000
HYENA	64,52	7/4,39 +7/1,93	5,79	14,57	105,95	20,48	126,43	291	162	453	41900	18,93	52400	82200	0,2697	360	2000
LEOPARD	80,65	6/5,28 +7/1,75	5,25	15,81	131,37	16,84	148,21	361	133	494	42200	19,54	47800	76300	0,2184	410	2000
COYOTE	80,65	26/2,54 +7/1,91	5,73	15,89	131,74	20,06	151,80	365	159	524	47300	19,54	51900	76000	0,3035	420	2000 2000
TIGER	80,65	30/7/2,36	4,72	16,52	131,23	30,62	161,85	364	242	606	58700	18,43	56900	83400	0,2202	420	2000
WOLF	96,77	30/7/2,59	7,77	18,13	158,06	36,88	194,94	438	292	730	69200	18,43	55700	83400	0,1828	470	2000
LYNX	112,90	30/7/2,79	8,37	19,53	183,41	42,80	226,20	508	330	846	79300	18,43	54900	83400	0,1576	520	2000
PANTHER	129,00	30/7/3,00	9,00	21,00	212,06	49,48	261,54	588	391	970	90800	18,43	54300	83400	0,1363	560	2000
LION	145,20	30/7/3,18	9,54	22,26	238,27	55,60	293,86	660	440	1100	101000	18,43	53900	83400	0,1213	610	2000
BEAR	161,30	30/7/3,35	10,05	23,45	264,42	61,70	326,12	733	488	1220	112000	18,43	53600	83400	0,1093	650	2000
GOAT	193,50	30/7/3,71	11,13	25,97	324,31	75,67	399,98	899	598	1500	136000	18,43	53100	83400	0,0891	730	2000
SHEEP	225,80	30/7/3,99	11,97	27,93	375,11	87,53	462,63	1040	692	1730	157000	18,43	52900	83400	0,0770	800	2000
ANTELOPE	225,80	54/7/2,97	8,91	26,73	374,11	48,50	422,60	1040	383	1420	117000	19,91	47700	73200	0,0773	790	2000
BISON	225,80	54/7/3,00	9,00	27,00	381,70	49,48	431,18	1060	391	1450	119000	19,91	47600	73200	0,0757	800	2000
DEER	258,10	30/7/4,27	12,81	29,89	429,60	100,24	529,84	1190	792	1980	179000	18,43	52800	83400	0,0673	870	2000
ZEBRA	258,10	54/7/3,18	9,54	28,62	428,88	55,60	484,48	1190	440	1630	133000	19,91	47300	73200	0,0674	860	1500
ELK	290,30	30/7/4,50	13,50	31,50	477,13	111,33	588,46	1320	880	2200	199000	18,43	52700	83400	0,0606	930	2000
CAMEL	290,30	54/7/3,35	10,05	30,15	475,96	61,70	537,66	1320	488	1810	147000	19,91	47000	73200	0,0607	920	2000
MOOSE	322,60	54/7/3,53	10,59	31,77	528,49	68,51	596,99	1460	542	2000	162000	19,91	46700	73200	0,0547	980	2000
DINOSAUR	414,63	54/3,95 +19/2,36	11,80	35,50	661,73	83,11	744,84	1835	658	2493	202920	19,91	46700	72200	0,0437	1110	2000
BERSFORD	430,70	48/4,27 +7/3,32	9,96	35,58	687,36	60,60	747,96	1906	480	2386	177650	20,68	43200	68800	0,0420	1132	2000

Question 7

7.1 A 10 tonne locomotive is used to haul twelve 5 tonne hoppers down an incline of 1:40 towards a tip. The coefficient of friction between the locomotive wheels and the rails is 0.2, the rolling resistance for the train is 200 N/t, the mass of the locomotive is 10t and only the locomotive has been equipped with brakes.

7.1.1 Calculate the stopping distance, travelling at 12 km/h towards the tip. (8)

7.1.2 Discuss the feasibility of adding more hoppers to the train without sacrificing the safety standards. (2)

7.2 A tripod consists of three steel pipes, is to be used to lift a transformer having a mass of 1,8t. The footings of the tripod are spaced equidistant and are 17 m apart. The pipes, for the purpose of this calculation, may be considered to have pin-jointed struts. Ignore eccentricity and the initial curvature of the pipes.

Factor of safety = 5
Young's modulus = 200 GPa
Outside diameter of the pipes = 150 mm
Wall thickness = 6 mm
Length of pipes = 12 m

Determine the maximum safe load that may be raised without the pipes buckling. (10)

Given: $P_{cr} = \frac{\pi^2 EI}{4L^2}$ (Euler)

Total = (20)

[Total: Section B = 40]

Total Section A and Section B = 100 marks]