

UNIVERSITY OF SOUTH AUSTRALIA

School of Natural and Built Environments

ANNUAL EXAMINATION

3.00 pm Thursday 28 October 2004 in GP1-02 and GP 1-06

Civil Engineering 1 (CIVE-2001)
Mineral Economics and Mine Management (RENG 3006)

OPTIMISATION OF OPERATIONS

Time: 90 minutes

Candidates are allowed an additional **20** minutes to read the paper and set up their workstations before the examination begins.

- Answer **BOTH** questions
- Notes and textbooks may be used.
- Each question carries **25 marks**
- Solve each question using Excel, if appropriate
- **Summarise, explain and discuss** your solutions in your answer book, **and/or** print out the relevant spread sheets with appropriate annotations, and insert them into your answer book
- Put your name on all separate sheets
- If you experience difficulties in using Excel, explain the procedures that you would have adopted, or solve the problem by hand in your answer book

PLEASE SEE NEXT PAGE

QUESTION 1

Three mines, A, B and C, discharge waste process water into the same river. Mine A is 2 km up-stream from mine B which in turn is 3 km up-stream from mine C. The three mines discharge water into the river at a rate and silt concentration, as tabulated below.

River flow and river silt concentration is monitored at four stations. Station 1, which is upstream of Mine A, currently records a flow of 10,000 m³/hr at a silt concentration of 0.001 kg/m³, as tabulated below. The other three monitoring stations are located approximately 500 m downstream of the discharge point for each mine. Silt load (kg/hr) is given by flow, or discharge rate, (m³/hr) multiplied by silt concentration (kg/m³). Since there is no other significant gain or loss of water over this stretch of river, the river flows are as tabulated below. It can be assumed that the mine discharge and river flow are fully mixed within 500 m.

Mines A, B and C have installed silt removal cyclone systems that each have the capacity to remove 50 kg of silt load per hour from the discharge before it is released into the river. The costs of silt removal are \$0.40, \$0.50 and \$0.35 per kg at Mines A, B and C respectively. So the total silt removal cost is \$62.50/hr and the resulting downstream river silt concentrations are as tabulated below.

The EPA will introduce a requirement that the river silt concentration monitored 500 m downstream of the discharge point for **each mine** should be **no more than 0.002 kg/m³**. By formulating this system as a linear programming problem, calculate the revised silt removal capacities that should be installed at Mines A, B and C in order to satisfy the EPA limits at minimum total cost. A maximum of **90% of the total silt discharge load** can be removed by the silt removal systems at each mine. Use the silt removal costs specified above.

	Units	Station 1	Mine A	Mine B	Mine C	Total
Discharge rate from mine	m ³ /hr		6,000	4,000	5,000	
Silt concentration in discharge	kg/m ³		0.0140	0.0170	0.0160	
Silt discharge load	kg/hr		84.00	68.00	80.00	
Installed silt removal capacity	kg/hr		50.00	50.00	50.00	
Silt removal cost per kg	\$/kg		\$0.40	\$0.50	\$0.35	
Maximum silt removal	%		90%	90%	90%	
Down-stream river flow	m ³ /hr	10,000	16,000	20,000	25,000	
Down-stream river silt concentration	kg/m ³	0.001	0.00275	0.00310	0.00368	
Down-stream river silt load	kg/hr	10.00	44.00	62.00	92.00	
Silt removal cost	\$/hr		\$20.00	\$25.00	\$17.50	\$62.50

25 marks

QUESTION 2

The description and data for the project in this question are exactly the same as Assignment 4, 2004.

Your contracting company is about to construct a wind farm, which involves completing two substantially independent projects: (A) construction of the wind turbines and (B) construction of the underground transmission line connection to the national electricity grid. The projects A and B will start at the same time and will run concurrently. Each of these projects consists of a number of separate activities, identified as A1, A2, A3 etc for project A and similarly for project B. The activities within each project must be conducted in series, ie A1 must be completed before A2 can commence, and so on. The optimistic d_o , most likely d_m and pessimistic d_p PERT durations in **weeks** for activities in the two projects are listed in the table on the next page. The wind farm venture cannot be handed over to the operators until the wind turbines have been completed **and** they have been connected to the electricity grid.

Calculate the probability that the wind farm venture will be completed **during** the n^{th} week, for $n = 45$ up to 60 inclusive. Calculate the sum of these 16 probability values and comment on the result.

The owner of the project has proposed three alternative bonus/penalty plans A, B and C, as tabulated on the next page. A bonus payment is an additional payment added to the contract amount; a penalty payment is deducted from the contract amount. Calculate the **expected value** of each bonus plan and hence identify the plan that is most beneficial for your contracting company.

25 marks

All durations in weeks			
Activity	d_o	d_m	d_p
A1	5	8	11
A2	6	9	12
A3	8	10	14
A4	5	7	10
A5	4	6	9
A6	3	5	8
A7	2	4	6
Activity	d_o	d_m	d_p
B1	4	7	10
B2	6	9	12
B3	7	10	13
B4	6	8	10
B5	5	7	12
B6	4	6	9
B7	2	5	7

	Bonus (+ve) or penalty (-ve) Plan A	Bonus (+ve) or penalty (-ve) Plan B	Bonus (+ve) or penalty (-ve) Plan C
Wind farm, venture completed and handed over during week 45	\$800,000	\$600,000	\$450,000
Reduction in bonus for each week beyond 45	\$100,000	\$70,000	\$55,000

So the three bonus plans in full are as tabulated below.

Wind farm, venture completed and handed over during week	Bonus (+ve) or penalty (-ve) Plan A	Bonus (+ve) or penalty (-ve) Plan B	Bonus (+ve) or penalty (-ve) Plan C
45	\$800,000	\$600,000	\$450,000
46	\$700,000	\$530,000	\$395,000
47	\$600,000	\$460,000	\$340,000
48	\$500,000	\$390,000	\$285,000
49	\$400,000	\$320,000	\$230,000
50	\$300,000	\$250,000	\$175,000
51	\$200,000	\$180,000	\$120,000
52	\$100,000	\$110,000	\$65,000
53	\$0	\$40,000	\$10,000
54	-\$100,000	-\$30,000	-\$45,000
55	-\$200,000	-\$100,000	-\$100,000
56	-\$300,000	-\$170,000	-\$155,000
57	-\$400,000	-\$240,000	-\$210,000
58	-\$500,000	-\$310,000	-\$265,000
59	-\$600,000	-\$380,000	-\$320,000
60	-\$700,000	-\$450,000	-\$375,000