UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

SCHOOL OF ENGINEERING

EXAMINATIONS: NOVEMBER 2019

COURSE AND CODE: PROJECTS AND THE ENVIRONMENT ENCH4PE

DURATION: 2 HOURS **TOTAL MARKS:** 90

INTERNAL EXAMINER(S): MR N BRIJMOHAN

INTERNAL MODERATOR(S): MR E M OBWAKA

EXTERNAL MODERATOR: PROF P MUSONGE

INSTRUCTIONS:

1. **ALL** questions should be attempted.
2. Any programmable or non-programmable calculator may be used provided it has been cleared of any information that would subvert the purpose of the examination.
3. Calculations must be shown in sufficient detail to illustrate your understanding of the procedure.
4. **Appropriate formulae are provided on page 3.**
5. This examination question paper, together with all associated diagrams **MUST BE HANDED IN TOGETHER WITH YOUR SCRIPT.**

Student Number:

QUESTION 1

A colliery has a capacity to produce 150 000 tons run-of mine anthracite (coal with high carbon content) per month. After washing, about two-thirds of the run-of mine tonnage is sold as prime. The colliery is currently producing 105 000 run-of-mine tons per month. The fixed cost of the mine per month are R 2.2 million and the variable cost per run-of mine ton amounts to R 55. The selling price is R 120 per ton of prime.

a) Determine the current profit per month. (5)

b) What is the smallest number of prime tons that have to be sold every month to avoid losses? (4)

c) Determine the increase in profit and volume (expressed as a percentage) if the mine runs at full capacity. (7)

d) What phenomenon does your answer in part (c) illustrate? (4)

TOTAL /20/

QUESTION 2

It is imperative in determining an initiative's feasibility to have an indication of the breakdown of costs.

a) List three categories of costs typically accounted for in the feasibility study of a chemical process. Include four examples in each category. E.g. direct costs – buildings. (15)

b) Briefly describe four methods of determining capital costs. State the expected accuracy levels of each method. (12)

TOTAL /27/

QUESTION 3

In 2015, all member states of the United Nations adopted a sustainable development agenda which *"provides a shared blueprint for peace and prosperity for people and the planet, now and into the future"*.

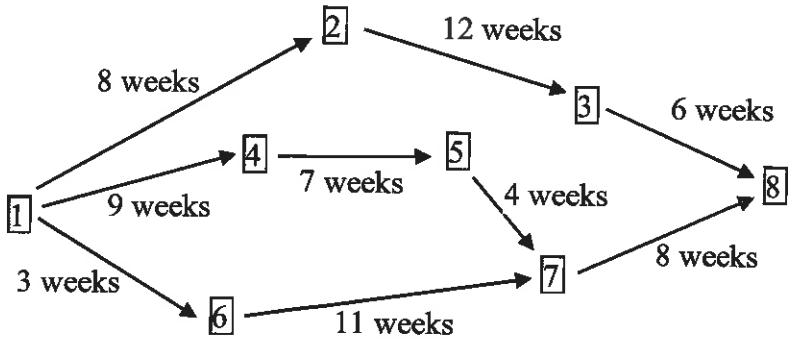
a) With the aid of a diagram, explain how sustainable development is defined. (7)

b) Discuss how sustainable development can be assessed and monitored in the chemical industry, and the benefits of doing so. (6)

TOTAL /13/

QUESTION 4

The following diagram represents the length (in weeks) of the major activities of a building project.



Determine:

a) The overall length of the project (5)

b) If the standard cost of the project amounts to R20 000 per week, use the data in the following table to determine the optimum cost and length of the project if appropriate activities are crashed. Show your working in table format. (15)

Activity	Normal time (weeks)	Crash time (weeks)	Cost (R per week) to crash
1-2	8	8	--
2-3	12	11	8000
3-8	6	5	11000
1-4	9	6	7000
4-5	7	6	5000
5-7	4	4	--
7-8	8	6	12000
1-6	3	2	9000
6-7	11	10	10000

TOTAL /20/

QUESTION 5

In an industrial process the effluent is treated by an anaerobic stage, followed by an aerobic stage. The outflow from the anaerobic stage is 0.6 ML/d at a COD concentration of 490 mg/l. In the aerobic stage, the COD must be reduced to 50 mg/l. There are three activated sludge tanks of dimensions 10m x 6m x 3m deep each operating in parallel. The mixed liquor suspended solids (MLSS) in these tanks is 1750 mg/l. Determine:

a) The detention time of the effluent in the aeration tanks. (3)

b) The volumetric organic loading rate. (3)

c) The F/M ratio. (4)

TOTAL /10/

Formulae:

$t = V / Q$;
volumetric organic loading = (mass COD load /day) / total volume of the system
F / M = (Mass COD added to system each day) / (total mass MLSS in system).

SOLUTIONS

Question 1

a)

Prime Units = (2/3)(Run of Mine Throughput)
= (2/3)(105 000)
= 70 000 tons

Profit = (Prime Units)(SP) – Fixed Costs – (Throughput)(Variable Costs)
= (70 000)(120) – 2 200 000 – (105 000)(55)
= R425 000

(5)

b)

$$Breakeven = \frac{FC}{SP - \frac{VC}{2/3}} = \frac{2200000}{120 - \frac{55}{2/3}} = 58667 \text{ tons prime}$$

(4)

c)

Prime Units = (2/3)(Run of Mine Throughput)
= (2/3)(150 000)
= 100 000 tons – Increase of 43%

Profit = (Prime Units)(SP) – Fixed Costs – (Throughput)(Variable Costs)
= (100 000)(120) – 2 200 000 – (150000)(55)
= R1 550 000 – Increase of 265%

(7)

d)

The answer in part (c) illustrates the impact of economies of scale.
The total unit cost is lower at high throughput (inverse proportion).
Thus relatively small increases in production may yield large increases in profit.
43% increase in production –> 265% increase in profit

(4)

Question 2

a)

Direct costs - related to the actual production facility.
Purchased equipment
Installation
Instrumentation
Piping
Electrical equipment (motors, switches, wiring)
Buildings

Indirect Costs
Engineering costs
Supervision
Security
Construction expenses (site office, storage yard)
Insurance

Operating Costs
Raw material
Direct operating labour
Supervisory and clerical labour
Plant maintenance & repairs
Power, utilities & royalties

(15)

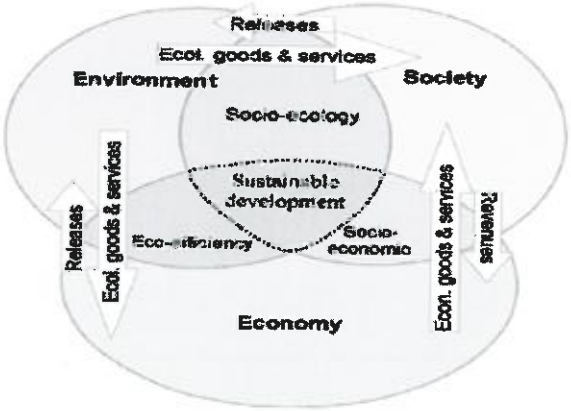
b)

Order of magnitude (ball-park) estimates (±30%) – scale of operations method (takes historical cost data of similar process/facility and scales it by size)
Factor method (± 30%) – used when specialized equipment forms major portion of total project cost (project cost is a factor of equipment cost)
Group method of estimating costs (± 20%) – representatives from departments such as engineering, purchasing, manufacturing & accounting get together and produce a joint cost estimate
Detailed and definitive estimates (± 5%) – a comprehensive list of materials to be used (with quantities), subcontractor work, equipment required etc is developed from the design and quotes are obtained from possible vendors

(12)

Question 3

a) The diagram below indicates how sustainable development is defined:



(7)

b)

Sustainability indicators were developed to give organizations the capacity to evaluate current performance.
These indicators can be categorized under environment, society, and economics.
They can be calculated as part of the daily mass and energy balances to ascertain the plant's "sustainability performance".
Benchmarks for these indicators can be set as an organizational improvement goal or KPI
They can then be used to ascertain if the impact of process and equipment modifications were successful in increasing sustainable development

(6)

Question 4

a) Path: 1-2-3-8 = 8 + 12 + 6 = 26 weeks

1-4-5-7-8 = 9 + 7 + 4 + 8 = 28 weeks **(3)**
1-6-7-8 = 3 + 11 + 10 = 22 weeks
Critical path = 1-4-5-7-8 Standard length of project = **28 weeks** **(2)** **[5]**

b) Ranking of crashing costs

Activity	Crashing cost (R per week)	No. of weeks available	No. of weeks used
4-5	5000	1	1
1-4	7000	3	
2-3	8000	1	
1-6	9000	1	
6-7	10000	1	
3-8	11000	1	
7-8	12000	2	

Activity	Weeks crashed	Still available	Crash cost (R/wk)	Total Project time	Total project cost (R'000)	New critical path
--	--	--	-	28	560	1-4-5-7-8
4-5	1	0	5	27	545	1-4-5-7-8
1-4	1	2	7	26	532	1-4-5-7-8 &1-2-3-8
2-3 & 1-4	1 1	0 1	8 7	25	527	1-4-5-7-8 &1-2-3-8
1-4 & 3-8	1 1	0 0	7 11	24	**525**	1-4-5-7-8

7-8	1	0	12	24	537	&1-2-3-8 1-2-3-8
Marks: 2			**2**	**2**	**5**	**2**

Optimum time = 24 weeks, optimum cost = **R 525 000** **(2)** **[15]**

Question 5

a) t = V/Q = 3 x(10 x 6 x 3) m_3 / [(0.6 x 1000)] m^3/d = 0.9 day = **21.6 h (3)**
b) Organic loading rate = Total COD load/day / Volume
= 600 m^3 /day x {0.49 – 0.05} kg/m^3) / [3x (10 x 6 x 3)] = **0.489 kg COD / m^3.d (3)**
c) F/M = Total daily COD load / Total MLSS = [600 m^3 /day x 0.440 kg COD /m^3day]/ [1.750 kg MLSS/m^3 x 540 m^3] = **0.279 kg COD / kg MLSS/day (4)**

- units.
0.9 days