UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2024 SEMESTER

COURSE	:	**OAI5123/OBI5123 – REFINERY OPTIMIZATION**
DATE	:	**10 AUGUST 2024 (SATURDAY)**
TIME	:	**2:30 PM –6:30 PM (4 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. This is an online open-book final examination. Students can refer to online/offline resources including learning materials, textbooks, and other reading materials to answer the questions.
2. Answer **ALL** questions.
3. Only ONE (1) duly completed online answer script submission is permitted. Multiple submissions are **NOT** allowed.
4. You **MUST** upload your answers in **ONE (1) PDF file** in ULearnX as per given guideline and click submit. The **maximum** allowable file size is **100 MB**.
5. Please make sure your answers are clear and readable in the PDF file and name your file as: **"your Examination ID_Course Code"**.
6. Late submission and unclear/unreadable answers will not be accepted.

Note :

i. There are **SIX (6)** pages in this Question Booklet including the cover page .

1. You are provided with the details as indicated in **TABLE Q1** regarding the specification of a specific refinery plant ABC.

TABLE Q1: Refinery plant details

Information/Details	Specification
Continuous plant operation	330 days/year or 7920 hr/year
Feedstock	4135 kg/hr @ RM 5.07/kg
Product	2527 kg/hr @ RM 8.31/kg
Average sales revenue per annum	RM 2,074,838,282
Average production cost per annum	RM 2,065,711,744
Average annual depreciation	RM 999,999
Total bare module investment	RM 9,978,000
Cost of site preparation	RM 789,000
Cost of service facilities	10% of cost of site preparation
Allocated cost for utilities and related facilities	RM 423,000
Cost of contingencies	18% of total direct permanent investment
Cost of land	1.9% of total depreciable capital
Cost of royalty	2.2% of total depreciable capital
Cost of startup	2.5% of total depreciable capital
10 barg steam	1579 kg/hr at RM 10/1000 kg
Corporate income tax	24%

a. Based on the information above, evaluate the total depreciable capital and total capital investment by stating appropriate assumptions.

[15 marks]

b. Based on the information in **part (a)**, investigate and explain whether this production should proceed, based on the return of investment and payback period calculation:

[10 marks]

2. A refinery system contains two crude oils (A & B) to develop four different products, namely gas oil, heavy fuel oil, kerosene, and motor gasoline. The crude yields (in wt%) are indicated in **TABLE Q2**.

TABLE Q2: Crude yield

	A	B
Gas oil	35	25
Heavy fuel oil	25	15
Motor gasoline	20	40

It is given that:

- Due to tankage limitation, the maximum quantity of products (gas oil, heavy fuel oil, kerosene, and motor gasoline) that can be manufactured (in tonne) are 1890, 1450, 1670, and 1420, respectively.
- The total revenue of processing one tonne of crude oil is RM 500 and RM 699 for crude oil A and B, respectively.

a. Build the appropriate equations and determine the quantity of two crude oils required to maximize the overall revenue.

[15 marks]

b. Based on the scenario below, evaluate the maximum revenue that can be achieved if the total processing cost for processing one tonne of crude A and B is indicated as follows:

Scenario 1: RM 0 (Crude oil A); RM 699 (Crude oil B)

Scenario 2: RM 500 (Crude oil A); RM 0 (Crude oil B)

[10 marks]

3. Hydrogen pinch analysis is one technique to optimize the production and consumption of hydrogen in a refinery plant. **FIGURE Q3** shows the process flow diagram of a hydrogen network in a refinery plant in Pengerang, Johor, which has 4 different processing units utilizing the hydrogen in its process. **TABLE Q3** is the process data representing the amount and quality of hydrogen for each process. The off gas that comes out from the plant is burnt to the flare and the hydrogen plant is supplying 220 m^3/hr with 99% hydrogen purity.

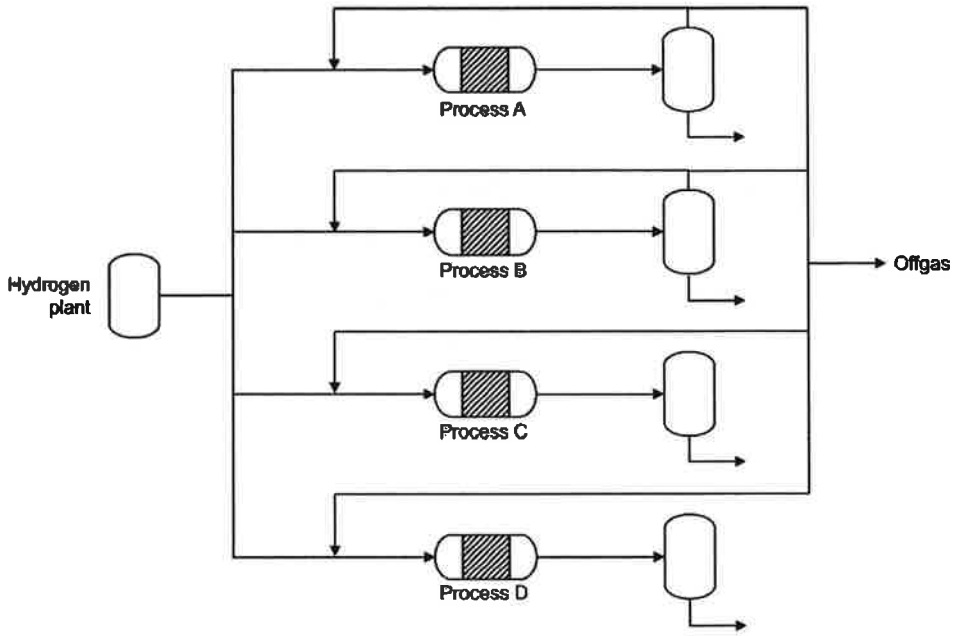

FIGURE Q3: Hydrogen network in a refinery plant.

TABLE Q3: Process data for the hydrogen network in the refinery plant.

Process	Makeup (M)		Purge (P)		Recycle (R)
	F_M, m^3/hr	Purity, $\%H_2$	F_P, m^3/hr	Purity, $\%H_2$	F_R, m^3/hr
A	80	92	20	91	320
B	135	87	25	85	465
C	30	75	10	70	240
D	25	70	35	68	225

Develop the hydrogen supply/demand composite curve and hydrogen surplus curve to determine the optimum flow rate of hydrogen from the hydrogen plant to achieve the pinch value. [25 marks]

4. Energy Saga Sdn. Bhd. produces 100 MT of biodiesel and bioethanol annually to supply the current demand for renewable and clean energy. The company has around 250 staff, which include technical and non-technical backgrounds. After few years of operating the process plant, to strengthen the financial and production capacity of the company, the higher management suggested that they should implement some optimization exercise to explore if it is techno-economically feasible and profitable.

   a. As a process engineer, justify to the higher management, either the company should go into real time optimization for their current process plant or not. Explain the information or requirement needed to perform the real time optimization.

   [8 marks]

   b. **TABLE Q4** shows the details of investment with its revenue increment. If the higher management can only invest around RM 9 million that year, propose which option of the investment that can achieve the best revenue for the company.

TABLE Q4: Investment and revenue increment

Option	Investment, RM million/year	Revenue increment, RM Million/year	Debottlenecking mix
1	1.5	4.2	Extra reactor
2	5.0	9.8	Extra reactor + tank
3	12.1	15.0	Extra reactor + tank + catalyst regeneration
4	24.0	51.5	Extra reactor + tank + catalyst regeneration + co-gen unit

[7 marks]

c. The company has 3 different site productions with 3 different product terminals. If they have to supply to 3 different suppliers at different locations, create a mathematical model to describe the network optimization to achieve the lowest minimum cost for the transport of products from the production site to the suppliers, through the terminal points. Formulate the suitable objective function and constraints without solving the problem.

[10 marks]

-END OF PAPER-