UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
JANUARY 2024 SEMESTER

COURSE : **MEB4343 - ASSET PERFORMANCE ASSESSMENT &
MAINTENANCE**

DATE : **20 APRIL 2024 (SATURDAY)**

TIME : **9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.

2. Begin **EACH** answer on a new page in the Answer Booklet.

3. Indicate clearly answers that are cancelled, if any.

4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.

5. **DO NOT** open this Question Booklet until instructed.

Note :

   i. There are **SEVEN (7)** pages in this Question Booklet including the cover page and appendix.

   ii. **DOUBLE-SIDED** Question Booklet.

   iii. **Graph papers will be provided.**

1. As a condition-based maintenance engineer, you are tasked to analyze the viscosity of lube oil based on the data collected after 6 months of operation. The analysis is expected to be useful for assessing the deterioration of lube oil operated using diesel engine. **TABLE Q1** shows the sample of 40 observations on viscosity (mm²/s) of lube oil analyzed in accordance with ASTM D445 at 40 °C.

TABLE Q1

Sample No.	Data	Sample No.	Data	Sample No.	Data	Sample No.	Data
1	102.3	11	103.3	21	102.8	31	101.2
2	101.2	12	101.2	22	104.2	32	100.2
3	99.3	13	102.6	23	101.3	33	98.3
4	100.2	14	102.1	24	100.2	34	99.6
5	103.6	15	103.8	25	103.7	35	103.7
6	102.1	16	104.3	26	102.1	36	104.5
7	97.8	17	104.2	27	99.8	37	103.3
8	105.2	18	102.6	28	100.2	38	104.2
9	104.3	19	103.7	29	104.1	39	100.7
10	105.1	20	104.2	30	101.3	40	101.1

a. Create a frequency histogram using an appropriate bin size. Comment on your findings.

[10 marks]

b. Construct a boxplot and comment on any interesting features.

[10 marks]

c. Describe the important features for a histogram and a boxplot and their applications.

[5 marks]

2. Containers of a certain treatment for septic tanks are supposed to contain 452 gram of liquid. A sample of five containers is selected from the production line once each hour, and the sample average content is determined as shown in **TABLE Q2.**

TABLE Q2

Sample	Reading (gram)
1	453.4
2	455.0
3	455.5
4	451.1
5	454.4
6	455.3
7	453.1
8	450.7
9	454.7
10	455.7
11	454.4
12	451.7
13	454.5
14	452.5
15	455.2

a. With the aid of a sketch, describe any **FIVE (5)** rules to say that the process is out of control.

[10 marks]

b. Construct the Cumulative Sum (CUSUM) control chart and comment on the findings.

[12 marks]

c. Describe the main disadvantage of Shewhart control charts compared to CUSUM control chart.

[3 marks]

3. Z-valve Sdn Bhd is a valve manufacturing plant producing double seal-fire safe valves meeting American Petroleum Institute standards. In the effort to reduce maintenance cost, the plant manager requested the asset reliability and management team to analyze the past year's performance. During a particular observation duration, the plant had an unplanned downtime of 90 min. The production rate of the plant is 3 parts/minute. The total number of valves rejected and sent for rework identified by the quality control team is 12.

    a. Determine the availability of the plant if it achieved 0.65 and 0.95 of performance and quality, respectively. Also, if there was an additional activity for equipment set-up or correction, briefly explain if this could have affected the availability.

    [11 marks]

    b. Explain the **FOUR (4)** key maintenance performance indicators and recommend how the asset reliability and management team could use it to gauge the performance or condition of an asset followed by highlighting the sort of decision can be made using it.

    [14 marks]

4. Sun chemical industries was expected to run for 130 hours/week continuously with a production capacity of 2500 metric tons/hour. At the end of the week, it produced 220,000 tons together with a waste of 3000 tons. It had 120 minutes breakdowns and 460 minutes changeover and adjustment.

    a. Evaluate the overall equipment effectiveness (OEE) of the facility.

        [10 marks]

    b. From **part (a)**, identify which of the major OEE component resulted in low OEE and recommend **TWO (2)** possible ways to improve the efficiency of the identified component.

        [5 marks]

    c. In the effort to reach greater heights, the company management decided to embrace total productive maintenance (TPM). Explain **FIVE (5)** philosophies of total productive maintenance and provide one example of real-life situation for each.

        [10 marks]

- END OF PAPER –

Appendix

$$\%Availability = \frac{loading\ time - breakdown\ \&\ setup\ loss}{loading\ time} x100$$

$$\%Performance = \frac{quantity\ produced}{time\ run\ x\ \frac{capacity}{given\ time}} x100$$

$$\%Quality = \frac{amount\ produced - amount\ defect - amount\ re-processed}{amount\ produced} x100$$

Histogram

$$No.\ of\ bin = \sqrt{N}$$

$$Bin\ width = \frac{max - min}{\sqrt{N}}$$

Boxplot

- **Median** is the middle value of the data set.
  $$\therefore Median = \frac{1}{2}(n+1)\text{th value where } n \text{ is the number of data values in the data set.}$$
- **Lower quartile** (Q_1) is the <u>median</u> of the lower half of the data set
  $$\therefore Q_1 = \frac{1}{4}(n+1)\text{th value where } n \text{ is the number of data values in the data set.}$$
- **Upper quartile** (Q_3) is the <u>median</u> of the upper half of the data set.
  $$\therefore Q_3 = \frac{3}{4}(n+1)\text{th value where } n \text{ is the number of data values in the data set.}$$
- **Interquartile range** (*IQR*) is the spread of the middle 50% of the data values.

  $$Interquartile\ range = Upper\ quartile - Lower\ quartile$$
  $$\text{I.e. } IQR = Q_3 - Q_1$$

CUSUM

$$\bar{x} = \frac{sum}{N}$$

$$\sigma_{sample} = \sqrt{\frac{\sum(x_i - \bar{x})^2}{N - 1}}$$

$$K = \frac{\sigma}{2}$$

$$H = \sigma\ x\ 4$$

Linear Regression

Intercept: $a = \bar{y} - b\bar{x}$

Slope: $b = \dfrac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2}$

Coefficient of correlation:

$$r = \dfrac{n\sum xy - (\sum x)(\sum y)}{\sqrt{\left[n\sum x^2 - (\sum x)^2\right]\left[n\sum y^2 - (\sum y)^2\right]}}$$

Control Chart Factors

Sample Size (n)	X-bar and R Chart				X-bar and S Chart		
	A_2	D_3	D_4		A_3	B_3	B_4
2	1.88	0	3.27		2.66	0	3.267
3	1.02	0	2.57		1.96	0	2.568
4	0.73	0	2.28		1.63	0	2.266
5	0.58	0	2.11		1.427	0	2.089
6	0.48	0	2.00		1.287	0.030	1.970
7	0.42	0.08	1.92		1.182	0.118	1.882
8	0.37	0.14	1.86		1.099	0.185	1.815
9	0.34	0.18	1.82		1.032	0.239	1.761
10	0.31	0.22	1.78		0.975	0.284	1.716

$\bar{x}$-R chart

R- chart	$\bar{X}$ chart
$UCL = D_4\bar{R}$	$UCL = \bar{\bar{X}} + A_2\bar{R}$
$CL = \bar{R}$	$CL = \bar{\bar{X}}$
$LCL = D_3\bar{R}$	$LCL = \bar{\bar{X}} - A_2\bar{R}$

7