

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

**MSC SYSTEMS ENGINEERING AND ENGINEERING
MANAGEMENT**

SEMESTER TWO EXAMINATION 2023/2024

MONITORING OF MECHANICAL SYSTEMS

MODULE NO: EEM7018

Date: Thursday 16th May 2024

Time: 10:00 – 12:00

INSTRUCTIONS TO CANDIDATES:

There are **FOUR** questions.

Answer **ANY THREE** questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

For reference, a Formula sheet follows after the questions.

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Question 1

a) A source with an internal voltage of $V_s = 20 \text{ mV rms}$ and an internal resistance of 10Ω .
(a) An amplifier has a gain of 100, input resistance of $1 \text{ k}\Omega$ and an output resistance of 10Ω . The amplifier is connected to a sensor that produces a voltage of 2 V and has an output resistance of 100Ω , and also to a load of 50Ω .

(i) Draw the equivalent circuit diagram. **[9 marks]**

(ii) Calculate the output voltage. **[7 marks]**

(iii) Calculate the voltage gain. **[3 marks]**

(b) An operational amplifier has high input impedance and low output impedance. Briefly explain why this is desirable.

[6 marks]

Total 25 marks

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Question 2

(a) Define the following maintenance strategies, explain their benefits and applications and critically analyse the possible challenges of applying each of these maintenances:

(i) Breakdown Maintenance

(ii) Preventive Maintenance

(iii) Predictive Maintenance

(iv) Total Productive Maintenance

[18 marks]

(b) Identify and explain, with the use of a diagram the warning signs of various machine failures in Machine Condition Monitoring system.

[7 marks]

Total 25 marks

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Question 3

a) Determine the bandwidth of the filter below

[15 marks]

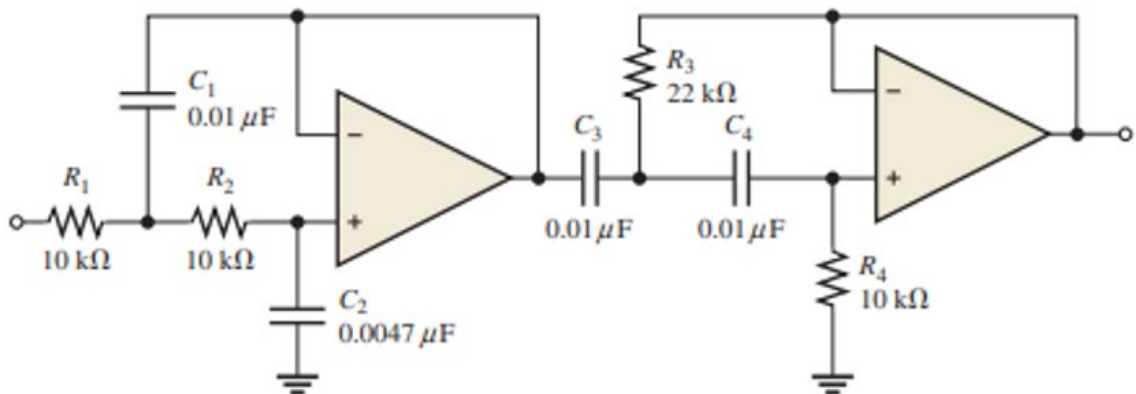


Figure Q3(a) An active filter circuit

b) Explain with the aid of a diagram, how Butterworth, Chebyshev, and Bessel responses differ.

[10 marks]

Total 25 marks

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Question 4

A mechanical engineering company intends to introduce the lean manufacturing into their company. TPM could be one of the key areas for success. The company owns four assembly machines. You are asked by the management to investigate the effectiveness of the system. After inspecting the assembly machine for a week, you record the following:

- The assembly machines work a total of 40 hours over 6 days.
- Every noon all the operators have a 45-minute lunch break.
- The standard time for the assembly process is 15 minutes.
- After assembling 200 parts, the tool needs to be checked and changed if necessary. 250 minutes required for each time.
- 11 defective parts have been detected.
- Detailed data was recorded on each failure and presented in Table Q4(a) (The normal processes time is from 9:00 am to 5:00 pm).
- The total assemblies made in the week were 100.

Table Q4(a)

Failure No.	Reported day and time	Machine handed back to production
1	Day 2 – 1:15 pm	Day 2 – 4:00 pm
2	Day 4 – 3:40 pm	Day 5 – 9:30 am
3	Day 5 – 2:00 pm	Day 5 – 3:15 pm

- a) Describing the procedure clearly, estimate the Availability, Performance Efficiency, Rate of Quality Products, and the Overall Equipment Effectiveness. **[12 marks]**

Question 4 continues on the next page...

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...Question 4 continued.

- b) Explain the basic elements involved in a vibration diagnosis monitoring system. **[6 marks]**

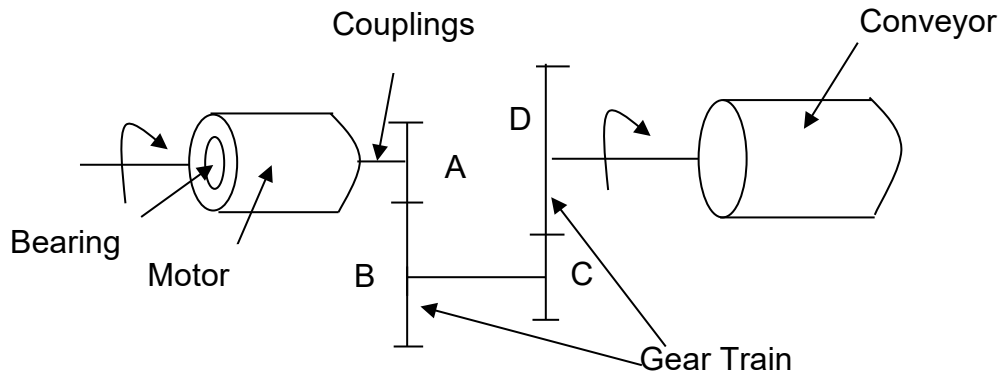


Figure Q4(b) A conveyor system

- c) A production line has seven stations operating series. Station 1 feeds Station 2, Station 2 feeds Station 3, Station 3 feeds Station 4, Station 4 feeds station 5, Station 5 feeds Station 6 and Station 6 feeds into Station 7. There is no buffer stock between each Station. That means that if one station stops, the whole cell stops.

Historical data collection by maintenance and operating workers shows that the individual reliabilities of each station are as follows:

- Station 1: 96.5%
- Station 2: 90.4%
- Station 3: 96.1%
- Station 4: 92.0%
- Station 5: 89.9%
- Station 6: 98.0%
- Station 7: 88.0%

Calculate and explain the reliability of the full production line. **[3 marks]**

Question 4 continues over the page....

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...Question 4 continued

- d)** A process engineer advises that a duplicate station be installed in Station 5, in parallel with the original one. What might be the effect(s) of this change on the reliability of the system (show your working)? What are the benefits and disadvantage of redundancy systems?

[4 marks]

Total 25 marks

END OF QUESTIONS

Formula sheet follows over the page

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Appendix

FORMULA SHEET

These equations are given to save short-term memorisation of details of derived equations and are given without any explanation or definition of symbols; the student is expected to know the meanings and usage.

$$E_f = \frac{1}{2\pi} \int_{-\infty}^{\infty} |F(\omega)|^2 d\omega$$

Butterworth Response Table

ORDER	ROLL-OFF DB/DECADE	1ST STAGE			2ND STAGE			3RD STAGE		
		POLES	DF	R_1/R_2	POLES	DF	R_3/R_4	POLES	DF	R_5/R_6
1	-20	1	Optional							
2	-40	2	1.414	0.586						
3	-60	2	1.00	1	1	1.00	1			
4	-80	2	1.848	0.152	2	0.765	1.235			
5	-100	2	1.00	1	2	1.618	0.382	1	0.618	1.382
6	-120	2	1.932	0.068	2	1.414	0.586	2	0.518	1.482

END OF PAPER