UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

MSC SYSTEMS ENGINEERING AND ENGINEERING MANAGEMENT

SEMESTER TWO EXAMINATION 2020/2021

MONITORING OF MECHANICAL SYSTEMS

MODULE NO: EEM7018

Date: Thursday 19th May 2022   **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.

Formula sheet has been provided.

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Question 1

a) A source with an internal voltage of V_s= 20 mV rms and an internal resistance of
(a) An amplifier has a gain of 100, input resistance of 1kΩ and an output resistance
of 10Ω. The amplifier is connected to a sensor that produces a voltage of 2V 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) Explain, with the use of examples, the difference between active and passive amplifiers.   **[6 marks]**

(b) Fig.2b is a diagram of a summing inverting negative feedback operational amplifier circuit with two inputs V1 and V2 and an output Vo. What is the value of Vo if V1=5V and V2 = 8V   **[4 marks]**
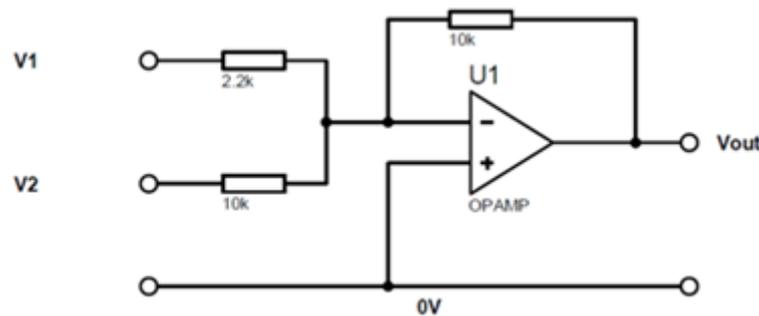

Fig.2b: Summing amplifier

(c) Briefly define the term common mode rejection ratio. An amplifier has a CMRR of 42dB. Restate this CMRR as an arithmetic ratio e.g. x:1, where x is a numerical value.   **[7 marks]**

(d) An op-amp has a differential gain G_d = 4000 and a CMRR ratio of 100. Determine the output voltage given input voltages of V_+= 150µV and V_-=140 µV
                                                                                                                      [8 marks]

                                                                                                            Total 25 marks

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Question 3

(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 4

a) You recently got hired in a mechanical engineering company. At your company, you have 6 processes in series, with the reliability shown below for each process:

- Process 1: 96.2%
- Process 2: 90.5%
- Process 3: 96.4%
- Process 4: 91.0%
- Process 5: 85.9%
- Process 6: 98.0%

What is the overall reliability of the plant? You decide to install in parallel with the original Process 5, one more Process 5 as redundancy. What is now the reliability of this process and the plant? (show in detail your calculation)? **[7 marks]**

What are the benefits and disadvantage of redundancy systems? **[3 marks]**

b) For the period of a week, you collected the following data. The assembly machines worked a total of 48 hours over 6 days. Everyday 2 operators have 1-hour lunch breaks. The standard time for the assembly process is 6 minutes. After assembling 100 parts, the tool needs to be checked and changed if necessary. 240 minutes required for each time. You detected 12 defective parts. The total assemblies made in the week were 175. 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).

Table Q4(a)

Failure No.	Production day/time machine reported down	Production day/time machine handed back to production
1	02 – 10:30	02 – 13:00
2	03 – 16:15	04 – 10:00
3	05 – 13:00	05 – 14:15
4	06 - 13:15	06 - 15:15

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

c) Based on the information obtained from above investigation, comment on the performance of the assemble machine and recommend to the management about adopting TPM. **[3 marks]**

Total 25 marks

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Question 5.

a) If you had five electric motors connected to an automatic circuit that you could then turn on and off once per hour for 1,000 hours, giving you the following data:

- Motor 1 burned out after 322 hours.
- Motor 2 burned out after 644 hours
- Motor 3 burned out after 903 hours
- Motor 4 worked for 1000 hours
- Motor 5 worked for 1000 hours

Calculate the following:

I. Failure rate (FR %)
II. Failure rate per hour (FR(N))
III. MTBF

[12 marks]

b) Identify and briefly explain sources of vibrations in electromechanical systems.

[5 marks]

c) Explain why maintenance is important **[5 marks]**

Identify three commonly used maintenance strategies in industry and **explain** their benefits and applications and critically **analyse** the possible challenges of applying each of these maintenances. **[3 marks]**

Total 25 marks

END OF QUESTION

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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