



**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES
BACHELOR OF ELECTRICAL AND ELECTRONICS ENGINEERING
END OF SEMESTER EXAMINATION**

BEE 2203: NETWORK THEORY

DATE: Monday, 16th March 2026

Time: 13.30 - 16.00 Hours

Instructions

1. This examination consists of **FIVE** questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.
3. Do not write on the question paper.

QUESTION ONE

(Total:30 Marks)

- a) Describe your understanding and importance of the following concepts. (3 Marks)
 - i. Transfer Function
 - ii. Stability of a system
 - iii. Poles & Zeros
- b) A digital data acquisition system processes low-frequency sensor signals corrupted by high-frequency noise and is sampled with period T . A digital low-pass filter is required such that the passband magnitude remains within $\pm\delta_p$ of unity and the stopband magnitude does not exceed δ_r . The passband and stopband edge frequencies are ω_p and ω_r respectively, with $\omega_r > \omega_p$. Sketch the magnitude response $|H(\omega)|$ for $0 \leq \omega \leq \pi/T$, clearly showing the passband, transition band, and stopband, and labeling the ideal and practical responses together with all relevant parameters. (5 Marks)
- c) A given robotic arm control system is designed to position objects with high precision. The characteristic equation of the closed-loop control system is given as:
$$P(s) = s^5 + 15s^4 + 85s^3 + 225s^2 + 274s + 120$$
To ensure precise and stable operation of the robotic arm, the system must be stable. Using the Routh-Hurwitz criterion, determine if the system is stable. *Show all the steps.* (5 Marks)
- d) A second-order speed control system of an electric motor is represented by the transfer function given below. Determine the magnitude and phase responses of the system and construct the corresponding Bode plots. (8 Marks)

$$H(\omega) = \frac{5(j\omega + 2)}{j\omega(j\omega + 10)}$$

- e) Determine the type of the filter shown in figure 1 and derive its transfer function. (6 Marks)

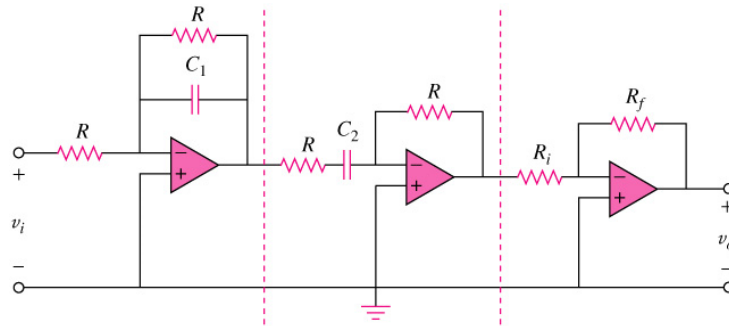


Figure 1

- f) A temperature control system is used to maintain a constant temperature in an industrial oven. However, the sensor readings are affected by high-frequency noise caused by nearby machinery. This noise introduces instability in the feedback loop, leading to erratic temperature control.
- Which type of filter would be best suited to address this issue and ensure stable operation of the control system? Explain your choice. (2 Marks)
 - Suggest suitable key characteristics of the filter (e.g., cutoff frequency or filter order) for this application. (1 Mark)

QUESTION TWO

(Total: 15 Marks)

- a) Test whether the following polynomials are Hurwitz or not using continued fraction expansion. *Show all the steps*
- $F(s) = s^5 + s^3 + s$ (3 Marks)
 - $F(s) = s^4 + s^3 + 3s^2 + 12$ (3 Marks)
- b) Test whether the following polynomial is Hurwitz stable using the Routh–Hurwitz criterion. *Show all the steps* (5 Marks)

$$P(s) = s^4 + 7s^3 + 6s^2 + 21s + 8$$

- c) Check the positive realness of the following function (4 Marks)

$$H(s) = \frac{s^3 + 5s}{s^4 + 2s^2 + 1}$$

QUESTION THREE

(Total: 15 Marks)

- a) In the design of a passive filter network for a communication system, the driving-point impedance of the network is required to be physically realizable using only inductors and capacitors. The impedance function of the network is given by:

$$Z(s) = \frac{s(s^2 + 4)}{s^2 + 1}$$

- Show that the given function is a positive real (PR) function suitable for LC realization. (2 Marks)
- Realize the given impedance using Foster's First Form and draw the resulting circuit. (6 Marks)
- Repeat question 3a(ii) using Foster's Second Form. (6 Marks)

- iv. Compare Foster I and Foster II realizations and recommend the better option (with justification). (1 Mark)

QUESTION FOUR

(Total: 15 Marks)

- a) In the development of a vibration-damping network for a mechanical system modelled using electrical analogies, the driving-point impedance must be realizable using only resistors and inductors (RL network) to ensure energy dissipation and stability. The impedance function of the system is given by:

$$Z(s) = \frac{(s+1)(s+3)}{(s+2)}$$

- i. Show that the given impedance function is a positive real function suitable for RL realization. (3 Marks)
- ii. Realize the given impedance using Cauer's First Form and draw the resulting circuit. (5 Marks)
- iii. Repeat part (ii) using Cauer's Second Form. (5 Marks)
- iv. Compare Cauer I and Cauer II realizations and recommend the better option, giving reasons. (2 Mark)

QUESTION FIVE

(Total: 15 Marks)

- a) Sketch Chebyshev Type 1 filter attenuation responses for $n = 3$ and 6 on the same plot. (3 Marks)
- b) A given lowpass filter has the following desired specifications: Maximum attenuation $\alpha_{max} = 0.25dB$, Minimum attenuation $\alpha_{min} = 20.5 dB$, Passband edge frequency $\omega_p = 1200 rad/s$, and Stopband edge frequency $\omega_s = 2000 rad/s$. Design the filter with a Butterworth response that meets the specifications given. (12 Marks)