L-2/T-1/EEE **Date : 27/03/2024**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2022-2023

Sub : **EEE 201** (Electronic Circuit I)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

The corresponding Course Outcomes (COs) of each part of Question 1 and 5 are mentioned on the right most column. The COs of the Course are mentioned at the end of the question.

SECTION – A

There are **FOUR** questions in this section. Answer question no 1 is compulsory and any 2 questions from Question 2-4.

1. (a) A full-wave bridge rectifier with a filter capacitor C is to be designed to produce a peak output voltage of 12 V, deliver 120 mA to the load and produce an output with a ripple of not more than 5 percent. An input line voltage of 120 V (rms), 50 Hz is available. Analyze the rectifier circuit to calculate the value of C, i_{Dmax}, $i_{D(avg)}$, PIV and turns ratio of the transformer. (18) (CO3, CO4)

(b) Consider a half-wave peak rectifier fed with a voltage v_s having a triangular waveform with 20 V peak to peak amplitude, zero average and 1 kHz frequency. Assume that the diode has a 0.7 V drop when conducting. Let the load resistance R = 100 Ω and the filter capacitor C = 100 μF. Solve the rectifier circuit to calculate the average dc output voltage, the time interval during which the diode conducts, the average diode current during conduction and the maximum diode current. (17) (CO2)

2. (a) For a common-emitter npn transistor in active mode, explain the term "Early effect" with necessary diagrams. Also, draw the large-signal equivalent circuit model for a common-emitter npn transistor considering the early effect. **(15)**

(b) Find the voltages of all nodes and the currents through all branches in the circuit shown in Fig. for Q. 2(b). Assume $\beta_{min} = 30$ **(20)**

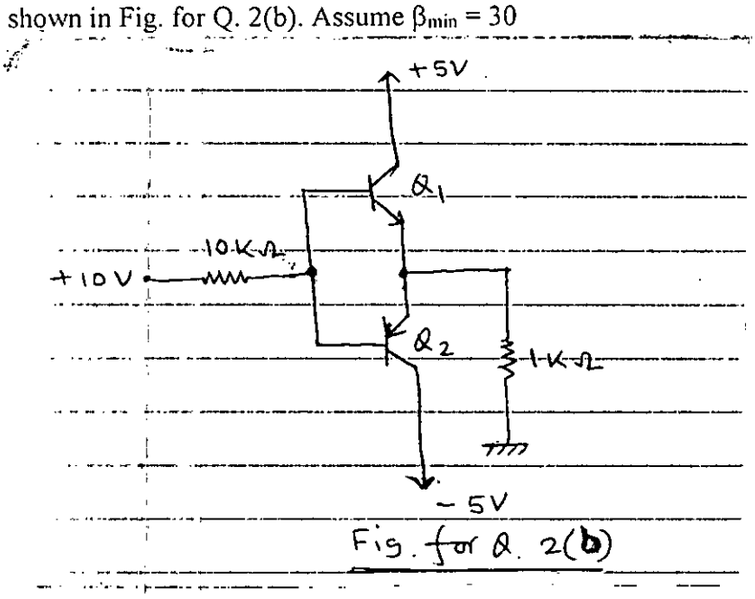

Fig. for Q. 2(b)

Contd P/2

EEE 201

3. (a) Briefly explain the constant-current source amplifier biasing circuit shown in Fig. for Q. 3(a). For the circuit shown in Fig. for Q. 3(a) (i), with Vcc = 10V, I = 1 mA, β = 100, R_B = 100 kΩ and R_c = 7.5 kΩ, find the dc voltages at the base, the emitter and the collector. For V_{EE} = 10 V, find the required value of R in order for the circuit of Fig. for Q. 3(a) (ii) to implement the current source I. **(18)**

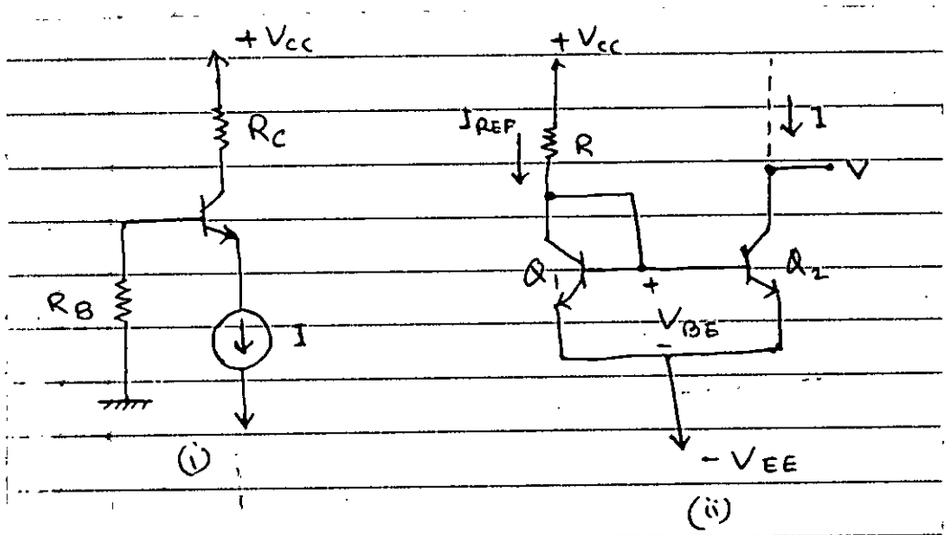

Fig. for Q. 3(a)

(b) For the circuit shown in Fig. for Q 3(b), design a bias stable circuit with β = 120 such that I_{CQ} = 0.8 mA, V_{CEQ} = 5V and the voltage across R_E = is 0.7V and R_E = 0.875 k Ω. Calculate the percentage change in I_{CQ} if β varies in the range 75 ≤ β ≤ 150. **(17)**

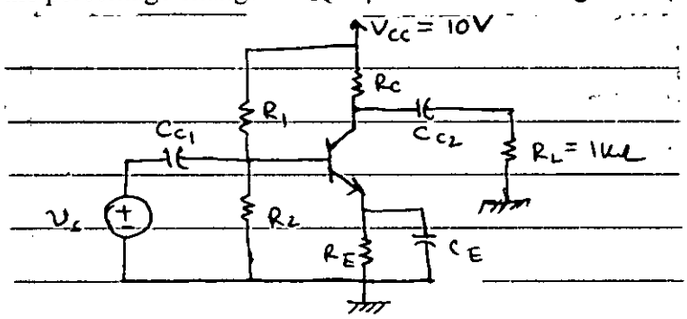

Fig. for Q. 3(b)

4. (a) For the circuit shown in Fig for Q. 4(a), under small signal condition, determine the expressions of g_m, r_π, r_e and A_v, where the symbols have their usual meanings. **(15)**

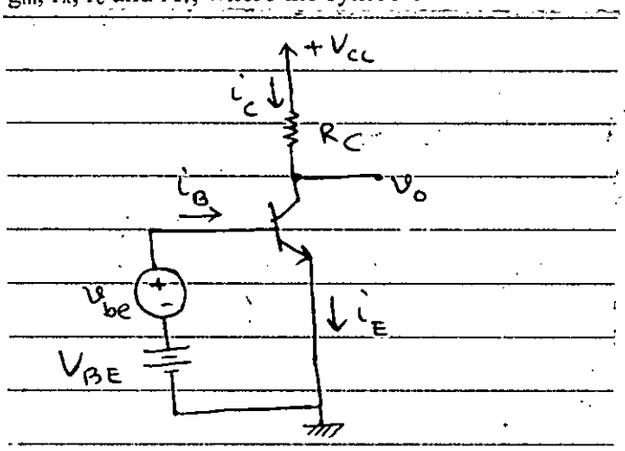

Fig. for Q.4(a)

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Contd...Q.No. 4

(b) For the emitter follower circuit shown in Fig. for Q. 4(b) the BJT used is specified to have β values in the range of 40 to 200. For the two extreme values of β (β = 40 and β = 200), find (i) I_E, V_E and V_B, (ii) the input resistance R_{in} and (iii) the voltage gain v_o/v_{sig}. **(20)**

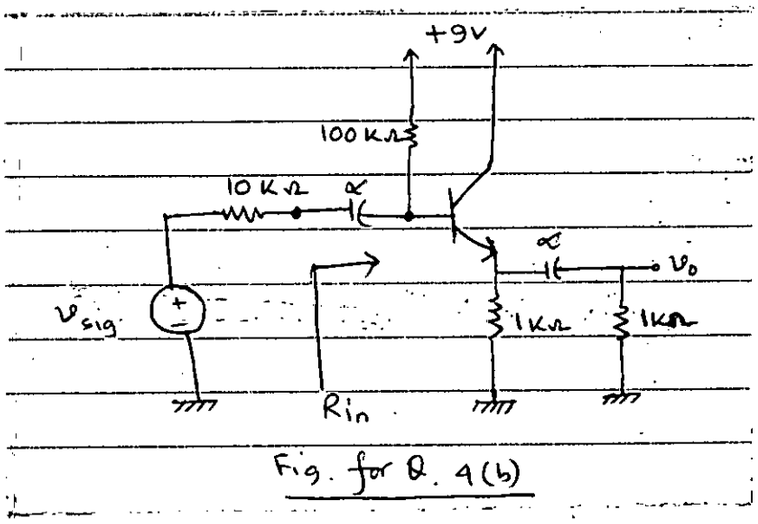

Fig. for Q. 4(b)

SECTION – B

There are **FOUR** questions in this section. **Question No. 5 is compulsory** and Answer any **TWO** from Question 6-8.

Assume reasonable values for missing data if necessary.

5. (a) Explain the operation of the Zener diode circuit shown in Fig. for Q. 5(a). Sketch output voltage, V_o as a function of time (V_o vs t) for the given time variation of V_Q and V_K, Neglect forward drop across the Zener diode. **(20) (CO1)**

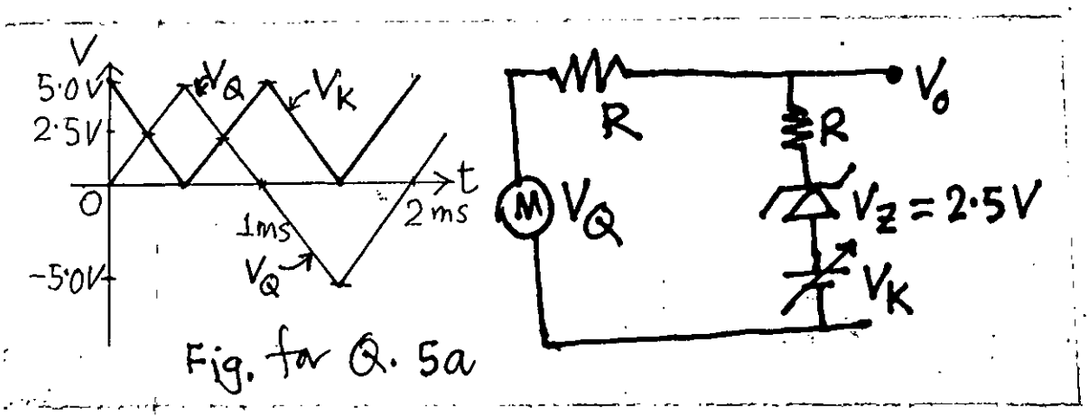

Fig. for Q. 5a

(b) A current-mirror circuit (see Fig. for Q. 5(b)) is designed to obtain a drive current of 100 μA. The desired operation could not be obtained for a design fault. Identify the fault and redesign the circuit for the desired operation. Given: $\mu_n C_{ox} W/L$ = 1.0 mA/V², V_t = 1V. Transistors Q_1 and Q_2 are identical Neglect channel length modulation effect. **(15) (CO2)**

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Contd...Q. no. 5(b)

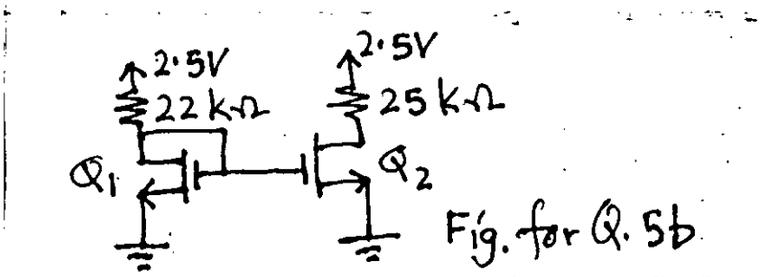

Fig. for Q. 5b

6. (a) Design an electronic circuit using diodes and other necessary elements to realize the transfer characteristics (V_0 vs V_i) as illustrated in Fig. for Q. 6(a). **(20)**

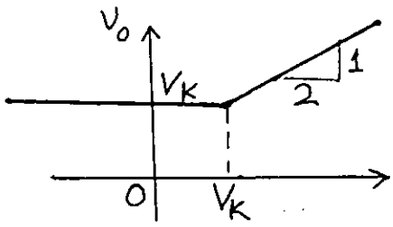

Fig. for Q. 6a

(b) A metal-oxide-semiconductor (MOS) device (capacitor) is fabricated with multiple dielectrics. Schematic cross sectional view of the device is illustrated in Fig. for Q. 6(b). A dc voltage (V_{GS}) is applied across the structure to turn the silicon surface beneath the SiO_2/p-Si interface into strong inversion. Estimate the capacitance per unit area of the device under the given conditions. Given: relative permittivity values of HfO_2, Si_3N_4 and SiO_2 are 25, 5.7 and 3.9, respectively. **(15)**

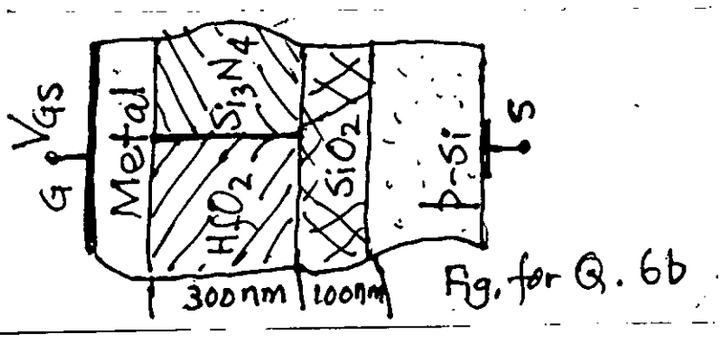

Fig. for Q. 6b

7. (a) Draw a CMOS logic inverter circuit and explain the operation. **(20)**

(b) Design suitable values for R_D and R_S in the MOSFET circuit shown in Fig. for Q. 7(b) such that the transistor operates in the linear region with a channel current of 70 μA. Given: $\mu_n C_{OX} W/L = 1.0$ mA/V^2, $V_t = 1$V. Neglect channel length modulation effect. **(15)**

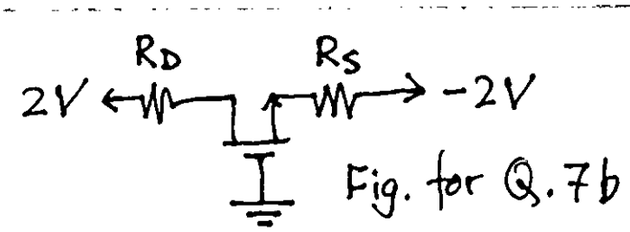

Fig. for Q. 7b

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8. (a) Calculate the current passing through 5kΩ resistor in the circuit shown in Fig. for Q. 8 (a). Assume a forward voltage drop of 0.7V across diode and make justified assumptions if necessary. **(20)**

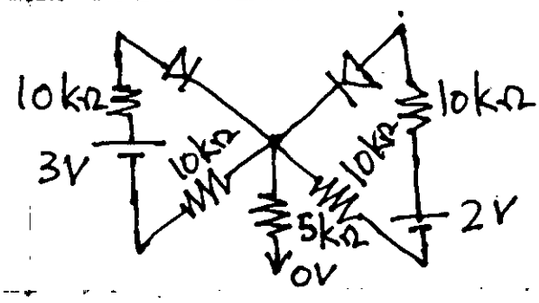

Fig. for Q. 8a

(b) Draw a single stage Source Follower Amplifier circuit using n-channel MOSFET and obtain an expression for the voltage gain (A_v) using an appropriate small signal model and analysis. **(15)**

Course Outcomes of EEE 201

CO No.	CO Statement
1	**understand** the formation, properties and characteristics of pn junction diode and **explain** diode applications in rectifiers, clampers and clippers. Moreover, Zener diode circuits (voltage regulators), photo diodes and LED circuits are analyzed.
2	**explain** the operation of MOSFETs including it's characteristics and able to **solve** problems associated with DC circuits & small-signal analyses of various MOS amplifiers.
3	**describe** the principle of operation of BJTs and **analyze** it's characteristics. Biasing techniques are fully described for BJT amplifiers and switches. Large- and small- signal models are analyzed to **calculate** the parameters of various BJT circuits and amplifiers.
4	**describe** and **analyze** the BJT and FET amplifier frequency responses at low, intermediate and high frequencies
5	**describe** the classifications of power amplifiers based on biasing and analyze the circuits

18/05/2024

L-2/T-1/EEE Date : ~~27/04/2024~~

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2022-2023

Sub : **EEE 203** (Energy Conversion I)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

The corresponding Course Outcomes (COs) of each part of Question 1 and 5 are mentioned on the right most column. The COs of the Course are mentioned in the end of the question paper.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are FOUR questions in this section. Answer to Question No. 1 is compulsory. Answer any TWO Questions from Question Nos. 2-4.

Symbols represent usual meaning.

1. (a) Applying the knowledge of electrical circuits and electromagnetic induction, prove that the ratio of the primary voltage caused by the mutual flux to the secondary voltage caused by the mutual flux is equal to the turns ratio of the transformer. **(10)** (CO1)

   (b) Suppose that a Δ-Δ transformer bank composed of separate single phase transformers has a damaged phase that must be removed for repair. Show that the remaining system still works as a three phase transformer and the available power out of the remaining system is 57.7 percent of the original bank's rating. **(15)** (CO3)

   (c) Consider two single phase transformers connected as shown in Figure 1(c). **(10)**

   If $V_{ab} = V\angle 120°$, $V_{bc} = V\angle 0°$, $V_{ca} = V\angle -120°$ and $N_p/N_s = a$, prove that $V_1 = \frac{V}{a}\angle 0°$ (CO2)

   and $V_2 = \frac{V}{a}\angle 90°$.

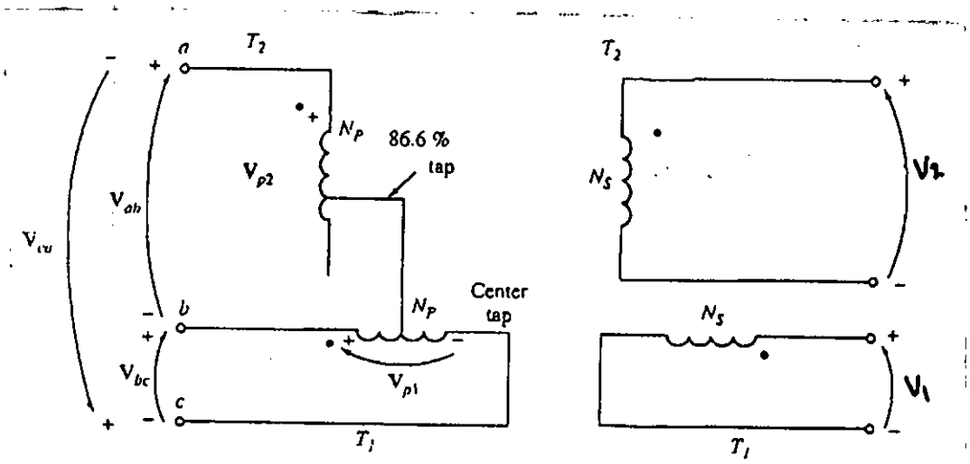

Figure 1(c)

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2. (a) What is *derating* of transformer and why is it necessary? **(10)**

(b) When travelers from the USA and Canada visit Europe, they encounter a different power distribution system. Wall voltages in North America are 120 V rms at 60 Hz, while typical wall voltages in Europe are 230 V rms at 50 Hz. Many travelers carry small step-up/step-down transformers so that they can use their appliances in the countries that they are visiting. A typical transformer might be rated at 1 kVA and 115/230 V. It has 750 turns of wire on the 115-V side and 1500 turns of wire on the 230-V side. The magnetization curve for this transformer is shown in Figure 2(b). Suppose that this transformer is connected to a 120-V, 60-Hz power source with no load connected to the 240-V side. What is the rms of the magnetization current? What percentage of full-load current is the magnetization current? **(15)**

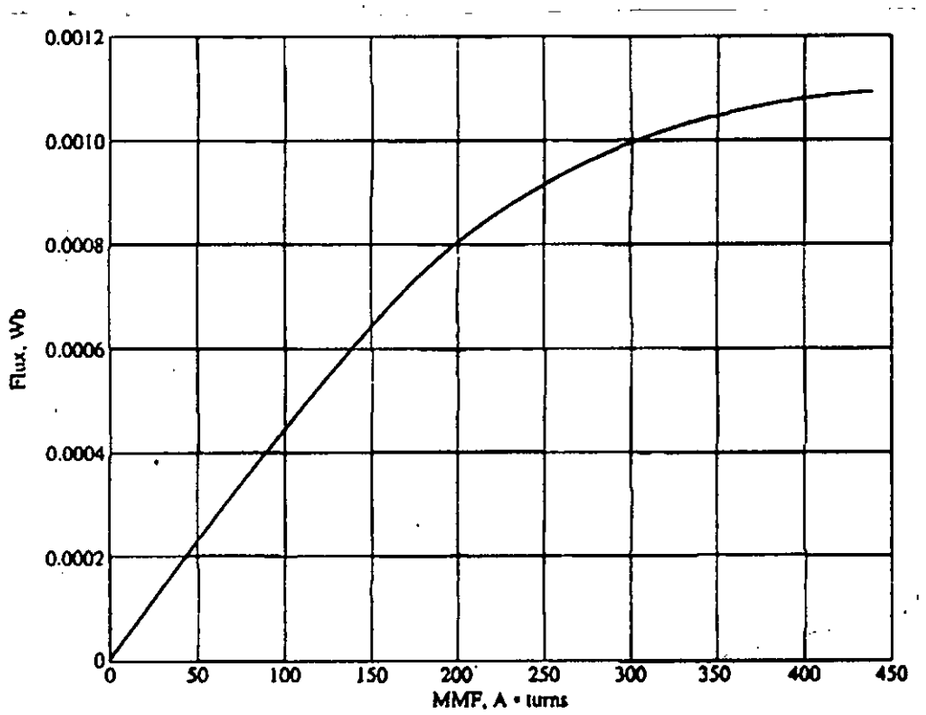

Figure 2(b)

(c) A 100-VA, 120/12-V transformer is to be connected so as to form a step-up autotransformer. A primary voltage of 120 V is applied to the transformer. (i) What is the secondary voltage of the transformer? (ii) What is the maximum volt-ampere that the autotransformer can handle? **(10)**

3. (a) What is inrush current of a transformer? Derive the condition for zero inrush current. **(14)**

(b) A 50-kVA, 13,800/208-V, Δ-Y distribution transformer has a resistance of 1 percent and a reactance of 7 percent per unit. (i) What is the transformer's phase impedance referred to the high-voltage side? (ii) Calculate this transformer's voltage regulation at full load and 0.8 PF lagging using the calculated high-side impedance. (iii) What is the efficiency of the transformer? **(21)**

Contd P/3

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4. (a) What is the application of a current transformer? **(7)**

(b) Draw the exact equivalent circuit of a real transformer using an ideal transformer. **(10)**

(c) A 75-kVA transformer A is to be paralleled with a 200-kVA transformer B. Both transformers have a turns ratio equivalent to their 2400-240 voltage ratio and are operated in the step-down mode. The percent impedance of transformers A and B based on individual transformer ratings are 1.64 + j3.16 and 1.10 + j4.03, respectively. Determine (i) the rated high-side current of each transformer, (ii) the percent of the total bank-current drawn by each transformer, (iii) the maximum load that can be handled by the bank overloading any one of the transformers. **(18)**

SECTION – B

There are FOUR questions in this section. Answer to Question No. 5 is compulsory. Answer any TWO Questions from Question Nos. 6-8.

5. (a) What is plugging? Explain the nature of the rotational magnetic field to achieve plugging. Describe how the three phase windings have to be placed to achieve this magnetic field with necessary mathematical derivation. **(15)** (CO1)

(b) A 240 V, 50 Hz, six pole, Y connected 25 hp design class A induction motor is tested in the laboratory, with the following results: **(20)** (CO2)

No Load	240 V, 25 A, 1000 W, 50 Hz
Locked Rotor	20 V, 60 A, 2000 W, 12.5 Hz
DC Test	15 V, 57 A

Find the equivalent circuit of this motor. Given that, $X_1 = X_2$ for class A induction motors.

6. (a) Describe the advantages and limitations of an induction generator. With necessary diagram, explain why capacitor bank is necessary for an induction generator operating alone. **(15)**

(b) A 208 V, two pole, 60 Hz Y-connected wound rotor induction motor has following rated circuit components: **(20)**

$R_1 = 0.2\ \Omega$, $R_2 = 0.12\ \Omega$, $X_1 = 0.41\ \Omega$, $X_2 = 0.41\ \Omega$, $X_M = 15\ \Omega$

$P_{mech} = 250$ W, $P_{misc} = 0$, $P_{core} = 180$ W and slip, s = 5%

(i) Determine the starting torque and maximum air gap power of this induction motor.

(ii) If the starting torque is increased to 110% of its current value, what will be the motor speed at pullout torque?

Contd P/4

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7. (a) Graphically develop the torque-speed characteristics of an induction motor. Show necessary phasor diagrams to establish your explanation. **(15)**

   (b) A 50 kW, 440 V, 50 Hz, six pole induction motor has a slip of 6 percent when operating at rated conditions. The friction and windage losses are 300 W, and the core losses are 600 W. Find the following values for the given scenario: **(15)**

   (i) The shaft speed, (ii) Output power, (iii) Load torque, (iv) Induced torque and (v) Rotor frequency.

   (c) Explain why an induction motor cannot run at synchronous speed. **(5)**

8. (a) Design an automatic wye-delta three phase induction motor starter using magnetic relays and contacts. Also incorporate short circuit, overload and under voltage protection to your design. **(20)**

   (b) Explain how the speed of an induction motor can be controlled by varying (i) the line voltage and (ii) the rotor resistance. **(10)**

   (c) Calculate the starting current of a 20 hp, 208 V, code letter E three phase induction motor. Here, starting kilo volt-ampere per horsepower of rating is 4.5-5. **(5)**

Course Outcomes of EEE 203

CO No.	CO Statement
CO1	**Explain** the operations of transformers and 3-ϕ induction motor/generator by **applying** the knowledge of electrical circuits and electromagnetic induction.
CO2	**Analyse** the performance of the transformer and 3-Φ induction motor using the equivalent circuit model.
CO3	**Design/develop** three-phase transformer using single-phase transformers.

L-2/T-1/EEE **Date: 02/05/2024**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **HUM 135** (English)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer **Q. No. 1** and any **TWO** from the rest.

1. (a) Explain with reference to the context any two of the following: **(15)**

   (i) "It will do you good to sit down for a while and chat with me."

   (ii) "It came whispering from the movement of the rocking-horse and even the horse, bending his woodenhead impatiently to go faster, heard it."

   (iii) "We want to be rescued; and of course we shall be rescued."

   (b) Answer any one of the following: **(15)**

   (i) What does D. H. Lawrence intend to delineate in the story 'The Rocking Horse Winner'?

   (ii) How would you analyze the character of the Astrologer in 'An Astrologer's Day'?

   (c) Answer any three of the following: **(15)**

   (i) What plan did the boys in 'Fire on the Mountain' make for their rescue?

   (ii) What were the "endless discussion" about the shooting of the elephant?

   (iii) Why was the astrologer unable to carry on the work of his forefathers in his village?

   (iv) "A great load is gone from me today." Who said this and why?

   (v) Why did the writer say the young Buddhist Priests were the worst?

2. (a) Recast and correct any ten of the following sentences: **(15)**

   (i) Peter is to be the first choice, and Pamela and Sharpe the second and third.

   (ii) We were not impressed by him speaking softly.

   (iii) I enjoyed during the holidays.

   (iv) She could not think up an answer.

   (v) Erosion is where the soil is washed away.

   (vi) I should have liked to have heard music.

   (vii) The students tried to give answer to the question.

   (viii) We have sick of all these types of reading.

   (ix) If I were him, I should not accept the post.

   (x) The jury are arguing among itself.

   (xi) I cannot bear your separation.

   (xii) Everybody likes his childish simplicity.

   (b) Give meanings of and make sentences with any ten of the following words: **(15)**

   Alluring, Bicker, Credulous, Eulogy, Gauche, Hilarious, Intrepid, Moron, Obsequious, Perforated, Quell, Tyro.

Contd P/2

3. Amplify the idea in any one of the following: **(30)**

   (a) A picture is worth a thousand words.

   (b) Hope for the best, prepare for the worst.

4. Write a précis of the following: **(30)**

   Over the years, influential people have been able to fill up the Buriganga mostly due to the indifference of government agencies. Large parts of the water bodies connected to it have been filled by factories and business establishments. Out of the 1,092 boundary pillars set up to demarcate the river, 718 are broken and 114 are missing. By comparing satellite images from 1990 to 2020, a study found a 37.67 percent of increase in settlements on the river, with the area occupied by residential and commercial buildings growing from 176.46 square kilometres in 1990 to 201.67 square kilometres in 2020. At present, there are 108 factories, 43 shipyards, 23 small factories, 22 industrial establishments, 19 warehouses and 17 brick kilns on its banks. The government has eight projects worth Tk. 3,294 crore for the restoration of the Buriganga. But none of them have produced any meaningful result. So, on the one hand, it has totally failed to restore the river while, on the other, it has wasted thousands of crores of taxpayer's money in the process. Despite a number of High Court directives urging government agencies to save it, the river has literally been used as a dumping ground over the last few decades, polluting it to an extent that it can hardly nurture aquatic life now. The government must take responsibility for the harm that is being done to the Buriganga, and to us by extension. And it must immediately begin a serious drive to evict river grabbers, ensure its proper water flow, and stop all sources of pollution.

SECTION – B

There are **FOUR** questions in this section. Answer **Q. No. 5** and any **TWO** from the rest.

5. Read the following passage and answer the questions that follow. **(45)**

   It was only minus 28 degree Celsius when we landed in Irkutsk. But that was cold enough to make breathing an effort - the air felt like ice as it scraped the back of my throat. Five minutes later, I needed a second pair of gloves and pulled my scarf tight over my nose and mouth. I was obviously a beginner at this. At the petrol station, Mikhail the attendant laughed when we asked if he wasn't freezing. He'd spent the whole day outside with no more than his fur hat and a sheepskin coat for warmth. It was mid-afternoon and icicles were hanging from his moustache like Dracula's fangs. He said he never drank to stay warm-unlike many others.

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HUM 135/EEE

Contd... Q. No. 5

There's a belief in Siberia that enough vodka will insulate you from the cold. It's been proved tragically wrong in the past few weeks. Dozens of bodies of the homeless or men walking drunkenly back from the pub were hauled out of the snowdrifts, frozen or so badly frost-bitten that many will never walk again. The local hospital in Irkutsk is overwhelmed. Ironically, it's the burns unit that's taken all the frostbite victims - 200 of them in just two weeks in one town. Even here, icicles are hanging down on the inside of the windows, though the heating is on full power. The doctor was too busy performing amputations to talk to us. But we could hear the screams from the operating room. They'd run out of anaesthetic after performing 60 amputations that week. The other patients could hear it too, and one girl in the corridor, clinging to her mother for support, was near to tears. Nastya is only 16. Last week she missed her last bus home, so she walked instead - seven kilometres through the snow, in temperatures of minus 40. She had no gloves. Now her hands are bandaged and hang down uselessly. She'll find out soon if they need to be amputated. She was far from the worst case. In one bed, Nikolai Dobtsov lay quietly staring at the ceiling. Underneath the sheets, blood was seeping through his bandages, from where his feet and hands had been amputated the day before. He was a truck driver, he explained, with a good job delivering wood - and recently there'd been a lot of demand. So he'd set out to deliver a last load upcountry. The weather forecast - just minus 25 in Irkutsk - seemed to suggest that the journey was safe. It wasn't. His truck broke down miles from anywhere, and for 6 desperate hours he fought to repair the axle. He even greased his hands for protection, and finally managed to get the truck going again. Somehow he found the strength to drive himself back and straight to hospital, but it was already too late. I asked Nikolai what would happen to him now. He just laughed, and shrugged. Nikolai has no wife or family in Irkutsk - and invalidity benefit is a pittance. Life is an institution may be the best he can hope for, and he'll almost certainly never work again. That incredible stoicism is everywhere. In Irkutsk at least, people seem simply to accept that winter is harsh - and this one especially so. It is without doubt the cruellest Siberian winter in living memory. Yet outdoors, everything appears to function normally - even schools re-opened as the temperature rose briefly to minus 25.

The trams and buses are back on the roads, though everyone drives slowly to avoid skidding on the layers of ice below the grit. The main street bustles with people wrapped in layers against the cold. But even indoors, the chill is inescapable. After her shift as a tram conductor, Natasha Fillipova comes home to a freezing house. She shows us the bedroom - where ice has built up on the inside walls. She scrapes it off with her fingers, but that has little effect. One night, Natasha says, she washed her hair before going to bed. When she woke up, it was frozen solid to the wall. The children are doing their homework in the bathroom - the only room warm enough to sit in. Natasha doesn't want to complain. But she is angry with the state and the architects for building shoddy houses. The flats here are supposed to withstand up to minus 40 degrees. They don't, and her children are ill with coughs and colds. Natasha's anger is brief, and she seems faintly embarrassed about it. Siberians are used to cold weather, she explains. Here, she tells us, people prefer to rely on themselves - and the knowledge that eventually, spring will come.

Contd P/4

HUM 135/EEE

Contd... Q. No. 5

(a) Give a suitable title of the passage with justification.

(b) Summarize the passage in your own words.

(c) How does the harsh Siberian winter reveal the resilience and challenges the local community faces regarding health, infrastructure, and social support system?

(d) Give the meanings of the following words as used in the passage.

Insulate, snowdrifts, frost-bitten, shrugged, skidding, bustles.

6. (a) You have purchased 100 chairs from a furniture supplier after carefully reviewing their specifications and examining samples. However, you have noticed significant differences between the chairs received and the approved samples upon delivery. Now, write a complaint letter to the supplier requesting replacements for the chairs that do not meet the agreed specifications and quality standards. **(10)**

(b) Write phonetic transcription of the following words (any five). **(10)**

Hard, sing, date, think, hospital, how

(c) Discuss the basic differences between a business letter and a personal letter. **(10)**

7. (a) Briefly discuss the 'front matter' elements of a report. **(10)**

(b) Write a short essay on (any one) of the following topics. **(10)**

(i) Impact of technology on students' creativity

(ii) Mental Health Awareness and Support

(iii) Impact of globalization on your culture

(c) Write a dialogue between two interview candidates who have come to attend a job interview and waiting for their turns. **(10)**

8. (a) Transform <u>any five</u> of the following sentences as directed. **(10)**

(i) I knew about her previous activities. (Complex)

(ii) No other dish in the menu is as cheap as mutton chop. (Comparative)

(iii) You have arrived very early. (Exclamatory)

(iv) She said her prayers and visualized the accomplishment of her goals. (Complex)

(v) We avoided that restaurant because of its bad reputation. (Compound)

(vi) I woke up and received your phone call. (Simple)

(b) What is the difference between an informational and interpretive report? **(5)**

(c) Write short notes on <u>any three</u> of the following: **(15)**

(i) Coherence and cohesion

(ii) Routine Reports

(iii) Monophthongs

(iv) Topic sentence

L-2/T-1/EEE **Date: 22/04/2024**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B.Sc. Engineering Examinations 2022-2023

Sub: **MATH 259 (Linear Algebra)**

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are FOUR questions in this section Answer any THREE questions.

Symbols have their usual meaning.

1. (a) Solve the system of homogenous equation. **(18)**

$$2x_1 + 2x_2 - x_3 + x_5 = 0$$
$$-x_1 - x_2 + 2x_3 - 3x_4 + x_5 = 0$$
$$x_1 + x_2 - 2x_3 - x_5 = 0$$
$$x_3 + x_4 + x_5 = 0$$

by reducing the coefficient matrix to the canonical form. Write down the solution in vector form.

(b) Determine the values of 'a' for which the system **(17)**

$$x + 2y - 3z = 4$$
$$3x - y + 5z = 2$$
$$4x + y + (a^2 - 14)z = a + 2$$

have no solutions, unique solution, or infinitely many solutions.

2. (a) Reduce the matrix $A = \begin{bmatrix} 2 & 7 & 3 & 5 \\ 3 & 9 & 6 & 9 \\ 3 & 8 & 1 & -2 \\ 4 & 13 & 1 & -1 \end{bmatrix}$ to echelon form then to its canonical form **(17)**

and write down the rank and nullity.

(b) Find the eigen values, eigen vectors and eigen spaces of the matrix $A = \begin{bmatrix} 5 & 3 & -1 \\ 3 & 5 & -1 \\ -3 & -3 & 3 \end{bmatrix}$. **(18)**

3. (a) State Cayley-Hamilton theorem and verify it for the matrix $A = \begin{pmatrix} 6 & 2 & -2 \\ 2 & 3 & -1 \\ -2 & -1 & 3 \end{pmatrix}$ **(17)**

and hence find the inverse of A.

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(b) Find non-singular matrices P and Q such that PAQ is in the normal form, where **(18)**

$$A = \begin{pmatrix} 3 & 2 & -1 & 5 \\ 5 & 1 & 4 & -2 \\ 1 & -4 & 11 & -19 \end{pmatrix}$$

4. (a) Find the inverse of the matrix, $A = \begin{bmatrix} 1 & 0 & 2 \\ 2 & -1 & 3 \\ 4 & 1 & 8 \end{bmatrix}$ using adj(A) and verify your **(15)**

result by showing $AA^{-1} = I_3$.

(b) Write down the symmetric matrix A corresponding to the quadratic from **(20)**

$q = X'AX = x^2 + 5y^2 - 2z^2 - 4xy + 2xz - 6yz$. Then find nonsingular matrix P such that P'AP = D (a diagonal matrix). Write down the rank, index and signature. Identify the geometrical object represented by $X'AX$ = constant.

SECTION –B

There are FOUR questions in this section Answer any THREE questions.
Symbols have their usual meaning.

5. (a) Determine whether the following subsets are subspaces of $\mathbb{R}^4$. If so, then find a basis in each case and their dimensions. **(12)**

(i) All vectors of the form. *(a,b,c,d),* where *d = a+b, c = a-b.*

(ii) all vectors of the form *(a,b,c,d),* where *d = 2a+7c* and *3c = 2a-5b.*

(b) Determine whether the set of vectors $S = \{\mathbf{u},\mathbf{v},\mathbf{w},\mathbf{x}\}$, where **(12)**

$$\mathbf{u} = (3,6,3,-6),\ \mathbf{v} = (0,-1,-1,0),\ \mathbf{w} = (0,-8,-12,-4),\ \mathbf{x} = (1,0,-1,2)$$

is a basis for $\mathbb{R}^4$. If so, find a vector in $\mathbb{R}^4$ whose coordinate vector with respect to the basis S is (-1,1,2,3),

(c) Let T : $\mathbb{R}^4 \rightarrow \mathbb{R}^3$ be the linear transformation defined by **(11)**

$$T(x,y,s,t) = (x - y + s + t,\ x + 2s - t,\ x + y + 3s - 3t).$$

Find a basis and the dimension of (i) Null space of T and (ii) Range space of T.

6. (a) Find the standard matrix for the transformation T or $\mathbb{R}^3$, where T is the composition of a rotation of 45° about the y-axis, followed by a reflection about the yz-plane, followed by a dilation with factor k = $\sqrt{2}$. Then find the image of the triangle whose vertices are (-1,0,-3), (2,-2,-3),(-1.-2,3) with respect to the stated composition. **(18)**

MATH 259 (EEE)

(b) Given $A = \begin{bmatrix} 1 & -2 & 0 & 0 & 3 \\ 2 & -5 & -3 & -2 & 6 \\ 0 & 5 & 15 & 10 & 0 \\ 2 & 6 & 18 & 8 & 6 \end{bmatrix}$. Find bases for the row space and null space of **(17)**

A. Also, verify the dimension theorem for A.

7. (a) Find a subset of vectors **(17)**

$$\mathbf{u} = (1,-2,0,3),\ \mathbf{v} = (2,-5,-3,6),\ \mathbf{w} = (-4,11,9,-12)\ \mathbf{x} = (2,-1,4,-7),\ \mathbf{s} = (5,-3,11,-11)$$

that forms a basis for the space spanned by these vectors. Express each vector not in the basis as a linear combination of the basis vectors.

(b) Find a basis for the orthogonal complement of the subspace of $\mathbb{R}^5$ spanned by the **(18)**

vectors $\mathbf{u} = (2,2,-1,0,1),\ \mathbf{v} = (-1,-1,2,-3,1),\ \mathbf{w} = (1,1,-2,0,-1),\ \mathbf{x} = (0,0,1,1,1)$.

8. (a) (i) Apply Gram-Schmidt process to transform the basis vectors $\underline{u_1} = (1,-1,0)$, $\underline{u_2} = (2,0,-2)$, and $\underline{u_3} = (3,-3,3)$ into an orthogonal basis, (ii) Then normalize the orthogonal basis vectors to obtain the orthonormal basis, (iii) Write the QR-decomposition of the matrix A whose columns are he given vectors. **(15)**

(b) *Let* $T : P_2 \to P_3$ be the linear transformation defined by **(10)**

$$T(a+bx+cx^2) = x(a+b(3x-5)+c(3x-5)^2)$$

Find the matrix for T with respect to the standard bases $E = \{1,x,x^2\}$ and $E' = \{1,x,x^2,x^3\}$.

(c) Write a short note on computed tomography. Consider the following system of linear equations: **(10)**

$$\begin{aligned} x_1 + x_2 &= 2 \\ x_1 - 2x_2 &= -2 \\ 3x_1 - x_2 &= 3 \end{aligned}$$

Write an algorithm that generates three sequences of points and describe the limit cycle of the iterative process.