L-3/T-2/EEE **Date : 06/04/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-II B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 303** (Digital Electronics)

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**.

All the symbols have their usual meanings.

Assume reasonable values for any missing data.

1. (a) Explain setup time and hold of latches using timing diagram. **(6)**

   (b) What is the difference between level-sensitive and edge-triggered storage elements? **(7)**

   (c) An SR flip-flop has set and reset inputs like a gated SR latch. Show how an SR flip-flop can be constructed using a D flip-flop and other logic gates. **(10)**

   (d) Design a four-bit synchronous counter with parallel load using T flip-flops. **(12)**

2. (a) Design a three-bit up/down counter using T flip-flops. It should include a control input called $\overline{UP}$/Down. If $\overline{UP}$/Down = 0, then the circuit should behave as an up-counter. If $\overline{UP}$/Down = 1 then the circuit should behave as a down-counter. **(12)**

   (b)Design a modulo-8 up-counter with synchronous reset using D flip-flops. **(13)**

   (c) Derive a CMOS complex gate for the logic function $f=(\overline{x_1}+\overline{x_2})(\overline{x_3}+\overline{x_4})$. Consider that the variables are available only in true form. **(10)**

3. (a) Draw a circuit using transmission gates to implement a gated D latch. **(7)**

   (b) Draw a 2×2 array of SRAM cells and explain the operation. **(10)**

   (c) Explain the operation of a circuit using flip-flop and MOSFETs to implement a single-pole double-throw switch. **(8)**

   (d) Draw the circuit diagram of a D/A converter using R, 2R ladder. Show that the output will be $V_0 = 0.5V_R$ when the MSB is turned on and all others are off. Here V_R is the reference voltage. **(10)**

4. (a) A sequential circuit has two inputs, w_1 and w_2 and an output, z. Its function is to compare the input sequences on the two inputs. If $w_1 = w_2$ during any four consecutive clock cycles, the circuit produces z = 1; otherwise, z = 0. Derive the state table, state-assigned table and, expression for next-states and output. **(15)**

   (b) Suppose that you want to swap the contents of registers R_1 and R_2. You need to achieve this by first transferring the contents of R_2 into the third register, R_3. Next, you transfer the contents of R_1 into R_2. Finally, you transfer the contents of R_3 into R_1.

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Contd. to Q. 4(b)

The process starts when an input signal W becomes '1' and, also a 'Done' signal is asserted at the end of this transfer operation. Considering the Moore-type design, draw the state diagram, the state table, the state-assigned table using one-hot encoding method, and the ASM chart for the desired logic circuit. **(20)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.
All the symbols and notations used in this section have their usual meanings.

5. (a) Derive the canonical SOP expression for the following function using minterms. Now simplify the expression using (Boolean) algebraic manipulation and implement is using NAND gates only. **(17)**

$$f(x_1, x_2, x_3) = \sum m(2, 3, 4, 6, 7)$$

(b) Use Karnaugh map to determine the minimum-cost POS expression for the following function:

$f(x_1, x_2, x_3, x_4) = \sum m(4, 6, 8, 10, 11, 12, 15) + D(3, 5, 7, 9)$ **(18)**

Also determine the cost of the digital circuit after simplification.

6. (a) Design a full-adder block using two half-adder blocks and an OR gate. Hence construct an n-bit ripple-carry parallel adder using required number of full-adder blocks. **(10)**

(b) In relation to binary adder, explain the terms arithmetic overflow. For n-bit numbers, derive the expression for arithmetic overflow. **(8)**

(c) Explain the concept of fast adders. Determine the number of gates needed to implement an n-bit carry-lookahead adder, assuming no fan-in constraints. Use AND, OR, and XOR gates with any number of inputs. **(17)**

7. (a) What is the major difference between a multiplexer and an encoder? Design a 4-to-1 line multiplexer by using only 2-to-1 line multiplexers. **(10)**

(b) Contruct the truth table for a three-input majority function and modify the truth table to implement the function using a 4-to-1 multiplexer. Choose w_1 and w_2 as the multiplexer select inputs. **(13)**

(c) Consider the following minimal sum-of- products expression:

$f = \overline{w_1}\,\overline{w_2} + \overline{w_2}\,\overline{w_3} + w_1 w_2 w_3$. **(12)**

Use Shannon's expansion to derive a multilevel circuit that has a lower cost and give the cost of that circuit.

Contd. P/3

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8. (a) Design a comparator that has two n-bit inputs, A and B which represent unsigned binary numbers. The comparator produces three outputs, called AeqB, AgtB, and AltB. The AeqB output is set to 1 if A and B are equal. The AgtB output is 1 if A is greater than B, and the AltB output is 1 if A is less than B [for ease of implementation purpose, assume $n = 4$]. **(12)**

   (b) Design and implement a 4-to-16 decoder using only 2-to-4 decoders (decoder tree). **(10)**

   (c) What is the main problem of a binary encoder? How the priority encode overcomes this? Design and implement an 4-to-2 (lower) priority encoder using basic gates only. **(13)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **IPE 493** (Industrial Management)

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**.

1. (a) Mr. Brown has received his annual salary of \$40,000 in 1st January 2019 which is considered as present time. Under normal conditions he will retire 16 years from the present. His annual retirement income will be 60% of his last year's salary, with his first annual payment occurring at the moment of retirement payment. He expects to receive 20 equal annual retirement payments. **(16)**

Because Mr. Brown served for three years in the military before being employed by this present firm, the current pension system allows him the option of purchasing 3 years of credit. That is, if he pays a single amount now, he will be able to retire 3 years earlier. For this option he will receive 60% of his last year's salary beginning at the moment of retirement. In this case he expects to receive 23 equal annual payments.

He expects his salary to increase at the rate of 6% per year, and inflation rate for 46 years starting from 2019 is shown in Table 1(a). If the market rate of interest 4.881% resulting from compounded quarterly with a time interval of half year, what is the maximum amount he would pay for the improved net advantage in retirement income if he retired early rather at the normal time?

Table 1(a): Frequency of various inflation rate from 2019 to 2054

Inflation rate from 2019 to 2031	
Number of years	Inflation rate (%)
2	3.5
3	4.0
1	2.5
4	5.0
3	3.5
Inflation rate from 2032 to 2034	
Number of years	Inflation rate (%)
1	3.5
2	4.25
Inflation rate from 2035 to 2054	
Number of years	Inflation rate (%)
5	3.5
5	4.5
5	5.0
5	3.0

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Contd ... Q. No. 1

(b) Consider a project named 'Surplus inventory at project X'. The project team consists of the following members: **(10)**

- Project Management Director
- Supply Chain Director
- Engineering Project management Director
- MMI Deputy Manager of Welding
- Manufacturing purchasing Manager

The problem description under the project is a follows:

Surplus inventory for Project X (tubes and plates)

Surplus after job closing: 3.92% of total purchase

Cost: 4,103,103 RMB

Build a '5W2H analysis' using the above information under the project called 'Surplus inventory at project X'. Also, sepearately relate corresponding tool(s) from the seven tools of TQM that should be used to answer each of the seven questions from '5W2H analysis'.

(c) Do you think any one market segmentation basis is independent of others? Justify your answer with suitable examples. Also, provide a marketing example that focuses at least three marketing segmentation bases at a time. **(5)**

(d) Do marketing shape consumer needs or merely reflect the needs and wants of consumers? Support your answer with proper examples. **(4)**

2. (a) K9 is a German petrochemical company. The firm's management intends to renovate its production and distribution network, which is presently composed of two refining plants, two DCs and hundreds of sales points (gas pumps and liquefied gas retailers). After a series of meetings, it was decided to relocate the DCs, leaving the position and features of the two production plants unchanged. The products of K9 are subdivided into two homogenous commodities: fuel for motor transport and liquefied gas (the latter sold in cylinders). There are four potential sites suited to receive a DC and their maximum daily throughputs (expressed in hectoliters) are, respectively, 1500, 1200, 2300 and 2500. Minimum daily throughputs (expressed in hectoliters) expected from these four DCs, are respectively, 800, 700, 1100 and 1200. The sales points have been grouped into three districts characterized by the daily demands shown in Table 2(a-i). The annual fixed costs (in €) of the distribution centers are the following: 960000, 880000, 1540000, 1610000. The daily storage facility costs are, respectively, 0.15, 0.14, 0.20 and €0.25/hl. The transport costs are obtained by multiplying the cost per kilometer and per hectoliter (equal to €0.0067 for fuel and to €0.0082 for liquefied gas) by the return trip distances between the manufacturing plants and the centroids of the sales districts through DC (see Table 2(a-ii)). Finally, Table 2(a-iii) shows the daily average quantities of the two commodities available at the two manufacturing plants. Build a mathematical model to find two optimal facility locations for DCs considering 220 working days annually. **(21)**

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Contd ... Q. No. 2(a)

Table 2(a-i): Average daily sales districts demand (in hl) of the two commodities in the K9 problem

	Commodity	
District	1	2
1	800	300
2	600	400
3	700	500

Table 2(a-ii): Kilometric distances between the refining plants and the centroids of the sales districts through the potential DC in the K9 problem.

		Sales District		
Refining plant	DC	1	2	3
1	1	423	612	1108
	2	613	434	927
	3	1031	631	918
	4	1628	1236	954
2	1	826	1028	1531
	2	864	638	1158
	3	838	464	782
	4	1227	871	544

Table 2(a-iii): Average daily quantity (in hl) of the two commodities available at the refining plants in the K9 problem.

	Commodity	
Refining plant	1	2
1	1200	500
2	1500	800

(b) A series of 'why' questions for investigating the reasons of poor gas mileage of an automobile are listed below: **(9)**

Q: Why was the driver using the wrong gear?
A: The driver couldn't hear the engine.
Q: Why couldn't the driver hear the engine?
A: The radio was too loud. A: Poor hearing
Q: Why were the tires underinflated?
A: No record of tire pressure
A: Difficult air stems
Q: Why were the air stems difficult?
A: Poor design.
Q: Why was maintenance poor?
A: Lack of money
A: No awareness
Q: Why was wrong octane gas used?
A: Didn't know recommended octane
Q: Why wasn't recommended octane known?
A: No owner's manual

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Contd ... Q. No. 2(b)

Now build a cause-enumeration type fishbone diagram incorporating all the above why questions and their answers in detail.

(c) How does co-branding influence customers' usage trait psychologically? Briefly describe with a suitable example. Also, provide a suitable marketing example that influences the customers' usage trait in a similar fashion as done by co-branding, however, is mainly introduced focusing on a demographic market segmentation basis. **(5)**

3. (a) MCE is an international freight forwarder headquartered in New Zealand with more than 500 terminals and representatives around the world. The daily sales (in NZ$) at the Wellington center during the past 16 days are shown in Table 3(a). **(10)**

Table 3(a): Daily sales (in NZ$) at the Wellington MCE center.

Period	Revenue
1	215
2	1768
3	10331
4	287
5	10689
6	4003
7	2801
8	4056
9	10989
10	6520
11	5790
12	9685
13	2366
14	1119
15	9991
16	10252

(i) Predict the sales in 17th day using winter method with proper quantitative justification.

(ii) Do you see any anomaly while pursuing the enumeration in 3(a)-(i)? If yes, with proper justification, suggest three methods to deal the anomaly.

(b) What do you mean by business cycle? Which type of time series can be used for its forecasting? Justify your answer. **(4)**

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Contd ... Q. No. 3

(c) On which traditional marketing mix 4 p's do 'discount' and 'allowance' lie? Differentiate 'discount' and 'allowance' with suitable examples. Also, relate the modern marketing mix 4p's with the corresponding traditional marketing mix 4p's and fundamental bases of holistic marketing with proper reasoning. **(7)**

(d) The lognormal distribution is closely related to the normal distribution. If x is distributed lognormally with parameters μ and σ, then $\log(x)$ is distributed normally with mean μ and standard deviation σ. The lognormal distribution is applicable when the quantity of interest must be positive, since long(x) exists only when x is positive. The pdf, mean, and variance of lognormal distribution is defined, respectively, as **(7)**

$$f(x \mid \mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}} exp\left\{\frac{-(log\, x-\mu)^2}{2\sigma^2}\right\}$$

$$\text{Mean} = \exp\left(\mu + \frac{\sigma^2}{2}\right)$$

$$\text{Var}=\exp\left(\mu+\frac{\sigma^2}{2}\right)\left(exp(\sigma^2)-1\right)$$

Assume, outcomes from two portfolio (A and B) are denoted as x_1 and x_2 which are lognormally distributed with parameters (1,1) and (0,5,1.5), respectively. Which portfolio apparently will be preferable to one who has inclination to risk-averse decision making? Change in which parameter will affect his decision making more?

(e) How can you explain the consistency in production requirement of product mix of RFL group? Also, explain how the vertical integration approach in RFL is exploited through the 'RFL Best Buy'. **(7)**

4. (a) 'Use of IRR method compared to NPV method in capital budgeting becomes ineffective in presence of (i) varying discount rate, (ii) unpredictable cash flows, (iii) unequal risk, and (iv) a longer time horizon.' – Verify the claim for each of the four scenarios with proper quantitative examples. **(18)**

(b) Motivational force: force directing specific alternatives = perceived likelihood that effort will lead to performance × perceived likelihood that performance will lead to desired rewards × value of expected rewards to the individual. Which motivational theory is comprised of three multiplicative factors as defined in the definition of motivational force above? Name each of these three multiplicative factors. Also, range the value each of these three multiplicative factors can hold with proper implication of each of the value in the corresponding range. **(6)**

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Contd ... Q. No. 4

(c) Having a car to get to work is a necessity for many workers. When two crucial employees of Vurv Technology, in Jacksonville, Florida, had trouble getting to work, owner Derek Mercer decided to buy two inexpensive used cars for the employees. He said, "I felt that they were good employees and valuable asset to the company." One of the employees who got one of the cars said, "It wasn't the prettiest car. But boy did my overwhelming feeling of dread go to enlightenment. The 80-hour weeks we worked after that never meant anything. It was give and take. I was giving and the company was definitely giving back." Which motivation theory can properly help Mercer to motivate the employee after understanding the present situation? Explain with proper justification. **(7)**

(d) What do you mean by 'milking cash cows' from marketing management perspective? Briefly discuss with example. **(4)**

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) What do you understand by *margin of safety* and *degree of operating leverage*? If variable expense is increased keeping everything else constant, will *margin of safety* and *degree of operating leverage* increase or decrease? Justify your answer. **(2+8)**

(b) Because of an increase in the volume of sales, Mr. John Doe, the owner of Melder, Inc., a small manufacturing firm located in Indiana, has decided to expand production capacity. A new wing has been added to the plant that will house four machines: (i) a punch press, (ii) a grinder, (iii) a lathe, and (iv) a welding machine. There are six possible locations for these machines, say A, B, C, D, E and F. However, the welding machine, which is the largest machine, will not fit in location B. The plant foreman has made estimates of the handling cost of locating each of the machines in each of the possible locations. These costs, expressed in terms of dollars per hour, are represented in the following table. **(25)**

		Locations					
		A	B	C	D	E	F
Machines	1	94	13	62	71	82	25
	2	62	19	84	96	24	29
	3	75	88	18	80	16	78
	4	11	-	81	21	45	14

How Mr. John Doe should allocate the machines to the available locations economically?

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6. (a) What is *product life cycle?* How can you increase the value of a product with respect to products entire life cycle? **(7)**

(b) Compare *product layout* with *process layout.* Which one is better? **(8)**

(c) An *assembly* consists of the following elements as given in the table below.

Task	A	B	C	G	D	E	F	I	H	K	J
Follower	B	C,D ,E,F	G	H	G	I	J	J	K	L	K
Task Time	12	6	6	7	2	2	12	1	5	6	4

The production rate required is one assembly every 15 minutes. Assign the tasks to suitable workstations in order of the greatest positional weight. Also determine the following: **(20)**

(i) Minimum number of workstations required

(ii) Idle time and efficiency.

7. (a) What are some basic *out of control* indications in control charts? Explain with examples. **(7)**

(b) Calculate the total earnings of a worker where payment of bones is under (i) the Halsey scheme and (ii) the Rowan scheme from the particulars mentioned below: **(8)**

Basic wage rate per hour – $10.80, Time allowed for the job – 48 hours, Actual time taken – 36 hours.

(c) At the end of each month, a research and development team writes status reports for the projects at work. The team leaders, Andrew and Julie, submit them to the R&D director on the first Monday of each month. Unfortunately, they forgot to check their calendar once and to their surprise, they discovered that the reports were due the following Monday morning. As they had not started writing them, they decided to come to work early Saturday morning, so they could finish the reports before Monday morning. They split the work as follows: Andrew collates data and draws all the necessary graphs and Julie writes and edits the reports. Assume that Julie starts her work on a report only after Andrew is finished with it and that Andrew works continuously. Times for the reports (in hours) are as follows: **(20)**

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Contd... Q. No. 7(c)

Project	Julie	Andrew
A	2	4
B	5	3
C	1	5
D	3	7
E	6	8

(i) What is the order of the tasks using Johnson's rule?

(ii) How many hours will it take them to finish all the reports?

(iii) How many hours are Andrew and Julie idle?

8. (a) State some reasons for and against keeping inventory. **(5)**

(b) Explain the managerial roles described by Henry Mintzberg. **(10)**

(c) Explain *Hersey* and *Blanchard's Situational Leadership Theory* model. How do you think follower readiness changes according to this theory? **(10)**

(d) Briefly describe the divisional structure of an organization. Write down the advantages and disadvantageous. **(10)**

L-3/T-2/EEE Date : 31/03/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 315** (Power Electronics)

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**.

1. (a) With a neat diagram, explain the operation of a triac-diac based ac fan regulator. Consider a sinusoidal ac voltage supply. Draw the fan voltage waveform at a given firing angle α, supply voltage waveform and supply current waveform. **(20)**

   (b) An electric heater based oven is controlled with an ac voltage controller using phase angle control technique. At a particular setting, the oven gives 25 kW. If the heater resistance at 2.5 kW is 10Ω, determine the firing angle α. Consider a sinusoidal supply voltage of 240V (RMS) at 50 Hz. **(15)**

2. (a) Draw a step-down chopper circuit and explain how it controls the dc (average) output voltage when supplied from a dc voltage source. Also explain the function of the anti-parallel diode across the load. **(20)**

   (b) A solenoid magnet is supplied from a dc-dc step-down chopper. The solenoid needs a dc current of 50A. The solenoid coil resistance is 0.1Ω. Determine the duty cycle of the chopper if the supply voltage is 12V. **(15)**

3. (a) Design a buck regulator (main components e.g. L, C and f) with the following constraints: **(20)**

   $\Delta I_{max} = 12$ mA

   $\Delta Vc_{max} = 5$mV

   (b) A switching buck regulator is supplied from a dc voltage source of 48V dc. The filter inductance and capacitance of the regulator are 2mH and 220μF, respectively. If maximum ripple in output voltage is 7.5mV, determine the switching frequency of the regulator. **(15)**

4. (a) With a neat diagram explain how a fly back switching regulator can do buck-boost operation. **(20)**

   (b) A fly-back switching regulator is supplied from a 340V dc power supply. The regulator uses a ferrite core transformer with turn-ratio of 15:1. The switching frequency is 100 kHz. Determine the duty cycle for the following output voltages: **(15)**

   i) Va = 5V

   (ii) Va = 15V

   (iii) Va = 48V

Contd P/2

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.
Symbols have their usual meanings. Make necessary assumptions.

5. (a) Explain the operating principle of an SCR using two transistor model. **(10)**
   (b) Explain the I-V characteristic curve of an SCR and define holding current, latching current, Breakover voltage and reverse breakdown voltage. **(10)**
   (c) Describe natural and forced commutation of SCR, with proper circuit diagrams and necessary waveforms, explain three methods of commutation of SCR. **(15)**

6. (a) Draw the circuit diagram of a three phase voltage source square wave inverter. Show the gate pulses and with proper calculations, derive and draw the line to line and line to neutral voltages. Find the Fourier series co-efficients of the line to line voltage. **(6+4+10+5+10=35)**

7. (a) Draw and explain the operation of full bridge resonant inverter. Show proper waveforms for your explanation. **(12)**
   (b) Design a multilevel inverter circuit for a five level operation and explain the operation of the circuit. **(10)**
   (c) Derive the input power factor of a single phase full wave controlled rectifier with resistive load. What problem does arise in case of inductive load and how that problem can be addressed? **(13)**

8. (a) Draw the circuit diagram of a three phase full bridge controlled rectifier. Show the gate pulses and explain the operation of the circuit. Assuming a firing angle, $\alpha = 120°$, draw the output voltage and input current waveforms. Also, derive the average output voltage in terms of input line to neutral voltage. **(6+4+10+7=27)**
   (b) Explain the problem that arises for using a filter capacitor at the load side of a rectifier to eliminate ripple voltage. Also propose a solution to address that problem. **(8)**

L-3/T-2/EEE Date : 25/03/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 313** (Solid State Devices)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

All symbols have their usual meaning. Assume a reasonable value for any parameter, if needed and justify you assumption.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) What do you mean by intrinsic and extrinsic carrier concentration? Prove that, $np = n_i^2$. **(10)**

   (b) A Si sample is doped with $N_d = 10^{15}$ cm^{-3} of As atoms. Calculate the electron and hole concentrations and the Fermi level position (w.r.t. E_c/E_v) at 300 k, assuming full ionization. Justify the assumption by calculating the probability of donor states being occupied by electrons and therefore not ionized (assume, $E_C - E_D = 50$ meV). Repeat the above clauclations for T = 30 K and comment on the values and assumptions. [$N_C = 2.8\times10^{19}$ cm^{-3}, for Si]. **(25)**

2. (a) Define drift mobility. Explain the mechanism of carrier scattering in semiconducting materials and the significance of τ. **(5+12)**

   (b) An electron is moving in a piece of very lightly doped Ge under an applied field such that its drift velocity is 1/10-th of its thermal velocity. Calculate the average number of collisions it will experience in traversing by drift a region 1.0 μm long. Calculate the voltage across this region [$\mu_n = 1400$ cm^2/v.s, $m_e = 0.26m_0$]. **(18)**

3. (a) A uniformly doped short-base Si diode has Nd = 10^{17}cm^{-3} and $N_a = 10^{16}$ cm^{-3}, $\tau_p = \tau_n = 1\mu s$, $D_p = 10$ cm^2/s and area = 10^{-5} cm^2. The length of the quasi-neutral N - and P-regions are $W_E' = W_B' = 1\mu m$. Calculate the density of minority carriers as a function of x (distance from the junction) when applied voltage is 23×kT/q volt. Calculate it for both n and p side. Plot the majority and minority carrier currents in both regions, and show the total current. **(20)**

   (b) How do you define a minority carrier? Why does it diffuse? What is the Poisson's equation and why is it important pn - junction? **(5+5+5)**

4. (a) Explain with proper diagrams, the Haynes -Shockley experiment and show that this experiment is an elegant why of demonstrating drift, diffusion and recombination in a single experiment. **(22)**

   (b) Explain the operation of a Schottky diode, and explain Richardson constant. **(3+10)**

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SECTION – B

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

The symbols have their usual meaning. Assume reasonable values for any missing data.

5. (a) A uniformly doped silicon npn bipolar transistor is to be biased in the forward-active mode with the B-C junction reverse biased by 3V. The metallurgical base width is 1.10 μm and the dopings are $N_E = 10^{17}$ cm^{-3}, $N_B = 10^{16}$ cm^{-3} and $N_C = 10^{15}$cm^{-3}. For T = 300 K and $\varepsilon_r = 11.7$, **(20)**

   (a) Calculate the B-E voltage at which the minority carrier electron concentration at the depletion region edge in base is 10% of the majority carrier hole concentration.

   (b) At this bias, determine the minority carrier hole concentration at the depletion region edge in the emitter.

   (c) Determine the neutral base width for this bias.

   (b) Draw and briefly explain the Ebers-Moll equivalent circuit model of a bipolar junction transistor. **(15)**

6. (a) Describe the operational principle of a metal-semiconductor Ohmic contact with necessary band diagrams. **(20)**

   (b) Gold (ϕm = 5.1 V) is deposited on n-type GaAs (χ = 4.07 V) forming an ideal rectifying junction The doping concentration is $N_D = 5\times10^{16}$ cm^{-3}. Assume T = 300 K, $\varepsilon_r = 13.1$, $N_C = 4.7\times10^{17}$ cm^{-3} and V_R = 5 V. Determine the theoretical values of (a) ϕ_{B0}, (b) V_{bi}, and (c) x_d and (d) $|E_{max}|$. **(15)**

7. (a) An n-channel depletion mode silicon MOSFET with n+ polysilicon gate and n-channel dopoing, $N_D = 10^{15}$cm^{-3} has an oxide (ε_r =3.9) thickness of 50 nm and fixed oxide charge Q'ss = 10^{10}cm^{-2}. The n-channel thickness is equal to the maximum induced spaces charge width. Disregarding the space charge region at the n-channel -p-substrate junction, **(20)**

   (a) Determine the channel thickness and

   (b) Calculate the threshold voltage.

   (b) Draw the band diagrams of a pMOSFET from source to drain direction at $V_{GS} < 0$V for $V_{DS} < 0$V and $V_{DS}<<0$V. Why high-κ dielectric was introduce in CMOS technology instead of using SiO_2? **(15)**

8. (a) Draw the schematic of a double-gate MOS structure. What are the benefits of such structure over single-gate MOS? Show the band diagrams corresponding to your schematic diagram for (i) ultra-thin body and (ii) thick body, assuming the MOS is biased in the inversion mode. **(20)**

   (b) An nMOS silicon device has the following parameters; n+ poly gate, t_{ox} = 40 nm, $N_A = 10^{15}$ cm^{-3} and $Q'_{ss} = 5\times10^{10}$cm^{-2}, Φ_{ms} = -1V. Is it possible to apply a substrate voltage such that the threshold voltage becomes zero? If so, what is the value of the substrate to body voltage (V_{SB})? Assume, SiO_2 as he oxide material with relative permittivity of 3.9. **(15)**

L-3/T-2/EEE **Date : 14/03/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **EEE 317** (Control Systems I)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols and abbreviation have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

Semilog Graph paper, Nichol's chart and Tracing paper are to be supplied.

1. (a) Consider a unity feedback control system whose open loop transfer function is **(25)**

$$G(s)=\frac{K}{s(s+1)(s+4)}$$

Design a compensator $G_c(s)$ such that the static velocity error constant is 10 sec^{-1}. The phase margin is 50°, and the gain margin is 10 dB or more. Use Frequency response method to design the compensator.

(b) Derive the expressions for maximum phase angle and maximum magnitude of a lead compensator. **(10)**

2. (a) A feedback control system having the open loop transfer function of **(22)**

$$GH(j\omega)=\frac{10(1+j0.5\omega)}{(1+j\omega)\left[1+j0.5\omega+0.25(j\omega)^2\right]}$$

The log-magnitude and phase angle at different frequencies of GH(jω) is given in the following table.

ω	dB	<GH(jω)	ω	dB	<GH(jω)
0	20	0	4.0	2.7	–161°
1.2	18.4	–65°	6.0	–5.2	–170°
1.6	17.8	–86°	8.0	–10.0	–175°
2.0	16.0	–108°			
2.8	10.5	–142°			

Determine the phase margin and M_m of the system. Is the system stable or unstable? Adjust the gain of the system so that M_m = 6 dB. Use Nichol's chart. Attach the used Nichol's chart and other records with the answer script.

(b) Explain the theory of Nyquist's stability criterion. Sketch the Nyquist diagram for a unity negative feedback system with $G(s)=\frac{s+3}{s^2}$ and comment on the stability of the system. **(13)**

Contd P/2

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3. (a) Find the output response of the following system to a unit impulse input for the underdamped case. Also, find the maximum overshoot. **(15)**

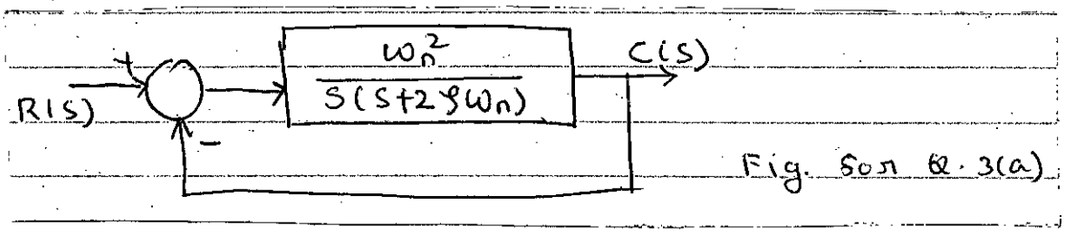

Fig. Son Q. 3(a)

(b) The open-loop transfer of a unity feedback system is $G(s)=\frac{K}{s(s+2)}$. The system is required to meet the following specification peak time (t_p) = 1.0 sec and peak overshoot (M_p) = 10%. **(15)**

(i) Is it possible to find a value of K to meet both these specifications? If not possible, what should be the value of K so that t_p and M_p are violated by the same percentage?

(ii) Assume that the open loop s = –2 can be adjusted. Let it be s = –α. Determine the values of K and α in order to meet both the specifications.

(c) With a suitable example explain the effect of adding a zero on the second order system response. **(5)**

4. (a) From the block diagram, obtain a state space model for the system shown in Figure 4(a). **(12)**

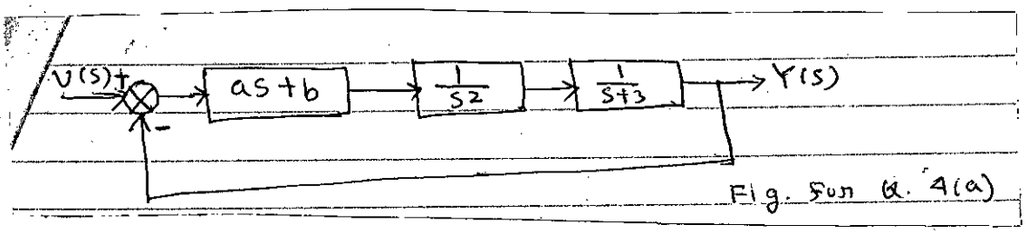

Fig. Son Q. 4(a)

(b) State Mason's gain formula. Find the overall transfer for the following Signal Flow Graph (SFG) as shown in Figure 4(b) by using Mason's gain formula. **(10)**

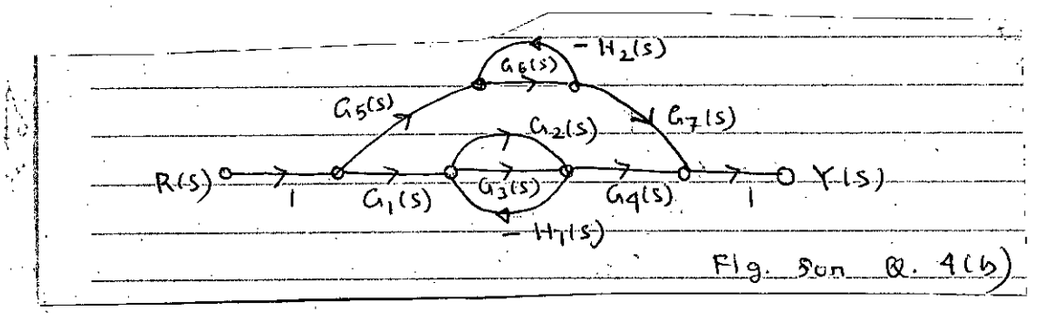

Fig. Son Q. 4(b)

Contd P/3

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Contd ... Q. No. 4

(c) Evaluate the transfer function for the Bode plot shown in the Figure below. **(13)**

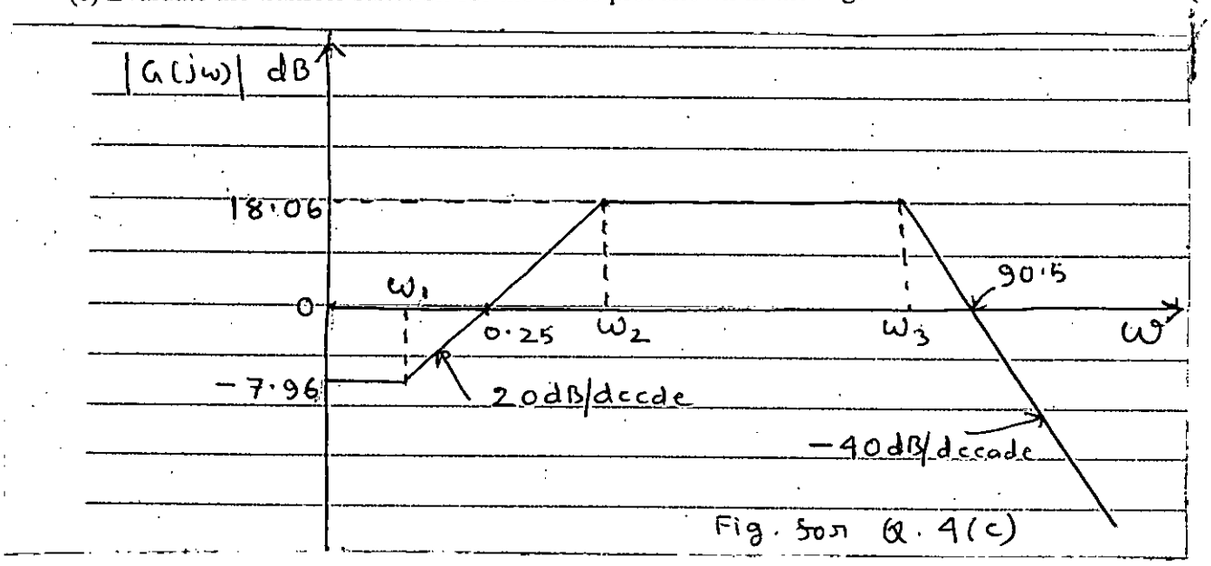
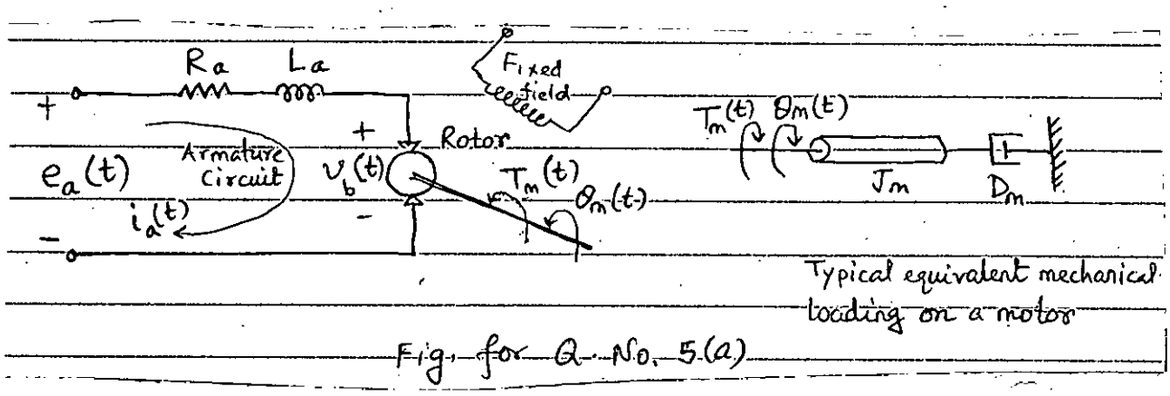


Fig. for Q. 4(c)

SECTION – B

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

5. (a) For an armature controlled DC servomotor shown in Fig. for Q. No. 5(a), derive the overall transfer function. Consider the typical equivalent mechanical loading shown in the figure. **(10)**



Typical equivalent mechanical loading on a motor

Fig. for Q. No. 5(a)

(b) Find the equivalent transfer function $T(s)=\frac{C(s)}{R(s)}$ for the system shown in Fig. for Q. No. 5(b). Use block diagram reduction method. **(10)**

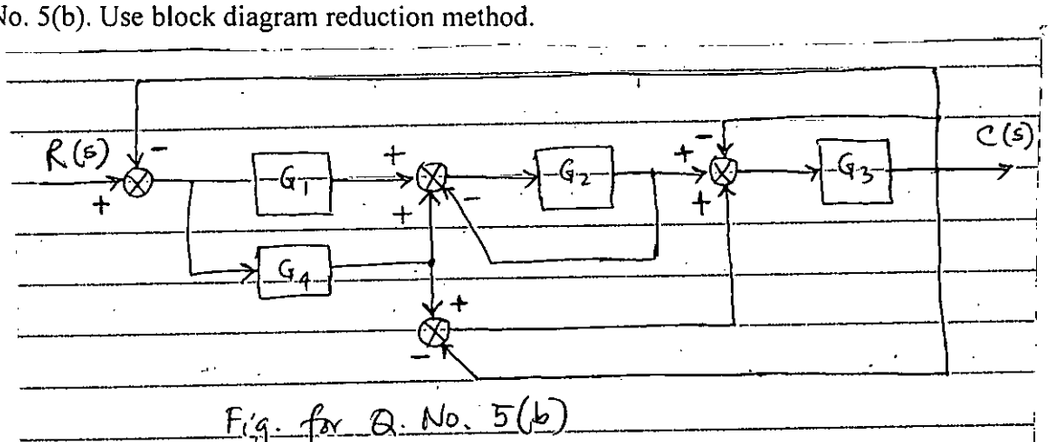


Fig. for Q. No. 5(b)

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Contd ... Q. No. 5

(c) Using the Routh-Hurwitz criterion and considering a unity feedback control system with **(15)**

$$G(s)=\frac{K}{s(s+1)(s+2)(s+5)}$$

(i) find the range of K for stability, and (ii) find the value of K for marginal stability.

6. (a) (i) What is a root locus? Do the zeros of a system change with a change in gain? (ii) What rules for plotting the root locus are the same whether the system is a positive or negative feedback system? **(10)**

(b) For the system shown in Fig. for Q. No. 6(b), sketch the root locus as p is varied. **(10)**

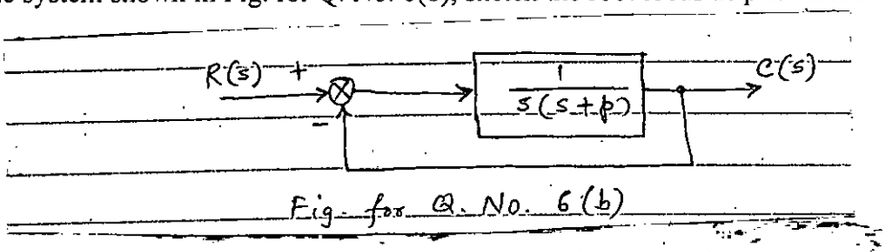

Fig. for Q. No. 6 (b)

(c) For a unity feedback control system with $G(s)=\frac{K(s-1)(s-2)}{s(s+1)}$, sketch the root locus and find the following: **(15)**

(i) the breakaway and break-in points, (ii) the jω-axis crossing, and (iii) the range of gain to keep the system stable.

7. (a) Write the general expression of transfer function of a PID controller. Explain why a PID controller can offer better steady-state and transient performance? What will be the major difference if a lag-lead compensator is used instead of a PID controller? **(10)**

(b) For a unity negative feedback system with **(25)**

$$G(s)=\frac{K}{s(s+5)(s+11)}$$

(i) Sketch the root locus and find the operating point on the root locus for the uncompensated system with peak time (T_p) = 0.823 sec and 30% overshoot, (ii) Find K_v for the uncompensated system, (iii) Design a lag-lead compensator to decrease the peak time by a factor of 2, and improve the steady-state error by a factor of 30.

8. (a) Vertical lines on the s-plane are the lines of constant settling time. Find equivalent representation in the z-plane and comment on stability. **(10)**

(b) Find $G(z)=\frac{C(z)}{R(z)}$ for the system shown in Fig. for Q. No. 8(b) if T = 0.3 sec. **(10)**

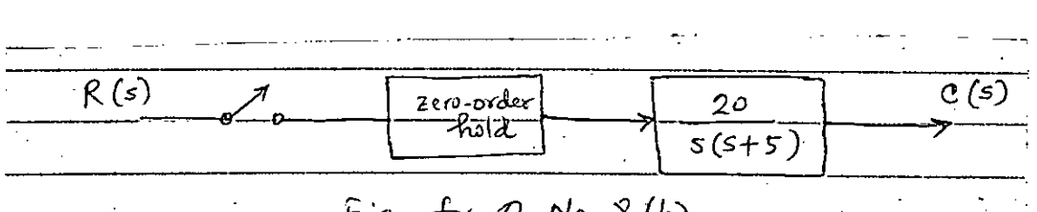

Fig. for Q. No. 8 (b)

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Contd ... Q. No. 8

(c) A unity negative feedback system is to be designed with $G(s)=\frac{K(s+a)}{(s+b)^2}$, steady-state error for a unit step input = 0.1, damping ratio = 0.5, natural frequency = $\sqrt{10}$. Determine K, a and b. **(15)**

Nichols Chart