Dhirubhai Ambani Institute of Information & Communication Technology
Mid Semester Test-2, 1st Semester 2018- 19

Course Title	IT304 Computer Networks		**Max Marks**	25
Date	16 October 2018	**CLOSED BOOK**	**Time**	90 min

1. Using clear examples, briefly explain the working of DHCP, NAT, and CIDR. Describe how these protocols help in more efficient use of the Internet address space [5]

2. A router is said to be congested if its buffer and packet forwarding resources are inadequate to handle incoming flows for a sustained period. TCP has the mechanism to manage congestion. In this context,
   a. What is the effect of congestion on the TCP and UDP flows passing through the congested router?
   b. What is the effect of congestion on the two TCP flows with unequal round trip times passing through the congested router.
   c. How is TCP protocol ack-timeout calculated? Give justification.
   d. Briefly describe the connection establishment and termination mechanisms in TCP. Explain the rationale for using such a mechanism and the role of the initial sequence number. [4*2]

3. Draw the sort network, shuffle-exchange network, and the Banyan network for a 8x8 Batcher-Banyan switch. What additional modules/functionalities are needed to make this switch perform as an Internet router? [5]

4. Compute the average throughput of a TCP connection if the packet loss probability is p and the round trip time is T (constant). What would be the effect on throughput if the round trip time is not a constant but varies between $T - \Delta$ to $T + \Delta$. ($\Delta << T$) [4]

   $\frac{1.22\ MSS}{RTT\sqrt{L}}$ $0.75\ \frac{MSS}{RTT}$

5. Estimating the correct buffer size is important as an overestimate makes the router unnecessarily costly and underestimate leads to frequent buffer overflow and packet loss. Assuming that the traffic is predominantly TCP, derive an expression for the *buffer size* as a function of relevant router and flow parameters. [3]

In-Semester Exam-IV (Autumn'2017)

IT 214 Database Management Systems

Time: 75 minutes

Max Points: 75

IMPORTANT NOTE:

1. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
2. In all questions marks awarding strategy will be discrete (i.e., 0, half, and full marks).

1. Consider Company Schema. Write a stored function (in pseudo code) that computes standard deviation of salary from EMPLOYEE relation and returns.

   Formula for standard deviation is given here for your reference.

   $$SD = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n}}$$

   [20]

2. What are the parameters to getConncection message in JDBC?

   [5]

3. Consider Indian Railways scenario from one of a Lab. It has been copied here in the box below for your reference. A short name for every attribute is given in parenthesis.

   [20]

   Train_Number(**TN**) – every train has unique number. For same pair of stations a train has different numbers for to and return.

   Train_Run_Day (**DAY**) – like Monday, Tuesday or so; it is day of run from source station [note that train may not run on all days of a week]

   Source_Station_Code (**SRC_SCODE**) – like ADI for Ahmedabad and is unique.

   Destination_Station_Code (**DST_SCODE**)

   Station_Code (**SCODE**) – any other station on train route

   Date_of_Run (**DATE**) – a particular date of run

   Scheduled_Arrival_Time (**SAT**) – on a station; assume that train arrives at a on same time on all days.

   Scheduled_Departure_Time (**SDT**) – from a station

   Expected_Arrival_Time (**EAT**) – on the run date on a station

   a. List down minimal FD set on all attributes given here.

   b. Beginning from a single schema R, given below, derives BCNF relations using BCNF decomposition algorithm. Make sure that no FD is lost.

   R(TN, DAY, SRC_SCODE, DST_SCODE, SCODE, DATE, SAT, SDT, EAT)

4. Are following FD sets F and G are equivalent (Yes or NO, Give proofs) - [10]

$F = \{A \rightarrow B, AB \rightarrow C, D \rightarrow E\}$ and $G = \{A \rightarrow BC, D \rightarrow AE\}$

5. Give a relation R(ABCDEF), and following FD set F [10]

$A \rightarrow B; A \rightarrow C; CD \rightarrow E; CD \rightarrow F; B \rightarrow E$

Do following FDs are inferred from F? Yes/No, Give Proof.

$A \rightarrow E$
$CD \rightarrow EF$
$AD \rightarrow F$
$B \rightarrow CD$

6. Given a relation R(ABCDEF), and following FDs [10]

$ABC \rightarrow E$
$ABCD \rightarrow F$

What is the key? What normal form it is in? Name FD that violates requirement of next immediate higher normal form.

Can you loss-lessly decompose R into BCNF? If yes, give decomposed relations.

Q-2 Q-3 (b1P) + 1.½ + 3 = 53.5

14 + 8½ 25.5

In-Semester Exam-III (Autumn'2017)
IT 214 Database Management Systems

A

Time: 90 minutes

Max Points: 70

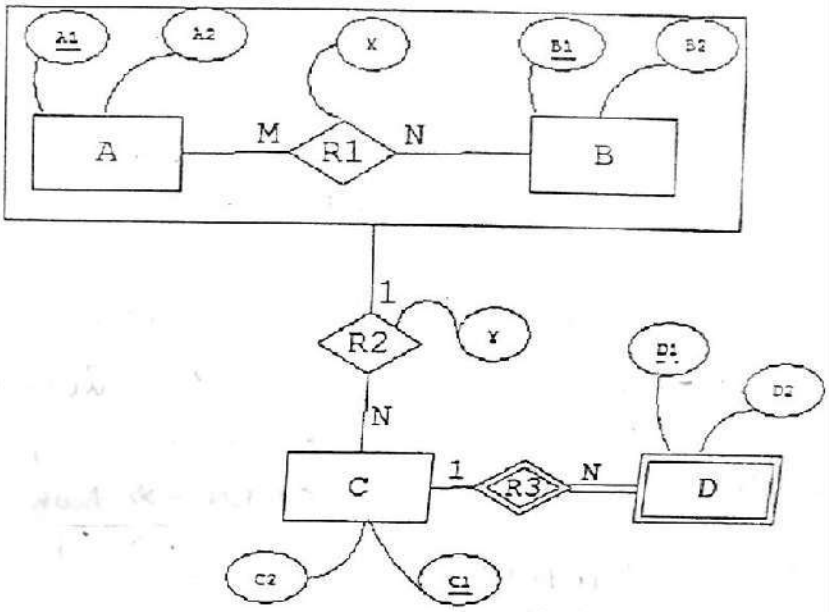
Your ID: 20150124

Name: Shubhangi Mehrotra.

IMPORTANT NOTE:
1. There are 4 pages in question paper, ensure that you have got all.
2. Answer questions in the space provide against the question itself. Overwriting is not allowed.
3. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
4. In all questions marks awarding strategy will be discrete (i.e., 0, half, and full marks).

1. Consider ER Diagram given here, and do following [14]
   (a) Derive Relational schema from this ER diagram using ER to Relational mapping rules. Also indicate all keys and foreign keys.
   (b) Find out minimal FD set from semantics of attributes in given ER Diagram.
   (c) Indicate normal form of each derived relation in (a)

14



a) A (A1, A2)
B (B1, B2)
R1 (A1, B1, x)
FK: A1 refers to A1 in A and B1 refers to B1 in B.

5

C (C1, C2, B1, A1, Y)
FK: ~~B1 refers to B1 in~~ (A1, B1) refers to (A1, B1) in R1.
D (D1, C1, D2)
FK: C1 refers to C1 in C.

(c) All the relations are in BCNF.

2½

b) Minimal FD set.
A1 → A2
B1 → B2.
{A1, B1} → x
C1 → C2.
C1 → B1
C1 → A1
C1 → Y
{C1, D1} → D2

201501124 Shubhangi Mehrotra.

A

2. Again consider scenario of book database for an on-line store. Details of books are ISBN, Title, Price (consists of Currency, and Amount), Author-Name, Publisher-Name, Publisher-Address. You can assume publisher-name to be unique, and we record only one address of a publisher. A book has one (at least) or more authors, and published by exactly one publisher. ISBN is a universally unique number each book has. Some of books are reprinted by different publisher in some other country or region. In that case reprint of the book is given different ISBN, and will have different price in some other currency. However Title and author of book remain same as original print. Let us also maintain relationship of reprint with original publication.

[10+10]

Suppose all attributes here has been placed in a single universal relation
R(ORG-ISBN, Title, Currency, ~~Price~~ Amount, Author-Name, Publisher-Name, Publisher-Address, Reprint-ISBN, Reprint-Currency, Reprint-~~Price~~ amount, Reprint-Publisher-Name)

For compact representation, let us rename attribute of R as following
R(OISBN, TITLE, C, P, AUTH, PUB, PUBADD, RISBN, RC, RP, RPUB)

Task #1. Use your understanding of attributes in R here, and give minimum set of functional dependencies.

Minimal Set of Functional Dependencies.

OISBN → Title
OISBN → C
OISBN → Amount
OISBN → Pub
OISBN → PubAdd
OISBN ↠ Auth
RISBN → RC
RISBN → RAmount
~~RISBN → RC~~
RISBN → RPub

Canonical Form

OISBN → {Title, C, Amount, Pub, PubAdd}
OISBN ↠ Auth
RISBN → {RC, RAmount, RPub}

Key : {OISBN, RISBN}

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Task #2. Using BCNF decomposition algorithm, derive normalized relations for the said database requirement. In the derivation, give only final and intermediate results, and do not give any textual descriptions.

On applying BCNF decomposition algo. R(...) decomposes to

1½ R1 (OISBN, Title, C, Amount, Pub, PubAdd, Auth) and 1½

R2 (RISBN, RC, RAmount, RPub).

R2 is in BCNF.
R1 in in 4NF.

In-Semester Exam-IV (Autumn'2018)
IT 214 Database Management Systems

Max Points: 50

Time: 1 hour

Your ID: 201601056 Name: Maru Priyanka

1	2a	2b	2c	2d	2e	3	4		
10	20					10	10		50

IMPORTANT NOTE:

1. There are 4 pages in question paper, ensure that you have got all.
2. Answer questions in the space provide against the question itself. **Overwriting is not allowed.**
3. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
4. In all questions marks awarding strategy will be discrete (i.e., 0, half, and full marks)

1. Considering DA-ACAD database, write a "stored function" with following functionality. [10]

Input: AcadYr, Semester, StudentID
Output: returns total credits taken by the student
Note: do not use any aggregate operations.

```
CREATE OR REPLACE FUNCTION total_credits (Acadyr ~~DATE~~ integer(4), Semester
    integer(5), studentID integer(10))
RETURNS integer AS $BODY$
DECLARE
stud registers%ROWTYPE;          cr integer(10) := 0;
course-taken registers%ROWTYPE;  sum-credit (~~100~~) integer(100) := 0
BEGIN
  FOR stud IN SELECT * FROM Registers where year='Acadyr
  loop                 and, semester = Semesters and
                       SID = Student ID
    FOR course-taken IN SELECT * FROM Register
    loop  where year='Acadyear' and semester = Semester
                       and SID = Student ID
      SELECT credit into cr FROM courses where
                       courseno = courseTaken.courseno
      sum-credit := sum_credit + cr;
    end loop
  end loop
RETURN sum-credit;
END
$BODY$ LANGUAGE 'plpgsql';
```

10

2. In next question you are given a number of relations and FDs over them. You need to do following for each relation -
   a. Compute key(s)
   b. Determine highest normal form of the relation (consider only up-to 4NF)
   c. Name all FDs that "violate the requirement" of the relation being in next higher normal form. If a relation is already in 4NF you have answer "NONE" here.
   d. Give 4NF Normalized relations. Make sure that decomposition is lossless and FD preserving. If you cannot decompose due to any loss, mention the same. Also underline key attributes of each normalized relation.

5x4=20

R(ABCDE)F A → B B → CDE DE → F	Key: A	Normal Form: 2NF	Culprit FD: B → CDE, DE → F
4	Normalized Relations $R_1\{DEF\}$ $R_2\{BA\}$ $R_3\{BCDE\}$		
R(ABCDEFH) ABC → DEF AB → CGH	Key: AB	Normal Form: 4NF	Culprit FD: None
4	Normalized Relations		
R(ABCDE) A → BCDE E –>> ABCD	Key: A	Normal Form: 4NF	Culprit FD: None
4	Normalized Relations		
R(ABCD) A → B BC → D A → C	Key: A	Normal Form: 2NF	Culprit FD: BC → D
4	Normalized Relations $R_1\{ABC\}$ $R_2\{BCD\}$		
R(ABCDE) A → BC CD → E B → D E → A	Key: A	Normal Form: 2NF	Culprit FD: CD → E, B → D, E → A
4	Normalized Relations By BCNF and 4NF decomposition, there is loss of FD CE → A Relations : (CDE), (ABC), (BD) Hence by 3NF decomposition we get {ABC} {CDE} {BD} {EA}		

Your ID: 201601056 Name: Haru Pranjali

For preparing time table of courses (let us say only for lectures), there is a notion of time slot. Each slot will have start time and end time for each scheduled day. For example there is slot A that has lecture on Monday 9-10AM, Wednesday 10-11AM, and Thursday 9-10AM.

All offered courses are assigned a slot. No two courses of an instructor are assigned same time slot. Assume that all courses are of three credits.

Each course offering is assigned a faculty. Each slot for a course is assigned a room. There is possibility that lectures of a course can be allocated different rooms on different days - for example room for lectures of your IT214 can be assigned as following – Monday and Wednesday in LT-1 and Thursday in LT-3. Obviously no two courses are assigned same room in a slot on a day.

Also a staff is delegated to take attendance. There can be different staff in a room on different days (not date). We also record seating capacity of a room.

For simplicity ignore academic year and semester. Assume that all data are for current semester.

Answer next two questions based on this description-

10+10

3. Based on semantics of attributes, enumerate minimal FD set for the database.

courseno → credit
courseno → instructor (faculty) ID
RoomNO → seating- capacity
courseno → slot ID
slotID → RoomNO
facultyID → facultyIDname
slotID → Day
slotID → Start_time
slotID → End-time
RoomID → staffID
staffID → staffName

10

Dhirubhai Ambani Institute of Information & Communication Technology
Mid Semester Test-1, 1st Semester 2017- 18

Course Title	IT304 Computer Networks		**Max Marks**	15
Date	1 September 2017	**CLOSED BOOK**	**Time**	1 Hour

In protocol design problems,

- Assume that all the nodes run the required application components.
- Give a brief description of how your protocol functions.
- Provide the details of the message structure, message sequence, timer functions (if needed), and other actions performed by the nodes.
- Give brief justification for each component of your design.

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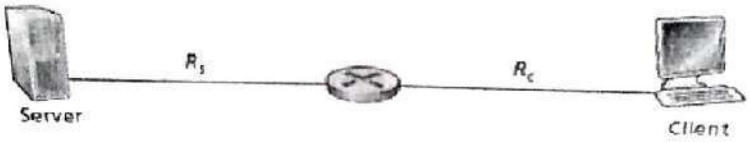
1. Assume that the resolving name-server is running on DAIICT network and there is an *iterative* DNS server at each domain level. Draw the relevant DNS hierarchy and list the DNS messages sent and received and records processed in obtaining the IP address corresponding to "mail.cse.mit.edu". [4]



2. Assume that we know the bottleneck link along the path from the server to the client is the first link with rate R_s bits/sec. Suppose we send a pair of packets back to back from the server to the client, and there is no other traffic on this path. Assume each packet of size L bits, and both links have the same propagation delay d_{prop}.
   a. What is the packet inter-arrival time at the destination? That is, how much time elapses from when the last bit of the first packet arrives until the last bit of the second packet arrives?
   b. Now assume that the second link is the bottleneck link (i.e., $R_c < R_s$). Is it possible that the second packet queues at the input queue of the second link? Explain. Now suppose that the server sends the second packet T seconds after sending the first packet. How large must T be to ensure no queuing before the second link? Explain. [4]

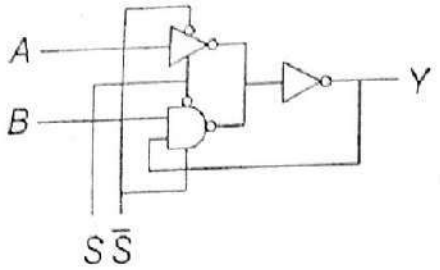
3. On a LAN server, a ToD (time of day) application runs that periodically (at interval D) broadcasts the time to all the nodes connected on the LAN. A node, on booting, however, can ask for the ToD server to send the time immediately. ToD server responds with a single message, even if multiple requests come within time interval d. Design the protocol specifying the functionalities, message structure, actions, and syntax. [7]

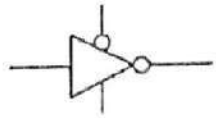
Registration Nos .....

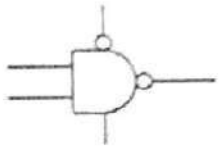
EL203: Embedded Hardware Design
DA-IICT, Gandhinagar
Nov 30, 2018 (Friday)...Exam: Final
Duration: 120 minutes (Time: 1430hrs-1630hrs) Total Marks: 100

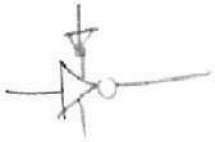
[5 marks]

1. Identify the following circuits:









2. a. Provide a state diagram and state output table of the Mealy machine which implements the followi behavior:

$$z(t) = \begin{cases} x'(t) & if\ x(t) = 0\ and\ x(k) = 0\ for\ all\ k < t \\ 0 & if\ x(t) = 1\ and\ x(k) = 0\ for\ all\ k < t \\ x(t) & otherwise \end{cases}$$

[10 marks]

b. Illustrate the time behavior for the input sequence shown below. [10 marks]

Assume $x(k) = 0\ for\ k < 0$

t	0	1	2	3	4	5	6
x(t)	0	0	1	0	1	1	0
z(t)							

3.

a. A modulo 6, synchronous binary counter cycles through the states 000_2 to 101_2 and then repeats the sequence. Design a synchronous sequential circuit that implements the counter, using D-type flip-flops and logic gates. [12 marks]

b. Show how the counter you designed can be used to write incoming synchronous data into a RAM device. Assume the RAM has 3 bits of address and is 1 byte per address. A clock signal on the input shows valid data on the rising edge. Your RAM should store the last 6 bytes of the data. [8 marks]

Registration Nos .....

4. Find an equivalent finite state machine with a minimum number of states. Show all the steps while reaching to the minimal state table. Design the circuit using appropriate combinational and sequential elements.

[20 marks]

PS	x=0	x=1
A	E,0	C,0
B	C,0	A,0
C	B,0	G,0
D	G,0	A,0
E	F,1	B,0
F	E,0	D,0
G	D,0	G,0

5. *A synchronous counter has the following counting sequence*

$$0 \rightarrow 1 \rightarrow 3 \rightarrow 2 \rightarrow 6 \rightarrow 7 \rightarrow 5 \rightarrow 4 \rightarrow 0$$

The outputs are interpreted as binary integers.

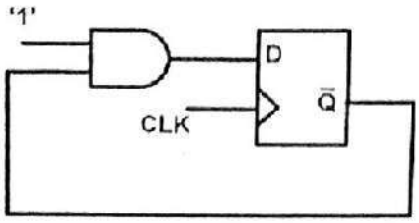
a. *Produce the next state equations such that the counter is hazard-free.* [6 marks]

b. Using positive-edge D-type bistables and only 2-input NAND gates, sketch the circuit diagram of the above counter. [4 marks]

c. Given that, a D-type bistable has T_{PHL}= *12 ns*, T_{PLH}= *10 ns*, T_{SU} = *2 ns*, and a 2-input NAND gate has propagation delay of *4 ns*, estimate the maximum clock frequency at which the above counter could operate. [6 marks]

d. Describe one way by which the counter could be initialized to count from a specified count value. [4 marks]

6. The following circuit aims to provide an output **Q** whose frequency is *15MHz* when the clock (CLK) frequency is *30 MHz*.



For a D-type bistable, T_{SU} = *10 ns*, T_H = *2 ns*, and T_{PHL} = T_{PLH} = *13 ns*. For the AND gate T_{PHL} = T_{PLH} = *12 ns*. Explain what happens in the clock cycle immediately following a rising edge. Will the circuit satisfy its aims? [15 marks]

-END OF PAPER-

201511124 Shubham

CNs insem 2

Dhirubhai Ambani Institute of Information & Communication Technology
Mid Semester Test-2, 1st Semester 2017- 18

Course Title	IT304 Computer Networks		**Max Marks**	25
Date	12 October 2017	**CLOSED BOOK**	**Time**	90 min

1. In the context of a reliable link-layer protocol
   a. Define the efficiency of the protocol.
   b. Compute the efficiency of GBN and SR for a noisy link with constant RTT.
   c. What is the optimal window size and maximum sequence number for each of these protocols? [1+4+1]

2. A transport layer congestion control protocol like TCP relies only on the information contained in ACK feedback received from the receiver along with estimating packet timeout timer.
   a. Describe the TCP timeout timer estimation for each packet.
   b. Describe how the packet timeout may be used to manage congestion.
   c. Describe how the RTT values of the ACK may be used to manage congestion.
   d. Under appropriate assumptions, show that the dependency of expected throughput on **RTT** and packet loss probability **p**. *[2+2+2+3]*

3. A node can use an *echo* packet to find the round-trip-delay to its direct neighbors. Let's define the weight of a link between neighbor nodes A and B as $W_{AB} = W_{BA} = (RTT_{AB} + RTT_{BA})/2$.
   a. Design this *echo* protocol to compute W_{AB}.
   b. Design a protocol that uses repeated communication between direct neighbors to find the shortest path between any pair of nodes in the network. [2+3]

4. A UDP socket application typically needs to build flow-control logic within the application itself. This requires, among other things, implementing sliding window operations (buffer management, packet sequencing), and retransmissions.
   Using a combination of socket library functions and system calls, provide a pseudocode skeleton for implementing these. Detailed code is not required but familiarity with the function and system calls signature and their usage is expected. [5]

CNS endsem

DA-IICT **Dhirubhai Ambani Institute of Information & Communication Technology**
Final Examination, Semester I 2017-18

Course Title	IT304 Computer Networks	PART-B	**Max Marks**	30%
Date	30 November 2017	CLOSED BOOK	**Time**	2 Hours

All questions carry 5 marks each.

1. A TCP sender is transmitting data to a receiver. The initial congestion window size is 2KB and the threshold is 16KB. Maximum segment size is 64KB. The first 4 RTT value measured by the sender are (in milliseconds) [400, 300, 900, 100].
   a. What is the congestion window size after the 4 successive ACKs are received?
   b. Assuming the smoothing parameter (weight given to old value) $\alpha = 0.9$, what is the estimated RTT for the next packet sent?
   c. What is the value of the Timeout Timer? $\beta = 0.2$

2. An organization has some 500 nodes in its network divided into 3 segments. This can be done by sub-netting one class B address block. Using specific addresses explain the subnetting mechanism. How does routing between subnets take place?

3. Using clear examples, briefly explain how DHCP, NAT, and CIDR help in more efficient use of the Internet address space.

4. Explain how tunneling is used to allow incremental deployment of IPv6 and co-existence of IPv4 and IPv6?

5. What are switching element and switching fabric? Draw the schematic of an 8x8 Banyan switch. Using an example, show that Banyan design leads to internal blocking?

6. In the context of IEEE 802.3 (Ethernet) LAN protocol, answer the following:
   a. Derive an expression for the maximum length L_{max} of a LAN as a function of relevant LAN parameters (e.g. link capacity C, min packet size P_{min}, max packet size P_{max}, propagation speed V etc.)
   b. Explain the need of exponential back-off mechanism in 1-presistent CSMA/CD.

L_{max}

8
2 2T6

cw = 2 kB
Thr. = 16kB

Registration Nos 201601056

DA-IICT, Gandhinagar
EL203: Embedded Hardware Design
Oct 15, 2018 (Monday)...Exam: Insem2
Duration: 60 minutes (Time: 1630hrs-1730hrs)
Total Marks: 50

No Calculators allowed.

1. Design a combinational network that finds the largest and the second largest of four nonnegative integers A, B, C, D. Each integer is represented by four bits. You may use one of the following module types: 4x2 input muxes and 4 bit comparators. The two bit output of the comparator is z = (z_1, z_0). If the first integer is larger than the second, the output is z= 10. If the second number is larger, the output is z=01 and if the numbers are equal, the output is z=00. Indicate all the inputs and connections and the modules being used.

[15 marks]

2. a. Complete the following table. If there is a problem completing the table, explain. All implicit and explicit values are given in the decimal number system. [6 marks]

Number System	Number of digits n	Signed integer x	Representation value x_R	Digit vector X
2's complement	7	-39	103	1100111
1's complement	8		167	
2's complement				100100100
2's complement	6	-43		

b. Compute $z=a+2b-c$ in 2's complement for $a=-7$, $b=12$, and $c=-97$. Perform calculations on bits representing a, b, and c and show every step of your work. How many bits should z have to represent the correct result? Check your work by showing, for each step, the corresponding values in decimal number system. [4 marks]

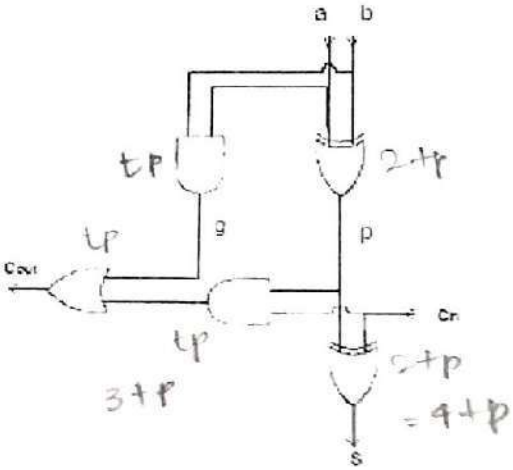
3. Design a 4-bit by 2-bit multiplier module. The operands are positive: the multiplicand X=(x_3, x_2, x_1, x_0), the multiplier Y= (y_1, y_0) and the product p = (p_5, p_4, p_3, p_2, p_1, p_0). You are allowed to use AND gates, full adders (FA) and half adders (HA) **only**.

[15 marks]

CNS endsem

Registration Nos .201601056

4. Calculate the worst case delay of a Ripple carry adder consisting of the full adder blocks shown below. You can use t_p for the AND and OR functions and $2t_p$ for the XOR gates. Express your answer in terms of t_p.



Repeat the same calculations for 32-bit adders. [10 marks]

-END OF PAPER-

In-Semester Test-2

IT 214 Database Management Systems

Time: 90 minutes

Max Points: 80

IMPORTANT NOTE

1. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
2. Answer all queries in order. If you want to defer answering a query, may move to next by leaving sufficient blank space. You may follow a strategy of not answering more than two queries on a page.
3. Each query is for 10 points, and awarding strategy will be discrete (i.e., 0, 5, and 10).
4. You may have to pay penalty for lengthier query expressions.
5. All queries are to be answered in **Relational Algebra**. No marks will be awarded if answered in SQL.

1. Given below is relational schema extended version of schema **DA-Acad** (discussed in lectures and used in labs). While extending it, names and meaning of original relations and attributes is retained.

Student(StudetID, StdName, ProgID, Batch, CPI)

Course(CourseNo, CourseName, Credit)

Faculty(FacultyID, FacultyName)

Offers(AcadYear, Semester, CourseNo, FacultyID, Grade_Submitted_Flag)

//Attribute "Grade_Submitted_Flag" is used to store grade submission status of a course offer

//FK: CourseNo refers to Course(CourseNo)

//FK: FacultyID refers to Faculty(FacultyID)

Registers(StudetID, AcadYear, Semester, CourseNo, grade)

//for better machine interpretability, let us store grades *in numeric form, i.e. 10, 8, and so.*

//FK: StudetID refers to Student (StudetID)

//FK: (AcadYear, Semester, CourseNo) refers to Offers

SemesterResult(StudetID, AcadYear, Semester, SPI, CPI)

//FK: StudetID refers to Student (StudetID)

HoR_Wing(wing, gender)

//wing attribute identifies a HoR wing, and draws value from alphabets A to J.

//wings are reserved for a specific gender 'M' or 'F', however assume that

// a wing can be assigned to other gender anytime.

HoR_Room(rno, wing, floor)

//FK: wing refers to HoR_Wing

//floor is labeled as 1 for ground, 2 for first, and 3 for second floor.

//to be informative to human users, attribute rno draws value from pattern

// "<wing><floor><number>", for example rno C110, indicates that it is in

// C wing, ground floor, and number is 10.

Allot(sid, rno)

//FK: **sid** refers to **student**

//All room allotments are recorded in this relation.

// the relation also has **NOT NULL** constraint for attribute **rno**.

// A students whose sid does not appear in this relation indicates that student does not reside in HoR.

Pass.

Student (82) empty

Using given relational schema, write relational algebra expressions for following queries-

1. Report (CourseNo, FacultyName) who have not submitted grades for semester 'Autumn', 2016.

2. Report (StudentID) who have got more than two F (i.e. zero) grade in 'Winter', 2016.

3. Report (Faculty-Name) who have taught more than three courses in academic year, 2015-16.

4. Report (StudentID, Student-Name, Grade) of students who are residing in C second floor and took course IT633 in 'Autumn', 2015.

5. Report (StudentID, Student-Name) of M Tech 2015 (progid=11) residing in HoR (Man).

6. Report (StudentID, CourseNo) backlogs* for B Tech ICT (progod = '01') batch 2012.

   ---

   *Let us define backlog as a set of courses that a student has taken ever MINUS set of courses student has got pass grade (i.e. not zero) . Also account for that a student takes a course, let us say IT123, got zero grade in first attempt, and got pass grade in second (or even third) attempt.

7. Report (StudentID, Student-Name, CPI) that have scored more 7.0 grade in all of the courses given here {IT110, IT214, IT205, SC215, IT314, IT301}.

8. Report (CourseNo, Acad Year FacultyName) for courses offered since 'Autumn', 2010 in which more than 50% students got grade got more than 7.0.

Second in-Semester Examination, Autumn 2015
IT 615 Database Management Systems

Time: 90 minutes

Max Points: 50

IMPORTANT NOTE: Write answers neat and clean. May be you can first work in rough area and write final version as answer. Answers that are difficult to read may simply be ignored.

1. Convert following SQL queries to relational algebra

[3x5]

a. `SELECT * FROM EMPLOYEE AS e1 WHERE e1.SALARY > (SELECT SALARY FROM EMPLOYEE AS e2 WHERE e2.SSN = e1.SUPERSSN);`

b. `SELECT * FROM r1 WHERE (a1,a2,a3) IN (SELECT (b2,b5,b7) FROM r2);`
//do not use SEMI JOIN

c. `SELECT ssn2, count(ssn1) FROM (SELECT e1.ssn as ssn1, e2.ssn as ssn2 FROM EMPLOYEE AS e1 JOIN EMPLOYEE as e2 ON (e1.superssn=e2.ssn)) as r1 GROUP by ssn2 HAVING count(ssn1) > 2;`

2. Consider following schema. Answers queries given below in **Relational Algebra**.
[All queries approx carry equal weightage.]

[5x7]

`DEP(dno, dname, head_eno)`
-- attribute `head_eno` is emp no of the head of the department
-- and refers into EMP relation
`EMP(eno, name, gender, cat, super_eno, dno)`
-- attribute `super_eno` is emp no of the employee's supervisor
-- and refers to `eno` of EMP itself.
-- attribute `cat` is employee category and has domain of {worker, manager, engineer, staff}
`PROJ(pno, pname, dno)`
-- attribute `dno` is FK referring into DEP relation
`WORK_HOURS(eno, pno, hours_per_month)`
-- Attributes `eno` and `pno` are FKs referring into EMP and PROJ respectively.

a. Suppose there is a rule in the company that employees that are of manager category can only be head of a department. Write query expression that checks if there is any head who is not manager.
b. Compute Average salary for each category of employees.
c. Compute total salary for each employee category for each department.

Suppose workers are paid an extra incentive on-top of salary at the rate of Rs. 50 per month per hour. Note that incentive is paid to workers only and applicable to next two queries only.

d. Find out total incentive each department has to pay every month. Note that incentive is paid by the department by which the project is managed.
e. Due to incentive scheme, some workers may get salary more than their supervisors. Produce list (eno, name, salary including incentive) of such workers.

Time: 60 Minutes

Max Points: 60

IMPORTANT NOTE:

1. Write answers neat and clean. May be you can first work in rough area and write final version as answer. Answers that are difficult to read may simply be ignored.
2. In Algebra do not use semi-difference and semi join operations, and In SQL do not perform join through cross product.
3. All queries carry equal marks and there will be no partial marking.

1. Given relation schema R(x,y,z), and S(z,a,b), convert following Relational Algebra expressions into SQL: $R \div \Pi_z(S)$

[10]

```
SELECT * FROM R
WHERE NOT EXISTS (
  ( SELECT z FROM S )
   EXCEPT
  ( SELECT z FROM R AS r1
      WHERE r1.x = r.x and r1.y = r.y)
);
```

OR

```
SELECT * FROM R
WHERE x, y not in (
SELECT x, y FROM
   (SELECT x, y, z FROM
          (SELECT x, y FROM S) AS r1, (SELECT z FROM S) AS s1
   EXCEPT
   (SELECT x, y, z FROM R)) AS r
);
```

2. Consider following schema for Halls of Residence, and write algebraic expressions for following queries

[7+7+4x9]

STUDENT(id, name, email, prog_code, batch, cpi)
ROOM(rno, wing, floor)
ALLOT(sid, rno)
HMC(wing, floor, sid)

i. List Rooms (RooNo, Floor, Wing) that are vacant.
ii. List Rooms (RooNo, Floor, Wing) that are having single occupancy.
iii. Give Floor wise (Wing and Floor) count of vacant positions, i.e. number of students can be accommodated on each floor. Considering that rooms are double seated.
iv. Give Wing wise distribution of M.Sc.(IT) students (any batch), that is how many students are residing in each wing.
v. List Floors (wing and Floor) that are not having HMC representatives.
vi. List Floors in which 20 or more students are residing from a single batch of a program.

ROOM ⋈ ALLOT

(SELECT count(*) FROM ALLOT)

In-Semester Exam-II (Autumn'2017)

IT 214 Database Management Systems

Time: 80 minutes

Max Points: 80

IMPORTANT NOTE:

1. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
2. Answer all queries in order. If you want to defer answering a query, may move to next by leaving sufficient blank space. You may follow a strategy of not answering more than two queries on a page.
3. In all questions marks awarding strategy will be discrete (i.e., 0, half, and full marks).
4. You may have to pay penalty for lengthier solutions.

Consider relational schema given below, and write relational algebra expressions for following queries (NO SQL)-

Student(StudetID, StdName, ProgID, Batch, CPI)
Course(CourseNo, CourseName, Credit)
Faculty(FacultyID, FacultyName)
Offers(AcadYear, Semester, CourseNo, FacultyID)
Registers(StudetID, AcadYear, Semester, CourseNo, grade)
HoR_Room(rno, wing, floor)
Allot(sid, rno)
SBG(sid, **Committee, Role**)
-- sid is student id of sbg member, and role can be like convener, or member, committee is name of committee like "CMC", or Cultural, or so

[6x10]

1. List CourseNo, Number_of_Registrations, Faculty_Name for course offering (in term Autumn'2017) where number of registrations are less than 10.
2. List of ID and Name of students from B.Tech. (progid='01') and 2015 batch who do not reside in HOR.
3. List Room Nos' along with ID and Name of resident that are singly occupied.
4. List ID, Name, and Role of all members of "Cultural" committee who are residing in J or K wings.
5. Report (StudentID, Student-Name, Grade) of course of students who are residing in C wing, progid='01' and took course IT633 (in Autumn'16) and passed with grade >= 7.0.
6. Report (StudentID, Student-Name, CPI) that have scored more than 7.0 grade in all of the courses given here {IT110, IT214, IT205, SC215, IT314, IT301}.
7. Consider maintaining database of books (let us say by an on-line book-store) with details of ISBN, Title, Price (consists of Currency, and Amount), Author-Name, Publisher-Name, Publisher-Address. A book has one (at least) or more authors, and published by exactly one publisher. ISBN is a universally unique number each book has. Some of books are reprinted by different publisher in some other country or region. In that case reprint of the book is given different ISBN, and will have different price in some other currency. Let us also maintain relationship of reprint with original publication.

   Draw ER Diagram for the said database requirement. Do not add any additional attribute from your own, unless you have proper justification.

[20]

End Semester Examination (Autumn'2018)
IT 214 Database Management Systems

A

Student ID: 201601056 Name: Hari Prasad

Time: 90 minutes Max Points: 115

IMPORTANT NOTE:
1. There are six pages make sure that you have them all in your set.
2. You need to answer all questions in question paper itself.
3. Write answers neat and clean. Over-writing is not allowed.

79

Marks

1	2	3	4	5	6	7	8	9
7½	18	0	12	5	5	7	4.5	20

1. Tick the correct option (there can be multiple options be correct; check them all) – [10]

1 i. Heap files are roughly good for operations <INSERT/DELETE/SEARCH>

1 ii. Secondary index can be <dense/clustered/b+-tree/sparse>

1 iii. Participation of a weak entity with identifying relationship is always total [True/False]

1 iv. Materialized view hold data <true/false> _____

If yes, what data? Data of view operators (Result of queries)

1 v. Unbound cursor can be bound with dynamic query <Yes/No>

0 vi. TP_OP is a <implicit local variable/implicit parameter variable/global variable/ no such variable>

0 vii. Embedded SQL provides an environment in which SQL statements are sent to DBMS for execution <Yes/No/both-depends on configuration>

1 viii. Using "CREATE ASSERTION", we can create constraints that span to multiple tables <True/False/No such command>

1 ix. In case of B+-tree based index, index scan mean "sequential scan of leaf nodes" <True/False/No such operation>

½ x. Bloated index refers to index having <too much void spaces in blocks/ too much overflow/index corrupted /all of these>

[30]

2. Fill in the blanks-

i. Referential Integrity constraint requires that referenced key should be primary key

ii. Prepared statement helps in _____

iii. Entity Integrity constraint requires that _____

iv. `CallableStatement` object in JDBC is used for _____

v. Which property of schedule ensures **Isolation** serialization

vi. Which property of schedule ensures **Atomicity** Recoverability

vii. Which property of schedule ensures **Durability** Recoverability

viii. Weak entity is the one that is derived from strong entity

ix. Which SQL Isolation level may cause Dirty Read Read uncommitted

x. Advantage of strict 2PL over standard 2PL concurrency

xi. System logs helps in durability and atomicity

xii. Write Ahead Logging Protocol is used for Recovery

xiii. Noted problem in basic Snapshot Isolation is skew write

xiv. Main problem in 2PL protocol is deadlocks

xv. Main problem with basic time stamp ordering techniques is concurrency

xvi. What is the name of technique that is used for avoiding cascaded rollbacks
recoverable principle

xvii. What is highest SQL isolation level that has Phantom row problem Repeatable read

xviii. One of the most important advantage of sql views is
Abstraction

xix. Name one of the procedural data manipulation language
Embedded SQL, C

xx. Can you determine Normal form of relation R(AB), in absence of FD information. Note that, no information does not mean NO FD; if yes what is NF? NO

Student ID: 20180105L Name: Hasu Pasanjaa

3. Consider following keys; Primary Key(PK), Key(K), Candidate Key(CK), Super Key (SK), and choose which symbols is most appropriate to be placed in the blank space ($\subseteq$ or $\supseteq$ or $=$) below. [5]

i. PK ___$\subseteq$___ K 2

ii. PK ___$\subseteq$___ CK 2

iii. CK ___$\subseteq$___ K 2

iv. CK ___$\supseteq$___ SK 2

v. K ___$\supseteq$___ SK 2

4. Give short answers -

i. Suppose Employee relation has B+-tree index on DNO. Compute approximately execution cost of query "SELECT * FROM EMPLOYEE WHERE DNO=5"? May express in terms number of block read/writes, and assume other parameters! [3]

3

Let the height of B+ tree be H
since DNO is not PK. execution cost

Cost = H + S (S = selectivity = $\frac{N}{\text{distinct no attribs}}$

ii. Suppose you have following query to be executed
$\sigma_{SALARY>30000 \wedge DNO=5}(EMPLOYEE)$
What could be best strategy to execute this query. [3]

3

index by DNO (in B+ tree), here any formula could be applied such as H+1 (H = height).
After that do linear scan for salary.

iii. Compute Join selectivity of join EMPLOYEE JOIN DEPARTMENT ON DNO. What is "Join Selectivity" of the JOIN? May assume other parameters [3]

join selectivity $js = \frac{|R \text{ JOIN } S|}{|R \text{ CROSSJOIN } S|}$

3

for EMP ⋈ DEP
e.dno = d.dno

$js \leq \frac{|E|}{|E||D|}$ $js \leq \frac{1}{|D|}$ If there are non NULL values $js = \frac{1}{|D|}$ [3]

iv. Translate following SQL query in terms of relational algebra:
SELECT * FROM EMPLOYEE WHERE SSN IN
(SELECT DISTINCT ESSN FROM DEPENDENT)

0

$r_1 \leftarrow \sigma_{essn}$ (dependent)

$r_2 \leftarrow \sigma_{*}$ (employee ⋈ r_1)
e.ssn = r_1.essn

v. Consider relation R(A, B, C) and set of FDs { {A → B}, {B → C} }; can you find out a join dependency here. [3]

yes there is a join dependency here.
{A→B, B→C} this will give A → C

vi. Given, A → B and XB → C, prove that XA → C. [3]

A → B (given)
XA → XB (Augmentation Rule) (1)
XB → C (given) (2)
From (1) and (2) by transitivity,
XA → C

3

vii. Suppose following schedule is executed by interleaving operations from transactions T1 and T2. What kind of concurrency problem do you see in following schedule? Give short reason. [5]

T1: Read X	$R_1(X)$ $W_2(X)$
T1: X = X + 50	$W_1(X)$ $W_2(X)$
T1: Write X	$W_1(X)$ $R_2(X)$
T2: Read X	
T2: X = X + 100	
T2: Write X	
T1: Abort	
T2: Commit	

Here T1 updates the value of x. It has not yet committed. T2 reads the value of x and updates it. Now T1 ~~will~~ aborts (it will roll back the value). T2 already committed. (It made update on new value of x which is wrong) This type of concurrency problem is Dirty Read which happens because of Read Uncommitted isolation level

5

viii. Is the schedule given in previous question is recoverable? Give short reason. [5]

The above schedule is not recoverable. Transaction T2 reads from T1 which has not yet committed. It is against the Recoverably principle

Recoverable principle states that a transaction must not commit until and unless the transaction from which it is reading gets committed. Here it is not followed. Hence schedule is not recoverable

5

7. Consider the three transactions T1, T2, and T3, and the schedules S1 and S2 given below. Draw the serializability (precedence) graphs for S1 and S2, and state whether each schedule is serializable or not. If a schedule is serializable, write down the equivalent serial schedule(s).

[10]

S1: r2(Z); r2(Y); w2(Y); r3(Y); r3(Z); r1(X); w1(X); w3(Y); w3(Z); r2(X); r1(Y); w1(Y); w2(X);

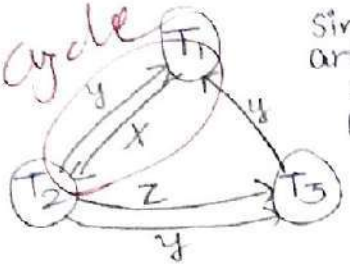
S2: r3(Y); r1(Z); r1(X); w1(X); w3(Y); w3(Z); r2(X); r1(Y); w1(Y); r2(Y); w2(Y); r2(Z); w2(Z);

Conflicting operations

$r_2(Z)$	$w_3(Z)$	$w_2(Y)$	$r_1(Y)$
$r_2(Y)$	$w_3(Y)$	$w_2(Y)$	$w_1(Y)$
$r_2(Y)$	$w_1(Y)$	$r_3(Y)$	$w_1(Y)$
$w_2(Y)$	$r_3(Y)$	$r_3($	
$w_2(Y)$	$w_3(Y)$	$r_1(X)$	$w_2(X)$
$w_3(Y)$	$r_1(Y)$	$w_1(X)$	$w_2(X)$
$w_3(Y)$	$r_1(Y)$	$w_1(X)$	$r_2(X)$

7

cycle

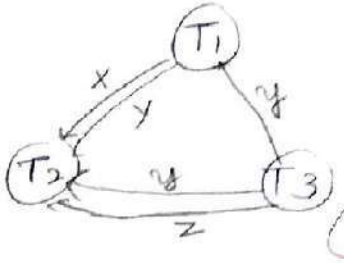


2

Since there are no cycles formed. S1 is serializable

Eq serial schedule : T2 : T3 : T1

$r_3(Y)$	$w_1(Y)$	$w_3(Y)$	$w_1(Y)$
$r_3(Y)$	$w_2(Y)$	$w_3(Y)$	$r_2(Y)$
$r_3(Z)$		$w_3(Y)$	$w_2(Y)$
$r_1(X)$	$w_2(X)$	$w_3(Z)$	$r_2(Z)$
$w_1(X)$	$r_2(X)$	$r_1(Y)$	$w_2(Y)$
$w_1(Y)$	$w_2(X)$	$w_1(Y)$	$r_2(Y)$
$w_3(Y)$	$r_1(Y)$	$w_1(Y)$	$w_2(Y)$



No cycles formed. S2 is serializable

5

serial schedule : T3 : T1 : T2

8. Consider following schedule executed on PostgreSQL. Assume that initial salary for employee with SSN 123 is 50000. [Here labels T1 and T2 against statements indicate Transaction that is issuing the statement.] What will be shown by SELECT statements at line numbers 3, 5, 7, 10 if transaction T2 is specified to execute at READ COMMITTED isolation level and SERIALIZABLE isolation level?

[6+6]

```
1  T1: begin;
2  T1: update employee set salary = salary+3000 where ssn = 123;
3  T1: select salary from employee where ssn = 123;
4  T2: begin;
5  T2: select salary from employee where ssn = 123;
6  T2: update employee set salary=salary+5000 where ssn = 123;
7  T2: select salary from employee where ssn = 123;
8  T1: commit;
9  T2: commit;
10 T1: select salary from employee where ssn = 123;
```

$4\frac{1}{2}$

READ COMMITTED level		SERIALIZABLE level	
Line 3:	50000 ✗	Line 3:	50000 ✗
Line 5:	53000 ✗	Line 5:	– ✗
Line 7:	53000 ✗	Line 7:	– ✓
Line 10:	58000 ✓	Line 10:	53000 ✓

201601056 Hari Pranjali

9. Suppose following attributes are drawn from a sales/purchase system of trading company.

`Sales_bill_no, sales_bill_date, customer_no, customer_name, item_no, item_name, quantity_in_stock, quantity_in_bill, item_rate, item_rate_in_bill, item_category, item_category_sales_tax_rate, supplier_id, supplier_name, purchase_bill_no, purchase_bill_date, quantity_in_purchase_bill, item_rate_in_purchase_bill, average_purchase_price`

Assume that: (1) there is only one supplier for each ~~item~~ bill purchase, (2) an item comes only once in a bill (3) there is only one customer for a sales bill (4) sales tax rate in a bill depends on item category (5) a sales bill contains all items of same category.

Your tasks here are following - [10+10]

i Identify Minimal FD Set

ii. Give normalized relations that are in BCNF. Specify Keys and FKs also.

FDs
sales-bill-no → sales-bill-date
sales-bill-no → customer-no
customer-no → customer-name
sales-bill-no → item-no
item-no → item-name, item-rate
item-no → quantity-in-stock, ~~quantity-in-bill~~
{sales-bill-no, item-no} → quantity-in bill, item-rate in-bill
item-no → item-category
item-category → item-category-sales-tax-rate
supplier-id → supplier-name
purchase-bill no → purchase-bill-date, quantity-in-pur-bill
{purchase-bill-no, item-no} → item-rate-in-purchase-bill
{quantity-in-purchase-bill, item-rate-in-p-b} → average purchase price

10

Relations

underlined attributes are keys

sales-bill-no → {sales-bill-date, customer-no, item-no}
customer-no → {(customer-name)}
item-no → {item-name, item-rate, quantity-in-stock, item-category}
supplier-id → {supplier-name}
purchase-bill-no → {purchase-bill-date, quantity-in-purchase-bill}
{sales-bill-no, item-no} → {quantity-in-bill, item-rate-in-bill}
{purchase-bill-no, item-no} → item-rate-in-purchase-bill
{quantity-in-purchase-bill, item-rate-in-pb} → avg-purchase-price

10

READ THE INSTRUCTIONS CAREFULLY

DA-IICT, Gandhinagar
EL2xx: Embedded Hardware Design
Aug 31, 2018 (Friday)
Exam: Insem1
Duration: 60 minutes (Time: 1100hrs-1200hrs)
Total Marks: 50

Keep the rough workings along side your solution.
No Calculators allowed.
No extra sheet provided.

1. Show how a demultiplexer could be used to allow a microcontroller to control eight LEDs from three digital outputs.
(8 marks)

2. Implement the function

$$f = \sum_{ABC} (1,3,4,7)$$

using a 4-1 line multiplexer and a NOT gate, and
using a 3-1 line decoder and an OR gate.
Describe the commonality between the two implementations.
(10 marks)

3. Design a combinational logic circuit which subtracts 1 from the input. Given a 3-bit binary input ABC_2, design a circuit which provides a 3-bit binary output DEF_2. Where

$DEF_2 = ABC_2 - 1$ if $ABC_2 > 0$
$= 0$ if $ABC_2 = 0$

(12 marks)

4. Apply Quine McCluskey method on the following expression:

$$X = \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}CD + \bar{A}B\bar{C}\bar{D} + \bar{A}B\bar{C}D + A\bar{B}C\bar{D} + AB\bar{C}\bar{D} + AB\bar{C}D + ABCD$$

And write the reduced solution.
(20 marks)

-END OF PAPER-

Dhirubhai Ambani Institute of Information & Communication Technology
Mid Semester Test-1, 1st Semester 2018- 19

Course Title	IT304 Computer Networks	CLOSED BOOK	Max Marks	20
Date	1 September 2018		Time	1 Hour

In protocol design problems,

- Give a brief description of how your protocol functions
- Provide the details of the message structure, message sequence, timer functions (if needed), and other actions performed by the nodes.
- Give brief justification for each component of your design.

1. Write the pseudocode for a TCP client and server application where client sends a single "whoami" message to the server and the server responds with the message containing the "IP address" of the client. Your pseudocode should contain (a) the calls needed for establishing a connected socket, and (a) the logic for extracting the client IP address on the server side. You don't need to give the exact syntax of the library calls; however you should be aware of the arguments of the calls being used. [5]

2. Discuss the pros and cons of layered architecture. Be brief and precise. List the services offered by layers of Internet protocol stack. In particular, discuss the design choices made for the services that are offered in the Transport layer. *[1+2+2]*

3. In the context of the DNS protocol,
   a. Draw the DNS hierarchy, and list the DNS *messages* sent and received and *records processed* in obtaining the IP address corresponding to `server1.google.com`. Assume that the local resolving name-server is `ns1.daiict.ac.in` and all DNS servers performed iterated queries.
   b. Heavily loaded application servers are frequently replicated across multiple networks and machines. In these cases, all these replicated servers have different IP addresses but are mapped to same domain name entry. For example, www.google.com is mapped to a number of physically separated machines across networks. How can DNS be used to *balance load* and improve fault-tolerance on such replicated servers? [3+2]

4. An ack-based link protocol (waiting for ack before sending next packet) uses a timer to abort ack_wait function after the timeout period T and retransmits the same packet. This process continues till the packet is successfully transmitted before moving to a new packet.
   a. How would you define the efficiency of such a protocol.
   b. 10 packets are sent on a channel. Each packet takes 10ms to transmit. Acks take exactly 100ms to arrive after the transmission. Two of the ten packets got corrupted the first time they were sent (these needed to be retransmitted once). No other packets suffered corruption. Compute the efficiency of the protocol in each case when timeout value T is set to (i) 150ms, (ii) 120ms, and (iii) 80ms. [2+3]

Dhirubhai Ambani Institute of Information & Communication Technology
Final Examination, Semester I 2018-19

Course Title	IT304 Computer Networks		**Max Marks**	35%
Date	28 November 2018	**CLOSED BOOK**	**Time**	2 Hours

Questions are worth 5 marks each.

1. What is the purpose of the flow ID field in IPv6 header? Explain how tunneling is used to allow incremental deployment of IPv6 and co-existence of IPv4 and IPv6?

2. A token bucket controller for bursty traffic can be designed by using different [A,B] values where A is the token generation rate and B is the token bucket size. An bursty source has a peak rate of 200 KB/sec, long term average of 100 KB per second and burst size of 500 KB.

   Compute the maximum delay suffered by packets for the values of A=100 KB/sec, A=150 KB/sec and A=200 KB/sec. What are the respective values of B so that there are no packet losses?

3. Briefly describe the operation of slotted ALOHA. For a system with N active nodes, find the relation between p and N that maximizes the system throughput.

4. In the context of IEEE 802.3 (Ethernet) LAN protocol, answer the following:
   a. Briefly describe the functioning of CSMA/CD protocol.
   b. In terms of the relevant LAN parameters (length L, packet size B, link capacity C etc.) derive an expression for the maximum time T_{cl} during which collision may take place.
   c. Explain the need of exponential back-off mechanism in 1-presistent CSMA/CD.

5. Clearly describe a reverse-path-forwarding based multicast protocol that is suitable for dense multicasting. Your answer should contain the following details:
   a. Multicast group creation
   b. Reverse Path Forwarding
   c. Multicast Tree management

6. Briefly describe the Token-ring protocol. Derive the expression for efficiency of the protocol as a function of active nodes N in terms of relevant MAC parameters (Lengh L, pkt size B, propagation speed V, capacity C, Token size b etc.)

7. Describe the functioning of a switched hub in a LAN and its impact on the system goodput. Explain the additional capabilities present in a port-based L3 switch and how it functions.

Q-1

NAT – Network Address Translation (1 marks)

Definition:

- Network Address Translation (NAT) is a process in which one or more local IP address is translated into one or more Global IP address and vice versa in order to provide Internet access to the local hosts.
- Operates on router or firewall.

- No marks are given if only definition is written in the answer.
- 0.5 marks - definition + if correct NAT table is shown.
- 0.5 marks - if how translation happens is described correctly with an appropriate example (No marks provided if the translation scheme is written in words without any example.)

DHCP – Dynamic Host Configuration Protocol(1 marks)

Definition:

- The Dynamic Host Configuration Protocol (DHCP) is a network management protocol, whereby a DHCP server dynamically assigns an IP address and other network configuration parameters to each device on a network so they can communicate with other IP networks. It is a client-server protocol.

- 0.5 marks – correct definition of DHCP, a simple example, what is lease time and what happens after expiration of lease time.
- 0.5 marks – if 4 step DORA procedure is described correctly with simple.
- No marks if only definition was written in the answer.

CIDR – Classless Inter-Domain Routing Protocol (1 marks)

- No marks provided if answer was describing what is CIDR and how it helps reduce wastage of IP which was happening in classful addressing scheme.
- 0.5 marks are given if student has explained how it helps reducing the routing table size.
- 0.5 marks are given if student has taken a nice and simple example.

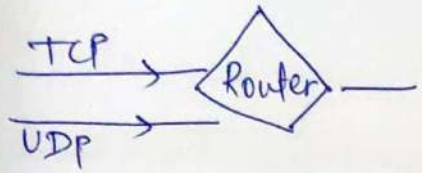
How these protocols help to manage Internet Address Space more efficiently?
0.5 marks for each i.e. 1.5 marks total.

NAT – allows to use same range of IP for multiple private networks connected to internet via NAT router.
CIDR – Helps to reduce routing table entry size using concept of VLSM.
DHCP – allows to allocate IP addresses to host as and when needed, and allows reuse of the same. As lease time is used so IP won't be blocked if client do not require.

- Marks are only given if student has explicitly mentioned the advantage of these three protocols (after every protocol or at the last after explaining all three protocols).
- No marks given for the same if student has written that "this is how it utilizes Internet Address Space more efficiently" after describing the protocol.
- The remaining 0.5 marks are up to the me. If I found that the student has explained some answer really well with a nice example.
- As the question asked specifically to mention all three protocols with a suitable example, if student has just explained protocols in words without any example no marks are given.
- I have tried to mention the key points that were missing in the answer in almost all the answer sheets.

Note: Detailed answer is discussed at the end of the solution file.

Q-2 [a] total : 2 marks



When Router experiencd congestion, there can be possibilities of packet loss with two types. ① TCP ② UDP

If lost packet was TCP :→ TCP follows congestion policy and decreases transfer rate.

→ Whereas UDP rate remain same.

1

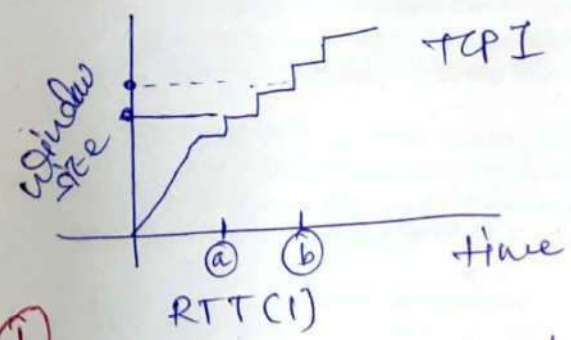
And As conclusion UDP grab more bandwidth and resulted in higher throughput as compare to TCP.

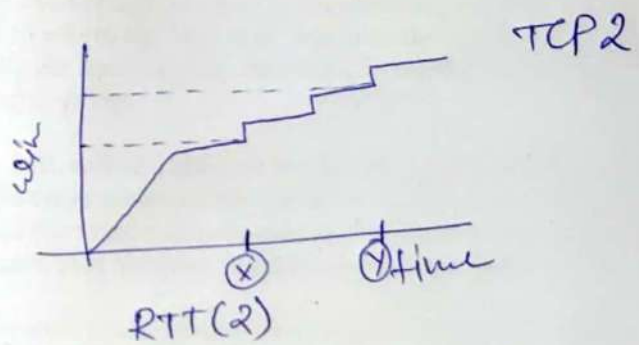
If lost packet was UDP :→ UDP does not follow any congestion policy, so UDP flow remain same

1

→ TCP packets were not loss, so TCP sending rate will be the same.

[b] total : 2 marks





1

For transmitting same bytes of data TCP 1 takes lesser time then TCP 2. As you can see in figure data transmission with lesser RTT(1) it will take b-a time which less then RTT(2) [Y-X]

→ As a result lesser RTT flow will grab more bandwidth very fast then higher one and resulted in higher throughput

$$\bar{x}_1 \propto \frac{1}{RTT_1} \qquad \bar{x}_2 \propto \frac{1}{RTT_2} \qquad [\bar{x} = \text{throughput}]$$

$$\frac{\bar{x}_1}{x_2} \propto \frac{RTT_2}{RTT_1}$$

1

Scanned by CamScanner

Q2 (c)

1/2 mark

estimated rtt = $(1-\alpha)$. estimated rtt + α . sample rtt $\quad 0<\alpha<1$

recommended $\alpha = 0.125$

1/2 mark

Devrtt = $(1-\beta) \times$ DevRTT + β |Sample rtt − estimated rtt|

$0<\beta<1$

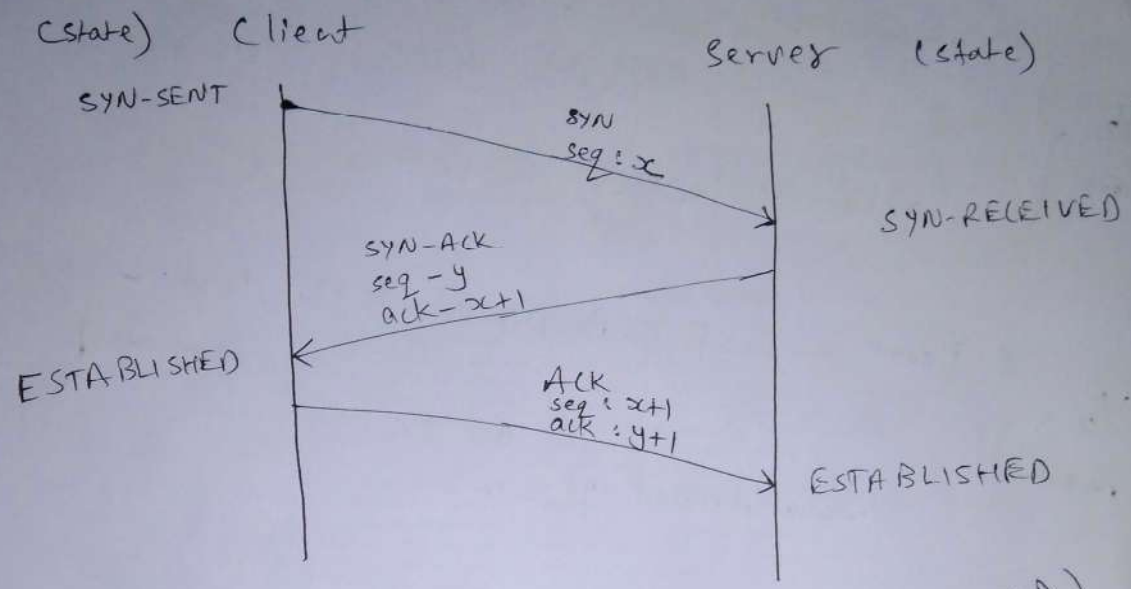
recommended $\beta = 0.25$

1/2 mark

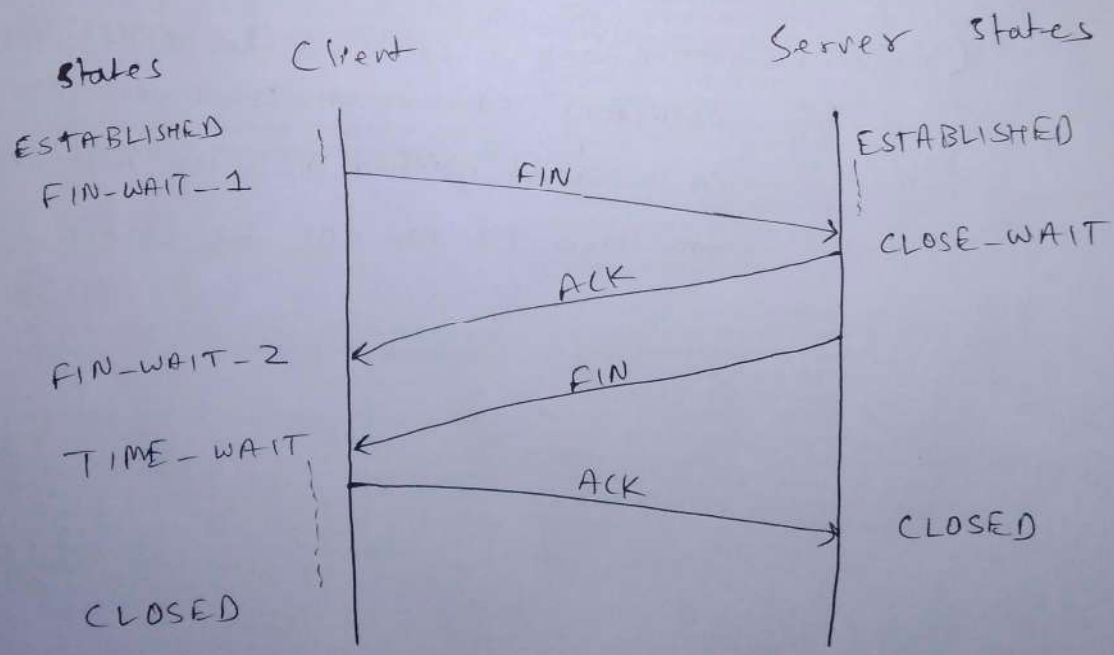
Time out = Estimatted rtt + 4 . Devrtt

Conclusion - rtt changes with each packet and estimating correct rtt is important so it should neither be too high or too low. It can not be static.

Q2 (d)



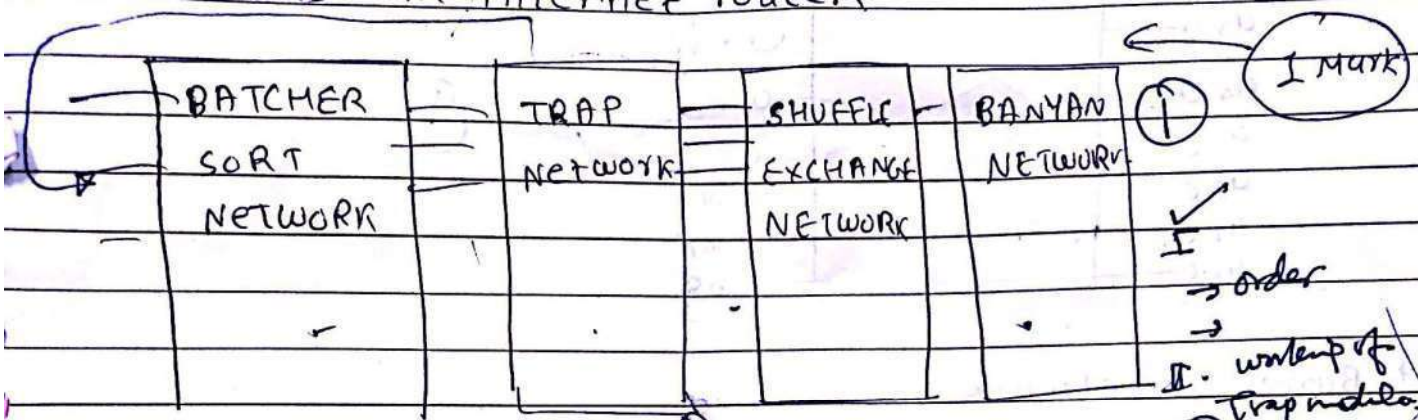
(Connection Establishment (1 mark))



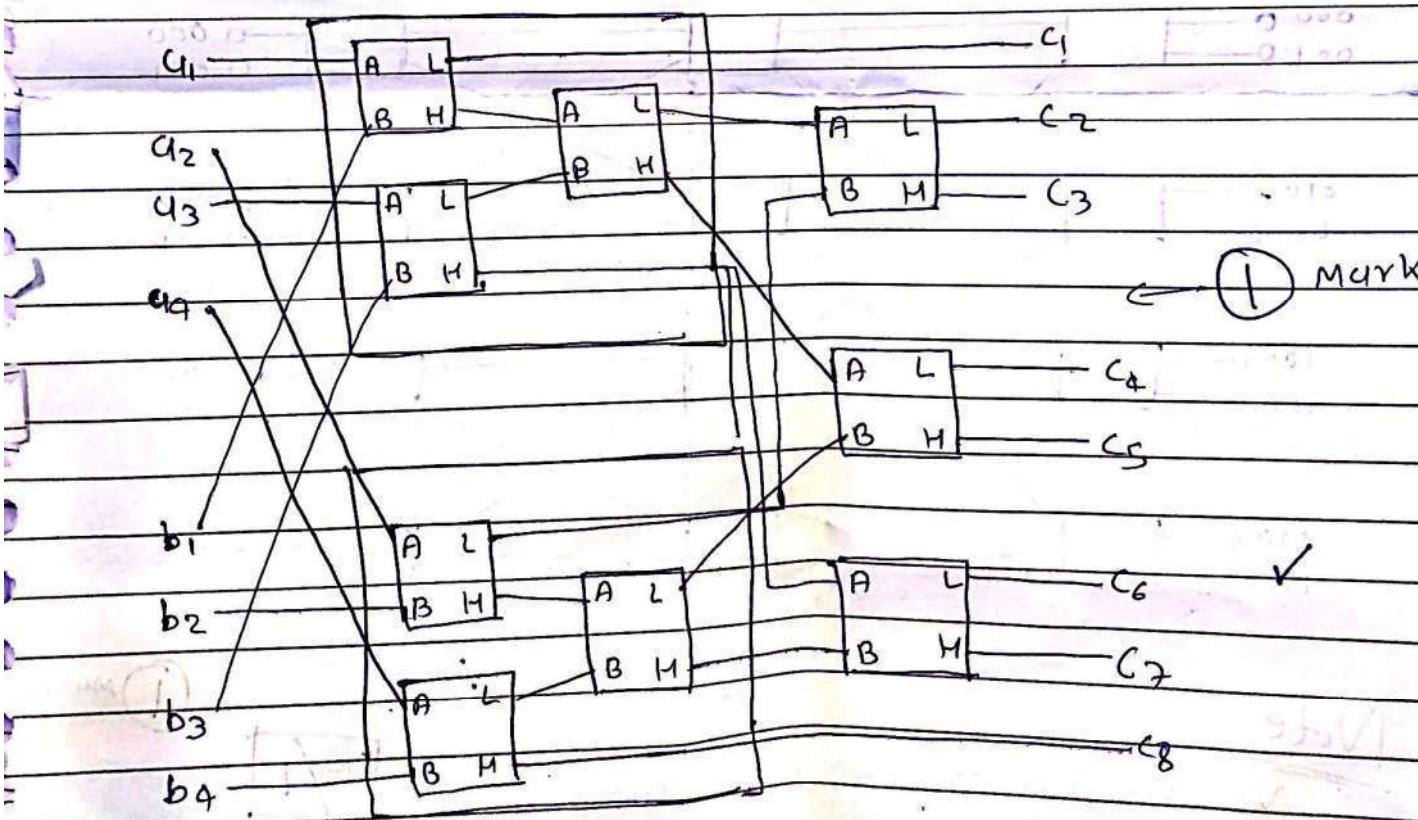
(Connection termination (1 mark))

Q = 3

sort network, shuffle-exchange network & Banyan network for 8x8 Batcher-Banyan switch. what additional modules / functionalities are needed to make this switch perform as an internet router?



→ sort network for 8 input required

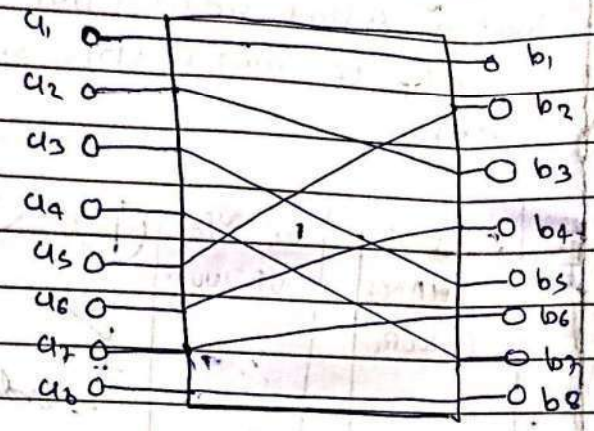


⇒ Require Trap Network to work as Router 1 Mark

Trap: detect multiple pkts for the same output

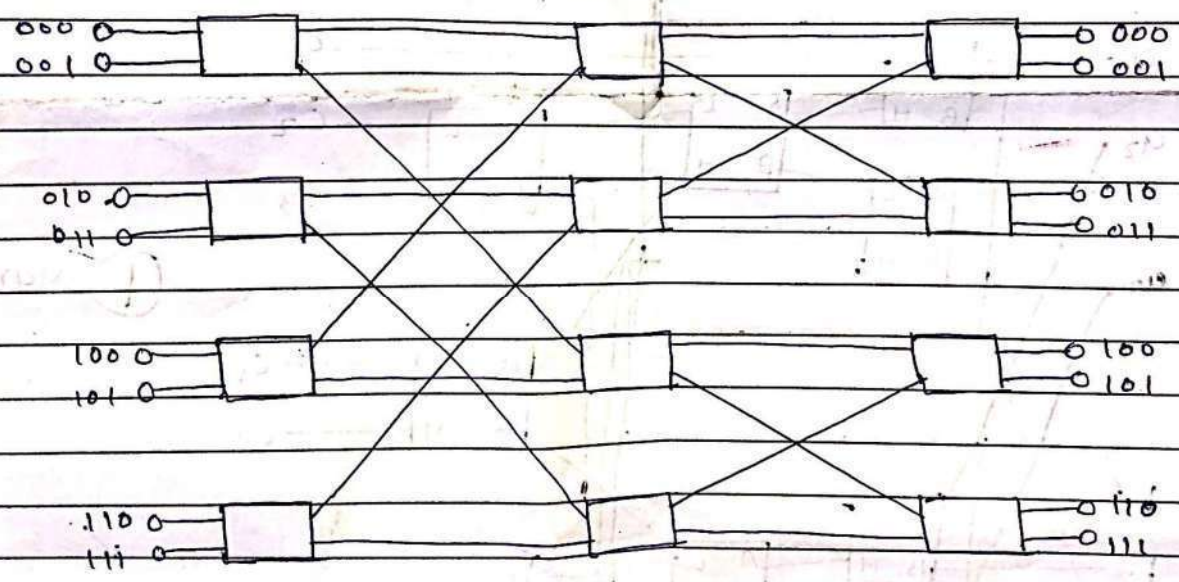
Require functionalities of Trap Network

* A shuffle-network



✓ (1) Mark

* Banyan network



✓ (1) Mark

Note:

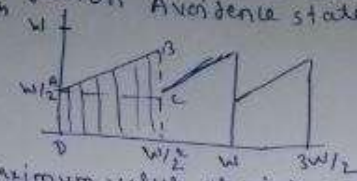
No Partial mark for figure

either 0 or 1

0/1

Answer:-4

(a) we will ignore slow start we will consider congestion Avoidance state



maximum value of window size is W, minimum value of window size is W/2 (swing steady state)

Total window change = W/2

hence cycle duration = RTT × (W/2)

total data delivered = Area (ABC) + Area (ACDE)

$$= \frac{1}{2}\left(\frac{W}{2}\right)^2 + \frac{1}{2}\left(\frac{W}{2}\right)^2$$

$$= \frac{W^2}{8} + \frac{W^2}{4} = \frac{3}{8}W^2 \quad (i)$$

total packet delivered $= \frac{1}{p}$ (ii) [p = packet loss probability]

from (i) and (ii)

$$\frac{1}{p} = \frac{3}{8}W^2$$

$$W = \sqrt{\frac{8}{3p}} \quad (iii)$$

Therefore throughput $(\bar{X}_0)$ = $\frac{\text{data delivered per cycle}}{\text{time per cycle}}$

$$= \frac{3/8\, W^2 \times (MSS)}{RTT \times (W/2)}$$

$$= \frac{MSS}{RTT} \times \frac{3}{4} W$$

$$= \frac{MSS}{RTT} \times \frac{3}{4} \times \sqrt{\frac{8}{3p}}$$

$$\boxed{(\bar{X}_0) = \frac{MSS}{RTT}\sqrt{\frac{3}{2p}} \quad (iv)}$$

Answer 4 (b)

from (iv)

$$\bar{x} \propto \frac{1}{T\sqrt{p}}$$

If T is variable $(T \pm \Delta)$ $\Delta << T$

$$\bar{x} \propto \frac{1}{\sqrt{p}(T \pm \Delta)}$$

$$\bar{x} \propto \frac{1}{\sqrt{p}\, T(1 \pm \frac{\Delta}{T})}$$

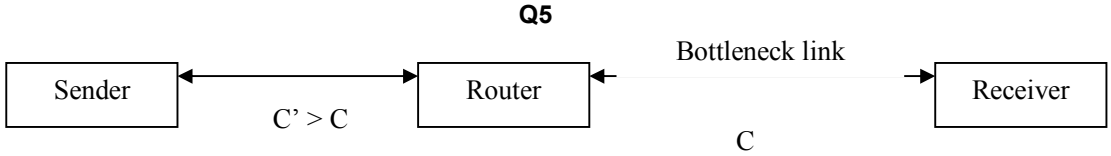
$$\bar{x} \propto \bar{x}_0 \left(1 \pm \frac{\Delta}{T}\right)^{-1}$$

$$\bar{x} \propto \bar{x}_0 \left(1 + c\left(\frac{\Delta}{T}\right)^2 + \dots\right)$$ on expanding

where c is some constant.

$$\boxed{\bar{x} \simeq \bar{x}_0 + \bar{x}_0 c \left(\frac{\Delta}{T}\right)^2}$$

Q5



-
- Let us assume that capacity of router is C.
- If input rate is < C, no buffer is needed.
- But if input rate may go till R_{max},buffer of size $(R_{max} - C) * t$ is needed.
- For TCP , time for which input rate becomes >C is called T_{burst} .and it is order of RTT. So buffer size should be

$$(R_{max} - C) * RTT$$

- If R_{max} is order of c. this equation can be as following

$$B = C * RTT$$

- If there are n TCP flows ,

$$B = \frac{C * RTT}{\sqrt{n}}$$

- 1 marks only if logic is discussed or only one equation is written without justification
- 2 marks: both equations are written without proper justification

3 marks: both the equations are written with detailed justification

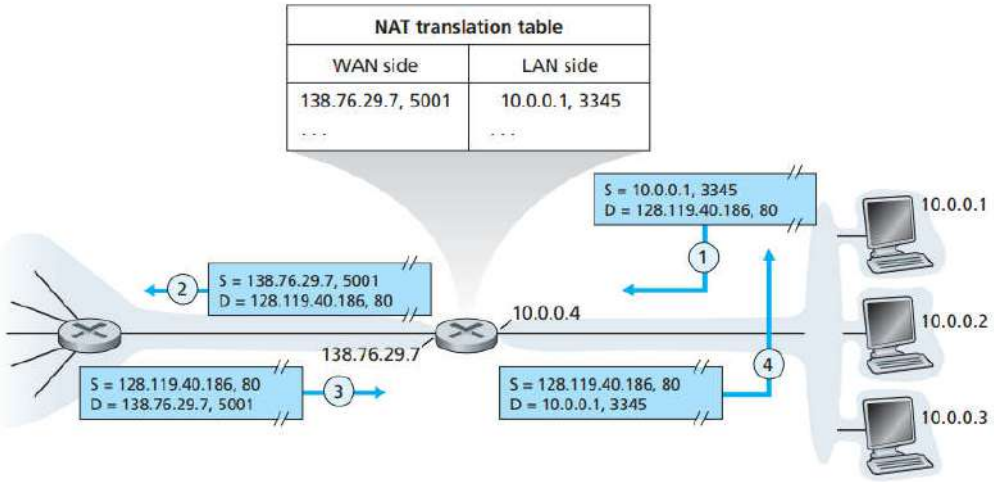
Detailed answer of question 1
NAT – Network Address Translation(1 marks)

Definition:

- Network Address Translation (NAT) is a process in which one or more local IP address is translated into one or more Global IP address and vice versa in order to provide Internet access to the local hosts.
- Operates on router or firewall.

Working:

- The router which have one interface in local (inside) network and one interface in global (outside) network is configured as NAT.
- When packet enters inside the network, the local IP is converted to public IP and vice-versa.
- If NAT runs out of addresses – an ICMP host unreachable is sent to the destination node.
- Subnet address 10.0.0/24 is reserved for realm with private addresses such as home network.



- These addresses cannot be used to address node in global network, as many private networks are there using these blocks of addresses.
- NAT router has its own IP address.
- In example given above, all traffic leaving router for larger internet has source IP address of 138.76.29.7 and same applies for entering traffic.
- DHCP server to provide addresses to computers within the NAT-DHCP-router-controlled home network's address space.
- NAT translation table: Suppose a user sitting in a home network behind host 10.0.0.1 requests a Web page on some Web server (port 80) with IP address 128.119.40.186. The host 10.0.0.1 assigns the (arbitrary) source port number 3345 and sends the datagram into the LAN. The NAT router receives the datagram, generates a new source port number 5001 for the datagram, replaces the source IP address with its WAN-side IP address 138.76.29.7, and replaces the original source port number 3345 with the new source port number 5001. When datagram arrives at the NAT router, the router indexes the NAT translation table using the destination IP address and destination port number to obtain the appropriate IP address (10.0.0.1) and destination port number (3345) for the browser in the home network. The router then rewrites the datagram's destination address and destination port number, and forwards the datagram into the home network.

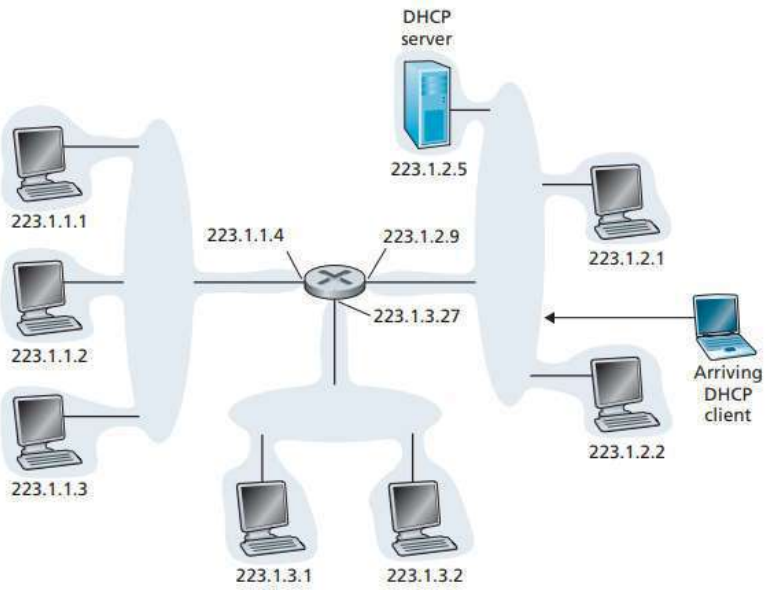
DHCP – Dynamic Host Configuration Protocol(1 marks)

Definition:

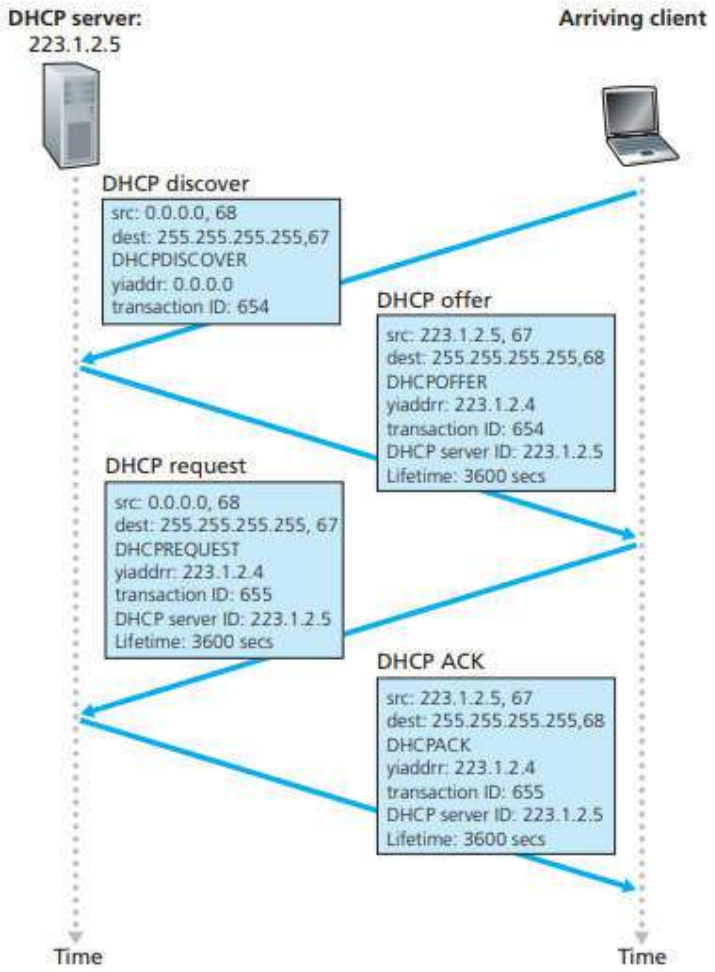
- The Dynamic Host Configuration Protocol (DHCP) is a network management protocol, whereby a DHCP server dynamically assigns an IP address and other network configuration parameters to each device on a network so they can communicate with other IP networks. It is a client-server protocol.

Working:

- A network administrator can configure DHCP so that a given host receives the same IP address each time it connects to the network, or a host may be assigned a temporary IP address that will be different each time the host connects to the network.
- Additional info provided by DHCP server: subnet mask, address of first hop router, lease time and address of local DNS server.
- Plug and play protocol.
- DHCP server allocates an arbitrary address from its current pool of available addresses; each time a host leaves, its address is returned to the pool.
- In simple scenario, each subnet will have a DHCP server, if not then router will provide address of DHCP server for that network.

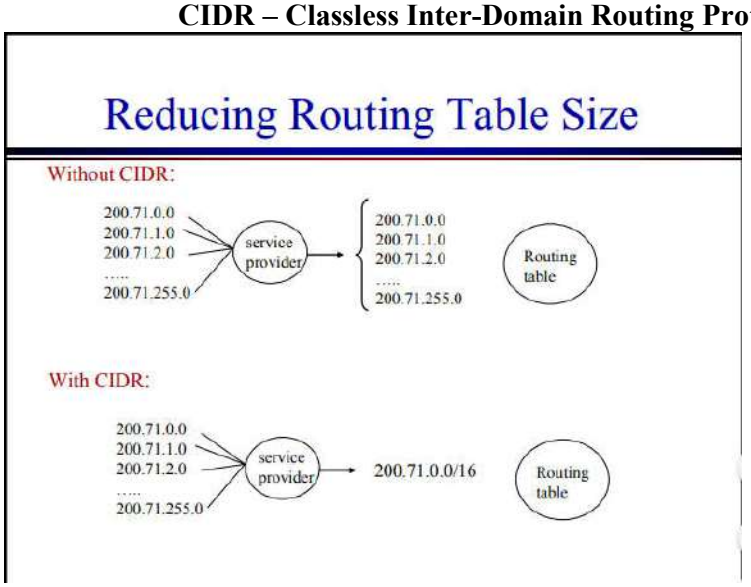


- Figure shows a DHCP server attached to subnet 223.1.2/24, with the router serving as the relay agent for arriving clients attached to subnets 223.1.1/24 and 223.1.3/24.
- Four steps:
    - DHCP sender discovery: New host finds DHCP server to interact with. As host doesn't know IP of DHCP server, it broadcasts discovery message to all the nodes i.e. using 255.255.255.255
    - DHCP server offer(s): DHCP server receiving this discovery message, responds to client with broadcast message. Here client might get response from multiple DHCP server(s). DHCP server response contains: proposed IP, network mass, lease time.
    - DHCP request: From multiple/single offer, client will choose and reply send DHCP request sending back the provided parameters.
    - DHCP ack: Server responds with ACK message.



- Now client can use, DHCP allocated IP.
- After lease time expires, client has to request again to DHCP server.

CIDR – Classless Inter-Domain Routing Protocol (1 marks)



Dhirubhai Ambani Institute of Information & Communication Technology
Mid Semester Test-2, 1st Semester 2017- 18

Course Title	IT304 Computer Networks		**Max Marks**	25
Date	12 October 2017	**CLOSED BOOK**	**Time**	90 min

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1. In the context of a reliable link-layer protocol
   a. Define the efficiency of the protocol.
   b. Compute the efficiency of GBN and SR for a noisy link with constant RTT.
   c. What is the optimal window size and maximum sequence number for each of these protocols? [1+4+1]

2. A transport layer congestion control protocol like TCP relies only on the information contained in ACK feedback received from the receiver along with estimating packet timeout timer.
   a. Describe the TCP timeout timer estimation for each packet.
   b. Describe how the packet timeout may be used to manage congestion.
   c. Describe how the RTT values of the ACK may be used to manage congestion.
   d. Under appropriate assumptions, show that the dependency of expected throughput on **RTT** and packet loss probability **p**. [2+2+2+3]

3. A node can use an *echo* packet to find the round-trip-delay to its direct neighbors. Let's define the weight of a link between neighbor nodes A and B as $W_{AB} = W_{BA} = (RTT_{AB} + RTT_{BA})/2$.
   a. Design this *echo* protocol to compute W_{AB}.
   b. Design a protocol that uses repeated communication between direct neighbors to find the shortest path between any pair of nodes in the network. [2+3]

4. A UDP socket application typically needs to build flow-control logic within the application itself. This requires, among other things, implementing sliding window operations (buffer management, packet sequencing), and retransmissions.
   Using a combination of socket library functions and system calls, provide a pseudocode skeleton for implementing these. Detailed code is not required but familiarity with the function and system calls signature and their usage is expected. [5]

Q1

(a) Efficiency $\eta = \dfrac{\text{time spent transmitting useful data}}{\text{total time spent (incl. retrans. \& wait)}}$

$\boxed{1}$

(b) GBN: If $W \cdot \tau_{trans} \geq (\tau_{trans} + 2\tau_{prop})$

there is no waiting for ACK; $W = W_{opt}$

$W_{opt} = 1 + 2a$.

$\boxed{2}$

In GBN, every timeout leads to the whole window retransmitted

$$\langle N_r \rangle = \sum_{i=1}^{\infty} [1 + (i-1)W] p^{i-1}(1-p) = \frac{(1-p+Wp)}{(1-p)}$$

$$\eta_{GBN} = \frac{1}{\langle N_r \rangle} \text{ (with optimal Window)} = \boxed{\frac{1-p}{1+2ap}}$$

$\boxed{2}$ SR $\eta_{SR} = (1-p)\,\mathrm{Min}\left(1, \frac{W}{W_{opt}}\right) = \boxed{(1-p)}$ for opt. window.

(c) GBN: Max Seq. Size $\geq$ Window size + 1

$\boxed{1}$ SR: Max Seq. Size $\geq$ 2 * Window size.

Q2.

(a) $\langle RTT \rangle^{new} = (1-\alpha)\langle RTT \rangle^{old} + \alpha \cdot RTT^{sample}$; $0 < \alpha < 1$

Suggested $\alpha = 1/8$. $\beta = \frac{1}{4}$

2 $\langle devRTT \rangle^{new} = (1-\beta)\langle devRTT \rangle^{old} + \beta \cdot \left| RTT^{sample} - \langle RTT \rangle \right|$

$$\text{Timeout} = \langle RTT \rangle + 4 * \langle devRTT \rangle$$

(b) Packets timeout either because it got corrupted or the Ack took lot longer to arrive. If it is assumed that packet corruption probability is quite low (ignorable),

2 timeout $\Rightarrow$ large queueing delay & congestion). Hence window size can be reduced at timeout (multiplicative decrease) to manage congestion.

(c) Relatively low RTT value is an indicator of less congested network. This may be used to adjust rate <u>before</u>

2 congestion related packet loss occurs. Here, rate is linearly increased/decreased as RTT values becomes small/large in relation to RTT_{min} observed over the session.

(d) $\#\text{ of pkts} = \left(\frac{3W}{4}\right) \cdot \left(\frac{T}{RTT}\right) = \frac{1}{p}$.

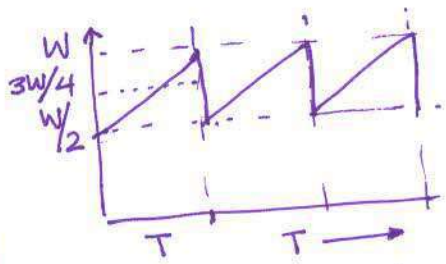
Also Window increases by 1 every RTT

3 $\Rightarrow T = \frac{W}{2} \cdot RTT \Rightarrow \frac{T}{RTT} \propto W$

$\Rightarrow W^2 \propto \frac{1}{p}$.

$$\langle X \rangle = \frac{\#\text{ of pkts in a cycle}}{\text{Time}} = \frac{1/p}{RTT \cdot \frac{W}{2}}$$

$$\Rightarrow \boxed{\langle X \rangle \propto \frac{1}{RTT \cdot \sqrt{p}}}$$



- Ignore slow-start phase
- Assume pkt loss happens exactly every $\frac{1}{p}$ pkts.
- $\langle X \rangle = \frac{\langle W \rangle}{\langle RTT \rangle}$.

Ques 3 .A node can use an *echo* packet to find the round-trip-delay to its direct neighbors. Let's define the weight of a link between neighbor nodes A and B as $W_{AB} = W_{BA} = (RTT_{AB} + RTT_{BA})/2$. (2+3)

a. Design this *echo* protocol to compute W_{AB}. (1+1)

1. <u>Learning about its neighbors:</u> When a router is booted, its first task is to learn who its neighbors are. It accomplishes this goal by sending a special HELLO/ECHO packet on each point-to-point line. The router on the other end is expected to send back a reply to the query.

   <u>Hello packet structure:</u>

Source Ip address	**Source port no.**	**Destination port no.**	**"Hello"**	**Timer**

2. <u>Measuring Line Cost:</u> To estimate of the delay to each of its neighbors. The most direct way to determine this delay is to send over the line a special ECHO packet that the other side is required to send back immediately.

   - Start the timer and flag =0 for echo packet from A to B.
   - Send a packet with the following structure from A to B :

Source Ip Address	**Destination Ip Address**	**Timer**	**ACK**	**Flag**

   - Upon receiving the packet at B, it store the value of timer and set the flag =1 in order to remove any packet loss .
   - Send the Same Echo packet as response from B to A in the following form:

Source Ip Address	**Destination Ip Address**	**Timer**	**ACK**	**Flag**

   - Upon receiving the packet with flag =1, stop the timer and store the value of RTT_{AB} = Timer.

   Similarly we will perform follow same procedure for calculating RTT_{BA} from B to A.

   - By measuring the round trip time as RTT_{AB} and RTT_{BA} then summing both and then dividing it by two, we will get the average W_{AB} OR W_{BA} .
     For even better results, the test can be conducted several times, and the average used.

$W_{ab} = W_{ba} = (RTT_{ab} + RTT_{ba})/2$

b. Design a protocol that uses repeated communication between direct neighbors to find the shortest path between any pair of nodes in the network. (1+1+1)

In order to compute shortest path between any pair of nodes in network we can use Distance Vector routing protocol or Bellman Ford Algorithm.

A distance-vector routing protocol requires that a router inform its neighbours of topology changes periodically due to which it have less computational complexity and message overhead.

Routers using distance-vector protocol do not have knowledge of the entire path to a destination. Instead they use two methods:

1. Direction in which router or exit interface a packet should be forwarded.
2. Distance from its destination

Distance-vector protocols are based on calculating the direction and distance to any link in a network. Here in this answer we are

Define distances at each node X :: dx(y) = cost in form Weight W_{ij} path from X to Y

Update distances based on neighbors :: dx(y) = min {W(x,v) + dv(y)} over all neighbors V.

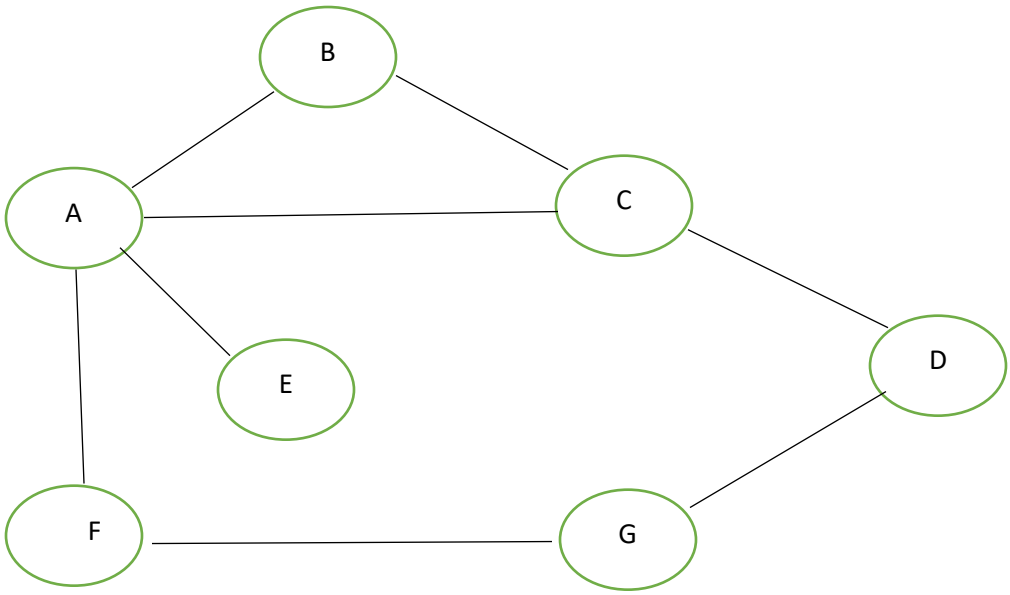
The least cost route between any two nodes is the route with minimum distance.

Algorithm With Example:

Each node constructs a one-dimensional array containing the "distances"(W_{ab}) to all other nodes and distributes that vector to its immediate neighbors.

1. The starting assumption for distance-vector routing is that each node knows the cost of the link to each of its directly connected neighbors.
2. A link that is down is assigned an infinite cost.

Each node maintains a vector (table) of minimum distance to every node. The cost of reaching a destination is calculated using various route metrics.



Information Stored at Node	Distance to Reach Node						
	A	B	C	D	E	F	G
A	0	1	1	?	1	1	?
B	1	0	1	?	?	?	?
C	1	1	0	1	?	?	?
D	?	?	1	0	?	?	1
E	1	?	?	?	0	?	?
F	1	?	?	?	?	0	1
G	?	?	?	1	?	1	0

? MEANS INFINITY

Table shows the initial distances stored at each node

We can represent each node's knowledge about the Weights to all other nodes as a table like the one given in above table

Note that each node only knows the information in one row of the table.

1. Every node sends a message to its directly connected neighbors containing its personal list of Weights (W). (for example, **A** sends its information to its neighbors **B,C,E**, and **F**.)
2. If any of the recipients of the information from **A** find that **A** is advertising a path shorter than the one they currently know about, they update their list to give the new path length and note that they should send packets for that destination through **A**. (node **B** learns from **A** that node **E** can be reached at a cost of 1; **B** also knows it can reach **A** at a cost of 1, so it adds these to get the cost of reaching **E** by means of **A**. **B** records that it can reach **E** at a cost of 2 by going through **A**.)
3. After every node has exchanged a few updates with its directly connected neighbors, all nodes will know the least-cost path to all the other nodes.
4. In addition to updating their list of Cost in terms of weights when they receive updates, the nodes need to keep track of which node told them about the path that they used to calculate the cost, so that they can create their forwarding table.
5. For example, **B** knows that it was **A** who said " I can reach **E** in one W_{AE}" and so **B** puts an entry in its table that says " To reach **E**, use the link to **A**.

Information Stored at Node	Distance to Reach Node						
	A	B	C	D	E	F	G
A	0	1	1	2	1	1	2
B	1	0	1	2	2	2	3
C	1	1	0	1	2	2	2
D	2	2	1	0	3	2	1
E	1	2	2	3	0	2	3
F	1	2	2	2	2	0	1
G	2	3	2	1	3	1	0

Table 2 Final distance stored at each node

Each node's forwarding table consists of a set of triples of the form: (Destination, Cost(W_{ij}), NextHop).

For example, Table 3 shows the complete routing table maintained at node B for the network in figure1.

Destination	Cost	NextHop
A	1	A
C	1	C
D	2	C
E	2	A
F	2	A
G	3	A

Table 3: Routing table maintained at node B

<u>NOTE with Marks Distribution:</u>

For Q3 a part

Explanation with Message Structure + W_{AB} derivation then 1+1

For Q3 b part

Marks have not been given for using link state protocol or link state using flooding as well as using Dijkstra's Algorithm with flooding in order to find shortest path.

Besides it if you have used any other Algorithm or protocol but have not used above W_{ij} as Weighted cost then also marks have been deducted.

Algorithm + Example + Proper Table Structure then 1+1+1

Q4. *A UDP socket application typically needs to build flow-control logic within the application itself. This requires, among other things, implementing sliding window operations (buffer management, packet sequencing), and retransmissions. Using a combination of socket library functions and system calls, provide a pseudo code skeleton for implementing these. Detailed code is not required but familiarity with the function and system calls signature and their usage is expected.*

Answer should contain following components:

- Basic Socket library functions for initial connection and data exchange.
- Given Window Size (W) and Sequence Number, what type of Data structure for Buffer management you are going to use.
- RTT Estimation to calculate Timeout for retransmission of packet.
- System calls for implementing Timer.
- How you manage Window (how Sliding of window occurs.) and brief explanation of algorithm you used for sliding window (i.e., GBN or SR).

<u>1).Basic Socket library functions for initial connection and data exchange.</u>

```
1..socket (domain, type, protocol)

2..bind(udpSocket, (struct sockaddr *) &serverAddr, sizeof(serverAddr));

3..send to(int socket, const void *buffer, size_t length, int flags, const
struct sockaddr *dest_addr, socklen_t dest_len)

4..recvfrom(int socket, void *restrict buffer, size_t length, int flags,
struct sockaddr *restrict src_addr,socklen_t *restrict *src_len)
```

Exact syntax not required but socket library functions for UDP should be mentioned.

Data Structure -How you manage Buffer

If size of each packet is constant then circular array (else an appropriate DS) can be used as a buffer(Data Structure). Pointers(ACK and OUTSTANDING) are maintained to keep track of ACKed packets and the outstanding packets. Load the buffer by replacing ACKed packets with new packets.

- If SW protocol is SR(Selective Repeat) then timer is maintained for each packet .
- If GBN is used then Timer is maintained for the packet sent first or the one pointed by ACK pointer.
- What happens when Sequence numbers exhausted.

RTT Estimation for time out:

(Store current time after transmitting the packet and subtract it from the time when its ACK arrives.)

You need a **gettimeofday()** or similar system call to get current time with millisecond accuracy.Formula for timeout is that given in the solutions of Q2.Here, Exact equations are not required but idea should be explained briefly.

System calls for implementing Timer. (syntax not required)

1).poll(): `int poll(struct pollfd fds[], nfds_t nfds, int timeout);`

2).select(): `int select(int nfds, fd_set *readfds, fd_set *writefds,`

```
    fd_set *errorfds, struct timeval *timeout);
```

For Selective Repeat, poll() should be called for each packet in window and for GBN poll() should be called for First packet pointed by ACK pointer. When poll() returns 0 ,all the packets between ACK and OUTSTANDING pointers should be retransmitted.

How you manage Window (how Sliding of window occurs.) and brief explanation(pseudo code) of algorithm you used for sliding window (i.e., GBN or SR).

Ex. For SR

```
While (true)
        While( ((ACK-OUTSTANDING+1)%W)<MAX_OUTSTANDING_ALLOWED)
                Transmit_pkt(OUTSTANDING);
                Increment OUTSTANDING
                Insert_timer();//select() or poll()
        End
End
```

Here, ACK pointer increments when sender receives Acknowledgement

ACKed	Pkt-1	Pkt-2	Pkt-3	Pkt-4	NULL	NULL

^ ^

ACK OUTSTANDING

Q1:Consider an application that transmits data at a steady rate(for example, the sender generates an N-bit unit of data every k time units, where k is small and fixed).Also when such an application starts, it will continue running for a relatively long period of time. Would a packet-switched network or a circuit switched-network be a more appropriate for this application?Why?

Ans: Circuit Switched network would be more appropriate for such an application that transmits data at a steady rate and it would take a longer time to run the application. The reasons are listed below:

1. As we know that in circuit switched network there is a reservation of the resources from the very beginning of the establishment of the communication between the sender and the receiver. The application is going to run for a relatively longer period of time i.e, after every k time units N bits message would be passed and it is said that the k time unit is very small hence the resource or bandwidth utilization would be maximum in the case of circuit switched network and there is an additional advantage of packet not being lost as the path would be a dedicated one. ……..(1mark)

2. In case of packet switching the message which is being sent gets divided into various packets. Each packet is comprised of message start bits(headers) and end bits. Hence packet overhead cost is more in packet switching as compared to circuit switching. ……..(1mark)

Q2 Derive a formula for the end-to-end delay of sending one packet of length L over N links of

Given Data
L-length
R-Transmission rate
N-number of links

Formula for end to end delay(d):N*(L/R)

Generalize:

The first packet is serialized onto the first link
As soon as the first packet has been serialized onto the first link, as we are only considering serialization delay, it can begin serializing on the second link
At this same time, the second packet can begin serializing on the first link, it can't begin any sooner as the first link was clocking the first packet up until this time.
In this simple model, the first and second packets finish serializing on second and first links (respectively) at the same time
The first packet can now begin serializing on the third link
The second packet can now begin serializing on the second link

The third packet can now begin serializing on the first link
And it goes on until the last packet is serialized onto the first link
Each packet must then serialize on each remaining link until it reaches the last link.
So really, you need to look at the time taken to send all packets across the first link, one-by-one, then
look at the time taken for the last packet to traverse the remaining links.
So if you consider (L/R) as the time taken to transport one packet across one link.
Then consider there are P of these delays to transport all packets over the first link, one-by-one
And there are (N-1) of these delays to transport the last packet over the remaining links
Then the formula for this would be
(P + (N-1)) * (L/R)transmission rate R. Generalize this formula for sending P such packets back-to-back over
the N links. Ignore all other type of delays.

Q. 3 For a router with a single queue, answer the following:
A. Suppose N packets arrive simultaneously at a free router with an empty queue. Each packet is of length L and the router has the processing rate R. What is the average queuing delay for the N packets?
Ans:
The queuing delay for the first packet is 0; for the second packet it is L/R; for the third packet it is 2L/R etc. The last packet (number N) has already been transmitted when the second batch (i.e., group) of packets arrives.
The first of the N packets has no queuing delay. The second packet has a queuing delay of L/R seconds. The n-th packet has a delay of (n − 1)L/R.
Therefore the average delay is

$$\frac{1}{N}\sum_{n=1}^{N}(n-1)\frac{L}{R} = \frac{L}{R}\frac{1}{N}\sum_{n=0}^{N-1} n = \frac{L}{R}\frac{1}{N}\frac{(N-1)N}{2} = \frac{1}{2}(N-1)\frac{L}{R}$$

……....(2Marks)

B. Now suppose that N such packets arrive to the link every LN/R seconds. What is the average queuing delay of a packet?
Ans:
CASE-1 It takes LN/R seconds to transmit the N packets. Thus, the buffer is empty when a each batch of N packets arrive. Thus, the average delay of a packet across all batches is the average delay within one batch, i.e., (N-1)L/2R.
OR
CASE-2: One packet per L/R seconds

In this case ,if one packet per L/R second then it takes 0 sec delay because time taken to process one packet is L/R ,so when new packet arrived after L/R seconds there will be no packets in queue. In this case queuing delay will be Zero.

……(1 Mark)

Q. 4. What are the five layers in the internet protocol stack? What are the principal responsibilities of each of these layers? Be very brief.
Answer
Five layers in the internet protocol stack are:
Application Layer
Transport layer
Network layer
Data link layer
Physical layer

Principal responsibilities are:
Application layer: Here application protocols are running over transport layer services and network layer services to accomplish some task eg. SMTP,HTTPS,POP3,IMAP4 etc.

Transport layer : It is responsible for end to end connection,reliability,congestion control and connection management.
TCP and UDP are the two main protocols used here.

Network layer: Main functions are packetisation, routing and IP addressing.

Data link layer: This layer is responsible for framing,error detection and correction, flow control,multiplexing/shared access.

Physical layer : This layer is mainly responsible for signal coding, 0/1bits to signal conversion and vice versa, modulation and transmission of signals on the physical medium.

Note: here writing principal responsibilities of each layer carries ½ marks which sums up to 2½ marks and the rest ½ depends on the overall correctness of the written answer, writing a responsibility which does not belong to that layer may result in losing marks. Only listing down layers of internet protocol stack does not carry any marks. Written answer should contain atleast 2 responsibilites from the above mentioned for each layer to acquire ½ mark for each layer.

Q 5. How do you achieve cooperation among the nodes in a p2p application? Explain using a BitTorrent type application.

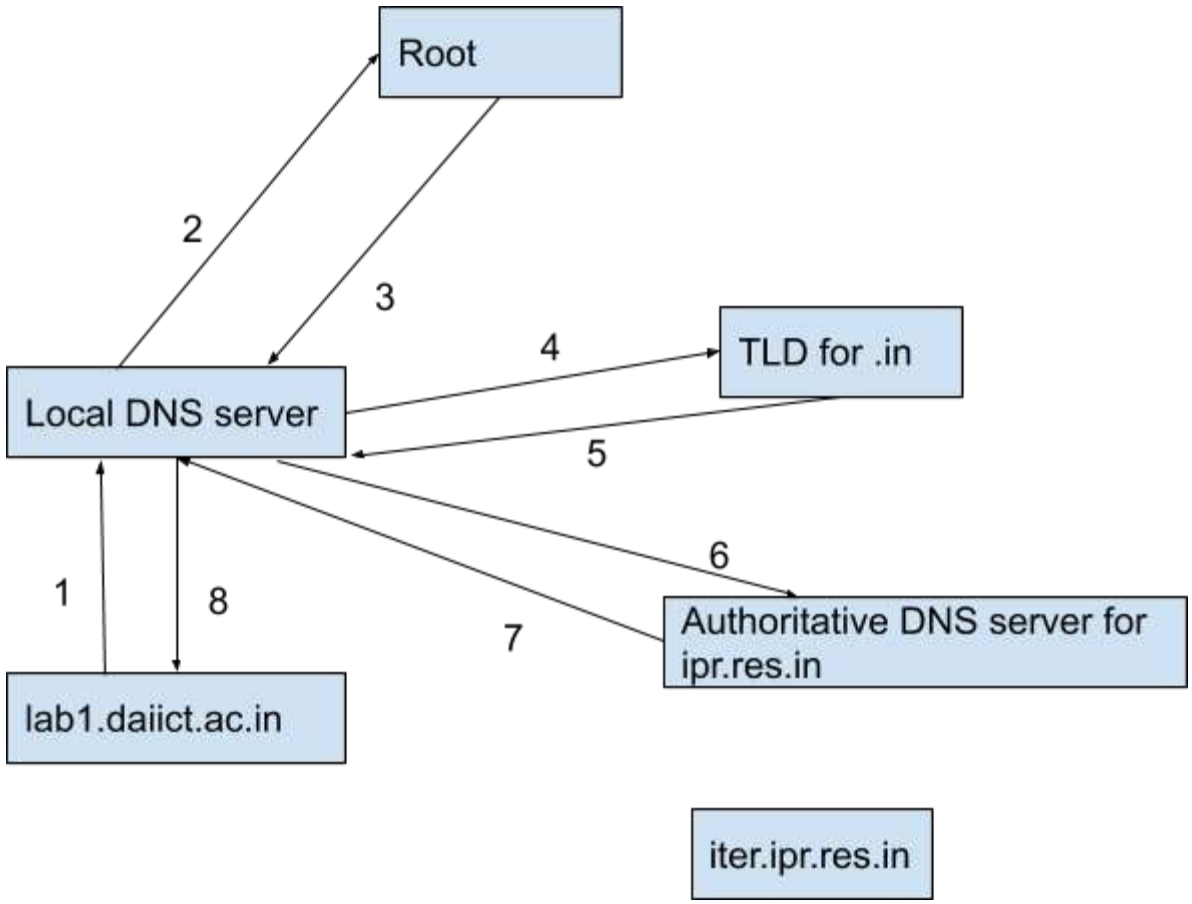
Tit for Tat(TFT) algorithm use to achieve cooperation among the nodes in A peer-to-peer (P2P)application:

1) Clever Trading Algorithm: To determine which request peer responds to Peers have L different neighbours peer gives priority to the neighbours that are currently supplying her data at the highest rate(must mention highest rate)
2 a) Peer continually measure the rate at which peer receives bits and determines the four peers (any k number) that are feeding her bits at the highest rate. Every 10 seconds peers recalculate the rates and possibly modifies the set of four peers. These four peers are said to be unchoked.
2 b) Send/upload chunks to these neighbours.

3) Periodically(every 30 seconds), Choose a random neighbour and send/upload chunk to that neighbour as well (optimistically unchocked)

(NOTE: 1 mark for each point. Question is specifically ask about cooperation method so No marks for explanation of what is peer to peer or figure of p2p application)

Q-6



1 - Query for iter.ipr.res.in

2 - Query for iter.ipr.res.in

3 - Response from the Root server
(iter.ipr.res.in, some.tld.in, NS)
(some.tld.in, ip_of_tld, A)

4 - Query for iter.ipr.res.in

5 - Response from TLD
(iter.ipr.res.in, dns.ipr.res.in, NS)
(dns.ipr.res.in, ip_of_authoritative_server, A)

6 - Query for iter.ipr.res.in

7 - Response from Authoritative DNS Server
(iter.ipr.res.in, ip_of_iter, A)

8 - Response from Local DNS server
(iter.ipr.res.in, ip_of_iter, A)

Mark distribution:
2 marks for showing a clear understanding of “iterative” and “recursive” query sequences for the given scenario. i.e. Correct interpretation of root and TLD are iterative and others are recursive.
1 mark for mentioning NS and A responses correctly.

Q 7.

1. Client sends request to server to get time with following information.
    a. Server address
    b. Client address
    c. Time stamp($T_{sent,i}$)
    d. Request to get time
2. Server calculates the RTT of each client i by following formula
    $$\Delta T_i = T_{rec,i} - T_{sent,i}$$
3. Server sends the correct time with following message structure:
    - Client address
    - Correct time (T)
    - ΔT_i

4. Client adds the delay in the correct time as following
    $$T_{correct} = T + \frac{1}{2}\Delta T_i$$

Variation:

- Step 2(RTT calculation can be done at the client side also if server sends the reply with time stamp)
- Step 4 can be done at the server side also

Marking scheme:

- Logic=1 mark
- RTT calculation formula :0.5 marks
- Message structure: 1 Mark
- $T_{correct}$ formula : 0.5 mark

Dhirubhai Ambani Institute of Information & Communication Technology
Mid Semester Test-1, 1st Semester 2017- 18

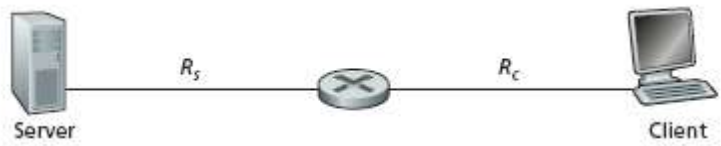
Course Title	IT304 Computer Networks		**Max Marks**	15
Date	1 September 2017	**CLOSED BOOK**	**Time**	1 Hour

In protocol design problems,

- Assume that all the nodes run the required application components.
- Give a brief description of how your protocol functions.
- Provide the details of the message structure, message sequence, timer functions (if needed), and other actions performed by the nodes.
- Give brief justification for each component of your design.

---

1. Assume that the resolving name-server is running on DAIICT network and there is an *iterative* DNS server at each domain level. Draw the relevant DNS hierarchy and list the DNS messages sent and received and records processed in obtaining the IP address corresponding to "mail.cse.mit.edu". [4]

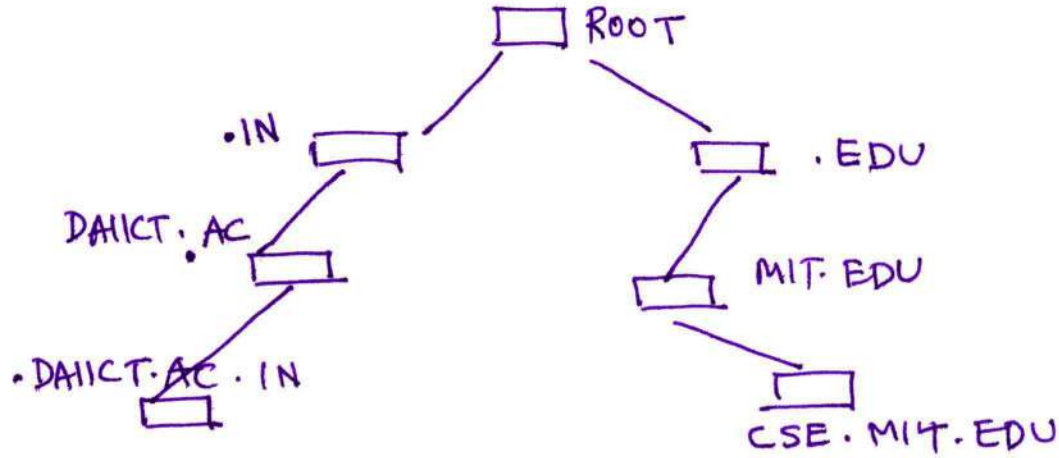


2. Assume that we know the bottleneck link along the path from the server to the client is the first link with rate R_s bits/sec. Suppose we send a pair of packets back to back from the server to the client, and there is no other traffic on this path. Assume each packet of size L bits, and both links have the same propagation delay d_{prop}.
    a. What is the packet inter-arrival time at the destination? That is, how much time elapses from when the last bit of the first packet arrives until the last bit of the second packet arrives?
    b. Now assume that the second link is the bottleneck link (i.e., $R_c < R_s$). Is it possible that the second packet queues at the input queue of the second link? Explain. Now suppose that the server sends the second packet T seconds after sending the first packet. How large must T be to ensure no queuing before the second link? Explain. [4]

3. On a LAN server, a ToD (time of day) application runs that periodically (at interval D) broadcasts the time to all the nodes connected on the LAN. A node, on booting, however, can ask for the ToD server to send the time immediately. ToD server responds with a single message, even if multiple requests come within time interval **d**. Design the protocol specifying the functionalities, message structure, actions, and syntax. [7]

Q 1.

(1)



(1) All servers are iterative ⇒ server resolves a query only to its immediate next level. Records will be either A type (final resolution) or NS type (intermediate resolution). The sequence

(1) of messages from the local name server (LNS) sent and received would be:

LNS → ROOT query for mail.cse.mit.edu

ROOT → LNS NS recorded with addr of .EDU.

LNS → .EDU query

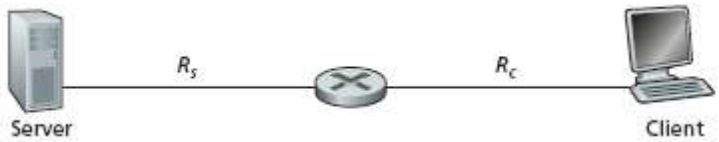
(1) .EDU → LNS NS record with addr of MIT.EDU

LNS → .MIT.EDU query

MIT.EDU → LNS NS record

LNS → CSE.MIT.EDU query

CSE.MIT.EDU → LNS A record for fully resolved addr. of mail.cse.mit.edu.



Assume that we know the bottleneck link along the path from the server to the client is the first link with rate R_s bits/sec. Suppose we send a pair of packets back to back from the server to the client, and there is no other traffic on this path. Assume each packet of size L bits, and both links have the same propagation delay d_{prop}.

a. What is the packet inter-arrival time at the destination? That is, how much time elapses from when the last bit of the first packet arrives until the last bit of the second packet arrives?
b. Now assume that the second link is the bottleneck link (i.e., $R_c < R_s$). Is it possible that the second packet queues at the input queue of the second link? Explain. Now suppose that the server sends the second packet T seconds after sending the first packet. How large must T be to ensure no queuing before the second link? Explain. [4]

Let's call the first packet A and call the second packet B.

a) If the bottleneck link is the first link, then packet B is queued at the first link waiting for the transmission of packet A. So the packet inter-arrival time at the destination is simply L/R_s.

b) If the second link is the bottleneck link and both packets are sent back to back, it must be true that the second packet arrives at the input queue of the second link before the second link finishes the transmission of the first packet. That is,

$$L/R_s + L/R_s + d_{prop} < L/R_s + d_{prop} + L/R_c$$

The left hand side of the above inequality represents the time needed by the second packet to *arrive at* the input queue of the second link (the second link has not started transmitting the second packet yet). The right hand side represents the time needed by the first packet to finish its transmission onto the second link.

If we send the second packet T seconds later, we will ensure that there is no queuing delay for the second packet at the second link if we have:

$$L/R_s + L/R_s + d_{prop} + T >= L/R_s + d_{prop} + L/R_c$$

Thus, the minimum value of T is $L/R_c - L/R_s$.

Q3

1. Broadcast ToD message at interval D.

   Message structure and size of each field (Logic behind that):……. 1 + 1 Marks
   a. Src address : ToD server
   b. Dest. Address -**All**
   c. ToD – Counter from reference time/Systime
2. Timer – Set to D for broadcast……. 1 Mark

3. When client boots up…… 1 Mark
   Request Message Structure:
   a. Src Address : client
   b. Dest. Address : TOD server
   c. flag to indicate TOD request – size of flag.

   Reply Message Structure: (same as in 1.)
   a. Src Address : ToD server
   b. Dest. Address : All
   c. ToD – Counter from reference time/Systime

4. Approach for timer d…… Max 2 Marks
   When server gets first request pkt, start Timer…….. 2 Mark
   wait till it times out d.
   Send reply pkt.
   (If you have sent the pkt first and then wait for time d, the protocoll may fail. Partial Marks -1)

Computer Networks (IT308)

MidSem Exam Solution

Q1.

A. Socketaddr:

struct sockaddr contains variables for family (AF_NET/AF_NET6), port no, IP address information about the connection. ..... 0.5 Marks

B. Server Pseudo Code:

a. **Socket creation:**

int sockfd = socket(**domain**, **type**, protocol)

sockfd: socket descriptor, an integer (like a file-handle)

domain: integer, communication domain e.g., AF_INET (IPv4 protocol) , AF_INET6 (IPv6 protocol)

type: SOCK_STREAM for TCP or SOCK_DGRAM for UDP

protocol: Protocol value for Internet Protocol(IP), which is 0.

b. Bind:

int bind(**int sockfd**, **const struct sockaddr *addr**, socklen_t addrlen);

bind function binds the socket to the address and port number specified in addr.

c. Listen:

int listen(**int sockfd**, **int pending**);

It puts the server socket in a passive mode, where it waits for the client to approach the server to make a connection.

The pending defines the maximum length of the queue of pending connections.

d. Accept:

int new_socket= accept(**int sockfd**, **struct sockaddr_in *addr**, socklen_t *addrlen);

It extracts the first connection request on the queue of pending connections for the listening socket, sockfd and creates a new connected socket with new file descriptor.

e. receive/send

valread = receive(**new_socket** , buffer, 1024);

send(**new_socket** , hello , strlen(hello) , 0);

C. Client Pseudo Code:

a. Socket Creation:

int sockfd = socket(**domain**, **type**, protocol)

b. Connect:

int connect(**int sockfd**, **const struct sockaddr *addr**, socklen_t addrlen);

c. receive/send

valread = receive(**new_socket** , buffer, 1024);
send(**new_socket** , hello , strlen(hello) , 0); …..... 3.5 Mark

Note: The function calls must have arguments which are bold and should be explained.

D. logic for server to extract Client IP address:

On accept() call, the input argument struct sockaddr *addr contains the IP address (addr→sin_addr) of Client which needs to be returned to client on receipt of message "whoamI". …..... 1 Mark

Q2.

a) Pros & cons of layered architecture: (1 marks)

Pros: Layer interface are defined i.e we can make changes in any layer without disturbing other layers.

--- 0.5 marks

Cons: It does not allow querying an interface which is not directly below it. ---0.5 marks

b) Service provided by layers of Internet Protocol Stack: (2 marks)

Layers	Services Provided
Application layer	Protocols, logic
Transport layer	End to end reliability, congestion control, connection management
Network layer	Addressing, routing, packetization
Data link layer	Error detection and correction, framing, MAC or Sharing of medium
Physical layer	Bit stream to signal

Only layers are defined ---0.5 marks
Services are defined ---1.5 marks

c) Discuss design choices made for the services that are offered in transport layer: (2 marks)

Transport layer provides following services:

I. Multiplexing
II. Reliability
III. Congestion control
IV. Connection management --- 0.5 marks

All the above can be done in other layers also.

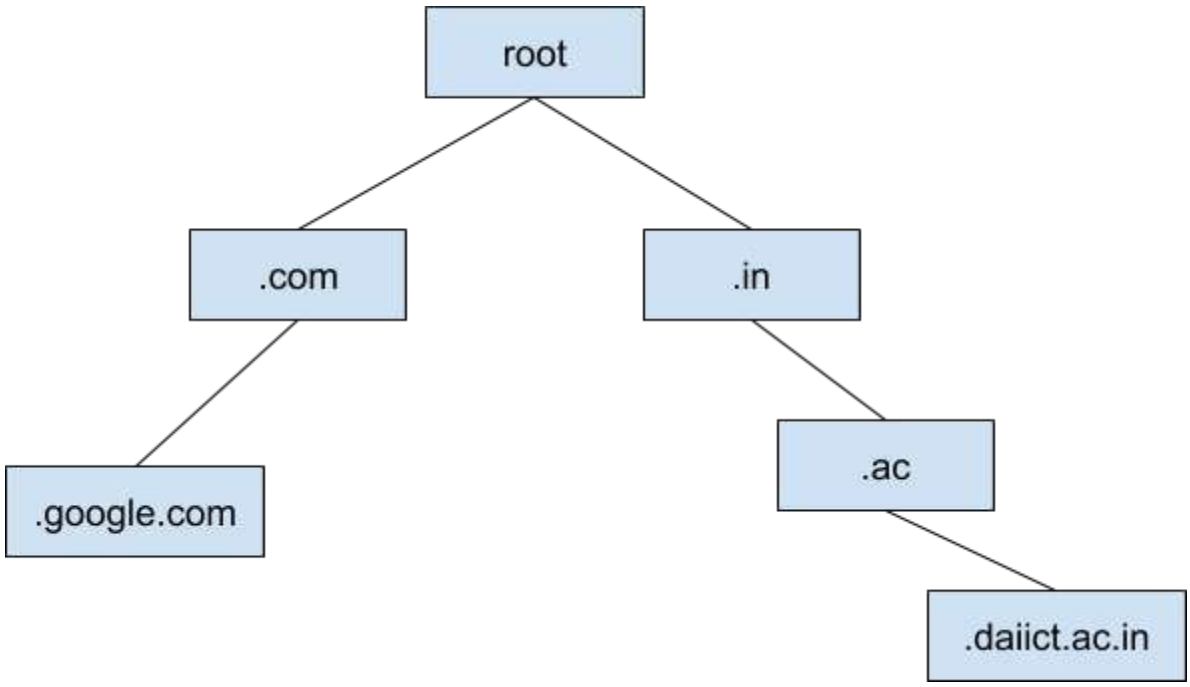
Design choices for TL are:

Internet architecture was designed for Store and Forward packets, datagrams and routers are stateless. This was done so that router can be simple and run fast.

Main reason is to keep Network interface simple(routers) and handle complexity at end-nodes(computers) . --- 1.5 marks

Q3.

DNS Hierarchy: [1 mark]



Obtaining IP of server1.google.com [2 marks]
(for mentioning correct message sequence - 1 mark,
for mentioning type of records in each message - 1 mark)

Local nameserver : *ns1.daiict.ac.in*

Suppose,
Host name: *pc1.daiict.ac.in*
Authoritative DNS server for google.com: *dns.google.com*
And the required DNS record is not found it cache

1. Host *pc1.daiict.ac.in* first sends a DNS query message to its local DNS server(*ns1.daiict.ac.in)*.
   The query message contains the hostname to be translated(*server1.google.com),*in the name field and A in the type field in the question section as it's a query message for getting ip address for a hostname.

2. Generally, The query from the requesting host to the local DNS server is recursive, and the remaining queries are iterative.

3. Then local DNS will send the query message to one of the root servers with *server1.google.com* in name field and A in type field.

4. The **root server** takes note of the *.com* suffix and responds with two types of records in answer section of the **response message**.
   1. **NS records** for the TLD servers for *.com*
   2. **A records** containing IP addresses of these TLD servers

5. The local DNS then sends the same query message to one of these TLD servers.

6. The **TLD server** takes note of the *google.com* suffix and responds with two types of records in answer section of this DNS response message.
    1. NS records for the authoritative DNS server *dns.google.com*
    2. A record containing IP address of the authoritative DNS server

7. Finally, the local DNS sends the query message to **authoritative server** *dns.google.com*, which responds with the IP address of *server1.google.com*(in form of **A records**).

8. Now the **local DNS** has the IP address of server1.google.com and it send the **A record** to the requesting host(*pc1.daiict.ac.in*).

DNS for Load balancing/distribution across heavily loaded application servers: [2 marks]
(rotations on set of IP addresses - 1 mark,
client generally sends request to first IP from the set - 1 mark)

DNS is also used to perform load distribution among replicated servers, such as replicated Web servers.

Busy sites, such as google.com, are replicated over multiple servers, with each server running on a different end system and each having a different IP address.

For replicated Web servers, a set of IP addresses is thus associated with one canonical hostname. The DNS database contains this set of IP addresses. When clients make a DNS query for a name mapped to a set of addresses, the server responds with the entire set of IP addresses, but **rotates the ordering of the addresses** within each reply. **Because** a client typically sends its HTTP request message to the IP address that is listed first in the set, DNS rotation distributes the traffic among the replicated servers.

4. An ack-based link protocol (waiting for ack before sending next packet) uses a timer to abort ack_wait function after the timeout period T and retransmits the same packet. This process continues till the packet is successfully transmitted before moving to a new packet.

(a). How would you define the efficiency of such a protocol. [1 mark]

ANSWER=>

$$Efficiency = \frac{\tau}{\tau + RTT}$$

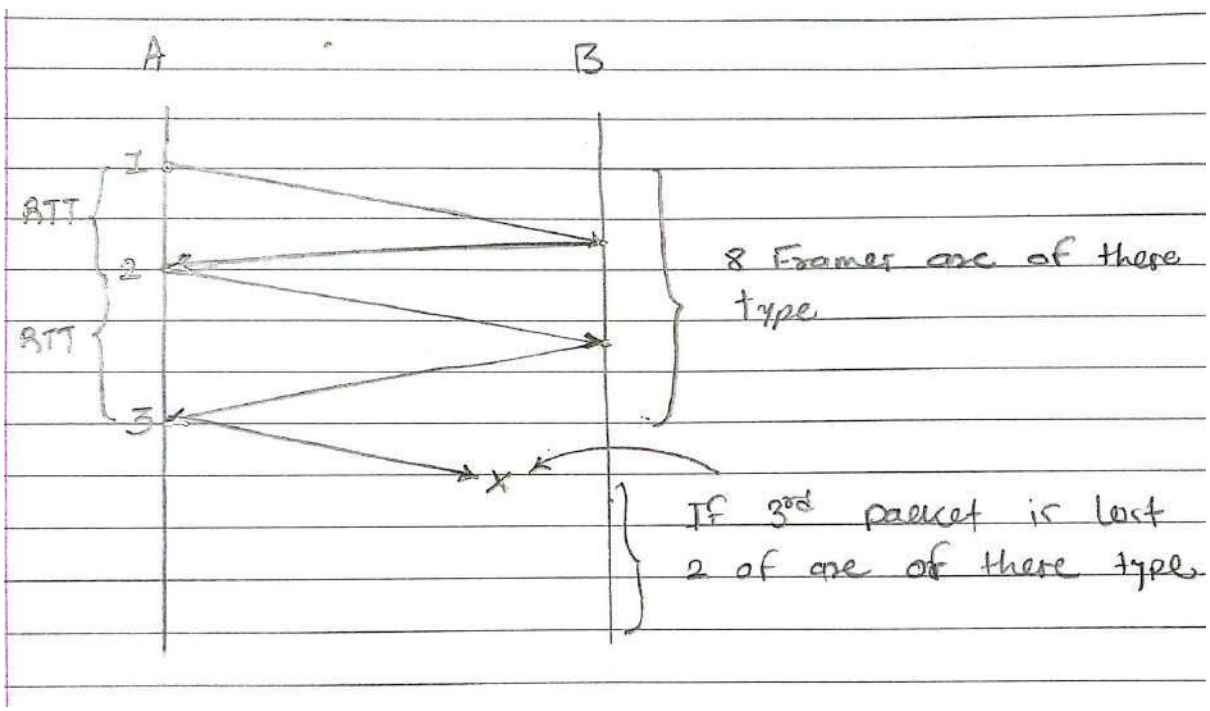
$$Efficiency = \frac{1}{1+2\alpha}$$

OR

$$Efficiency = \frac{Total\ time\ taken\ for\ transmitting\ a\ frame}{Total\ time\ including\ number\ of\ retransmissions}$$

(b). 10 packets are sent on a channel. Each packet takes 10ms to transmit. Acks take exactly 100ms to arrive after the transmission. Two of the ten packets got corrupted the first time they were sent (these needed to be retransmitted once). No other packets suffered corruption. Compute the efficiency of the protocol in each case when timeout value T is set to (i)150 ms, (ii)120 ms, (iii)80 ms.

ANSWER=>



$$T_{total} = 8 * RTT + 2(RTT + T_0) \quad \text{if , } T_0 > RTT$$

$$\eta = \frac{Transmission\ time}{Total\ time} = \frac{10 * T_{trans}}{T_{total}}$$

(i) 150ms: **[1 marks]**

T_0 = 150ms

τ = 10ms

RTT = 100ms

$$\eta = \frac{10 * 10\ ms}{1300\ ms} = \frac{1}{13} = 7.69\%$$

T_{total} = 8*100 + 2(100+150)

= 1300 ms

$$\eta_{eff} = \frac{100}{1300} = 7.69\%$$

(ii) 120ms: **[1 marks]**

T_0 = 120ms

T_{total} = 8*100 + 2(100+120)

= 1240 ms

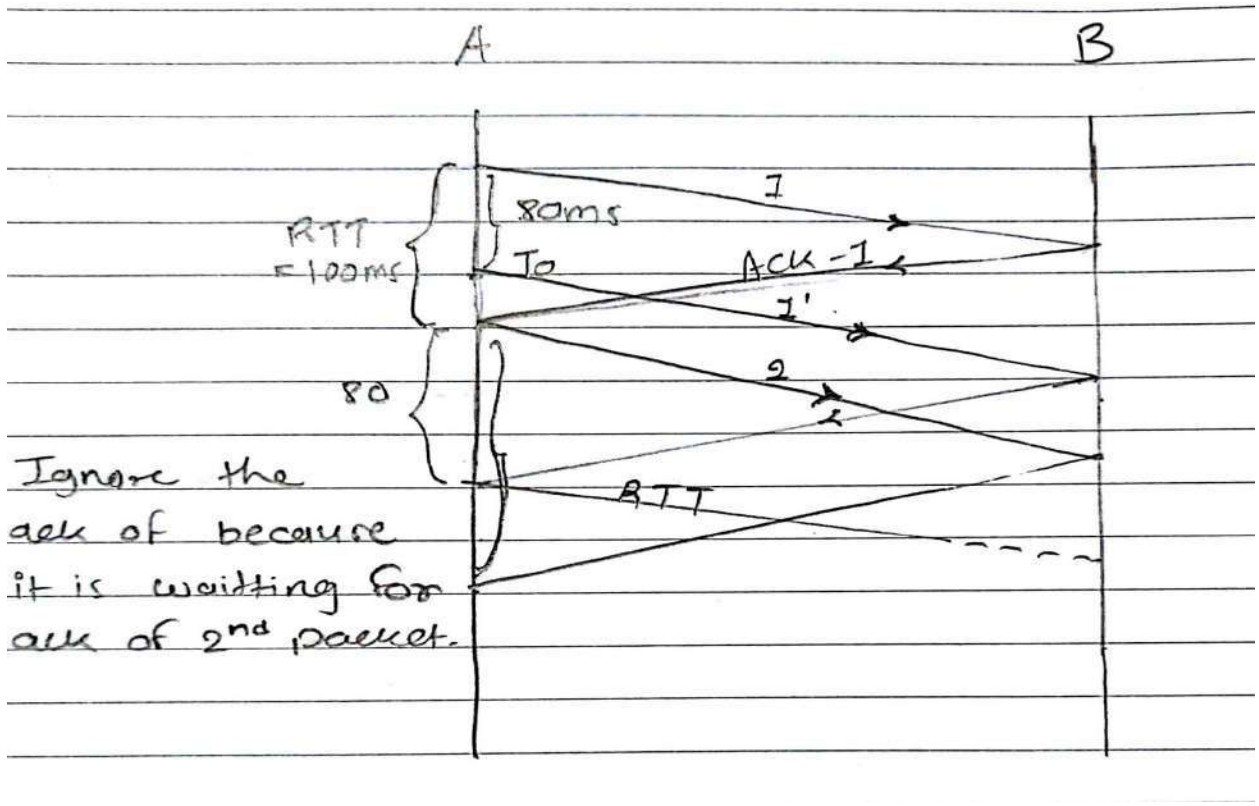
$$\eta_{eff} = \frac{100}{1240} = 8.06\,\%$$

(iii) 80ms: **[1.5 marks]**

T_0 = 80ms (T_0 < RTT)

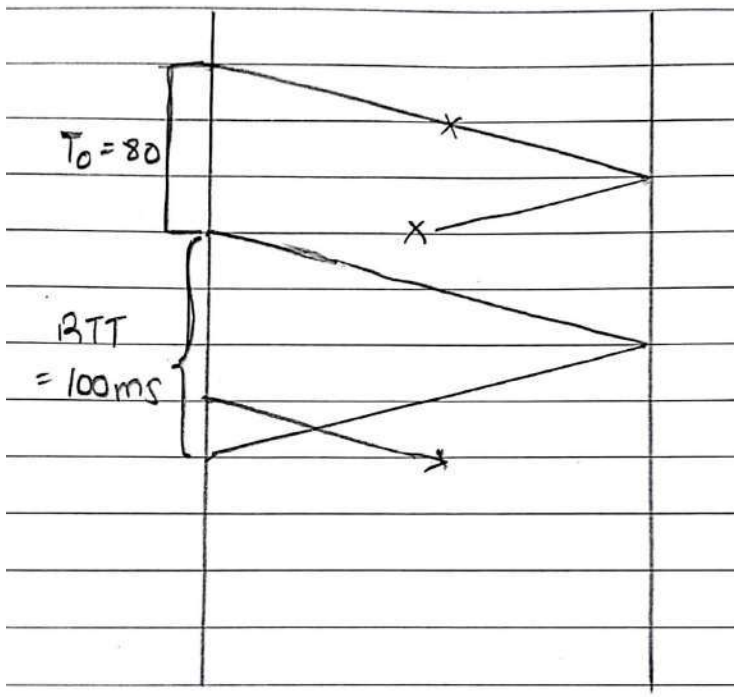
RTT is bigger than T_0 , so all the packets will get retransmitted.

(a). If no packet get lost ,



- Here, we consider T_0 = RTT.
- All packets get retransmitted, but need not to wait for ack, so no additional time waste.

(b). If 2 packets will lost then , **[0.5 marks]**



- Here, if packet lost, then it retransmits before RTT because T_0 is lesser, so it retransmits it.

$$T_{total} = 8 * T_0 + 2(RTT + T_0)$$

$$= 8*80 + 2(100+80)$$

$$= 1000 \text{ ms}$$

$$\eta = \frac{10 * 10 \ ms}{1000 \ ms} = \frac{1}{10} = 10\%$$

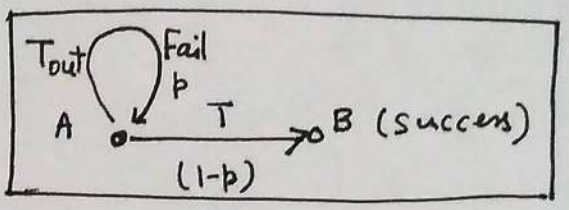
Stop & Wait Efficiency

Time to transmit & recv an Ack $= \underline{\tau_{trans} + \tau^{ack}_{trans} + 2\tau_{prop} + 2\tau_{proc}}$

$$\simeq \tau_{trans} + 2\tau_{prop} \equiv T$$

- Efficiency (no-noise) $\eta = \dfrac{\tau_{trans}}{\tau_{trans} + 2\tau_{prop}} = \boxed{\dfrac{1}{1+2a}}$; $a = \dfrac{\tau_{prop}}{\tau_{trans}}$

Let $p =$ prob. of pkt error



$\langle \tau \rangle =$ Expected time to send a pkt $= (1-p)T + p(T_{out} + \langle \tau \rangle)$

η (noisy) $= \dfrac{\tau_{trans}}{\langle \tau \rangle}$; $\langle \tau \rangle = T + \dfrac{p}{(1-p)} T_{out}$

$T_{out} \gtrsim T$ so Assume $T_{out} = T$

$$\langle \tau \rangle = \frac{T}{(1-p)} = (\tau_{trans} + 2\tau_{prop}) \cdot \frac{1}{(1-p)}$$

$$\boxed{\eta_{noisy} = (1-p) \cdot \frac{1}{(1+2a)}}$$

Selective Repeat Efficiency

$W =$ Window size. If $\underline{W \cdot \tau_{trans} > (\tau_{trans} + 2\tau_{prop})}$

there is no waiting for ACK. $W = W_{opt}$

$$\Rightarrow \boxed{W_{opt} = 1 + 2a}$$

(no noise) $\eta^{SR} = \underline{\mathrm{Min}\left(1, \dfrac{W}{W_{opt}}\right)}$

As in stop & wait, noise-induced retransmissions lead to $(1-p)$ factor.

$$\boxed{\eta^{SR}_{noisy} = (1-p) \cdot \mathrm{Min}\left(1, \frac{W}{W_{opt}}\right)}$$

Dhirubhai Ambani Institute of Information & Communication Technology
Final Examination, Semester I 2017-18

Course Title	IT304 Computer Networks	**PART-B**	**Max Marks**	30%
Date	30 November 2017	**CLOSED BOOK**	**Time**	2 Hours

All questions carry 5 marks each.

[MODEL SOLUTIONS]

1. A TCP sender is transmitting data to a receiver. The initial congestion window size is 2KB and the threshold is 16KB. Maximum segment size is 64KB. The first 4 RTT value measured by the sender are (in milliseconds) [400, 300, 900, 100].
   a. What is the congestion window size after the 4 successive ACKs are received?
   b. Assuming the smoothing parameter (weight given to old value) α = 0.9, what is the estimated RTT for the next packet sent?
   c. What is the value of the Timeout Timer?

   a. After 3 ACKs, the window size is 16KB. After the 4th ACK, it increases linearly to **18KB**. (1 mark)
   b. $<RTT>_{new} = (1- \alpha) <RTT>old + \alpha RTT$
   After 1st RTT, estimate is 400. After 2nd RTT estimate is 400*.9 + 300*.1 = 390. After 3rd RTT, estimate is 390*.9 + 900*.1 = 441. After 4th RTT, estimate is 441*.9 + 100*.1 = **407** ms. (2 marks)
   c. RTO = <RTT> + 4D
   $D_{new} = \beta<D_{old}> + (1- \beta) |RTT - <RTT>|$
   After 1st ACK, D=0. After 2nd ACK, D is 0 + (390-300)*.8 = 72. After 3rd ACK, D is 72*.2 + (900-441)*.8 = 381.6. After 4th ACK, D is 381.6*.2+ (407-100)*.8 = 321.9 ms. **RTO** = 407 + 4*321.9 = **1695** ms. [marks are given if a value of β other than .2 is used.] (2 marks)

2. An organization has some 500 nodes in its network divided into 3 segments. This can be done by sub-netting one class B address block. Using specific addresses explain the subnetting mechanism. How does routing between subnets take place?

   Class B IP address: Range 128-191 (0.5 marks deducted if it is not in range)

   1: For 3 subnets minimum 3 bits are required (all 0's and all 1's are reserved so 2 bits are not enough. However, no deduction if using 2 bits only)
   16 + (3 or 2) i.e. 18 or 19 are for network id

   2: For 500 subnets minimum 3 bits are required (2^9) (23 bits are for network id and 9 bits are for host id). If division of 500 host for subnet is considered, (200,200,100) then 8 bits are for host id and 24 bits are for network id.

   Worked out example to be given.

   Explanation of network bits and host bits are required. - **2 marks.** 3 subnet address should be written - **1 mark.** Subnet mask should be written - **1 mark.** Routing: given Ip address should be masked(Logical AND) with subnet mask. This will give subnet id. Packet should be transferred to that subnet id's interface – **1 mark**

3. Using clear examples, briefly explain how DHCP, NAT, and CIDR help in more efficient use of the Internet address space.

   DHCP: DHCP dynamically allocates a IP address from a pool of available addresses. For this purpose request is made by the client machine. DHCP server leases the IP address for a given time. Client has to make new request, once lease time is out.
   If all users are not loggef at same time, a smaller pool can be used to give address to a large group of users. [*some suitable example*]

   NAT: It is used for address translation. Intranet (local) address to internet (global) address. *[With necessary diagram, table structure and example.]* NAT table is looked up to transmit the respective packet back to client. Local IP address can be used (with only one internet IP address) to allow outward connection to client. Different organizations may use same pool of private network IP addresses.

   CIDR: Classless inter domain outing. Save addresses space by assigning e.g. a group of class C address instead of a class B address without having multiple entries in the routing table. Address: net ID = host ID, prefix length for net ID. e.g. IP: 128.1.2.3/24, 128.1.2.0 is the net ID
   Routing is done based on the both IP and the prefix. *[With appropriate example]*

4. Explain how tunneling is used to allow incremental deployment of IPv6 and co-existence of IPv4 and IPv6?

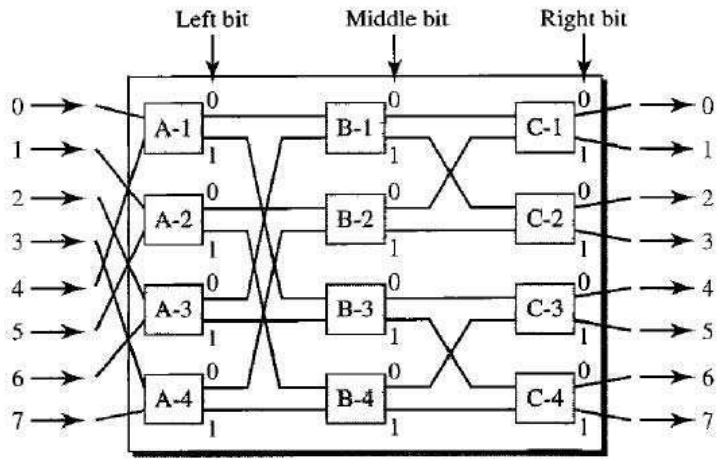
   A packet of one protocol, when encapsulated as payload of a packet of a different protocol, is said to be tunneled.

   Tunneling is used to connect IPv6 islands (group of connected IPv6 routers) through the intermediate IPv4 routers. Each IPv6 island has a 4-6 gateway router. As a packet reaches a gateway router, it is encapsulated in a IPv4 packet and sent to the destination gateway IPv6 router where the original packet is extracted and delivered to the destination. 4-6 routers participate in both IPv4 and IPv6 routing protocols and maintain two separate routing tables. This mechanism allows for incremental deployment of IPv6 routers.

5. What are switching element and switching fabric? Draw the schematic of an 8x8 Banyan switch. Using an example, show that Banyan design leads to internal blocking?

   Switching element: 2x2 block responsible for the transport of data across a network.
   Switching Fabrics : It is interconnection of links and switching elements.
   Routing rule: if 0, send packet to upper output, else to lower Output and If both packets to same output, buffer or drop.

   Banyan Switch :
   A banyan switch is a multistage switch with switching elements at each stage that route the packets based on the output port represented as binary string. For n inputs and n outputs, we have $\log_2(n)$ stages with n/2 microswitches at each stage. The first stage routes the packet based on the high order bit of the binary string. The second stage routes the packet based on the second high order bit, and so on in below figure.



Internal blocking: Because of the design of banyan switch there is possibility of internal collision due to the shared paths leading to different output ports. E.g. pkts for output ports 6 and 7 at input ports 2 and 3 respectively will block internally.

6. In the context of IEEE 802.3 (Ethernet) LAN protocol, answer the following:
    a. Derive an expression for the maximum length L_{max} of a LAN as a function of relevant LAN parameters (e.g. link capacity C, min packet size P_{min}, max packet size P_{max}, propagation speed V etc.)
    b. Explain the need of exponential back-off mechanism in 1-presistent CSMA/CD.

IEEE 802.3 protocol specifies that the collision should be detected while the data frame is still being transmitted. In the worst case (when the two transmitting nodes are at the opposite end of the LAN), the time lag between the onset of transmission and detection of collision is equal to the RTT (round trip time). The time to transmit a packet on the link is equal to P_{min}/C.
Hence $P_{min}/C > RTT = 2L_{max}/V$. This gives $L_{max} = (V*P_{min})/2*C$.

If the number of active nodes N is known then optimal p=1/N. However, it is assumed that N is not known and that it changes rapidly as a function of time. Hence, to keep the latency low, an aggressive 1-persistent mechanism is used. Further, to minimize the number of contention slots before success, a backoff doubling (exponential backoff, analogous to binary search mechanism) is used.

DA-IICT **Dhirubhai Ambani Institute of Information & Communication Technology**
Final Examination Semester I, 2007- 08

Course Title	IT304 Computer Networks	**PART-B**	**Max Marks**	15
Date	27 November 2007	**CLOSED BOOK**	**Time**	2 Hours

MODEL SOLUTIONS

1. **A TCP sender is transmitting data to a receiver. The initial congestion window size was 2KB and the threshold was 16KB. Maximum segment size is 64KB. The first 4 RTT value measured by the sender are (in milliseconds) [400, 300, 900, 100].**
   a. **What is the congestion window size after the 4 successive ACKs are received?**
   b. **What is the estimated RTT for the next packet sent?**
   c. **Assuming the smoothing parameter (weight given to old value) a = 0.9, what is the value of the Timeout Timer?**
   d. **Fifth ACK was not received before the Timeout period. What would be the size of the Threshold? [4]**

a. After 3 ACKs, the window size is 16KB. After the 4th ACK, it increases linearly to **18KB**. (17KB as answer will also be accepted)

b. $<RTT>_{new}$ = (1- a) <RTT>old + a RTT
After 1st RTT, estimate is 400. After 2nd RTT estimate is 400*.9 + 300*.1 = 390. After 3rd RTT, estimate is 390*.9 + 900*.1 = 441. After 4th RTT, estimate is 441*.9 + 100*.1 = **407** ms.

c. RTO = <RTT> + 4D
D_{new} = a<D_{old} + (1- a) |RTT - <RTT>|
After 1st ACK, D=0. After 2nd ACK, D is 0 + (390-300)*.1 = 9. After 3rd ACK, D is 9*.9 + (900-441)*.1 = 54. After 4th ACK, D is 54*.9 + (407-100)*.1 = **79** ms. **RTO** = 407 + 4*79 = **723** ms. [marks are given if a value of ß other than 4 is used.

d. Congestion window before the timeout was 18KB. After the timeout, the threshold will be set to **9KB.**

2. **Clearly describe a reverse-path-forwarding based multicast protocol that is suitable for dense multicasting. Also explain the mechanism by which nodes on the LAN receive multicast data. Your answer should contain the following details:**
    a. **Multicast group creation**
    b. **Reverse Path Forwarding**
    c. **LAN membership to multicast groups**
    d. **Multicast Tree management** **[4]**

a. Every m/cast group Has a unique class-D address assigned to it. A router becomes a member of a group by informing other appropriate routers/source nodes to forward m/cast data for that group to it.

b. RPF mechanism uses the unicast routing table to deduce the interface on which packets from a source should usually come. Router forwards these packets to other interfaces only if a packet from the sources comes at the right interface, otherwise these packets are dropped. Thus RPF acts as a controlled flooding mechanism that reduces unnecessary duplications of the packets.

c. LAN node membership to a m/cast group is managed by IGMP protocol. A node joins a group by broadcasting a join_request in the LAN. LAN gateway router becomes a member of the m/cast group in response of this request. Routers periodically query the LAN nodes if a membership is to be continued. Nodes give a staggered response to this query if they are members of the group. Staggering ensures that there is no traffic surge in the LAN.

d. RPF based m/cast begin with the routers forwarding m/cast packets to the all the interfaces if the packets came on the right interface (dense m/cast). If a router is not a member of that group, it may send a prune request to upstream router. Routers maintain a table that has {m/cast group address, outgoing interface} records. For sparse m/cast, a join mechanism may be used where a routers sends join request to upstream router and the upstream router becomes a member and updates its m/cast table appropriately.

3. In the context of datagram networks, answer the following:

a. What are the merits and demerits of hierarchical routing?

b. What is the mechanism used by OSPF like routing protocol to expose the routing information from one area to another area while maintaining the hierarchy. [3]

a. In hierarchical routing, network is divided into a hierarchical tree structure. Nodes maintain and exchange routing information with only those routers who are at the same level. A border or gateway router, which is part of two levels act as a gateway for routing packets and a summary link state information across hierarchy. This leads to more compact routing table and lookup becomes faster. Also, routing information distribution overhead is also low. Demerit is the possibility of suboptimal routing and lesser fault tolerance (not all paths are utilized)

b. Border or gateway router may create a summary record LSP containing the cost of various lower level routers. These summary records are exchanged among gateway routers and these are used to build shortest path cost to routers at the lower level.

4. **A router is said to be congested if its buffer and packet forwarding resources are inadequate to handle incoming flows for a sustained period. In this context,**

e. What is the effect of congestion on the TCP and UDP flows passing through the router?

f. Explain if Internet congestion recovery mechanism is fair to the TCP and UDP flows.

g. **Briefly outline an AQM mechanism which may be able to manage congestion and remain fair to both TCP and UDP flows. [4]**

a. Congestion is the result of routers not beings able to handle the incoming traffic on a sustained basis. This leads to long queueing delays and packet drops at the congested routers. UDP flows passing through a congested router simply lose packets with a higher probability. TCP flows however, besides losing packets with higher probability, also get affected in another way. Due to higher queueing delay, RTT increases and hence in the congestion avoidance phase, the rate of flow increase slowly due to congestion.

b. In Internet, routers drop packets from the tail of the queue without any distinction between TCP and UDP flow. A TCP packet drop leads to the slow-start-algorithm dropping the flow rate drastically whereas UDP flow rates don't get affected. Hence the recovery mechanism is biased towards UDP flow in Internet.

c. Active Queue Management (AQM) mechanisms are implemented at the routers to provide better congestion handling. A router may maintain two separate queues for TCP and UDP flows and drop packets with higher probability from UDP queue compared to TCP queue. If the probabilities are properly worked out, this mechanism can be fair to both the flows. Alternately, a single queue is maintained. During congestion, a packet is randomly selected. If the selected packet is a UDP packet, it is dropped. If it is a TCP packet, it is replaced in the queue with a probability p. Again, with proper p, this may lead to fair treatment of TCP and UDP flows.

Efficiency of CSMA/CD

L = length of the LAN. σ = propagation speed.

$\rho = \frac{L}{\sigma}$ = end to end propagation time.

Collision window, the time after a transmission starts and a collision may occur is $\underline{2\rho}$. (Consider two ~~end~~ nodes at extreme ends of the LAN who transmit $\underline{\rho - \epsilon}$ time apart)

- Assume slot duration of 2ρ. This guarantees that ~~if~~ two transmissions in two diff. slot can never collide.
- Assume N nodes compete for the channel, transmitting with probability p.

$\alpha(p)$ = prob. that exactly one node transmit $= Np(1-p)^{N-1}$

$\alpha(p)$ is maximum when $p = \frac{1}{N}$ (Solve for $\frac{d\alpha}{dp} = 0, \ldots$)

$$\alpha_{Max} = \alpha\left(\frac{1}{N}\right) = \left(1 - \frac{1}{N}\right)^{N-1} \longrightarrow \frac{1}{e} \text{ as } N \to \infty$$

- Assume $\langle A \rangle$ = avg. no. of time slots wasted before successful transmission

$$\langle A \rangle = \alpha * 0 + (1-\alpha)(1 + \langle A \rangle)$$

[with prob. α, no slot wasted and with prob $(1-\alpha)$, $1 + A$ slots will be wasted.

$$\langle A \rangle = \frac{1}{\alpha} - 1 \qquad \underline{\alpha \approx .4 \quad \langle A \rangle \approx 1.5}$$

$$\eta_{CSMA} \approx \frac{\tau}{\tau + \langle A \rangle * 2\rho}$$; τ = pkt transmission time.

define $\boxed{\frac{\rho}{\tau} = a}$

$$\boxed{\eta_{CSMA} \approx \frac{1}{1+3a}}$$

Q1

(a) **Explain the important modification done in ipv6 over ipv4.**

- 32bit -> 128bit to handle large number of nodes
- Flow id field for facilitating Quality of service(Qos)
- Simplified header for faster processing
- example : removing fragmentation,header checksum

  (0.5 marks for each point)

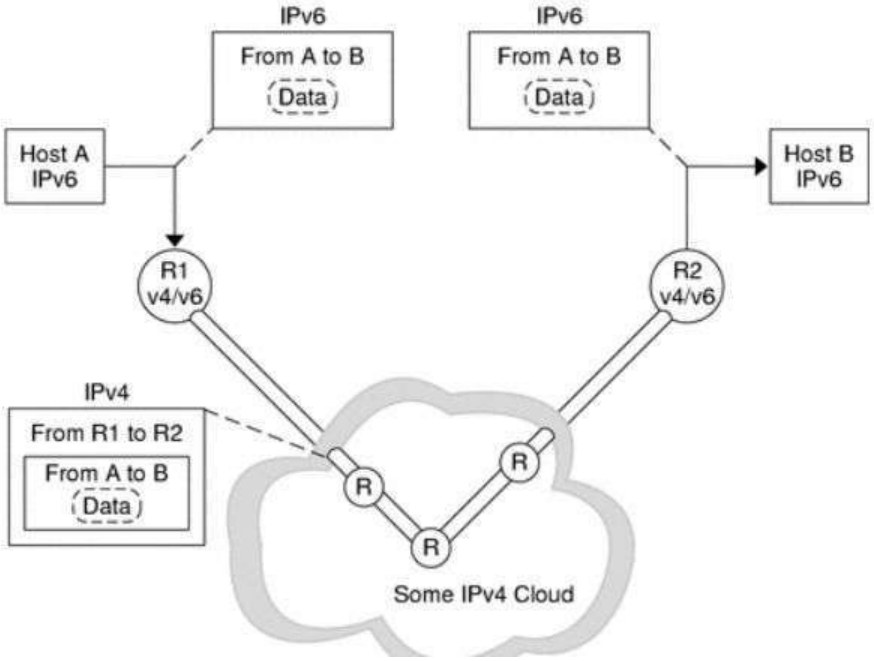
(b)Describe the mechanisms used for incremental deployment of ipv6 and co-existence with ipv4.

- Ipv6 incremental deployment + coexistence with ipv4 using tunneling

  Tunneling: To minimize any dependencies during the transition, all the routers in the path between two IPv6 nodes do not need to support IPv6. This mechanism is called tunneling. Basically, IPv6 packets are placed inside IPv4 packets, which are routed through the IPv4 routers. The following figure illustrates the tunneling mechanism through IPv4 routers.

  Encapsulation done from R1 and decapsulation of ipv6 packet done on R2**.**

  R1 and R2 is gateway router or 4-6 router.



For conversation of ipv4 to ipv6, add 96 0's as prefix. (96 0's+32bit ipv4)

(2 marks for tunneling and its explanation (0.5 marks will be deducted if you didn't mention about gateway router which do encapsulation and decapsulation)

(c)What is the role of flowid field in ipv6?

Flow id is user for Qos.

Mechanism: Everyflow is assigned a unique Fid and supporting routers have table entry for action associated with Fid. Routers implement specific action based flowid table.

(1 mark for example and explanation)

Q2. **Operations of slotted aloha.(2 Marks)**

Assumptions:(1 Marks)

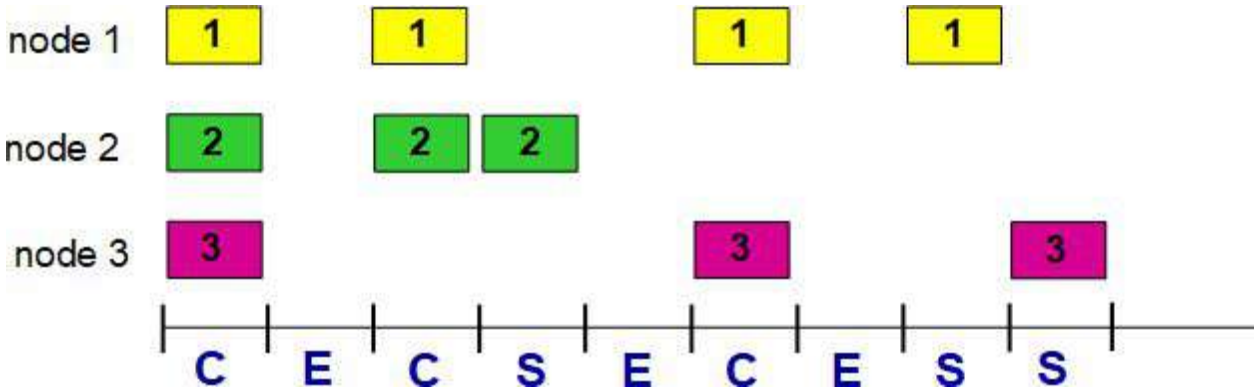
1. all frames same size
2.time divided into equal size slots (time to transmit 1 frame)
3.nodes start to transmit only slot beginning
4.nodes are synchronized
5.if 2 or more nodes transmit in slot, all nodes detect collision

Operation:(1 Marks)

when node obtains fresh frame, transmits in next slot

if no collision: node can send new frame in next slot

if collision: node retransmits frame in each subsequent slot with prob. p until success



Slotted Aloha efficiency.(2 Marks)

suppose: N nodes with many frames to send, each transmits in slot with probability p

prob that given node has success in a slot = p(1-p)N-1

prob that any node has a success = Np(1-p)N-1

max efficiency: find p* that maximizes Np(1-p)N-1

for many nodes, take limit of Np*(1-p*)N-1 as N goes to infinity, gives:

max efficiency = 1/e = .37

Unslotted aloha efficiency.(1 Marks)

no synchronization

when frame first arrives

transmit immediately

collision probability increases:

frame sent at t0 collides with other frames sent in [t0-1,t0+1]

P(success by given node) = P(node transmits) .

P(no other node transmits in [t0-1,t0] .

P(no other node transmits in [t0-1,t0]

= p . (1-p)N-1 . (1-p)N-1

= p . (1-p)2(N-1)

… choosing optimum p and then letting n very large.

= 1/(2e) = .18

Q5. (a) router has buffer which stores packets in FIFO order. When it overflows, it start dropping new incoming packet without considering whether it is TCP or UDP packet. This packet loss indicates congestion (1 mark)

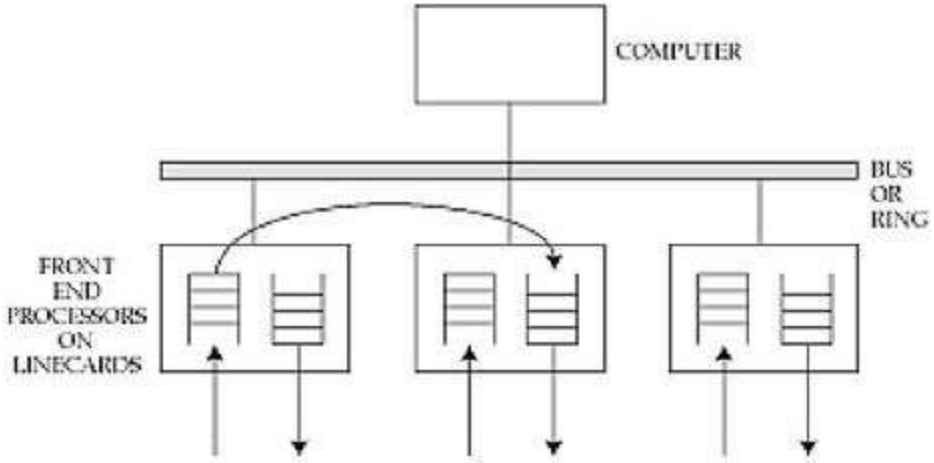
When congestion occurs it TCP slows down its transmission rate to minimize congestion (1 mark)

Whereas, UDP doesn't have congestion control policy, therefore it's continues transmitting packets at the same rate (1 mark)

(B) Congestion policy is not fair between TCP and UDP because TCP slows down transmission rate therefore the proportion of TCP packets over UDP packets becomes less than 0.5 (1 mark)

TCP continues slowing down the transmission rate until it reaches the state where there is no packet loss. At the end it is stabilized (1 mark)

Ans 8: In second generation switch the port mapping functionality is distributed among the line cards. Line cards have intelligence, so that they are able to decide a packet's output port without help from central processor.



Lets assume a scenario where source is A and destination is B. If a route is found in adapter local cache (for packet 1), the card sends the packet over a bus to an output port. If no route found in cache, card sends the packet to a control computer, which forwards the packet and installs a route in the line card. (2)

Therefore if a packet is sent to control computer, packets can be reordered, because packets forwarded on the fast path may be sent before packets that arrived earlier, but were forced to go through the slower path. (1)

To prevent reordering, cache entry done only after packet 1 is forwarded. (1)

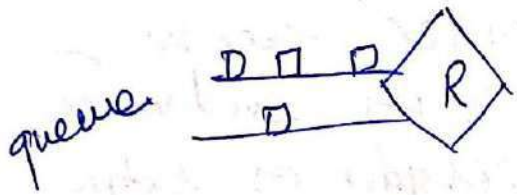
Performance loss: During this time gap, direct forwards are blocked, therefore time utilization is poor.

Q-4 a) constant bit rate + fix pkt size

Marks	
0	1 | 2

suppose there is rate of R, so duration of packet transfer would be $1/R$ for each packet

⇒ Now there can be number of queues attached to Router,



so, scheduling mechanism that router can implement to each queue is to establish the timer for each queue for time D_i

where D_i could be $1/R_i$

⇒ whenever timer expire, relay the packet and reset the timer for next upcoming packet

⇒ This algo called as leaky bucket algorithm.

CS Scanned with CamScanner

⇒ count --; —— (4)

Does algorithm explained above can handle the variable ~~bit~~ rate traffic at routerside.

Scanned with CamScanner

Q 6

Efficiency of CSMA/CD

(L35)

L = length of the LAN. σ = propagation speed.

$\rho = \frac{L}{\sigma}$ = end to end propagation time.

(1) 0|1

Collision window, the time after a transmission starts and a collision may occur is 2ρ. (Consider two ~~end~~ nodes at extreme ends of the LAN who transmit $\rho - \epsilon$ time apart)

(2) 0|1|$\frac{p}{2}$|p

- Assume slot duration of 2ρ. This guarantees that if two transmissions in two diff. slot can never collide.
- Assume N nodes compete for the channel, transmitting with probability p.

$\alpha(p)$ = prob. that exactly one node transmit $= Np(1-p)^{N-1}$

$\alpha(p)$ is maximum when $p = \frac{1}{N}$ (solve for $\frac{d\alpha}{dp} = 0, \ldots$)

$\alpha_{max} = \alpha\left(\frac{1}{N}\right) = \left(1 - \frac{1}{N}\right)^{N-1} \longrightarrow \frac{1}{e}$ as $N \to \infty$

- Assume $\langle A \rangle$ = avg. no. of time slots wasted before successful transmission

I. 0|T|2

$$\langle A \rangle = \alpha \times 0 + (1-\alpha)(1 + \langle A \rangle)$$

[with prob. α, no slot wasted and with prob $(1-\alpha)$, $1 + A$ slots will be wasted.

$$\langle A \rangle = \frac{1}{\alpha} - 1$$

$\alpha \approx .4$ $\langle A \rangle \approx 1.5$

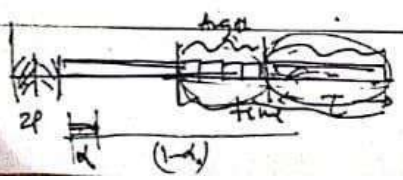
$$\eta_{CSMA} \approx \frac{T}{T + \langle A \rangle * 2\rho}$$

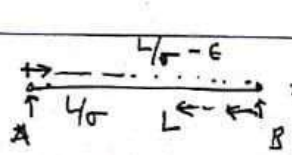
; T = pkt transmission time.

define $\frac{\rho}{T} = a$

$$\eta_{CSMA} \approx \frac{1}{1 + 3a}$$

$$\eta = \frac{\text{useful time}}{\text{total time}}$$





= coll. time $= \frac{2L}{\sigma} = 2\rho$

Other way:

P_K = Prob. of K collisions followed by success.

$$P_K = \underbrace{(1-\alpha)^K}_{K \text{ succ. colli}} * \underbrace{\alpha}_{\text{success.}}$$

$$\langle K \rangle = \sum_{K=0}^{\infty} K \cdot (1-\alpha)^K \cdot \alpha$$

$=$ Comes to same answer!

Q7 Using clear example, briefly explain how DHCP and NAT protocols help in more efficient use of Internet address space. Does it make sense to use them together? Explain.

Answer:

DHCP

DHCP server contains a list of IP address also known as pool of IP address which are assigned when a client request for it. Below is an illustrated example

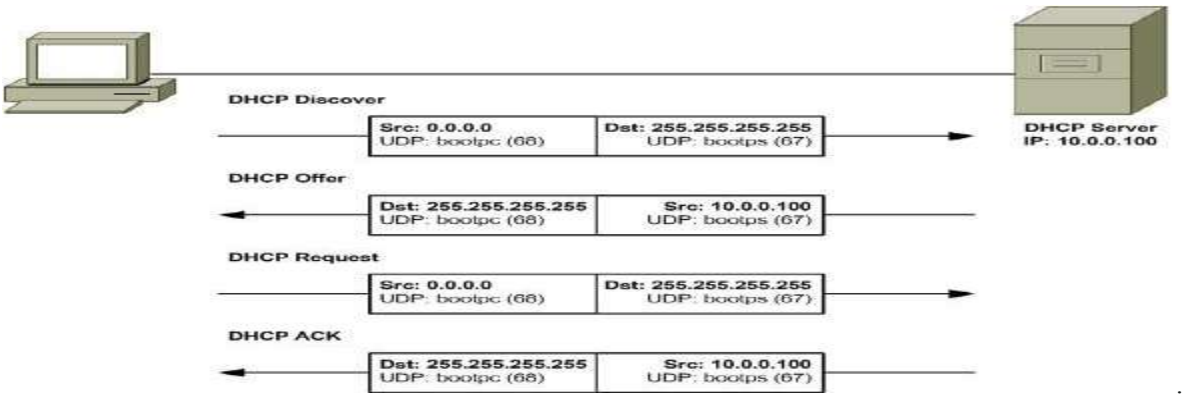


Figure shows process how IP address are assigned dynamically using DHCP. The first time a DHCP client computer attempts to log on to the network, it requests IP address information from a DHCP server by broadcasting a DHCPDiscover packet. The source IP address in the packet is 0.0.0.0 because the client does not yet have an IP address. Each DHCP server that receives the client DHCPDiscover packet responds with a DHCPOffer packet containing an unleased IP address 10.0.0.100 and additional TCP/IP configuration information, such as the subnet mask and default gateway. When a DHCP client receives a DHCPOffer packet, it responds by broadcasting a DHCPRequest packet that contains the offered IP address, and shows acceptance of the offered IP address. The DHCP Acknowledge is a unicast packet sent by the DHCP server to the DHCP client computer acknowledging the assignment of the offered IP address for a specific lease time.

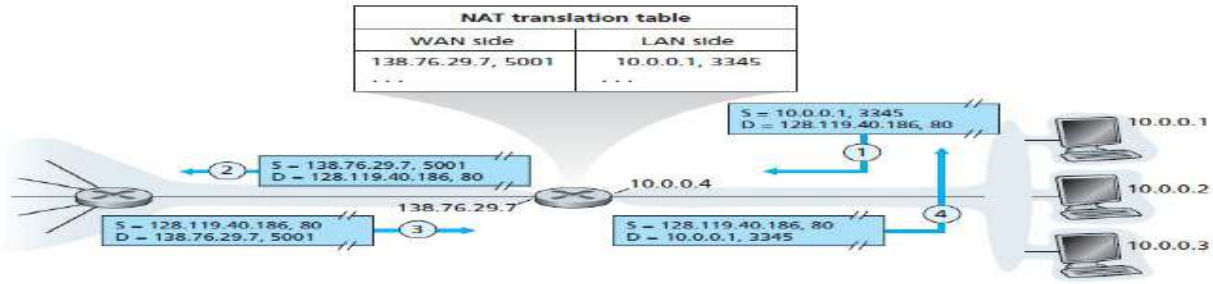
(1.5 Marks)

After expiration of lease time, if client needs to renew IP address than it needs to request server to renew its address. If client is inactive, assigned IP is taken back by server and assigned to client who need. Hence address space is utilized by assigning IP dynamically.

(0.5 Marks)

NAT

Network Address Translation (NAT) is the process of translating local IP address to global IP address, as to communicate with the internet a unique global IP is required.



As shown in figure, router is NAT enables, hence a global IP address 138.76.29.7 which will be used by devices connected in local area to communicate with internet. Devices in local network are assigned private IP address which can be used any NAT enabled router. A NAT translation table is maintained by router in which entries contain IP address and port number for each connected device.

If Node with IP address 10.0.0.1 requests a web page on web server (port 80) with IP address 128.119.40.186. The host 10.0.0.1 assigns the (arbitrary) source port number 3345 and sends the datagram into the LAN. The NAT router receives the datagram, generates a new source port number 5001 for the datagram, replaces the source IP address with its WAN-side IP address 138.76.29.7, and replaces the original source port number 3345 with the new source port number 5001. The Web server, blissfully unaware that the arriving datagram containing the HTTP request has been manipulated by the NAT router, responds with a datagram whose destination address is the IP address of the NAT router, and whose destination port number is 5001. When this datagram arrives at the NAT router, the router indexes the NAT translation table using the destination IP address and destination port number to obtain the appropriate IP address (10.0.0.1) and destination port number (3345) for the browser in the home network. The router then rewrites the datagram's destination address and destination port number, and forwards the datagram into the home network.

(1.5 Marks)

Hence by using one global IP address many hosts can be connected, so whenever a new device is added to local area it does not need to take IP address from ISP. NAT by using DHCP locally solves issue of address space as ipv4 has limited amount of available addresses.

(0.5 Marks)

Q7(b)

It makes sense to use them together as both are not in conflict with each other. As DHCP can be used to assign an IP address with local area and NAT will be responsible for local to global and global to local communication.

(1 Marks)

Q3.

Q-3

- Switched hub is designed to directly switch packets using MAC address only.

⇒ Each port has a buffer where packets are stored.

→ Switch build a IP ↔ MAC Table

MAC ID	Port No
MAC 2	2

→ when a packet arrives at a port (e.g. at #2), switch store source MAC add. & ~~store~~ source port No. in a table

→ switch looks at destination MAC (e.g. port 7) and looks up table to find corresponding port Number.

1	2	3	4
5	6	7	8

⇒ when Both 2 & 7 are Free then Packet is Switched from 2 → 7.

⇒ switching can be done parallely for a different port.

→ 2 marks.

→ Table entries have an expiration time attached to it.

→ If there is no update/activity for given MAC, the entry is removed.

→ 1 mark.

⇒ VLAN :- single switch works as two separate logical / virtual LANs.

→ 1 mark

⇒ L3 switch :- It integrates routing functionality to allow direct comm. between separate LANS.

LAN1		LAN2	
O^1	O^2	O^5	O^6
O^3	O^4	O^7	O^8

→ 1 mark

Q-1: What is the purpose of the flow ID field in IPv6 header? Explain how tunnelling is used to allow incremental deployment of IPv6 and co-existence of IPv4 and IPv6?

ANS:

A):IPv4 routers were stateless so they were understand only datagrams. However, many new application requires Quality of Services.

Eg. Video streaming ,which is requires less interframe delay as well as delay must be bounded and delay jitter must be less than some time amount, it requires rate R is more.

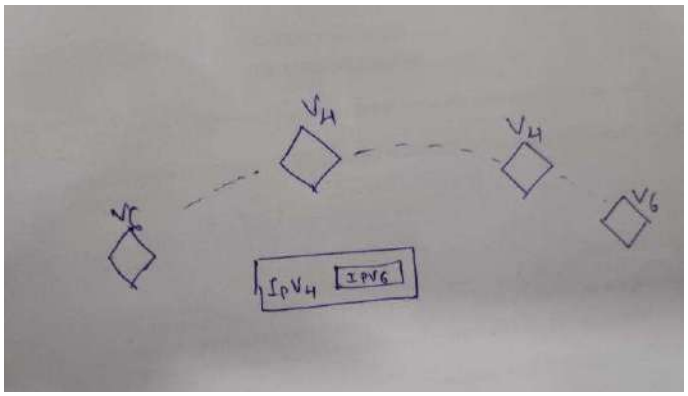
To support QoS, there is a need to handle packets from the same type application in particular way.

As an example, on YouTube all the frame needs to reach at a time that video does not get affect and it gives clean pictures.

For that we need Flow field is easy way to identify packets of same application, Which indicates same Ids and same flow.

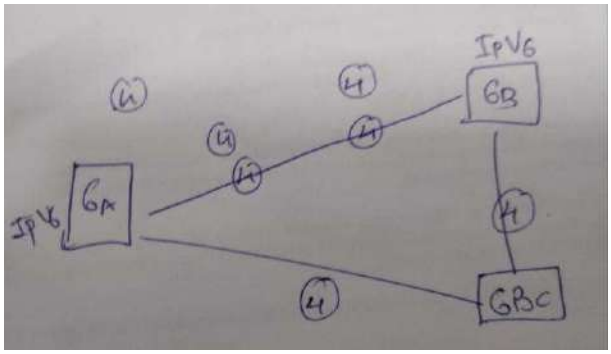
.....2 marks

(B): Tunneling: Embed IPv6 packets as a payload into IPv4 packets called tunnelling.



This is how packets are tunnelled through IPv4 networks.

Overlay network:



In overlay n/w there are so many routers of IPv4 and IPv6 type. here, A->B are overlay neighbours, as there are so many routes between A and B but they are of IPv4 types so A and B called overlay neighbours. A will tunnelled the packet B for further program.

There are some big networks like Microsoft or google they are used some 4-6gateways to understood both the types of packets IPv4 and IPv6.

All the IPv4 addresses can converts into IPv6 by prefixing sufficient no.of zeros as

128.1.2.3 to 000...0.128.1.2.3

As 32 bits to 128 bits.

..... 3 marks.

2) A token bucket controller for bursty traffic can be designed by using different [A,B] values where A is the token generation rate and B is the token bucket size. An bursty source has a peak rate of 200 KB/sec, long term average of 100 KB per second and burst size of 500 KB.

Compute the maximum delay suffered by packets for the values of A=100 KB/sec, A=150 KB/sec and A=200 KB/sec. What are the respective values of B so that there are no packet losses?

Sol:

Delay= (Burst Size/token generation rate);

Burst Time=(size/peak rate);
So Burst time=burst size/peak rate
=500/200
=2.5 Sec

a) A=100 KB/S
B=500 KB

Delay=500/100
=5 Second

Token Bucket size does not matter for having No packet loss because token generation rate is same as long term average so regardless of bucket size once burst arrived,token bucket will never have extra token.

Note->2 Marks if you have calculate any of delay or bucket size with explanation/understanding otherwise 1 mark for each numerical correct answer.

b)

A=150 KB/s

Delay=500/150
=3.33 Sec

Burst time is 2.5 Sec So 2.5*150 KB/s=375 kb so here we need 125 extra tokens to transmit whole burst without having any packet loss.
So for not having packet loss B>500-375=125

Note->2 Marks if you have calculate any of delay or bucket size with explanation/understanding otherwise 1 mark for each numerical correct answer.

C)

A=200 KB/s
Here, token generation rate is equal to peak rate hence any packet will never face delay so,

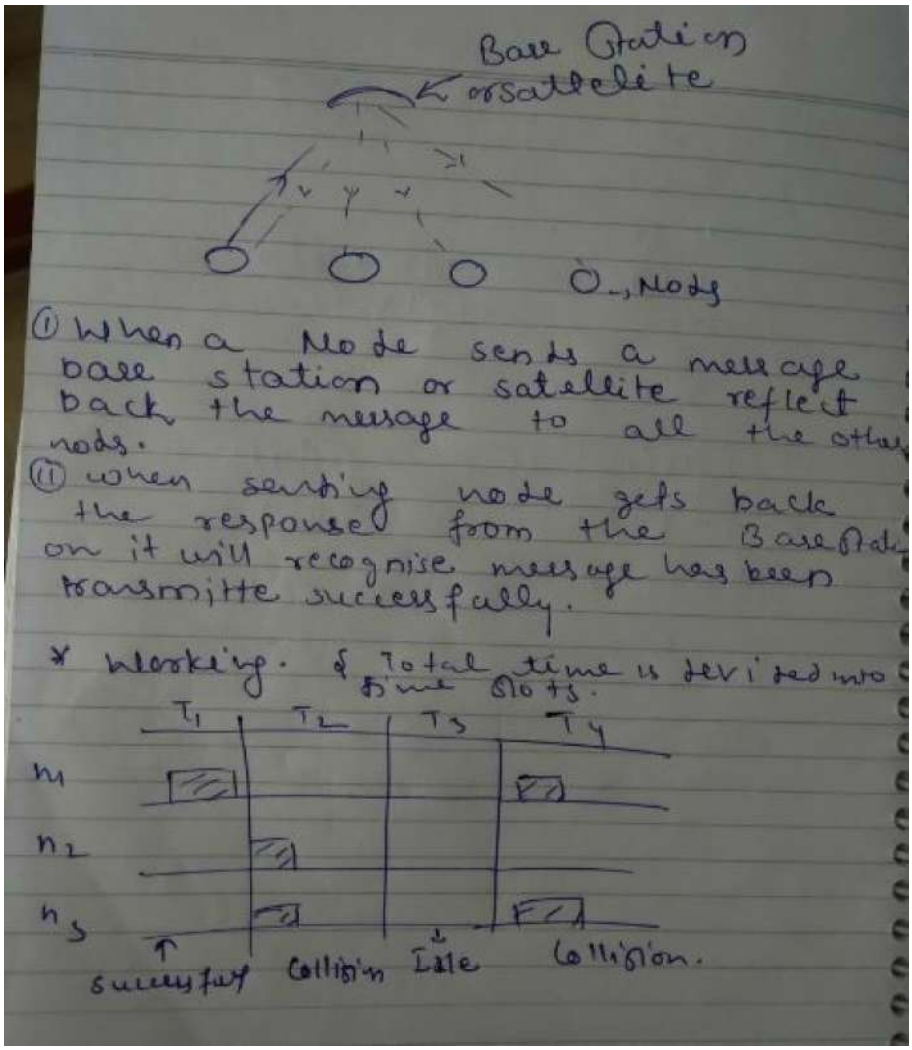
Delay=0
And as there will be no delay we will do not need extra token for the burst hence bucket size B=0 KB

Note->1 mark for each numerical correct answer otherwise 2 marks for any correct answer with proper explanation.

Important Note->This question will be consider of 6 Marks(2+2+2) so Once can get Maximum 6 Marks if they answer all answer correctly.

Answer 3-

1.



2.

a.in slotted aloha time is dived into the time slots.

b.All the timing slots are synchronized .

3.

a.A node is ready with the data will sent the data only at the starting of the time slots.if a station misses the slot then it will sent the message at the start of the next time slot.

b.If more than one node transmitting data at the same time in same slot then collision

occure

Then node will sent the data in next time slot at the start of the timing slots.

Part 2-

N nodes with many frames to send, each transmits in slot with probability p

probability that node 1 has success in a slot = $p(1-p)^{N-1}$.

Total expected utilization = $Np(1-p)^{N-1}$

For max efficiency with N nodes, find p* that maximizes $Np(1-p)^{N-1}$ (1).

Differentiate w.r.t. N then equate with 0.you will get p=1/N.

On putting p=1/N in equation 1 we will get maximum efficiency $=(1-1/N)^{N-1}$

for n to be infinity maximum efficiency will become 1/e.

Q4. In the context of IEEE 802.3 (Ethernet) LAN protocol, answer the following:

a. Briefly describe the functioning of CSMA/CD protocol.

a. In terms of the relevant LAN parameters (length L, packet size B, link capacity C etc.) derive an expression for the maximum time T_{ct} during which collision may take place.

b. Explain the need of exponential back-off mechanism in 1-persistent CSMA/CD.

Ans.

a.

Assumptions :

- Each node can simultaneously transmit and receive
- Node compare Tx and Rx signal. If these don't match then it is collision

Protocol:

Each node : a. Listens to the channel, if busy continue to listen.

b. If channel is quiet, then send packet

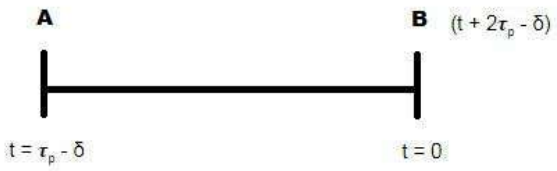
c. if collision detected, then stop. Retransmit packet with probability less than 1 (prob p < 1) when channel is quiet again.

OR

c. First time send with p=1 and after each collision (i^{th}) wait for time random[$0-2^{i-1}$]

Marking :1 mark for assumptions and 1 mark for protocol. partial marks given [0 **|** 1 **|** 1 1/2 **|** 2]

b.



End to end propagation delay time = τ_p = L/V

For very small δ : A may still transmit as there is not signal present from B.

So maximum time after which B will detect collision = t + $2\tau_p - \delta$ (here $\delta \rightarrow 0$)

∴ $T_{ct} = 2\tau_p = 2$□(L/V)

Here, L is length of link and V velocity of packet on link.

Marking : 1 mark if written and explained answer. No partial marking [0 **|** 1].

c.

Reason 1:

- Ethernet standard assumes that Load (Active users 'N') those trying to transmit is unknown
- N rapidly changes with time so N is function of time that is N(t).
- N users competing for channel (with probability of p)
- Success : P_s : N□$(1-p)^{N-1}$□p, P_s is maximum ($dP_s/dN = 0$)
  - ▪ ▪ $p_{opt} = 1/N$
- **Since N is not known at any given time, best value of p can not be estimated. This is why fixed p is not used.**

Reason 2:

- Instead we assume that in round 1 (only 1 node is present) →p=1
- If collision → p=½
- Another collision→$p=1/2^2$ (geometric progression)
- **This works like binary search. Rapidly reduces to optimal value of p in $\log_2 N$ steps.**

Marking : 1 mark for reason 1 and 1 mark for reason 2 : partial marks given [0 **|** 1 **|** 1 1/2 **|** 2]

Q5:

a) Multicast group creation (**1 mark**)

1. Class D addresses are reserved/used for Multicast. It ranges from 224.*.*.* to 241.*.*.* with four MSB bits of first byte is 1110.
2. Group is created by a source(node) assigning a multicast address (Class D) to itself [in addition to unicast address].
3. Any other node that wishes to be part of this group should also assign the same multicast address to itself.

b) Reverse Path Forwarding (**2 marks**)

1. Flooding ---> Broadcast
   Router relays a packet received on one interface to all other interfaces. Multiple copies of the same are received at a node (with example).
2. RPF is a way to reduce multiple copies by using information "unicast routing table" for reverse lookup.
   When intermediate router receives any packet and it is not from the interface which it uses to send a packet to the source node.
   This works when metric is symmetric such as hop count.

c) Multicast tree management (**2 marks**)

1. A router is a member of a group if it has either some users or a downstream router connected to it. Every router determines if it needs to continue being a member then it will.
2. If a user wants to join, it sends a message to its edge router. The router also becomes the member first by sending a message to upstream router. (**join message**)
3. To leave the group, it sends a message to upstream router that it is no longer interested in receiving packets and updates the table. (**prune message**)
4. In RPF based multicast, upstream router will now update **negative forwarding list**.

Question 6 – Token Ring Protocol

MAC shared access protocol-Token Ring or Taking Turn Protocol.

- Clear explaination of ring topology... notion of prev, next node etc.
- Clear explaination of token, why it is needed.. like it gives permission to transmit.
  1 mark for above two points. **Marks not given if notion of token and ring is not explained explicitly before start of protocol explaination.**

Explaination of protocol working :

- Wait for token
- Once token is received (1 mark)
  - if node has packet to send
    - hold the token
    - transmit packet
    - release token
  - else release token
- If a data packet is received (1 mark)
  - check if you are destination for received packet
    - if yes
      - accept
      - process
      - forward
    - else forward to next node

As no one has explained what happens if a data packet is received, highest marks for this question is 4 marks. If student has explained 1 line explaination of token and then written what happens when it is received and how it gets passed to next node in turn, only 1 mark is given for that. (Sir requires clear explaination of token and ring, before explaination of protocol.)

Efficiency: (2 marks)

↳ Efficiency $= \dfrac{\text{Time doing useful work}}{\text{Total time}}$.

N - active nodes

L - length

~~B - pckt~~ B - packet size

V - propagation speed

C - capacity

b - token size

$T_{data} = \dfrac{B}{C}$

$T_{token} = \dfrac{b}{C}$

$T_{prop} = \dfrac{L}{v}$

$T_{token} << T_{data}$.

Useful total time =

$N * \dfrac{B}{C}$

Total token transmission time $= N * \dfrac{b}{C}$

$$\eta = \frac{N T_{data}}{N(T_{data} + T_{token}) + T_{prop}}$$

$$= \frac{N * \frac{B}{C}}{\frac{N}{C}*(B+b) + \frac{L}{v}}$$

1 mark

1 mark.

1 mark for equation of efficiency, token transmission,time, data transmission time and propagation time. 1 mark for correct answer of efficiency.

Q7 Describe the functioning of a switched hub in a LAN and its impact on the system goodput. Explain additional capabilities present in a port-based L3 and how it functions.

Sol:

Functions of switched hub in LAN:

i) It generates MAC table

- It monitors incoming packets to a port and looks at Source MAS address of the packet and does mapping.

- If the time of entries expire than they are removed from table.

ii) Switching

- Every packet received at port is buffered by lookup at destination MAC to port .
- Relays the packet to destination port through back plane which operates at >N* port capacity where N is number of ports.

Other functions like filtering , forwarding , blocking etc.

-- 2 Marks

Impact on System goodput:

Collisions are nearly eliminated , hence even at very high load it runs at peak speed .

-- 1 Mark

(Note if equation of goodput is mentioned 0.5 marks)

Additional Capabilities in port based L3 switch: (Level 3 or Network layer switch**)**

i) If there is 8 port switch of which port 1-3 belong to LAN1 and ports 4-8 belong to LAN2 which helps in making VLAN's

-Broadcast of LAN1 is limited within LAN1 and vice versa for LAN2.

ii) It is aware of Network layers address, so data packets can be routed from LAN1 to LAN2 but at switching speed.

-- 2 Marks

In-Semester Exam-III (Autumn'2018)

IT 214 Database Management Systems

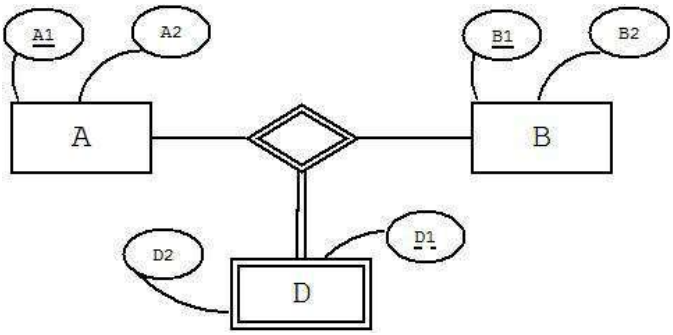
Time: 1 hour | Max Points: 60

Your ID: _____ Name: _____

1a	1b	2a	2b	2c	2d	2e	3a	3b	3c

IMPORTANT NOTE:
1. There are 4 pages in question paper, ensure that you have got all.
2. Answer questions in the space provide against the question itself. **Overwriting** is not allowed.
3. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
4. In all questions marks awarding strategy will be discrete (i.e., 0, half, and full marks)
5. You may have to pay penalty for lengthier solutions.

1. Consider ER Diagram given here, and do following [15]
   (a) Derive Relational schema from this ER diagram using ER to Relational mapping rules. Also indicate all keys and foreign keys.
   (b) Find out minimal FD set from semantics of attributes in given ER Diagram.



A1 → A2 B1 → B2 A1B1D1 → D2	A(A1A2) B(B1B2) D(A1B1D1D2)

2. In next question you are given a number of relations and FDs over them. You need to do following for each relation -
    a. Compute key(s)
    b. Determine highest normal form of the relation (consider only up-to 4NF)
    c. Name all FDs that "violate the requirement" of the relation being in next higher normal form. If a relation is already in 4NF you have answer "NONE" here.
    d. Give 4NF Normalized relations. Make sure that decomposition is lossless and FD preserving. If you cannot decompose due to any loss, mention the same. Also underline key attributes of each normalized relation.

5x4=20

R(ABCDE) AB → CDE C → ADE	Key: AB	Normal Form: 2NF	Culprit FD: C→DE
	Normalized Relations R1(ABC); 3NF [can't decompose because FDs will be lost] R2(CDE); 4NF		
R(ABCDE) AB →CD A → BE	Key: A	Normal Form: 4NF	Culprit FD: None
	Normalized Relations		
R(ABCDE) A → BCDE BC →DE	Key: A	Normal Form: 2NF	Culprit FD: BC → DE
	Normalized Relations R1(<u>BC</u>DE) R2(<u>A</u>BC)		
R(ABC) A -->> BC B -->> AC AB → C	Key: AB	Normal Form: 4NF	Culprit FD: None
	Normalized Relations		
R(ABCD) A -->> BC A -->> D	Key: ABCD	Normal Form: BCNF	Culprit FD: Both MVDs
	Normalized Relations R1(ABC) R2(AD)		

Your ID: _____	*Name:* _____

3. Consider following Relation R and given FD set [5+10+10]
   R(ABCDEFGHIJ)
   A → BDEF
   G → ABDEFHIJ
   D → E
   I → J

   a. Compute Minimum FD set and write in compact and canonical form.

   A → BDF (FD1)
   G → AHI (FD2)
   D → E (FD3)
   I → J (FD4)

   b. Compute Key and Normal Form

   GC [GC^+=ACGHIBDFEJ]

   c. Decompose the R using BCNF Decomposition Algorithm [Try choosing steps where FDs are not lost]

R(ABCDEFGHIJ)

Decompose R based on FD I→J
R1(IJ)
I→J (BCNF)
R2(ABCDEFGHI)
A → BDF (FD1)
G → AHI (FD2)
D → E (FD3)
Key: AC (not in BCNF)

Decompose R2based on FD D→E
R21(DE)
D→E (BCNF)
R22(ABCDFGHI)
A → BDF (FD1)
G → AHI (FD2)
Key: AC (not in BCNF)

Decompose R22 based on FD2
R221(GAHI)
G → AHI (BCNF)
R222(ABCDF)
A → BDF (FD1)
Key: AC (not in BCNF)

R2221(ABDF)
A → BDF (BCNF)
R2222(AC)
BCNF

In-Semester Exam-II (Autumn'2019)

IT 214 Database Management Systems

Time: 90 minutes | Max Points: 100

IMPORTANT NOTE:
1. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
2. In all questions marks awarding strategy will be discrete (i.e., 0, half, and full marks).
3. You may have to pay penalty for lengthier solutions.

Consider following relational schema for storing various students' related data. Brief description is also given alongside.

student(id, name, prog_id, batch, cpi)
-- attribute **prog_id** is like '01' for BTech, '11' for M.Tech, '12' for MScIT, and so
-- Assume that this relation stores data of only current students of the institute; say all past data
-- have been archived.

room(rno, wing, floor)
-- the relation stores details of rooms
-- floors are represented by numbers 0 (Ground), 1(First), and 2 (Second), and so

allot(sid, rno)
-- The relation stores residential facts of students. Note that that RNO cannot be NULL.
-- SIDs' of students who are not residing hostel does not appear here.

course(courseno,course_title, credit, coursetype)
-- the relations stores basic information of courses. Course type: core and elective.

offers(termid,courseno, facultyid)
-- The relation stores instances of course offerings.For example-<AUT17, IT214, I001>

registers(termid,courseno, studid, grade)
-- let this relation be storing academic performance of students.
-- let the grades be stored as AA, AB, and so forth.

grade2point(grade, point)
-- the relation records mapping from letter grade to numeric value.
-- as AA --> 10, AB --> 9, and so forth

clubs(clubid, club_name)
-- the relation records all the offers that are made to students in 2018.

clubmembers(sid, clubid, role)
-- role is like 'conveyor', 'member', or so.

HMC(wing, floor, hmc_representative)
-- Let us say we have one student as HMC member for each floor.
Assume that attribute hmc_representative cannot be NULL.
We have no tuple here for floor for which no HMC representative.

Write **expressions in Relational Algebra** to answer queries in following five questions.
(No marks will be awarded if answered in SQL)

5x10

1. List (Wing, Floor) for floors that do not have HMC members.

$$result \leftarrow \pi_{wing,floor}(room) - \pi_{wing,floor}(hmc)$$

2. List (Club_name, convenor_name) for all clubs.

$$r1 \leftarrow \sigma_{role='convenor'}(clubmembers)$$

$$r2 \leftarrow r1 \overset{\bowtie}{\boxed{sid = id}} student$$

$$result \leftarrow \pi_{club_name,name}\left(clubs \overset{LEFT \bowtie}{\boxed{clubs.clubid = r2.clubid}} r2\right)$$

3. List (id, name, progid, cpi) of students who are residing in E wing, second floor and have cleared course of 'Algorithms' (IT215) with grade BC or higher.

$$r1 \leftarrow \sigma_{wing='E' \text{ and } floor=2}(allot * room)$$
$$r2 \leftarrow \sigma_{courseno='IT215'}(registers)$$

$$r3 \leftarrow r2 \overset{\bowtie}{\boxed{studid = sid}} r1$$

$$r4 \leftarrow \sigma_{point \geq 7.0}(grade2point * r3)$$
$$result \leftarrow \pi_{id,name,progid,cpi}\left(r4 \overset{\bowtie}{\boxed{sid = id}} student\right)$$

4. List (id, name) of BTech (progid=01) students whose room mate is MSc(IT) student. Assume that there can be at most two students in a room.

$$b1 \leftarrow \sigma_{progid='01'}(student)$$
$$m1 \leftarrow \sigma_{progid='12'}(student)$$

$$b2 \leftarrow allot \overset{\bowtie}{\boxed{sid = sid}} b1$$

$$m2 \leftarrow allot \overset{\bowtie}{\boxed{sid = sid}} m1$$

$$result \leftarrow \pi_{b2.id,b2.name}\left(b2 \overset{\bowtie}{\boxed{b2.rno = m2.rno}} m2\right)$$

5. Suppose we need to compute that to what fraction of students a faculty awards AA grade in semester AUT17.List (FacultyId, fraction).

$$r1 \leftarrow (\sigma_{termid='AUT17'}(registers)) * offers$$

$$r2 \leftarrow \sigma_{grade='AA'}(r1)$$

$$r3 \leftarrow {}_{facid}\mathcal{F}_{count(*) \rightarrow scount}(r1)$$

$$r4 \leftarrow {}_{facid}\mathcal{F}_{count(*) \rightarrow aacount}(r2)$$

$$result(facid, fraction) \leftarrow \pi_{facid,aacount/scount}(r3 * r4)$$

6. Read following description for a database design and produce a **Neat ER Diagram**.

Consider the scenario of placement activities at your institute. Let us say, placement database is separate from e-campus and other institutional databases.

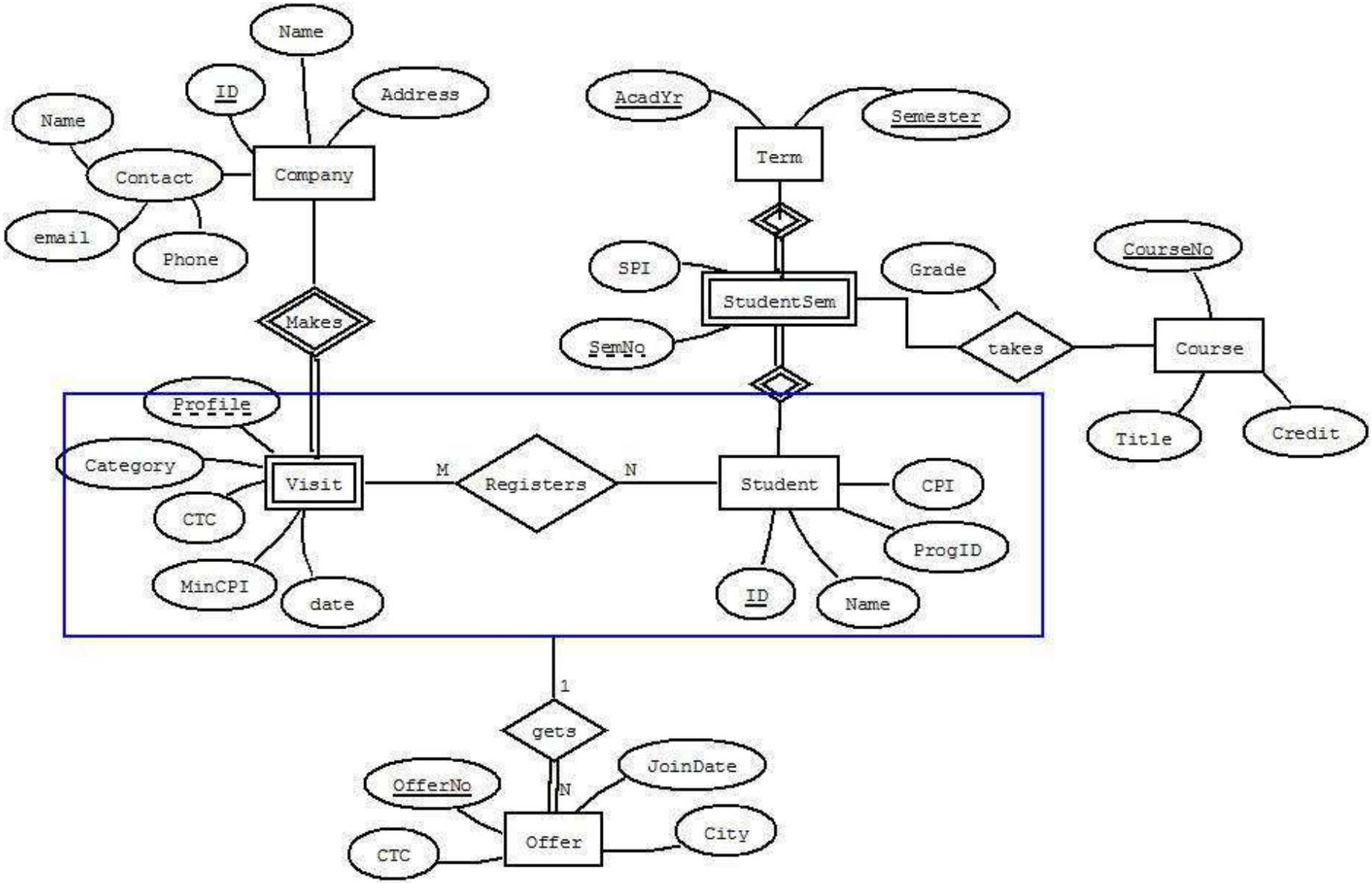
Companies visiting to institute and students interested for placement require registering through a web interface. Note that placement database may turn out to be complex, therefore limit the scope within data requirement and constraints mentioned in given description here.

For companies, registration is two-step process - First time registration and Visit Registration. On first time registration let us say they provide information of Company ID (Unique), Name, Address, Contact Person's Name, Email, and Phone. In Visit registration, following information about company's visit are captured – profile-name, profile category ('A', 'B', and so), CTC offered for the profile, minimum CPI. Let us say companies require separate visit registration for each profile for which they come. Once visit registration is done, placement office allocates a visit date to a profile registration in consultation with company contact person.

Students who are interested in placement require registering. Student registration is also two-step process - basic registration and profile registration. Basic registration is only once for a drive, and following information is provided – ID, Name, ProgramID, CPI. Let transcript of every student is also stored. For transcript, we store semester wise following information – semester no (1,2,3, or so), acadyr, semester (aut-1, wint-2, summer-3),list of courses(courseno, title, credit, grade), semester SPI[while creating ER diagram, be careful of redundancies here].

Students require doing profile registration for every profile student is interested in. No additional information is furnished at the time of profile registration – just interest is stored.

Once student registrations are done, companies visit the institute for conducting recruitment process at institute. Let us say we do not record anything for recruitment process; we only record final offers that are made. For offers we store what company makes offer to which student and for what profile. Let us assume that for each offer that is made, we also store – offer no (can assume to be unique), CTC, joining date, joining city name.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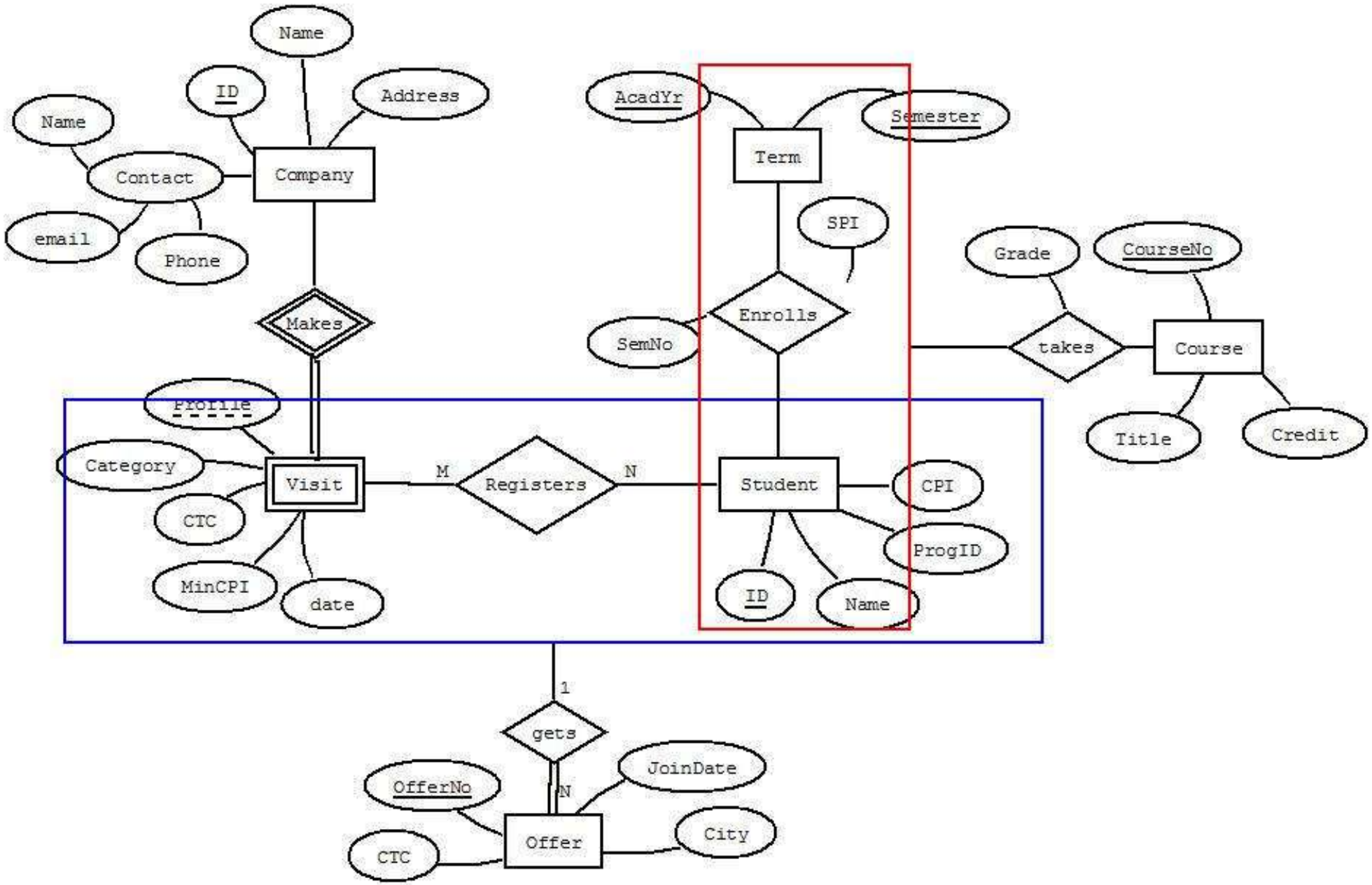
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201501099

Dhirubhai Ambani
Institute of Information and Communication Technology, Gandhinagar

PLEDGE
I hereby Pledge that I shall answer the questions at the examination to the best of my ability and that I shall not resort to any unfair means of any nature.

Supervisor's Signature : .....
Student's Signature: A.A.Shah
Course : D.B.M.S
Name : Agum Shah
Date : 1-11-17
Student Identity Number : 201501099
Number of Supplementaries : .....
Programme : B.Tech I.C.T with C.S

Questions	1	2	3	4	5	6	7	8	9	10	TOTAL
Marks Obtained	20	5	17 +1.5	8.5	10	10					70-5 +1.5 +2.5
Questions	11	12	13	14	15	16	17	18	19	20	
Marks Obtained											76

Examiner's Signature

Start here

1.
```
CREATE OR REPLACE FUNCTION SD_salary
RETURNS numeric AS $BODY$
DECLARE
    emp        employee%Rowtype ;
    SD         numeric ;
    sum        numeric ;   sum := 0;
    Avg        numeric ;
    sum2       numeric ;   sum2 := 0;
    count      int     ;   count := 0;
BEGIN
  FOR emp IN SELECT * FROM employee
  Loop
  IF emp.salary is NOT NULL THEN
      sum = sum + emp.salary ; count = count +1;
  END IF
  END LOOP
    Avg = sum/count ;
```

```
FOR emp IN SELECT * FROM Employee
LOOP IF empsalary IS NOT NULL THEN
    sum2 = sum2 + (empsalary - Avg)^2
    END IF
END LOOP

SD := sqrt( sum2 / count );
RETURN SD;
END $BODY$ LANGUAGE 'PLPGSQL'
```

2. getConnection(Url, user, password)

username

Url of database

Password

(1) Url
(2) Username
(3) password

3.

(P.T.

uivalent (Yes or NO, Give proofs) -

l G = {A →

3. R(TN, DAY, SRC_SCODE, DST_SCODE, SCODE, DATE, SAT, SDT, EAT)

Minimal FDs:-

TN → {SRC_SCODE, DST_SCODE} — 2

{TN, SCODE} → {SAT, SDT} — 3

{TN, SCODE, DATE} → {EAT} — 3

KEY:- {TN, SCODE, DATE, DAY}

MVDs:-

TN →→ DAY

TN →→ SCODE

TN →→ DATE

* BCNF Decomposition:-

R_1(TN, DAY) → BCNF

R_2(TN, SRC_SCODE, DST_SCODE, SCODE, DATE, SAT, SDT, EAT)

R_{21}(TN, SCODE, SAT, SDT) → BCNF

FD:- {TN, SCODE} → {SAT, SDT}

R_{22}(TN, SRC_SCODE, DST_SCODE, SCODE, DATE, EAT)

FD:- TN → {SRC_SCODE, DST_SCODE}

{TN, SCODE, DATE} → {EAT}

R221 (TN , SRC_SCODE, DST_SCODE) → BCNF

TN → { SRC_SCODE, DST_SCODE }

R222 (TN , SCODE , DATE , EAT) → BCNF

{TN , SCODE, DATE} → EAT

Final :-

→ (TN , SRC_SCODE , DST_SCODE) 3

FD :- TN → { SRC_SCODE, DST_SCODE }

→ (TN, SCODE , SAT , SDT) 3

FD :- { TN, SCODE } → { SAT, SDT }

→ (TN, SCODE, DATE, EAT) 3

FD :- { TN, SCODE, DATE } → EAT

→ (TN, DAY) 1.5

FD :- No FD

are equivalent (Yes or NO, Give proofs) -

E} and G = {A → BC

4. $F\{A \to B, AB \to C, D \to E\}$

$G = \{A \to BC, D \to AE\}$

* Proof of: G can be inferred from F
(Try that)

~~A → B ~~ D~~

→ For $A \to BC$

① $A \to B$ ~~and AB → C~~ (given)
② $A \to AB$ Augmentation Rule
③ $AB \to C$ (given)
④ $A \to C$ (from ② and ③)
⑤ $A \to BC$ (Union or ① and ④)

→ for $D \to AE$

① $D \to E$ given

we can't have $D \to A$ from F because D is only in left side only in $D \to E$ and E does not determine any thing

why? So $D \to AE$ can't infer from F

So G can't infer from F So F and G are not equivalent

→ F can be inferred for G

→ for $A \to B$

① $A \to BC$ given
② $A \to B$ (from Decomposition)

→ for $AB \to C$

① $A \to BC$ given
② $A \to C$ (Decomposition on ①)
③ $AB \to BC$ (Augmentation)
④ $AB \to C$ (Decomposition

→ for $D \to E$

① $D \to AE$ given
② $D \to E$ (decomposition)

So F can be obtain from G but G can't be obtain from F

So F is not equivalent to G

ent (Yes or NO, Give proofs) -

(A → BC D

5. R(ABCDEF)

$A \to B$
$A \to C$
$CD \to E$
$CD \to F$
$B \to E$

S-1 $A \to E$ YES

① $A \to B$ (given)
② $B \to E$ (given)
③ $A \to E$ (Transitivity on ① and ②)

S-2 $CD \to EF$ YES

① $CD \to E$ (given)
② $CD \to F$ (given)
③ $CD \to EF$ (Union rule on ① and ②)

S-3 $AD \to F$ YES

① $A \to C$
② $AD \to CD$ (Augmentation on ①)
③ $CD \to F$ (given)
④ $AD \to F$ (Transitivity on ① and ③)

S-9 $B \to CD$ NO

① $B \to E$

reason:-

① B is on left side only in $B \to E$

② Here E can't determines any thing.

So from ① and ② you can't have $B \to CD$

10

P.T.O

alent (Yes or NO, Give proofs) -

= {A → BC, D → AE}

6. R(ABCDEF)

ABC → E
ABCD → F

→ Key :- ABCD

→ NF :- 1NF

-x CULPRIT :- ABC → E because E is not fully dependent on ABCD

→ YES

R_1 (ABCE)

FD :- ABC → E

R_2 (ABCDF)

FD :- ABCD → F

End-Semester Examination, Autumn'2016

IT 214 Database Management Systems

Time: 2 hours

Max Points: 90

IMPORTANT NOTE:

1. Write answers neat and clean. Answers that are difficult to read may simply be discarded. Answers written using pencil will also be ignored.
2. Answer all parts of a question together at one place.
3. For every question, mark awarding strategy will be discrete (i.e., zero, half, and full)

1. Consider the three transactions T1, T2, and T3, and the schedules S1 and S2 given below. Draw the serializability (precedence) graphs for S1 and S2, and state whether each schedule is serializable or not. If a schedule is serializable, write down the equivalent serial schedule(s).

[15]

T1: r1(X); w1(X); r1(Y); w1(y);
T2: r2(Z); r2(Y); w2(Y); r2(X); w2(X);
T3: r3(Y); r3(Z); w3(Y); w3(Z);
S1: r2(Z); r2(Y); w2(Y); r3(Y); r3(Z); r1(X); w1(X); w3(Y); w3(Z); r2(X); r1(Y); w1(Y); w2(X);
S2: r3(Y); r3(Z); r1(X); w1(X); w3(Y); w3(Z); r2(Z); r1(Y); w1(Y); r2(Y); w2(Y); r2(X); w2(X);

2. Consider following schedule executed on postgreSQL. Find output, when both transactions are specified to execute at (i) READ COMMITTED (ii) SERIALIZABLE isolation levels. Assume that initial salary for employee with SSN ~~101~~ 123 is 50000.

[10]

```
T1: begin;
T1: update employee set salary = 60000 where ssn = 123;
T2: begin;
T2: select salary from employee where ssn = 123;
T2: update employee set salary=(select salary from employee where ssn=123)+5000
        where ssn = 123;
T1: commit;
T2: commit;
T1: select salary from employee where ssn = 123;
```

3. Consider scenario where I want to create a database of your groups doing project in this course, IT214. A number of students form groups for projects; a student cannot be in more than one group. For each group, I want to record GroupNo (Unique), Project Title, Student ID and Contact Number of the team leader. I would also like to record details of members in each team; i.e., student id, name and email of each student. Also suppose there are TAs in the course, and a number of groups are assigned to each TA. A group is supervised by a single TA. For TAs, I would like to record TA-Stud-ID, TA-Name, TA-email, and TA-Contact-Number.

The projects are evaluated at multiple stages on multiple parameters. At each stage, there are maximum marks for each parameter. Assume that each stage and parameters are determined by unique IDs; also set of parameters remain same at all stages of evaluation. Marks (out of max marks) for each student are recorded for each parameter and for each stage.

.... turn overleaf ....

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Assume that scope of the proposed database is limited to this course, and this semester only; that means, I would not be adding more student groups to it when I take this course next time, possibly I would be emptying it out, and putting altogether new set of students and groups.

Determine following for the proposed database- [30]

a. Minimal Set of Function Dependencies
b. Normalized (BCNF) relational Schema.

4. Following relational schema for recording of state elections (from second in-semester examination). Note that the schema has few additional relations, and some reshuffle of attributes.

Constituency(<u>ConstituencyName</u>, Elected)
FK: **Elected** (candidate that wins election) refers to **Candidate**
Candidate(<u>CandidateName</u>, CandidatePartyName, AssetsDeclared)
Party(<u>PartyName</u>, PartyElectionSymbol, ProjectedCM)
FK: **ProjectedCM** refers to **Candidate**
Fights(<u>ID</u>, ConstituencyName, CandidateName, VoteCount)
FK: **CandidateName** refers to **Candidate, ConstituencyName** refers to **Constituency**
PollingBooth(<u>BoothID</u>, ConstituencyName, NoOfVoters, VotesCasted, District)
FK: **ConstituencyName** refers to **Constituency**
Votes(<u>UUID</u>, BoothID, VotedTo)
FK: **VotedTo** refers to **Fights, BoothID** refers to **PollingBooth**
You can assume that we have tuple in this relation only when a voter votes and vote is valid, that means it refer to a valid ID (exists in fights)

(A) Considering above schema, write **<u>Relational Algebra</u>** expressions for answering following queries (No marks will be awarded if answered in SQL) [20]

a. Polling percentage at each constituency (= total votes casted / NoOfVoters)
b. List candidates (Candidate Name, Constituency Name) who have won from more than one constituency.
c. Name of political party (PartyName, MLA_Count) having maximum number of candidates won.
d. List Candidates whose victory is more than 50000 votes.
e. Give Polling booth names where winner candidate in the constituency is looser (i.e. not having highest votes)

(B) Write a stored function (in pseudo code) **CountVotes**, that updates *VoteCount* attribute of Fights relation, VotesCasted in PollingBooth relation, and elected attribute in Constituency relation. [15]

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In-Semester Test-4

IT 214 Database Management Systems

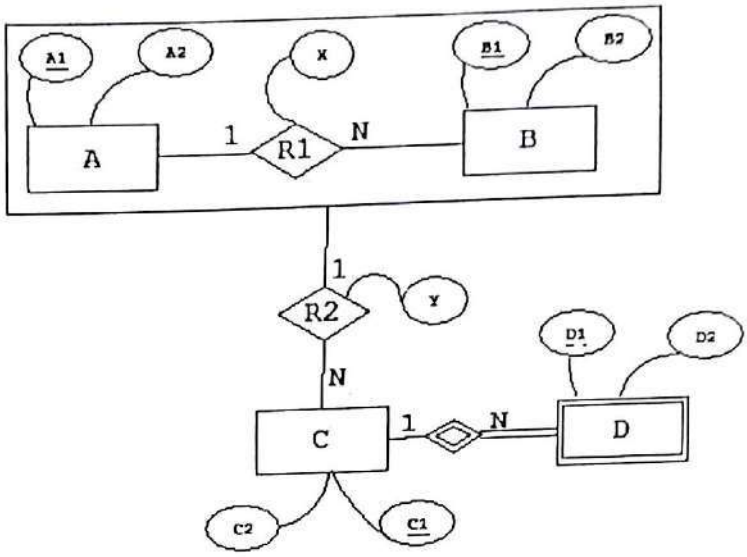
Time: 90 minutes

Max Points: 60

IMPORTANT NOTE:

1. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
2. In every question, mark awarding strategy will be discrete (i.e., zero, half and full).

1. Consider following Entity Relationship Diagram. [10+10]



   a. Find out minimal set of FDs from semantics of attributes in given ER Diagram.
   b. Draw best possible normalized relational schema from the given ER diagram. Also indicate all candidate keys and foreign keys.

2. Suppose polling data of forthcoming assembly elections in Gujarat are to be recorded. Below are some terms that are used here-

Assembly Constituency: a political territory from where an assembly member is to be elected. Each constituency has definite set of voters.

Election Candidate: At each constituency various political party nominate their candidates in the election race. Normally there are many candidates fighting elections at a constituency. When polling starts, a voter votes to only one candidate. Once voting is done, counting is done, and candidate with maximum votes is declared as winner. The winner candidates is said to be an elected Member of Legislative Assembly (MLA) from that constituency.

Let us decide to record following data-

- For political parties: Name of party, party symbol, and name of projected chief minister.
- For constituency: Name, and Number of voters.
- For candidate: Candidate name, value of assets declared
- As counting is done, we record vote count for each candidate (for each constituency it fight at), votes casted in each constituency, and name of elected candidate for each constituency.

Assume: (1) constituency name and candidate names are unique; (2) One candidate belongs to only one party but can be candidate from more than one constituency. Also, one candidate can get elected from more than one constituency. [10+20]

   a. Draw ER Diagram for required database. Specify cardinality and participation constraints.
   b. Produce appropriate relational schema for the database. Try to have best possible normal form. Indicate keys, projected functional dependencies, and normal form of each relation.

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3. Given following relations, and sets of functional dependencies.

[5+5]

R(ABCDE),	FDs: {AB → C, B → D, C → E}
R(ABCDE),	FDs: {A → B, BC → E, ED → A}

Do following-

(1) Compute all Key(s)

(2) Determine Normal Form

(3) Name FD (at least one) that violate requirement of immediate next higher normal form

(4) Normalize each of relation to highest possible normal form without losing any FD

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End-Semester Examination (Autumn'2018) IT 214 Database Management Systems	A

Student ID: _____ Name: _____

Time: 90 minutes Max Points: 115

IMPORTANT NOTE:
1. There are six pages make sure that you have them all in your set.
2. You need to answer all questions in question paper itself.
3. Write answers neat and clean. Over-writing is not allowed.

Marks

1	2	3	4	5	6	7	8	9	

1. Tick the correct option (there can be multiple options be correct; check them all) – [10]

   i. Heap files are roughly good for operations <INSERT/DELETE/SEACRH>

   ii. Secondary index can be <dense/clustered/b+-tree/~~sparse~~>

   iii. Participation of a weak entity with identifying relationship is always total [True/False]

   iv. Materialized view hold data <true/false> _____

   If yes, what data? __ result of query associated with view _____

   v. Unbound cursor can be bound with dynamic query <Yes/No>

   vi. TP_OP is a <implicit local variable/implicit parameter variable/~~global variable/ no such variable~~>

   vii. Embedded SQL provides an environment in which SQL statements are sent to DBMS for execution <Yes/No/both-depends on configuration>

   viii. Using "CREATE ASSERTION", we can create constraints that span to multiple tables <True/False/No such command>

   ix. In case of B+-tree based index, index scan mean "sequential scan of leaf nodes" <True/False/No such operation>

   x. Bloated index refers to index having <too much void spaces in blocks/ too much overflow/index corrupted /all of these>

2. Fill in the blanks-

[30]

i. Referential Integrity constraint requires that
__FK referring to existing tuple in referenced relation__

ii. Prepared statement helps in
__ Avoiding SQL Injection | faster execution | avoiding run-time errors __

iii. Entity Integrity constraint requires that __ PK cannot be NULL __

iv. `CallableStatement` object in JDBC is used for __ Calling Stored Procedure __

v. Which property of schedule ensures **Isolation** __ Serializability __

vi. Which property of schedule ensures **Atomicity** ___ Recoverability __

vii. Which property of schedule ensures **Durability** __ Recoverability ___

viii. Weak entity is the one that ___ Does not have its own key _____
_____Requires owner entity to be identified _____

ix. Which SQL Isolation level may cause Dirty Read ___Read Uncommited ____

x. Advantage of strict 2PL over standard 2PL ___Reduced Cascaded Rollback/aborts __

xi. System logs helps in __ Database Recovery __

xii. Write Ahead Logging Protocol is used for __ Database Recovery __

xiii. Noted problem in basic Snapshot Isolation is __ Skew Write __

xiv. Main problem in 2PL protocol is __ Deadlocks __

xv. Main problem with basic time stamp ordering techniques is
_Unnecessary aborts __

xvi. What is the name of technique that is used for avoiding cascaded rollbacks
__ (1) Do not read from uncommitted transaction__
__ (2) Rigorous 2PL __

xvii. What is highest SQL isolation level that has Phantom row problem
__ Repeatable Read _

xviii. One of the most important advantage of sql views is
__ (1) Abstraction __ (2) Hide Complexities __
__ (3) Reusability ___ (4) Data Hiding __
__ (5) logical data independence __

xix. Name one of the procedural data manipulation language
__ PL/PgSQL ____ PL/SQL _____

xx. Can you determine Normal form of relation R(AB), in absence of FD information. Note that, no information does not mean NO FD; if yes what is NF? __ BCNF____

Student ID: _____ Name: _____

3. Consider following keys; Primary Key(PK), Key(K), Candidate Key(CK), Super Key (SK), and choose which symbols is most appropriate to be placed in the blank space (⊆ or ⊇ or =) below.

[5]

i. PK ___=____ K

ii. PK ___=____ CK

iii. CK ___=___ K

iv. CK ___⊆___ SK

v. K ___⊆___ SK

4. Give short answers -

i. Suppose Employee relation has B+-tree index on DNO. Compute approximately execution cost of query "SELECT * FROM EMPLOYEE WHERE DNO=5"? May express in terms number of block read/writes, and assume other parameters! [3]

H+ ⌈S/BF⌉ or H+1

Where H is index height, S is selectivity (no of tuples / distinct values of DNO), BF is blocking factor number of records in a block

ii. Suppose you have following query to be executed

$\sigma_{SALARY>30000 \wedge DNO=5}(EMPLOYEE)$

What could be best strategy to execute this query. [3]

Strategy#1: if there is index on DNO, use this index and then sequential scan and apply salary selection criteria

Strategy#2: if there is index on DNO and SALARY both, select records on individual index and compute intersection

Strategy#3: if there is no index on any of attribute (i.e. DNO and SALARY), sequential scan is only option

iii. Compute Join selectivity of join EMPLOYEE JOIN DEPARTMENT ON DNO. What is "Join Selectivity" of the JOIN? May assume other parameters [3]

(1) What is JS = |R JOIN S| / (|R| * |S|)

(2) EMPLOYEE JOIN DEPARTMENT ON DNO = |EMP| / (||EMP| * |DEP|)

= 1 / |DEP|

iv. Translate following SQL query in terms of relational algebra: [3]

```
SELECT * FROM EMPLOYEE WHERE SSN IN
                (SELECT DISTINCT ESSN FROM DEPENDENT)
```

Solution-1

$$EMPLOYEE \frac{SEMI\ JOIN}{e.ssn = d.essn} DEPENDENT$$

Solution-2

$$EMPLOYEE * (\pi_{SSN}(EMPLOYEE) \cap \pi_{ESSN}(DEPENDENT))$$

v. Consider relation R(A, B, C) and set of FDs { {A → B}, {B → C}}; can you find out a join dependency here. [3]

Yes: *{(AB), (BC)}

vi. Given, A → B and XB → C, prove that XA → C. [3]

A → B (FD1-given)
XB → C (FD2-given)
XA → XB (FD3- using Augmentation rule to FD1)
XA → C (using transitive rule on FD2 & FD3)

5. Suppose following schedule is executed by interleaving operations from transactions T1 and T2. What kind of concurrency problem do you see in following schedule? Give short reason. [5]

```
T1: Read X
T1: X = X + 50
T1: Write X
T2: Read X
T2: X = X + 100
T2: Write X
T1: Abort
T2: Commit
```

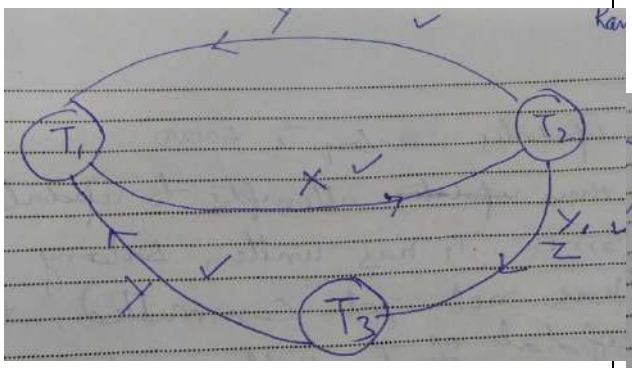
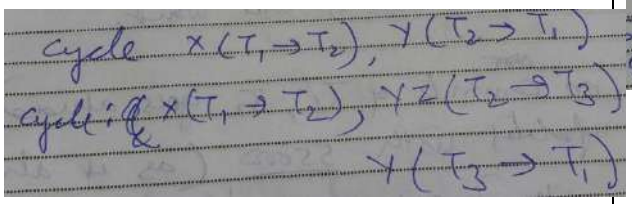
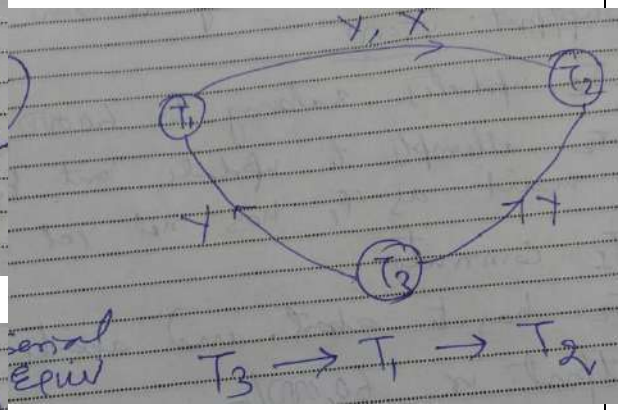
DIRTY READ: T2 reads write of T1, and T1 aborts.

6. Is the schedule given in previous question is recoverable? Give short reason. [5]

No, not recoverable; because T2 commits while T1 aborts.

7. Consider the three transactions T1, T2, and T3, and the schedules S1 and S2 given below. Draw the serializability (precedence) graphs for S1 and S2, and state whether each schedule is serializable or not. If a schedule is serializable, write down the equivalent serial schedule(s).

[10]

S1: r2(Z); r2(Y); w2(Y); r3(Y); r3(Z); r1(X); w1(X); w3(Y); w3(Z); r2(X); r1(Y); w1(Y); w2(X);	S2: r3(Y); r3(Z); r1(X); w1(X); w3(Y); w3(Z); r2(Z); r1(Y); w1(Y); r2(Y); w2(Y); r2(X); w2(X);
 	

8. Consider following schedule executed on PostgreSQL. Assume that initial salary for employee with SSN 123 is 50000. [Here labels T1 and T2 against statements indicate Transaction that is issuing the statement.] What will be shown by SELECT statements at line numbers 3, 5, 7, 10 if transaction T2 is specified to execute at READ COMMITTED isolation level and SERIALIZABLE isolation level?

[6+6]

```
1  T1: begin;
2  T1: update employee set salary = salary+3000 where ssn = 123;
3  T1: select salary from employee where ssn = 123;
4  T2: begin;
5  T2: select salary from employee where ssn = 123;
6  T2: update employee set salary=salary+5000 where ssn = 123;
7  T2: select salary from employee where ssn = 123;
8  T1: commit;
9  T2: commit;
10 T1: select salary from employee where ssn = 123;
```

READ COMMITTED level	SERIALIZABLE level
Line 3: ___ 53000 _____	Line 3: ___ 53000 ___
Line 5: ___ 50000 _____	Line 5: ___ 50000 ___
Line 7: ___ 58000 ____	Line 7: _ ERROR _(53000_is also OK)
Line 10: ___ 58000 ___	Line 10: ___ 53000 __

Student ID: _____ Name: _____

9. Suppose following attributes are drawn from a sales/purchase system of trading company.
   Sales_bill_no, sales_bill_date, customer_no, customer_name, item_no, item_name, quantity_in_stock, quantity_in_bill, item_rate, item_rate_in_bill, item_category, item_category_sales_tax_rate, supplier_id, supplier_name, purchase_bill_no, purchase_bill_date, quantity_in_purchase_bill, item_rate_in_purchase_bill, average_purchase_price

   Assume that: (1) there is only one supplier for each purchase bill,
   (2) an item comes only once in a bill
   (3) there is only one customer for a sales bill (4) sales tax rate in a bill depends on item category
   (5) a sales bill contains all items of same category.

Your tasks here are following - [10+10]

i. Identify Minimal FD Set
ii. Give normalized relations that are in BCNF. Specify Keys and FKs also.

FDs

sales_bill_no → {sales_bill_date, customer_no}

customer_no → customer_name

item_no → {item_name, qty_in_stock, item_rate, item_category, average_purc_price}

{sales_bill_no, item_no} → {quantity_in_bill, item_rate_in_bill}

item_category → item_category_sales_tax_rate,

supplier_id → supplier_name

purch_bill_no → {purch_bill_date, supplier_id}

{purch_bill_no, item_no}→{qty_in_purch_bill, item_rate_in_purch_bill}

Relations

sales_bill(sales_bill_no, sales_bill_date, customer_no)

customer(customer_no, customer_name)

item(item_no, item_name, qty_in_stock, item_rate, item_category, average_purc_price)

billitems(sales_bill_no, item_no, quantity_in_bill, item_rate_in_bill)

category(item_category, item_category_sales_tax_rate)

supplier(supplier_id, supplier_name)

purchase(purch_bill_no, purch_bill_date, supplier_id)

purchasebill(purch_bill_no, item, qty_in_purch_bill, item_rate_in_purch_bill)

End-Semester Examination (Autumn'2018) IT 214 Database Management Systems	B

Student ID: 201601049 Name: MONIL SONI

Time: 90 minutes Max Points: 115

IMPORTANT NOTE:
1. There are six pages make sure that you have them all in your set.
2. You need to answer all questions in question paper itself.
3. Write answers neat and clean. Over-writing is not allowed.

Marks

1	2	3	4	5	6	7	8	9	
7½	19.5	5	10.5	5	5	10	7.5	20	~~20~~

90

1. Tick the correct option (there can be multiple options be correct; check them all) – [10]

1 i. Unbound cursor can be bound with dynamic query <Yes/No>

½ ii. TP_OP is a <implicit local variable/implicit parameter variable/global variable/ no such variable>

1 iii. Embedded SQL provides an environment in which SQL statements are sent to DBMS for execution <Yes/No/both-depends on configuration>

1 iv. Using "CREATE ASSERTION", we can create constraints that span to multiple tables <True/False/No such command>

2 v. In case of B+-tree based index, index scan mean "sequential scan of leaf nodes" <True/False/No such operation>

2 vi. Heap files are roughly good for operations <INSERT/DELETE/SEACRH>

1 vii. Secondary index can be <dense/clustered/b+-tree/sparse>

1 viii. Participation of a weak entity with identifying relationship is always total [True/False]

1 ix. Bloated index refers to index having <too much void spaces in blocks/ too much overflow/index corrupted /all of these>

1 x. Materialized view hold data <true/false> _____

If yes, what data? Data obtained by querying the 'view' query statement

2. Fill in the blanks-

[30]

i. Which property of schedule ensures **Isolation** Serializability

ii. Which property of schedule ensures **Atomicity** Recoverability

iii. Which property of schedule ensures **Durability** Recoverability

iv. Weak entity is the one that needs attribute from some other table to uniquely identify tuples

v. Which SQL Isolation level may cause Dirty Read Read uncommitted

vi. Advantage of strict 2PL over standard 2PL doesn't let you release lock without committing or aborting ⇒ no dirty reads

vii. Referential Integrity constraint requires that referred tuple must exist in the referenced table

viii. Prepared statement helps in executing same query with diff parameters

ix. Entity Integrity constraint requires that primary key must uniquely identify tuple.

x. **CallableStatement** object in JDBC is used for stored procedure execution

xi. System logs helps in recovering from crash

xii. Write Ahead Logging Protocol is used for recoverability

xiii. Noted problem in basic Snapshot Isolation is concurrent starting may lead to unwanted results.

xiv. Main problem in 2PL protocol is deadlock

xv. Name one of the procedural data manipulation language
PostgreSQL

xvi. Can you determine Normal form of relation R(AB), in absence of FD information. Note that, no information does not mean NO FD; if yes what is NF? NO

xvii. Main problem with basic time stamp ordering techniques is ~~sup~~ cannot support multiple transactions at once. & read gets blocked sometimes

xviii. What is the name of technique that is used for avoiding cascaded rollbacks
Locking

xix. What is highest SQL isolation level that has Phantom row problem Nonrepeatable reads

xx. One of the most important advantage of sql views is
abstraction over classified data.

Student ID: 201601049 Name: MONIL SONI

3. Consider following keys; Primary Key(PK), Key(K), Candidate Key(CK), Super Key (SK), and choose which symbols is most appropriate to be placed in the blank space (⊆ or ⊇ or =) below. [5]

   i. CK ___=___ K

   ii. CK ___⊆___ SK

   iii. K ___⊆___ SK

   iv. PK ___=___ K

   v. PK ___=___ CK

4. Give short answers -

   i. Translate following SQL query in terms of relational algebra: [3]

```
SELECT * FROM EMPLOYEE WHERE SSN IN
                (SELECT DISTINCT ESSN FROM DEPENDENT)
```

3

$$result \leftarrow \pi_{e.*}\,(EMPLOYEE_e \underset{e.ssn = d.essn}{\underline{\text{SEMI-JOIN}}} DEPENDENT_d)$$

   ii. Consider relation R(A, B, C) and set of FDs { {A → B}, {B → C}}; can you find out a join dependency here. [3]

If (a, b) exists and (b, c) exists in the decomposed relations, then ~~(a, c) must~~ (a, b, c) must exist in original rel^n.

   iii. Given, A → B and XB → C, prove that XA → C. [3]

$$A \rightarrow B \models AX \rightarrow \cancel{AB}\ XB$$

$$\cancel{AX \rightarrow AB}$$

$$\{XA \rightarrow XB,\ XB \rightarrow C\} \models XA \rightarrow C$$

3

   iv. Suppose Employee relation has B+-tree index on DNO. Compute approximately execution cost of query "SELECT * FROM EMPLOYEE WHERE DNO=5"? May express in terms number of block read/writes, and assume other parameters! [3]

$$H + \lceil B/2 \rceil$$

H: height of index tree

B: number of blocks in the file

3

v. Suppose you have following query to be executed
$\sigma_{SALARY>30000 \wedge DNO=5}(EMPLOYEE)$
What could be best strategy to execute this query. [3]

0

min { $\sigma_{SALARY>30000}$ ($\sigma_{DNO=5}$ (EMPLOYEE)), #
$\sigma_{DNO=5}$ ($\sigma_{SALARY>30000}$ (EMPLOYEE)) }

vi. Compute Join selectivity of join EMPLOYEE JOIN DEPARTMENT ON DNO. What is "Join Selectivity" of the JOIN? May assume other parameters [3]

$1\frac{1}{2}$

Join selectivity = $\frac{N_E}{N_E \times N_D}$ N_E : no of records in employee
N_D : no of records in dept.

5. Suppose following schedule is executed by interleaving operations from transactions T1 and T2. What kind of concurrency problem do you see in following schedule? Give short reason. [5]

```
T1: Read X
T1: X = X + 50
T1: Write X
T2: Read X  // T2 reading uncommitted data.
T2: X = X + 100
T2: Write X
T1: Abort
T2: Commit
```

5

Dirty Read.
T2 reads data(X) which was written by T1. Since T1 then aborts its updates were supposed to be not taken into consideration, which doesn't happen here since T2 reads from those same updates & commits.

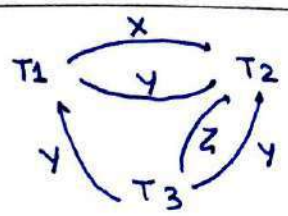
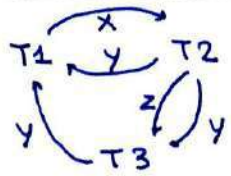
6. Is the schedule given in previous question is recoverable? Give short reason. [5]

No. For a schedule to be recover T2 should not be able to read/write data until T1 commits. This is the recoverability principle.

5

7. Consider the three transactions T1, T2, and T3, and the schedules S1 and S2 given below. Draw the serializability (precedence) graphs for S1 and S2, and state whether each schedule is serializable or not. If a schedule is serializable, write down the equivalent serial schedule(s).

[10]

S1: r3(Y); r3(Z); r1(X); w1(X); w3(Y); w3(Z); r2(Z); r1(Y); w1(Y); r2(Y); w2(Y); r2(X); w2(X);	S2: r2(Z); r2(Y); w2(Y); r3(Y); r3(Z); r1(X); w1(X); w3(Y); w3(Z); r2(X); r1(Y); w1(Y); w2(X);
 T3; T1; T2 5	 Not serializable 5

10

8. Consider following schedule executed on PostgreSQL. Assume that initial salary for employee with SSN 123 is 40000. [Here labels T1 and T2 against statements indicate Transaction that is issuing the statement.] What will be shown by SELECT statements at line numbers 3, 5, 7, 10 if transaction T2 is specified to execute at READ COMMITTED isolation level and SERIALIZABLE isolation level?

[6+6]

```
1  T1: begin;
2  T1: update employee set salary = salary+3000 where ssn = 123;
3  T1: select salary from employee where ssn = 123;
4  T2: begin;
5  T2: select salary from employee where ssn = 123;
6  T2: update employee set salary=salary+5000 where ssn = 123;
7  T2: select salary from employee where ssn = 123;
8  T1: commit;
9  T2: commit;
10 T1: select salary from employee where ssn = 123;
```

43000

7½

READ COMMITTED level	SERIALIZABLE level
Line 3: 43000 ✓	Line 3: 43000 ✓
Line 5: 40000 ✓	Line 5: 40000 ✓
Line 7: 45000 ✗	Line 7: 45000 ✗
Line 10: 48000 ✓	Line 10: Error ✗

Roll No. (ID) 201601049 Name: MONIL SONI

9. Suppose following attributes are drawn from a sales/purchase system of trading company.

Sales_bill_no, sales_bill_date, customer_no, customer_name, item_no, item_name, quantity_in_stock, quantity_in_bill, item_rate, item_rate_in_bill, item_category, item_category_sales_tax_rate, supplier_id, supplier_name, purchase_bill_no, purchase_bill_date, quantity_in_purchase_bill, item_rate_in_purchase_bill, average_purchase_price

Assume that: (1) there is only one supplier for each ~~item~~ purchase bill, (2) an item comes only once in a bill (3) there is only one customer for a sales bill (4) sales tax rate in a bill depends on item category (5) a sales bill contains all items of same category.

Your tasks here are following - [10+10]

i. Identify Minimal FD Set

ii. Give normalized relations that are in BCNF. Specify Keys and FKs also.

FDs

sales_bill_no → {sales_bill_date, customer_no, ~~customer_name~~}

customer_no → customer_name

item_no → {item_name, quantity_in_stock, item_rate, item_category, average_purchase_price}

{sales_bill_no, item_no} → {quantity_in_bill, item_rate_in_bill}

supplier_id → supplier_name

item_category → item_category_sales_tax_rate

purchase_bill_no → {supplier_id, purchase_bill_date, quantity_in_purchase_bill}

{purchase_bill, item_no} → item_rate_in_purchase_bill

10

Relations

R_1(sales_bill_no, sales_bill_date, customer_no) FK: customer_no

R_2(customer_no, customer_~~date~~ name)

R_3(item_no, item_name, quantity_in_stock, item_rate, item_category, average_purchase_price) FK: item_category

R_4(sales_bill_no, item_no, quantity_in_bill, item_rate_in_bill) FK: sales_bill_no FK: item_no

R_5(supplier_id, supplier_name)

R_6(item_category, item_category_sales_tax_rate)

R_7(purchase_bill_no, supplier_id, purchase_bill_date, quantity_in_purchase_bill) FK: supplier_id

R_8(purchase_bill, item_no, item_rate_in_purchase_bill) FK: purchase_bill FK: item_no.

10

CT303 - Digital Communications
Autumn 2019/20

In-Sem 1 — 6th September 2019
Duration: 90 minutes — Total Marks 20

Note: You may use any result/example derived/stated in class/lab without proof.

1. Assume that you are sitting at a point on the rim of a Ferris wheel, as you did in Lab-1. The only difference is that, the Ferris wheel is a *nested* one, i.e., a second wheel rotates about its center c_1 which is fixed on the rim of the first one (and moves with the first wheel), and a third wheel rotates about its center c_2 which is fixed on the rim of the second wheel (and moves with the first and second wheel). The wheels are each of radius r_0, r_1, r_2, each completing one rotation in $T, \frac{T}{2}, \frac{T}{4}$ seconds respectively with constant velocity, and center of the first wheel c_0 is fixed at the point $(0, h)$. Each wheel rotates in the direction indicated in Figure 1, and you are seated on the rim of the third wheel. **[3+1]**

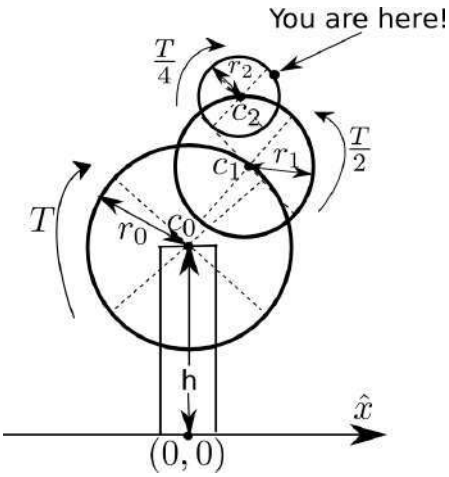


Figure 1: Nested Ferris wheel. Assume $\hat{y}$ along the height of the Ferris wheel, and $h > r_0 + r_1 + r_2$.

   (a) Assuming any starting position you want (draw it), describe your (x, y) position as a function of time.

   (b) What is the Nyquist sampling rate for sampling these functions.

2. Short Questions (and short answers):

   (a) Let $X(t)$ be a stochastic process with ACF $R_X(\tau) = k\delta(\tau)$, $\tau \in \mathbb{R}$, where $k \in \mathbb{R}$ is some positive constant. Find an LTI system (i.e. specify its impulse response h) such that if X is given as an input, the output stochastic process Y has a cross-correlation with the input X given by $R_{YX}(\tau) = \frac{1}{2}\cos(\tau), \tau \in \mathbb{R}$. **[2]**

   (b) Let $X(t)$ be a zero-mean White Gaussian stationary process with PSD N_0. Compute the variance of $X(t)$. **[2]**

   (c) Let $\eta(t)$ be a stationary zero-mean stochastic process that models noise. Let it contaminate a known but arbitrary deterministic signal $s(t)$ to yield the noisy signal (stochastic process) $Z(t) = s(t) + \eta(t)$. Find whether $Z(t)$ is stationary or not. **[1]**

(d) Verify if the following functions are valid autocorrelation functions defined on $\mathbb{R}$ with justification. (a) $R_x(\tau) = \exp(-\tau)$, (b) $R_x(\tau) = (sinc(\tau T))^2$, (c) $R_x(\tau) = rect(\frac{\tau}{T})$. **[3]**

(e) Given a noiseless channel with bandwidth W Hz, state with justification the theoretical maximum symbol rate in symbols/sec that the channel can support? What about the maximum data rate in bits/sec? **[2]**

3. Consider a binary PCM signalling scheme with waveforms s_1 (for bit 0) and either s_2 or s_3 (for bit 1) as shown in Figure 2 below. For each waveform, determine the expression of the matched filter impulse response. On the receiver end, the bit transmitted is estimated based on which of the two matched filter produces a higher output every T seconds. Assume same prior probabilities, AWGN noise with PSD $\frac{N_0}{2}$ Watts/Hz and no inter-symbol interference. Compute the probability of error of the receiver with the matched filters (maybe in terms of the Q function, if possible), and decide which of the two waveforms s_2 and s_3 will you choose to represent bit 1. **[6]**

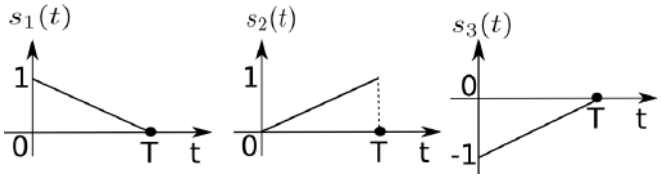


Figure 2: Binary PCM signaling. What will you prefer, $\{s_1, s_2\}$ or $\{s_1, s_3\}$?

Brief Solutions

1. Ferris Wheel:

   (a) Let $c_i(t), i = 0, 1, 2$ denote the coordinated of the center of the ith Ferris wheel. Coordinates of your position $p(t)$ is then given by $p(t) = r_2(\cos\left(\frac{8\pi t}{T}\right), -\sin\left(\frac{8\pi t}{T}\right)) + c_2(t)$. Similarly, $c_2(t) = r_1(\cos\left(\frac{4\pi t}{T}\right), \sin\left(\frac{4\pi t}{T}\right)) + c_1(t)$, and $c_1(t) = r_0(\cos\left(\frac{2\pi t}{T}\right), -\sin\left(\frac{2\pi t}{T}\right)) + c_0$. Thus,

$$\begin{aligned} p(t) =& r_2(\cos\left(\frac{8\pi t}{T}\right), -\sin\left(\frac{8\pi t}{T}\right)) \\ &+ r_1(\cos\left(\frac{4\pi t}{T}\right), \sin\left(\frac{4\pi t}{T}\right)) \\ &+ r_0(\cos\left(\frac{2\pi t}{T}\right), -\sin\left(\frac{2\pi t}{T}\right)) + (0, h). \end{aligned}$$

   (b) Nyquist sampling rate: $f_s = \frac{8}{T}$ Hz.

2. Short Questions.

   (a) $R_{YX}(\tau) = (h * R_X)(\tau)$. Thus $h(t) = \frac{1}{2k}\cos(\tau)$.

   (b) $\sigma^2 = \mathbb{E}[X_t X_t] = R_X(0) = \int_{-\infty}^{\infty} |G_x(f)|\, df$. Given that $G_x(f) \equiv N_0$, $\sigma^2 = \infty$.

   (c) $\mathbb{E}[Z(t_1)] = \mathbb{E}[s(t_1) + \eta(t_1)] = s(t_1)$, while $\mathbb{E}[Z(t_2)] = \mathbb{E}[s(t_2) + \eta(t_2)] = s(t_2)$. Since $s(t_1) \neq s(t_2)$, $Z(t)$ is not a stationary stochastic process.

   (d) Valid autocorrelation functions. (a) Invalid, since $R_X(-1) > R_X(0)$. (b) Valid, since $R_X(0) \geq RX(\tau), \forall\tau$, $R_X(\tau) = R_X(-tau)$, $G_X(f)$ is the triangle hat/tent function, which is non-negative and real. (c) Invalid, since $G_X(f)$ is the sinc function, which is negative at several frequencies.

   (e) As already shown in class, given a noiseless channel with bandwidth W Hz, it can support $2W$ symbols/sec using sinc pulses. Since no constraint if given on the receiver, each symbol can encode infinitely many bits, and thus there is no upper bound for the bit rate.

   (f) Matched filter:
   $h_1(t) = s_1(T-t) = s_2(t) = \frac{t}{T}, \forall t \in [0, T]$, $h_2(t) = s_2(T-t) = s_1(t) = 1 - \frac{t}{T}, \forall t \in [0, T]$, $h_3(t) = s_3(T-t) = -s_1(t) = \frac{t}{T} - 1, \forall t \in [0, T]$. Note that $|H_1(f)| = |H_2(f)| = |H_3(f)|$. Thus noise power at the output of the filter is the same for all three matched filters. Let z_1, z_2, z_3 represent the output of the three corresponding filters sampled at time T. The distributions of the three random variables are: $z_1 \sim \mathcal{N}(a_{11}, \sigma_0) + \mathcal{N}(a_{12}, \sigma_0)$ or $z_1 \sim \mathcal{N}(a_{11}, \sigma_0) + \mathcal{N}(a_{13}, \sigma_0)$, where σ_0 is the noise output power, and a_{ij} is the output of filter i when the received signal is purely $s_i(t)$. Since energy of the three symbols is the same $a_{11} = a_{22} = a_{33}$. Similarly, $z_2 \sim \mathcal{N}(a_{21}, \sigma_0) + \mathcal{N}(a_{22}, \sigma_0)$, and $z_3 \sim \mathcal{N}(a_{31}, \sigma_0) + \mathcal{N}(a_{33}, \sigma_0)$. For symbols s_1, s_2 the probability of error is $p(e) = 0.5p(z_1 < z_2|s_1) + 0.5p(z_1 > z_2|s_2) = p(z_1 < z_2|s_1)$, which in turn will depend on the difference between a_{11} and a_{21}. Similarly, for the symbol set s_1, s_3, the probability of error will depend on the difference between a_{33} and a_{31}, which is greater than the difference between a_{22} and a_{21}. Thus the symbol set s_1, s_3 will have a lesser probability of error.

CT303 - Digital Communications
Autumn 2019/20

In-Sem 2 — 22nd October 2019
Duration: 90 minutes — Total Marks 25

1. Which among the two equalization filters: Zero forcing solution and Minimum Mean-Square error solution is better? Justify and provide any assumptions made. **[3]**

2. Let $s_1(t) = \sqrt{\frac{2E}{T}}\cos(\omega_0 t), s_2(t) = \sqrt{\frac{E}{T}}\cos(\omega_0 t + \frac{3\pi}{4}), 0 \leq t \leq T$ be the two waveforms to be used for Binary bandpass communication. The demodulation/detection is to be performed using a coherent demodulator/detector shown in Figure 1 below, with matched filter impulse response $h(t) = \sqrt{\frac{2}{T}}\cos(\omega_0 t)$. Assuming prior probabilities for

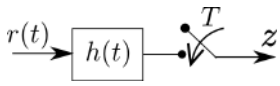


Figure 1: Coherent Demodulator/Detector.

bits 0 and 1 to be the same, find the optimal threshold γ to be used on z for detection, and compute/comment on the bit-error probability under AWGN assumption. **[4]**

3. Answer the following questions with short justifications. **[3 × 6 = 18]**

   (a) Let $s_1(t) = \cos(2\pi 100t), s_2(t) = \cos(2\pi 110t), 0 \leq t \leq 0.05$ secs be two waveforms. In terms of the bit-error performance, should we be using a coherent or non-coherent binary OFSK demodulation/detection? What if the second waveform is changed to $s_2(t) = \cos(2\pi 120t)$ for the same T?

   (b) Data generated at a rate 1024 bits/second is to be transmitted using M-ary PSK with M = 4, and carrier frequency $f_0 = 1$ MHz. What is the theoretical minimum channel bandwidth required to support this communication without introducing ISI?

   (c) In binary OFSK modulation schemes with minimum separation, two carrier frequencies are used, say f_1, f_2 Hz. The OFSK signal at any time will contain only these two frequencies. Does the bandwidth of the OFSK signal then depend on the data rate?

   (d) The worst performing digital communication system is one with a bit-error probability 1. Is that right? Justify.

   (e) A waveform $p(t)$ with Fourier transform $P(f)$ is shown in Figure 2 below. Assuming a channel bandwidth of $\frac{1}{T}$ Hz, will there be any ISI?

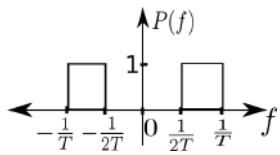


Figure 2: Fourier transform $P(f)$ of the waveform $p(t)$.

   (f) In DBPSK quadrature demodulator, one needs to compute the phase for each waveform using $\phi = \tan^{-1}\left(\frac{y}{x}\right)$. The range of $\tan^{-1}$ is known to be $[-\pi/2, \pi/2]$. How can we resolve this issue? Do not simply state MATLAB functions that do the job, explain how is this handled.

Solutions

1. The equations to solve in order to determine the filter coefficients (with length $2N+1$) for the Zero forcing solution and the MMSE solution are

$$\tilde{X}_{2N+1\times 2N+1}c = \tilde{z}_{2N+1}$$
$$X^T_{2N+1\times 4N+1}X_{4N+1\times 2N+1}c = X^T z_{4N+1},$$

respectively. The matrix X contains entries from samples of a single received waveform. In the Zero-forcing solution, the filter coefficients are based only on a single measurement. The filter may not perform the desired task for a different waveform since noise statistics do not play any role in determining the filter coefficients. For the MMSE solution, under the assumption of ergodicity (which in turn assumes stationarity), the matrix $X^T X$ is the autocorrelation matrix of the sampled received waveform that incorporates the statistics, and thus minimizes the error (between lhs and rhs) in the mean square sense. The zero-forcing solution also suffers from noise amplification around close-to-zero channel response frequencies. Thus, MMSE is a better solution under the assumption of ergodicity.

2. Since matched filters compute projections, $a_1 = \mathbb{E}[z_1] = \langle s_1, h\rangle = \sqrt{E}$, while $a_2 = \mathbb{E}[z_2] = \langle s_2, h\rangle = \sqrt{\frac{E}{2}}\cos(\frac{3\pi}{4}) = -\frac{\sqrt{E}}{2}$. Thus, the optimal threshold under the assumption of equi-probable symbols is $\gamma = \frac{a_1+a_2}{2} = \frac{\sqrt{E}}{4}$. The bit-error probability is $Pb = Q\left(\frac{a_1-a_2}{2\sigma_0}\right) = Q\left(\frac{3\sqrt{E}}{4\sigma_0}\right)$, which is higher when compared to antipodal signals $s_1 = \sqrt{\frac{2E}{T}}\cos(w_0 t)$ and $\tilde{s}_2 = -\sqrt{\frac{2E}{T}}\cos(w_0 t)$ in which case $P_B = Q\left(\frac{\sqrt{E}}{\sigma_0}\right)$.

   (a) Minimum frequency difference for coherent OFSK is $\frac{1}{2T}$, while that for non-coherent OFSK is $\frac{1}{T}$. Since $T = 0.05$, $\frac{1}{T} = 20$. Thus in the first case, only coherent OFSK can be used. In the second case, one can use both, coherent or non-coherent OFSK, but as far as bit-error performance is concerned, coherent detection performs better. If simplicity of implementation is the main concern, one should use non-coherent OFSK.

   (b) Since the bit-rate is 1024 bps, and QPSK transmits 2 bits per symbol, the QPSK symbol-rate is $R = 512$ symbols/sec. For bandpass modulation, the minimum bandwidth is $W = R$ (considering $r = 0$), thus the minimum required bandwidth is $W = 512$ Hz.

   (c) For coherent and non-coherent OFSK, the minimum frequency separation is $f_{min} \propto \frac{1}{T}$. Moreover the data-rate $R = \frac{1}{T}$, thus $f_{min} \propto R$. Thus the bandwidth increases with R. Moreover note that for each symbol duration of T secs, a particular carrier, f_1 or f_2 is transmitted. The waveform that is transmitted is $p_i(t) = \cos(2\pi f_i t)rect(t/T)$. Smaller the duration T, larger will be the bandwidth occupied by $p_i(t)$.

   (d) Incorrect. If the bit error probability is known to be 1, then by taking the complement of each bit, all bits would be correctly detected implying the bit error probability to be 0. Thus, the worst bit-error rate is 0.5.

   (e) The Nyquist pulse shaping equation is $\sum_{n\in\mathbb{Z}} P(f - nR) = T$. As can be verified, the given pulse satisfies the criteria (assume $T = 1$).

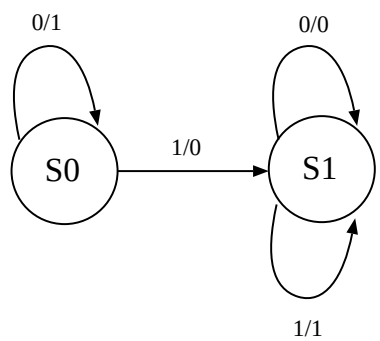
   (f) The range of $\tan^{-1}$ is $(-\frac{\pi}{2}, \frac{\pi}{2})$ and BPSK detection cannot be done. In computing $\tan -1(y/x)$, if both x and y are known, the angle ϕ can be correctly computed over a range $[-\pi, \pi)$ from the signs of x and y.

Introduction to Digital Design
SAMPLE FINAL EXAM
- Solutions –

Problem 1. (10 points)

a) Give a state diagram and state/output table of a Mealy machine which implements the following behavior:

$$z(t) = \begin{cases} x'(t) & \text{if } x(t) = 0 \text{ and } x(k) = 0 \text{ for all } k < t \\ 0 & \text{if } x(t) = 1 \text{ and } x(k) = 0 \text{ for all } k < t \\ x(t) & \text{otherwise} \end{cases} \tag{1}$$



PS	x=0	x=1
S0	S0,1	S1,0
S1	S1,0	S1,1
	NS,z	

b) Illustrate the time behavior for the input sequence shown bellow. Assume that $x(k) = 0$ for $k < 0$.

t	0	1	2	3	4	5	6
$x(t)$	0	0	1	0	1	1	0
$z(t)$	1	1	0	0	1	1	0

c) Is this a finite-memory system? Explain your answer.

No; the output cannot be determined from the last m inputs for any fixed integer m.

Problem 2. (8 points)

Find an equivalent finite state machine with a minimum number of states. Show all partitions and the minimal state table.

PS	$x = 0$	$x = 1$
A	E,0	C,0
B	C,0	A,0
C	B,0	G,0
D	G,0	A,0
E	F,1	B,0
F	E,0	D,0
G	D,0	G,0

The partitions are:

P1 = (A B C D F G)(E)

P2 = (A F)(B C D G)(E)

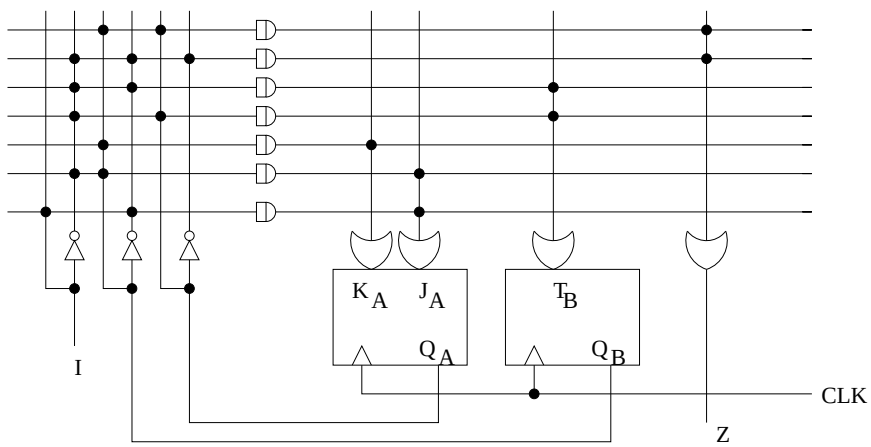
P3 = (A F)(B D)(C G)(E)

P4 = (A)(F)(B D)(C G)(E) = P5

The minimal state table is:

PS	$x = 0$	$x = 1$
A	E,0	C,0
B	C,0	A,0
C	B,0	C,0
E	F,1	B,0
F	E,0	B,0

Problem 3. (10 points) Derive the state transition/output table for the implementation of the finite state machine shown in the figure below. The next state and output functions are implemented by a PLA structure. The machine has one input I and one output Z. Show expressions for the flip-flop inputs.



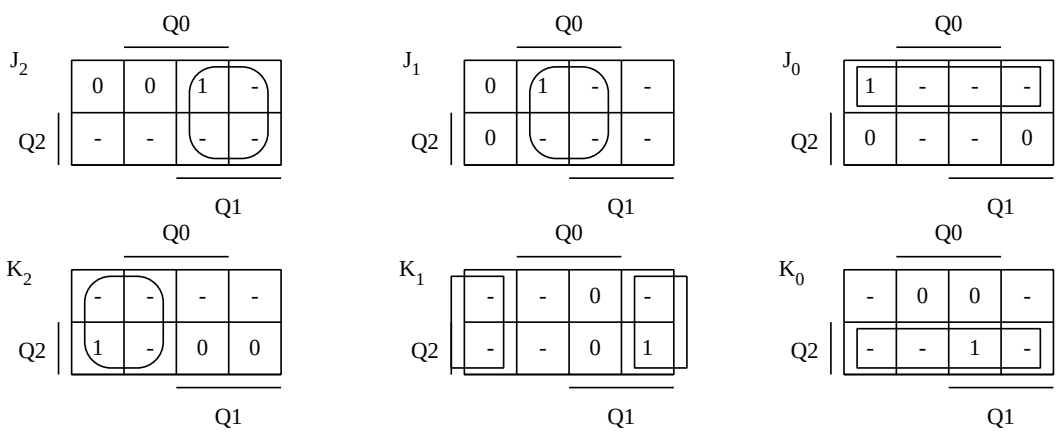
$$
\begin{aligned}
J_A &= Q_B I' + Q'_B I \\
K_A &= Q_B \\
T_B &= Q'_B I' + Q_A I' \\
Z &= Q_A Q_B + Q'_A Q'_B I'
\end{aligned}
$$

PS($Q_A Q_B$)	I	J_A	K_A	T_B	NS	Z
00	0	0	0	1	01	1
00	1	1	0	0	10	0
01	0	1	1	0	11	0
01	1	0	1	0	01	0
10	0	0	0	1	11	0
10	1	1	0	0	10	0
11	0	1	1	1	00	1
11	1	0	1	0	01	1

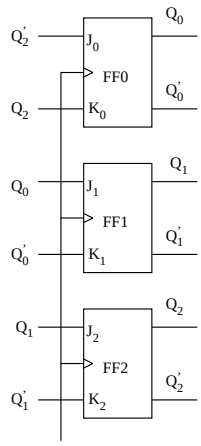
Problem 4. (14 points) (a) Design a cyclic counter with the output sequence $0, 1, 3, 7, 6, 4, 0, 1, \ldots$ (of period 6) using JK flip-flops and AND, OR, NOT gates if needed. Assume that the input $x = 1$ always. Select a state assignment that is the same as the coding for the output, that is $z(t) = s(t)$. Show the state/output table. Minimize all expressions. Show the logic diagram of the counter.

State/output table:

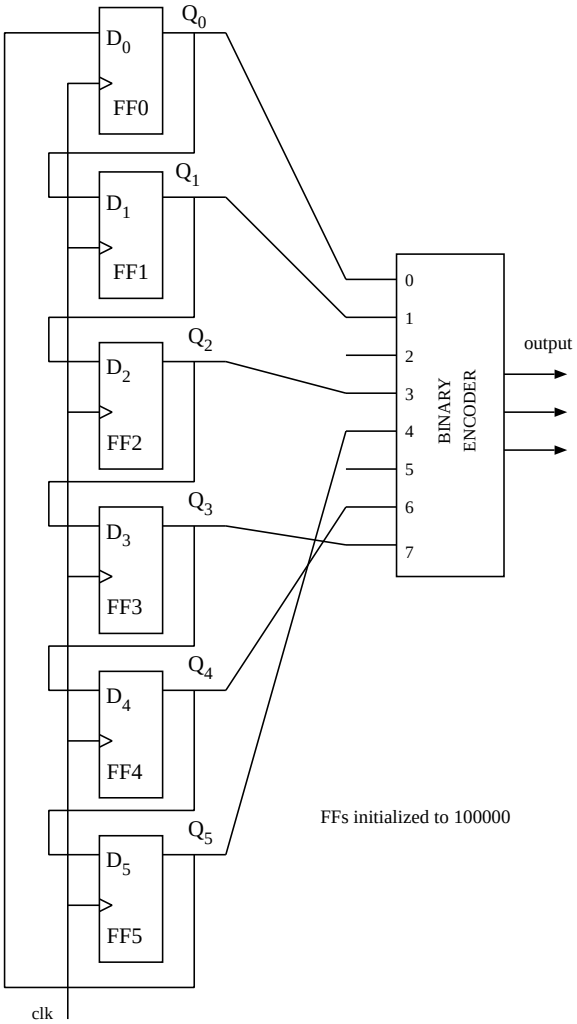
PS	NS	J_2K_2	J_1K_1	J_0K_0
000	001	0-	0-	1-
001	011	0-	1-	-0
010	—	–	–	–
011	111	1-	-0	-0
100	000	-1	0-	0-
101	—	–	–	–
110	100	-0	-1	0-
111	110	-0	-0	-1



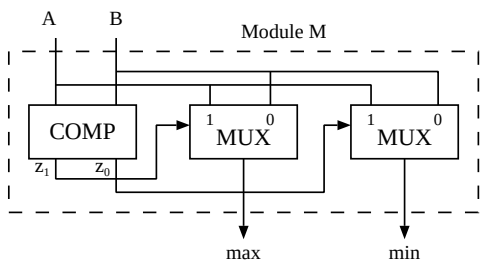
$J_0 = Q_2'$ $K_0 = Q_2$ $J_1 = Q_0$ $K_1 = Q_0'$ $J_2 = Q_1$ $K_2 = Q_1'$

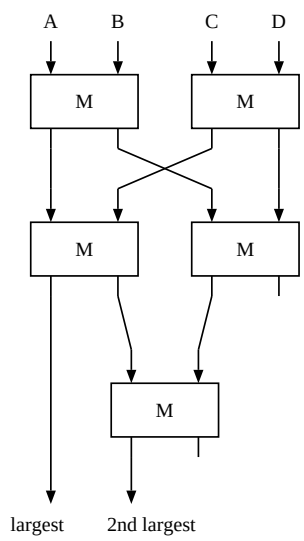


Problem 4 (cont.) (b) Design the cyclic counter defined in part (a) using the "one flip-flop per state" approach with D flip-flops. To obtain the output, use a 8-input binary encoder. Show all connections. How is the counter initialized?


Q0
D0
FF0
Q1
D1
FF1
Q2
D2
FF2
Q3
D3
FF3
Q4
D4
FF4
Q5
D5
FF5
clk
0
1
2
3
4
5
6
7
BINARY
ENCODER
output
FFs initialized to 100000

Problem 5. (10 points) Design a combinational network that finds the largest and the second largest of four nonnegative integers A, B, C, D. Each integer is represented by four bits. You may use only the following module types: 4×2-input multiplexer and four-bit comparator. The two-bit output of the comparator is $z = (z_1, z_0)$. If the first integer is larger than the second, the output is $z = 10$. If the second number is larger, the output is $z = 01$ and if the numbers are equal, the output is $z = 00$). Indicate all inputs and connections on the modules being used.





Problem 6. (8 points)

a) Complete the following table assuming true-and-complement number systems. If there is a problem in completing the table, explain. All implicit and explicit values are given in the decimal number system.

Number system	Number of digits n	Signed integer x	Representation value x_R	Digit-vector X
2's compl.	7	-39	89	1011001
1s' compl.	8	-89	167	10100111
2's compl.	9	-220	292	100100100
2's compl.	6	-43	NA	NA

b) Compute $z = a + 2b - c$ in 2's complement for $a = -7$, $b = 12$, and $c = -97$. Perform calculations on bit-vectors representing a, b and c and show every step of your work. How many bits should z have to represent the correct result? Check your work by showing, for each step, the corresponding values in decimal number system.

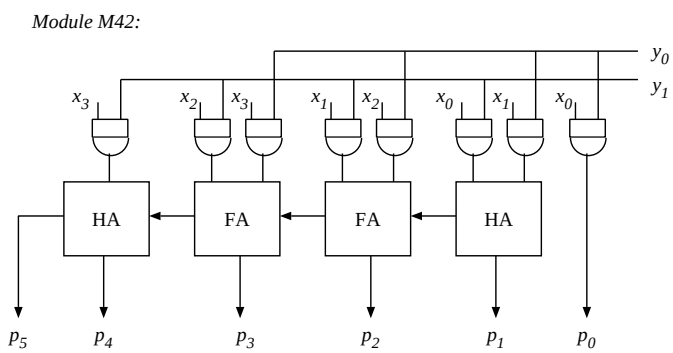
a =	111001	(-7)
b =	001100	(12)
2b=	011000	(24)
c =	10011111	(-97)
a+2b =	010001	(17)
z=a+2b-c =	01110010	(114)

The result z has 8 bits.

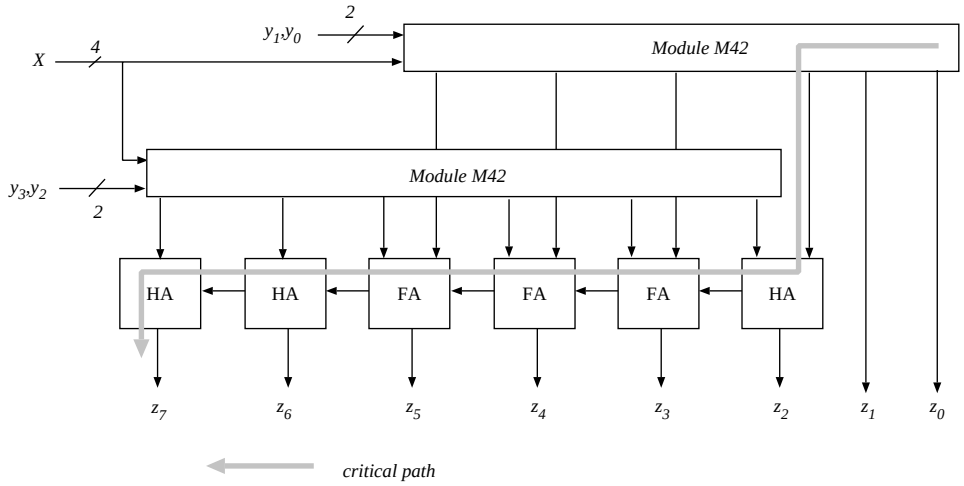
Problem 7. (10 points)

a) Design a 4-bit by 2-bit multiplier module M42. The operands are positive: the multiplicand is $X = (x_3, x_2, x_1, x_0)$, the multiplier is $Y = (y_1, y_0)$, and the product $p = (p_5, ..., p_0)$. You are allowed to use AND gates, full-adders (FA) and half-adders (HA) only.

		x_3	x_2	x_1	x_0
				y_1	y_0
		x_3y_0	x_2y_0	x_1y_0	x_0y_0
	x_3y_1	x_2y_1	x_1y_1	x_0y_1	
p_5	p_4	p_3	p_2	p_1	p_0



b) Using two M42 modules from part a), and extra full-adders (FA) and half-adders (HA), design a 4 by 4 multiplier. Show clearly all modules and connections. Label the inputs and outputs assuming $X = (x_3, x_2, x_1, x_0)$ and $Y = (y_3, y_2, y_1, y_0)$ as inputs and Z bit-vector as the output. Make the design as fast and simple as possible.



c) Determine the critical path in the 4 by 4 multiplier and its delay. Assume that the low to high and high to low propagation delays are the same. For AND gate, the delay is t_g. The sum and carry-out delays of the full-adder are $t_s = t_c = t_f$ and of the half-adder t_h.

$T_{critical_path} = t_g + 4t_h + 4t_f$

Problem 8. (10 points)

Design a sequential system specified by the following state transition and output table using a modulo-8 counter with parallel load as the state register, a 8-to-1 multiplexer for the CNT input and NAND gates. Assume LD = CNT'. The design must take advantage of the count and parallel mode capabilities of the counter. Show all your work.

	PS $Q_2Q_1Q_0$	Input $x=0$	Input $x=1$
S_0	000	000,0	001,0
S_1	001	000,0	010,0
S_2	010	000,0	011,0
S_3	011	100,0	011,0
S_4	100	101,0	001,0
S_5	101	000,1	001,0
		NS, z	NS, z

don't care counter states: S_6 and S_7

$CNT = S_0x + S_1x + S_2x + S_3x' + S_4x' \quad LD = CNT'$

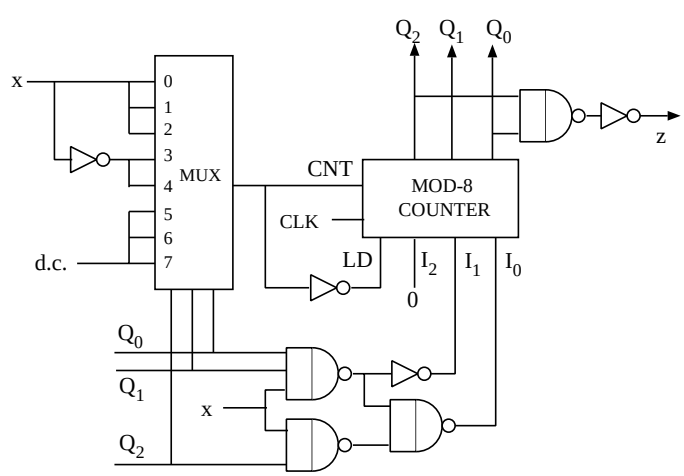
$I_2I_1I_0$

000 if $S_1x' + S_5x' + S_0x'$

001 if $S_4x + S_5x$

011 if S_3x

$I_2 = 0 \quad I_1 = S_3x = Q_1Q_0x \quad I_0 = (Q_2 + Q_1Q_0)x \quad z = Q_2Q_0x'$



COE/EE 243 **From Fall 98**

Sample Final Exam
Solutions

Show your work. Do **NOT** use a calculator!

1. (9 pts) Complete the following table of equivalent values.

Binary	Octal	Decimal	Hexadecimal
1011.0011	13.14	11.1875	B.3
11101.11111101	35.77	29.99	1D.FD
11011.010011	33.23	$27\frac{19}{64}$	1B.4C

2. (12 pts) Calculate the following
   a) $(11001)_2$ plus $(101)_2$ $= 11110$
   b) $(11010)_2$ minus $(10101)_2$ using 1's complement representation $= 000101$
   c) $(1101)_2$ times $(1001)_2$ $= 1110101$
   d) $(101101)_2$ divided by $(110)_2$ $= 111.1$

3. (9 pts) Complete the following table of equivalent values. Use binary numbers with a sign bit and 5 bits for the value

Decimal	Signed Magnitude	Two's Complement	One's Complement
-11	101011	110101	110100
-2	100010	111110	111101
-1	100001	111111	111110

4. (8 pts) Give the Characteristic equations and the Excitation tables for the *SR* and *JK* flip-flops.

SR flip-flop

$$Q+ = S + R'Q$$

S	R	Q	Q+
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	-
1	1	1	-

JK flip-flop

$$Q+ = JQ' + K'Q$$

J	K	Q	Q+
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

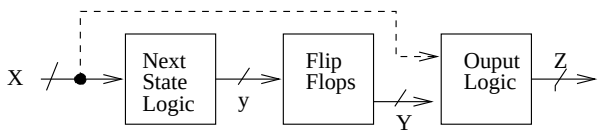
5. (10 pts) (a) Explain the difference between a **Moore** machine and a **Mealy** machine.

   Sol The outputs in a Moore machine depend only on the present state. The outputs in a Mealy machine depend on both the present state and the present input.

   (b) What is the same about both kinds of state machines?

   Sol Both have present state dependent on past inputs.

   (c) Draw a block diagram indicating the structure of a general state machine. Indicate on the diagram where one can find the **present state** and **next state**.



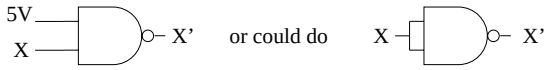
6. (5 pts) Give a truth table and a standard sum of products expression that describes $F = A \oplus B \oplus C$

A	B	C	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

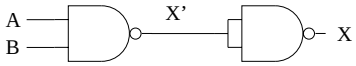
$$F = AB'C' + A'B'C + A'BC' + ABC$$

7. (8 pts) Indicate how a Nand gate can be used to implement:

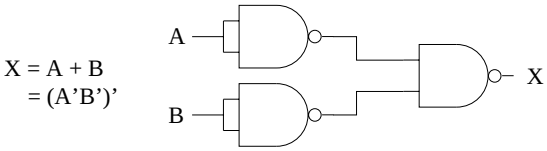
   (a) An Inverter:



   (b) An And Gate:

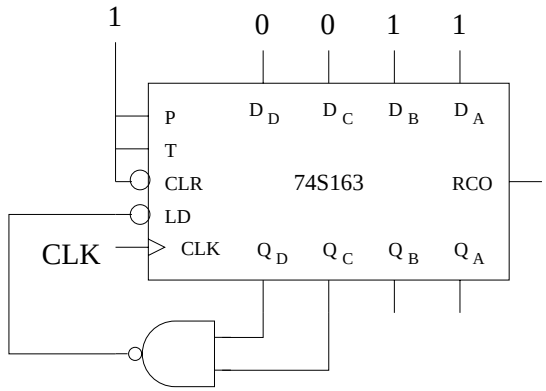


   (c) An Or Gate:



   (d) Because a Nand gate can be used to implement all three basic Boolean functions, how would we describe it? **Functionally Complete**

8. (8 pts) Using the 74ALS163 counter shown below and logic gates design a counter that counts in the sequence 3,4, 5, 6, 7, 8, 9, 10, 11, 12, 3, ... Connect all unused inputs. The counter may cycle through several unwanted states before settling into the final count sequence. Q_d is the MSB of the counter output.



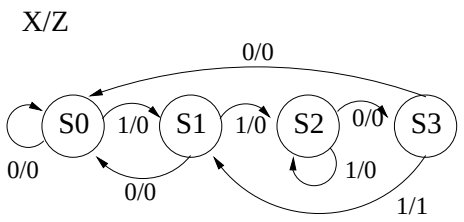
9. (6 pts) Find a minimum sum of products expresssion for $F = abc' + bc'd' + cd + a'b$

f: ab \ cd	00	01	11	10
00	0	0	1	0
01	1	1	1	1
11	1	1	1	0
10	0	0	1	0

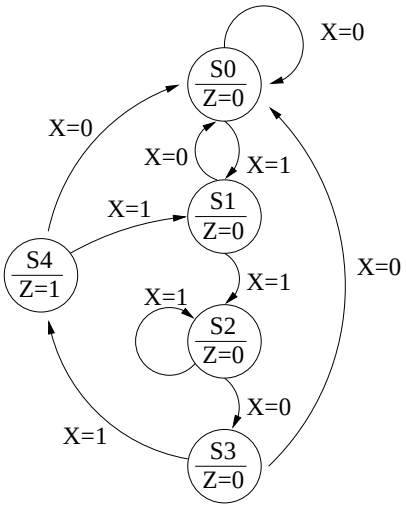
F = a'b + cd + bc'

10. (10 pts) Create a state diagram for a sequence detector that outputs a 1 when it detects the final bit in the serial data stream 1101.

Mealy Machine



Moore Machine



11. (10 pts) Determine the D flip-flop excitation equations for the system represented with in the state-transition table below. Assign states: $S0 = 00$, $S1 = 01$, $S2 = 10$ and $S3 = 11$.

Present **AB**	Present S	Next State X=0	Next State X=1	Output Z
00	S0	S1	S2	0
01	S1	S1	S2	1
10	S2	S2	S3	1
11	S3	S3	S0	0

Da

X \ AB	00	01	11	10
0	0	0	1	1
1	1	1	0	1

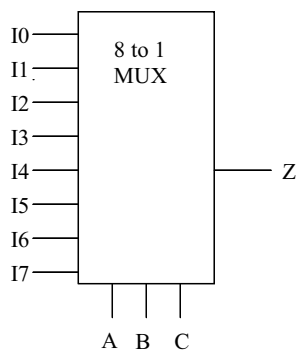
Da = X'A + XA' + { AB' / XB'

Db

X \ AB	00	01	11	10
0	1	1	1	0
1	0	0	0	1

Db = XAB' + X'A' + X'B

12. (5 pts) Give the output expression for the 8-to-1 MUX shown below.



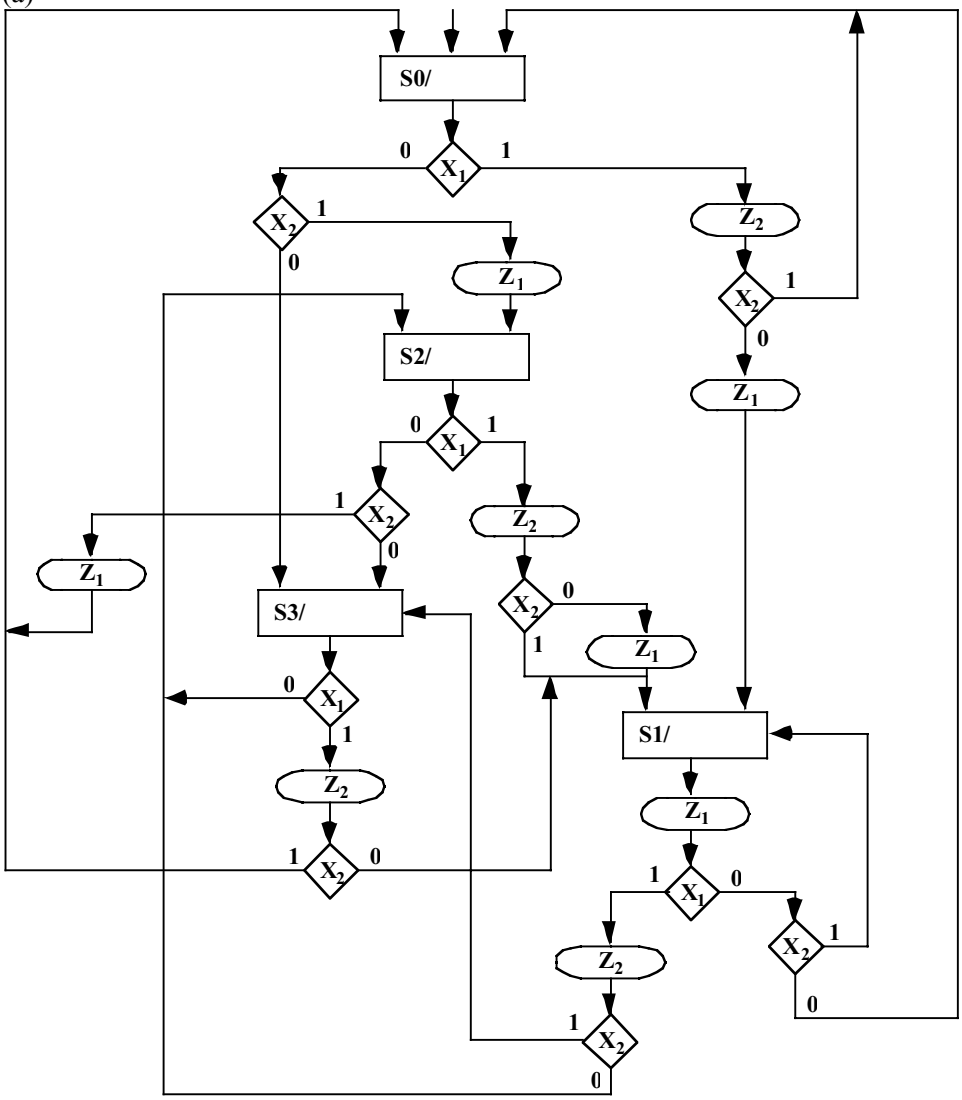
$$Z = A'B'C'I0 + A'B'CI1 + A'BC'I2 + A'BCI3 + AB'C'I4 + AB'CI5 + ABC'I6 + ABCI7$$

The University of Alabama in Huntsville
Electrical & Computer Engineering
CPE/EE 422/522
Spring 2004
Homework #5 Solution

5.1 (a) Construct an SM chart equivalent to the following state table. Test only one variable in each decision box. Try to minimize the number of decision boxes.
(b) Write a VHDL description of the state machine based on the SM chart.

Present		Next State					Output Z_1Z_2			
State	X_1X_2=	00	01	10	11	X_1X_2=	00	01	10	11
S0		S3	S2	S1	S0		00	10	11	01
S1		S0	S1	S2	S3		10	10	11	11
S2		S3	S0	S1	S1		00	10	11	01
S3		S2	S2	S1	S0		00	00	01	01

(a)



(b)

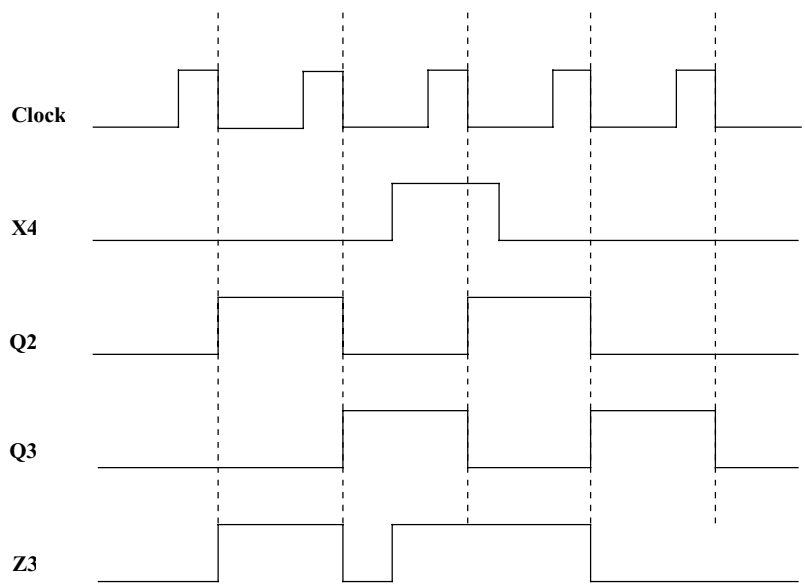
```
entity 5_1 is
  port (CLK, X1, X2 : in bit;
        Z1, Z2 ; out bit);
end 5_1;

architecture Smbehave of 5-1 is
  type states is {S0, S1, S2, S3};
  signal state, next_state : states;
begin
  process (X1, X2, state)
  begin
    Z1 <= ‘0’;  Z2 <= ‘0’;
    case state is
      when S0 => if (X1 = ‘0’) then
                   if (X2 = ‘0’) then
                     next_state <=  S3;
                   else
                     next_state <= S2;
                   end if;
                 else
                   if (X2 = ‘0’) then
                     Z1 <= ‘1’;
                     Z2 <= ‘1’;
                     next_state <= S1;
                   else
                     Z2 <= ‘1’;
                     next_state <= S0;
                   end if
                 end if;
      when S1 => if (X1 = ‘0’) then
                   Z1 <= ‘1’;
                   if (X2 = ‘0’) then
                     next_state <=  S0;
                   else
                     next_state <= S1;
                   end if;
                 else
                   Z1 <= ‘1’; Z2 <= ‘1’;
                   if (X2 = ‘0’) then
                     next_state <= S2;
                   else
                     next_state <= S3;
                   end if
                 end if;
      when S2 => if (X1 = ‘0’) then
                   if (X2 = ‘0’) then
                     next_state <=  S3;
                   else
                     Z1 <= ‘1’;
                     next_state <= S0;
                   end if;
                 else
                   next_state <= S1;
                   Z2 <= ‘1’
                   if (X2 = ‘0’) then
                     Z1 <= ‘1’;;
```

```
                    end if
                  end if;
      when S3 => if (X1 = '0') then
                    next_state <= S2;
                  else
                    if (X2 = '0') then
                      Z2 <= '1';
                      next_state <= S1;
                    else
                      Z2 <= '1';
                      next_state <= S0;
                    end if
                  end if;
    end case;
  end process;
  process (CLK)
  begin
    if (CLK = '1' and CLK'event) then
      state <= next_state;
    end if;
  end process;
end Smbehave;
```

5.6 For the given SM chart:

(a) Complete the following timing diagram (assume that X1 = 1, X2 = 0, X3 = 0, X5 = 1, and X4 is as shown)/ Flip-flops change state on falling edge of clock.



10.1 (a) Determine the necessary inputs to the following network to test for u stuck-at-0.
(b) For this set of inputs, determine which other stuck-at faults can be tested.
(c) Repeat (a) and (b) for r stuck-at-1.

(a) & (b)	A	B	C	D	Faults Tested
	d	1	0	1	u s-a-0, b s-a-0, d s-a-0, w s-a-0
	d	1	1	0	u s-a-0, b s-a-0, c s-a-0, w s-a-0
	d	1	1	1	u s-a-0

(c)	A	B	C	D	Faults Tested
	0	1	0	0	a s-a-1, c s-a-1, d s-a-1, q s-a-1, r s-a-1, u s-a-1, v s-a-1, w s-a-1, p s-a-0

10.3 For the following network, find a minimum number of test vectors that will test all s-a-0 and s-a-1 faults at the AND and OR gate inputs. For each test vector, specify the values of A, B, C, and D, and the stuck-at faults that are tested.

A	B	C	D	Faults Tested
0	1	d	1	k s-a-0, l s-a-0, m s-a-0, r s-a-0, z s-a-0
1	1	0	d	e s-a-0, f s-a-0, g s-a-0, p s-a-0, z s-a-0
1	0	1	d	h s-a-0, i s-a-o, j s-a-0 , q s-a-0, z s-a-0
0	0	1	1	h s-a-1, l s-a-1, p s-a-1, q s-a-1, r s-a-1, z s-a-1
0	1	0	0	e s-a-1, m s-a-1, p s-a-1, q s-a-1, r s-a-1, z s-a-1
1	0	0	d	f s-a-l, j s-a-1, p s-a-1, q s-a-1, r s-a-1, z s-a-1
1	1	1	1	g s-a-1, i s-a-1, k s-a-1, p s-a-1 , q s-a-1, r s-a-1, z s-a-1

10.7 State graphs for two sequential machines are given below. The first graph represents a correctly functioning machine, and the second represents the same machine with a malfunction. Assuming that the two machines can be reset to their starting states (S0 and T0), determine the shortest input sequence that will distinguish the two machines.

Input:	0	0	0	1	1	1	1
Correct Output:	1	1	1	0	0	0	1
Incorrect Output:	1	1	1	0	0	0	0

Q-1 (a) Whether the quadratic form

$f: -x_1^2 + 4x_1x_2 - 9x_2^2 + 2x_1x_3 + 8x_2x_3 - 4x_3^2$ is positive definite / negative definite / indefinite ? Give reason.

Sol^n The matrix of the quadratic form is

$$A = \begin{bmatrix} -1 & 2 & 1 \\ 2 & -9 & 4 \\ 1 & 4 & -4 \end{bmatrix}$$ (1)

$A_1 = -1 < 0$

$A_2 = \begin{vmatrix} -1 & 2 \\ 2 & -9 \end{vmatrix} = 9 - 4 = 5 > 0$ ($1\frac{1}{2}$)

$A_3 = \begin{vmatrix} -1 & 2 & 1 \\ 2 & -9 & 4 \\ 1 & 4 & -4 \end{vmatrix} = -1(36-16) - 2(-8-4) + 1(8+9)$

$= -20 + 24 + 17 = 21 > 0$

So the matrix A is indefinite matrix

Hence the quadratic form f is also indefinite.

Q-1 (b) Find the stationary points of $f = x^3 - 3xy^2$ and identify their nature

Sol^n

$$\frac{\partial f}{\partial x} = 0 \Rightarrow 3x^2 - 3y^2 = 0 \Rightarrow x = \pm y \quad \text{--- (1)}$$

$$\frac{\partial f}{\partial y} = 0 \Rightarrow -6xy = 0 \quad \text{--- (2)}$$

$$\Rightarrow x = 0 \text{ or } y = 0 \qquad \left(\tfrac{1}{2}\right)$$

From (1) & (2) we have $x = y = 0$

$(0,0)$ is the stationary point.

$$\text{Hess} f\Big|_{(0,0)} = \begin{bmatrix} \frac{\partial^2 f}{\partial x^2} & \frac{\partial^2 f}{\partial x \partial y} \\ \frac{\partial^2 f}{\partial y \partial x} & \frac{\partial^2 f}{\partial y^2} \end{bmatrix} \text{ at } (0,0)$$

$$= \begin{bmatrix} 6x & -6y \\ -6y & -6x \end{bmatrix} \text{ at } (0,0) \qquad \left(\tfrac{1}{2}\right)$$

$$= \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \text{ which is semi-definite.}$$

We have to compute $d^3 f\big|_{(0,0)}$

$$d^3 f\Big|_{(0,0)} = \sum_{i=1}^{2}\sum_{j=1}^{2}\sum_{k=1}^{2} h_i h_j h_k \frac{\partial^3 f}{\partial x_i \partial x_j \partial x_k}(0,0)$$

(1)

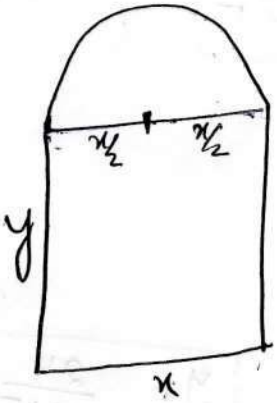
$$= h_1 h_1 h_1 \frac{\partial^3 f}{\partial x^3} + 2h_1 h_1 h_2 \frac{\partial^3 f}{\partial x^2 \partial y} + h_1 h_2^2 \frac{\partial^3 f}{\partial x \partial y^2}$$

$$+ h_2 h_1 h_1 \frac{\partial^3 f}{\partial y \partial x^2} + 2 h_2 h_1 h_2 \frac{\partial^3 f}{\partial y^2 \partial x} + h_2 h_2 h_2 \frac{\partial^3 f}{\partial y^3}$$

As $\frac{\partial^3 f}{\partial x^3} = 6 \neq 0$ So $d^3 f\big|_{(0,0)} \neq 0$ 3 is odd. So $(0,0)$ is a saddle point.

Q.2 A window is being built, the bottom is a rectangle and the top is a semi-circle. If there are 12 meters of framing materials available. What will be the dimensions of the window so that it can allow maximum light?

Sol^n



We want to maximize the area to allow maximum light

$$\text{Maximize } f = xy + \frac{1}{2}\pi\left(\frac{x}{2}\right)^2 = xy + \frac{\pi x^2}{8} \quad \text{—— (1)}$$

$$\text{subject to } 2(x+y) + \pi\frac{x}{2} = 12 \quad \text{—— (2)}$$

$$\Rightarrow \frac{4x+4y+\pi x}{2} = 12 \Rightarrow (4+\pi)x + 4y = 24$$

$$\Rightarrow 4y = 24 - (4+\pi)x$$

$$\Rightarrow y = \frac{1}{4}(24 - 4x - \pi x) = 6 - x - \frac{\pi}{4}x$$

New objective function after putting the value of y in (1) becomes

$$f = x\left(6 - x - \frac{\pi}{4}x\right) + \frac{\pi}{8}x^2$$

$$= 6x - x^2 - \frac{\pi}{4}x^2 + \frac{\pi}{8}x^2 = 6x - x^2 - \frac{\pi}{8}x^2$$

$$f'(x) = 6 - 2x - \frac{\pi}{4}x = 0 \Rightarrow \left(2 + \frac{\pi}{4}\right)x = 6$$

$$\Rightarrow x = \frac{6}{(2+\pi/4)} = \frac{6}{\frac{8+\pi}{4}} = \frac{24}{8+\pi}.$$

is the stationary or critical point

$f''(x) = -2 - \frac{2\pi}{8} < 0$

So $x = \frac{24}{8+\pi}$ corresponds to maximum value to the objective function f

$$\boxed{x = \frac{24}{8+\pi}}, \quad y = 6 - x - \frac{\pi x}{4}$$

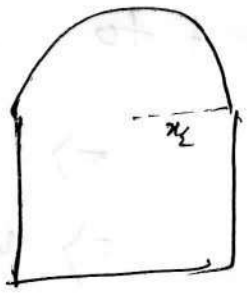
$$= 6 - \frac{24}{8+\pi} - \frac{\pi}{4}\frac{24}{(8+\pi)}$$

$$= \frac{24(8+\pi) - 96 - 24\pi}{4(8+\pi)}$$

$$= \frac{192 + \cancel{24\pi} - 96 - \cancel{24\pi}}{4(8+\pi)} = \frac{96}{4(8+\pi)} = \frac{24}{8+\pi}$$

$$\boxed{y = \frac{24}{8+\pi}}$$

$$\boxed{r = \frac{x}{2} = \frac{12}{8+\pi}}$$



OR

Maximize $f = xy + \frac{1}{2}\pi\left(\frac{x}{2}\right)^2$

$= xy + \frac{\pi x^2}{8}$ — (1)

subject to $2y + x + \pi\frac{x}{2} = 12$

$\Rightarrow 2y = 12 - x - \frac{\pi x}{2} = \frac{24 - 2x - \pi x}{2}$

$= 12 - x - \frac{\pi}{2}x$

$\Rightarrow y = 6 - \frac{x}{2} - \frac{\pi}{4}x$

putting the value of y in (1)

$$f = x\left(6 - \frac{x}{2} - \frac{\pi}{4}x\right) + \frac{\pi x^2}{8} = 6x - \frac{x^2}{2} - \frac{\pi}{4}x^2 + \frac{\pi x^2}{8}$$

$$= 6x - \frac{x^2}{2} - \frac{\pi}{8}x^2$$

Q-2 OK continued: - -

$$f'(x) = 6 - x - \frac{\pi}{8}\cdot 2x = 0$$

$$\Rightarrow 6 - x - \frac{\pi}{4}x = 0 \quad \Rightarrow \quad x(1+\pi/4) = 6$$

$$\Rightarrow x = \frac{6}{1+\pi/4} = \frac{6}{\frac{4+\pi}{4}} = \frac{24}{4+\pi}$$

stationary point

2

2

$$f''(x) = -1 - \pi/4 < 0$$

So $x = \frac{24}{4+\pi}$ corresponds to maximum value of f.

So $\boxed{x = \frac{24}{4+\pi}}$

$$y = 6 - \frac{x}{2} - \frac{\pi}{4}x = 6 - \frac{24}{2(4+\pi)} - \frac{\pi}{4}\cdot\frac{24}{4+\pi}$$

1

$$= 6 - \frac{12}{4+\pi} - \frac{6\pi}{4+\pi} = \frac{6(4+\pi) - 12 - 6\pi}{4+\pi}$$

$$= \frac{24 + \cancel{6\pi} - 12 - \cancel{6\pi}}{4+\pi} = \frac{12}{4+\pi}$$

$$\boxed{y = \frac{12}{4+\pi}}$$

1.68

$$\boxed{r = \frac{x}{2} = \frac{12}{4+\pi}}$$

Q.3 Using KKT conditions find the value(s) of β for which the point $x_1^* = 1$, $x_2^* = 2$ will be an optimal solution to the problem

$$\text{Maximize } f(x_1, x_2) = 2x_1 + \beta x_2$$

$$\text{subject to} \quad x_1^2 + x_2^2 \le 5, \quad x_1 - x_2 \le 2.$$

Sol^n $(x_1^*, x_2^*) = (1, 2)$

$$g_1(x_1, x_2) = x_1^2 + x_2^2 - 5 \le 0$$

$$g_2(x_1, x_2) = x_1 - x_2 - 2 \le 0$$

$g_1(1,2) = 0$, So g_1 is active at $(1,2)$

$g_2(1,2) \neq 0$, So g_2 is not active at $(1,2)$

So KKT Conditions are

$$\frac{\partial f}{\partial x_1} + \lambda_1 \frac{\partial g_1}{\partial x_1} = 0 \Rightarrow 2 + 2\lambda_1 x_1 = 0 \quad \text{—} (1)$$

$$\frac{\partial f}{\partial x_2} + \lambda_1 \frac{\partial g_1}{\partial x_2} = 0 \Rightarrow \beta + 2\lambda_1 x_2 = 0 \quad \text{—} (2)$$

From (1) $\lambda_1 x_1 = -1 \Rightarrow \lambda_1 = -1$ at $(1,2)$

From (2) $\beta + 2\lambda_1 x_2 = 0 \Rightarrow \beta + 2(-1) \times 2 = 0$

$$\Rightarrow \boxed{\beta = 4}$$

$\lambda_1 < 0$.

Q.4 Solve the following problem by the method of Lagrange multipliers

Minimize $f(X) = \frac{1}{2}(x_1^2+x_2^2+x_3^2)$

subject to $g_1(X) = x_1 - x_2 = 0$

$g_2(X) = x_1+x_2+x_3-1 = 0$

Sol^n

$$L(x_1, x_2, x_3, \lambda_1, \lambda_2) = f + \lambda_1 g_1 + \lambda_2 g_2$$

$$= \frac{1}{2}(x_1^2+x_2^2+x_3^2) + \lambda_1(x_1-x_2) + \lambda_2(x_1+x_2+x_3-1)$$

$\frac{\partial L}{\partial x_1} = 0 \Rightarrow x_1+\lambda_1+\lambda_2 = 0$ — (1)

$\frac{\partial L}{\partial x_2} = 0 \Rightarrow x_2-\lambda_1+\lambda_2 = 0$ — (2)

$\frac{\partial L}{\partial x_3} = 0 \Rightarrow x_3+\lambda_2 = 0$ — (3)

$\frac{\partial L}{\partial \lambda_1} = 0 \Rightarrow x_1-x_2 = 0$ — (4)

$\frac{\partial L}{\partial \lambda_2} = 0 \Rightarrow x_1+x_2+x_3-1 = 0$ — (5)

From eq^n (3), $\lambda_2 = -x_3$

From eq^n (1) + (2), $x_1+x_2+2\lambda_2 = 0$

$\Rightarrow \lambda_2 = -\frac{(x_1+x_2)}{2}$

$\Rightarrow -x_3 = -\frac{(x_1+x_2)}{2}$

$\Rightarrow x_3 = \frac{x_1+x_2}{2}$

$\Rightarrow x_1+x_2-2x_3 = 0$ — (6)

From eqn (4), (5) and (6)

$$x_1 - x_2 = 0 \quad -(4)$$
$$x_1 + x_2 + x_3 - 1 = 0 \quad -(5)$$
$$x_1 + x_2 - 2x_3 = 0 \quad -(6)$$

$(5)-(6) \Rightarrow \quad 3x_3 - 1 = 0 \Rightarrow 3x_3 = 1 \Rightarrow x_3 = \frac{1}{3}$

From eqn (4) and (6)

$$x_1 - x_2 = 0 \quad -(7)$$
$$x_1 + x_2 = \frac{2}{3} \quad -(8)$$

$(7)+(8) \quad \Rightarrow \quad 2x_1 = \frac{2}{3} \Rightarrow x_1 = \frac{1}{3}$

2.5 From (7) $x_2 = \frac{1}{3}$

$$\boxed{x_1 = x_2 = x_3 = \frac{1}{3}}$$

Sufficient condition:

$$\begin{vmatrix} L_{11}-\alpha & L_{12} & L_{13} & g_{11} & g_{21} \\ L_{21} & L_{22}-\alpha & L_{23} & g_{12} & g_{22} \\ L_{31} & L_{32} & L_{33}-\alpha & g_{13} & g_{23} \\ g_{11} & g_{12} & g_{13} & 0 & 0 \\ g_{21} & g_{22} & g_{23} & 0 & 0 \end{vmatrix} = 0 \quad \text{——— (A)}$$

$L_{11} = \frac{\partial L}{\partial x_1^2} = 1 \qquad L_{12} = \frac{\partial L}{\partial x_1 \partial x_2} = 0 = L_{21}$

$L_{13} = \frac{\partial L}{\partial x_1 \partial x_3} = 0 = L_{31} \qquad L_{22} = \frac{\partial L}{\partial x_2^2} = 1$

$L_{23} = \frac{\partial L}{\partial x_2 \partial x_3} = 0 = L_{32} \qquad L_{33} = \frac{\partial L}{\partial x_3^2} = 1$

$$g_{11} = \frac{\partial g_1}{\partial x_1} = 1 \qquad g_{21} = \frac{\partial g_2}{\partial x_1} = 1$$

$$g_{12} = \frac{\partial g_1}{\partial x_2} = -1 \qquad g_{22} = \frac{\partial g_2}{\partial x_2} = 1$$

$$g_{3} = \frac{\partial g_1}{\partial x_3} = 0 \qquad g_{23} = \frac{\partial g_2}{\partial x_3} = 1$$

(A) becomes

$$\begin{vmatrix} \begin{bmatrix} 1-\alpha & 0 & 0 \\ 0 & 1-\alpha & 0 \\ 0 & 0 & 1-\alpha \end{bmatrix} & \begin{bmatrix} 1 & 1 \\ -1 & 1 \\ 0 & 1 \end{bmatrix} \\ \begin{bmatrix} 1 & -1 & 0 \\ 1 & 1 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{vmatrix} = 0$$

$\Rightarrow$ ~~$\det\begin{pmatrix} A & B \\ C & 0 \end{pmatrix}$~~

$$(1-\alpha) \begin{vmatrix} \begin{pmatrix} 1-\alpha & 0 \\ 0 & 1-\alpha \end{pmatrix} & \begin{pmatrix} -1 & 1 \\ 0 & 1 \end{pmatrix} \\ \begin{pmatrix} -1 & 0 \\ 1 & 1 \end{pmatrix} & \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix} \end{vmatrix} - 1 \begin{vmatrix} 0 & 1-\alpha & 0 & 1 \\ 0 & 0 & 1-\alpha & 1 \\ 1 & -1 & 0 & 0 \\ 1 & 1 & 1 & 0 \end{vmatrix}$$

$$+1 \begin{vmatrix} 0 & 1-\alpha & 0 & 1 \\ 0 & 0 & 1-\alpha & 0 \\ 1 & -1 & 0 & 0 \\ 1 & 1 & 1 & 0 \end{vmatrix} = 0$$

~~$(1-\alpha)\det(AD-BC)$~~

$$\Rightarrow (1-\alpha)\left[(1-\alpha)\begin{vmatrix} 1-\alpha & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{vmatrix} - 1\begin{vmatrix} 0 & 1-\alpha & 1 \\ -1 & 0 & 0 \\ 1 & 1 & 0 \end{vmatrix} + 1\begin{vmatrix} 0 & 1-\alpha & 0 \\ -1 & 0 & 0 \\ 1 & 1 & 0 \end{vmatrix}\right)$$

$$-1\left[-(1-\alpha)\begin{vmatrix} 0 & 1-\alpha & 1 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \end{vmatrix} - 1\begin{vmatrix} 0 & 0 & 1-\alpha \\ 1 & -1 & 0 \\ 1 & 1 & 1 \end{vmatrix}\right)$$

$$+1\left[-(1-\alpha)\begin{vmatrix} 0 & 1-\alpha & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \end{vmatrix} - (-1)\begin{vmatrix} 0 & 0 & 1-\alpha \\ 1 & -1 & 0 \\ 1 & 1 & 1 \end{vmatrix}\right] = 0$$

$$\Rightarrow (1-\alpha)\left[(-1)\left[-(1-\alpha)(0) + 1(-1-0)\right] - 1\left[0\right]\right]$$

$$+1\left[-(1-\alpha)\left\{1(1-0)\right\} - 1\left\{(1-\alpha)(1+1)\right\}\right]$$

$$+1\left[-(1-\alpha)\times 0 + 1\left((1-\alpha)(1+1)\right)\right] = 0$$

$$\Rightarrow (1-\alpha)(+1) - 1\left[-(1-\alpha) - 2(1-\alpha)\right] + 1\left[2(1-\alpha)\right] = 0$$

$$\Rightarrow (1-\alpha) + (1-\alpha) + 2(1-\alpha) + 2(1-\alpha) = 0$$

$$\Rightarrow 6(1-\alpha) = 0 \Rightarrow 1-\alpha = 0 \Rightarrow \alpha = 1 > 0$$

corresponds to minimum value

(1.8) So $x_1 = \frac{1}{3} = x_2 = x_3$

$$\text{Min } f = \frac{1}{2}\left(\frac{1}{9}+\frac{1}{9}+\frac{1}{9}\right) = \frac{1}{2}\left(\frac{3}{9}\right) = \frac{1}{2}\times\frac{1}{3} = \frac{1}{6}$$

(Ans)

Q.5 Minimize $f = (x_1-2)^2+(x_2-1)^2$

subject to $2 \geq x_1+x_2$

$x_2 \geq x_1^2$

Using KKT conditions, find which of the following vectors is/are local minima.

$X_1 = \begin{pmatrix} 1.5 \\ 0.5 \end{pmatrix}$, $X_2 = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$.

Sol^n Consider $X_1 = \begin{pmatrix} 1.5 \\ 0.5 \end{pmatrix}$

$f = (x_1-2)^2+(x_2-1)^2$

$g_1 = x_1+x_2-2 \leq 0$

$g_2 = x_1^2-x_2 \leq 0$

At the point $X_1 = \begin{pmatrix} 1.5 \\ 0.5 \end{pmatrix}$, g_1 is active, g_2 is inactive.

$L = f+\lambda_1 g_1 = (x_1-2)^2+(x_2-1)^2+\lambda_1(x_1+x_2-2)$

$\frac{\partial L}{\partial x_1} = 0 \Rightarrow 2(x_1-2)+\lambda_1 = 0$ — (1)

$\frac{\partial L}{\partial x_2} = 0 \Rightarrow 2(x_2-1)+\lambda_1 = 0$ — (2)

$\frac{\partial L}{\partial \lambda_1} = 0 \Rightarrow x_1+x_2-2 = 0$ — (3)

From (1) and (2)

$\lambda_1 = -2(x_1-2) = -2(x_2-1)$

$\Rightarrow x_1-2 = x_2-1 \Rightarrow x_1 = x_2+1$

Putting in (3) $x_2+1+x_2-2 = 0 \Rightarrow 2x_2 = 1 \Rightarrow \boxed{x_2 = \frac{1}{2}}$

$\boxed{x_1 = 3/2}$

$\lambda_1 = -2(x_1-2) = -2(\frac{3}{2}-2) = -2(-\frac{1}{2}) = +1 \geq 0$

But this $(x_1, x_2) = (1.5, 0.5)$ ~~corresponds to~~ ~~minimum value of f~~ does not satisfy the constraint g_2

2.5

$X_1 = \begin{pmatrix} 1.5 \\ 0.5 \end{pmatrix}$ is not a local minimum.

<u>Next point $X_2 = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$</u>

At $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$ both g_1 and g_2 are active.

$$L = f + \lambda_1 g_1 + \lambda_2 g_2$$
$$= (x_1-2)^2 + (x_2-1)^2 + \lambda_1(x_1+x_2-2) + \lambda_2(x_1^2-x_2)$$

$$\frac{\partial L}{\partial x_1} = 0 \Rightarrow 2(x_1-2) + \lambda_1 + 2\lambda_2 x_1 = 0 \quad \text{— (1)}$$

2.5

$$\frac{\partial L}{\partial x_2} = 0 \Rightarrow 2(x_2-1) + \lambda_1 - \lambda_2 = 0 \quad \text{— (2)}$$

$$\frac{\partial L}{\partial \lambda_1} = 0 \Rightarrow x_1 + x_2 - 2 = 0 \quad \text{— (3)}$$

$$\frac{\partial L}{\partial \lambda_2} = 0 \Rightarrow x_1^2 - x_2 = 0 \quad \text{— (4)}$$

At the point $(1,1)$

(1) $\Rightarrow$ $-2 + \lambda_1 + 2\lambda_2 = 0 \Rightarrow \lambda_1 + 2\lambda_2 = 2$ — (5)

(2) $\Rightarrow$ $\lambda_1 - \lambda_2 = 0 \Rightarrow \lambda_1 - \lambda_2 = 0$ — (6)

Solving (5) and (6), we get

$\lambda_1 + 2\lambda_1 = 2 \Rightarrow 3\lambda_1 = 2$

$\Rightarrow \lambda_1 = \frac{2}{3} > 0$

$\lambda_2 = \frac{2}{3} > 0$

Also All the constraints are satisfied

$(1, 1)$ corresponds to local minimum.

Q.6 Find the admissible and constrained variations at the point $X = (0,4)^T$ for the following problem

$$\text{Minimize } f = x_1^2 + (x_2 - 1)^2$$

$$\text{subject to } -2x_1^2 + x_2 = 4.$$

Sol^n

$$g(x_1, x_2) = -2x_1^2 + x_2 - 4 = 0$$

$$X^* = \begin{pmatrix} 0 \\ 4 \end{pmatrix}$$

dx_1 and dx_2 will be admissible and constrained variations at X^* if

$$g(X^* + dX) = 0$$

By Taylor's series

$$g(X^* + dX) = g(X^*) + d\,g(X^*)$$

$$= 0 + \frac{\partial g}{\partial x_1} dx_1 + \frac{\partial g}{\partial x_2} dx_2 \Big|_{(0,4)}$$

$$= -4x_1\, dx_1 + dx_2 \Big|_{(0,4)}$$

$g(X^* + dX)$ will be 0 when $dx_2 = 0$

and dx_1 is any arbitrary value.

as $x_1^* = 0$

Admissible variations

$$\begin{cases} dx_1 & \text{arbitrary} \\ dx_2 = 0 \end{cases}$$

Problem Set 1

1. Find the maxima and minima, if any, of the function
   $f(x) = 4x^3 - 18x^2 + 27x - 7$.

2. Verify whether the following matrices is positive definite, negative definite, or indefinite.

   (a) $\begin{pmatrix} 3 & 1 & -1 \\ 1 & 3 & -1 \\ -1 & -1 & 5 \end{pmatrix}$

   (b) $\begin{pmatrix} 4 & 2 & -4 \\ 2 & 4 & -2 \\ -4 & -2 & 4 \end{pmatrix}$

   (c) $\begin{pmatrix} -1 & -1 & -1 \\ -1 & -2 & -2 \\ -1 & -2 & -3 \end{pmatrix}$

3. Determine whether each of the following quadratic form is positive definite, negative definite, or neither

   (a) $f = x^2 - y^2$

   (b) $f = 4xy$

   (c) $f = x^2 + 2y^2$

   (d) $f = -x^2 + 4xy + 4y^2$

   (e) $f = -x^2 + 4xy - 9y^2 + 2xz + 8yz - 4z^2$

4. Match the following equations and their characteristics.

(a) $f = 4x - 3y + 2$	Relative maximum at $(1, 2)$
(b) $f = (2x - 2)^2 + (x - 2)^2$	Saddle point at origin
(c) $f = -(x - 1)^2 - (y - 2)^2$	No minimum
(d) $f = xy$	Inflection point at origin
(e) $f = x^3$	Relative minimum at $(1, 2)$

5. State whether each of the following functions is convex, concave, or neither.

   (a) $f = -2x^2 + 8x + 4$

(b) $f = x^2 + 10x + 1$

(c) $f = x^2 - y^2$

(d) $f = -x^2 + 4xy$

(e) $f = e^{-x},\ x > 0$

(f) $f = \sqrt{x},\ x > 0$

(g) $f = xy$

(h) $f = (x-1)^2 + 10(y-2)^2$

6. Find the third-order Taylor's series approximation of the function $f(x, y, z) = y^2 z + xe^z$ at the point $(1, 0, -2)$.

7. Find the dimensions of a closed cylindrical soft drink can, that can hold soft drink of volume V for which the surface area (including top and bottom) is minimum.

8. An open rectangular box is to be manufactured from a given amount of sheet metal (area S). Find the dimensions of the box to maximize the volume.

9. Find the dimensions of a straight beam of circular cross section that can be cut from a conical log of height h and base radius r to maximize the volume of the beam.

10. Find the value of x, y and z that maximize the function $f(x, y, z) = \frac{6xyz}{x+2y+2z}$, where x, y and z are restricted by the relation $xyz = 16$.

11. Minimize

$$f(X) = \frac{1}{2}(x_1^2 + x_2^2 + x_3^2)$$

subject to the constraints

$$g_1(X) = x_1 - x_2 = 0$$
$$g_2(X) = x_1 + x_2 + x_3 = 1.$$

* Optimization

→ Problem Set 1

— Mann

Q.1 maxima and minima $f(x) = 4x^3 - 18x^2 + 27x - 7$

$f'(x) = 0$

$12x^2 - 36x + 27 = 0$

$4x^2 - 12x + 9 = 0$

$(2x-3)^2 = 0$

$\underline{x = 3/2}$

$x = 3$

$f''(x)\Big|_{x=3/2} = 6(2x-3) \times 2 = 0$

$f'''(x) = 24$ → no maxima or minima (Point of inflection) at $x = 3/2$.

Q.2 (a) positive definite

(b) positive semidefinite

(c) negative definite

Q.3 To check the hessian matrix of the following quad. eq^{n}'s.

(1) $f = x^2 - y^2$

$$\text{Hess}(f) = \begin{bmatrix} 2 & 0 \\ 0 & -2 \end{bmatrix} \rightarrow \text{indefinite}$$

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(2) $f = 4xy$

$$\text{Hess}(f) = \begin{bmatrix} 0 & 4 \\ 4 & 0 \end{bmatrix} \quad \text{indefinite}$$

(3) $f = x^2 + 2y^2$

$$\text{Hess}(f) = \begin{bmatrix} 2 & 0 \\ 0 & 4 \end{bmatrix} \quad \text{positive definite.}$$

(4) $f = -x^2 + 4xy + 4y^2$

$$\text{Hess}(f) = \begin{bmatrix} -2 & 4 \\ 4 & 8 \end{bmatrix} \quad \text{indefinite}$$

(5) $f = -x^2 + 4xy - 9y^2 + 2xz + 8yz - 4z^2$

$$\text{Hess}(f) = \begin{bmatrix} -2 & 4 & 2 \\ 4 & -18 & 8 \\ 2 & 8 & -8 \end{bmatrix}$$

indefinite

$A_1 = -2 < 0$

$A_2 = 36 - 16 = 20 > 0$

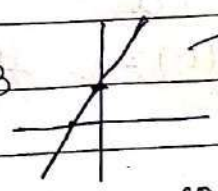
$A_3 = (18\times8 - 8\times8)(-2) + (-8\times4 - 8\times2)(-4) + (8\times4 + 18\times2)\,2$

$= -160 + 192 + 136 > 0$

Q.4 Match the following

(a) $f = 4x - 3y + 2$

$\frac{\partial f}{\partial x} = 4 \neq 0 \quad \frac{\partial f}{\partial y} = -3$



→ necessary cond^n

so no minima (3)

(b) $f = (2x-2)^2 + (x-2)^2$

$\frac{df}{dx} = 2(2x-2)\times2 + 2(x-2) = 0$

$8(x-1) + 2(x-2)$

$x = 1, 2$

$d^2f\big|_{x=1,2} > 0$

Date :

(5) Relative minimum at (1, 2).

(c) $f = -(x-1)^2 - (y-2)^2$

$\frac{df}{dx} = 0 \quad \therefore$

$\therefore \frac{\partial f}{\partial y} dy + \frac{\partial f}{\partial x} dx = 0$

$\therefore \frac{\partial f}{\partial x} = -2(x-1) = 0 \qquad x = 1$

$y = 2$

$\begin{bmatrix} -2 & 0 \\ 0 & -2 \end{bmatrix}$

↑negative definite

$\therefore \frac{\partial f}{\partial y} = -2(y-2) = 0$

(1) so Relative maximum at (1, 2).

(d) $f = xy$

$\frac{\partial f}{\partial x} = y = 0$

$\frac{\partial f}{\partial y} = x = 0 \qquad \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \rightarrow$ saddle point at origin

(2)

(e) $f = x^3 \Rightarrow$ point of inflection at origin (4)

Q.5 State the function is convex, concave, or neither.

if at critical point, a

ie. $f'(a) = 0$ then if $f''(a) > 0$ → Convex min

$f''(a) < 0$ → concave.

if $f''(a) = 0$ neither

(a) $-2x^2 + 8x + 4$

$-4x + 8 = 0 \qquad f'' < 0$ Concave

$x = 2$

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Date :

(b) $x^2 + 10x + 1$

$f' = 2x + 10 = 0 \quad x = -5 \quad f''(x) > 0$ convex

(c) $f = x^2 - y^2$

$(0,0) \qquad d^2 f = \sum_{i=1}^{2}\sum_{j=1}^{2} h_i h_j \frac{\partial^2 f}{\partial x_i \partial x_j}$

$= h_1^2 \frac{\partial^2 f}{\partial x^2} + h_1 h_2 \frac{\partial^2 f}{\partial x \partial y} + h_2 h_1 \frac{\partial^2 f}{\partial y \partial x} + h_2^2 \frac{\partial^2}{\partial y^2}$

$\begin{bmatrix} 2 & 0 \\ 0 & -2 \end{bmatrix}$

$= h_1^2 (2) + 0 + 0 + h_2^2 (-2)$

indefinite

$= 2(h_1^2 - h_2^2)$

can't be said >0 or <0

$\therefore$ neither

(d) $f = -x^2 + 4xy$

$\begin{bmatrix} -2 & 4 \\ 4 & 0 \end{bmatrix} \rightarrow$ indefinite $\therefore$ neither

(e) $f = e^{-x} \quad x > 0$

$-e^{-x} = 0 \quad \therefore e^{-x} = 0 \qquad -e^{-x} \Rightarrow f''(x) = e^{-x}$

$\frac{1}{e^x} = 0 \quad x \to \infty \qquad = \frac{1}{e^\infty}$

$\therefore$ neither $\qquad = 0 \therefore$

(f) $f = \sqrt{x}$

$\frac{1}{2\sqrt{x}} = 0 \quad x = \infty \quad f''(x) = -1 \quad x^{-3/2} = 0$

neither

(g) $f = xy$

$\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ neither

(h) $f = (x-1)^2 + 10(y-2)^2 \qquad 2(x-1) = 0 \;\&\; 10 \times 2(y-2) = 0$

$x = 1 \;\&\; y = 2$

$\begin{bmatrix} 2 & 0 \\ 0 & 20 \end{bmatrix}_{(1,2)}$ positive definite $\rightarrow$ convex.

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Q.6 3rd order taylor series expansion at $x^* = (1, 0, -2)$

$f(x, y, z) = y^2 z + e^z x$.

From notes $\Rightarrow x = \begin{Bmatrix} x \\ y \\ z \end{Bmatrix}$ df and d^2f

$f(x+dx) = y^2 z + x e^z + df + d^2f + d^3f$

$f = e^{-2}$

$df = (x + z + 1)e^{-2}$

$d^2f = 2(x-1)(z+2)e^{-4} + (z+2)^2 e^{-2} - 4y^2$

$$d^3f = \sum_{i=1}^{3}\sum_{j=1}^{3}\sum_{k=1}^{3} h_i h_j h_k \frac{\partial^3 f}{\partial x_i \partial x_j \partial x_k}$$

$$= \underline{i=1} \quad h_1^3 \cancel{\frac{\partial^3 f}{\partial x^3}}^{0} + 3\Big(h_1^2 h_2 \cancel{\frac{\partial^3 f}{\partial x^2 \partial y}}^{0} + h_1^2 h_3 \cancel{\frac{\partial^3 f}{\partial x^2 \partial z}}^{0} +$$

$$+ h_2^3 \cancel{\frac{\partial^3 f}{\partial y^3}}^{0} \quad h_2^2 h_1 \cancel{\frac{\partial^3 f}{\partial y^2 \partial x}}^{0} + h_2^2 h_3 \frac{\partial^3 f}{\partial y^2 \partial z} \Big\} +$$

$$+ h_3^3 \frac{\partial^3 f}{\partial z^3} \quad h_3^2 h_1 \frac{\partial^3 f}{\partial z^2 \partial x} + h_3^2 h_2 \cancel{\frac{\partial^3 f}{\partial z^2 \partial y}}^{0} \Big)$$

$$+ 6\left(\underset{\uparrow 3!}{h_1 h_2 h_3} \frac{\partial^3 f}{\partial x \partial y \partial z} \right)$$

here

$h_1 = x - 1$

$h_2 = y$

$h_3 = z + 2$

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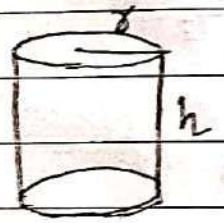
Date :

$$d^3f = h_3^3 (e^z x) + 3\left(h_2^2 h_3 (2) + h_3^2 h_1 (e^z) \right) + 6(0)$$

$$= (z+2)^3 e^{-2} + 3\left(y^2 (z+2)(2) + (z+2)^2 (x-1) e^{-2} \right)$$

$$= 6y^2 (z+2) + e^{-2}\left((z+2)^2 \left((z+2) + 3(x-1) \right) \right).$$

Q.7



volume $= V$, let h be height of cylinder and r be radius of top and bottom

$V = \pi r^2 h$

minimize $f(r,h) = 2\pi r h + 2\pi r^2$ subject to $V = \pi r^2 h$.

Using method of constrained variation.

$$g(r,h) = \pi r^2 h - V = 0$$

so

$df = 0$ $\qquad$ $dg = 0$

$$\frac{\partial f}{\partial x_1} dx_1 + \frac{\partial f}{\partial x_2} dx_2 = 0 \quad \text{and} \quad \frac{\partial g}{\partial x_1} dx_1 + \frac{\partial g}{\partial x_2} dx_2 = 0$$

at (x_1^*, x_2^*)

eleminating dx_1 and dx_2.

$\therefore$

$$\left(\frac{\partial f}{\partial r}\frac{\partial g}{\partial h} - \frac{\partial f}{\partial h}\frac{\partial g}{\partial r} \right)\Bigg|_{(x_1^*, x_2^*)} = 0$$

$$\therefore (2\pi h + 4\pi r)(\pi r^2) - (2\pi r)(2\pi r h) = 0$$

$$\therefore 2\pi h + 4\pi r = 4\pi h$$

$$\therefore h = 2r$$

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$V = \pi r^2 h$,

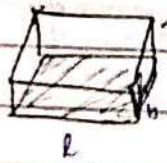
$\leftarrow h = 2r$

$V = \pi r^2 (2r)$

$\therefore r^3 = \frac{V}{2\pi}$ $\quad \therefore r = \left(\frac{V}{2\pi}\right)^{1/3}$

minimum is at $\rightarrow h = 2\left(\frac{V}{2\pi}\right)^{1/3}$

$$S = 2\pi r h + 2\pi r^2$$
$$= 2\pi\left(2r^2 + r^2\right) = 6\pi r^2$$
$$= 6\pi\left(\frac{V}{2\pi}\right)^{2/3}$$
$$= \underline{\underline{3(2\pi)^{1/3} V^{2/3}}}$$

Q.8 

$\rightarrow$ open box

let l, h and b,
length, height and breath

$S = lb + 2bh + 2lh$, maximize lbh.

Lagrange's multiplier $\rightarrow$

$f(l, b, h) = lbh$.

$$L = lbh + \lambda(lb + 2bh + 2lh - S)$$

$$\frac{\partial L}{\partial l} = bh + 2\left(\frac{b\lambda}{2} + h\lambda\right)$$

$\swarrow \frac{\partial L}{\partial \lambda}$

$$= bh + 2\lambda\left(\frac{b}{2} + h\right) = 0 \qquad S = lb + 2bh + 2lh$$

$$\frac{\partial L}{\partial b} = lh + 2\lambda\left(\frac{l}{2} + h\right) = 0$$

$$\frac{\partial L}{\partial h} = lb + 2\lambda(l + b) = 0$$

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Instead of solving 4 eq^n we use method of substitution

$$f = lb(h) \qquad \frac{S - lb}{2(b+l)} = h$$

$$f = lb\left(\frac{S - lb}{2(b+l)}\right)$$

$$= \frac{Slb - l^2b^2}{2(b+l)}$$

$$\frac{\partial f}{\partial b} = \frac{(Slb - l^2b^2)1 - (b+l)(Sl - 2bl^2)}{2(b+l)^2} = 0$$

$$\therefore \cancel{l}\cancel{b}(S - lb) = (b+l)\cancel{b}l(S - 2lb)$$

$$\frac{\partial f}{\partial l} = \frac{(Slb - l^2b^2)1 - (b+l)(Slb - 2lb^2)}{2(b+l)^2}$$

$$\cancel{l}b(S - lb) = (b+l)(S - 2lb)$$

$$\frac{b}{l} = 1 \qquad \therefore \underline{\underline{b = l}} \qquad h = \frac{S - l^2}{2(2l)}$$

$$S(l^2 - l^4) = 2l(Sl^2 - 2l^3) = 0 \qquad = \frac{S - l^2}{4l}$$

$$\cancel{l^2}(S - l^2) = 2l(S - 2l)$$

$$S - l^2 = 2lS - 4l^2$$

$$3l^2 = S \qquad \left(\frac{S}{3}\right)^{1/2} = l$$

$$\therefore \quad l = \left(\frac{S}{3}\right)^{1/2} \quad \text{and} \quad h = \frac{S - S/3}{4(S/3)^{1/2}} = \frac{2S^{1/2} \times 3^{1/2}}{3 \times 4}$$

$$b = \left(\frac{S}{3}\right)^{1/2} \qquad = \left(\frac{S}{12}\right)^{1/2}$$

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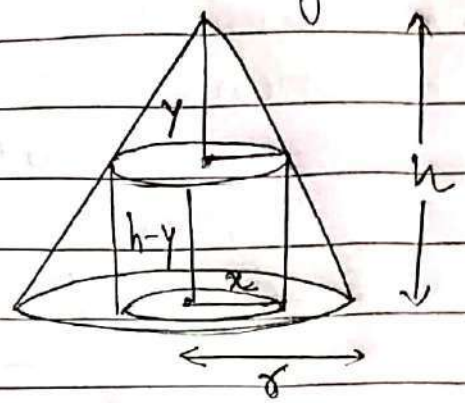
Q.9

figure



radius of beam $= x$

Volume $=$ (area of base cylinder)(height)

$= \pi x^2 \times (h-y)$, $h, r > 0$

from figure, (similarity principle)

$$\frac{y}{x} = \frac{h}{r}$$

$$y = \frac{hx}{r}$$

$$f(x) = \pi x^2 \left(h - \frac{hx}{r}\right)$$

$$= \frac{\pi h x^2}{r}(r - x)$$

$$f'(x) = 0$$

$$\frac{\pi h}{r}(2xr - 3x^2) = 0 \qquad \therefore 3x^2 = 2xr$$

$$x = \frac{2r}{3}$$

$$f''(x) = \frac{\pi h}{r}(2r - 6x)\Big|_{x = 2r/3}$$

$$= \frac{\pi h}{r}\left(2r - \frac{6 \times 2r}{3}\right) = -4\pi h < 0$$

so maximum value of f at $x = \frac{2r}{3}$

$$\therefore V_{Max} = \frac{\pi h}{r}\left(\frac{2r}{3}\right)^2\left(r - \frac{2r}{3}\right)$$

$$= \frac{\pi h}{3}\,\frac{4r^2}{9} = \frac{4\pi h r^2}{27}$$

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Date :

Maximize

Q.10 $f(x,y,z) = \dfrac{6xyz}{x+2y+2z}$ subject to $xyz = 16$.

using method of substitution,

$z = \dfrac{16}{xy}$

$$f = \frac{6 \times \cancel{xy} \times \frac{16}{\cancel{xy}}}{x + 2y + \frac{2 \times 16}{xy}} = \frac{16 \times 6\, xy}{x^2y + 2xy^2 + 32}$$

$$\frac{\partial f}{\partial x} = xy(2xy + 2y^2) - (x^2y + 2xy^2 + 32)\,y = 0 \quad \text{—} ①$$

$$\frac{\partial f}{\partial y} = xy(4xy + x^2) - (\quad '' \quad)\,x = 0 \quad \text{—} ②$$

dividing ① and ②

$$\frac{2xy + 2y^2}{4xy + x^2} = \frac{y}{x}$$

$$2x^2y + 2xy^2 = 4xy^2 + x^2y$$

$$x^2y = 2xy^2$$

$$x = 2y$$

now putting this in ①

$$2y^2(2y^2 + 2y^2) = (4y^3 + 4y^3 + 32)\cancel{y} \times$$

$$8y^3 = \cancel{4y}\ 8y^3 + 32$$

②

$$\cancel{2}y^2(8y^2 + 4y^2) = \cancel{2y}(4y^3 + 4y^3 + 32)$$

$$12y^3 = 8y^3 + 32$$

$z = \dfrac{16}{2 \times 4} = 2$ $\quad 4y^3 = \cancel{32}\ 8 \quad y = 2, \quad x = 4$

$, z = 2$ ✓

$\frac{2x}{3}$

$-\frac{(x)}{3}$

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Q.11 Maximize $f(x) = \frac{1}{2}(x_1^2 + x_2^2 + x_3^2)$ subject to constraints

$$g_1(x) = x_1 - x_2 = 0 \quad \text{—— (1)}$$
$$g_2(x) = x_1 + x_2 + x_3 = 1 \quad \text{—— (2)}$$

here $n = 3$
and $m = 2$.

So let us consider x_3 be independent

$$J\begin{pmatrix} g_1 & g_2 \\ x_1 & x_2 \end{pmatrix} = \begin{vmatrix} \frac{\partial g_1}{\partial x_1} & \frac{\partial g_2}{\partial x_2} \\ \frac{\partial g_2}{\partial x_1} & \frac{\partial g_1}{\partial x_2} \end{vmatrix}$$

$$= \begin{vmatrix} 1 & 1 \\ 1 & -1 \end{vmatrix} = -2 \neq 0 \checkmark$$

Necessary Cond^n

wrt x_3 $= \begin{vmatrix} \frac{\partial f}{\partial x_3} & \frac{\partial f}{\partial x_1} & \frac{\partial f}{\partial x_2} \\ \frac{\partial g_1}{\partial x_3} & \frac{\partial g_1}{\partial x_1} & \frac{\partial g_1}{\partial x_2} \\ \frac{\partial g_2}{\partial x_3} & \frac{\partial g_2}{\partial x_1} & \frac{\partial g_2}{\partial x_2} \end{vmatrix} = 0$

$$\begin{vmatrix} x_3 & x_1 & x_2 \\ 0 & 1 & -1 \\ 1 & 1 & 1 \end{vmatrix} = 0$$

$$2x_3 - x_1 - x_2 = 0$$

$$\therefore x_1 + x_2 = 2x_3 \quad \text{—— (3)}$$

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Solving ①, ② and ③.

$x_1 = x_2$

$\therefore 2x_1 = 2x_3$ $\qquad x_1 + x_1 + x_1 = 1$

$x_1 = x_3$ $\qquad x_1 = \frac{1}{3}$

$\left(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}\right)$

$x_1 \quad x_2 \quad x_3$ gives the ~~maximum~~ minimum value.

Thus, $f_{min} = \frac{1}{2}\left(\left(\frac{1}{3}\right)^2 \times 3\right)$

$= \frac{1}{2} \times \frac{3}{3^2} = \frac{1}{6}$

Check ~~maxima~~ minima

$$\text{Hess}(f) = \left[\frac{\partial^2 f}{\partial x_3^2}\right] \rightarrow$$

$x_1 = x_3$
$x_2 = x_3$

$f = \frac{1}{2}\left(x_3^2 + x_3^2 + x_3^2\right)$

$= \frac{3}{2} x_3^2$ $\qquad \frac{df}{dx_3} = 3x_3 = 0$ $\qquad \frac{d^2f}{dx_3^2} = 3 > 0$

even and > 0

so minima at x_3

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Unused

Name: ~~Jay Bhuva~~ Roll Number: ~~201501087~~

HM 116: Principles of Economics

Second Mid-term

Date: 17 March, 2016 Time: 8.30 – 9.30 am A

1. Say an economy is a supply constrained economy (A supply constrained economy is the economy where there are some constraints in increasing the supply. Therefore there are shortages). This leads to inflation because of shortage of fundamental goods. It is a bad idea to solve the problem of inflation in this economy by decreasing money supply. Can you explain why? (2 marks)

When an economy is supply constrained, it needs investment for overcoming those constraints & increasing production. If money supply is decreased, it would actually lead to lesser investment, and the problem would become more acute.

2. Which is the inflation situation where decreasing money supply would help? (1 mark)

When there is overheated economy or too much deficit financing - in situations of demand pull inflation

1/2 if either one is written

full marks

3. India experienced double digit inflation in 2009-10. This was mainly due to the boom and according to the Prime Minister, due to uncontrolled increase in salaries in some sectors. What should the government do in such circumstances with its expenditures and taxes? (2 marks)

1 mark

Government should (decrease its expenditure) & (increase taxes.) Because it is an overheated economy. There is already too much money going around.

4. Convert the following series into index numbers: (3 marks)

Year	Agriculture Production	Index Number
2008	956	93.725
2009	800	78.431
2010 (base year)	1020	100
2011	1180	115.686
2012	1250	122.549
2013	930	91.176

5. In 2012, the nominal GDP was Rs. 16000. In 2011, it was 17000. The WPI for 2011 was 176 and WPI for 2012 was 105. Calculate the growth rate for GDP. (2 marks)

$$\frac{\frac{16000}{105} - \frac{17000}{176}}{\frac{17000}{176}} \times 100 = \frac{152.38 - 96.59}{96.59} \times 100$$

$= 57.78\%$

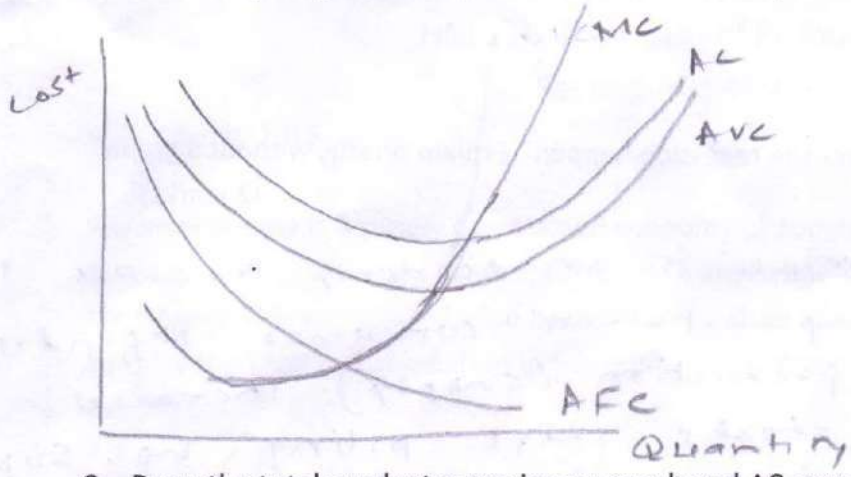
$= 57.78\%$

6. How is the CPI different from WPI? Why is it necessary to keep revising the CPI? (2 marks)

CPI is ~~the~~ determined by looking at change in price of a basket of goods consumed by a particular group of people, like agriculture laborers, industrial workers, etc. WPI is determined by movement in wholesale price of 676 items that are deemed important for Indian economy.

The basket of goods consumed changes over a period of time. That is why CPI needs to be revised periodically.

7. Draw MC, AVC, AFC and AC. What does the u-shape indicate? (1 mark)

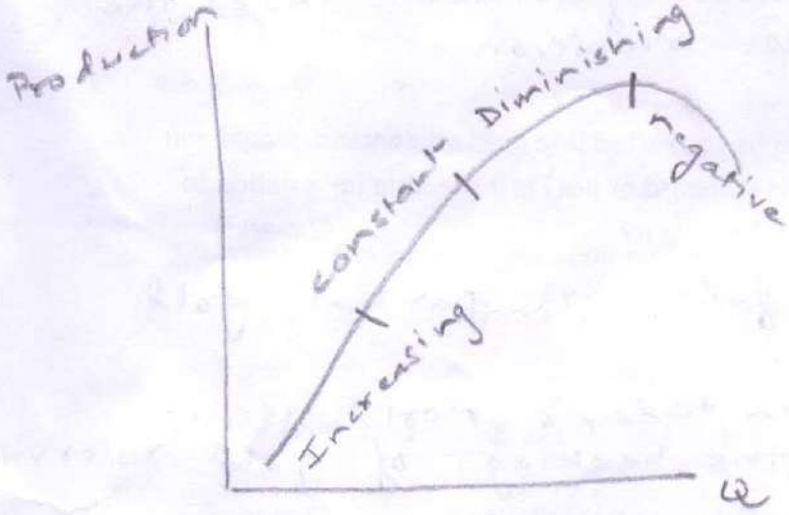


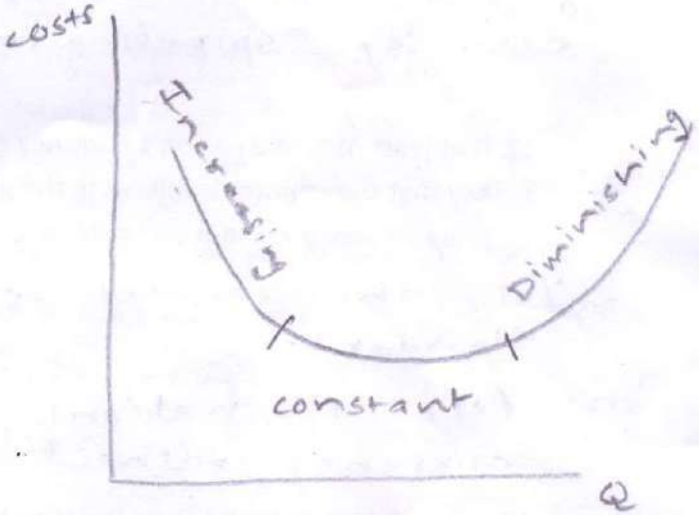
The U-shape indicates the law of returns.

AC/AVC → distance has to decrease

MC → under AC/AVC cuts at lowest pt

8. Draw the total product curve in one graph and AC curve in the other graph. Show on the graphs how both of these reflect the law of returns. (2 marks)





9. What does the Keynesian multiplier tell us? In other words, how is the multiplier theory related to the Keynesian discussion on recession? (2 marks)

The Keynesian multiplier shows by how much amount the total income increased when x amount of investment is infused into the economy. So Keynes says that during recession, the government can spend some money but it would multiply into much bigger amount to impact the economy.

10. In ancient times, the value written on the coin (1 mark)

- ✓ Was the same as the metal contained in it
- Was much more than the metal contained in it
- Was lesser than the metal contained in it

11. According to Keynes, how does the recession happen? Explain briefly, without a graph. (2 marks)

When incomes increase in an economy, because the MPC <1, the gap between consumer expenditure (demand) and production (supply) increases. As the gap widens, stocks start piling up. Suppliers produce less and fire workers. As workers are fired, demand decreases further. Thus the economy spirals into recession.

12. If at least 45% of a nation's currency can be converted into gold on demand, would you say that the country is following the gold standard or not? Is it possible for a nation to issue currency without any gold reserves backing it? (2 marks)

- Yes, the country is following partial gold standard.
- Yes, all nations in today's world issue currency without the backing of gold reserves.

13. What is CRR and SLR? How can they be used to control inflation? (3 marks)

CRR = Cash Reserve Ratio. The proportion of deposits that banks have to keep with RBI to facilitate inter-bank transactions.

SLR = Statutory Liquidity Ratio. The proportion of deposits that banks have to keep with themselves to meet the demands of the depositors.

To control inflation, CRR & SLR should be raised. As they increase, banks will have lesser money to lend out. So they will not be able to generate too much money. That would reduce the total money supply in the economy & reduce inflation.

46/50

Roll Number: 201601049 Name: MONIL SONI

HM 116: Principles of Economics

End Semester Exam

Date: December 1, 2018. Duration: 1.5 hours

Marks: 50

1. In the following market structures, how much percentage share of the market an individual firm can possibly have? (4 marks)

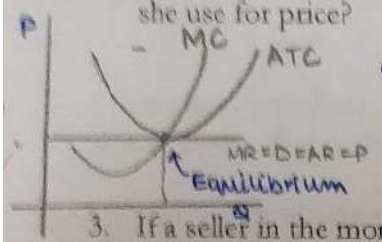
   i. Perfectly competitive markets 2-3 %.

   ii. Monopolistic competition 15-20%.

   iii. Oligopoly 30-40%.

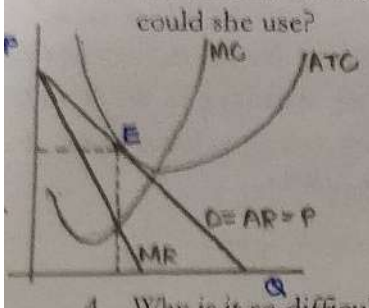
   iv. Monopoly 100%.

2. If a seller in the perfectly competitive market wants to increase her sales, what strategy should she use for price? (2 marks)



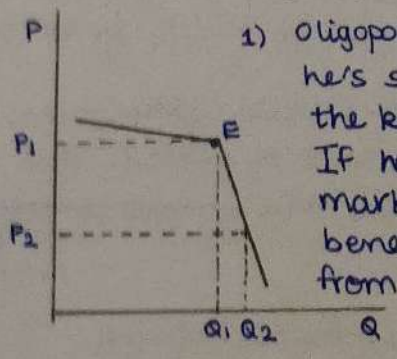
In a P-C market an individual seller is already selling at the lowest price. Any more ↓ in price will lead to the seller making loss.
Therefore, only strategy that can be applied is increase in production.

3. If a seller in the monopolistically competitive market wants to increase her sales, what strategies could she use? (4 marks)

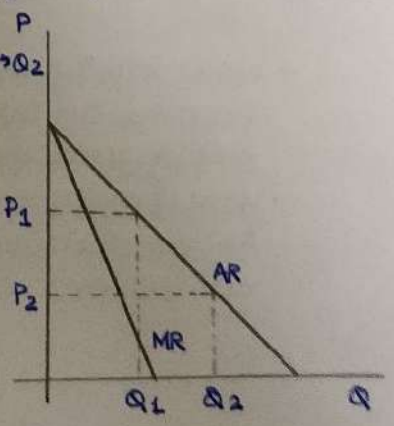


Here, the seller faces the same problem with ↓ prices ⇒ firm will start incurring losses.
However, since the products are not completely homogenous, the seller can use advertisements to reach out to more people. She can advertise on the product image, services, some unique thing that differentiates the product etc.

4. Why is it so difficult for an oligopolist to increase his sales by reducing prices? Can a monopolist increase his sales by lowering the prices? Explain by drawing curves. (6 marks)



1) Oligopolist faces a kinked demand curve where he's stuck at the kink i.e. equilibrium is reached at the kink.
If he reduces his price, other players in the market will do so too. This leads to not much benefit overall. In the figure price is decreased from $P_1 \rightarrow P_2$ yet quantity only increases a little $Q_1 \rightarrow Q_2$

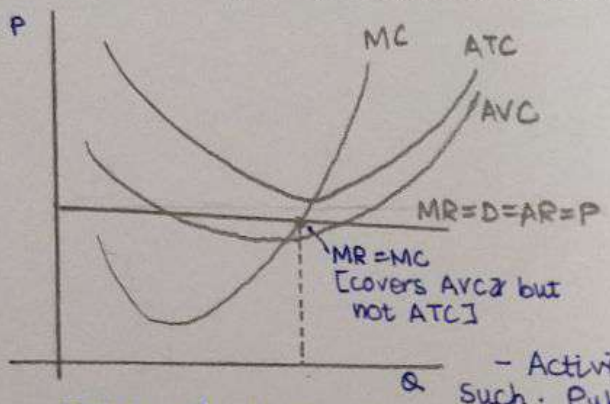


2) Monopolist, on the other hand can ↑ his sales by lowering the prices as more people will be willing to buy the product & they have nowhere else to go since there is only 1 player in the market.

6

MR D AR P

5. Draw up MC, MR, AR, ATC and AVC curves in a perfectly competitive market such that AVC is below the price line and ATC above it. Why should a public enterprise (company owned by the government) want to continue its activities like this? Why is it desirable by the society? (4 marks)



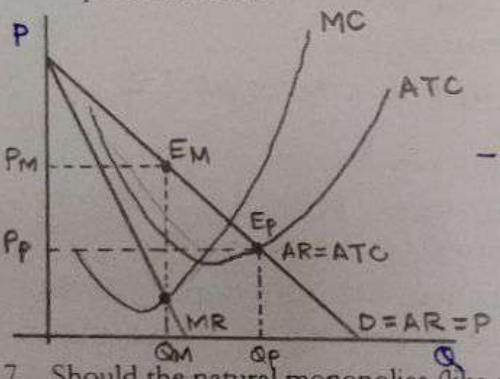
4

- A public enterprise wants to continue its activities because
  1. No private firm ~~to~~ will risk their money for this.
  2. Government will bear the fixed cost as long as the average variable cost gets covered.

  ~~Afterall, compet~~

- Activities like pipeline etc. are ~~su~~ examples of such. Public [society] ~~wo~~ desires this as these are some of the basic requirements.

6. Draw a demand curve with which you can show that a monopolist can exploit the consumers. Explain the curve. (2 marks)



2

E_M is the equilibrium point for a monopolist and E_P, for a perfectly competitive market.

- As one can see, monopolist charges a lot ($P_M > P_P$) and in return provides much fewer goods ($Q_M < Q_P$). ~~Charg~~ Thus, a monopolist exploits the consumers by taking a lot of price for few goods. This can even be catastrophic if he controls a necessity of life.

7. Should the natural monopolies (like electricity) be owned by the government or private sector? Discuss which natural monopoly managing system can lead to maximum social welfare. (3 marks)

2

- Government. This is too much power (as in previous question) for a private capital-minded firm to handle ~~&~~ ~~it~~ plus natural monopolies have a huge centralized system, maintainance of which is out of the reach of a single private firm.
- Government can issue tenders for private companies, which they can buy & serve for a pre-defined amount of period. This will keep the private comp in check of no-work & exploitation, and let govt control the prices. It can also help escape the vices of govt such as corruption.

8. List out two most important factors that determine which currency can rise to be the international currency. (4 marks)

2

- How easily the currency is obtainable: Pound Sterling became an international currency as England had its empire widespread ⇒ easily available. For USD, it was the Marshall plan.
- How easily the currency is convertible: In case of Pound Sterling gold standard came to rescue as it made conversion easier.

9. Gir is a popular tourism spot in Gujarat. Do you think Hunters' dilemma can apply there? Have we reached Nash equilibrium there? (4 marks)

- Yes, Hunters' Dilemma can be applied there as they host the majestic Asiatic Lions which are very rare, as well as there are nearby forest tribes who might benefit from the hunting.
- Nash equilibrium has been avoided there due to the stepping in of Gujarat Government. This intervention has prevented the hunting of Lions & ~~have~~ has also been the reason for tourism development - a regular source of income of locals. ⇒ win-win for everyone.

4

10. Why would a philosophy like socialism, which believes in ultimate equality and justice, tend to become a communist society during its implementation phase? (3 marks)

- One of the central requirements of communism is "redistribution of resources". The worker class of the nation hold no such power as to accomplish such a humongous task. Therefore when the workers of the world rise, and break their chains they're usually met with fire-power or in general violence from governing authority which stirs up even more violence leading to thefts, killings, kidnapping etc "for humanity sake".

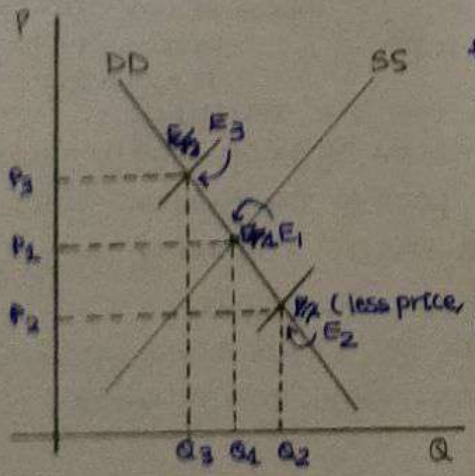
3

11. Give any two practices of socialism that show that it is human centric as opposed to capitalism that is focused on material wealth. (2 marks)

- Free food, health & education.
- Minimal difference of income and employment for all.

2

12. Consider a demand supply framework. For a market of petroleum, which is imported at a high cost, should the government tax it or give subsidy? Explain the impact of both by drawing graphs. (4 marks)



Petroleum has become one of the crucial necessities in the current world and hence it has a steeper demand curve.

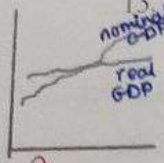
CASE 1 - tax: when govt taxes petroleum, its demand ↓ but not by a large amount [ofcourse, a larger tax will trigger inflation but we're not talking about that]. A ~~minima~~ tax just enough to cover govt operations.

CASE 2 - subsidy: Decrease in ~~d~~ prices leads to increase in demand. Now, there are increased # of people buying petroleum at a cheaper rate ⇒ huge losses for the govt and hence, for the society. So this is definitely not the favorable option.

- Therefore the govt should go for taxes ~~ed~~ as it will help govt break-even and use the tax collected for public welfare. Win-win for the govt & society.

4

13. Why do we need to calculate real GDP? (2 marks)



Nominal GDP ~~*~~ is just current production × current prices. It does not reflect the changes in consumption habits of people as well as inflation. Also, Nominal GDP shows growth which isn't there. Its just ↑ in prices over time.

2

14. The CPI is 132 for 2017. Calculate real GDP for the current GDP value of Rs. 45,00,000. (1 mark)

$$\text{Real GDP} = \frac{\text{Nominal GDP} \times 100}{\text{price index}}$$

$$= \cancel{45 \times 10} \quad \frac{4500000 \times 100}{132} \quad \cancel{*}3409091$$

1

15. The bank interest rate increases by 3%. Explain how the money supply would be affected. (2 marks)

With increase in interest rate, people would be less likely to withdraw money from banks. Hence, their consumption would decrease and money circulation in the market would decrease.

- This step is often taken by the government to curb ~~*~~/ regulate inflation – more money in society.

2

16. Say inflation has started increasing in India. What should be Reserve Bank buy – government bonds or rupees in exchange for dollars? (1 mark)

Rupees in exchange for dollars. Buying bonds will only get more money in the market. ~~This~~ ₹ in exchange for $ on the other hand increases the demand of ~~*~~ ₹. ⇒ regulate the supply.

1

17. Recession hits the economy. The government is ready to infuse money into the economy but it wants the expenditure to generate maximum effect. Use the Keynesian multiplier formula and explain in whose hands the money should be put. (2 marks)

$$\text{Government spending multiplier} = \frac{1}{1 - mpc}$$

mpc = marginal propensity to consume.

⇒ Greater the value of mpc, more will be the multiplier. Hence money should be put in ~~p~~ hands of people with greater marginal propensity to consume ⇒ poor of the Nation. Since they will have a tendency to spend more instead of saving [they can't afford to save] & hence money multiplies.

⇒ more demand & hence supply must be increased ⇒ employment ↑ and ~~t~~ spending ↑. This cycle continues and gets ~~recession~~ economy out of recession.

2

201601049
MONIL SONI

26.5

First Mid-Semester Exam

Date: September 12, 2018. Duration: 1 hour

A

All questions are compulsory.

1. If a PPF is drawn for two products that are perfectly substitutable in the production process, what would be the shape of the PPF:
   a. Convex
   b. Concave
   c. Straight line ✓

2. A new product is introduced in the market. At the initial price, it is found that the demand is more than supply in the market. Is this an equilibrium?

   Yes No ✓ (1 mark)

   What is the condition for equilibrium in the demand supply framework? (1 mark)

   Quantity demanded = Quantity supplied

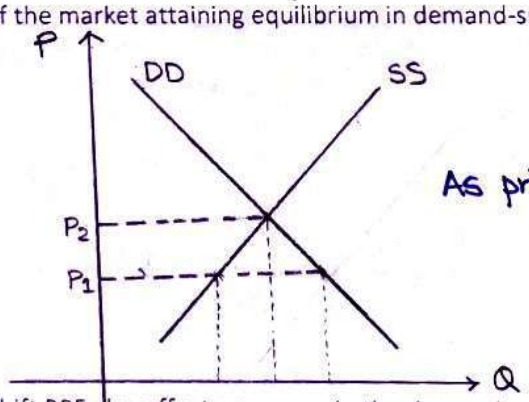
   In this condition of excess demand, who would act first: (1 mark)

   a. The supplier ✓
   b. The consumer
   c. Both

   Whoever acts first, what will s/he do? (1 mark)

   Increase the price till demand becomes equal to the supply.

Show this entire process of the market attaining equilibrium in demand-supply framework. (1 mark)



P1: price at which demand > supply in market.

As price is increased to P2 demand becomes equal to supply & equilibrium is reached

3. The factors that shift PPF also affect one curve in the demand-supply framework. Identify which curve that gets affected:
   a. Demand
   b. Supply ✓
   c. Both

Explain by one example how. (2 marks)

1 Consider introduction of automation in a mass-prod^n factory. ~~That~~ or even land increment. That would mean either production has increased because of efficiency or increase in inputs. This leads in increase of prod^n that is supply.

4. One of the basic questions that economics addresses is how to produce. PPF answers that question in some way:
   i. It shows which method of production should be used from various methods available. That is shown by:
      a. Looking at technical efficiency
      ✓b. Looking at allocative efficiency
      c. Looking at x-efficiency

2

Explain by giving an example. (2 marks)

Allocative efficiency gives us the idea of how resources are allocated in various approaches and what is the distribution that suits your needs. eg is the different types/diversity of people in a national cabinet of the Prime Minister.

   ii. It shows what could be the best results given by a method of production. That is shown by:
      ✓a. Looking at technical efficiency
      b. Looking at allocative efficiency
      c. Looking at x-efficiency

2

Explain by giving an example. Given allocation of resources (2 marks)

we can tell the best results as after this point everything is mechanical. Production of carpets with x number of machineries cascaded or in parallel.

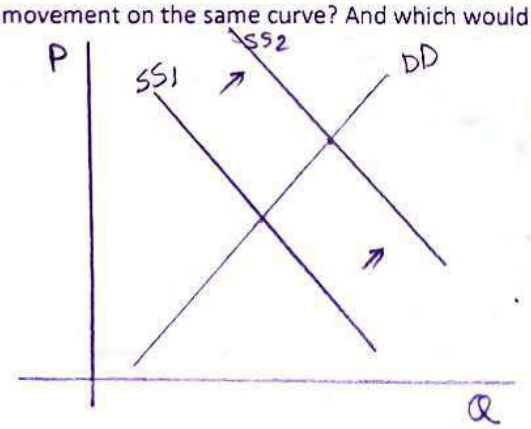
5. If you are walking inside a funfair and you realize that you are hungry. You have some money in the pocket. There are many food stalls there, each showing the menu. When you purchase the food, in the demand supply framework,
   a. You are on the existing demand curve
   ✓b. Your demand curve shifts
   c. You are on the existing supply curve

0

Because now there is one more person (me) that is demanding one or more than one items.

6. It is announced on TV that from tomorrow, the price of petrol will go up by Rs. 10. In the demand supply framework of petrol market, draw the curves to show what would happen tonight, when the prices have not yet increased. (hint: would some curve shift or would it be the movement on the same curve? And which would be that curve?) (2 marks)

1.5



Supply curve doesn't 'shift' per say. It is to show the increase in demand for the same supply, as people wish to buy it ~~for~~ as early as possible.

7. What is the advantage of calculating Green GDP? Why do nations still not calculate it? (2 marks)

One of the criticisms of GDP is that it does not take destruction of natural resources into consideration & production continues at the cost of environment degradation. Green GDP takes natural resources into account.

- Nations do not calculate it as ~~they~~ it is difficult to arrive at a consensus on the price of the resources such as trees. [since they have a variety of application]

2

8. Why do nations resort to rationing during food shortage? Don't they have any other option? (2 marks)

- During food shortage, the price of the product is controlled to be less than the equilibrium price. That implies demand is more than supply. Rationing ensures everyone gets an equal amount of food & thereby no person goes hungry [as this is generally employed when there is less food prod^n].
- Alternative to this is importing food/food grains but not all nations have the foreign reserves to do so. Hence, they resort to a rather risky method of rationing.

2

9. Why is it desirable to tax cigarettes and alcohol? (Answer by showing what can happen to demand and what are the consequences of these changes in demand) (3 marks)

~~If~~ Cigarettes & Alcohol is a necessity ~~of~~ for people who regularly consume this. Now taxing them can result in one of two things:

1. Consumption is decreased, which indeed is beneficial and adds to health benefits of the citizen.
2. ~~Govern~~ Consumption remains the same [demand unchanged]

This also is beneficial since the govt. will get more money for its tax reserves & invest them in the welfare of its people.

3

10. The price of a product was Rs. 16 and the family bought 25 kg. The prices increased to 20. Now the family buys 22 kg. Please find whether the demand is relatively elastic or inelastic. Decide whether the product is a necessity or not. (2 marks)

$$e = \frac{25-22/(25+22)/2}{16-20/(16+20)/2} = \frac{3}{-4} \times \frac{36}{47} \Rightarrow |e| < 1 \Rightarrow$$ demand is relatively inelastic & the product is a necessity.

2

11. Under income approach of measuring GDP, which item will be included:

a. Interest earned on a deposit
b. Money paid for buying a car
c. Sale value of a furniture

1

$$\frac{\frac{Q_1 - Q_2}{(Q_1+Q_2)/2}}{\frac{P_1 - P_2}{(P_1+P_2)/2}} = \frac{\frac{25-22}{25+22}}{\frac{16-20}{16+20}} = \frac{3}{-4} \times \frac{36}{47}$$

12. The value added approach for a cycle factory would include in its calculation:

a. Contribution of manager in a cycle factory
b. Contribution of electricity company in supplying electiricty
c. Contribution of travel agency in transporting the cycles

1

13. What would be a proper measure of national income for Japan: GDP or GNP? Explain why. (2 marks)

GNP. (Gross National Product)
Since Japan is a country with a large ~~amou~~ number of companies overseas the income of the companies will go uncounted if Gross Domestic product method is used.
- If it didn't have the foreign production that is large enough, GDP would have been a proper measure.

2

Roll Number: 201601049 Name: MONIL SONI

20+2/25

Second Mid-Semester Exam

Date: October 16, 2018. Duration: 1 hour

All questions are compulsory. A

1. If the government invests 50,00,000 in the economy, and the marginal propensity to consume is .8, how much would be the overall increase in national income? Would this lead to growth, recession or stagflation? (1 mark)

$Y = C + I$ ~~mpc~~ only $(5000000)(0.8) = 4000000$ amount will be added into consumption & hence the overall increase in national income. Since 80% of money is put back into circulation & only 20% leaks as savings, I would say this will result in growth. Ofcourse, if prodn/supply couldn't keep up to this much↑ in purchasing power it would result in stagflation.

2. All nations try to attract FDIs. Why would Stiglitz, a reputed economist, in his book "Globalization and its Discontents" warn against FDIs? (1 mark)

- FDIs are fickle in nature, i.e., they can go away very quickly. A nation, if not sustainable on its own, faces such a situation then its economy would be devastated

3. Rupee is falling fast nowadays. RBI is asked to intervene. What can RBI do? (Remember, India has decided to keep rupee partially convertible; it is not going to change that policy). (1 mark)

- RBI can exchange dollars for rupees. That would cause the demand of ₹ to increase leading to a higher value consequently.

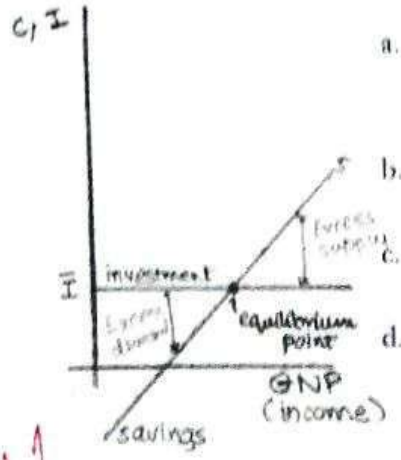
4. Why did Zimbabwe go through hyper inflation? (1 mark)

a) It went through war, all its production units was destroyed. With no supply and normal demands, the inflation increased

b) It took away lands from one community and distributed it to others who did not know cultivation

c) It borrowed recklessly and did not invest that money, resulting into huge debt burden that could not be paid.

5. Draw the saving and investment curves of Keynesian economics. (2 marks)



1½

a. If the economy was on the left side of the equilibrium point, would the stocks accumulate or exhaust?

Exhaust

b. Would there be more demand than supply or more supply than demand?

more demand than supply

c. So would the investment increase or decrease?

It would remain constant.

d. What period would this be? Boom or recession?

~~Recession~~. Boom

Recession [people dont have jobs & hence no money]

Boom will be on RHS of equi. point where income will be high & ~~wort~~ most of it would be saved.

6. Think of the coins from Akbar's time. There is a coin that has 20 written on it. What does it mean? If the coin is to be used today, how would you use this "20" to determine its value? (1 mark)

1

- The ~~coin~~ mark on coins from Akbar's time, ~~need~~ indicated the grams or weight of metal used in making it.
- If the coin is to be used today, the coin would be melted (or not) & then current value of 20 gm [or whatever measure they used] of that metal.

7. When wheat costed Rs. 15 per kg, 100 tons were bought in 1990. When price became Rs. 20 per kg in 1991, 80 tons were bought. Calculate CPI. (1 mark)

0

$$\text{CPI ratio} = \frac{P_1 q_1}{P_0 q_0} = \frac{(20)(80)}{(15)(100)} = 1.067$$

$$\text{CPI} = 1.067 \times 100 = 106.7$$

8. The following is the table for GDP index numbers. Find the index numbers for 1951 and 1953 if the base year changes to 1952. (1 mark)

1½

Year	GDP index number	Index number
1950	100	
1951	108	89.2
1952	121	100
1953	139	107

$\frac{P_t}{P_b} \times 100 = \text{Index}$

$P_1 = 1.08 P_b$

$P_2 = 1.21 P_b$

$P_3 = 1.39 P_b$

$\frac{P_1}{P_2} = \frac{1.08}{1.21} \times 100 = 89.2$

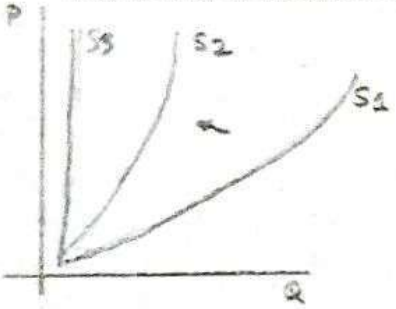
$\frac{P_3}{P_2} = \frac{1.39}{1.29} \times 100 = 107$

9. Why is it important to keep changing the composition of CPI? (2 marks)

- Over the time, tastes change, which also leads to the less consumption of that good X. Now, let us say good X costed R_1 amount for C_1 quantity and now it costs R_2 amount for C_2 quantity. ~~Sine~~ And let us say $R_2 > R_1$. But since $C_2 < C_1$ the products R_2C_2 will ~~be not~~ not reflect the change in price ~~on~~ when compared to R_1C_1. And hence, if it was inflation, it escapes one's notice.

2

10. Say China declares war on Japan. All possible resources of Japan are put to use in war. Would there be inflation? Explain with graph. (2 marks)



when there is a war, the supply curve shifts towards S3 [which is the curve for an absolutely war torn country]. This happens because most (all) possible resources are engaged in war, this leads to less resources for other production. ⇒ Shortage of fundamental goods & hence inflation.

2

11. Inflation is overall general upward trend in prices. Which of the following statements is **incorrect**:

a. "If shoe prices increase by 50%, it is not inflation"

b. "If computer prices increase by 50%, it is not inflation"

✓. "If petroleum prices increase by 50%, it is not inflation".

Explain your answer. Petroleum price, when increased, ~~caus-~~ set start a chain of price rises. Transportation cost & production cost increases. This leads to supplier decreasing the supply for same demand. Hence, "too ~~fe~~ much money chases too few goods". [This is cost-push inflation & happened in 1970s OPEC oil shock] (2 Marks)

2

12. The CPI is 145 and 153 for 2002 and 2003. The GDP is 345743 crores and 376587 crores respectively. The HDI is 145 rank and 142 rank respectively. Find the real GDP growth rate in percentage. (2 marks)

$$\text{Real GDP} = \frac{\text{Nominal GDP}}{\text{Index no.}}$$

$$R(2002) = \frac{345743}{145} = 2384.43$$

$$R(2003) = \frac{376587}{153} = 2461.35$$

$$\text{Real GDP growth rate [in percentage]} = \frac{R(2003) - R(2002)}{R(2002)} \times 100$$

$$= 3.22\%$$

2

13. I want to sell a beautiful statue in a market where only barter exchange exists. I want to buy in return my daily needs. What problems am I likely to encounter? (2 marks)

[Assuming ~~the~~ Since beautiful statue is costly] Since your daily needs are likely to cost much less than the statue, you will find no perfect deals as such. Also, you cannot divide/cut the statue since it is very plausible that the initial value will be lost. Another possibility is that ~~no~~ you won't find a seller with the goods you want AND willing to buy that statue. Plus if market is far, weight of statue becomes an issue.

2

14. These economists say that gold standard should not be used. But there is less inflation with gold standard. And it is so reassuring to know that the currency can be converted to gold anytime. Then why governments do not go for the gold standard? (1 mark)

The rate at which the economy is growing, is far greater than the rate a gold standard can keep up to. Moreover ~~physt~~, the value of gold remains constant & can by no means ~~indicate~~ accomodate ~~an economy~~ the fluctuations in economy.

1

15. How does a bank generate money? Start with a deposit of Rs. 1000 and show how the money gets generated. The SLR is 20% and CRR is 4%. (2 marks)

1000 : Bank1 keeps 200 ₹ as SLR and 40 ₹ as ~~SLR~~ CRR and lends out ₹760 to another bank B2.

760 : B2 keeps ₹152 as SLR and ₹30.4 as CRR. and lends out ₹577.6 to another bank B3 [or people, who then deposit in B3]

577.6 : B3 keeps ₹115.52 as SLR and ₹4.62 as CRR and hence lends out ₹457.46 to another bank B4 and so on.

Therefore we have ₹1795.06 in circulation while we only started with ₹1000.

2

16. Say you are the RBI governor. And due to overheated economy, the inflation is in double digits. Which will be the most effective measure to use from the three control measures? Explain why. (2 marks)

Double digits indicate Hyperinflation which means no more waiting & direct, strict action to be taken. ⇒ I will increase the SLR and CRR. This means banks will have less money to give out/lend which inturn will lead to less money in circulation overall. Hence - no more "too much money". ⇒ inflation will slowly be controlled.

2

17. Under import substitution model, which is one is true? (1 mark)

a. You specialize in some products and trade in those

✓ You produce everything that you need and become self-sufficient

Does this have any implications for product quality?

Since most of my industry ~~does not face~~ compet ~~are~~ is starting out, they will be ~~a~~ of substandard quality. [which will improve in time as my products get sold]. ~~Plus, gi~~

Dhirubhai Ambani Institute of Information & Communication Technology
Mid Semester Test-1, 1st Semester 2019-20

Course Title	IT304 Computer Networks		**Max Marks**	20
Date	5 September 2019	**CLOSED BOOK**	**Time**	90 min

In protocol design problems,

- Give a brief description of how your protocol functions.
- Provide the details of the message structure, message sequence, timer functions (if needed), and other actions performed by the nodes.

1. Consider an application that transmits data at a steady rate (for example, the sender generates an N-bit unit of data every k time units, where k is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why? [2]

2. Derive a formula for the end-to-end delay of sending one packet of length L over N links of transmission rate R. Generalize this formula for sending P such packets back-to-back over the N links. Ignore all other type of delays. [3]

3. For a router with a single queue, answer the following:
   a. Suppose N packets arrive simultaneously at a free router with empty queue. Each packet is of length L and the router has the processing rate R. What is the average queuing delay for the N packets?
   b. Now suppose that N such packets arrive to the link every LN/R seconds. What is the average queuing delay of a packet? [3]

4. What are the five layers in the Internet protocol stack? What are the principal responsibilities of each of these layers? Be very brief. [3]

5. How do you achieve cooperation among the nodes in a p2p application? Explain using a Bit-Torrent type application. [3]

6. Assuming that the root and TLD servers are always *iterative* and other lower level servers are *recursive*, write down the queries and responses for resolving *iter.ipr.res.in* from *lab1.daiict.ac.in*. [3]

7. A server on a LAN provides correct time to all the client nodes. Clients request the server for the correct time Ts but must also estimate the total delay ΔT from the server to the client to properly synchronize its clock. Design a protocol to achieve this task. [3]

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In-Semester Exam-I (Autumn'2019)

IT 214 Database Management Systems

Time: 90 minutes

Max Points: 100

IMPORTANT NOTE:

1. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
2. In all questions marks awarding strategy will be discrete (i.e., 0, half, and full marks).
3. You may have to pay penalty for lengthier solutions.

Consider following relational schema for storing various students' related data. Brief description is also given alongside.

student(id, name, prog_id, batch, cpi)
-- attribute **prog_id** is like '01' for BTech, '11' for M.Tech, '12' for MScIT, and so
-- Assume that this relation stores data of only current students of the institute; say all past data
-- have been archived.

room(rno, wing, floor)
-- the relation stores details of rooms
-- floors are represented by numbers 0 (Ground), 1(First), and 2 (Second), and so

allot(sid, rno)
-- The relation records residential facts of students. Note that that RNO cannot be NULL.
-- SIDs' of students who are not residing hostel does not appear here.

registers(studid, courseno, grade)
-- let this relation be storing academic performance of students.
-- let us not record year/sem of student taking the course, grade is latest grade in course, if repeated
-- let the grades be stored as AA, AB, and so forth.

grade2point(grade, point)
-- the relation records mapping from letter grade to numeric value.
-- as AA --> 10, AB --> 9, and so forth

clubs(clubid, club_name)
-- the relation records all the offers that are made to students in 2018.

clubmembers(sid, clubid)

Write **expressions in Relational Algebra** to answer queries in following ~~five~~ seven questions.
(No marks will be awarded if answered in SQL)

7x10

1. Give list (id, name, progid, cpi) of students who are residing in E wing, second floor.
2. Give list (id, name) of students from B.Tech. 2nd second year (2018 batch) who are residing in E wing.
3. Give list (id, name) of students who are singly occupying rooms. (Note that a room is to be allocated to multiple students, typically two)
4. Give list of students (*) B.Tech. 1st year (2019 batch) who do not reside in hostel.
5. What is average grade point in the course 'Algorithms' (IT215) of students who are member of 'Programming Club'?
6. Give program wise count of students in 'Programming Club'.
7. Give program wise percentage of students residing in hostel for each program. Assume that student relation contains data of current students only.

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8. Consider relations - R1(StudID, CourseNo, Grade) and R2(StudID, EventID).
Suppose, we need to compute CourseNos in which all students that are participating in event-id=3 have taken. Let us say this problem can be solved by division operation. Write sequence of operations performing division operation without using division operator.

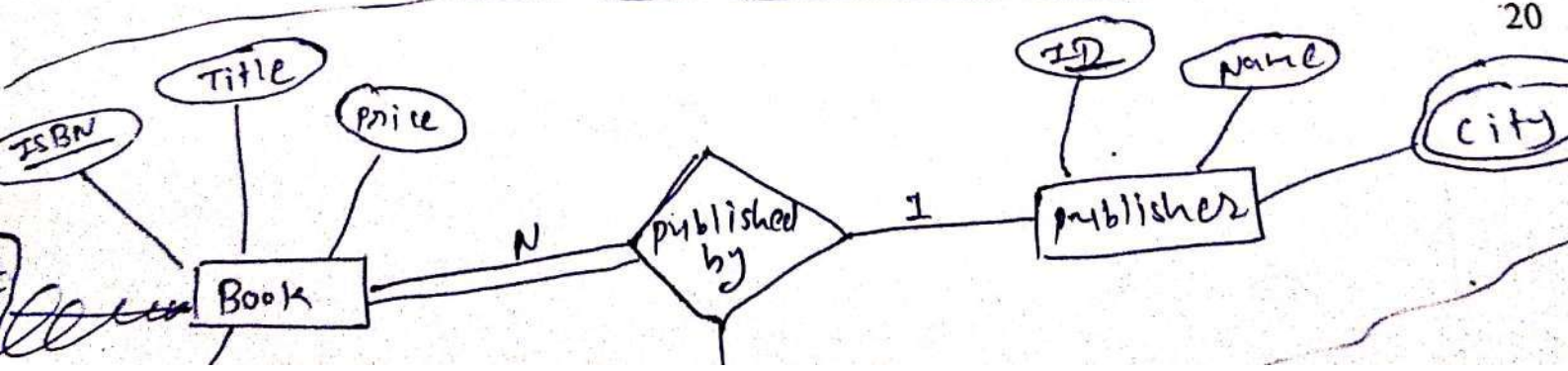
10

9. Read following description for a database design and produce a **Neat ER Diagram.**

Suppose we need to design database for an online book store ***Abazon***. Let us say *Abazon* wants to have a database to store required data for books, authors, publishers, and distributers. For Books we record ISBN, Title, PubYear, Price, Authors information. ISBN is a unique number that every published book has. Book can be authored by multiple authors. For Authors, let us say we record ID, Name, Email, Affiliation, BriofBio. Every book is published by some Publisher. For publisher, let us say we record ID, Name, City. A publisher can be located in multiple cities. Also there is concept of Distributors. Publishers do not sale book directly. Books are sold through distributers, and book stores buy book from distributors. Let us say, we record ID, Name, and Address (location, City, PIN) for distributors. *Abazon* is on a policy that they buy a book (one ISBN) from single distributor. This gives *Abazon* a good bargain in buying books. However *Abazon* can buy multiple books from a distributor. We also record in what price *Abazon* gets a book from the distributer.

Your ER Diagram should be clearly depicting Entities, Attributes and Key Attributes, Relationships and related constraints. If you find do not find explicit mention of any constraints, you can make necessary assumption, and depict accordingly. However, you should not be ignoring explicit mention of a constraint. You are not expected to add additional attribute, and drop any of attributes.

20



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CT303 - Digital Communications
Autumn 2019/20

In-Sem 1 | 6th September 2019
Duration: 90 minutes | Total Marks 20

Note: You may use any result/example derived/stated in class/lab without proof.

1. Assume that you are sitting at a point on the rim of a Ferris wheel, as you did in Lab-1. The only difference is that, the Ferris wheel is a *nested* one, i.e., a second wheel rotates about its center c_1 which is fixed on the rim of the first one (and moves with the first wheel), and a third wheel rotates about its center c_2 which is fixed on the rim of the second wheel (and moves with the first and second wheel). The wheels are each of radius r_0, r_1, r_2, each completing one rotation in $T, \frac{T}{2}, \frac{T}{4}$ seconds respectively with constant velocity, and center of the first wheel c_0 is fixed at the point $(0, h)$. Each wheel rotates in the direction indicated in Figure 1, and you are seated on the rim of the third wheel. [3+1]

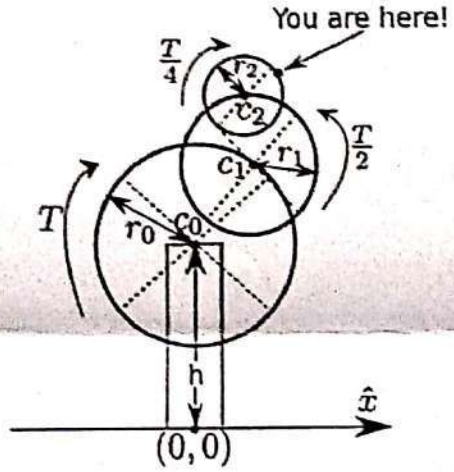

Figure 1: Nested Ferris wheel. Assume $\hat{y}$ along the height of the Ferris wheel, and $h > r_0 + r_1 + r_2$.

(a) Assuming any starting position you want (draw it), describe your (x, y) position as a function of time.

(b) What is the Nyquist sampling rate for sampling these functions.

2. Short Questions (and short answers):

(a) Let $X(t)$ be a stochastic process with ACF $R_X(\tau) = k\delta(\tau)$, $\tau \in \mathbb{R}$, where $k \in \mathbb{R}$ is some positive constant. Find an LTI system (i.e. specify its impulse response h) such that if X is given as an input, the output stochastic process Y has a cross-correlation with the input X given by $R_{YX}(\tau) = \frac{1}{2}\cos(\tau), \tau \in \mathbb{R}$. [2]

(b) Let $X(t)$ be a zero-mean White Gaussian stationary process with PSD N_0. Compute the variance of $X(t)$. [2]

(c) Let $\eta(t)$ be a stationary zero-mean stochastic process that models noise. Let it contaminate a known but arbitrary deterministic signal $s(t)$ to yield the noisy signal (stochastic process) $Z(t) = s(t) + \eta(t)$. Find whether $Z(t)$ is stationary or not. [1]

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(d) Verify if the following functions are valid autocorrelation functions defined on $\mathbb{R}$ with justification. (a) $R_x(\tau) = \exp(-\tau)$, (b) $R_x(\tau) = (sinc(\tau T))^2$, (c) $R_x(\tau) = rect(\frac{\tau}{T})$. [3]

(e) Given a noiseless channel with bandwidth W Hz, state with justification the theoretical maximum symbol rate in symbols/sec that the channel can support? What about the maximum data rate in bits/sec? [2]

3. Consider a binary PCM signalling scheme with waveforms s_1 (for bit 0) and either s_2 or s_3 (for bit 1) as shown in Figure 2 below. For each waveform, determine the expression of the matched filter impulse response. On the receiver end, the bit transmitted is estimated based on which of the two matched filter produces a higher output every T seconds. Assume same prior probabilities, AWGN noise with PSD $\frac{N_0}{2}$ Watts/Hz and no inter-symbol interference. Compute the probability of error of the receiver with the matched filters (maybe in terms of the Q function, if possible), and decide which of the two waveforms s_2 and s_3 will you choose to represent bit 1. [6]

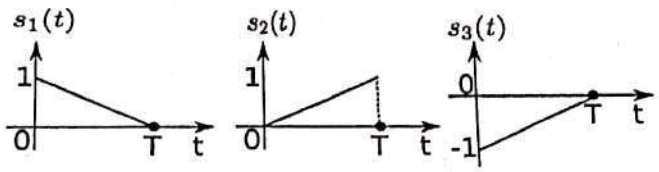
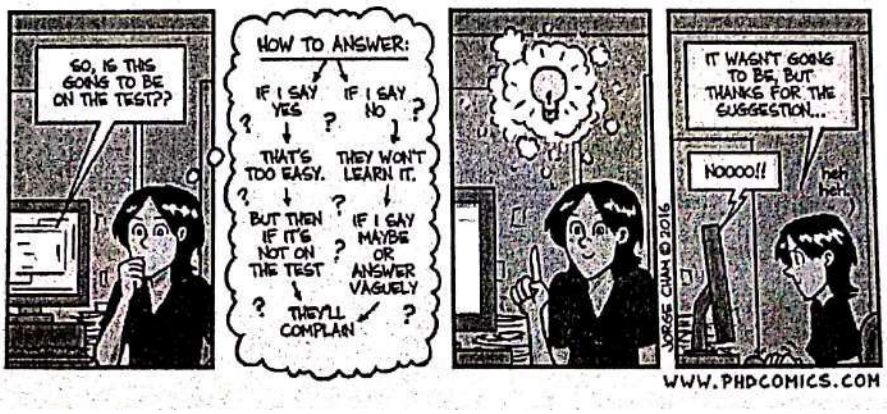


Figure 2: Binary PCM signaling. What will you prefer, $\{s_1, s_2\}$ or $\{s_1, s_3\}$?



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DA-IICT, Gandhinagar
EL203- Embedded Hardware Design
Oct 24, 2019 (Thursday)...Exam: Insem-II
Duration: 60 minutes (Time: 1100hrs-1200hrs)
Total Marks: 100

Each question carries equal marks
Calculators are not allowed.

1. A carpenter has a rectangle piece of wood 25 inches by 36 inches in his workshop. He needs a square piece of wood out of this. Fortunately, he manages to make a perfect square out of this rectangle piece.

   Draw the square wood (with dimensions). Additionally, help the carpenter find the perimeter of the square block using an 8bit carry save adder (CSA). Remember that CSA is capable of performing multi-operand additions.

   Let us know how you helped this carpenter!

   Full marks to those who help this carpenter for an efficient solution! Any wastage of resources (wood) is an inferior solution and will be penalized.

2. Your friend is coordinating a getaway trip after the examinations, and asked you to send the first letter/alphabet (in ASCII) of your name with odd parity to him electronically. He can receive the data over only
   i. RS232 and
   ii. SPI interface.

   Mention the data, CLOCK, START, STOP bit, odd parity scheme and any other signals wherever applicable in your timing diagram(s). Draw both the transmitter (you) and the receiver (friend) side and label the pins clearly within the block diagram for both the protocols.

   Note: You may miss out on the fun if you are unable to send the information correctly, he has asked for!

MK-20K

00110018
00110010
01100100
64+32

64
32/96

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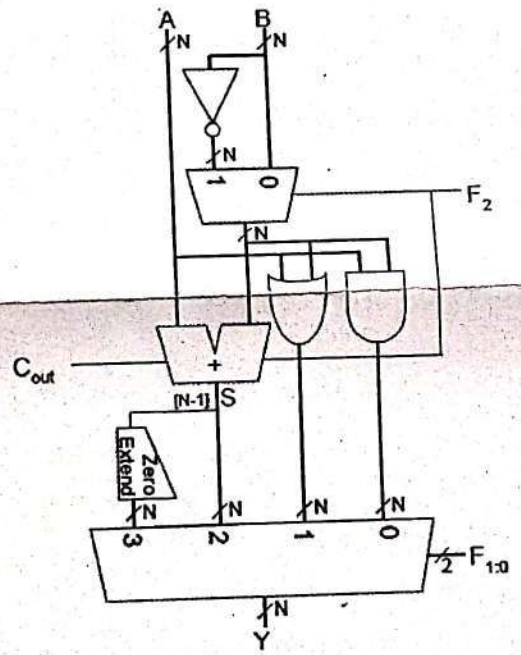
3. You are given two resistors that are connected in parallel. The total resistance has been measured at 2 Ohms, and one of the resistors is known to be 3 ohms more than the other. What are the values of the two resistors? The two resistors now have to be added up using an ALU.

Please use the following ALU datapath to find the R_{Total}. The formula to work out the total resistance is "R_{Total}" and should be expressed as a sequence of control strings that configures the multiplexers. Specify the number system (signed, unsigned, 2's complement etc.) for addition of the two resistors in the ALU datapath. What will be the output at Y where N =32? Please mention the steps clearly for the above computation.

$R_{total} = R_1 + R_2$



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In-Semester Exam-II (Autumn'2019)
IT 214 Database Management Systems

Time: 90 minutes | Max Points: 100

IMPORTANT NOTE:
1. Write answers neat and clean. Answers that are difficult to read may simply be discarded.
2. In all questions marks awarding strategy will be discrete (i.e., 0, half, and full marks).
3. You may have to pay penalty for lengthier solutions.

Consider following relational schema for storing various students' related data. Brief description is also given alongside.

student(id, name, prog_id, batch, cpi)
-- attribute **prog_id** is like '01' for BTech, '11' for M.Tech, '12' for MScIT, and so
-- Assume that this relation stores data of only current students of the institute; say all past data
-- have been archived.

room(rno, wing, floor)
-- the relation stores details of rooms
-- floors are represented by numbers 0 (Ground), 1(First), and 2 (Second), and so

allot(sid, rno)
-- The relation stores residential facts of students. Note that that RNO cannot be NULL.
-- SIDs' of students who are not residing hostel does not appear here.

course(courseno, course_title, credit, coursetype)
-- the relations stores basic information of courses. Course type: core and elective.

offers(termid, courseno, facultyid)
-- The relation stores instances of course offerings. For example-<AUT17, IT214, I001>

registers(termid, courseno, studid, grade)
-- let this relation be storing academic performance of students.
-- let the grades be stored as AA, AB, and so forth.

grade2point(grade, point)
-- the relation records mapping from letter grade to numeric value.
-- as AA --> 10, AB --> 9, and so forth

clubs(clubid, club_name)
-- the relation records all the offers that are made to students in 2018.

clubmembers(sid, clubid, role)
-- role is like 'conveyor', 'member', or so.

HMC(wing, floor, hmc_representative)
-- Let us say we have one student as HMC member for each floor.
Assume that attribute hmc_representative cannot be NULL.
We have no tuple here for floor for which no HMC representative.

Write **expressions in Relational Algebra** to answer queries in following five questions.
(No marks will be awarded if answered in SQL)

5x10

1. List (Wing, Floor) for floors that do not have HMC members.
2. List (Club_name, convenor_name) for all clubs.
3. List (id, name, progid, cpi) of students who are residing in E wing, second floor and have cleared course of 'Algorithms' (IT215) with grade BC or higher.
4. List (id, name) of BTech (progid=01) students whose room mate is MSc(IT) student. Assume that there can be at most two students in a room.
5. Suppose we need to compute that to what fraction of students a faculty awards AA grade in semester AUT17. List (FacultyId, fraction).

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6. Read following description for a database design and produce a **Neat ER Diagram**.

Consider the scenario of placement activities at your institute. Let us say, placement database is separate from e-campus and other institutional databases.

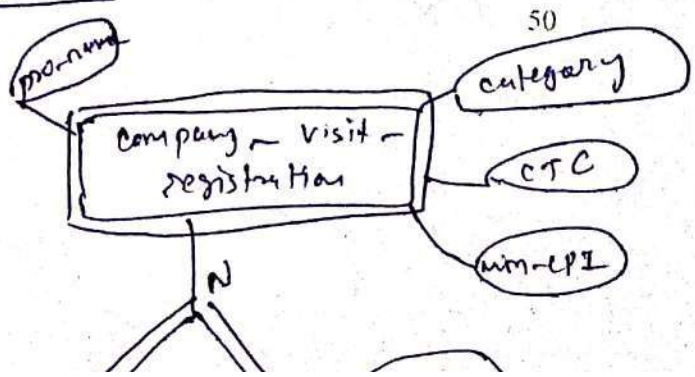
Companies visiting to institute and students interested for placement require registering through a web interface. Note that placement database may turn out to be complex, therefore limit the scope within data requirement and constraints mentioned in given description here.

For companies, registration is two-step process - First time registration and Visit Registration. On first time registration let us say they provide information of Company ID (Unique), Name, Address, Contact Person's Name, Email, and Phone. In Visit registration, following information about company's visit are captured – profile-name, profile category ('A', 'B', and so), CTC offered for the profile, minimum CPI. Let us say companies require separate visit registration for each profile for which they come. Once visit registration is done, placement office allocates a visit date to a profile registration in consultation with company contact person.

Students who are interested in placement require registering. Student registration is also two-step process, basic registration and profile registration. Basic registration is only once for a drive, and following information is provided – ID, Name, ProgramID, CPI. Let transcript of every student is also stored. For transcript, we store semester wise following information – semester no (1,2,3, or so), acadyr, semester (aut-1, wint-2, summer-3), list of courses (courseno, title, credit, grade), semester SPI. [while creating ER diagram, be careful of redundancies here].

Students require doing profile registration for every profile student is interested in. No additional information is furnished at the time of profile registration – just interest is stored.

Once student registrations are done, companies visit the institute for conducting recruitment process at institute. Let us say we do not record anything for recruitment process; we only record final offers that are made. For offers we store what company makes offer to which student and for what profile. Let us assume that for each offer that is made, we also store – offer no (can assume to be unique), CTC, joining date, joining city name.



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READ THE INSTRUCTIONS CAREFULLY

DA-IICT, Gandhinagar
EL203: EHW, Sep 04, 2019 (Wednesday) INSEM-I
Duration: 120 minutes
Total Marks: 100

All Questions Carry Equal Weightage.

No Calculators allowed.

1. Convert the two binary numbers 0111 and 1100 to Gray code numbers and add. Design a 4-bit adder to support the addition of the above gray code numbers. Discuss if there exists any difference of the above gray code adder (area, speed) with the ripple carry adder.

2.
   a. If the cost of development or non-recurring cost of an electronic system is expressed as NRE and the cost of manufacturing each copy of the system (unit cost) is UC, what is the total cost (TC) of the design, if Q quantity of units is manufactured? What is the final cost (FC)?

   b. Discuss briefly with example, the following:
      i. Dedicated Systems
      ii. Reconfigurable Systems
      iii. Programmable Systems

   c. Draw the data dependency block diagram for the system adopting
      i. Von-Neumann Architecture
      ii. Harvard Architecture

3. In a single precision floating point representation
   a. What is the smallest value?
   b. What is the largest value?
   c. What is the relative precision?
   d. Represent -0.8125 using
      i. a 16 bit fixed point (signed) number system
      ii. single precision floating point number
   e. What number is represented by the following single precision float number represented as $(11000001100010000000000000000000)_2$

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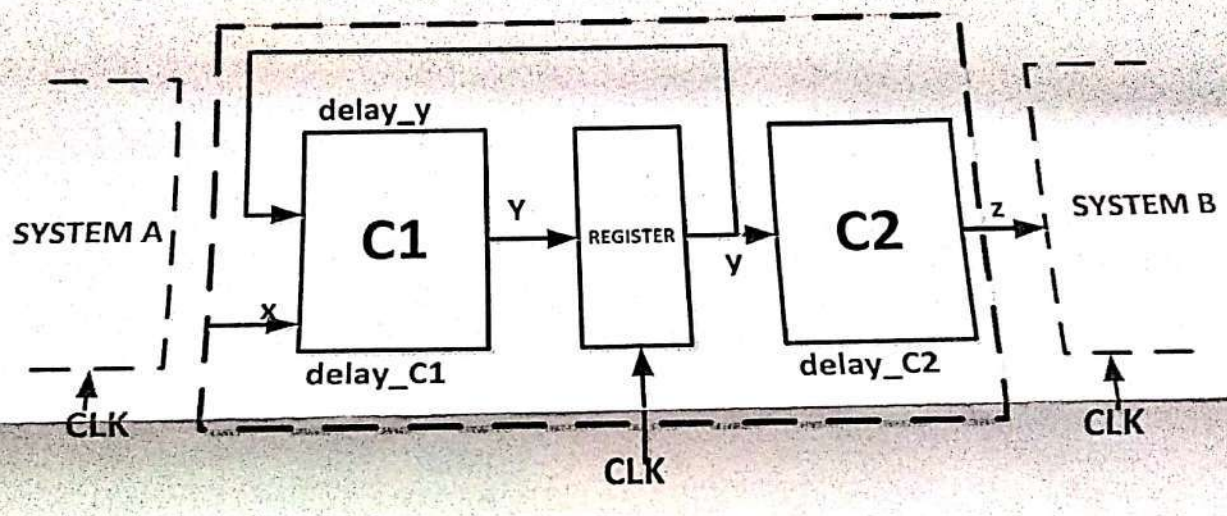
4. For the following network, the propagation delays of the input and the output network are: delay_C1 = delay_y = 2.5ns; delay_C2 = 3ns.
The setup of the register $t_{(su)}$=0.3ns, and the propagation delay is t_p= 1ns.

The network stabilizes no later than t_{in}=2ns after the clock triggers; the output needs to be stable for t_{out} = 3ns before the next triggering edge.

What is the maximum clock frequency?



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Dhirubhai Ambani Institute of Information & Communication Technology
Mid Semester Test-2, 1st Semester 2019- 20

Course Title	IT304 Computer Networks		**Max Marks**	20
Date	23 October 2019	**CLOSED BOOK**	**Time**	90 min

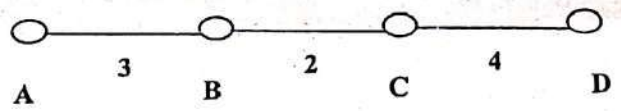
In protocol design problems,

- Give a brief description of how your protocol functions.
- Provide the details of the message structure, message sequence, timer functions (if needed), and other actions performed by the nodes.

---

1. For any link running Stop & Wait protocol,
   a. Write the expression for RTT in terms of relevant parameters. What is the effect of setting the timeout value in this protocol "too high" or "too low"?
   b. Derive the efficiency of the protocol as a function of <RTT>, packet loss probability P, and other relevant parameters.
   c. Using an example, show that this protocol may not work correctly for non-FIFO links. [1+1+1]

2. Nodes in a network use flooding to periodically send a packet to all the other nodes. Diameter **D** of the network is known. Propose a controlled flooding protocol. Describe the packet format and actions performed at intermediate nodes to minimize the communication overhead [3]



3. For the network given in the figure above, work out the distance vectors and the routing table at **A** at the end of round 1 and round 2 of vector exchange. [3]

4. A transport layer protocol like TCP relies only on the information maintained by itself and received from the receiver.
   a. What are the information available to a TCP sender?
   b. Describe the TCP timeout timer estimation for each packet. Justify this specific formulation.
   c. How is the flow control achieved? [3]

5. What are switching element and switching fabric? Draw the schematic of a 16x16 Banyan switch. Explain how this design removes bottleneck of earlier generation routers? [1+2+1]

6. In the context of TCP protocol,
   a. Explain the purpose and mechanism of connection establishment and termination in the TCP protocol. Also give the reasons for these specific mechanisms used for the purpose.
   b. Briefly explain the slow-start algorithm. Derive an expression for the average TCP throughput. [2+2]

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CT303 - Digital Communications
Autumn 2019/20

In-Sem 2
Duration: 90 minutes

22nd October 2019
Total Marks 25

1. Which among the two equalization filters: Zero forcing solution and Minimum Mean-Square error solution is better? Justify and provide any assumptions made. [3]

2. Let $s_1(t) = \sqrt{\frac{2E}{T}}\cos(\omega_0 t), s_2(t) = \sqrt{\frac{E}{T}}\cos(\omega_0 t + \frac{3\pi}{4}), 0 \leq t \leq T$ be the two waveforms to be used for Binary bandpass communication. The demodulation/detection is to be performed using a coherent demodulator/detector shown in Figure 1 below, with matched filter impulse response $h(t) = \sqrt{\frac{2}{T}}\cos(\omega_0 t)$. Assuming prior probabilities for

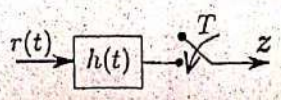

Figure 1: Coherent Demodulator/Detector.

bits 0 and 1 to be the same, find the optimal threshold γ to be used on z for detection, and compute/comment on the bit-error probability under AWGN assumption. [4]

3. Answer the following questions with short justifications. [3 × 6 = 18]

   (a) Let $s_1(t) = \cos(2\pi 100t), s_2(t) = \cos(2\pi 110t), 0 \leq t \leq 0.05$ secs be two waveforms. In terms of the bit-error performance, should we be using a coherent or non-coherent binary OFSK demodulation/detection? What if the second waveform is changed to $s_2(t) = \cos(2\pi 120t)$ for the same T?

   (b) Data generated at a rate 1024 bits/second is to be transmitted using M-ary PSK with M = 4, and carrier frequency $f_0 = 1$ MHz. What is the theoretical minimum channel bandwidth required to support this communication without introducing ISI?

   (c) In binary OFSK modulation schemes with minimum separation, two carrier frequencies are used, say f_1, f_2 Hz. The OFSK signal at any time will contain only these two frequencies. Does the bandwidth of the OFSK signal then depend on the data rate?

   (d) The worst performing digital communication system is one with a bit-error probability 1. Is that right? Justify.

   (e) A waveform $p(t)$ with Fourier transform $P(f)$ is shown in Figure 2 below. Assuming a channel bandwidth of $\frac{1}{T}$ Hz, will there be any ISI?

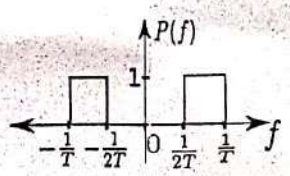

Figure 2: Fourier transform $P(f)$ of the waveform $p(t)$.

   (f) In DBPSK quadrature demodulator, one needs to compute the phase for each waveform using $\phi = \tan^{-1}\left(\frac{y}{x}\right)$. The range of $\tan^{-1}$ is known to be $[-\pi/2, \pi/2]$. How can we resolve this issue? Do not simply state MATLAB functions that do the job, explain how is this handled.

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IE 402 Optimization

End Semester Exam, Autumn 2019

Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT)

Time: 2 Hours

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1. Consider the following optimization problem:
   Maximize $f = -x_1 - x_2$
   Subject to $x_1^2 + x_2 \geq 2$
   $4 \leq x_1 + 3x_2$
   $x_1 + x_2^4 \leq 30$
   (a) Find whether the design vector $X = [1, 1]^T$ satisfies the KKT conditions for a constrained optimum. (5)
   (b) What are the values of the Lagrange multipliers at the given design vector?

2. Consider the LP problem:
   Minimize $f = x_1 + x_2 + ... + x_n, \quad x_1, x_2, ..., x_n \in \mathrm{R}$
   Subject to $a_1x_1 + a_2x_2 + ... + a_nx_n = 1$
   $x_1, x_2, ..., x_n \geq 0,$
   where $0 < a_1 < a_2 < .... < a_n$.

   (a) Write down the dual to the above problem and find a solution to the dual in terms of $a_1, a_2, ..., a_n$.
   (b) State the duality theorem and use it to find a solution to the above primal problem.
   (c) Suppose that we apply the simplex algorithm to the above primal problem. Show that if we start at a non optimal initial basic feasible solution, the algorithm terminates in one step if and only if we use the rule that the next nonbasic column to enter the basis is the one with the most negative reduced cost coefficient. (6)

3. Find the maximum value of the function $f(X) = 2x_1 + x_2 + 10$, subject to the constraint $x_1 + 2x_2^2 = 3$ using the method of Lagrange multiplier.
   What will be the value of objective function when the right hand side of the constraint 3 is changed to 2?
   What will be the value of objective function when the right hand side of the constraint 3 is changed to 5? (5)

4. Let $x_{11} = 5$, $x_{14} = 2$, $x_{23} = 7$, $x_{24} = 2$, $x_{32} = 8$, $x_{34} = 10$ be an initial basic feasible solution of the following transportation problem.

19	30	50	10
70	30	40	60
40	8	70	20

   Find the optimal solution using $u - v$ method. (5

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5. Find the optimal strategy for player B and the value of the game for the following 4×2 pay-off matrix.

	B_1	B_2
A_1	-2	0
A_2	3	-1
A_3	-3	2
A_4	5	-4

(5)

6. Reduce the following matrix game into 2×2 matrix and then find the optimal strategies for players A and B. Also find the value of the game.

	B_1	B_2	B_3
A_1	2	0	4
A_2	1	2	3
A_3	4	1	2

(5)

7. Let there be a single server system with infinite queue length and infinite population. The system has an arrival rate of $6/hr$ and service rate of $12/hr$. Then

(a) What is the probability that the system has at least 3 people?

(b) What is the expected length of the queue in the system?

(4)

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IE 402 Optimization

2nd In-semester Exam, Autumn 2019

Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT)

Time: 1hour 30 minutes

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1. (a) Solve the following LP problem graphically

   Maximize $2x_1 + 5x_2$

   Subject to $0 \le x_1 \le 4$

   $0 \le x_2 \le 6$

   $x_1 + x_2 \le 8$ (2)

   (b) What is a degenerate basic feasible solution? (1)

   (c) Give an example of a unbounded convex set with infinitely many extreme points. (1)

   (d) Convert the following LP problem into standard form

   Maximize $x_2 - x_1$

   Subject to $3x_1 = x_2 - 5$

   $|x_2| \le 2$

   $x_1 \le 0$ (2)

   (e) State complementary slackness theorem/condition. (1)

   (f) Find the dual of the following LP problem

   Minimize x

   Subject to $x \le 1$

   $\lambda^T \cdot 1$

   $\lambda^T \cdot 1 \ge 1$

   $\lambda \ge 0$

   Max λ_1

   sub. $\lambda \ge 1$

   λ

   What can you say about the solution of the primal problem? What can you say about the solution of the dual problem? (3)

2. Consider the LP problem

   Minimize $-x_1$

   Subject to $x_1 - x_2 = 1$

   $x_1, x_2 \ge 0$

   (a) Write down the basic feasible solution taking x_1 as a basic variable.

   (b) Write down the canonical augmented matrix corresponding to the basis in part (a).

   (c) If we apply the simplex algorithm to this problem, under what circumstances does it terminate?

   (d) Show that in this problem, the objective function can take arbitrarily large negative values over the constraint set. (4)

3. Consider the LP problem

   Minimize $c_1x_1 + c_2x_2$

   Subject to $2x_1 + x_2 = 2$

   $x_1, x_2 \ge 0,$

   where $c_1, c_2 \in R$. Suppose that the problem has an optimal feasible solution that is not basic.

   $\begin{bmatrix} 1 & 2 & 5 \\ 1 & 3 & 1 \end{bmatrix}$

   (a) Find all basic feasible solutions.

   $c^T x = \lambda^T b$

   $c^T x - \lambda^T A x$

   $x_1 + x_2 = 3$

   $2x_1 + 3x_2 = 6$

   $5x_1 + x_2 = 4$

   $c^T x$

   $Ax = b$

   $\lambda^T b$

   $A^T \lambda \le c^T$

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(b) Find all possible values of c_1 and c_2.

(c) At each basic feasible solution, compute the reduced cost coefficients $c_j - z_j$ for all nonbasic variables. (3)

4. Consider the LP problem

Maximize $c_1x_1 + c_2x_2 + \ldots + c_nx_n$

Subject to $x_1 + x_2 + \ldots + x_n = 1$

$x_1, x_2, \ldots, x_n \geq 0,$

where $c_1, c_2, \ldots, c_n \in R$.

(a) Write down the dual of the above LP problem.

(b) Suppose you know that $c_4 > c_i$ for all $i = 1, 2, \ldots, n$ and $i \neq 4$. Use this information to solve the dual problem. Find the optimal solution.

(c) Use complementary slackness condition to solve the primal LP problem. (3)

5. Solve the following LP problem using dual simplex method.

Minimize $z = 2x_1 + 2x_2$

Subject to $2x_1 + 4x_2 \geq 1$

$x_1 + 2x_2 \geq 1$

$2x_1 + x_2 \geq 1$

$x_1, x_2 \geq 0$

$(c^T - \lambda^T A)x = 0$

$\lambda^T(Ax - b) = 0$

(5

$[(c_1, c_2, c_3, \ldots, c_n) - (c_4, c_4, c_4, c_4, \ldots c_4)] \begin{bmatrix} x_4 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = 0$

$[(c_1 - c_4), (c_2 - c_4), (c_3 - c_4), \ldots ((c_n - c_4))] \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} = 0$

$c^T x$

$Ax \geq b$

$\lambda^T b$

$\lambda^T A \leq c^T$

$(c_1 - c_4)x_1 + (c_2 - c_4)x_2 + \ldots + (c_n - c_4)x_n = 0$

$x_i = 0 \; \forall i \in [1, 2, 3, 5 \ldots n]$

$\Rightarrow x_4 \neq 0$

$x_4 = 1$

minimize $2x_1 + 2x_2$

$x \begin{cases} -2x_1 - 4x_2 \leq -1 \\ -x_1 - 2x_2 \leq -1 \\ -2x_1 - x_2 \leq -1 \end{cases}$

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IE 402 Optimization

Ist In-semester Exam, Autumn 2019

Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT)

Time: 1hour 30 minutes

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1. (a) Whether the quadratic form $f = -x_1^2 + 4x_1x_2 - 9x_2^2 + 2x_1x_3 + 8x_2x_3 - 4x_3^2$ is positive definite/negative definite/indefinite? Give reason. (2)

   (b) Find the stationary points of $f = x^3 - 3xy^2$ and identify their nature (local maximum/local minimum/saddle point). (2)

2. A window is being built, the bottom is a rectangle and the top is a semi circle. If there is 12 meters of framing materials available. What will be the dimensions of the window so that it can allow maximum light? (4)

3. Using KKT conditions find the value(s) of β for which the point $x_1^* = 1$, $x_2^* = 2$ will be an optimal solution to the problem

$$\text{Maximize } f(x_1, x_2) = 2x_1 + \beta x_2$$

subject to

$$x_1^2 + x_2^2 \leq 5$$
$$x_1 - x_2 \leq 2.$$

(4)

4. Solve the following problem by the method of Lagrange multipliers

$$\text{Minimize } f(X) = \frac{1}{2}(x_1^2 + x_2^2 + x_3^2)$$

subject to

$$g_1(X) = x_1 - x_2 = 0$$
$$g_2(X) = x_1 + x_2 + x_3 - 1 = 0$$

(4)

5. Consider the following problem:

$$\text{Minimize } f = (x_1 - 2)^2 + (x_2 - 1)^2$$

subject to

$$2 \geq x_1 + x_2$$
$$x_2 \geq x_1^2$$

Using Kuhn-Tucker conditions, find which of the following vectors is/are local minima:

$X_1 = \begin{pmatrix} 1.5 \\ 0.5 \end{pmatrix}$, $X_2 = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$. (5)

$6 + 6 - 4\pi + 4$

12

$6 - \frac{3}{2}\pi$

$-4b - 2\pi l = -4l - \pi l$

$4l - \pi l = 4b$

$(4+\pi)$

192
132
324

$6, 8$
$+8$
14

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6. Find the admissible and constrained variations at the point $X = (0, 4)^T$ for the following problem

$$\text{Minimize} \quad f = x_1^2 + (x_2 - 1)^2$$

subject to

$$-2x_1^2 + x_2 = 4. \tag{4}$$

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Dhirubhai Ambani Institute of Information & Communication Technology
Final Examination, Semester I 2019-20

Course Title	IT304 Computer Networks		**Max Marks**	40%
Date	29 November 2019	**CLOSED BOOK**	**Time**	2 Hours

Questions are worth 5 marks each.

1. Explain the important modifications done in IPv6 compared to IPv4. Describe the mechanisms used for incremental deployment of IPv6 and co-existence with IPv4. What is the role of flowID field in IPv6?

2. Briefly describe the operation of slotted ALOHA. For a system with large number of active nodes N, find the expression for system efficiency. What should the efficiency be for unslotted ALOHA – explain.

3. Describe the functioning of a switched hub in a LAN. How does it learn the changes in the LAN configuration? Explain the concept of VLAN and the functioning of a port-based Level-3 switch.

4. IPv6 is designed to support quality of service (QoS) provisioning for applications. As part of this, routers need to implement proper scheduling mechanisms for application flows.
   a. Describe the scheduling discipline for CBR traffic. CBR stands for constant bit-rate traffic. Assume fixed packet size.
   b. Do the same for VBR traffic. VBR stands for variable bit-rate traffic that is characterized by the average rate and maximum burst size.

5. A router is said to be congested if its buffer and packet forwarding resources are inadequate to handle incoming flows for a sustained period. In this context,
   a. What is the effect of congestion on the TCP and UDP flows passing through the same router?
   b. Explain if TCP congestion recovery mechanism is **fair** to the TCP and UDP flows.

6. For a p-persistent CSMA/CD with N active nodes, find the relation between p and N that maximizes the LAN efficiency. Find the expression for this maximum efficiency as a function of relevant LAN parameters.

7. Using clear examples, briefly explain how DHCP and NAT protocols help in more efficient use of the Internet address space. Does it make sense to use them together? Explain.

8. A second-generation datagram switch may occasionally reorder packets. Explain how? Propose a modification in the switch design/functioning that will ensure no reordering. Has this functionality come at a cost of performance? Explain.

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DA-IICT, Gandhinagar
EL203: Embedded Hardware Design
26th Nov, 2019 (Tuesday)...Exam: Final
Duration: 120 minutes (Time: 1430hrs-1630hrs)
Total Marks: 100

REGISTRATION NOS: 201711157
NAME: .....Axi J. Patel.....

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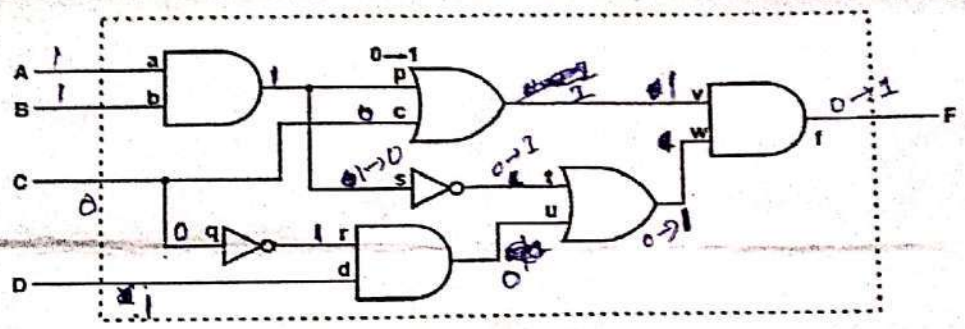
1. Use a 3-input Look Up Table (LUT) to realize a function $x=ab + bc$. [10 marks]

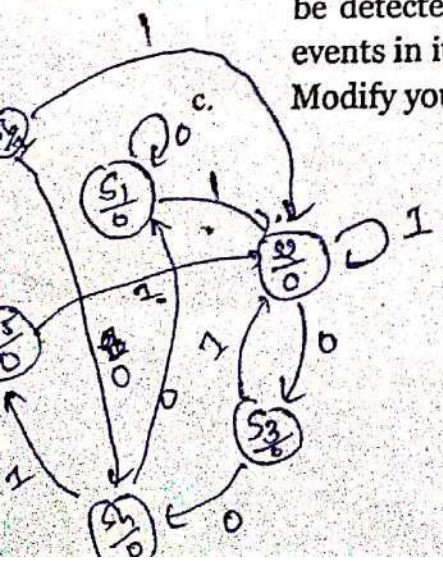
2. Determine the values of A, B, C and D necessary [30 marks]
   a. To test for p s-a-1. Specify the other faults tested by this input vector.
   b. To test for the fault condition so and to to be tested.

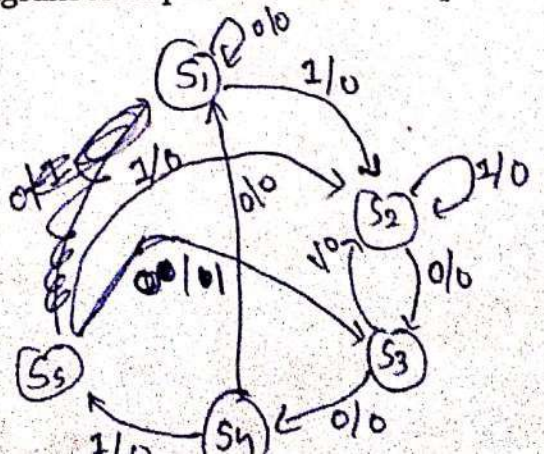


A	B	C	D
0	1	0	x
1	0	0	x
0	0	0	x

3. Design a pattern detector circuit that extracts the pattern "10010" from an input serial bit-stream. The circuit receives a new bit every clock cycle from its input "***in***" and has an output "***out***" used to indicate a pattern has been detected. ***out*** is pulled high for 1 clock cycle to indicate a pattern is detected, and then pulled low to prepare for the next match. [30 marks]

   a. Draw the state diagram of this circuit, marking the transition conditions and output values. The detected patterns should not overlap, i.e. it should take at least 5 more cycles after a pattern is detected to detect another pattern.
   b. Draw an updated state diagram of your circuit if you want overlapping patterns to be detected as two patterns, i.e. "10010010" should have two pattern detection events in it. Use a Moore state machine for your implementation.
   c. Modify your state diagram to implement the above part as a Mealy state machine.





0 0 0 1 0 1 0 0 1 0

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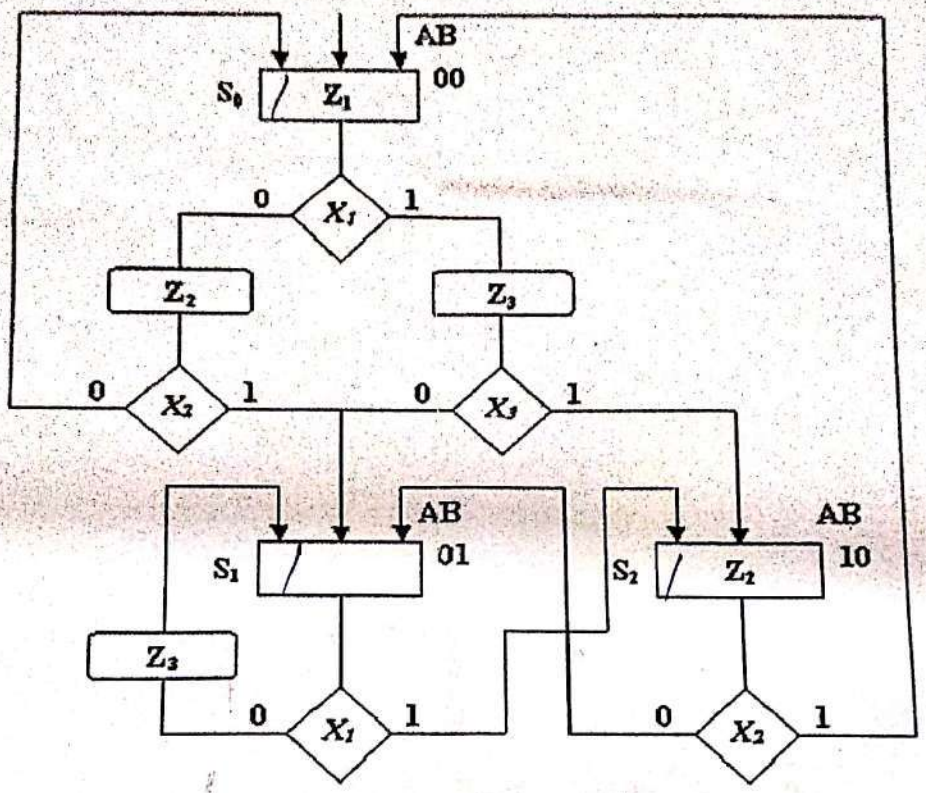
4. Realize the following SM chart using a PLA and D flip-flops that trigger on the falling edge of the clock pulse. Draw a block diagram and give the PLA table.

[30 marks]



Programmable Logic Array (PLA)

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-END OF PAPER-

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CT303 - Digital Communications
Autumn 2019/20

End-Sem Examination
Duration: 120 minutes

25th November 2019
Total Marks 25

1. Let $X(t)$ denote the stochastic process that generates NRZ-L pulse waveforms with pulse width T secs, for bit streams where the bits are independent. Let $X_d(n) = X(nT_s)$ be the sampled stochastic process with $T_s = T/10$ sec. Describe the autocorrelation matrix $R_{XX}(m,n)$, and conclude with proper justification whether the process X_d is stationary or not. [4]

2. Let $p_1, p_2, s_i, i = 1, \ldots, 4$ be sinusoid pulses as shown in Figure 1 below. [2+3=5]

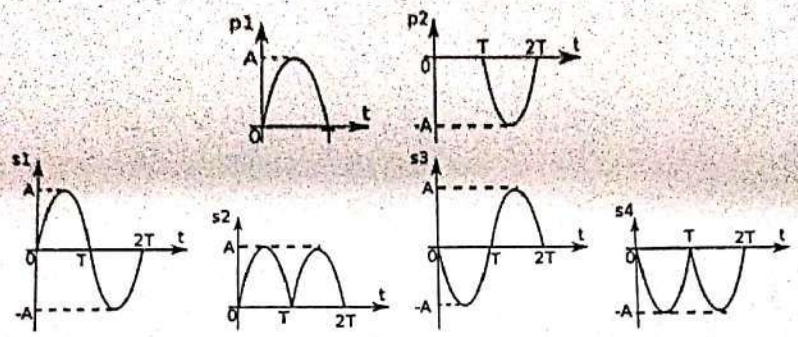

Figure 1: Sinusoid Symbol waveforms

(a) Write the expressions of the waveforms $s_i, i = 1, \ldots, 4$ in terms of the waveforms p_1, p_2.

(b) Represent the waveforms $p_1, p_2, s_i, i = 1, \ldots, 4$ in a 2D signal space diagram. With which modulation scheme does the signal space representation bear similarity with?

3. For a binary digital communication scheme let the two symbol waveforms be given by $s_1(t) = 0,\ 0 \le t \le T,\ s_2(t) = \sqrt{\frac{2E}{T}}\sin(2\pi f_0 t), 0 \le t \le T$. Assume that the channel is affected by AWG noise, and does not introduce any ISI. [3+2=5]

(a) Sketch the block diagram of the demodulator/detector using non-coherent detection and envelope detection, with a brief explanation.

(b) Let z_1 and z_2 be the sampled output of the two arms of the non-coherent demodulator. Determine the pdf of z_1 and z_2.

4. Answer the following questions briefly: [2+2+3+2+2=11]

(a) It is well known that the Matched filter maximizes the SNR at its *output* at multiples of T secs. What is the assumed SNR at the input of the Matched filter? Justify.

(b) The Euclidean distance between any two nearest signals represented in the constellation diagram for 8-PSK is 10 units. Determine the energy of the signals.

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(c) A channel with AWG noise with PSD $N_0 = 10^{-5} W/Hz$ and a bandwidth of 100 kHz is available for communication. What is the maximum bit rate that can be transmitted through the channel using (a) QPSK, (b) BPSK, and (c) 4-OFSK with non-coherent detection.

(d) Let $n(t)$ be a stationary stochastic process whose PSD is $N(f)$, with $N(f) \neq 0, \forall f$. Determine the frequency response of a filter whose output is a *white* stochastic process, when the input is $n(t)$.

(e) Binary data is to be transmitted at a rate 1 Mbps over a channel with bandwidth 700 kHz, using a Nyquist pulse whose Fourier transform is sketched below in Figure 2. Determine the roll-off factor and the frequencies f_1 and f_2.

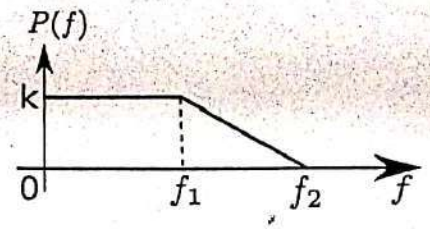

Figure 2: Fourier transform of a Nyquist pulse, $k \in \mathbb{R}$ is some arbitrary constant. Only positive frequencies have been shown, assume symmetry for negative frequencies.

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