

GATE CSE

# GATE CSE Book

November 2016

GATE CSE



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## Numerical Ability

### 1.1 Syllabus

- Numerical computation
- Numerical estimation
- Numerical reasoning and data interpretation

### 1.2 Syllabus Detailed

See 1.3 for reference materials

1. Numerical Computation - Geometry, Arithmetic, Geometric Series
2. Numerical Estimation
3. Numerical Reasoning
4. Data Interpretation - Pie Charts, Bar Charts

### 1.3 Web Links

1. Webpage for Numerical Ability
2. [http://amsi.org.au/teacher\\_modules/Circle\\_Geometry.html](http://amsi.org.au/teacher_modules/Circle_Geometry.html)

### 1.4 Exercise Solutions





## Verbal Ability

### 2.1 Syllabus

- English grammar, sentence completion
- Verbal analogies, word groups
- Instructions, critical reasoning and verbal deduction

### 2.2 Syllabus Detailed

See 2.3 for reference materials

1. English grammar
2. Sentence completion
3. Verbal analogies
4. Word groups
5. Instructions, critical reasoning and verbal deduction

### 2.3 Web Links

1. Webpage for Verbal Ability

### 2.4 Exercise Solutions



## Discrete Mathematics

### 3.1 Syllabus

- Propositional and first order logic
- Sets
- Relations
- Functions
- Partial orders and Lattices
- Groups
- Graphs(connectivity, matching, coloring)
- Combinatorics(counting, recurrence relations, generating functions)

### 3.2 Syllabus Detailed

Using Rosen [6] as reference.

1. Propositional and first order logic - Need to know how to translate between English statements and First order logic statements. De-Morgan's law is important which can be used to translate a first order logic statement with  $\forall$  to one with  $\neg\exists$  and vice-verse. Implications with first order logic statements are asked many times for validity in GATE - always try to see if RHS can be false with LHS true. A formula is valid means it holds for any instance (false for none). A formula is satisfiable, if it holds for some instance. So, to check if a formula is valid, we can just see if its negation is not satisfiable. Chapter 1. Easy scoring area if you get it.
2. Sets - Cardinality of a set which is the number of elements in it. Power set, which is the set of all subsets of a set. Chapter 2.
3. Relations - (Symmetric, Reflexive, Transitive, Equivalence). Chapter 9.
4. Functions - Function Types - One-one, One to many, Many to one, Onto. Number of possible functions between two given sets. A relation becomes a function when each element of the domain set maps to *one and only one* element of the co-domain set. For a relation  $A \rightarrow B$ ,  $A$  is the domain set and  $B$  is the co-domain set. Range is a subset of  $B$ , which includes all the elements actually mapped to by  $A$ . Chapter 2.
5. Partial orders and Lattices. Least Upper Bound, Greatest Lower Bound, Hasse Diagram. Total Order, Well Order. Chapter 2.

6. Groups - Definition, difference from semi-group, abelian group, monoid. Order of a group and Lagrange's theorem. Advanced Portions include generator, cyclic group, Klein 4 group. See Section 3.3.
7. Graphs - connectivity, matching, coloring - Chapter 10.
8. Combinatorics - counting, recurrence relations, generating functions. Chapter 6, 8. Chapter 7 is needed for Probability.

### **3.3 Web Links**

1. Webpage for Mathematical Logic & Algebra
2. Webpage for Set Theory & Algebra
3. Webpage for Combinatory
4. Webpage for Graph Theory
5. [http://gateoverflow.in/722/gate2001\\_2-4](http://gateoverflow.in/722/gate2001_2-4)

### **3.4 Exercise Solutions**

## Probability

### 4.1 Syllabus

- Random variables
- Uniform, normal, exponential, poisson and binomial distributions.
- Mean, median, mode and standard deviation.
- Conditional probability and Bayes theorem.

### 4.2 Syllabus Detailed

Using Rosen [6] as reference.

1. Random variables. Chapter 7.
2. Uniform, normal, exponential, poisson and binomial distributions. See Section 4.3
3. Mean, median, mode and standard deviation. See Section 4.3
4. Conditional probability and Bayes theorem. Chapter 7.

### 4.3 Web Links

1. Webpage for Probability

### 4.4 Exercise Solutions



## Digital Logic

### 5.1 Syllabus

- Boolean algebra
- Combinational and sequential circuits
- Minimization
- Number representations and computer arithmetic (fixed and floating point)
- Booths Algorithm

### 5.2 Syllabus Detailed

Using Mano [5] as reference.

NPTEL - Recommended Video

1. Boolean algebra - Boolean Functions, Canonical Forms. Chapter 2, sections 1-5.
2. Combinational circuits - Half/Full adder, Half/Full Subtractor, Code Conversion, **Binary Parallel Adder**, MUX, DEMUX, Encoder, Decoder, **ROM**, **PLA**. Chapters 4-5.
3. **Sequential circuits - SR FlipFlop, JK FlipFlop, T FlipFlop, D FlipFlop, Counters**, Synchronous Counters, Ripple Counters. Asynchronous Sequential Circuits- Hazards. Chapters 6, 7, 9.
4. **Minimization - K-MAP, SOP, POS, Prime Implicants**. Chapter 3.

No. of Boolean functions possible, simplification of Boolean functions

Determine the output of circuit, **propagation delay of adder, carry-look-ahead generation, minimum no. of NAND/NOR gates required**, static hazard

Flip-flops given and modulus of counter asked, for sequential circuit output after 't' cycles, counters using flipflops, static hazard

Minimization asked a lot, minimization with don't cares

5. Number representations and computer arithmetic - fixed and floating point, 1's complement, 2's complement, sign magnitude format for negative numbers, **IEEE 754 Floating Point Representation for single/double precision**, IEEE 754 Single Precision Ranges. Partly covered in Chapters 1, 8 and in Computer Organization. Also see Section 5.3 which details this beautifully.

As of now IEEE 754 representation is mostly asked and previous representations not required, range, precision, difference between 2's complement and 2's complement representation

### 5.3 Web Links

1. Webpage for Digital Logic
2. Previous GATE Questions in Digital Logic
3. GATECSE Discussion lead by Praveen Saini and Ravi Singh
4. NPTEL - Recommended Video
5. IEEE 754 - Must see
6. Multipliers
7. Number Representation
8. Fixed Point Representation

### Important Problems

1. <http://gateoverflow.in/65751/rs-complement>
2. <http://gateoverflow.in/29729/hexadecimal-subtraction>
3. <http://gateoverflow.in/31359/minimum-nand-gates-realization-exor-exnor-adder-sub>
4. <http://gateoverflow.in/28723/minimum-number-of-gates>
5. <http://gateoverflow.in/35739/number-of-nor-gates>
6. [http://gateoverflow.in/2206/gate2010\\_32](http://gateoverflow.in/2206/gate2010_32)
7. [http://gateoverflow.in/17407/gate1992\\_04\\_b](http://gateoverflow.in/17407/gate1992_04_b)
8. <http://gateoverflow.in/39575/gate-2016-2-07>
9. [http://gateoverflow.in/264/gate2005\\_62](http://gateoverflow.in/264/gate2005_62)
10. [http://gateoverflow.in/2776/gate1996\\_24](http://gateoverflow.in/2776/gate1996_24)- beautiful question
11. <http://gateoverflow.in/39670/gate-2016-1-8>
12. <http://gateoverflow.in/1814/gate2006-38>

### 5.4 Exercise Solutions



## Algorithms

### 6.1 Syllabus

- Searching, sorting, hashing.
- Asymptotic worst case time and space complexity.
- Algorithm design techniques: greedy, dynamic programming and divideandconquer.
- Graph search, minimum spanning trees, shortest paths.

### 6.2 Syllabus Detailed

Using Cormen et al. [2] as reference. Is the must follow book. Discrete Mathematics is a prerequisite.

1. Searching - Linear Search, binary search. Chapter 12 of CLRS.
2. Sorting - Bubble Sort, Selection Sort, Insertion Sort, Merge Sort, Heap Sort, Quick Sort, Radix Sort - Chapters 1, 2, 6, 7, 8 of which 1 is very important for GATE though it is just introduction. There is no use of by-hearting the sorting algorithms, rather you must know how the algorithm works given an example- i.e., output after each step of the algorithm for any example input like 4, 7, 1, 3, 2. Similarly, you should know the essence of every proof though there would not be any proof questions for GATE (this can be asked for research interviews).
3. Hashing - Hash functions, Linear Probing. Chapter 11 of CLRS.
4. Asymptotic worst case time and space complexity- Chapters 3,4. Should know the asymptotic notations  $O$ ,  $\Omega$ ,  $\Theta$ ,  $o$ ,  $\omega$ ,  $\theta$  and also given an algorithm to find its worst case time complexity as well as space complexity. Space complexity is usually measured in terms of auxiliary space being used by the algorithm – like extra arrays or stack space in case of recursion and not including the space taken by the input. It is advisable to see previous gate questions in this topic as they cover all the possibilities – just do not mug up them though.
5. Greedy - Chapter 16. Huffman code has been asked many times for GATE. Most algorithms which we think naively are greedy ones.
6. Dynamic Programming - Chapter 15. Again should know the working of the algorithm as example questions might be asked in GATE and asking to find out a wrong/missing step.
7. Divide and Conquer - Covered by merge sort in Chapter 2.
8. Graph Search - BFS, DFS - covered in chapter 22. Should know to work out an example and also their time complexities.

9. Minimum Spanning Trees - Chapter 23. Prim's and Kruskal's algorithms. Example workout and time complexities.
10. Shortest Paths
  - a) Single Source Shortest Path - Chapter 24. Single source shortest path is given by Dijkstra's algorithm and Bellman ford algorithm. Dijkstra's algorithm works for non-negative edge graphs and in case a negative edge(s) is present it may or may not produce correct result. Bellman Ford algorithm works for single source shortest path with negative edges but not if there is a negative edged cycle (what should be the output in such a case?)
  - b) All Pairs Shortest Path - Chapter 25. Floyd-Warshal algorithm and Johnson's algorithm the later using dynamic programming to improve the time complexity. This portion is rarely asked, still good to have a run through it.

### 6.3 Web Links

1. Webpage for Algorithms
2. <http://gateoverflow.in/47185/dijkstra-algorithm>
3. [http://gateoverflow.in/8313/gate2015-1\\_43](http://gateoverflow.in/8313/gate2015-1_43)
4. <http://gateoverflow.in/27180/tifr2014-b-5>
5. [http://gateoverflow.in/1247/gate2007\\_49](http://gateoverflow.in/1247/gate2007_49)
6. [http://gateoverflow.in/2019/gate2014-2\\_52](http://gateoverflow.in/2019/gate2014-2_52)
7. [http://gateoverflow.in/3355/gate2008-it\\_45](http://gateoverflow.in/3355/gate2008-it_45)
8. [http://gateoverflow.in/457/gate2008\\_45](http://gateoverflow.in/457/gate2008_45)
9. [http://gateoverflow.in/2048/gate2014-3\\_14](http://gateoverflow.in/2048/gate2014-3_14)
10. <http://gateoverflow.in/4916/hashing>

### 6.4 Exercise Solutions

## Data Structures

### 7.1 Syllabus

- Arrays, stacks, queues,
- Linked lists
- Trees, binary search trees, binary heaps,
- Graphs.

### 7.2 Syllabus Detailed

Using Cormen et al. [2] as reference.

1. Arrays. Covered as part of sorting.
2. Stacks, Queues. Stack is covered as part of runtime stack in Compilers, Queue is covered in Priority scheduling in OS etc. Need to know how to implement a stack with queues and vice versa. Previous GATE questions are enough. Chapter 10.
3. Linked lists. Chapter 10.
4. Trees. Chapter 11 in [6].
5. Binary search trees. Chapter 12.
6. Binary heaps. Chapter 6, covered in algorithms.
7. Graphs. Chapter 22, covered in algorithms.

### 7.3 Web Links

1. Webpage for Data Structures
2. <http://gateoverflow.in/39706/gate-2016-1-37>
3. [http://gateoverflow.in/8091/gate2015-2\\_17](http://gateoverflow.in/8091/gate2015-2_17)

### 7.4 Exercise Solutions



## Programming

### 8.1 Syllabus

- Programming in C (includes writing simple C code like for checking if a machine is little endian)
- Recursion

### 8.2 Syllabus Detailed

Using Kernighan [4] as reference.

1. Programming in C (includes writing simple C code like for checking if a machine is little endian). Chapters 1-6.
2. Recursion. See Section 8.3

### 8.3 Web Links

1. Webpage for Programming
2. [http://gateoverflow.in/736/gate2001\\_2-18](http://gateoverflow.in/736/gate2001_2-18)

### 8.4 Exercise Solutions



## Theory of Computation

### 9.1 Syllabus

- Regular expressions and finite automata
- Context-free grammars and push-down automata
- Regular and context-free languages
- pumping lemma
- Turing Machines and undecidability

### 9.2 Syllabus Detailed

See 9.3 for reference materials

1. Regular expressions and finite automata
2. Context-free grammars and push-down automata
3. Regular and context-free languages
4. pumping lemma
5. Turing Machines and undecidability(Recursive and Recursive Enumerable Language)

### 9.3 Web Links

1. Webpage for Theory of Computation

### 9.4 Exercise Solutions





## CO & Architecture

### 10.1 Syllabus

- Machine instructions and addressing modes.
- ALU, datapath and control unit.
- Instruction pipelining.
- Memory hierarchy: cache, main memory and secondary storage;
- I/O interface. (Interrupt and DMA mode)

### 10.2 Syllabus Detailed

Using Hamacher et al. [3] as Reference.

1. Machine instructions and addressing modes - No. of 0, 1, 2 address instructions possible. Direct, Indirect (pointers), Indexed (arrays), Immediate addressing modes (constants). Chapter 2, sections 1-5 and some portions of Number Representation of Digital Logic also covered. Questions on addressing modes PC value after a sequence of instructions etc. are usually asked. No. of 0, 1, 2 address instructions (Expanding opcodes) is also there.
2. ALU, datapath, control unit - Components inside CPU- MDR, MAR, PC, their working sequence. Hardwired Control, Microprogrammed Control. Horizontal microprogramming, vertical microprogramming. Chapter 7 complete.  
Data path for push, subroutine call instructions.
3. Instruction pipelining - Pipeline efficiency, Ideal speed up, Pipeline Hazards, How to handle them, Efficiency with Hazards. Chapter 8 sections 1-5. Do see notes part also. In an in-order machine, only RAW hazard is there. In out-of-order machines WAW and WAR hazards can be eliminated by register renaming. In pipeline  
Always try to get the best performance assuming operand forwarding. Split phase access is assumed between WB and RD stages where data is readily available. Similarly, if between any stages data is readily available (and not having to wait for an instruction execution or memory access), those stages can go in same cycle.
4. Memory hierarchy: cache, main memory and secondary storage; - Types of caches, numerous problems involving cache and virtual memory (prev. GATE questions is the best resource). Chapter 5 sections 5-9.  
The formula for average memory access time is

$$\text{Avg. Memory Access Time} = h \times \text{hit}_{time} + (1 - h) \times \text{miss}_{penalty} \quad (10.1)$$

where  $h$  is the hit rate in cache. The miss penalty often includes the cache access time (hierarchical) and subsequent memory access time. On such a system we can use any of the below two formulae

$$\text{Avg. Memory Access Time} = h \times \text{cache}_{time} + (1 - h) \times (\text{cache}_{time} + \text{memory}_{time}) \quad (10.2)$$

OR

$$\text{Avg. Memory Access Time} = \text{cache}_{time} + (1 - h) \times \text{memory}_{time} \quad (10.3)$$

The reason why hierarchical access is used is because it can reduce the amount of memory requests. But for the same reason, for write access and write through cache (all writes goes to memory as well), we usually have simultaneous update of cache and memory.

5. I/O interface. (Interrupt and DMA mode). Chapter 4 sections 1, 2, 4. When an interrupt happens CPU finishes execution of the current instruction and processes the ISR and finally comes back to process the next instruction onward.

### 10.3 Web Links

1. Webpage for CO & Architecture

### 10.4 Exercise Solutions

## Operating System

### 11.1 Syllabus

- Processes
- Threads
- Inter-process communication
- Concurrency
- Synchronization
- Deadlock
- CPU scheduling
- Memory management and virtual memory
- File systems

### 11.2 Syllabus Detailed

Using Silberschatz et al. [8] as reference.

1. Processes - Process/job scheduling, Interprocess Communication. Chapter 4.
2. Threads - Threading issues, difference between a thread and a process, User/Kernel level threads. Chapter 5. See weblinks.
3. Inter-process communication. Chapter 4.
4. Concurrency, Synchronization - Critical Section, Semaphore, Atomic Transactions. Chapter 7.
5. Deadlock - Resource Allocation, Deadlock prevention, avoidance, detection, recovery. Chapter 8.
6. CPU scheduling - Scheduling Algorithms, Criteria and problems on them. Chapter 6.
7. Memory management - Swapping, paging, segmentation. Problems on them- see notes. Chapter 9.
8. Virtual memory - Demand paging, Page replacement including problems, Thrashing - Chapter 10.
9. File systems. Directory structure, allocation methods. Chapters 11, 12.

### 11.3 Web Links

1. Webpage for Operating Systems

2. IO: [http://gateoverflow.in/1009/gate2004\\_12](http://gateoverflow.in/1009/gate2004_12)
3. Pagefault <http://gateoverflow.in/69160/os>
4. <http://algorithmsandme.in/2015/03/virtual-memory-using-paging/>

## **11.4 Exercise Solutions**

## Compilers

### 12.1 Syllabus

- Lexical analysis, parsing, syntax-directed translation.
- Runtime environments.
- Intermediate code generation.

### 12.2 Syllabus Detailed

Using Aho et al. [1] as reference.

1. Lexical analysis - No. of tokens in a C code. Chapter 3, previous GATE questions.
2. Parsing
  - Top Down Parsing
    - Recursive-Descent Parser - Elimination of Left Recursion, Left Factoring
    - Predictive Parser - Efficient way of Implementing Recursive-Descent parsing. First, Follow and Predictive Parsing Table construction.
  - Bottom-up Parsing
    - Shift Reduce Parsing
      - a) Operator Precedence - works for special type of grammar only (Rarely Asked)
      - b) LR(0)
      - c) SLR
      - d) LALR
      - e) CLR

Need to know how to construct the parsing tables for each.  $SLR < LALR < CLR$  in terms of parsing power. Chapters 5, 6. See weblinks first and understand how to construct tables. The writings in textbook are not easy to follow.

3. Syntax-directed translation - Parse trees, Postfix translation. Chapter 7.
4. Runtime environments - Parameter passing techniques. Runtime stack, heap. Chapter 11.
5. Intermediate code generation - SSA form - see Weblinks, Quick reads through Chapters 12, 13 in case asked.

### 12.3 Web Links

1. Webpage for Compilers

## **12.4 Exercise Solutions**

## Linear Algebra

### 13.1 Syllabus

- Matrices
- Determinants
- System of linear equation
- eigen value
- eigen vector
- LU decomposition

### 13.2 Syllabus Detailed

See 13.3 for reference materials

1. Matrices-symmetric matrix, skew symmetric matrix, singular matrix, Orthogonal matrix, hermitian matrix, diagonal matrix, identity matrix or unit matrix, upper triangular matrix, lower triangular matrix
2. Determinants
3. System of linear equation
4. eigen value
5. eigen vector
6. LU decomposition

### 13.3 Web Links

1. Webpage for Linear Algebra
2. [http://gateoverflow.in/2013/gate2014-2\\_47](http://gateoverflow.in/2013/gate2014-2_47)
3. <http://math.stackexchange.com/questions/82467/eigenvectors-of-real-symmetric-matrices->
4. [http://gateoverflow.in/33416/gate\\_2014-me](http://gateoverflow.in/33416/gate_2014-me)
5. [http://gatecse.in/linear-algebra/#disqus\\_thread](http://gatecse.in/linear-algebra/#disqus_thread)

### 13.4 Exercise Solutions





## Databases

### 14.1 Syllabus

- ERmodel, Integrity Constants, Relational model(Normal Form)
- Query Language(SQL)
- File Structure(sequential files, indexing, B and B+ trees)
- Transaction and concurrency control

### 14.2 Syllabus Detailed

Using Silberschatz et al. [7] as reference. Discrete Mathematics must be done before doing Database.

1. ERmodel. Understanding an ER diagram. Conversion from ER to Relational model. Chapter 6. [Minimum number of tables required for a given ER diagram]
2. Relational model. Normalization up to 4NF but till BCNF are mostly asked. 5NF is concerned with Join dependency in case asked. Understanding Relational Algebra, Tuple Relational Calculus, domain relational calculus (similar to Propositional Logic) Chapters 2, 5, 7. [Meaning of given tuple relational query etc., normal form of a given relation, FDs]
3. Query Language(SQL). Basic operations, Joins, Null Values, Nested Queries. Chapter 3. Questions are based on SQL standard and not tied to any implementation.
4. File Organization (Disk storage and File structure (Covered in OS too), Hashing (Covered in DS)). Chapter 11.
5. Indexing - Primary index, Dense Index, Secondary Index. Chapter 12 or Chapter 14 of Navathe
6.  $B$  Tree,  $B^+$  Tree. Chapter 12. [Minimum and maximum no. of nodes in  $B$ ,  $B^+$  trees]
7. Transaction - ACID properties, Serializability, Recovery. Chapter 15. [Finding view and conflict serializability]
8. Concurrency control - Lock-based, Timestamp-based, Validation-based Protocols. Chapter 16.

### 14.3 Web Links

1. Webpage for Databases
2. [http://gateoverflow.in/8482/gate2015-3\\_29](http://gateoverflow.in/8482/gate2015-3_29)
3. [http://gateoverflow.in/8151/gate2015-2\\_32](http://gateoverflow.in/8151/gate2015-2_32)
4. [http://gateoverflow.in/8047/gate2015-2\\_1](http://gateoverflow.in/8047/gate2015-2_1)

## **14.4 Exercise Solutions**

## Computer Networks

### 15.1 Syllabus

- Concept of layering. LAN technologies (Ethernet).
- Flow and error control techniques, switching.
- IPv4/IPv6,
- Routers and routing algorithms (distance vector, link state).
- TCP/UDP and sockets, congestion control.
- Application layer protocols (DNS, SMTP, POP, FTP, HTTP).
- Basics of Wi-Fi.
- Network security: authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls.

### 15.2 Syllabus Detailed

Using Tanenbaum [9] as reference.

1. Concept of layering. Chapter 1 section 4.
2. LAN technologies (Ethernet) - Medium Access Sublayer - Chapter 4 section 3.1-3.4.
3. Flow and error control techniques - Data Link Layer Chapter 3 sections 1-4.
4. Switching - Circuit Switching, Packet Switching. Chapter 2 section 4.5.
5. IPv4/IPv6 Chapter 5, section 5.
6. Routers and routing algorithms - Network Layer - distance vector, link state, hierarchical. Chapter 5 section 2.
7. TCP/UDP and sockets, congestion control. Chapter 6 sections 1-4.
8. Application layer protocols -DNS, SNMP, SMTP, POP, FTP, HTTP- Just a quick read is enough. Chapter 7.
9. Basics of Wi-Fi. IEEE 802.11. Chapter 4 section 2.6 gives a short introduction. See notes.
10. Network security: authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls.

Important Types :

Addressing related questions :: Subnet address, supernet address, broadcast address, range of network, no of host, classless addressing, non continuous addresses, first host and last host finding etc.

Properties Of Circuit Switching and packet switching, Routing Protocols and Numerical Problems on them.

Flow Control and Error Control Policies. Numerical Problems on Window Size [ sliding window protocols ] , No Of Sequence bits, frame size, bandwidth, round trip time, utilization, Hamming Distance, CRC.

Congestion Control policies like slow start, congestion avoidance and Congestion Detection.

IP Header , TCP and UDP header format, theory related to Ethernet and token ring.

Basics Of Different Type of protocols like : FTP, HTTP, DHCP, ARP, RARP, SMTP, ICMP, POP .

Basic Concepts of Cryptography and firewalls.

### **15.3 Web Links**

1. Webpage for Computer Networks

### **15.4 Exercise Solutions**

## Calculus

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### 16.1 Syllabus

- Limits
- Continuity and Differentiability
- Maxima and minima
- Mean value theorem
- Integration

### 16.2 Syllabus Detailed

See 16.3 for reference materials

1. Limits
  - a)  $\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1$
  - b)  $\lim_{x \rightarrow 0} \frac{e^{ax} - 1}{x} = a$
  - c) L hospital rule
2. Continuity
3. Differentiability
  - a) To see a function differentiable or not at a point  $p$   $\lim_{x \rightarrow p^-} \frac{f(x+h)-f(x)}{h} = \lim_{x \rightarrow p^+} \frac{f(x+h)-f(x)}{h}$
4. Maxima and minima
  - a) For a function  $f(x)$  if  $\frac{\partial^2 f}{\partial x^2} > 0$  Then there exists a local minima in the point  $\frac{\partial f}{\partial x} = 0$  and if  $\frac{\partial^2 f}{\partial x^2} < 0$  Then there exists a local maxima in the point  $\frac{\partial f}{\partial x} = 0$
5. Mean value theorem
  - a) Rolls Theorem
  - b) Lagranges Theorem
6. Integration
  - a) See formula of class 12 book

#### 16.2.1 Important Formulae

- b) Integration by parts:  $\int uv dx = u \int v dx - \int \frac{du}{dx} \int (v dx) dx$
- c) Odd and Even function :see grewal page:252

- d) <http://planetmath.org/integralsofevenandoddfunctions>
- e) forreference:[http://gateoverflow.in/1722/gate1998\\_8](http://gateoverflow.in/1722/gate1998_8)
- f) [http://gateoverflow.in/3782/gate2005-it\\_35](http://gateoverflow.in/3782/gate2005-it_35)
- g) [http://gateoverflow.in/41/gate2012\\_9](http://gateoverflow.in/41/gate2012_9)

### 16.3 Web Links

#### 1. Webpage for Calculus

- 2. [http://gateoverflow.in/2013/gate2014-2\\_47](http://gateoverflow.in/2013/gate2014-2_47)
- 3. <http://math.stackexchange.com/questions/82467/eigenvectors-of-real-symmetric-mat>
- 4. [http://gateoverflow.in/33416/gate\\_2014-me](http://gateoverflow.in/33416/gate_2014-me)
- 5. [http://gatecse.in/linear-algebra/#disqus\\_thread](http://gatecse.in/linear-algebra/#disqus_thread)

### 16.4 Exercise Solutions

## Conclusion

"I always thought something was fundamentally wrong with the teaching system in India. So why not change it."





## FAQs



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- [9] Andrew Tanenbaum. *Computer Networks*. Prentice Hall Professional Technical Reference, 3rd edition, 2002. ISBN 0130661023.