CBCS SCHEME

USN | | | | | | | | | | |

21EC72

Seventh Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025
Optical and Wireless Communication

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Briefly explain with a neat figure the propagation mechanism of meridional rays in an ideal step index optical waveguide. **(08 Marks)**

b. Define the term attenuation in optical fibers. Explain the different attenuation mechanisms in optical fibers. **(12 Marks)**

OR

2 a. Define Dispersion. Briefly explain intermodal and intramodal dispersion effects in optical waveguide. **(10 Marks)**

b. With neat figures, discuss the structure of single mode and multimode step-index and graded index optical fibers. **(06 Marks)**

c. A multimode fiber has a core refractive index of 1.480 and a core cladding index difference of 2.0 percent. Find the numerical aperture and critical angle at the core cladding interface. **(04 Marks)**

Module-2

3 a. What are the characteristic requirements of an optical source? With the help of neat diagram, explain the constructional features and emission pattern of surface emitting LED. **(10 Marks)**

b. Define optical isolator. With a neat figure, explain the design and operation of a polarization independent isolator. **(06 Marks)**

c. A given silicon avalanche photodiode has a quantum efficiency of 65 percent at a wavelength of 900 nm. If 0.5 μw of optical power produces a multiplied photocurrent of 10 μA. What is the multiplication M? **(04 Marks)**

OR

4 a. Discuss the operation of pin photodiode with a neat circuit and energy band diagram. **(10 Marks)**

b. What is Diffraction gratings? Discuss briefly Diffraction grating techniques. **(10 Marks)**

Module-3

5 a. Explain briefly the different propagation mechanisms that influence the signal propagation in a mobile communication environment. **(10 Marks)**

b. A cellular communication service area is covered with 12 clusters having 7 cells in each cluster and 16 channels assigned in each cell. Find the number of channels per cluster and the system capacity. **(03 Marks)**

c. Explain how the concept of frequency reuse increases the spectrum efficiency that intum increases the cellular communication system capacity. **(07 Marks)**

OR

6 a. Briefly discuss the generations of wireless communication network technology. (08 Marks)

b. Discuss the effects of co-channel interference in wireless communication in reducing the system capacity. (05 Marks)

c. Discuss the concept of multipath fading in mobile communication system. (07 Marks)

Module-4

7 a. With a neat block diagram, explain the operation of basic TDMA link. (10 Marks)

b. Explain the basic cellular system with necessary block diagram. (10 Marks)

OR

8 a. Discuss with a neat figure the call processing in a cellular system for mobile-originated calls. (12 Marks)

b. List the advantages of CDMA over TDMA and FDMA. (08 Marks)

Module-5

9 a. What is Hand off in GSM networks? Explain briefly the different handoff procedure in GSM. (10 Marks)

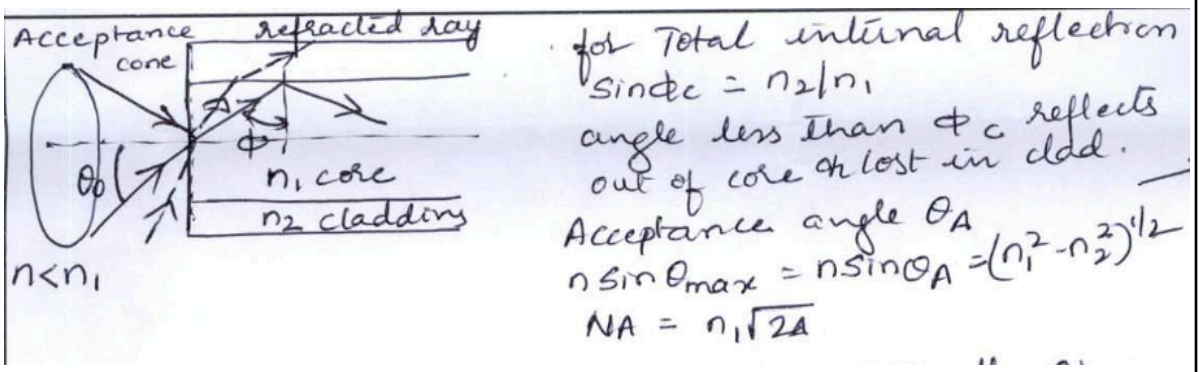
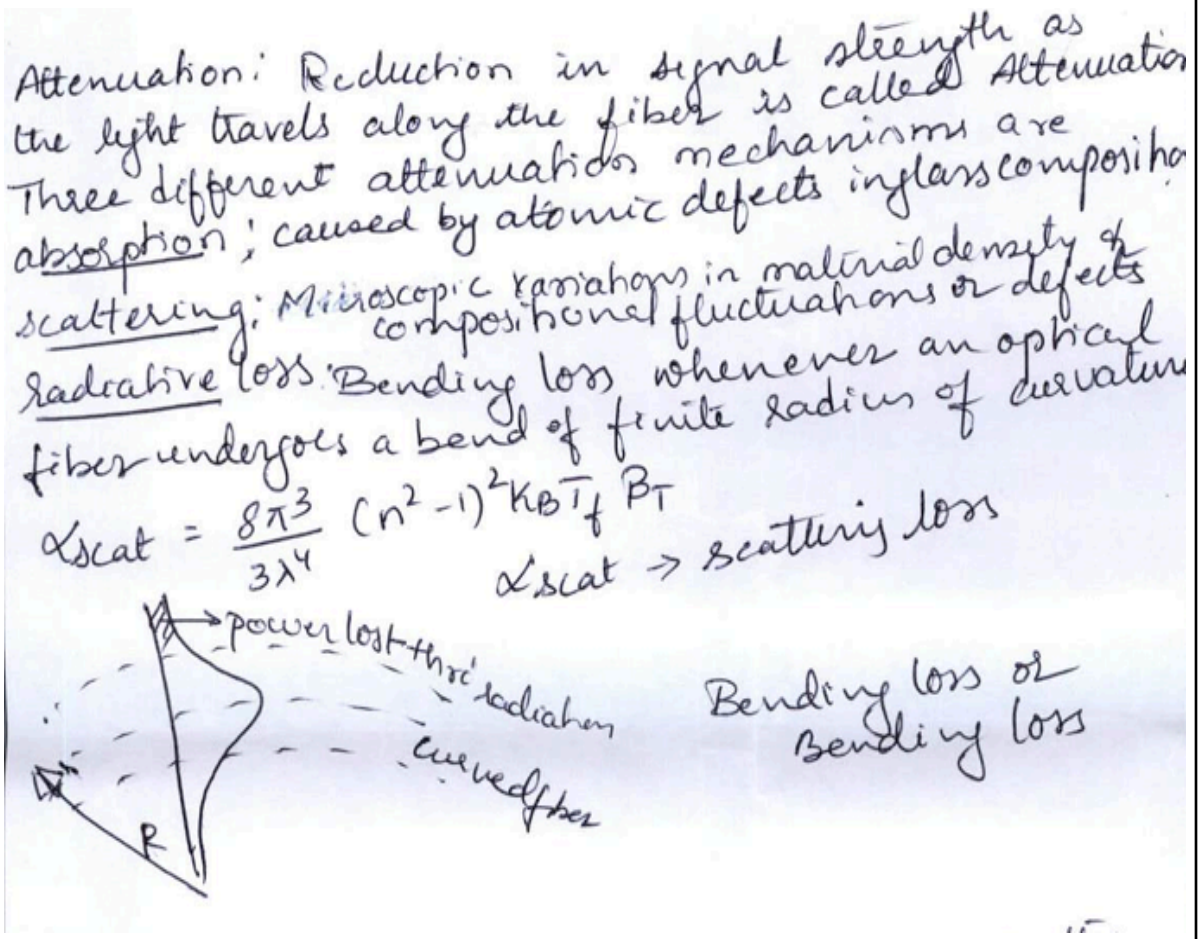
b. Explain the functions of data bases HLR and VLR at MSC in GSM network architecture and also explain how it is helpful in location updation in GSM networks. (10 Marks)

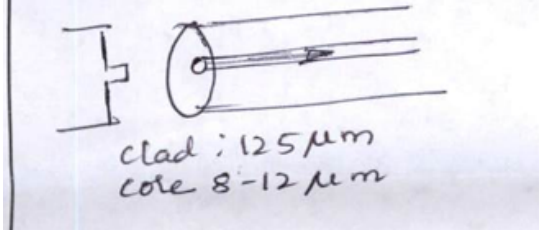
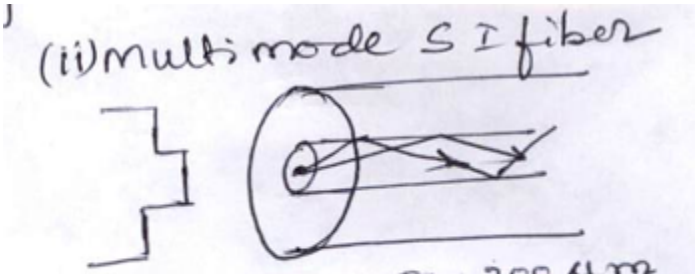
OR

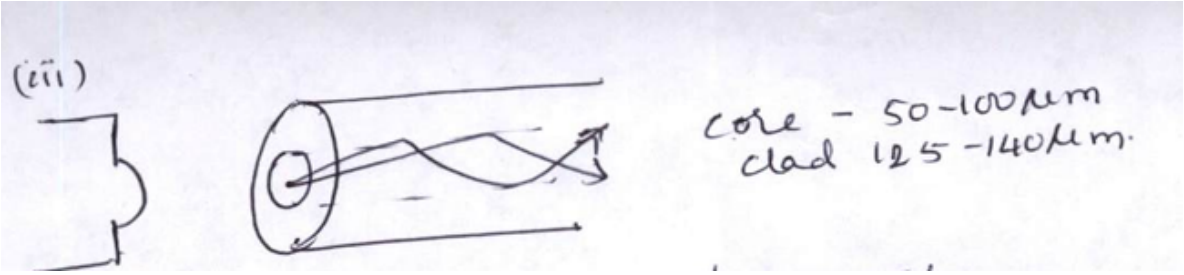
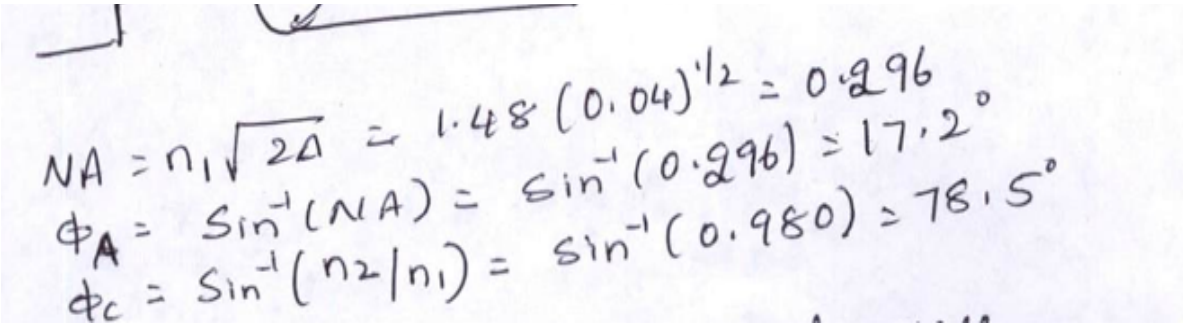
10 a. Briefly explain the three major subsystems in GSM network architecture with a neat block diagram. (10 Marks)

b. Explain briefly the following identifiers in GSM system:
(i) SIM
(ii) Mobile system ISDN with frame format
(iii) Location Area Identify (10 Marks)

* * * * *

1	a	Propagation mechanism in step index fibre:  for Total internal reflection $\sin\theta_c = n_2/n_1$ angle less than θ_c reflects out of core & lost in cldd. Acceptance angle θ_A $n\sin\theta_{max} = n\sin\theta_A = (n_1^2 - n_2^2)^{1/2}$ $NA = n_1\sqrt{2\Delta}$
1	b	Attenuation in Optical FIbers: 

2	a	Dispersion: Dispersion: Dispersion in an optical fiber is the spreading of light pulse as it propagates down the fiber Intramodal Dispersion: is pulse spreading that takes place within a single mode because of finite spectral width of an optical source. * It is a function of wavelength. Two types of Dispersion of Intramodal types are Material dispersion and waveguide dispersion Brief explanation of material dispersion ~~*~~ waveguide dispersion Intermodal dispersion: Appears in MM fibers. Modal delay is a result of each mode having a different value of the group ~~velocity~~ Velocity at a single frequency.
2	b	(i) Single mode SI fiber  clad : 125 μm core 8-12 μm (ii) Multi mode SI fiber  core : 50-200 μm clad : 125-400 μm

		
2	c	Problem: 

3	a	Optical Source:

characteristic requirements of optical source
• Narrow radiation pattern, Linearity, fast response time • Adequate output power

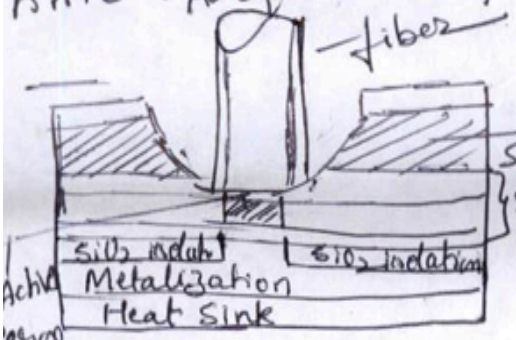
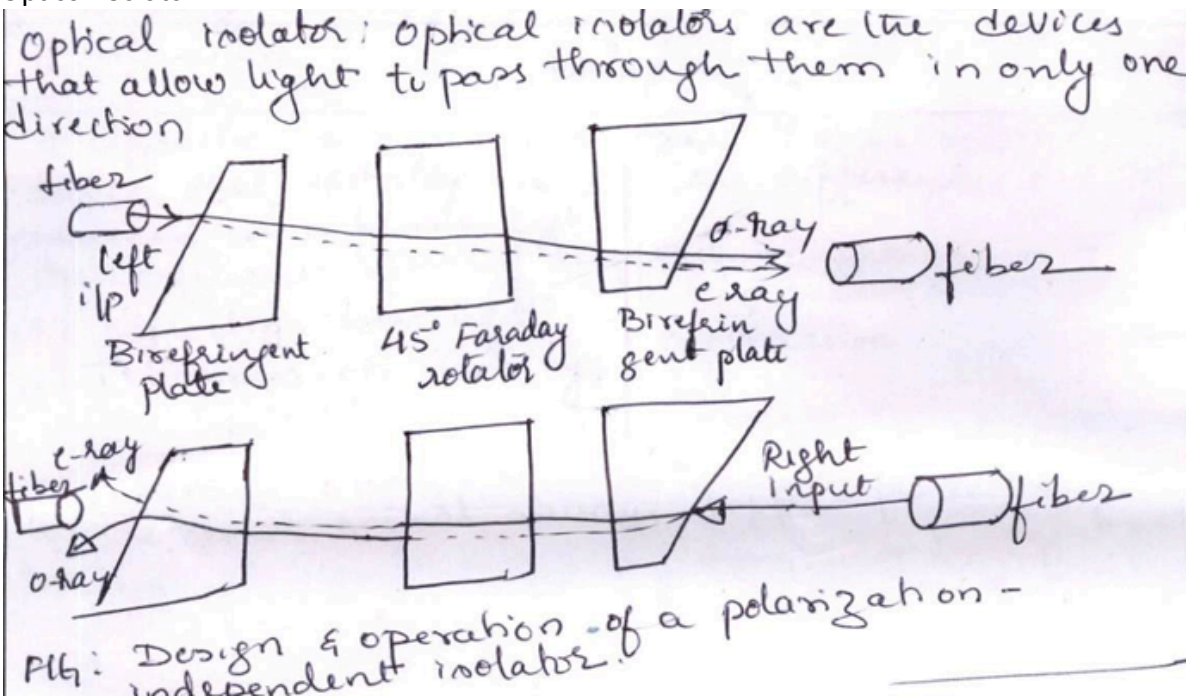
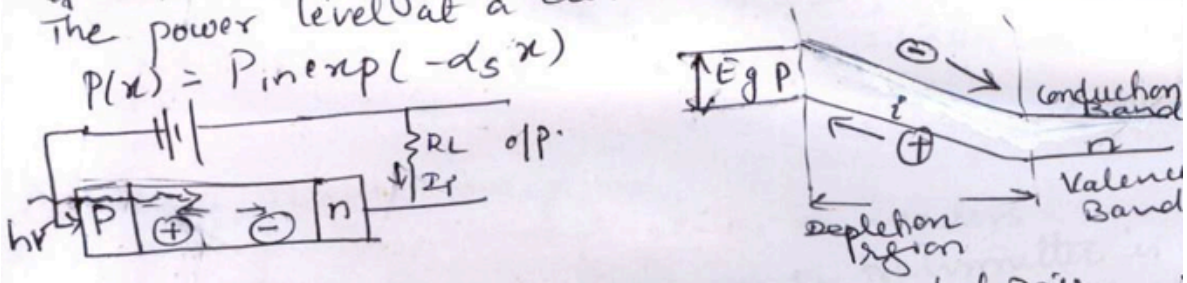
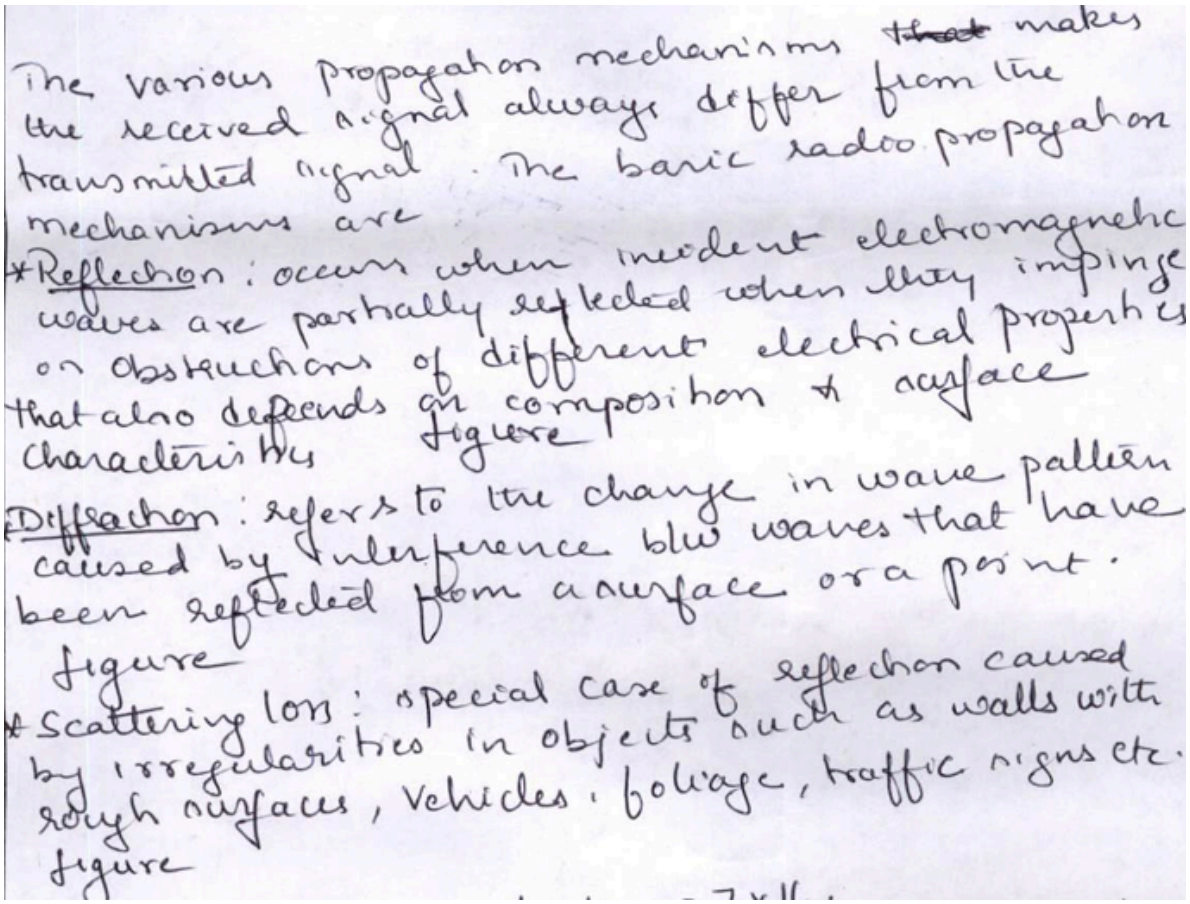
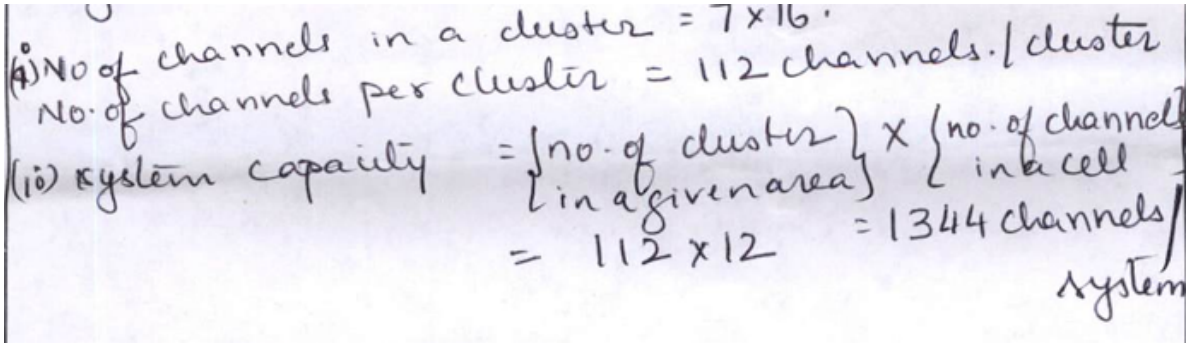


Fig: Surface-emitting LED

Explanation
* Plane of active light emitting region is oriented perpendicularly to the axis of the fiber.
• circular active area is 50 μm in diameter & upto 2.5 μm thick.
• Emission pattern is essentially isotropic with 120° HPBW. (lambertian Pattern)
• Source equally bright in viewing direction but power is down to 50 percent of its peak when θ = 60° & total HPBW = 120°

3	b	Optical Isolator: Optical isolator: Optical isolators are the devices that allow light to pass through them in only one direction  Fig: Design & operation of a polarization-independent isolator.
3	c	Problem: $I_p = \Re P_{in} = \frac{\eta q}{h\nu} P_{in} = \frac{\eta q \lambda}{hc} P_{in}$ $I_p = 0.235\ \mu A$ $M = I_M / I_p = 10\ \mu A / 0.235\ \mu A = 43$

4	a	PIN photodiode: PIN photodiode: The PIN photo diode consists of P and n regions seperated by a very lightly n-doped intrinsic layer. •Sufficient large reverse bias is applied acc the device so as to fully deplete the carriers from intrinsic region. * The pentration of photon flux ϕ is absorbed as it is progressed into the material The power level at a distance x is given by $P(x) = P_{in}\exp(-\alpha_s x)$  The absorption process generates electron-hole pair as shown in fig(b) that results in primary photocurrent $I_p = \frac{q}{h\nu} P_{in}(1-e^{-\alpha_s w})(1-R_f)$. and Efficiency $\eta = I_p/q / (P_{in}/h\nu)$
4	b	Diffraction Gratings: A diffraction grating is a conventional optical device that spatially seperates the different wavelength contained in a beam light. The different types of Diffraction gratings are (a) Reflection Gratings, b) Transmission Gratings } explanation

5	a	Propagation Mechanisms in mobile radio communication: 
5	b	Problem: 

The various propagation mechanisms ~~that~~ makes the received signal always differ from the transmitted signal. The basic radio propagation mechanisms are

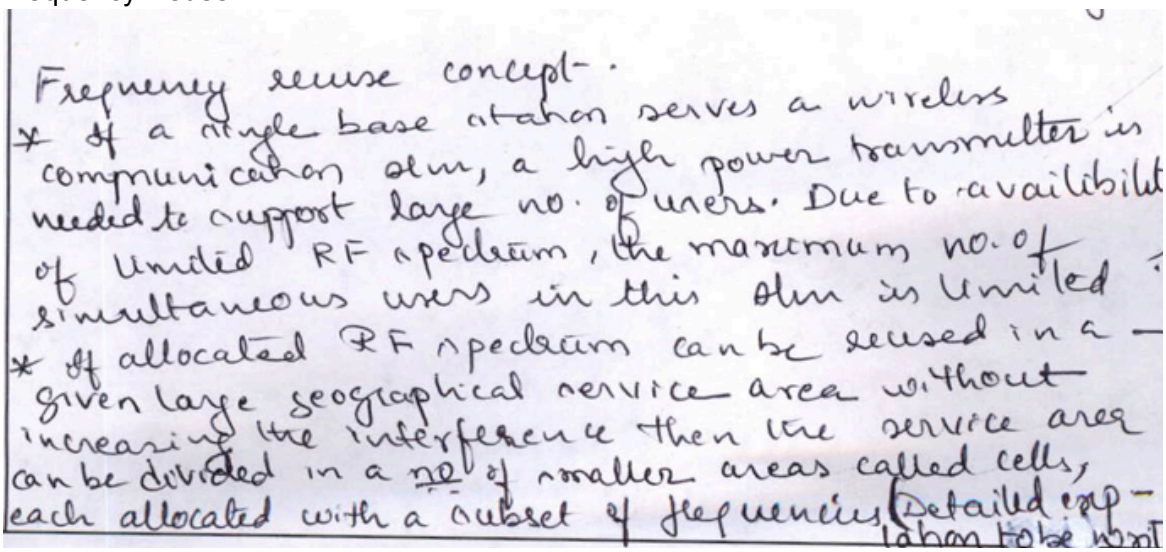
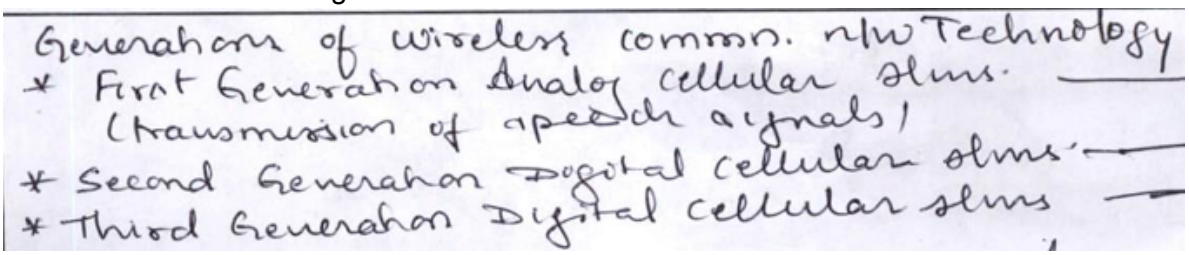
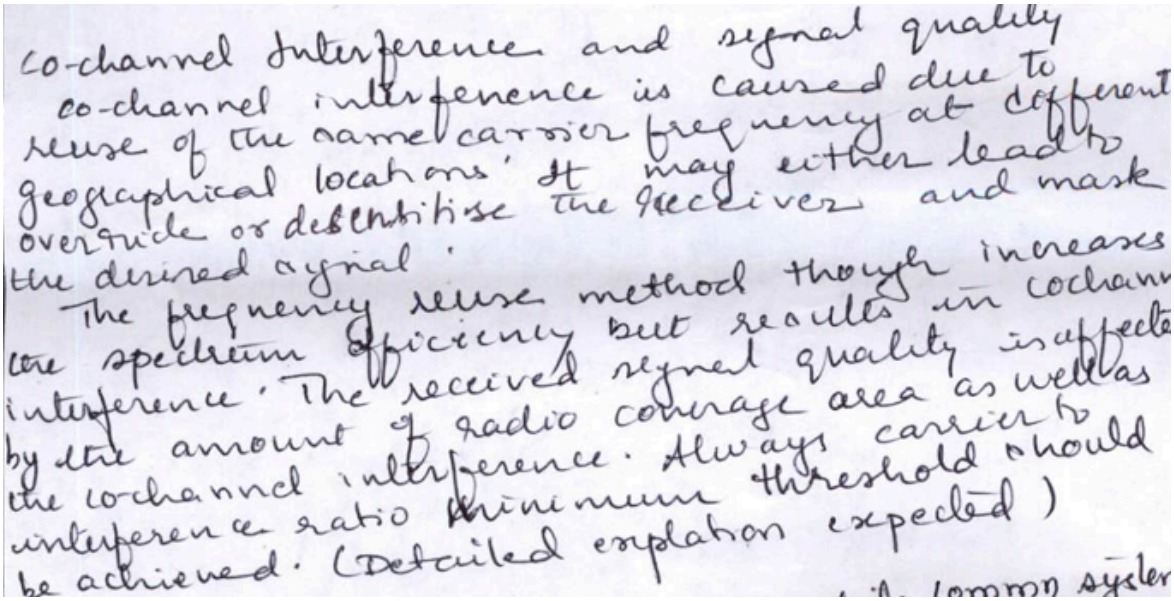
* Reflection: occurs when incident electromagnetic waves are partially reflected when they impinge on obstructions of different electrical properties that also depends on composition & surface characteristics figure

* Diffraction: refers to the change in wave pattern caused by interference b/w waves that have been reflected from a surface or a point. figure

* Scattering loss: special case of reflection caused by irregularities in objects such as walls with rough surfaces, vehicles, foliage, traffic signs etc. figure

(i) No of channels in a cluster = 7 × 16.
No. of channels per cluster = 112 channels./cluster

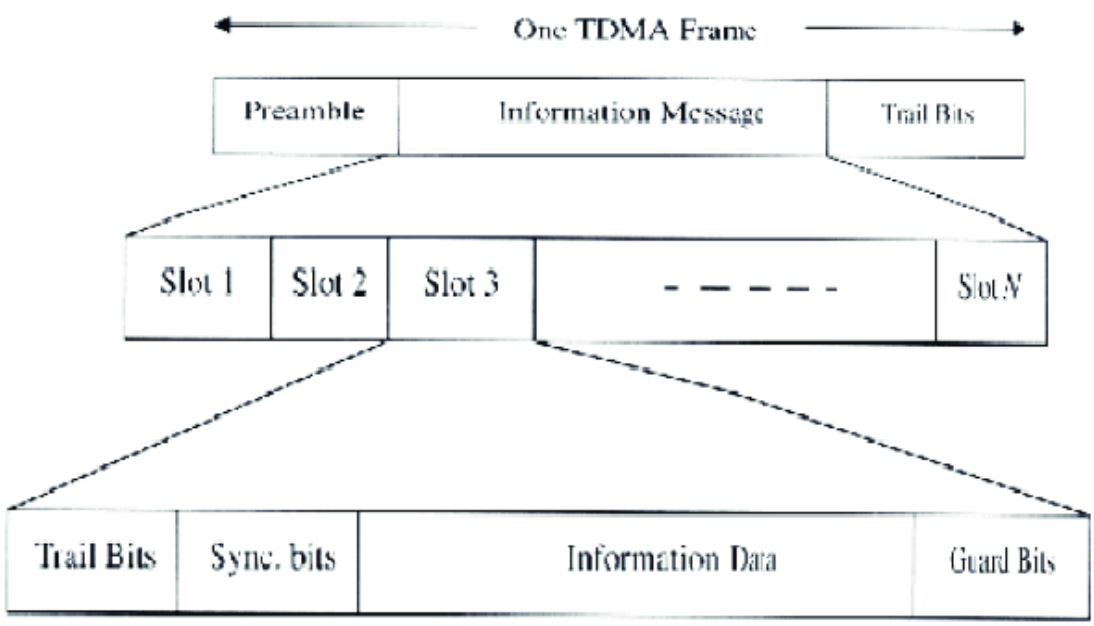
(ii) system capacity = {no. of cluster in a given area} × {no. of channels in a cell}
= 112 × 12 = 1344 channels/system

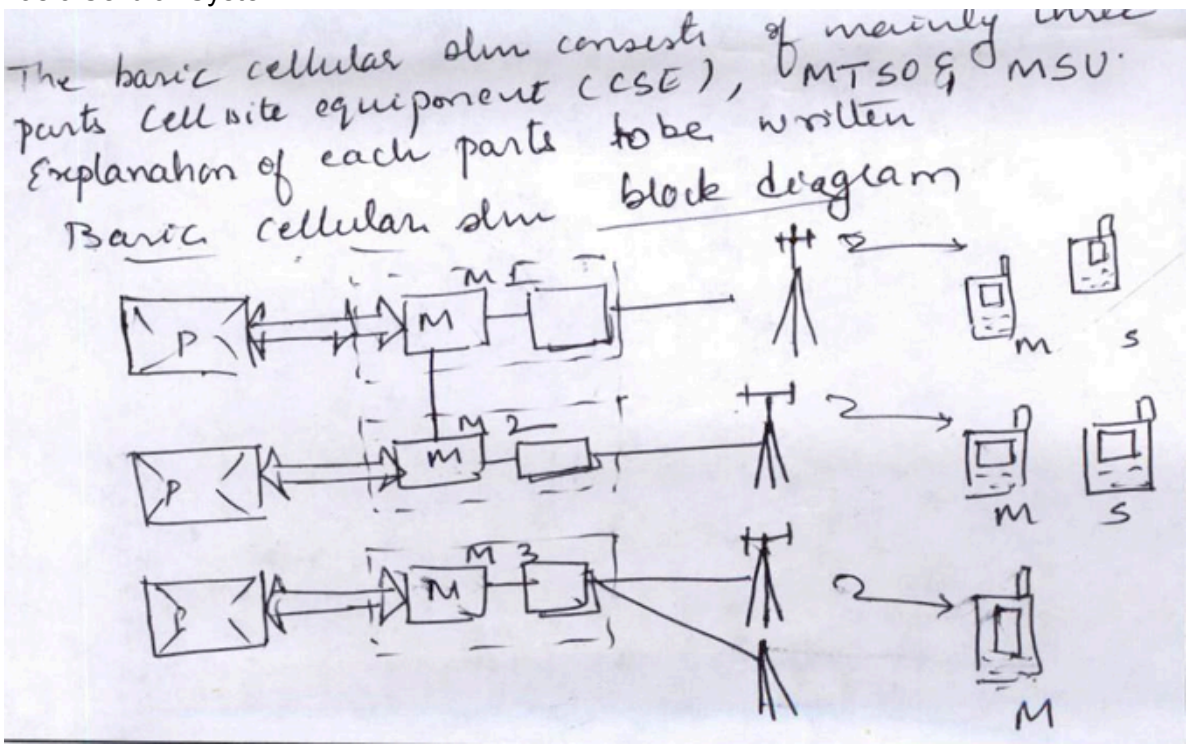
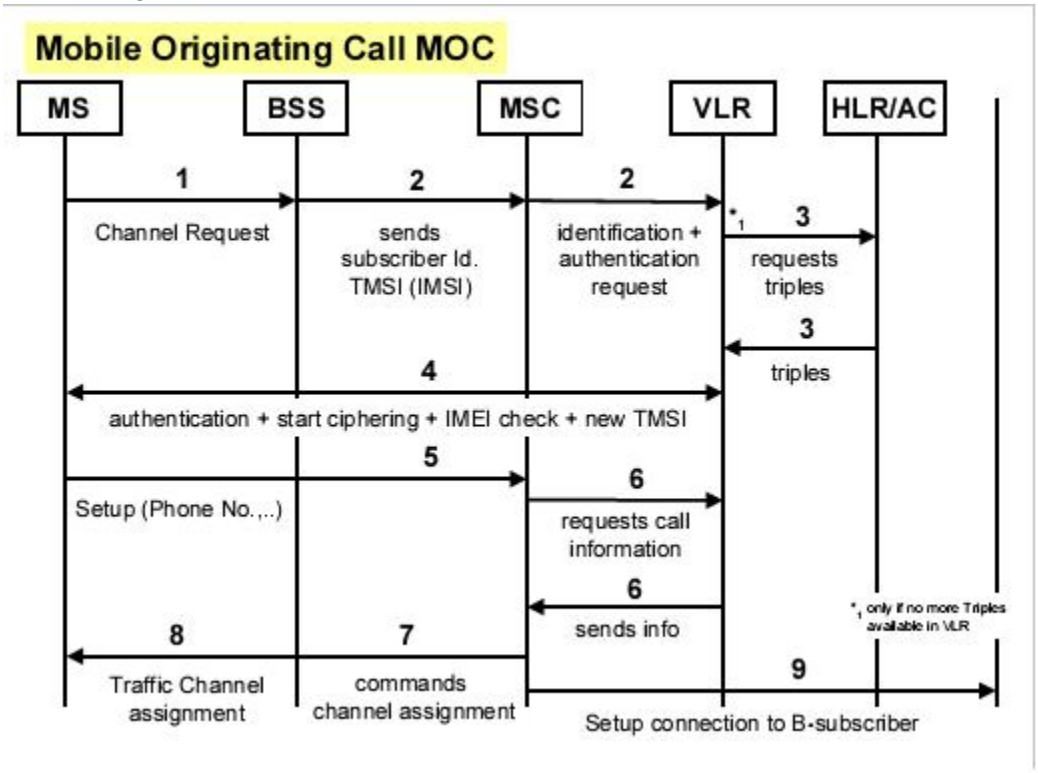
5	c	Frequency Reuse: 
6	a	Wireless Communication generations: 
6	b	Co channel Interference: 

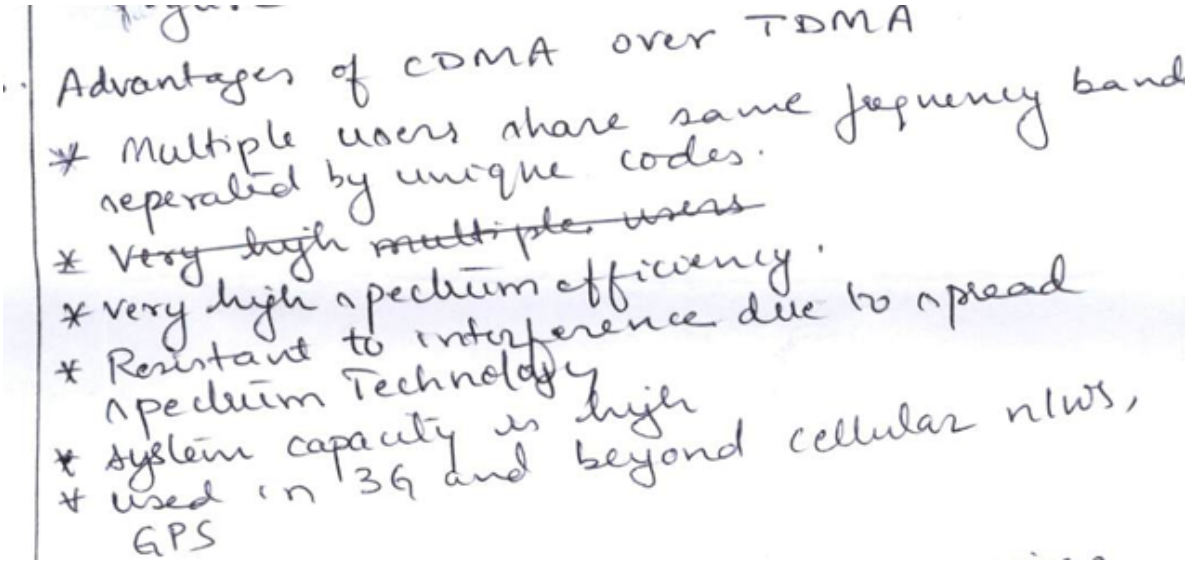
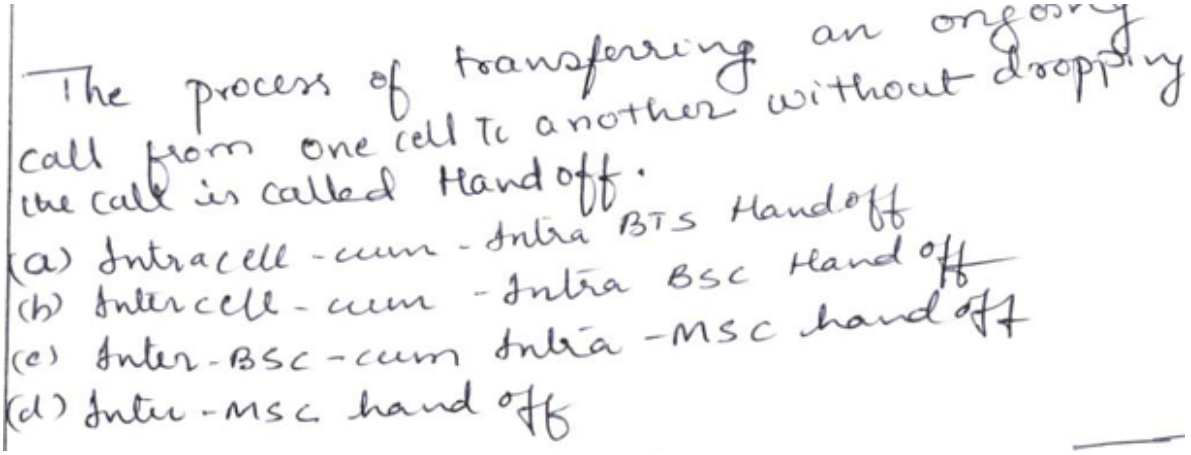
Frequency reuse concept-
* If a single base station serves a wireless communication system, a high power transmitter is needed to support large no. of users. Due to availibilit of limited RF spectrum, the maximum no. of simultaneous users in this system is limited
* If allocated RF spectrum can be reused in a given large geographical service area without increasing the interference then the service area can be divided in a no of smaller areas called cells, each allocated with a subset of frequencies (Detailed exp- lation to be writ

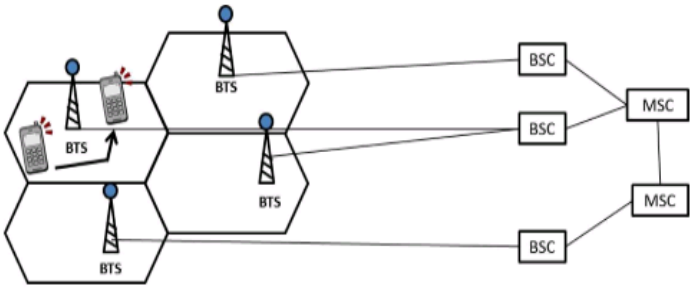
Generations of wireless comm. n/w Technology
* First Generation Analog cellular systems. (transmission of speech signals)
* Second Generation Digital cellular systems.
* Third Generation Digital cellular systems

Co-channel interference and signal quality
co-channel interference is caused due to reuse of the same carrier frequency at different geographical locations. It may either lead to override or desensitise the receiver and mask the desired signal.
The frequency reuse method though increases the spectrum efficiency but results in cochann interference. The received signal quality is affecte by the amount of radio coverage area as well as the cochannel interference. Always carrier to interference ratio minimum threshold should be achieved. (Detailed explation expected)

6	c	Multipath Fading: concept of multipath fading in mobile comm system Fading of signal received by the mobile unit is an inherent problem. Reasons are becoz of mobile unit changing in real time, multipath signal propagation between antennas Figure
7	a	TDMA: operation of basic TDMA link. explanation Block Diagram of basic TDMA link 

7	b	Basic Cellular System: 
8	a	Mobile Originated Calls: 

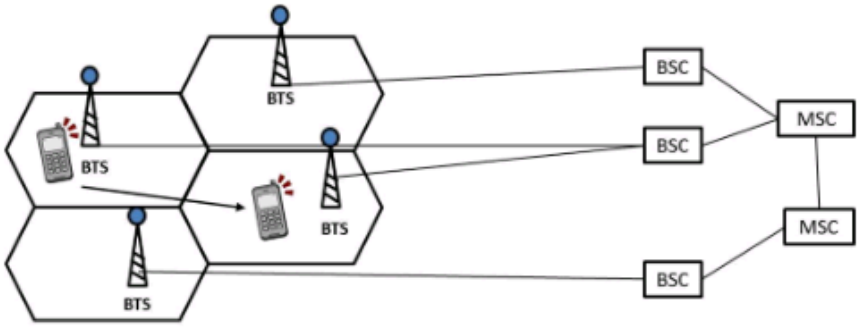
8	b	Advantages of CDMA over TDMA:  Advantages of CDMA over TDMA * Multiple users share same frequency band seperated by unique codes. * ~~Very high multiple users~~ * very high spectrum efficiency. * Resistant to interference due to spread spectrum Technology * System capacity is high * used in 3G and beyond cellular nlws, GPS
9	a	Handoff in GSM:  The process of transferring an ongoing call from one cell to another without dropping the call is called Handoff. (a) Intracell - cum - Intra BTS Handoff (b) Intercell - cum - Intra BSC Handoff (c) Inter-BSC - cum Intra - MSC handoff (d) Inter - MSC handoff • Handoff (or handover) is a control process initiated when a mobile moves from its current cell to its neighboring cell. • A user of a mobile phone will be moving continuously. In such a situation, the mobile connection should also remain intact especially if the user is currently using the phone. • This transfer of connection from one cell to another should be quick and in such a manner that user doesn't actually realize that a handoff has happened. • There are four basic types of handoffs in GSM network: **a) Intra-cell handover:** ◦ Such a kind of handover is performed to optimize the traffic load in the cell or to improve quality of a connection by changing carrier frequency.



Intra-cell handover

b) Inter-cell handover:

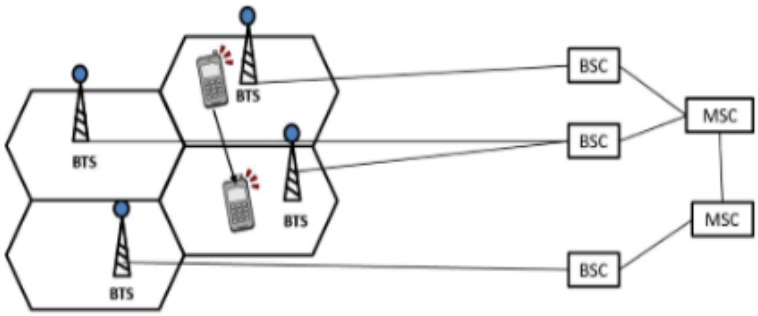
- It is also known as Intra-BSC handover.
- Here the mobile moves from one cell to another but remains within the same BSC (Base station controller).
- Here the BSC handles the handover process



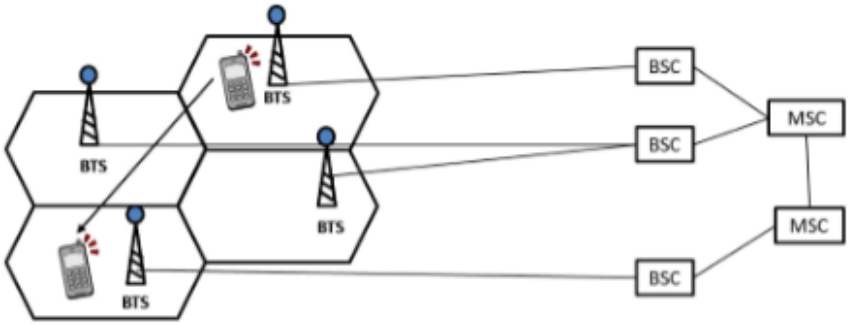
Intra-BSC handover

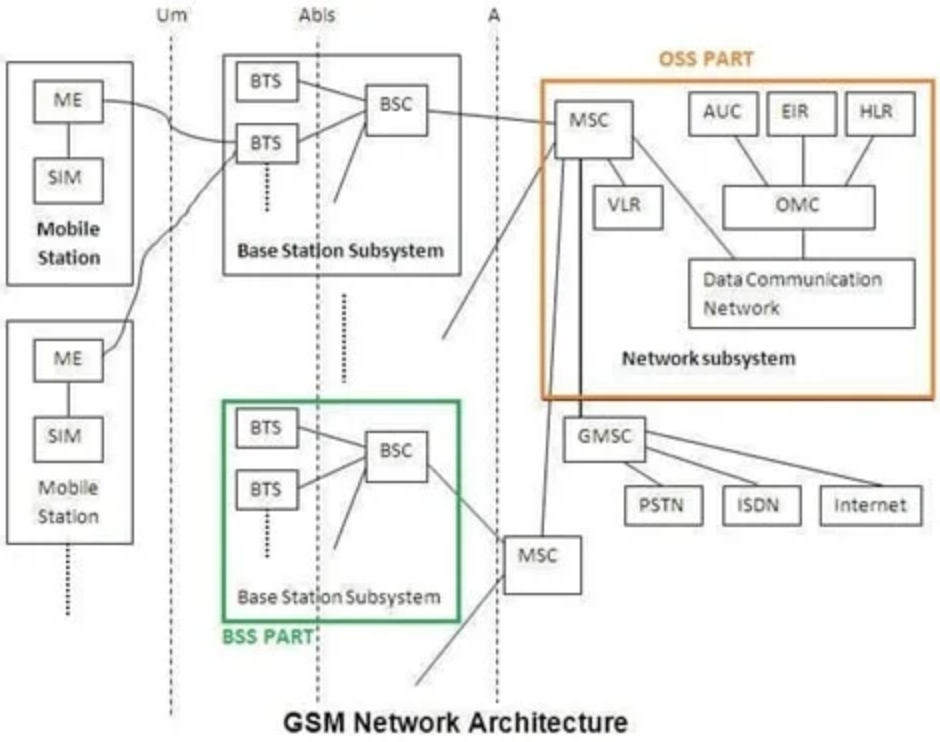
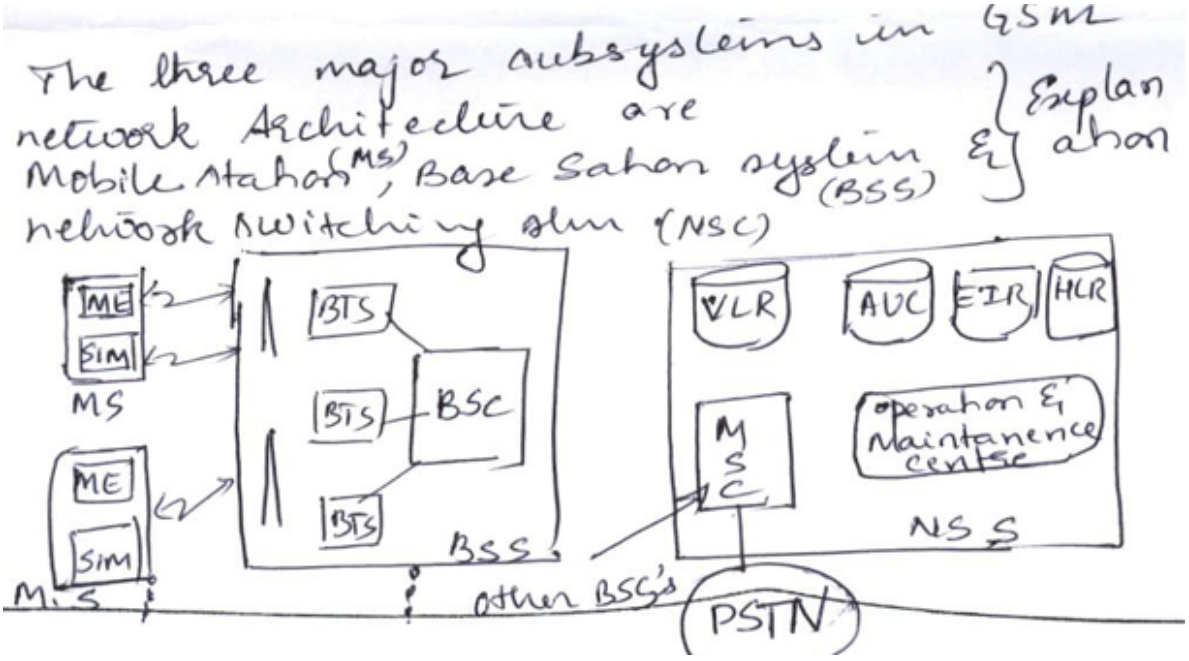
c) Inter-BSC handover:

- It is also called as Intra-MSC handover.
- As BSC can control only a limited number of cells, we might usually need to transfer a mobile from one BSC to another BSC.
- Here the MSC handles the handover process.



Inter-BSC handover

		d) Inter-MSC handover: • It occurs when a mobile moves from one MSC region to another MSC. • MSC cover a large area. It can be imagined as a handover from Maharashtra MSC to Gujarat MSC while travelling.  Inter-MSC handover
9	b	HLR and VLR in GSM: **HLR / VLR** ❖ **Home Location Registers (HLR)** o permanent database about mobile subscribers in a large service area(generally one per GSM network operator) o database contains IMSI, MSISDN, prepaid/postpaid, roaming restrictions, MSC/VLR, supplementary services. ❖ **Visitor Location Registers (VLR)** o Temporary database which updates whenever new MS enters its area, by HLR database o Controls those mobiles roaming in its area o Reduces number of queries to HLR o Database contains IMSI, TMSI, MSISDN, MSRN, Location Area, authentication key

		 GSM Network Architecture
10	a	GSM Network Architecture: 

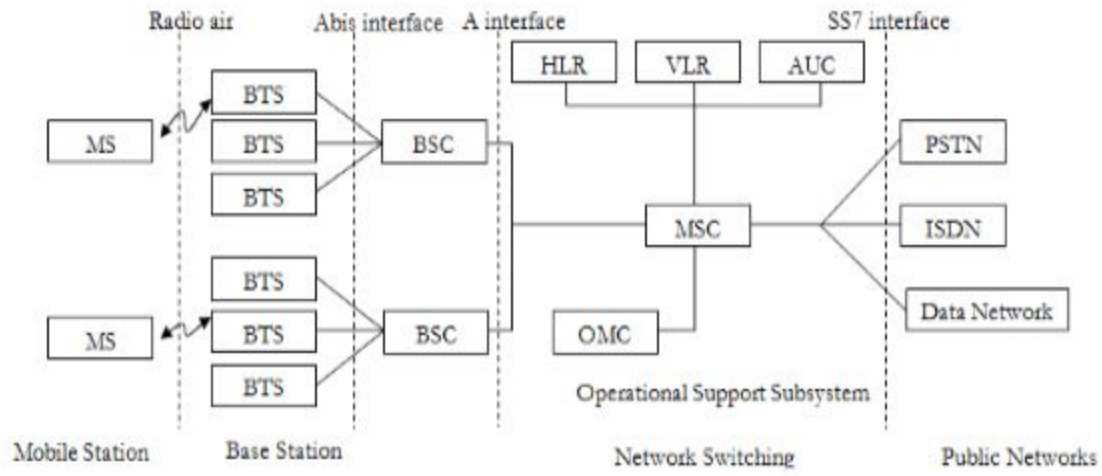


Fig: GSM Architecture

The GSM architecture consists of three major interconnected subsystems that interact with themselves and with users through a certain network interface. The subsystems are Base Station Subsystem (BSS), Network Switching Subsystem (NSS) and Operational Support Subsystem (OSS). Mobile Station (MS) is also a subsystem but it is considered as a part of BSS.

1. Mobile Station (MS): Mobile Station is made up of two entities.

A. Mobile equipment (ME):

- It is a portable, vehicle mounted, hand held device.
- It is uniquely identified by an IMEI number.
- It is used for voice and data transmission. It also monitors power and signal quality of surrounding cells foe optimum handover. 160 characters long SMS can also be sent using Mobile Equipment.

B. Subscriber Identity module (SIM):

- It is a smart card that contains the International Mobile Subscriber Identity (IMSI) number.
- It allows users to send and receive calls and receive other subscriber services. - It is protected by password or PIN.
- It contains encoded network identification details. it has key information to activate the phone.
- It can be moved from one mobile to another.

2. Base Station Subsystem (BSS): It is also known as radio subsystem, provides and manages radio transmission paths between the mobile station and the Mobile Switching Centre (MSC). BSS also manages the interface between the mobile station and all other subsystems of GSM. It consists of two parts.

A. Base Transceiver Station (BTS):

- It encodes, encrypts, multiplexes, modulates and feeds the RF signal to the

antenna.

- It consists of transceiver units.
- It communicates with mobile stations via radio air interface and also communicates with BSC via Abis interface.

B. Base Station Controller (BSC):

- It manages radio resources for BTS. It assigns frequency and time slots for all mobile stations in its area.
- It handles call set up, transcoding and adaptation functionality handover for each MS radio power control.
- It communicates with MSC via A interface and also with BTS.

3. Network Switching Subsystem (NSS): it manages the switching functions of the system and allows MSCs to communicate with other networks such as PSTN and ISDN. It consist of

A. Mobile switching Centre:

- It is a heart of the network. It manages communication between GSM and other networks.
- It manages call set up function, routing and basic switching.
- It performs mobility management including registration, location updating and inter BSS and inter MSC call handoff.
- It provides billing information.
- MSC does gateway function while its customers roam to other network by using HLR/VLR.

B. Home Location Registers (HLR): - It is a permanent database about mobile subscriber in a large service area. - Its database contains IMSI, IMSISDN, prepaid/post-paid, roaming restrictions, supplementary services.

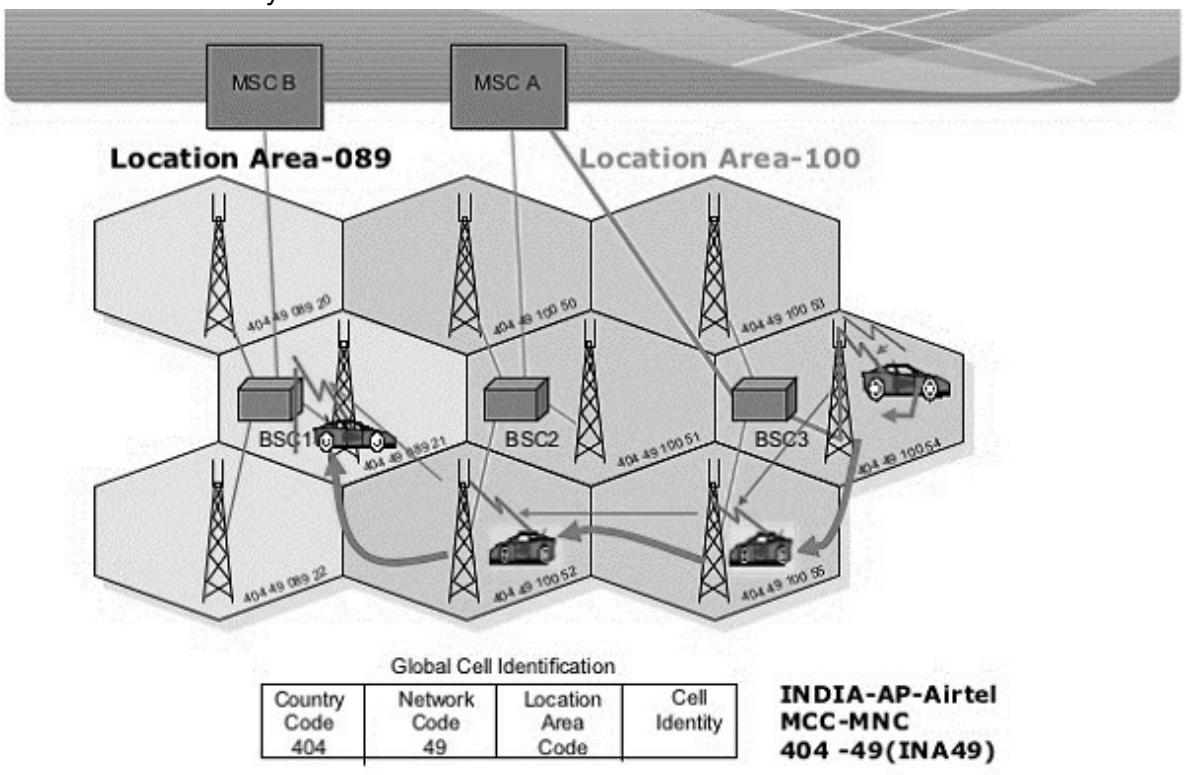
C. Visitor Location Registers (VLR): - It is a temporary database which updates whenever new MS enters its area by HLR database. - It controls mobiles roaming in its area. It reduces number of queries to HLR. - Its database contains IMSI, TMSI, IMSISDN, MSRN, location, area authentication key.

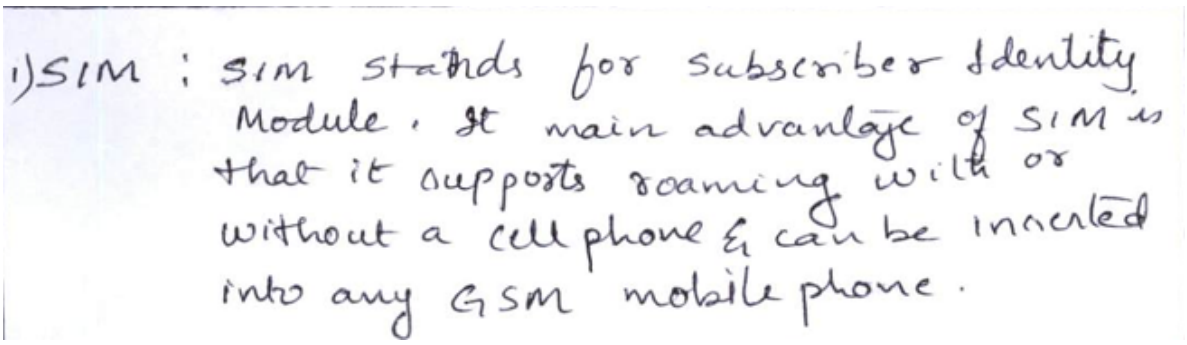
D. Authentication Centre: - It provides protection against intruders in air interface. - It maintains authentication keys and algorithms and provides security triplets (RAND, SRES, Ki).

E. Equipment Identity Registry (EIR):

- It is a database that is used to track handset using the IMEI number.
- It is made up of three sub classes- the white list, the black list and the gray list.

4. Operational Support Subsystem (OSS): It supports the operation and maintenance of GSM and allows system engineers to monitor, diagnose and troubleshoot all aspects of GSM system. It supports one or more Operation

		Maintenance Centres (OMC) which are used to monitor the performance of each MS, Bs, BSC and MSC within a GSM system. It has three main functions: ● To maintain all telecommunication hardware and network operations with a particular market. ● To manage all charging and billing procedures ● To manage all mobile equipment in the system. **Interfaces used for GSM network : (ref fig 2)** 1)UM Interface –Used to communicate between BTS with MS 2)Abis Interface— Used to communicate BSC TO BTS 3)A Interface-- Used to communicate BSC and MSC 4) Singling protocol (SS 7)- Used to communicate MSC with other network .
10	b	SIM Mobile Susbscriber ISDN with frame format Location Area Identity 



Mobile Subscriber ISDN Number (MSISDN)

The authentic telephone number of a mobile station is the Mobile Subscriber ISDN Number (MSISDN). Based on the SIM, a mobile station can have many MSISDNs, as each subscriber is assigned with a separate MSISDN to their SIM respectively.

Listed below is the structure followed by MSISDN categories, as they are defined based on international ISDN number plan –

- **Country Code (CC)** – Up to 3 decimal places.
- **National Destination Code (NDC)** – Typically 2-3 decimal places.
- **Subscriber Number (SN)** – Maximum 10 decimal places.

Location Area Identity (LAI)

Within a PLMN, a Location Area identifies its own authentic Location Area Identity (LAI). The LAI hierarchy is based on international standard and structured in a unique format as mentioned below –

- **Country Code (CC)** – 3 decimal places.
- **Mobile Network Code (MNC)** – 2 decimal places.
- **Location Area Code (LAC)** – maximum 5 decimal places or maximum twice 8 bits coded in hexadecimal (LAC < FFFF).