COURSE CONTENT

Course

Course code: EIE418
Course title: Data Communications and Computer Networks 3 Units
Course status: Compulsory

Course Duration

Three hours per week for 15 weeks (45hours)

Lecturer's Data

1. Engr. Oghogho Ikponmwosa
   Qualifications obtained: B. Eng.; M. Eng.
   Department: Electrical and Information Engineering
   Faculty: College of Science and Engineering
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   Office Location: Room A111; 1st floor, 1st College building.

Consultation Hours: Mondays, Tuesdays and Fridays (12:00noon-2:00pm)

2. Engr A.B.Adedayo
   Qualifications obtained: B. Eng., M.Eng.
   Department: Electrical and Information Engineering
   Faculty: College of Science and Engineering
   E-mail: @lmu.edu.ng
   Office Location: Room A014; 1st floor, Engineering building.

Course Content – Illustration below:

Interfacing: Interfaces for simple computer system and terminal to terminal. MODEM, terminal interfaces, CCITT V.24/RS-232, CCITT V.28, V.35, GPIB, EIA, RS-232C standard, speed and distance limitations for V.24, RS-232C, RS-449/422/423 interfaces and standards.

Channel Coding and Error Control: Forward Error Control; Error Detection Methods; Parity Checking; Linear Block Codes, Cyclic Redundancy Checking; Feedback Error Control.

Digitalisation: Sampling theorem, Shannon theorem, PCM and Quantisation Error; Multiplexing, FDM, TDM; Higher order multiplexing; Frame formatting, time-slot.

Digital Modulation Techniques: Line coding, intersymbol interference, Nyquist waveshaping, eye pattern, adaptive equalization. Transmission over bandpass channel. ASK, FSK, PSK, DPSK, M-ary modulation, continuous phase FSK, MSK, QAM, DSL Schemes.

Spread Spectrum Communications: Pseudo noise sequences, direct sequence spread spectrum, frequency hopping spread spectrum, CDMA, application examples.

Telephony: The telephone set and subscriber loop interface, basic function of the telephone set, cordless telephone, local loop, line characteristics and conditioning. Public switched telephone network, hybrids, echo suppression. Central office switching system.

Digital Switching: Digital Switching Systems, Space Switching, Time Switching Module; Time-Space-Time Switch Structure, Circuit switching networks; Packet switching networks; X.25 packet switched networks

ISDN interfaces and functions: Transmission structure, user-network interface configurations, ISDN protocol architecture, connections, addressing. Physical layer. Data link layer, network layer.

Frame Relay: Background, Protocols and service. Frame-mode protocol architecture, frame-mode call control, Frame relay congestion control: Traffic rate management, explicit congestion avoidance and implicit congestion control.

ATM: Virtual channels and virtual path. ATM protocols, transmission of ATM cells, ATM adaptation layer. AAL services. Traffic and congestion control. Latency/speed effect, cell delay variation. Network resource management, connection admission control, usage parameter control, priority control.

Cellular Mobile Network: Cellular network architectures; Frequency management; Channel types and assignment; types of hand-offs and hand-off management; Switching and transport; Wireline and microwave facilities and link design considerations. Call Processing and Signalling: Roaming and mobility management; Traffic engineering and performance issues, call set up and hand-offs; Capacity planning; Factors affecting economical network designs.

Course Description –:

The course teaches the students major data communications and computer networking techniques, design, standards etc. being used today in several telecommunications networks and systems. The students are taught network interfacing and standards, Channel Coding and Error Control, digitalization of signals from their analogue form, origin of internet and various network topologies. Digital Modulation Techniques, Spread Spectrum Communications and techniques, Telephony, Digital Switching, ISDN interfaces and functions, Frame relay protocol and architecture, ATM networks and protocols and mobile cellular Networks are also covered.

Course Justification –:

This course offers the students the basic knowledge required for planning, design and implementation of various types of data networks. The students are made to understand the advantages and draw backs of different data communications networks. The course covers the details involved in transmission of data from source to receiver in numerous data communication and computer network systems which are used extensively today. Knowledge gained from this course will prepare our students to be able to both design and maintain existing telecommunications networks as well as contribute new knowledge in any area of their choice and able to be part of those who will design and create the next generation of data communication and computer network devices for our world.

Course objectives

At the end of this course, students would be able to:

(i) Develop a deeper and rigorous understanding of the fundamental Principles of Data communication and Computer Networks.

(ii) Understand and discuss Interfacing and their standards for different data networks.

(iii) Understand and discuss Channel Coding and Error Control techniques.

(iv) Develop a deeper and rigorous understanding of Digitalisation of signals.

(v) Understand and discuss the concept of Spread Spectrum Communications and their numerous applications.

(vi) Understand and discuss the concept of Telephony and the processes involved in sending and receiving a telephone or voice signal.

(vii) Understand and discuss Digital Switching and the numerous digital switching systems used in data communication and computer systems.

(viii) Understand and discuss ISDN interfaces and functions.

(ix) Understand and discuss the concept of Frame relay in data communication and computer network.

(x) Understand and discuss the concept of ATM in data communication and computer systems.

(xi) Understand and discuss Cellular mobile networks with respect to their numerous features.

Course Requirement – Illustration below:

To derive maximum benefits from the course and for fast grasping of many of the data communication and computer network principles and concepts, the course requires that the students be familiar with basic telecommunication systems covering signals transmission concepts, signal analysis methods, modulation and demodulation techniques, etc. The students should also have a good knowledge of basic mathematics like algebra, numerical methods and calculus. However, the course is structured to accommodate to some extent, students that do not fall into this category since some of these basics will be introduced. A good knowledge and understanding of the course requires that students carry out some laboratory practical. This is done in another practical course compulsory for all 400Level students in the department.
The method of grading is shown in Table1. .

Table1: Method of Grading-

S/N	**Grading**	**Score** (%)
1.	1st Test	5
2.	2nd Test	10
3.	3rd Test	10
4.	Assignment	5
5.	Final Examination	70
	Total	**100**

Course Delivery Strategies – Illustration below:

1. Lecture delivery with explanations using lecture notes, real life examples, diagrams and graphs.
2. The use of the University's Intranet e-platform for quizzes, assignments, group discussions, etc.
3. Giving off net assignments and classwork.
4. Uploading the lecture materials on the e-learning platform.
5. Giving online assignments.
6. Having practical discussion sections at the end of the lecture.

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LECTURE CONTENT

For this section, the topic of each week, objectives, description, study question and other information are presented.

1. **Week 1:** Introduction of Data Communication and computer Networks.

   - **Objectives**

   The students at the end of the lectures for the week should be able to:

(i) Develop a deeper and rigorous understanding of the fundamental Principles of Data communication and computer networks.
(ii) List several data communication and computer networks available today.
(iii) List different types of data that can be transmitted using data communication and computer networks.

   - **Description**

   First hour: Introduction of basic concepts of data communication and computer networks. Data communication and computer networks available today
   Second hour: Types of data that can be transmitted using data communication and computer networks.
   Third hour: Discussion and questions.

   - **Study Question:**

1. What is a data communication network?
2. In sufficient details discuss the Internet as a global network.
3. What are involved in data communication?
4. Define and discuss the concept of Computer Networks.
5. In sufficient details give a brief history of Internet

   - **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9
3. Eugemo Lannone (2012) Telecommunications Networks. Taylor and Francis Group LLC. ISBN 978-1-4398-4636-0

- **Week 2:** Interfacing
- **Objectives**

At the end of the week, the students should be able to:

1. Develop a deeper and rigorous understanding of Interfaces for simple computer system and terminal to terminal.
2. Understand and discuss MODEM, terminal interfaces, CCITT V.24/RS-232, CCITT V.28/ V.35, GPIB, EIA, RS-232C standard,
3. Understand and discuss speed and distance limitations for V.24, RS-232C, RS-449/422/423 interfaces and standards.

- **Description**

First hour: Interfacing: Interfaces for simple computer system and terminal to terminal.

. Second hour: MODEM, terminal interfaces, CCITT V.24/RS-232, CCITT V.28, V.35, GPIB, EIA, RS-232C standard, ,

Third hour: speed and distance limitations for V.24, RS-232C, RS-449/422/423 interfaces and standards. Discussion and questions.

- **Study Question:**

1. What are the motivations behind setting up a network?
2. How is the Internet network set up?
3. What is a MODEM and what is its use in a data network.
4. Write short notes on the following terminal interfaces and standards:
   (i) CCITT V.24/RS-232,
   (ii) CCITT V.28/V.35,
   (iii) GPIB,
   (iv) EIA,
   (v) RS-232C standard
5. In sufficient details discuss speed and distance limitations for V.24, RS-232C, RS-449/422/423 interfaces and standards.

- **Reading List - Books and materials students can read. Illustration below:**

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2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9

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- **Week 3:** Channel Coding and Error Control
- **Objectives**

At the end of the week, the students should be able to:

1. Develop a deeper and rigorous understanding of the channel coding and error control used in data communication and Computer network systems.
2. List and discuss the various data coding and error control methods.

- **Description**

First hour: Channel Coding and Error Control: Forward Error Control; Error Detection Methods.

Second hour: Parity Checking; Linear Block Codes, Cyclic Redundancy Checking.

Third hour: Feedback Error Control, Discussion and questions.

- **Study Question:**

1. Discuss the concept of channel coding and error control in data communication

and computer networks.

2. Write short notes on the following error detection methods:
   (i) Forward Error Control;
   (ii) Parity Checking
   (iii) Linear Block Codes,
   (iv) Cyclic Redundancy Checking
   (v) Feedback Error Control

- **Reading List - Books and materials students can read. Illustration below:**

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- **Week 4:** Digitalisation
- **Objectives**

At the end of the week, the students should be able to:

1. Discuss the concept of digitalisation of signals.
2. Define and discuss sampling and Shannon theorems.
   (i) Discuss the concept of PCM and Quantisation Error;
3. Define Multiplexing and discuss the different types of multiplexing used in data transmission

- **Description**

First hour: Digitalisation: Sampling theorem, Shannon theorem, PCM and Quantisation Error.

Second hour: Multiplexing, FDM, TDM; Higher order multiplexing.

Third hour: Frame formatting, time-slot, Discussion and questions.

- **Study Question:**

1. What is digitalisation of signals?
2. Define and discuss sampling Shannon theorems.
3. Write short notes on the following:
   (i) PCM
   (ii) Quantisation Error;
   (iii) Multiplexing,
   (iv) FDM,
   (v) TDM;
   (vi) Higher order multiplexing;
   (vii) Frame formatting,
   (viii) Time-slot.

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9
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- **Week 5:** Digital Modulation Techniques
- **Objectives**

At the end of the week, the students should be able to:

1. List and discuss digital modulation techniques being used today.

2. Define and discuss Line coding, inter-symbol interference, Nyquist waveshaping, eye pattern and adaptive equalization.

3. Discuss the process of transmission of a digital signal over a bandpass filter

4. List and discuss the following types of modulation schemes:

   (i) ASK,
   (ii) FSK,
   (iii) PSK,
   (iv) DPSK,
   (v) M-ary modulation,
   (vi) continuous phase FSK,
   (vii) MSK,
   (viii) QAM,
   (ix) DSL.

- **Description**

First hour: Digital Modulation Techniques: Line coding, intersymbol interference, Nyquist waveshaping, eye pattern, adaptive equalization.

Second hour: Transmission over bandpass channel. ASK, FSK, PSK, DPSK, M-ary modulation.

Third hour: continuous phase FSK, MSK, QAM, DSL Schemes. Discussion and Questions.

- **Study Question:**

1. What is digital modulation?
2. List and discuss the different types of modulation techniques you know.
3. Define and discuss the following:
   (i) Line coding,
   (ii) inter-symbol interference,
   (iii) Nyquist waveshaping,
   (iv) eye pattern and adaptive equalization.
4. Discuss the process of transmission of a digital signal over a bandpass filter.
5. List and discuss the following types of modulation schemes:

   (x) ASK,
   (xi) FSK,
   (xii) PSK,
   (xiii) DPSK,
   (xiv) M-ary modulation,
   (xv) continuous phase FSK,
   (xvi) MSK,
   (xvii) QAM,
   (xviii) DSL

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9
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- **Week 6:** Spread Spectrum Communications.
- **Objectives**

At the end of the week, the students should be able to:

1. Understand and discuss spread spectrum communications.
2. List the various types of spread spectrum communications and their applications.

- **Description**

First hour: Spread Spectrum Communications: Pseudo noise sequences, direct sequence spread spectrum.

Second hour: Frequency hopping spread spectrum, CDMA.

Third hour: Applications and examples of the use of spread spectrum communications.

- **Study Question:**

1. What do you understand by the term "spread spectrum" in RF communications systems?
2. Write short notes on
   (i) Direct sequence spread spectrum
   (ii) Frequency hopping spread spectrum
3. List the modulation techniques that designers can employ when developing frequency-hopping or direct-sequence systems.
4. List the uses of codes in a spread spectrum system
5. List the advantages of spread spectrum based wireless systems

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9
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- **Week 7:** Telephony.
- **Objectives**

At the end of the week, the students should be able to:

1. Discuss the concept of Telephony.
2. Describe the basic function and principle of operation of a Telephone system.
3. Define and discuss the following terms as it relates to telephony:
   (i) Telephone set
   (ii) Subscriber loop
   (iii) Cordless telephone.

(iv) Local loop,
(v) Line characteristics and conditioning.
(vi) Public switched telephone network,
(vii) Hybrids,
(viii) Echo suppression.
(ix) Central office switching system

- **Description**

First hour: Telephony: The telephone set and subscriber loop interface, basic function of the telephone set, cordless telephone.
Second hour: Local loop, line characteristics and conditioning. Public switched telephone network, hybrids.
Third hour: Echo suppression. Central office switching system. Discussion and questions.

- **Study Question:**

1. What is Telephony?
2. Write short notes on the following:
   (i) The telephone set and subscriber loop interface
   (ii) Cordless telephone
   (iii) Line characteristics and conditioning.
   (iv) Public switched telephone network,
   (v) hybrids
   (vi) Echo suppression.
   (vii) Central office switching system
3. Draw the block diagram containing a telephone set, the subscriber loop and the control office and describe in sufficient details how it operates.
4. In a typical telephone system, all incoming subscriber loops terminate in the line card at the Control Office. List what the line card does.

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9

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- **Week 8:** Digital Switching
- **Objectives**

At the end of the week, the students should be able to:

1. Understand the concept of digital switching and digital switching systems.
2. List and discuss the different types of digital switching methods.

- **Description**

First hour: Digital Switching: Digital Switching Systems, Space Switching, Time Switching Module; Time-Space-Time Switch Structure.
Second hour: Circuit switching networks; Packet switching networks.

Third hour: X.25 packet switched networks, Discussion and questions.

- **Study Question:**

1. Define and discuss the concept of digital switching and digital switching systems.
2. List and write short notes on the different types of digital switching systems.
3. Compare and contrast the various types of digital switching systems you have listed in Question 2 above.

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9

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- **Week 9:** ISDN interfaces and functions.
- **Objectives**

At the end of the week, the students should be able to:

1. Understand and discuss ISDN interfaces and functions.
2. Understand and discuss the concept of Transmission structure and user-network interface configurations.
3. Understand and discuss the concept of ISDN protocol architecture, connections and addressing.
4. Understand and discuss the Physical layer, Data link layer, and network layer of ISDN.

- **Description**

First hour: ISDN interfaces and functions: Transmission structure, user-network interface configurations.

Second hour: ISDN protocol architecture, connections, addressing. Physical layer..

Third hour: Data link layer, network layer, Discussion and questions.

- **Study Question:**

1. In sufficient details discuss discuss ISDN interfaces and list their functions?
2. Discuss the concept of Transmission structure and user-network interface configurations.
3. Discuss the concept of ISDN protocol architecture, connections and addressing.
4. Discuss the Physical layer, Data link layer, and network layer of ISDN

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9

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- **Week 10:** Frame Relay

- **Objectives**

At the end of the week, the students should be able to:

1. Understand and discuss the concept of Frame relay.
2. Understand and discuss the background, protocols and service relating to frame relay.
3. Understand and discuss Frame-mode protocol architecture, frame-mode call control.
4. Understand and discuss Frame relay congestion control such as: Traffic rate management, explicit congestion avoidance and implicit congestion control.

- **Description**

First hour: Frame Relay: Background, Protocols and service. Frame-mode protocol architecture, frame-mode call control,

Second hour: Frame relay congestion control: Traffic rate management, explicit congestion avoidance.

Third hour: Implicit congestion control.

- **Study Question:**

1. What do you understand by Frame relay in data communication?
2. Discuss the background, protocols, service and congestion control methods relating to frame relay in data communication.
3. Discuss Frame-mode protocol architecture and frame-mode call control.
4. In sufficient details, explain Traffic rate management, explicit congestion avoidance and Implicit congestion control.

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9
3. Eugemo Lannone (2012) Telecommunications Networks. Taylor and Francis Group LLC. ISBN 978-1-4398-4636-0

- **Week 11:** ATM
- **Objectives**

At the end of the week, the students should be able to:

1. Understand the basic concept of ATM.
2. Understand and discuss virtual channels and virtual paths in ATM networks.
3. Understand and discuss ATM protocols, transmission of ATM cells, ATM adaptation layer and AAL services.
4. Understand and discuss Traffic and congestion control, Latency/speed effect and cell delay variation.
5. Understand and discuss Network resource management, connection admission control, usage parameter control and priority control in ATM.

- **Description**

First hour: ATM: Virtual channels and virtual path. ATM protocols, transmission of ATM cells, ATM adaptation layer. AAL services.

Second hour: Traffic and congestion control. Latency/speed effect, cell delay variation. Network resource management, connection admission control.

Third hour: Usage parameter control, priority control. Discussion and Questions.

- **Study Question:**

1. What is ATM as it relates to data communications and computer networks?
2. In sufficient details discuss virtual channels and virtual paths in ATM networks.
3. Discuss the following terms as it relates to ATM:
   (i) ATM protocols,
   (ii) transmission of ATM cells,
   (iii) ATM adaptation layer and
   (iv) AAL services.
4. Write short notes on the following:
   (i) Traffic and congestion control,
   (ii) Latency/speed effect and
   (iii) cell delay variation.
   (iv) Network resource management,
   (v) connection admission control

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9
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- **Week 12:** Cellular Mobile Network:
- **Objectives**

At the end of the week, the students should be able to:

1. Understand and discuss the basic concept of Cellular Mobile Network.
2. Understand and discuss cellular network architectures; Frequency management, Channel types and assignment, types of hand-offs and hand-off management, Switching and transport
3. Understand and discuss Wireline and microwave facilities and link design considerations.

- **Description**

First hour: Cellular Mobile Network: Cellular network architectures; Frequency management.

Second hour: Channel types and assignment; types of hand-offs and hand-off management, Switching and transport.

Third hour: Wireline and microwave facilities and link design considerations. . Discussion and Questions.

- **Study Question:**

1. Discuss the basic concept of Cellular Mobile Network.
2. Insufficient details discuss the following as it relates to cellular mobile networks:
   (i) Cellular network architectures;

(ii) Frequency management,
(iii) Channel types and assignment,
(iv) types of hand-offs and hand-off management.
(v) Switching
(vi) transport

3. What are Wireline and microwave facilities?
4. List and discuss link design considerations in wireline and microwave links.

- **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9
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- **Week 13:** Cellular Mobile Network
- **Objectives**

At the end of the week, the students should be able to:

1. Understand and discuss the concept of call processing and signalling.
2. Discuss the concept of Roaming and mobility management in cellular mobile networks.
3. Understand and discuss Traffic engineering and performance measurement issues.
4. Describe the process of call set up and hands off.
5. Discuss network capacity planning and state factors affecting economic network designs.

- **Description**

First hour: Call Processing and Signalling: Roaming and mobility management;;
Second hour: Traffic engineering and performance issues, call set up and hand-offs; Capacity planning.
Third hour: Factors affecting economical network designs. Discussion and Questions.

- **Study Question:**

1. Discuss the concept of call processing and signalling in cellular mobile networks.
2. What is Roaming and mobility management in cellular mobile networks?
3. Discuss Traffic engineering and performance measurement issues as they relate to cellular mobile networks.
4. Describe the process of call set up and hands off.
5. Discuss network capacity planning and state factors affecting economic netwrk designs.

6. **Reading List - Books and materials students can read. Illustration below:**

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9

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- **Week 14**

Topic: Revision
Objectives: To briefly review all topics covered in the course

- **Week 15**

Topic: Examination

Objectives:
To examine the students on all that has been taught during the semester.

Reading List:

1. Tao Jiang, Lingyang Song and Yan Zhang (2010) Orthogonal Frequency Division Multiple Access Fundamentals and Applications. ISBN 978-1-4200-8824-3.
2. William Stallings (2007) Data and Computer Communications 8th Edition. Pearson Prentice Hall, Pearson Education Inc. ISBN 0-13243310-9
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