UNIVERSITY OF GHANA

SCHOOL OF ENGINEERING SCIENCES
SECOND SEMESTER EXAMINATIONS: 2016/2017
LEVEL400: BACHELOR OF SCIENCE IN ENGINEERING
CPEN 406: WIRELESS COMMUNICATION SYSTEMS [*3 Credits*]

TIME ALLOWED: *THREE (3) HOURS*

INSTRUCTION:
Answer <u>ALL</u> questions. [100 MARKS]

1. (a) Explain the concept of *Timing Advance* (TA), in Cellular Communication systems. [2 marks]
   (b) Discuss the importance of *Timing Advance* explained in (a) above. [2 marks]
   (c) With the aid of a block diagram, describe the general architecture of a GSM cellular communication system. [3 marks]
   (d) Mention and explain the functions of two network elements in each subsystem of the GSM architecture described above. [3 marks]
   (e) Differentiate between physical and logical channels. [4 marks]
   (f) With the aid of a call flow diagram, describe how a prepaid subscriber in Airtel Ghana GSM network will make a call to another subscriber of Vodafone network in Ghana. State all possible situations that could hinder a successful call placement. [6 marks]

2. (a) Explain the terms *fast fading* and *slow fading* in mobile communication channels. [4 marks]
   (b) What is the *coherence bandwidth* of a communication channel, and how does it relate to the *frequency selective fading* characteristics of the channel? [4 marks]

(c) A few weeks ago, some of the fibre optic cables providing internet connectivity to some parts of campus were destroyed by rodents and hence internet connectivity to the School of Engineering was hampered. As a stop gap measure, a radio link was to be set up with the following parameters:

Maximum Radio Transmitter Power = 45 Watts.

Distance between Transmitter and Receiver = 143 m.

Design a radio link system given that 30 mW of received power is needed for an acceptable system performance, by using a reasonable operating system parameter values. [6 marks]

(d) A wireless LAN is operating in a factory near a conveyor belt. The transmitter and receiver have a line-of-sight (LOS) path between them with gain α_0, phase $\varphi_0$and delay τ_0. Every T_0seconds a metal item comes down the conveyor belt, creating an additional reflected signal path in addition to the LOS path with gain α_1, phase $\varphi_1$and delay τ_1. Find the time-varying impulse response $c(\tau, t)$of this channel. [6 marks]

3. (a) Distinguish between *multiplexing* and *multiple access.* [3 marks]

(b) Describe the operation of both the pure ALOHA and the slotted ALOHA multiple access schemes and distinguish between the throughput for both multiplexing schemes. [4 marks]

(c) In a multiplexing access scheme, the amount of offered traffic is 13.73 Erlangs. Determine the system throughput if the pure ALOHA method is used. [4 marks]

(d) If the throughput of the system in (c) above is doubled, determine the offered traffic for the case of slotted ALOHA. [4 marks]

(e) For an application that requires continuous transmission of data and with only a small delay requirement for an acceptable level of service, state and explain the type of multiplexing access suitable for such an application. [5 marks]

4. (a) Explain the concept of *reuse ratio* in cellular communication systems and explain its relationship with system capacity. [3 marks]

(b) State and explain three ways by which the capacity of a cellular system can be improved. [3 marks]

(c) Explain *co-channel interference* and *adjacent channel interference* and state two ways each can be minimized. [2 marks]

(d) Akonfem Wireless, a wholly owned Ghanaian Company has just secured a license from the NCA to provide telecommunication services in Ghana. They planned to start in Kumasi, which has an area of 154 square km and is to be covered by a cellular system that uses a seven reuse pattern. Each cell has a radius of 4km and the city is allocated 50 MHz of

spectrum of a full duplex channel bandwidth of 60 kHz. Assuming a Grade-of-Service (GoS) of 2% for an Erlang-B system and a traffic load per user of 0.03 Erlangs, determine:

(i) The number of cells in the service area. [2 marks]

(ii) The number of channels per cell. [2 marks]

(iii) The maximum carried traffic. [2 marks]

(iv) Traffic intensity of each cell. [2 marks]

(iv) Total number of users that can be served for 2% GoS. [2 marks]

(v) Number of mobiles per channel. [2 marks]

5. (a) Explain the concept of *spread spectrum communications*. [3 marks]

(b) Differentiate between Slow Frequency Hopping (SFH) and Fast Frequency Hopping (FFH) with respect to the data symbol and chip duration. [2 marks]

(c) Briefly and precisely describe the process of implementing a direct sequence spread spectrum, DS-SS. [5 marks]

(d) As the Chief Engineer at the National Military Communication Department, you have the option of building a communication network for the military service using either the GSM or CDMA technology. The Commander only knows without any reason that CDMA is a better choice. Enumerate five reasons that will form part of a presentation you will deliver to your top echelon confirming why CDMA is a better choice. [5 marks]

(e) In the direct sequence spread spectrum communication system, the data sequence bit duration is 4.095ms, a PN chip duration of 1μs and $^{E_b}/_{N_0} = 10$ for average probability of error of less than 10^{-5}. Calculate the Processing Gain and Jamming Margin. [5 marks]