SCHOOL OF NATURAL SCIENCES
2004 FIRST SEMESTER EXAMINATION

BS 111	:	CELL BIOLOGY AND GENETICS
BS 211	:	CELL MOLECULAR BIOLOGY / Genetics
BS 221	:	FORM, FUNCTION AND DIVERSITY OF PLANTS
BS 319	:	BIOSTATISTICS
BS 321	:	ETHOLOGY AND EVOLUTION
BS 331	:	PLANT PHYSIOLOGY
BS 341	:	MICROBIOLOGY PAPER ONE (I) THEORY
BS 341	:	MICROBIOLOGY PAPER TWO (II) PRACTICAL
BS 351	:	ENTOMOLOGY
BS361	:	MOLECULAR BIOLOGY
BS 411	:	ENTOMOLOGY THEORY PAPER ONE (I)
BS 411	:	INSECT BEHAVIOUR AND ECOLOGY THEORY PAPER TWO
BS 425	:	IMMUNOLOGY
BS 441	:	ADVANCED MOLOCULAR BIOLOGY
BS 491	:	FRESH WATER BIOLOGY
BS 915	:	BIOLOGY OF SEED PLANTS
BS 935	:	PLANT PATHOLOGY
C 101	:	INTRODUCTORY CHEMESTRY
C 205	:	ANALYTICAL AND INORGANIC CHEMESTRY
C 225	:	ANALYTICAL CHEMESTRY I
C 245	:	INORGANIC CHEMESTRY I
C 251	:	ORGANIC CHEMESTRY I
C 311	:	BIOCHEMISTRY
C 321	:	ANALYTICAL CHEMISTRY (II)
C 341	:	INORGANIC CHEMISTRY (II)
C 351	:	ORGANIC CHEMISTRY (III)
C 365	:	CHEMICAL KINETICS AND NUCLEAR CHEMISTRY
C 411	:	ADVANCED BIOCHEMISTRY
C 421	:	APPLIED ANALYTICAL CHEMISTRY
C 445	:	BIO-INORGANIC CHEMISTRY
CST2021	:	INTRODUCTION TO COMPUTER SYSTEMS
CST 2011	:	INTRODUCTION TO PROGRAMMING (I)
CST2041	:	INTRODUCTIO TO OPERATING SYSTEMS
C	:	NETWORKING AND DATA COMMUNICATION
CST 3011	:	ALGORITHMS AND DATA STRUCTURES
CST 3031	:	INTRODUCTION TO SOFTWARE ENGINEERING
CST 3141	:	OBJECT ORIENTED ANALYYSIS AND DESIGN
CST 4011	:	ADVANCED DATABASES AND INFORMATION SYSTEMS
CST 4131	:	ADVANCED OBJECT ORIENTED PROGRAMMING
CST 4251	:	ELECTRONICS FOR COMPUTING (III)
EM 211	:	ENGINEERING MATHEMATICS (I)
EM 311	:	ENGINEERING MATHEMATICS (III)

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EM 411	:	ENGINEERING MATHEMATICS (V)
GEO 111	:	INTRODUCTION TON TO HUMAN GEOGRAPHY (I)
GEO 175	:	INTRODUCTION TO MAPPING TECHNIQUES
GEO 211	:	GEOGRAPHY OF AFRICA
GEO 271	:	QUANTITATIVE TECHNIQUES IN GEOGRAPHY (I)
GEO 381	:	ENVIRONMENT AND DEVELOPMENT (I)
GEO 451	:	LAND RESOURCE SURVEY
GEO 481	:	ENVIRONMENT AND DEVELOPMENT (II)
GEO 911	:	POPULATION GEOGRAPHY
GEO 921	:	ECONOMIC GEOGRAPHY
GEO 931	:	RURAL GEOGRAPHY
GEO 971	:	AERIAL PHOTOGRAPHY AND AERIAL INTERPRETATION
M 111	:	MATHEMATICAL METHODS (I)
M 161	:	INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS I
M 161	:	(DEFERRED)
M 211	:	MATHEMATICAL METHODS (III)
M 221	:	LINEAR ALGEBRA
M 221	:	LINEAR ALGEBRA (DEFERRED)
M 231	:	REAL ANALYSIS (I)
M 261	:	INTRODUCTION TO STATISTICS
M 325	:	INTRODUCTION TO ABSTRACT ALGEBRA
M 331	:	REAL ANALYSIS (III)
M 361	:	MATHEMATICAL STATISTICS
M 411	:	THEORY OF FUNCTIONS OF A COMPLEX VALUABLES (I)
M 421	:	STRUCTURAL AND REPRESENTATIONS OF GROUPS
M 431	:	REAL ANALYSIS (V)
M 431	:	DEFERRED
M 461	:	MULTIVARIATE ANALYSIS
M 911	:	MATHEMATICAL METHODS FOR PHYSICS
MP 415	:	MATHEMATICAL METHODS FOR PHYSICS
P 191	:	INTRODUCTORY PHYSICS
P 191	:	DEFERRED
P 231	:	PROPERTIES OF MATTER AND THERMAL PHYSICS
P 251	:	CLASSICAL MECHANICS (I)
P 261	:	ELECTRICITY AND MAGNETISM
P 341	:	INTRODUCTION ANALOGUE ELECTRONICS
P 351	:	INTRODUCTION TO QUANTUM MECHANICS
P 361	:	ELECTROMAGNETISM
P 401	:	COMPUTATIONAL PHYSICS
P 421	:	SOLID STATE PHYSICS (I)
P 441	:	ANALOGUE ELECTRONICS (II)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATARAL SCIENCES
JUNE 2004 - FIRST SEMESTER EXAMINATIONS
THEORY PAPER
BS 111 CELL BIOLOGY AND GENETICS

ANSWER SHEET

COMPUTER NUMBER								

Information

- Answer all questions
- All questions carry equal marks
- A correct answer carries +4 marks
- A wrong answer carries a –1 mark
- Choose the best answer to a question and place its number against the question
- **A blank answer space carries a mark of -1**
- The sixth alternative is "I don't know" and it carries a mark of 0
- **Answers indicated in pencil will not be marked**

1.		**26.**		**51.**		**76.**	
2.		**27.**		**52.**		**77.**	
3.		**28.**		**53.**		**78.**	
4.		**29.**		**54.**		**79.**	
5.		**30.**		**55.**		**80.**	
6.		**31.**		**56.**		**81.**	
7.		**32.**		**57.**		**82.**	
8.		**33.**		**58.**		**83.**	
9.		**34.**		**59.**		**84.**	
10.		**35.**		**60.**		**85.**	
11.		**36.**		**61.**		**86.**	
12.		**37.**		**62.**		**87.**	
13.		**38.**		**63.**		**88.**	
14.		**39.**		**64.**		**89.**	
15.		**40.**		**65.**		**90.**	
16.		**41.**		**66.**		**91.**	
17.		**42.**		**67.**		**92.**	
18.		**43.**		**68.**		**93.**	
19.		**44.**		**69.**		**94.**	
20.		**45.**		**70.**		**95.**	
21.		**46.**		**71.**		**96.**	
22.		**47.**		**72.**		**97.**	
23.		**48.**		**73.**		**98.**	
24.		**49.**		**74.**		**99.**	
25.		**50.**		**75.**		**100.**	

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATAURAL SCIENCES

2004 ACADEMIC YEAR - FIRST SEMESTER

JUNE FINAL EXAMINATIONS

THEORY PAPER

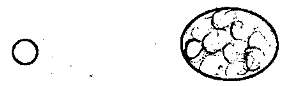
BS 111: CELL BIOLOGY AND GENETICS

TIME: THREE HOURS

INSTRUCTIONS:

1. ANSWER ALL QUESTIONS USING THE ANSWER SHEET
2. DO NOT USE A PENCIL ON THE ANSWER SHEET
3. ALL QUESTIONS CARRY EQUAL MARKS (+4)
4. A WRONG ANSWER AND A BLANK ANSWER SPACE CARRY –1 MARK
5. I DO NOT KNOW CARRIES NO MARK
6. SECTION ONE (Q1 – Q50): CELL BIOLOGY
   SECTION TWO (Q51 – Q100): GENETICS

1. Specimen **A** is a drawing of a nucleus as seen under a light microscope at a magnification of X100. Specimen **B** is a representation of the drawing on paper by a student. Indicate the magnification that the student put under specimen **B**



A **B**

1. X50
2. X10 X40
3. X800
4. X2 X10 X40
5. X300
6. I do not know

2. Which of the following terms is correctly described in a **biological** sense?

1. **reproduction**: production of young ones which can not mate
2. **growth**: increase in size
3. **respiration**: breathing in and breathing out of air through the lungs
4. **excretion**: method by which organism removes toxic secondary metabolites
5. **evolution**: organisms change and resemble each other more
6. I do not know

3. The following is a description of a **taxon**. Which organisms best suit the description?

"Genetic material is enclosed in a membrane bound structure. Ribosomes, the ER, and golgi bodies are all enclosed in a double membrane. The organisms are multicellular. Their cell walls are made up of chitin. They have an extra cellular mode of nutrition."

1. Fungi
2. Protozoa
3. Plantae
4. Bacteria
5. Mammals
6. I do not know

4. A virion is a very small particle, ranging from … to … in diameter.

1. 1 , 5μm
2. 10 , 400nm
3. 5 , 400μm
4. 100 , 500nm
5. 1 , 10μm
6. I do not know

5. Which of the following statements is **correct**?

    1. A water molecule is not electrically neutral
    2. Some water molecules are positively charged while others are negatively charged
    3. Water molecules normally repel one another
    4. Water molecules have a small positive charge on oxygen and a small negative charge on hydrogen
    5. The distribution of electrical charge on water is such that the oxygen end is partially negative while the hydrogen end is partially positive.
    6. I do not know

6. Which of the following groups of substances can dissolve or partially dissolve in chloform?

a. amino acids	**b.** amylopectin	**c.** lectin
proteins	amylose	triglycerides
glucose	sucrose	oleic acid

Amino acids

chloform

1. **a**	3. **c**	5. **a** and **b**
2. **b**	4. **a** and **c**	6. I do not know

7. Which of the following life molecules **is not** an example of an organic compound?

    1. sucrose
    2. galactose
    3. water
    4. RNA
    5. Valine
    6. I do not know

8. Carbon yields an immense variety of organic compounds because …

    1. carbon forms bonds with many other atoms such as carbon, nitrogen, sulphur, hydrogen and phosphorus
    2. carbon forms hydrogen bonds with water
    3. carbon forms bonds with cobolt, iron, and hydrogen
    4. carbon has a valence of four
    5. of both 1. and 4. above
    6. I do not know

18. Given the following information below, which cell(s) would achieve a more efficient metabolic rate?

Cell (a): diameter: 50mm
volume: $250mm^3$
surface area: $300mm^2$

Cell (b): diameter: 20mm
volume: $2.5mm^3$
surface area: $250mm^2$

Cell (c): diameter: 100mm
volume: $5mm^3$
surface area: $50mm^2$

1. cell (a) 2. cell (b) 3. cell (c) 4. cell (b) and (c) 5. cell (a) and (b) 6. I do not know

by ras

19. Complete the table below.

compound	example	function
lipid	**a**	energy source
b	DNA	Carrier of genetic materials
phospholipid	lectin	**c**

1. a) triglyceride b) nucleic acid c) component of plasmamembrane
2. a) sphingolipid b) chromosome c) plasma membrane by ras
3. a) glycoprotein b) histone c) transport of proteins
4. a) lipoprotein b) nucleotide c) storage of lipids
5. a) polysaccharide b) polyphosphate c) cell movement
6. I do not know

20. Deoxyribonucleic acid base pairs are as follows: DNA

1. pyrimidine: pyrimidine
2. purine: purine
3. purine: adenine
4. pyrimidine: cyotocine
5. pyrimidine: purine
6. I do not know

Thank me; phone 099541290 and reward me.

21. The two helical strands of deoxyribonucleic acid are held together by hydrogen bonds. A triple hydrogen bond forms between the following base pairs.

1. Guanine and adenine
2. Thymine and guanine
3. Adenine and Cytocine
4. Adenine and Uracil
5. Guanine and cytocine
6. I do not know

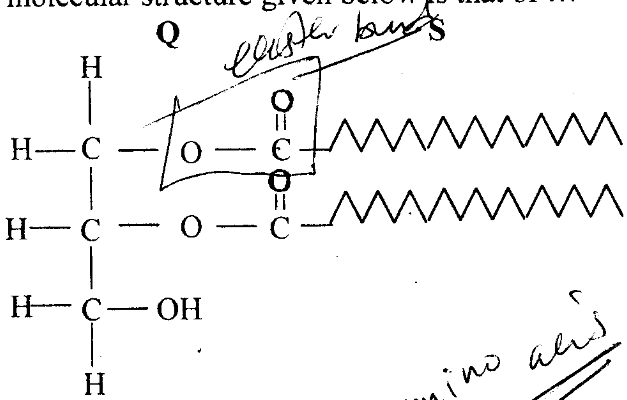
Guanine and Ade DNA

23

22. Explain why the yield of ATP from the respiration of one molecule of glucose when oxygen is present is more than the yield of ATP from the respiration of one molecule of glucose under anaerobic conditions.

1. It becomes possible for the acetyl group of pyruvic acid to enter the mitochondrion for further generation of energy
2. The Krebs cycle is not dependent on oxygen and therefore pyruvic acid is further broken down to release the required energy
3. Glycerate 3 – phosphate which leads to the formation of pyruvate forms abundantly under anaerobic conditions thereby releasing more ATP
4. Aerobic conditions make glycolysis proceed towards the formation of lactic acid instead of pyruvic acid.
5. Anaerobic conditions activate the electron transport chain to proceed much faster and more freely, thereby releasing more ATP
6. I do not know

23. The molecular structure given below is that of …



free amino acids

1. fatty acid
2. glycoprotein
3. protein
4. diglyceride
5. triglyceride
6. I do not know

24. What is the name of the molecule labeled **Q** in question **23** above?

1. carbohydrate
2. amino acid
3. stearic acid
4. nucleic acid
5. glycerol
6. I do not know

25. What kind of bond holds molecules **Q** and **S** in question **23** above?

1. glycosidic bond
2. peptide bond
3. hydrogen bond
4. ionic bond
5. ester bond
6. I do not know

26. Name one important by product of the Krebs cycle and state its significance in respiration.

1. Carbon dioxide;	It is the final electron acceptor
2. $FADH_2$;	helps to release more energy for synthesis of ATP
3. citric acid;	helps to decarboxylate the substrates of the Krebs cycle
4. Coenzyme-A;	helps to transport glucose into the mitochondrion
5. Oxaloacetate;	because it is the first product of the Krebs cycle
6. I do not know	

27. Why should it be significant for the electron transport chain to take place in the inner membrane of the mitochondria?

1. To protect the reduced forms of NAD+ and FAD from the oxidative conditions of the cytoplasm
2. That is where the enzyme hexokinase is in abundance
3. There is less interference from carbon dioxide in the mitochondria
4. That is where most of the respiratory enzymes are situated
5. There is more glucose in the mitochondria than in the cytoplasm
6. I do not know

28. The cell theory states that …

1. living things are all made up of cells
2. living things can only arise from pre-existing cells
3. there is an unbroken continuity between ancient and modern cells
4. all the statements 1,2 and 3 above are part of the cell theory
5. cells can not exist as solitary units
6. I do not know

29. Identify ribonucleic acid base pairs:

1. Guanine: Thymine
2. Adenine: Guanine
3. Cytocine: Thymine
4. Adenine: Uracil
5. Uracil: Thymine
6. I do not know

30. The following terms are from the respiratory pathway. Identify the group in which the terms are arranged in the order they would normally come.

1. glucose; Fructose 6 – phosphate; pyruvate; NADH+H; cytochromes
2. fructose 6 – phosphate; pyruvate; 3 phosphoglyceraldehyde; water
3. enolase; ATP'ase; hexose kinase
4. 3 dihydroxyacetone phosphate; acetyl Co-A; oxaloacetic acid; pyruvate
5. citric acid; cytochromes; electron transport chain; oxygen
6. I do not know

31. Name the specific location in the chloroplast where **chlorophyll-a** is found.

1. mitochondria
2. stroma
3. grana
4. thylakoid membrane
5. intra crystal space
6. I do not know

32. A virion is a very small particle, ranging from … to … in diameter.

1. 1 , 5μm
2. 10, 400nm
3. 5 , 400μm
4. 100, 500nm
5. 1 , 10μm
6. I do not know

33. A scientist wishes to determine the amount of starch in a leaf sample. Which of the following methods would give reliable results?

1. extract the starch using water and use chromatography to determine the amounts.
2. extract the starch using acetone and use appropriate enzymes to yield cellobiose whose concentration is measured through chromatography
3. make a water extract and hydrolyse the starch with appropriate enzymes and use chromatographic techniques to measure the quantity of sugars present
4. extract the starch in cooking oil and use chromatographic techniques to measure the quantity of the starch
5. extract the starch in chloroform, hydrolyse it with an appropriate enzyme and weigh the extract on a balance to determine its weight.
6. I do not know

18

34. The concentration of proteins in a solution are as follows;

a.	5mg in $1cm^3$ of water	**b.**	25mg in $100cm^3$ of water
c.	70mg in $5cm^3$ of water	**d.**	100mg in $20cm^3$ of water

1. **a** and **b** are colloidal solutions
2. **a** and **c** are colloidal solutions
3. **a** and **d** are examples of gels
4. **b** and **d** are examples of gels
5. **b** and **c** are examples of gels
6. I do not know

18

Given that the isoelectric point of an amino acid is pH 5.5, the environment of the amino acid is raised to a pH of 7. What will happen to the amino acids in solution?
(Answer questions 35 and 36 using this information)

35. 1. The amino acid molecules will disperse in solution
2. The amino acid molecules will precipitate out of solution
3. The amino acid molecules will become zwitterion ions
4. The amino group will develop a positive charge whereas the carboxyl group will develop a negative charge
5. The amino group will make the solution more acidic
6. I do not know

14

36. 1. The amino acid will react with the base to create a positive charge on itself
2. The base will be neutralized making the amino acid negatively charged
3. The carboxyl end of the amino acid will bear a positive electrical charge
4. A negative charge develops on the amino group
5. The amino acid will dissociate into a base and an acid
6. I do not know

0

Solution **X** contains a carbohydrate. The solution does not react with Benedicts solution. An acid is added to solution **X** and warmed in a water bath when a colour change is observed.
(answer questions 37 and 38 using this information)

37. Name the carbohydrate in solution **X**

1. amylose
2. fructose
3. protein
4. sucrose
5. glycogen
6. I do not know

38. Solution **X** actually changed from blue to green. What can you say about the concentration of the carbohydrate in solution **X**?

1. a low concentration of the carbohydrate
2. a high concentration of the carbohydrate
3. contaminated mixture of carbohydrates
4. there were no carbohydrates in the solution
5. carbohydrate was predominantly glycerol
6. I do not know

39. Cellulases are special enzymes that are capable of breaking the …

1. alpha 1,4 – linkages in starch
2. alpha 1,4 – linkages in cellulose
3. beta 1,4 – linkages in starch
4. beta 1,6 and alpha 1,4 linkages in starch
5. double bond in cellobiose
6. I do not know

40. Which of these amino acid is the simplest in structure?

1.	Alanine	3.	Cysteine	5.	Valine
2.	Glycine	4.	Asparagine	6.	I do not know

41. Disulphide bridges are bonds that help to keep ... molecular structures. They form between the amino acids ... and ... .

1. organic, asparagines, cysteine
2. nucleic acid, glycine, alanine
3. protein, cysteine, cysteine
4. carbohydrate, alanine, isoleucine
5. lipid, glycine, isoleucine
6. I do not know

8

42. Name the chemical compound that is responsible for the movement of amino acids to the 'protein assembly plant' in a cell.

1. messenger ribonucleic acid
2. ribosomal acid
3. deoxyribonucleic acid
4. ribonucleic acid
5. transfer ribonucleic acid
6. I do not know

9

43. The following organelles (golgi apparatus, ribosomes, centriole and cytoskeleton) are present in a given cell. What cell type is this?

1. plant cell
2. animal cell
3. bacterioghage
4. bacterial cell
5. fungal cell
6. I do not know

6

44. The asymmetric carbon in glucose is the carbon atom ...

1. with a hydroxyl group
2. with a hydrogen atom
3. next to methyl hydroxyl group
4. with a hydroxyl group next to the oxygen bridge
5. with a hydroxyl group next to the methyl hydroxyl bridge
6. I do not know

45. Most of the chemical energy, in the form of ATP is produced during ... of respiration.

1. glycolysis
2. oxidative phosphorylation
3. anaerobic conditions
4. citric acid cycle
5. calvin cycle
6. I do not know

46. Which of the following terms is **correctly** described?

1. **Condensation**: The process of synthesising a new compound by the removal of water from the reacting compounds
2. **Functional group**: Part of a chemical compound that participates in a chemical reaction
3. **Hydrolysis**: A chemical reaction in which water is added to release units of a compound
4. **Disaccharide**: A chemical compound made up of two sugar molecules
5. Terms in one, two, three and four above are all correctly described
6. I do not know

47. Waxes, terpenes and steroids are all examples of ...

1. proteins
2. lipids
3. carbohydrates
4. nucleic acids
5. sugars
6. I do not know

48. The structures responsible for movement in cells are called ...

1. microtubules
2. microtraberculae
3. microfilaments
4. cytoplasm
5. cytoskeleton
6. I do not know

49. The molecule pyruvic acid has …

1. only one carbon in it
2. two methyl groups in it
3. no hydroxyl groups in it
4. no double bonds in it
5. three carbons, four hydrogens and three oxygens
6. I so not know

(4) (1)

50. Glucose - 6 - phosphate is transformed into fructose - 6 – phosphate. The enzyme involved belongs to the group of …

1. hydrolases
2. isomerases
3. transferases
4. reductases
5. sythetases
6. I do not know

CONTINUE WITH SECTION B ON THE NEXT PAGE
(Q51 – 100)

51. It has been observed that the aquatic plant, known as the water starwort (*Callitriche*), produces two kinds of leaves, depending on whether they are under water or above it. The submerged leaves are narrow and finely dissected, whereas the leaves surrounded by air are more ``normal'' in appearance. What can you say about the expression of the genes that determine leaf shape in this plant?

1. Suppressors are at play in the expression of the genes for leaf shape
2. the expression of genes for leaf shape is under the influence of the environment
3. the genes have multiple effects (pleiotropy)
4. the genotype and the phenotype are different
5. the expression of the genes is at less than 100% penetrance
6. I do not know

52. Cystic fibrosis is inherited as a simple recessive trait. Suppose a woman who carries the trait marries a normal man who has no history of the condition in his family, what are chances that the couple would have an affected child.

1. 0%
2. 25%
3. 33%
4. 50%
5. 75%
6. I do not know

53. The genotype of a particular cell for a particular trait is Aa. The cell goes through meiosis. The result of this meiosis will be:

1. four daughter cells, one half with the genotype A and the other half with genotype a
2. four daughter cells, all with genotype Aa
3. two daughter cells, one with genotype A and the other with genotype a
4. two daughter cells, all with genotype Aa
5. none of the above
6. I do not know

54. The condition in which one pair of alleles code for contrasting phenotypic characteristics; one allele dominant and one recessive is termed as
    1. genotype
    2. gene interaction
    3. heterozygote
    4. phenotype
    5. epistasis
    6. I do nt know

55. Which of the following is **not** a feature of meiosis
    1. Crossing over
    2. Growth of zygote
    3. generating variation
    4. maintenance of the species integrity
    5. production of gametes
    6. I do not know

56. Genetic counselling involves certain tests to assess whether an individual possesses an abnormal gene or chromosome mutation. The presence of Down's syndrome in a fetus can be determined by amniocentesis. A small amount of amniotic fluid is removed for cell culture, and the metaphase chromosomes can be photographed and counted. How many chromosomes can you find in a Down's syndrome patient?

    1. 2n = 46
    2. 2n = 48
    3. 2n-1 = 45
    4. 2n-2 = 44
    5. 2n+1 = 47
    6. I do not know

57. Which of the following conditions best describe Down's syndrome patients

    1. male, sterile, female like breasts, mentally retarded
    2. female, normal appearance, fertile, mentally retarded
    3. male, fertile or infertile, usually very tall, aggressive
    4. male or female, babies have a cat cry, moon faced, mentally retarded
    5. male or female, mentally retarded, eye-folds like Mongolian race
    6. I do not know

58. A normal man and his normal wife have three children. Each child is an albino. What is the most likely explanation for the children's albinism?

1. the gene for albinism is dominant in the offspring but recessive in the parents
2. the three children have experienced a mutation in the genotype
3. the strong effluence of the environment on the children
4. the man is not the father of the children
5. the two parents are carriers of the gene for albinism
6. I do not know

59. A male who demonstrates a rare autosomal dominant inherited disease mates with a normal female. Each of their children will

1. have a 25 percent risk of inheriting the disease
2. have a 100 percent risk of inheriting the disease
3. be affected
4. have a 50 percent risk of inheriting the disease
5. have 75 percent risk of inheriting the disease
6. I do not know

60. Which of the following statements is **false** about the inheritance of the ABO blood group system?

1. AB blood group individuals have no antibodies in the serum
2. Blood group B individuals have only antibodies B in their serum
3. Blood group O people have no antigens in their erythrocytes
4. Blood group A individuals have antigen A in their erythrocytes
5. Two of the above
6. I do not know

61. Members of the same species are united by a common set of traits that set them apart from all other species. What could be the source of this species identity?

1. different species have different methods of sex determination
2. different species have different methods of reproduction
3. meiosis ensures this species distinction
4. different species have different genomes
5. Like begets like
6. I do not know

71. Mendels' First Law states that:

1. from any one parent, only one allelic form of a gene is transmitted through a gamete to the offspring
2. Independent assorting alleles occur in same numbers
3. differently segregating alleles assort equally
4. different segregating alleles assort independently
5. alleles assort from each in equal numbers
6. I do not know

72. Which of the following crosses would give the same F2 phenotypic ratio as the cross AABB x aabb?

1. AaBb x AABB
2. Aabb x aaBB
3. AaBb x AaBb
4. AABB x AABB
5. AaBb x Aabb
6. I do not know

73. Root shape in raddish is a result of two allelic pairs where L_1L_1 produces long roots, L_1L_2 produces oval root shape and L_2L_2 produces round root shape. What phenotypic ratio would you expect in the F2 generartion if you carried out the following cross: L_1L_1x L_2L_2

A

1. 3:1
2. 1:2:1
3. 3:0
4. 2:0
5. 9:3:3:1
6. I do not know

74. *Drosophila* have a diploid number of 8 chromosomes. In mitosis, how many chromatids are visible at metaphase?

1. 16
2. 4
3. 8
4. 24
5. 32
6. I do not know

75. In question 74 above, how many chromatids are found at each mitotic telophase pole?

1. 16
2. 4
3. 8
4. 24
5. 32
6. I do not know

76. In order to find the genotype of a phenotype that exhibits the dominant characteristic,

1. cross with a homozygous recessive
2. cross with a homozygous dominant
3. consult a geneticist
4. test-cross a parent with a recessive offspring
5. back cross with either parent
6. I do not know

77. How many different gametes can be obtained from the following genotype AABbCc?

1. 5
2. 10
3. 4
4. 16
5. 8
6. I do not know

78. Alleles are genes that

1. can control the development of different traits
2. are never homozygous
3. occupy corresponding places in homologous chromosomes
4. are linked
5. are lethal when homozygous
6. I do not know

79. A brown-eyed man marries a blue-eyed woman, and they have eight children all brown-eyed. What are the genotypes of all the children in the family?

1. Homozygous for the recessive allele for blue
2. Heterozygous for the dominant allekle for brown eyes
3. Both the dominant and recessive alleles are expressed equally in all the eight children
4. Homozygous for the dominant allele for brown eyes
5. some children are homozygous for the dominant brown eye allele while others are heterozygous
6. I do not know
   children

80. Chickens with shortened wings and legs are called creepers. When creepers are mated to normal birds they produce creepers and normals with equal frequency. When creepers are mated to creepers they produce 2 creepers to 1 normal. Crosses between normal birds produces only normal progeny. These observations point to which of the following phenomena?

1. continuous variation
2. discontinuous variation
3. pleoitropism
4. recessive lethal genes
5. variable expressivity
6. I do not know

QUESTIONS 81 - 83

Assume that in humans the following genetic situations apply:

Gene A produces normal skin pigment and is dominant over gene a, which controls albinism (lack of pigment in the skin, hair, and eyes).

Gene F gives a type of wide forehead and is dominant over f, which gives a narrow forehead.

Gene H and h show incomplete dominance, HH giving curly hair, hh giving straight hair, and Hh giving wavy hair.

81. A woman with a wide forehead marries a man with a narrow forehead. Their first child has a narrow forehead. What is the chance that the second child will have a wide forehead?

1. 0%
2. 25%
3. 50%
4. 75%
5. 100%
6. I do not know

82. Assume that the improbable marriage AaFF x aaff occurs. What is the ratio for the type of children expected?

1. 1:1:1:1
2. 9:3:3:1
3. 3:1
4. 27:9:9:9:3:3:3:1
5. 1:1
6. I do not know

83. From a mating of parents, each of whom has wavy hair and is heterozygous for wide forehead, what types of children would you expect and in what ratio are they expected?

1. 3 curly wide : 1 curly narrow: 6 wavy wide: 2 wavy narrow:3 straight wide:1 straight narrownarrow staight
2. 1 narrow curly: 1 narrow straight
3. 1 wide curly:1wide straight:1 narrow curly: 1 narrow straight
4. 9 wide curly:3 wide straight:3 narrow curly:1 narrow straight
5. 3 wide straight: 1 narrow curly
6. I do not know

QUESTIONS 84 & 85

In mice the dominant allele B determines a grey colour while the recessive allele b stands for black. The presence or absence of pigment is determined by yet another locus whereby the dominant allele C stands for presence of pigment while the recessive c alleles means no pigment.

84. What phenotypic proportions are expected in the offspring of a mating of two grey mice heterozygous for both colour and pigment formation?

1. 9:3:3:1
2. 9:3:4
3. 12:3:1
4. 9:7
5. 27:9:9:9:3:3:3:1
6. I do not know

85. What is the name given to the genetic phenomenon illustrated in Question 84 above?

1. Recessive epistasis
2. Dominnat epistasis
3. Duplicate recessive epistasis
4. Lethal genes
5. sub-lethal mutations
6. I do not know

86. Hemophilia is a recessive sex linked trait which leads to the lack of a blood clotting factor in affected individuals. If a normal woman who has a history of the condition in her family marries a normal man. What is the chance that the couple would produce hemophiliac children?

1. 50%
2. 100%
3. 75%
4. 0%
5. 25%
6. I do not know

87. A man of blood type A marries a woman of blood type B. There are four children in the family with blood groups A, B, AB and O. Which one of the children is most likely to have been adopted?

1. Blood group A child
2. Blood group B child
3. Blood group AB child
4. Blood group O child
5. None of the above
6. I do not know

88. Which of the following is the correct definition of penetrance?

1. the degree of effect produced by a penetrant genotype
2. the masking effect of one pair of alleles by another pair of alleles
3. the modification effect of the environment and the genotype on a particular pair of alleles
4. the percentage of individuals with a particular gene combination which exhibit the corresponding character
5. the product of gene mutation
6. I do not know

QUESTIONS 89-90

Sweet peas produce purple flowers when both the dominant gene C and P are present in the genotype but white flowers when either or both are absent.

89. Determine the ratio of the number of white flowered offspring and the number of purple flowered offspring from the cross: CcPp x ccPp

    1. purple only
    2. 5purple:3white
    3. 1purple:3white
    4. 3purple:1White
    5. 3purple:5white
    6. I do not know

90. Determine the genotypes of the pairs of white flowered parent plants which when crossed would produce offspring about half of which would be purple-flowered and half white-flowered.

    1. ccpp x ccPp
    2. ccPp x Ccpp
    3. CCpp x ccPP
    4. Ccpp x ccPP
    5. Ccpp x CCpp
    6. I do not know

91. If a trait which is not evident in the parents appears in their offspring, the parental genotypes are most likely to be

    1. pure recessive
    2. homogametic
    3. homozygous
    4. heterozygous
    5. heterogametic
    6. I do not know

92. Homologous chromosomes pair up gene for a gene. Which stage of cell division does this statement refer to?

    1. Anaphase I
    2. Prophase II
    3. Prophase I
    4. Metaphase I
    5. Metaphase II
    6. I do not know

93. Which of the following chromosome complements is true for a female sex cell in humans?

1. XX
2. X
3. 22A + 1 X
4. 44AA + 1XX
5. 22A + 1XX
6. I do not know

94. The AAXO genotype in humans produces a phenotypic complication known as

1. mongoloid idiocy
2. Turner's syndrome
3. 'Cri du Chat'
4. Klinefelter's syndrome
5. Monosomy
6. I do not know

95. In the evening primrose, a cross between the red-flowered variety and a the white-wflowered variety gave progeny of the pink-flowered variety only. This is an example of

1. co-dominance
2. incomplete dominance
3. multiple allelism
4. sex-linked inheritance
5. polygenic inheritance
6. I do not know

96. In humans how many barr bodies are expected in the cell nucleus of individuals of genotype AAXXY?

1. 0
2. 1
3. 2
4. 3
5. 4
6. I do not know

97. Which type of mutation is most likely to occur as a new mutant in humans?

1. a chromosomal duplication ✓
2. a chromosomal deletion
3. a single gene mutation
4. a monosomy
5. a trisomy
6. I do not know

98. A couple have 4 sons and are expecting a fith child. What is the probability that this child will be another son?

1. 100%
2. 25%
3. 50%
4. 0%
5. 75%
6. I do not know

99. One reason for Mendel's success with genetic experiments on garden peas was that he

1. used only pure breeding pea plants
2. discovered the sources of variation
3. peas had many contrasting characteristics
4. used peas with large chromosomes
5. used only hybrid pea plants
6. I do not know

100. Which of the following disoders is **not** caused by primary non disjunction

1. XYY syndrome
2. Cri-du Chat syndrome
3. Klinefelter's syndrome
4. Down's syndrome
5. Tuners's syndrome
6. I do not know

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCE

FIRST SEMESTER UNIVERSITY EXAMINATIONS

JUNE/JULY, 2004

BS 211:CELL MOLECULAR BIOLOGY

THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, OF WHICH TWO ARE FROM EACH SECTION AND THE FIFTH QUESTION IS CHOSEN FROM ANY SECTION.

SECTION A
CELL MOLECULAR BIOLOGY

1) The steady state kinetics of an enzyme are studied in the absence and presence of an inhibitor (inhibitor A). The initial rate is given as a function of substrate concentration in the following table:

	V [(m mol/L) min $^{-1}$]	
[S] (m mol/L)	No Inhibitor	Inhibitor A
1.25	1.72	0.98
1.67	2.04	1.17
2.50	2.63	1.47
5.00	3.33	1.96
10.00	4.17	2.38

a) What kind of inhabitation (competitive or non competitive) is involved?

b) Determine the $V_{\max}$ and K_M in the absence and presence of inhibitor.

2) In glucose metabolism, glucose is oxidised to pyruvate in a series of ten reactions collectively referred to as glycolysis. Show these reactions, clearly distinguishing detween the energy investment phase and the energy generation phase.

3)

a) In glycolysis Dihydroxyacetone (DHAP) phosphate is in equilibrium with Glyceraldehyde -3- phosphate (PGAL).

$$DHAP \Leftrightarrow PGAL$$

At equilibrium the ratio of DHAP to PGAL is 0.0475. Calculate the standard free energy change of this reaction.

b) In oxidative phosphorylation NADH from glycolysis and citric acid cycle is oxidised to water

$$\frac{1}{2}0_2 + NADH + H^+ \Leftrightarrow H_2 0 + NAD^+$$

(i) Write the half reactions for oxidation of NADH by molecular oxygen.

(ii) Calculate the standard free energy change of the reaction in kcal/mol.

Oxidation	reductant	n	$E_0^{'}(V)$
$\frac{1}{2}0_2 + 2H^+$	$H_2 0$	2	0.82
$NAD^+ + H^+$	NADH	2	-0.32

4) By means of a table show the similarities and differences of globular and fibrous proteins in terms of their primary, secondary and tertiary structures.

SECTION B
GENETICS

5) With the aid of clearly labelled diagrams, explain the differences between:

a) Gene duplications and deficiencies.

b) Gene inversions and translocations.

c) Linkage and crossing over.

d) Interference and coincidence.

6) State the Hardy – Weinberg law. Give brief explanation of the main assumptions relating to the Hardy – Weinberg law.

7) Identify three kinds of Ribonucleic acids (RNA) and indicate the main location of each type in the cell. Write short notes on the role of each type of RNA in the cell.

8)

a) Compare the sequence of events that take place during prophase stage of mitosis and meiosis. What are the differences in the end products of the two processes?

b) In peas, the gene yellow seed coat is dominant to it's allele, green. What offspring phenotypic ratio would be expected from a cross between a pea plant known to be heterozygous for seed coat colour and one that produced green seeds?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS

June 2004

BS 221

FORM, FUNCTION AND DIVERSITY OF PLANTS

Theory Paper

TIME: ***Three Hours***

ANSWER: **Five** questions, **One** from **Section A, Two** from **Section B** and **Two** from **Section C**.

Use a **separate** Answer Book for each of the three Sections.

SECTION A

1. In the Kingdom Plantae, bryophytes are often considered as representing an early step towards the invasion of the land. Mention two obstacles to life on land and describe the adaptations possessed by bryophytes that made them successful in this first step of land invasion.

2. Describe the general structure of a typical hornwort (Anthocerophyta) indicating which parts represent the different generations. Explain the similarities and differences in sporophyte structure and position on the gametophyte, between the described hornwort and the mosses and liverworts.

SECTION B

3. What structural features characterize diatoms? Describe in detail cell structure, reproduction and the economic importance of diatoms.

4. With appropriate examples, describe thallus structure and methods of reproduction in Chlorococcales.

5. Compare the thallus structure, cell structure and methods of reproduction in *Ulva* and *Cladophora*. Explain the importance of alternation of isomorphic generations with reference to *Ulva* and *Cladophora*.

6. Discuss thallus structure and methods of asexual and sexual reproduction with reference to fungi.

SECTION C

7. Describe, with examples, the diversity of sori arrangement in homosporous ferns and explain their significance in the identification of pteridophytes.

8. Give an illustrated account on the breeding systems of homosporous ferns in relation to the concept of the antheridiogen factor.

9. Outline the vegetative and reproductive features that are unique to species of the genus *Pinus*.

10. Write brief notes, supported by illustrations, on any **FOUR** of the following terms:
    (i) Amphivasal vascular bundles
    (ii) Amphiphytic species
    (iii) Heterospory in *Selaginella*
    (iv) Sporangiophores in *Equisetum*
    (v) Sporocarps in *Marsilea*
    (vi) Staminate cones in gymnosperms.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BS 319: BIOSTATISTICS

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ***FIVE*** QUESTIONS. ***TWO*** QUESTIONS FROM ***SECTION A*** AND ***TWO*** QUESTIONS FROM ***SECTION B*** AND ***ONE*** OTHER QUESTION FROM ***EITHER SECTION A OR B.*** ***SECTION A*** AND ***SECTION B*** SHOULD BE ANSWERED IN ***SEPARATE ANSWER BOOKS***. WHERE NECESSARY CALCULATIONS SHOULD BE DONE TO ***TWO DECIMAL PLACES***

SECTION A

1. A student investigated the effect of modifying experimentally the pH of the female reproductive duct of mice on the sex ratio of the offspring and obtained the results shown in the table below. Is there association between the sex ratio and the pH? ($\alpha = 0.05$)

Treatment	Number of offspring	
	Male	Female
Control (Untreated)	34	31
pH 7.0	22	16
pH 4.0	9	21
pH 9.2	21	7

2. The table below shows the lower face width of 6-year-old girls from two provinces in Zambia.

	Lower face width (cm)											
Province A	7.33	7.49	7.27	7.93	7.56	7.81	7.46	6.94	7.49	7.44	7.95	7.4
Province B	7.53	7.70	7.46	8.21	7.81	8.01	7.72	7.13	7.68	7.66	8.11	7.6

(i) Is there a difference in the lower face width of the girls from the two provinces when you assume that the population variance is unequal? ($\alpha = 0.05$)

(ii) What are the confidence limits of the mean lower face width of the two provinces? ($\alpha = 0.05$)

3. Seeds were taken from ripe tomatoes and set to germinate still surrounded by their gelatinous placental tissue. 400 seeds were sown and 344 seeds germinated after twelve days.

(i) What is the mean number of germination and the standard deviation?

(ii) In a sample of 10 seeds, what is the probability that (a) all the seeds will germinate (b) all the seeds will not germinate and (c) half of the seeds will germinate?

4. The number of bacteria in $1 cm^3$ of milk from five cows was counted during three periods and the results obtained are shown in the table below.

Cows	**Number of bacteria**		
	At the time of milking	**After 24 hours**	**After**
1	12000	14000	57
2	13000	20000	65
3	21500	31000	10
4	18500	26000	82
5	11000	14500	55

Calculate (i) The mean number of bacteria during the three periods

(ii) The log transformed mean number of bacteria during the three periods

(iii) The back-transformed mean number of bacteria during the three periods.

SECTION B

1. Three dose levels of an appetite stimulant were compared with a control in an experiment using individually caged rats. The results give the total food consumption (kg) for individual rats over the period of the experiment. Twelve rats were allocated to each treatment at random. The rats were then placed at random in the available cages. The values obtained were as follows.

	Dose-level of appetite stimulant (%)		
Control	**0.5**	**1**	**2**
2.79	4.90	5.90	5.82
2.58	4.63	5.87	6.44
2.57	3.94	4.86	6.32
2.14	4.46	5.85	6.25
3.02	4.82	6.01	6.08
3.72	5.58	5.69	6.00
3.06	4.47	5.63	5.79
3.19	4.21	6.13	5.86
4.20	4.19	5.52	6.21
2.72	4.76	5.78	5.23
3.51	5.07	5.65	6.78
3.06	4.21	4.68	6.76

(i) Check the homoscedasticity of this experiment (significance level: 0.05).

(ii) Upon the conclusions drawn from (i) above, perform an appropriate parametric or non-parametric test (significance level: 0.001).

2. Plan a biological study based on a survey protocol that would generate data appropriate to analyze using a two-way ANOVA.

3. An experiment to compare the effects of four fertilizer treatments on the yield of cabbage was laid out in a randomized block design with nine blocks. The treatment combinations were the factorial arrangement of two fertilizers, A and B, each used at two levels. The notations widely used for the treatment combinations would be:

- Low level of A with low level of B: (1) or 00
- High level of A with low level of B: a or 10
- Low level of A with high level of B: b or 01
- High level of A with high level of B: ab or 11

The vegetable yields (Kg/plot) were as follows:

	Treatment combinations			
Blocks	**00**	**01**	**10**	**11**
I	11.9	10.6	13.3	14.4
II	9.2	9.9	10.2	13.0
III	8.9	9.8	11.5	14.0
IV	9.1	12.5	13.7	13.7
V	7.6	8.3	9.6	13.2
VI	12.6	9.5	14.2	16.6
VII	11.0	11.9	15.8	14.2
VIII	8.5	10.0	14.6	14.8
IX	10.4	9.8	11.0	16.0

(i) Conduct an appropriate ANOVA for the results of this experiment.

(ii) Determine the main effects of fertilizers A and B and of their interactions, and test the significance of these effects (significance level: 0.05).

4. The function Y, natural log of fish number, versus X, natural log of mid-length, is often used to represent the size spectrum of fish communities. The following table provides the 1990 length-frequency distribution of the Sinazongwe area fish community, Lake Kariba, Zambia, as obtained from records of gill net surveys.

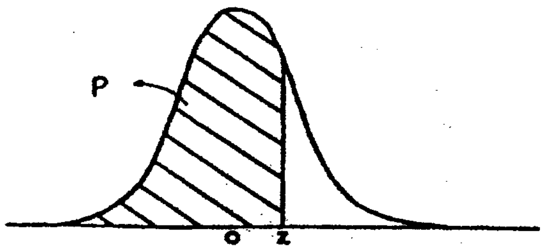
Mid-length (cm)	Number of fish
25	3264
35	1276
45	317
55	82
65	43
75	22
85	18
95	7
105	3
115	1

(i) Calculate the regression coefficients and give the equation (i.e. the size spectrum function) of the regression line (if any).

(ii) Conduct an ANOVA to calculate and interpret the coefficient of determination of the regression and to test the strength of the size spectrum function established in (i) (significance level = 0.05).

END OF EXAMINATION

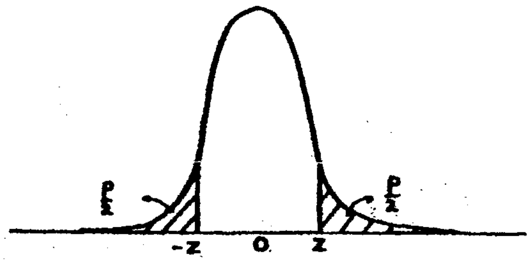
I. The Standardised Normal Distribution



The distribution tabulated is that of the normal distribution with mean zero and standard deviation 1. For each value of z, the standardised normal deviate, the proportion, P, of the distribution less than z is given. For a normal distribution with mean μ and variance σ^2, the proportion of the distribution less than some particular value, x, is obtained by calculating $z = (x - \mu)/\sigma$ and reading the proportion corresponding to this value of z.

z	P	z	P	z	P	z	P
-4.00	0.00003	-1.50	0.0668	0.00	0.5000	1.55	0.9394
-3.50	0.00023	-1.45	0.0735	0.05	0.5199	1.60	0.9452
-3.00	0.0014	-1.40	0.0808	0.10	0.5398	1.65	0.9505
-2.95	0.0016	-1.35	0.0885	0.15	0.5596	1.70	0.9554
-2.90	0.0019	-1.30	0.0968	0.20	0.5793	1.75	0.9599
-2.85	0.0022	-1.25	0.1056	0.25	0.5987	1.80	0.9641
-2.80	0.0026	-1.20	0.1151	0.30	0.6179	1.85	0.9678
-2.75	0.0030	-1.15	0.1251	0.35	0.6368	1.90	0.9713
-2.70	0.0035	-1.10	0.1357	0.40	0.6554	1.95	0.9744
-2.65	0.0040	-1.05	0.1469	0.45	0.6736	2.00	0.9772
-2.60	0.0047	-1.00	0.1587	0.50	0.6915	2.05	0.9798
-2.55	0.0054	-0.95	0.1711	0.55	0.7088	2.10	0.9821
-2.50	0.0062	-0.90	0.1841	0.60	0.7257	2.15	0.9842
-2.45	0.0071	-0.85	0.1977	0.65	0.7422	2.20	0.9861
-2.40	0.0082	-0.80	0.2119	0.70	0.7580	2.25	0.9878
-2.35	0.0094	-0.75	0.2266	0.75	0.7734	2.30	0.9893
-2.30	0.0107	-0.70	0.2420	0.80	0.7881	2.35	0.9906
-2.25	0.0122	-0.65	0.2578	0.85	0.8023	2.40	0.9918
-2.20	0.0139	-0.60	0.2743	0.90	0.8159	2.45	0.9929
-2.15	0.0158	-0.55	0.2912	0.95	0.8289	2.50	0.9938
-2.10	0.0179	-0.50	0.3085	1.00	0.8413	2.55	0.9946
-2.05	0.0202	-0.45	0.3264	1.05	0.8531	2.60	0.9953
-2.00	0.0228	-0.40	0.3446	1.10	0.8643	2.65	0.9960
-1.95	0.0256	-0.35	0.3632	1.15	0.8749	2.70	0.9965
-1.90	0.0287	-0.30	0.3821	1.20	0.8849	2.75	0.9970
-1.85	0.0322	-0.25	0.4013	1.25	0.8944	2.80	0.9974
-1.80	0.0359	-0.20	0.4207	1.30	0.9032	2.85	0.9978
-1.75	0.0401	-0.15	0.4404	1.35	0.9115	2.90	0.9981
-1.70	0.0446	-0.10	0.4602	1.40	0.9192	2.95	0.9984
-1.65	0.0495	-0.05	0.4801	1.45	0.9265	3.00	0.9986
-1.60	0.0548	0.00	0.5000	1.50	0.9332	3.50	0.99977
-1.55	0.0606					4.00	0.99997

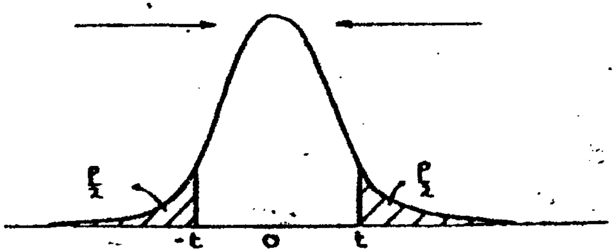
II. Percentage Points of the Normal Distribution



This table gives the values of z for which a given percentage, P, of the standardised normal distribution lies outside the range -z to +z.

P	z
90%	0.1257
80%	0.2533
70%	0.3853
60%	0.5244
50%	0.6745
40%	0.8416
30%	1.0364
20%	1.2816
10%	1.6449
5%	1.9600
2%	2.3263
1%	2.5758
0.2%	3.0902
0.1%	3.2905

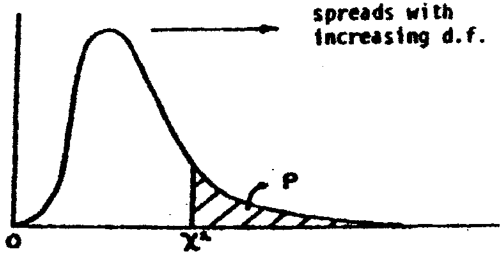
narrows with increasing degrees of freedom (d.f.)



This table gives the values of t for which a particular percentage, P, of the Student's t distribution lies outside the range -t to +t. These values of t are tabulated for various degrees of freedom.

P Degrees of freedom	50	20	10	5	2	1	0.2	0.1
1	1.00	3.08	6.31	12.7	31.8	63.7	318	637
2	0.82	1.89	2.92	4.30	6.96	9.92	22.3	31.6
3	0.76	1.64	2.35	3.18	4.54	5.84	10.2	12.9
4	0.74	1.53	2.13	2.78	3.75	4.60	7.17	8.61
5	0.73	1.48	2.02	2.57	3.36	4.03	5.89	6.87
6	0.72	1.44	1.94	2.45	3.14	3.71	5.21	5.96
7	0.71	1.42	1.89	2.36	3.00	3.50	4.79	5.41
8	0.71	1.40	1.86	2.31	2.90	3.36	4.50	5.04
9	0.70	1.38	1.83	2.26	2.82	3.25	4.30	4.78
10	0.70	1.37	1.81	2.23	2.76	3.17	4.14	4.59
12	0.70	1.36	1.78	2.18	2.68	3.05	3.93	4.32
15	0.69	1.34	1.75	2.13	2.60	2.95	3.73	4.07
20	0.69	1.32	1.72	2.09	2.53	2.85	3.55	3.85
24	0.68	1.32	1.71	2.06	2.49	2.80	3.47	3.75
30	0.68	1.31	1.70	2.04	2.46	2.75	3.39	3.65
40	0.68	1.30	1.68	2.02	2.42	2.70	3.31	3.55
60	0.68	1.30	1.67	2.00	2.39	2.66	3.23	3.46

spreads with increasing d.f.



This table gives the values of χ^2 for which a particular percentage, P, of the chi-squared distribution is greater than χ^2. These values of χ^2 are tabulated for various degrees of freedom.

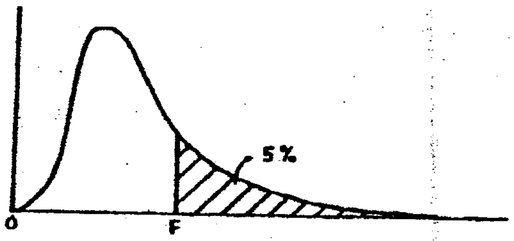
P Degrees of freedom	97.5	95	50	10	5	2.5	1	0.
1	0.000982	0.00393	0.45	2.71	3.84	5.02	6.64	10
2	0.0506	0.103	1.39	4.61	5.99	7.38	9.21	13
3	0.216	0.352	2.37	6.25	7.82	9.35	11.3	16
4	0.484	0.711	3.36	7.78	9.49	11.1	13.3	18
5	0.831	1.15	4.35	9.24	11.1	12.8	15.1	20.
6	1.24	1.64	5.35	10.6	12.6	14.5	16.8	22.
7	1.69	2.17	6.35	12.0	14.1	16.0	18.5	24.
8	2.18	2.73	7.34	13.4	15.5	17.5	20.1	26.
9	2.70	3.33	8.34	14.7	16.9	19.0	21.7	27.
10	3.25	3.94	9.34	16.0	18.3	20.5	23.2	29.
12	4.40	5.23	11.3	18.5	21.0	23.3	26.2	32.
15	6.26	7.26	14.3	22.3	25.0	27.5	30.6	37.
20	9.59	10.9	19.3	28.4	31.4	34.2	37.6	45.
24	12.4	13.9	23.3	33.2	36.4	39.4	43.0	51.
30	16.8	18.5	29.3	40.3	43.8	47.0	50.9	59.
40	24.4	26.5	39.3	51.8	55.8	59.3	63.7	73.
60	40.5	43.2	59.3	74.4	79.1	83.3	88.4	99.

V. The F Distribution

These tables give the values of F for which a given percentage of the F-distribution is great than F.

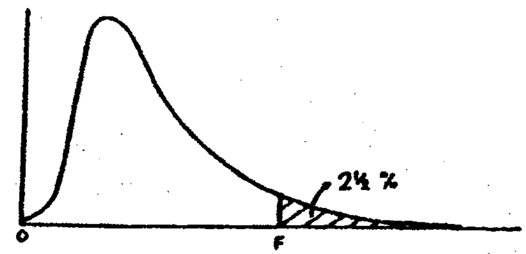
The F-distribution arises when two independent estimates of a variance are divided one by the other. Each of these estimates has its degrees of freedom associated with it, thus to specify which particular F-distribution is to be considered, the degrees of freedom of both the numerator n_1, and the denominator n_2, must be given.

Table V(a) 5 per cent point

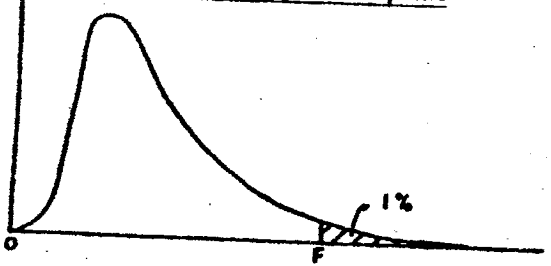


	n_1 = 1	2	3	4	5	6	7	8	10	12	24
n_2 = 2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.5
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.79	8.74	8.64
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	5.96	5.91	5.77
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.74	4.68	4.53
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.06	4.00	3.84
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.64	3.57	3.41
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.35	3.28	3.12
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.14	3.07	2.90
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	2.98	2.91	2.74
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.75	2.69	2.51
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.54	2.48	2.29
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.35	2.28	2.08
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.25	2.18	1.98
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.16	2.09	1.89
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.08	2.00	1.79
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	1.99	1.92	1.70

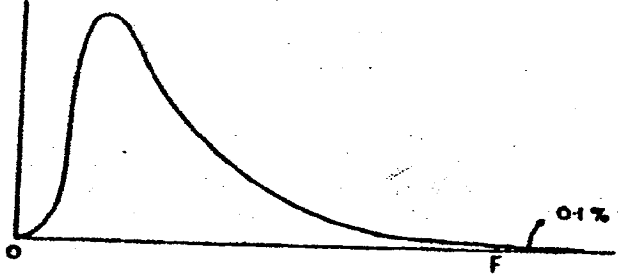
Table V(b) 2.5 per cent point



n_1	1	2	3	4	5	6	7	8	10	12	24
n_2 = 2	38.5	39.0	39.2	39.3	39.3	39.3	39.4	39.4	39.4	39.4	39.5
3	17.44	16.04	15.44	15.10	14.88	14.73	14.62	14.54	14.42	14.34	14.1
4	12.22	10.65	9.98	9.60	9.36	9.20	9.07	8.98	8.84	8.75	8.5
5	10.01	8.43	7.76	7.39	7.15	6.98	6.85	6.76	6.62	6.52	6.2
6	8.81	7.26	6.60	6.23	5.99	5.82	5.70	5.60	5.46	5.37	5.1
7	8.07	6.54	5.89	5.52	5.29	5.12	4.99	4.90	4.76	4.67	4.4
8	7.57	6.06	5.42	5.05	4.82	4.65	4.53	4.43	4.30	4.20	3.9
9	7.21	5.71	5.08	4.72	4.48	4.32	4.20	4.10	3.96	3.87	3.6
10	6.94	5.46	4.83	4.47	4.24	4.07	3.95	3.85	3.72	3.62	3.3
12	6.55	5.10	4.47	4.12	3.89	3.73	3.61	3.51	3.37	3.28	3.0
15	6.20	4.77	4.15	3.80	3.58	3.41	3.29	3.20	3.06	2.96	2.7
20	5.87	4.46	3.86	3.51	3.29	3.13	3.01	2.91	2.77	2.68	2.4
24	5.72	4.32	3.72	3.38	3.15	2.99	2.87	2.78	2.64	2.54	2.2
30	5.57	4.18	3.59	3.25	3.03	2.87	2.75	2.65	2.51	2.41	2.1
40	5.42	4.05	3.46	3.13	2.90	2.74	2.62	2.53	2.39	2.29	2.0
60	5.29	3.93	3.34	3.01	2.79	2.63	2.51	2.41	2.27	2.17	1.8



n_1 =	1	2	3	4	5	6	7	8	10	12	24
= 2	98.5	99.0	99.2	99.2	99.3	99.3	99.4	99.4	99.4	99.4	99.5
3	34.1	30.8	29.5	28.7	28.2	27.9	27.7	27.5	27.2	27.1	26.6
4	21.2	18.0	16.7	16.0	15.5	15.2	15.0	14.8	14.5	14.4	13.9
5	16.3	13.3	12.1	11.4	11.0	10.7	10.5	10.3	10.1	9.89	9.47
6	13.7	10.98	9.78	9.15	8.75	8.47	8.26	8.10	7.87	7.72	7.31
7	12.3	9.55	8.45	7.85	7.46	7.19	6.99	6.84	6.62	6.47	6.07
8	11.3	8.65	7.59	7.01	6.63	6.37	6.18	6.03	5.81	5.67	5.28
9	10.6	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.26	5.11	4.73
0	10.0	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.85	4.71	4.33
2	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.30	4.16	3.78
5	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.80	3.67	3.29
0	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.37	3.23	2.86
	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.17	3.03	2.66
	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	2.98	2.84	2.47
	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.80	2.66	2.29
	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.63	2.50	2.12



n_1 =	1	2	3	4	5	6	7	8	10	12	24
n_2 = 2	999	999	999	999	999	999	999	999	999	999	1000
3	167	149	141	137	135	133	132	131	129	128	126
4	74.1	61.3	56.2	53.4	51.7	50.5	49.7	49.0	48.1	47.4	45.8
5	47.2	37.1	33.2	31.1	29.8	28.8	28.2	27.7	26.9	26.4	25.1
6	35.5	27.0	23.7	21.9	20.8	20.0	19.5	19.0	18.4	18.0	16.9
7	29.3	21.7	18.8	17.2	16.2	15.5	15.0	14.6	14.1	13.7	12.7
8	25.4	18.5	15.8	14.4	13.5	12.9	12.4	12.1	11.5	11.2	10.3
9	22.9	16.4	13.9	12.6	11.7	11.1	10.7	10.4	9.87	9.57	8.72
10	21.0	14.9	12.6	11.3	10.5	9.93	9.52	9.20	8.74	8.44	7.64
12	18.6	13.0	10.8	9.63	8.89	8.38	8.00	7.71	7.29	7.00	6.25
15	16.6	11.3	9.34	8.25	7.57	7.09	6.74	6.47	6.08	5.81	5.10
20	14.8	9.95	8.10	7.10	6.46	6.02	5.69	5.44	5.08	4.82	4.15
24	14.0	9.34	7.55	6.59	5.98	5.55	5.23	4.99	4.64	4.39	3.74
30	13.3	8.77	7.05	6.12	5.53	5.12	4.82	4.58	4.24	4.00	3.36
40	12.6	8.25	6.59	5.70	5.13	4.73	4.44	4.21	3.87	3.64	3.01
60	12.0	7.77	6.17	5.31	4.76	4.37	4.09	3.86	3.54	3.32	2.69

VI. Random Numbers

This is a table of pseudo-random numbers generated on the computer using the random number generator

$$x_{n+1} = 3125\, x_n \pmod{2^{28}}$$

44 59	62 26	82 51	04 19	45 98	03 51	50 14	28 02	12 29	88 87
85 90	22 58	52 90	22 76	95 70	02 84	74 69	06 13	98 86	06 50
44 33	29 88	90 49	07 55	69 50	20 27	59 51	97 53	57 04	22 26
47 57	22 52	75 74	53 11	76 11	21 16	12 44	31 89	16 91	47 75
03 20	54 20	70 56	77 59	95 60	19 75	29 94	11 23	59 30	14 47
40 91	24 41	01 45	51 98	22 54	82 44	43 43	23 29	16 24	15 62
91 14	61 71	03 40	15 69	44 46	54 66	35 01	87 61	23 76	36 80
27 71	29 93	52 89	64 78	32 97	65 28	99 82	41 10	97 52	41 91
12 96	17 70	72 76	17 93	38 26	72 96	28 73	27 64	78 16	72 81
54 30	61 13	60 50	61 56	40 20	19 22	30 61	43 89	60 09	82 39
83 32	99 29	30 06	19 71	11 32	69 17	86 34	50 76	37 41	76 54
27 17	25 61	91 76	19 54	99 73	97 21	44 87	39 63	24 22	74 30
40 89	21 88	56 84	11 75	74 88	23 55	48 98	19 48	79 81	92 62
51 66	17 48	26 96	00 83	81 23	58 09	21 39	39 20	83 46	30 75
95 22	63 34	58 91	78 22	50 22	77 21	14 19	58 66	49 25	03 51
93 83	73 70	80 88	71 85	64 44	57 50	19 82	60 77	38 95	93 33
42 02	33 18	33 55	96 66	88 38	16 80	77 51	17 96	49 76	99 28
42 42	13 33	66 00	18 37	58 80	54 32	00 96	25 16	15 37	34 12
56 71	67 54	79 25	64 34	82 15	28 97	88 84	84 51	62 90	17 71
73 05	53 85	63 18	06 47	71 00	32 31	59 72	34 28	70 83	12 90
02 80	12 24	34 78	22 50	57 02	07 01	13 00	78 80	94 93	14 53
22 89	81 32	32 72	48 92	95 75	88 56	75 73	79 17	53 81	54 17
04 45	64 84	17 28	06 57	71 96	81 36	37 65	42 62	43 84	45 23
0 30	05 07	21 34	59 18	85 95	21 87	73 16	78 37	15 98	16 66
3 39	21 94	01 84	28 20	50 35	57 82	88 13	52 53	76 73	68 22
7 91	87 36	45 69	03 01	24 25	13 64	42 74	36 67	77 67	00 92
9 24	26 77	62 37	82 46	93 96	82 75	75 16	95 05	30 68	83 02
7 29	09 12	41 77	29 57	34 89	94 95	45 70	59 85	38 04	04 80
4 78	20 07	17 15	68 12	38 26	01 90	68 30	83 80	19 89	98 65
3 81	53 08	09 23	22 61	99 41	27 90	35 43	07 09	62 26	45 83
7 67	74 54	96 14	63 28	98 11	18 33	82 60	90 41	33 11	77 59
2 80	26 89	13 38	70 08	73 22	64 70	83 44	49 24	20 93	12 59
69	43 27	33 56	39 88	73 31	24 44	87 33	08 21	40 06	77 91
48	24 08	73 92	37 19	69 87	91 79	86 27	47 91	31 70	53 52
91	97 37	53 40	46 25	29 25	96 42	57 22	94 34	59 71	23 59
62	28 51	94 10	15 18	06 02	39 94	13 91	54 50	60 27	28 68
59	53 08	58 06	80 00	75 71	95 13	76 91	24 55	34 09	97 12
17	99 45	85 28	63 17	99 31	24 62	75 82	78 89	27 59	18 62
95	74 96	25 44	95 66	42 02	31 48	82 21	76 87	86 75	07 95
95	18 76	76 28	18 60	44 92	76 09	46 96	39 37	27 12	30 44

Table VII. Percentage Points for Distribution of Correlation Coefficier

This table gives absolute values of the sample correlation coeffict r which would lead to the rejection of the null hypothesis that the popu correlation coefficient $\rho = 0$ against the alternative hypothesis that ρ at the stated significance levels P. If r is calculated from n paired observations, enter the table with degrees of freedom = n-2. Note that partial correlation coefficient can be tested for significance similarly entering the table with degrees of freedom = n-k-2, where k is the numbe variables held constant.

P / Degrees of Freedom	0.10	0.05	0.01	0.001
1	0.9877	0.9969	0.9999	0.9999
2	0.900	0.950	0.990	0.999
3	0.805	0.878	0.959	0.991
4	0.729	0.811	0.917	0.974
5	0.669	0.754	0.875	0.951
6	0.621	0.707	0.834	0.925
7	0.582	0.666	0.798	0.898
8	0.549	0.632	0.765	0.872
9	0.521	0.602	0.735	0.847
10	0.497	0.576	0.708	0.823
11	0.476	0.553	0.684	0.801
12	0.457	0.532	0.661	0.780
13	0.441	0.514	0.641	0.760
14	0.426	0.497	0.623	0.742
15	0.412	0.482	0.606	0.725
16	0.400	0.468	0.590	0.708
17	0.389	0.456	0.575	0.693
18	0.378	0.444	0.561	0.679
19	0.369	0.433	0.549	0.665
20	0.360	0.423	0.537	0.652
25	0.323	0.381	0.487	0.597
30	0.296	0.349	0.449	0.554
40	0.257	0.304	0.393	0.490
50	0.231	0.273	0.354	0.443
60	0.211	0.250	0.325	0.408
80	0.183	0.217	0.283	0.357
100	0.164	0.195	0.254	0.321

TABLE B.11 CRITICAL VALUES OF THE WILCOXON T DISTRIBUTION

n	$\alpha(2) = 0.50$ $\alpha(1) = 0.25$	0.20 0.10	0.10 0.05	0.05 0.025	0.02 0.01	0.01 0.005	0.005 0.0025	0.00 0.00
4	2	0						
5	4	2	0					
6	6	3	2	0				
7	9	5	3	2	0			
8	12	8	5	3	1	0		
9	16	10	8	5	3	1	0	
10	20	14	10	8	5	3	1	
11	24	17	13	10	7	5	3	
12	29	21	17	13	9	7	5	
13	35	26	21	17	12	9	7	
14	40	31	25	21	15	12	9	
15	47	36	30	25	19	15	12	
16	54	42	35	29	23	19	15	
17	61	48	41	34	27	23	19	[illegible]
18	69	55	47	40	32	27	23	[illegible]
19	77	62	53	46	37	32	27	[illegible]
20	86	69	60	52	43	37	32	[illegible]
21	95	77	67	58	49	42	37	[illegible]
22	104	86	75	65	55	48	42	[illegible]
23	114	94	83	73	62	54	48	[illegible]
24	125	104	91	81	69	61	54	[illegible]
25	136	113	100	89	76	68	60	[illegible]
26	148	124	110	98	84	75	67	[illegible]
27	160	134	119	107	92	83	74	[illegible]
28	172	145	130	116	101	91	82	[illegible]
29	185	157	140	126	110	100	90	[illegible]
30	198	169	151	137	120	109	98	[illegible]
31	212	181	163	147	130	118	107	[illegible]
32	226	194	175	159	140	128	116	[illegible]
33	241	207	187	170	151	138	126	[illegible]
34	257	221	200	182	162	148	136	[illegible]
35	272	235	213	195	173	159	146	[illegible]
36	289	250	227	208	185	171	157	[illegible]
37	305	265	241	221	198	182	168	[illegible]
38	323	281	256	235	211	194	180	[illegible]
39	340	297	271	249	224	207	192	[illegible]
40	358	313	286	264	238	220	204	[illegible]
41	377	330	302	279	252	233	217	[illegible]
42	396	348	319	294	266	247	230	[illegible]
43	416	365	336	310	281	261	244	[illegible]
44	436	384	353	327	296	276	258	[illegible]
45	456	402	371	343	312	291	272	[illegible]
46	477	422	389	361	328	307	287	[illegible]
47	499	441	407	378	345	322	302	[illegible]
48	521	462	426	396	362	339	318	[illegible]
49	543	482	446	415	379	355	334	[illegible]
50	566	503	466	434	397	373	350	[illegible]
51	590	525	486	453	416	390	367	[illegible]
52	613	547	507	473	434	408	384	[illegible]
53	638	569	529	494	454	427	402	[illegible]
54	668	592	550	514	473	445	420	[illegible]
55	688	615	573	536	493	465	438	[illegible]
56	714	639	595	557	514	484	457	[illegible]
57	740	664	618	579	535	504	477	[illegible]
58	767	688	642	602	556	525	497	[illegible]
59	794	714	666	625	578	546	517	[illegible]
60	822	739	690	648	600	567	537	[illegible]

TABLE B.11 (cont.) CRITICAL VALUES OF THE WILCOXON T DISTRIBUTION

n	$\alpha(2) = 0.50$ $\alpha(1) = 0.25$	0.20 0.10	0.10 0.05	0.05 0.025	0.02 0.01	0.01 0.005	0.005 0.0025	0.001 0.0005
61	850	765	715	672	623	589	558	495
62	879	792	741	697	646	611	580	515
63	908	819	767	721	669	634	602	535
64	938	847	793	747	693	657	624	556
65	968	875	820	772	718	681	647	577
66	998	903	847	798	742	705	670	599
67	1029	932	875	825	768	729	694	621
68	1061	962	903	852	793	754	718	643
69	1093	992	931	879	819	779	742	666
70	1126	1022	960	907	846	805	767	689
71	1159	1053	990	936	873	831	792	712
72	1192	1084	1020	964	901	858	818	736
73	1226	1116	1050	994	928	884	844	761
74	1261	1148	1081	1023	957	912	871	786
75	1296	1181	1112	1053	986	940	898	811
76	1331	1214	1144	1084	1015	968	925	836
77	1367	1247	1176	1115	1044	997	953	862
78	1403	1282	1209	1147	1075	1026	981	889
79	1440	1316	1242	1179	1105	1056	1010	916
80	1478	1351	1276	1211	1136	1086	1039	943
81	1516	1387	1310	1244	1168	1116	1069	971
82	1554	1423	1345	1277	1200	1147	1099	999
83	1593	1459	1380	1311	1232	1178	1129	1028
84	1632	1496	1415	1345	1265	1210	1160	1057
85	1672	1533	1451	1380	1298	1242	1191	1086
86	1712	1571	1487	1415	1332	1275	1223	1116
87	1753	1609	1524	1451	1366	1308	1255	1146
88	1794	1648	1561	1487	1400	1342	1288	1177
89	1836	1688	1599	1523	1435	1376	1321	1208
90	1878	1727	1638	1560	1471	1410	1355	1240
91	1921	1767	1676	1597	1507	1445	1389	1271
92	1964	1808	1715	1635	1543	1480	1423	1304
93	2008	1849	1755	1674	1580	1516	1458	1337
94	2052	1891	1795	1712	1617	1552	1493	1370
95	2097	1933	1836	1752	1655	1589	1529	1404
96	2142	1976	1877	1791	1693	1626	1565	1438
97	2187	2019	1918	1832	1731	1664	1601	1472
98	2233	2062	1960	1872	1770	1702	1638	1507
99	2280	2106	2003	1913	1810	1740	1676	1543
100	2327	2151	2045	1955	1850	1779	1714	1578

Table B.11 is taken, with permission of the publisher, from the more extensive table of R. L. McCornack (1965, *J. Amer. Statist. Assoc.* 60: 864–871).

Examples:

$$T_{0.05(2),16} = 29 \quad \text{and} \quad T_{0.01(1),62} = 646.$$

For performing the Wilcoxon paired-sample test when $n > 100$, we may use the normal approximation (Section 10.4). The excellence of this approximation (without the correction for continuity) is shown as follows, as relative error = (true critical T − critical T from approximation)/true critical $T \times 100\%$. (Claypool and Holbert (1974) have determined that the approximation is improved by the correction for continuity—see Section 10.4—for $\alpha > 0.035$.)

$\alpha(2) =$ n	0.20 %	0.10 %	0.05 %	0.02 %	0.01 %	0.005 %	0.001 %
20	1.4	0.0	0.0	0.3	2.7	9.4	23.8
30	0.6	0.7	0.0	0.3	1.8	2.0	7.7
40	0.3	0.4	0.0	0.3	0.9	1.6	4.1
50	0.2	0.2	0.0	0.3	0.8	1.1	2.6
60	0.1	0.1	0.0	0.3	0.4	0.7	1.7
80	0.1	0.1	0.0	0.2	0.4	0.5	1.1
100	0.0	0.0	0.0	0.1	0.2	0.4	0.7

TABLE B.12 CRITICAL VALUES OF THE KRUSKAL-WALLIS *H* DISTRIBUTION

n_1	n_2	n_3	α = 0.10	0.05	0.02	0.01	0.005	0.002	0.001
2	2	2	4.571						
3	2	1	4.286						
3	2	2	4.500	4.714					
3	3	1	4.571	5.143					
3	3	2	4.556	5.361	6.250				
3	3	3	4.622	5.600	6.489	(7.200)	7.200		
4	2	1	4.500						
4	2	2	4.458	5.333	6.000				
4	3	1	4.056	5.208					
4	3	2	4.511	5.444	6.144	6.444	7.000		
4	3	3	4.709	5.791	6.564	6.745	7.318	8.018	
4	4	1	4.167	4.967	(6.667)	6.667			
4	4	2	4.555	5.455	6.600	7.036	7.282	7.855	
4	4	3	4.545	5.598	6.712	7.144	7.598	8.227	8.909
4	4	4	4.654	5.692	6.962	7.654	8.000	8.654	9.269
5	2	1	4.200	5.000					
5	2	2	4.373	5.160	6.000	6.533			
5	3	1	4.018	4.960	6.044				
5	3	2	4.651	5.251	6.124	6.909	7.182		
5	3	3	4.533	5.648	6.533	7.079	7.636	8.048	8.727
5	4	1	3.987	4.985	6.431	6.955	7.364		
5	4	2	4.541	5.273	6.505	7.205	7.573	8.114	8.591
5	4	3	4.549	5.656	6.676	7.445	7.927	8.481	8.795
5	4	4	4.619	5.657	6.953	7.760	8.189	8.868	9.168
5	5	1	4.109	5.127	6.145	7.309	8.182		
5	5	2	4.623	5.338	6.446	7.338	8.131	6.446	7.338
5	5	3	4.545	5.705	6.866	7.578	8.316	8.809	9.521
5	5	4	4.523	5.666	7.000	7.823	8.523	9.163	9.606
5	5	5	4.940	5.780	7.220	8.000	8.780	9.620	9.920
5	1	1	-----						
5	2	1	4.200	4.822					
6	2	2	4.545	5.345	6.182	6.982			
5	3	1	3.909	4.855	6.236				
5	3	2	4.682	5.348	6.227	6.970	7.515	8.182	
6	3	3	4.538	5.615	6.590	7.410	7.872	8.628	9.346
6	4	1	4.038	4.947	6.174	7.106	7.614		
5	4	2	4.494	5.340	6.571	7.340	7.846	8.494	8.827
5	4	3	4.604	5.610	6.725	7.500	8.033	8.918	9.170
6	4	4	4.595	5.681	6.900	7.795	8.381	9.167	9.861
6	5	1	4.128	4.990	6.138	7.182	8.077	8.515	
6	5	2	4.596	5.338	6.585	7.376	8.196	8.967	9.189
5	5	3	4.535	5.602	6.829	7.590	8.314	9.150	9.669
6	5	4	4.522	5.661	7.018	7.936	8.643	9.458	9.960
6	5	5	4.547	5.729	7.110	8.028	8.859	9.771	10.271
5	5	1	4.000	4.945	6.286	7.121	8.165	9.077	9.692
6	6	2	4.438	5.410	6.667	7.467	8.210	9.219	9.752
6	6	3	4.558	5.625	6.900	7.725	8.458	9.458	10.150
5	6	4	4.548	5.724	7.107	8.000	8.754	9.662	10.342
5	6	5	4.542	5.765	7.152	8.124	8.987	9.948	10.524
6	6	6	4.643	5.801	7.240	8.222	9.170	10.187	10.889

TABLE B.12 (cont.) CRITICAL VALUES OF THE KRUSKAL-WALLIS H DISTRIBUTION

n_1	n_2	n_3			α = 0.10	0.05	0.02	0.01	0.005	0.002	0.001
7	7	7			4.594	5.819	7.332	8.378	9.373	10.516	11.310
8	8	8			4.595	5.805	7.355	8.465	9.495	10.805	11.705
2	2	1	1		-----						
2	2	2	1		5.357	5.679					
2	2	2	2		5.667	6.167	(6.667)	6.667			
3	1	1	1		-----						
3	2	1	1		5.143						
3	2	2	1		5.556	5.833	6.500				
3	2	2	2		5.544	5.333	6.978	7.133	7.533		
3	3	1	1		5.333	6.333					
3	3	2	1		5.639	6.244	6.689	7.200	7.400		
3	3	2	2		5.745	6.527	7.182	7.636	7.873	8.018	8.455
3	3	3	1		5.655	6.600	7.109	7.400	8.055	8.345	
3	3	3	2		5.879	6.727	7.636	8.105	8.379	8.803	9.030
3	3	3	3		6.026	7.000	7.872	8.538	8.897	9.462	9.513
4	1	1	1		-----						
4	2	1	1		5.250	5.833					
4	2	2	1		5.533	6.133	6.667	7.000			
4	2	2	2		5.755	6.545	7.091	7.391	7.964	8.291	
4	3	1	1		5.067	6.178	6.711	7.067			
4	3	2	1		5.591	6.309	7.018	7.455	7.773	8.182	
4	3	2	2		5.750	6.621	7.530	7.871	8.273	8.689	8.909
4	3	3	1		5.539	6.545	7.485	7.758	8.212	8.697	9.182
4	3	3	2		5.872	6.795	7.763	8.333	8.718	9.167	8.455
4	3	3	3		6.016	6.984	7.995	8.659	9.253	9.709	10.016
4	4	1	1		5.182	5.945	7.091	7.909	7.909		
4	4	2	1		5.568	6.386	7.364	7.886	8.341	8.591	8.909
4	4	2	2		5.808	6.731	7.750	8.346	8.692	9.269	9.462
4	4	3	1		5.692	6.635	7.660	8.231	8.583	9.038	9.327
4	4	3	2		5.901	6.874	7.951	8.621	9.165	9.615	9.945
4	4	3	3		6.019	7.038	8.181	8.876	9.495	10.105	10.467
4	4	4	1		5.654	6.725	7.879	8.588	9.000	9.478	9.758
4	4	4	2		5.914	6.957	8.157	8.871	9.486	10.043	10.429
4	4	4	3		6.042	7.142	8.350	9.075	9.742	10.542	10.929
4	4	4	4		6.088	7.235	8.515	9.287	9.971	10.809	11.338
2	1	1	1	1	-----						
2	2	1	1	1	5.786						
2	2	2	1	1	6.250	6.750					
2	2	2	2	1	6.600	7.133	(7.533)	7.533			
2	2	2	2	2	6.982	7.418	8.073	8.291	(8.727)	8.727	
3	1	1	1	1	-----						
3	2	1	1	1	6.139	6.583					
3	2	2	1	1	6.511	6.800	7.400	7.600			
3	2	2	2	1	6.709	7.309	7.836	8.127	8.327	8.618	
3	2	2	2	2	6.955	7.682	8.303	8.682	8.985	9.273	9.364
3	3	1	1	1	6.311	7.111	7.467				
3	3	2	1	1	6.600	7.200	7.892	8.073	8.345		
3	3	2	2	1	6.788	7.591	8.258	8.576	8.924	9.167	9.303
3	3	2	2	2	7.026	7.910	8.667	9.115	9.474	9.769	10.026
3	3	3	1	1	6.788	7.576	8.242	8.424	8.848	(9.455)	9.455
3	3	3	2	1	6.910	7.769	8.590	9.051	9.410	9.769	9.974
3	3	3	2	2	7.121	8.044	9.011	9.505	9.890	10.330	10.637
3	3	3	3	1	7.077	8.000	8.879	9.451	9.846	10.286	10.549
3	3	3	3	2	7.210	8.200	9.267	9.876	10.333	10.838	11.171
3	3	3	3	3	7.333	8.333	9.467	10.200	10.733	10.267	11.667

The above values of H were determined from *Selected Tables in Mathematical Statistics*, Volume III, pp. 320–384, by permission of the American Mathematical Society. (Iman, Quade, and Alexander 1975.)

Examples:

$$H_{0.05,4,3,2} = 5.444 \quad \text{and} \quad H_{0.01,4,4,5} = H_{0.01,5,4,4} = 7.760.$$

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
FIRST SEMESTER EXAMINATIONS, JUNE 2004

BS 321: ETHOLOGY AND EVOLUTION

PAPER ONE

TIME: THREE (3) HOURS

INSTRUCTIONS: Answer five (5) questions. Question one is compulsory. Answer questions one and four others. Illustrate your answer where necessary.

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1. Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he travelled and collected specimens in South America and on the Galapagos Islands.

(i) Explain the theory of evolution by Natural Selection as presented by Darwin.

(ii) Each of the following relates to an aspect of evolution by natural selection. Explain **three** of the following:
   a) Convergent Evolution and the similarities among species
   b) Natural Selection and the insecticide-resistant insects or antibiotic-resistant bacteria
   c) Speciation and Isolation
   d) Natural Selection and Dominance Hierarchy.
   e) Natural Selection and Heterozygote Advantage

2. Provide brief definitions of the following terms as used in this course: (i) Associative learning (ii) Ivan Pavlov (iii) Kin selection (iii) Ritualized behaviour (iv) Australopithecus (v) Territory

3. Define the Hardy-Weinberg law, and discuss its limitations in the evolution of species

4. What is sexual selection? In your answer you should consider both intersexual selection and intrasexual selection and explain how the process can account for some forms of sexual dimorphism

5. How might the ideas that inform evolutionary theory such as "analogy," and "homology," affect our thinking about ethics with respect to animals.

6. What are the main differences between Lamarckism and Darwinism as they relate to the evolution of Aggressive Behaviour in social species?

7. Distinguish between Character Displacement and Habituation, and explain why each one is significant to the evolution of species

8. Briefly describe possible behavioural dysfunctions or pathologies that might be caused by damage to the following structures: (a) *Occipital Lobe* of the brain (b) *Pituitary Gland (c) Medulla Oblongata (d) Adrenal Medulla*

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

FIRST SEMESTER UNIVERSITY EXAMINATIONS

JUNE / JULY, 2004

BS 331

PLANT PHYSIOLOGY

PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS

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1. Determine the solute potential of the leaves of <u>Rhoeo</u> sp. provided using the method of limiting plasmolysis. (15 marks)

2. In an experiment to study the uptake of Potassium and nitrate ions by pea root cells from a nutrient at 25 °C the following results were obtained

Ion	Concentration in external medium. (m mole / litre)	Concentration in the root cells. (m moles / litre)
K+	1	75
NO^-_3	2	28

(a) Calculate the Nernst potential for K+ ~~the cell membranes of pea roots~~. (5 marks)

End of Examination

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMISTER
FINAL EXAMINATIONS

BS 341: MICROBIOLOGY
PAPER II PRACTICAL

TIME: THREE (3) HOURS
INSTRUCTIONS: ANSWER **ALL** QUESTIONS

Q1 Describe the growth characteristics and morphology of the bacterial cultures growing on plates I and II provided. The organisms were grown aerobically on agar medium at 37°C.
(i) Make representative diagrams of the organisms observed and indicate the staining method used.
(ii) Identify the medium used
(HAND IN PREPARED SLIDES, ONE FOR EACH ORGANISM. LABLE WITH YOUR COMPUTER NUMBER, DATE AND PLATE NUMBER)
(10 marks)

Q2 Several complex materials are used as ingredients of media for cultivation of microorganisms. What is the nature and nutritional value to bacteria of
(i) Peptone
(ii) Beef extract
(iii)Agar (6 marks)

Q3 (a) What staining technique is suitable for determining
(i) *Mycobacterium tuberculosis* in a sputum sample?
(ii) *Streptococcus pneumoniae* capsule?
(b) List three techniques used to demonstrate motility and flagella in bacteria.
(5 marks)

Q4 To determine the characteristics of a microorganism, a pure culture must be obtained.
(i) What are pure cultures and why are they important?
(ii) Explain three common approaches used to prepare pure cultures.
(iii) Who is credited with introducing the pure culture technique?
(iv) What is meant by aseptic technique? (8 marks)

Q5 Suppose you carry out a serial dilution of a 0.1ml sample of a bacterial broth culture (total volume 10 ml). Three hundred and fifty colonies are growing on the 10^{-3} plate, the 10^{-4} plate gives 66 colonies and the 10^{-5} plate yields 20 colonies. Calculate the concentration (bacteria/ml) of the original undiluted sample.

(1 mark)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF BIOLOGICAL SCIENCES
2003/04 FIRST SEMESTER
FINAL UNIVERSITY EXAMINATIONS

JUNE-JULY 2004

BS 351: ENTOMOLOGY

PRACTICAL PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS

---

1 (a). Identify the leg modifications exhibited by specimens A-E Provided.

(b). What modifications are demonstrated by the gnathal appendages Of specimens F-J provided, from the generalized condition?

(c). In which habitats would you expect to collect specimens K-O Provided?

2 Using specimens P-V, construct a natural dichotomous taxonomic key for their identification. The common names for the specimens are as follows:

P = Garden locust
Q = Dung beetle
R = Giant water bug
S = Moth
T = Earwig
U = Wasp
V = Water scorpion

3 Dissect specimen W to expose the thoracic ganglia. Draw and label. What is the total number of ganglia in the ventral nerve cord of the specimen and what is the function of an insect ganglion?

********** END OF EXAMINATION **********

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BS361: MOLECULAR BIOLOGY – PAPER 1

TIME: TWO (2) HOURS
Answer All questions.
Answers must be precise and to the point.

SECTION A

Q1. Define each of the following terms:
- a) Cytosol
- b) Nucleosome
- c) Nucleic acids
- d) Heterokaryon
- e) Operons

Q2. Write short notes on each of the following:
- a) Nucleoside triphosphates
- b) DNA Polymerase I
- c) Frame shift mutation
- d) Basal Promoters on Eukaryotic DNA

Q3. Explain why the Genetic code is said to be universal, non-overlapping and unambiguous

Q4. Describe the regulation of the *trp* Operon in *E. coli* by the repressor protein.

SECTION B

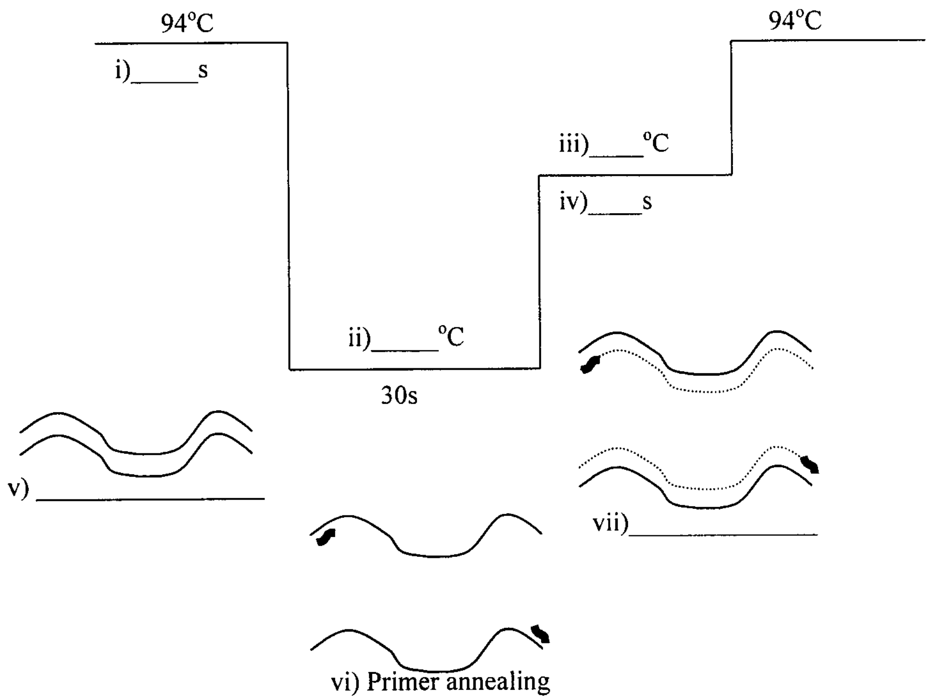
Please write all your answers on the answer sheet.

Q5. Eukaryotic transcription takes place in the (a) _______________ whereas translation takes place in the (b)_________________

Eukaryotic post transcriptional modifications include (c) ____________ of the 5' end, addition of a (d)__________________ to the 3' end, and (e) __________ to remove the introns.

Q6.

A) Fill in the blank spaces of the PCR profile below. (Use your answer sheet).



B) Briefly describe each of the stages v), vi) and vii)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

FIRST SEMESTER UNIVERSITY EXAMINATIONS

JUNE 2004

BS 411: INSECT BEHAVIOUR AND ECOLOGY

THEORY PAPER II

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS ONLY.

---

1. What is population density? Discuss the steps you need to develop a sampling Programme of a named insect storage pest.

2. In what type of functional response (I, II or III):

   a) Predator saturation is considered

   b) Predator search rate increases with prey density

   c) The proportion of killed prey is constant

   d) The proportion of killed prey first increases and then declines with increasing prey density

   e) The proportion of killed prey always declines with prey density?

3. What is inter – specific competition? Discuss under what conditions can two competing species co-exist. Illustrate your answer with diagrams.

4. Describe the most appropriate method for relating temperature to insect development. Discuss any potential limitations of such a method. How would you use such a method in insect pest management programmes?

5. Many insect populations show increases and decreases in density that correspond to conditions of the a biotic environment. Similarly, various insect species have

demonstrated increases corresponding to the action of natural enemies. Besides, laboratory studies have demonstrated the importance of intraspecific competition when resources are limiting. Given all these, in your opinion discuss what factors are most responsible for maintaining insect populations within the boundaries of under and over populations?

6. What are insect life tables? Using hypothetical data, how would you construct a full life-table of an insect species?

7. Write an essay on some effects of the environment on insect development using a life systems approach. Why is such an approach appropriate in the study of insect ecology?

8. Write short notes on **all** of the following:

a) Milne's (1957) theories on insect population
b) Agro-ecosystems
c) Population indices
d) Transects.

***** **** * END OF EXAMINATION **** ***********

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCE

FIRST SEMESTER UNIVERSITY EXAMINATIONS

JUNE/JULY, 2004

BS 441

ADVANCED MOLECULAR BIOLOGY THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS.

---

1) A mutant form of polypeptide hormone angiotensin II has the amino acid composition (Asp, Arg, ile, Met, Phe, Pro, Tyr, Val). The following observation was made:

   a) Trypsin yields a dipeptide containing Asp and Arg, and a hexapeptide with all the rest.

   b) Cyanogen bromide cleavage yields a dipeptide containing Phe and Pro and a hexapeptide containing all the others.

   c) Chymotrypsin cleaves the hormone into two tetrapeptides of composition (Asp, Arg, Tyr, Val) and (ile, Met, Phe, Pro)

   d) The dipeptide of composition (Pro, Phe) cannot be cleaved by either chymotrypsin or carboxypeptidase.

   What is the sequence?

2) A circular, double-stranded DNA contains 2100 base pairs. The solution conditions are such that DNA has 10.5 base pairs per turn.

a) What is the linking number (L_0) for this DNA.

b) The DNA is found to have 12 left-hand superhelical turns. What is the superhelix density?

3) Discuss the effectiveness of hydrophobic and hydrogen bonding forces in conferring stability to protein folding nuclei.

4) Discuss the process of chain initiation in polypeptide synthesis.

5)

a) Outline the causes of mutations in cells

b) Explain why the various classes of mutations can reverse a mutation of the same class but not a different class.

6) Discuss the factors that affect the mobility of proteins in gel electrophoresis.

7) Write briefly on

a) Genetic code degeneracy.

b) Translational accuracy.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

FIRST SEMESTER EXAMINATIONS: JULY 2004

BS 491 Freshwater Biology — **Practical Paper**

Maximum Time Allowed — **Three Hours**

Instructions

Attempt **all** questions in this paper. At the end of the examination, please hand in all the answer booklets and question papers.

Q1. A Freshwater ecologist assigned to study the limnology of a lake has completed one year of data collection. Table 1 below shows temperature measurements recorded during each month from January to December1999 at different depths.

Table 1 Temperature data °C from the lake at different depths for one annual cycle

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	5	6.6	7	10	12	15	16	15	13	10	8	6
2	5	6.2	7	10	11	15	15	14	12	10	7	6
4	5	5	7	10	10	15	15	14	1 0	9	6	6
6	5	5	6.5	10	10	15	15	14	10	8	6	6
8	5	5	6	9	10	15	15	14	10	7	6	5
10	5	5	6	9	9	14.5	15	12	8	8	7	5
15	5	5	6	7	9	12	11	9	6	6	5	5
20	5	5	5	6	7	7	7	6	6	5	5	5
25	5	5	5	5	6	6	6	5	5	5	5	5
30	5	5	5	5	6	6	6	5	5	5	5	5
35	5	5	5	5	5	5	5	5	5	5	5	5
40	5	5	5	5	5	5	5	5	5	5	5	5
45	5	5	5	5	5	5	5	5	5	5	5	5
50	5	5	5	5	5	5	5	5	5	5	5	5
55	5	5	5	5	5	5	5	5	5	5	5	5
60	5	5	5	5	5	5	5	5	5	5	5	5

i) Construct a diagram demonstrating the temperature profile for the month of July 1999 showing the various sections.

ii) Construct an appropriate diagram designed to aid in describing the annual thermal regime of the lake under investigation.

iii) Briefly describe the thermal regime for the lake based on the diagram constructed in ii) above.

iv) What is the appropriate category for the lake being investigated according to classification of lakes based on annual temperature regimes.

iv) Name the regions of the world where such a lake could be found.

Q2 Two small lakes with morphometric features indicated below are reported to occur within the same catchment area:

Lake A Depth(m)	Area(m2)	**Lake B** Depth(m)	Area (m2)
0m	558	0	1,468
20	324	10	886
40	242	20	92
60	164	30	55
80	68	50	14
100	24		
120	7		

i) Applying the relationship:

$$V = \frac{h}{3}\{A_1 + A_2 + (A_1 \times A_2)^{1/2}\}$$

Estimate the volume of water that is in lake A and in lake B

ii) Construct hypsographic depth area and depth volume curves for both lakes.

iii) Based on the graphs constructed in ii above compare both lakes.

iv) Indicate which lake, A or B, is most likely more productive that the other. Give reasons for your answer.

Q3 A sample of water was collected from Lake **A** from a depth of 10 m for the determination of phyto-plankton concentration and the Utermoh's 1958 method was used. In this procedure, a 50 cm^3 sedimentation chamber was used and he counting chamber had radius of 1.0 cm. The diameter of the transect under the microscope was estimated at 0.1 cm. A transect across the entire diameter of the counting chamber recorded a mean value of 50 cells of *Asterionella formosa.*

i) Estimate the mean number of *Asterionella formosa* cells in a cm^3 in this depth zone. Explain the various stages of your calculations.

ii) From Lake B a sample was collected for the analysis of zooplankton. The sample was collected using a plankton net which was raised from a depth of 10 metres to the surface. The diameter of the plankton net used was 40 cm and the volume of the bottle attached to the plankton net was 100 cm^3. From the bottle attached to the net a small sample of 1 cm^3 was collected for microscopic examination.

Twenty (4) individuals of *Brachionus calyciflorus* were enumerated in the 1 cm^3 of sample put on the glass slide.

Estimate the mean number of *Brachionus calyciflorus.* organisms per cubic meter above the depth of 10m.

Q4 Morphometric parameters of water bodies have been used to estimate potential fish yields of reservoirs, floodplains and rivers. Table 2 below provides surface areas of selected common water bodies in Zambia

Table 2 Mean surface areas of selected water bodies.

Water Body	Mean Surface Area
Lake Itezhi-tezhi	367 km^2
Kafue Floodplains	3,682 km^2
Lake Kariba	5,363 km^2
Zambezi River (Part of Zambezi now flooded by Lake Kariba)	328 km

i) Based on the relationships

$Y = 4.32 \times A^{1.005}$ for Floodplains

$\text{Log}_e Y = 3.57 + \text{Log}_e A$ for lakes and

$Y = \dfrac{L^2}{300}$ for rivers

Compute potential fish yields for the water bodies indicated above.

ii) Fish stock Assessments conducted after the formation of the Lake Kariba and Itezhi-tezhi indicated maximum sustainable yields as follows:

Lake Kariba	3,000 tonnes of fish per year
Lake Itezhi-tezhi	1,000 tonnes of fish per year

Give reasons for the differences between the predicted yields from morphometric parameters and those obtained from results of fish stock assessment studies.

iii) Briefly explain why reservoirs have different potential fish yields in comparison to natural lakes What can be done to improve the fishery potential performance of man made lakes?

END OF PRACTICAL EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS

June 2004

BS 915

BIOLOGY OF SEED PLANTS

Theory Paper

TIME: ***Three Hours***

ANSWER: ***Five*** questions, ***One*** from ***Section A*** and any ***Four*** from ***Section B***.

Use a **separate** *Answer Book* for **each** Section.

SECTION A

1. Discuss the botany and ecophysiology of wheat and explain its significance to world agriculture and human nutrition.

2. Discuss plant conservation and explain why plants should be conserved. Describe the important gene banks and their mandate.

3. What is vegetative plant propagation? Describe methods of vegetative plant propagation in detail and discuss the importance of this method in the cultivation of root and fruit crops.

SECTION B

4. Comment on the significance of palynology in the systematics of the seed plants.

5. Distinguish between the concepts of endemic species and vicariant species.

6. Comment on the probable factors that could have contributed to the evolution of thickets in Zambia, and provide some floristic information that would lend credence to distinguishing the Pemba thickets of Southern Province from the Luangwa Valley thickets found in the South Luangwa National Park.

7. The people of Mpika refer to both the indigenous palm (*Phoenix reclinata*) and the indigenous cycad (*Encephalartos schmitzii*) as **'Kanchindu'** being the local names applied to these two taxa. What convincing taxonomic data would you offer to help provide a botanical distinction between the cycad and the palm as members of different plant groups?

8. Discuss the postulate that the genus *Pinus* has evolved features designed to overcome a "*physiological drought*" in a temperate climatic environment.

9. Give a detailed floristic account that characterise the Zambezian Domain phytochorion in Africa.

END OF EXAMINATION

2

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS, JUNE 2004

BS 935- PLANT PATHOLOGY

THEORY PAPER

TIME ALLOWED: **THREE HOURS**

ANSWER: **ANY FIVE QUESTIONS**

---

1. Define elicitors and discuss their role in plant resistance. Describe the chemical nature and the action of known elicitors. What promise do they hold in disease management?

2. Discuss what common nematode diseases of okra, tomato and potato occur in Zambia? Describe symptoms, the organ of attack and the physiological effect of such diseases on plants. How would you manage nematode diseases of the three plants?

3. What growth-regulators are involved in plant disease? Discuss the role of growth-regulators in disease development with appropriate examples.

4. Define hypersensitivity and explain when this type of reaction is mostly encountered. Describe in detail the morphological and physiological changes involved in the hypersensitive reaction.

5. Define toxins and discuss their role in plant disease. Based on the evidence you give, suggest a common toxinogenic theory of disease in plants.

6. Distinguish between disease symptoms of anthracnose, leaf spots and late blight in plants and describe the causal organisms involved in each case. What measures of disease management would you recommend for them?

7. What characterize viroids and mycoplasmas? Describe their structure and the diseases they cause in plants.

8. Compare diseases caused by rusts, smuts, powdery mildews and vascular wilts in plants in relation to their:

   i. casual organisms
   ii. disease symptoms
   iii. disease cycle type
   iv. suitable management strategies

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS, JUNE 2004

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS SEMESTER I
2004 ACADEMIC YEAR

INTRODUCTORY CHEMISTRY I - C101

WEDNESDAY, 23RD JUNE 200

DURATION: 3 hours

INSTRUCTIONS TO THE CANDIDATES

Indicate your **computer number** and **TG number** on your answer sheet.

The Examination consists of two (2) sections: **A** and **B**

Section **A** has ten **(10)** short answer questions (Total marks = **40**).
ANSWER ALL QUESTIONS. Questions carry equal marks.

Section **B** has five **(5)** long answer questions. (Total marks = **60**).
ANSWER QUESTION B1 and ANY THREE (3) QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET. Questions carry equal marks.

YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.

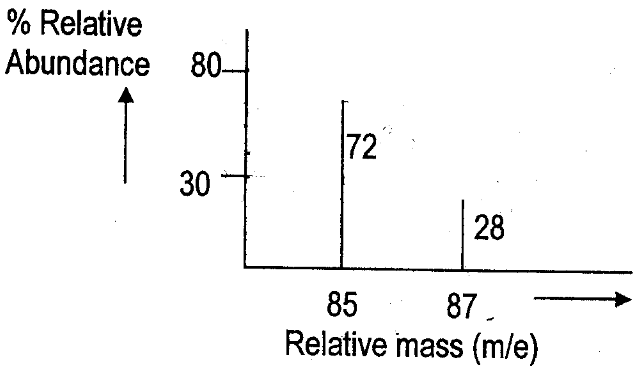
SECTION A: ANSWER ALL QUESTIONS

A1. Calculate the volume occupied by a gas containing 24 x 10^{23} molecules at RTP.

A2. (i) Under what conditions does a real gas behave like an ideal gas?

(ii) A gaseous mixture of 5.00 g of carbon dioxide and 10.00 g of carbon monoxide exerts a pressure of 1170 Pa. Calculate the partial pressure of carbon monoxide.

A3. The following figure shows the mass spectrum for rubidium.



(a) Identify the least abundant isotope.
(b) Calculate the relative atomic mass of rubidium.

A4. The lowest frequency of light that will produce the photoelectric effect is called the *threshold frequency*. This frequency for indium is 9.96 x 10^{14} s^{-1}. Will indium display the photoelectric effect when irradiated with 50 nm ultraviolet light? Explain.

A5. Using the CO_3^{2-} ion, explain the term *resonance*.

A6. The product of an electron deficient species and the electron donating molecule is called an *adduct*. Write a cross-and-dot diagram for the adduct of BF_3 and F^- ion. Show and name the type of bond formed.

A7. In the electrolytic cell $Zn|Zn^{2+}(aq) \,||\, Ag^+(ag)|Ag(s)$, what weight of silver will be deposited when 0.654 g of zinc is dissolved? Which electrode is positive?

A8. For the cell whose reaction is $2H^+(aq) + Cu(s) \rightarrow H_2(g) + Cu^{2+}(aq)$

Calculate the cell potential at 298.15 K when $[Cu^{2+}] = 10^{-4}$ *M*, $p(H_2(g)) = 10^{-3}$atm and $[H^+] = 10^{-2}$ *M*

A9. A calorimeter is to be calibrated. A current of 6.00 A and 12.00 V is passed for 30 sec through a resistance heater in the calorimeter. The temperature rise is 0.876°C

(a) Calculate the calorimetric constant.

(b) In an actual experiment using the same calorimeter 0.100 g of graphite is combusted in oxygen. The temperature of the calorimeter increases by 1.542°C. Calculate the heat of combustion per mole of graphite

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A10 (a) Define the term *Bond enthalpy.*

(b) Calculate the enthalpy change of the reaction;

$$C\ell_2\,(g) \;+\; CH_4(g) \longrightarrow CH_3C\ell\,(g) \;+\; HC\ell(g)$$

Given the following bond enthalpies, in kJ mol^{-1}.

H—Cℓ = 243, Cℓ—Cℓ = 414, C—H = 331 and C—Cℓ = 428

SECTION B.

ANSWER B1 and ANY OTHER THREE (3) QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET

COMPULSORY QUESTION

B1. A C101 student was caught for drunken driving. The blood sample was analysed by titrating the known mass of blood plasma with potassium dichromate solution as follows:

The analyst prepared 0.04961 milli-moles dm^{-3} potassium dichromate solution, rinsed and filled up to the tap of the burette. She transferred exactly 25.00 mg of blood plasma in the flask, which was rinsed with an appropriate solution. She performed a total of five titrations. During the titration she washed down all the dichromate on the wall of the flask with distilled water. As she was performing the second titration she noticed an air bubble in the tip of the burette. She recorded the results as follows.

Experiment	1	2	3	4	5
Final burette reading,	38.50	36.60	35.60	35.60	35.60
Initial burette reading, cm^3	0.50	0.10	0.10	0.15	0.20.
Volume of dichromate used, cm^3	38.00	36.50	35.50	35.45	35.40

The equation for titration reaction is

$$8H_2SO_4 + 2K_2Cr_2O_7^{2-} + C_2H_5OH \longrightarrow 2Cr_2(SO_4)_3 + 2K_2SO_4 + 2CO_2 + 11H_2O$$

Answer the following question to help the policeman to decide if the students should by punished.

(a) Name the solution that the analyst might have used to rinse the
 (i) titration flask.
 (ii) burette

(b) Policeman remarked that washing down the dichromate with distilled water in the conical flask might have caused an error. Comment on the policeman's remark.

(c) Name the hazard symbol you would expect to find on a bottle of $K_2Cr_2O_7$?

(d) What is the volume of the dichromate that reacted with 25.00 mg of blood plasma?

(e) Compute the mass percent of alcohol in the blood.

(f) Identify the errors in the above experiment and mention the effect, if any, on the calculated mass percent of alcohol in the blood.

B2. (a) A C101 student was asked to prepare 430 cm^3 of 0.2 M solution. He was told to use the information given on the label of the bottle as given below

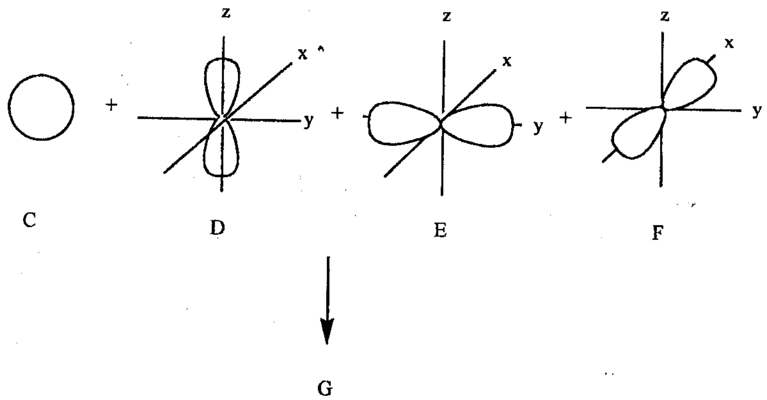
H_2SO_4
Specific Gravity = 1.84
95%(w/v)
MW = 98.08

(b) A large amount of energy is released when ^{235}U decays spontaneously to give isotopes of barium and an element **Y**. One way of inducing this process and tap the energy released is to fire neutrons at the ^{235}U nucleus and break it up as shown below.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U \rightarrow ^{141}_{56}Ba + ^{x}_{36}Y + 3^{1}_{0}n + \text{energy}$$

 (i) Identify the element **Y** and determine it's mass. Comment on its reactivity.
 (ii) Suppose the neutrons ejected have a velocity one-tenth the speed of light, calculate the de Broglie wavelength associated with the neutron.

B3. (a) The central atom in a molecule AB_4 has orbitals that result from the mixing of four atomic orbitals as shown below.



(i) Identify the orbitals **C** and **F**.

(ii) Show the orientation in space of the resultant orbitals about the central atom **A**.

(iii) If the A–B bond is polar, comment on the polarity of the molecule AB_4. Justify your answer.

(v) The molecule AB_3 has a similar orientation in space about the central atom A as in AB_4. Draw and name the molecular geometry of the AB_3 molecule and comment on its polarity.

(b) (i) Human plasma contains 10 millimoles dm^{-3} of Ca^{2+} ion. How many milligramsof $CaCl_2.2H_2O$ are required to prepare 750 ml of a solution of same concentration as human plasma?

(ii) What is the ratio of effusion rates for the lightest gas, H_2, and heaviest known gas, UF_6?

B4 The cell $Cd(s)|Cd^{2+}(0.050\ M) \| C\ell_2(g, p = 101325\ Pa), C\ell^{-}(0.10\ M)|Pt(s)$ generates 1.76 V when operating under standard conditions.

(a) (i) Calculate the voltage of the half-cell $Cd(s)|Cd^{2+}$ under the standard conditions.

(ii) What is the equilibrium constant of the half reaction?

(b) Could the metal cadmium be used for cathodic protection of iron water pipes? Briefly explain your answer.

(c) When the cell operates at 25°C and at the given concentrations, which electrode is the anode? Write the cell reaction.

(d) Calculate the Gibbs free energy for the cell reaction at 25°C and at the given concentrations.

B5. (a) $B_2H_6(g) + 3O_2(g) \longrightarrow B_2O_3(s) + 3H_2O(l) \quad \Delta E° = -2143.2$ kJ

(i) Calculate $\Delta H°$ for the reaction

(ii) Determine the value of the standard enthalpy of formation of $B_2H_6(g)$, giver the following information.

	$\Delta H°_f$, kJ/mol
$B_2O_3(s)$	– 1264.0
$H_2O(l)$	– 285.9

(iii) Draw the Hess's law cycle for the above process.

(b) Use the following information to construct the Born-Haber cycle and compute the lattice enthalpy change for Calcium Oxide.

	kJ mol^{-1}
Heart of formation of Calcium Oxide	= – 636
1st ionisation energy of Calcium	= + 590
2nd electron affinity of Oxygen	= + 790
Bond enthalpy of Oxygen	= + 497
2nd ionisation energy of Calcium	= + 1100
Heat of atomisation of Calcium	= + 177
1st electron affinity of Oxygen	= −141

THE END

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 205: ANALYTICAL AND INORGANIC CHEMISTRY

TIME: **THREE HOURS**

INSTRUCTIONS: ANSWER ALL QUESTIONS

1. (a) Write out four major steps in a typical chemical analysis.

(b) A solution contains 12.6 ppm of dissolved $Ca(NO_3)_2$ (which is a strong electrolyte dissociated into $Ca^{2+} + 2NO_3^-$) Calculate the concentration of NO_3^- in parts per million and parts per billion.

(c) To prepare a solution of NaCl, you weigh out 2.634 (±0.002) g and dissolve it in a volumetric flask whose volume is 100.00 (±0.08) mL. Express the molarity of the resulting solution, along with its uncertainty, with an appropriate number of significant figures.

(d) A new flame atomic-absorption spectrometric method of determining antimony in the atmosphere was compared with the recommended colorimetric method. For samples from an urban atmosphere, the following results were obtained(antimony found in mg/m^3):

Sample No.	New method	Standard method
1	22.2	25.0
2	19.2	19.5
3	15.7	16.6
4	20.4	21.3
5	19.6	20.7
6	15.7	16.8

Do the results obtained by the two methods differ significantly?

2. (a) Write a charge balance equation for a solution containing H^+, OH^-, Ca^{2+}, HCO_3^-, $Ca(HCO_3)^+$, $Ca(OH)^+$, K^+ and ClO_4^-.

(b) Write all mass balance equations for a solution of 0.050 M KH_2PO_4

(c) A dibasic compound, B, has $pK_{b1} = 4.00$ and $pK_{b2} = 6.00$. Find the fraction in the form BH_2^{2+} at pH 7.00. (HINT-this is the fraction of the undissociated acid form i.e. $K_{a1} = K_w/K_{b2}$ and $K_{a2} = K_w/K_{b1}$)

(d) A solution containing 50.0 mL of 0.0319 M benzylamine (a weak base B) was titrated with 0.0500 M HCl. Calculate the pH at the following volumes of added acid: ½ V_e and V_e. Benzylamine $K_b = 2.22 \times 10^{-5}$.

(e) In the titration of a weak diprotic acid H_2A with two dissociation constants (K_{a1} and K_{a2}) write the equation used to calculate the pH between 0 mL of added acid and the first equivalent point. Simplify the equation for the pH of the solution at ½ V_e?

3. (a) Calculate the potential required to initiate deposition of copper from a solution that is 0.010 M in $CuSO_4$ and contains sufficient H_2SO_4 to give a H^+ concentration of 1.00×10^{-4} M. Two unbalanced half reactions for the cell are given including the standard redox potentials.

$$O_2 \rightarrow H_2O \qquad E^\circ = +1.229\ V$$

$$Cu^{2+} \rightarrow Cu_{(s)} \qquad E^\circ = +0.337\ V$$

(b) A 20.0 mL solution of 0.00500 M Sn^{2+} in 1 M HCl was titrated with 0.0200 M Ce^{4+} to give Sn^{4+} and Ce^{3+}. Calculate the potential after adding 12.00 mL of Ce^{4+}. E' Ce^{4+}/Ce^{3+} = +1.47 and E' Sn^{4+}/Sn^{2+} = +0.139 V.

(c) Using K_f for a complex formed between M^{n+} and Y^{4-}, α_4 for Y^{4-} and C the analytical concentration of EDTA (H_4Y), derive the equation for the conditional formation constant K_f' for the complex. In your own words describe the meaning of the conditional formation constant.

(d) A 25.00 mL sample of unknown containing Fe^{3+} and Cu^{2+} required 16.06 mL of 0.05083 M EDTA for complete titration. A 50.00 mL sample of the unknown was treated with NH_4F to protect the Fe^{3+}. Then the Cu^{2+} was reduced and masked by addition of thiourea. Upon addition of 25.00 mL of 0.05083 M EDTA, the Fe^{3+} was liberated from its fluoride complex and formed an EDTA complex. The excess EDTA required 19.77 mL of 0.01883 M Pb^{2+} to reach an end point using xylenol orange as an indicator. Calculate the molarity of Cu^{2+} in the unknown.

(e) Suppose that 0.0100 M Fe^{3+} is titrated with 0.00500 M EDTA at pH 2, calculate the molarity of free Fe^{3+} at the equivalent point. At pH = 2 α_4 $Y^{4-} = 3.3 \times 10^{-14}$, and log K_f (FeY^-)= 25.1

4. (a) With respect to the de Broglie's theory and the Heisenberg's uncertainty principle, briefly explain (avoid being overly verbose) the concepts that led to the development of the Schrödinger equation. Write the Schrödinger equation and explain the meaning of all terms in the equation

(b) Predict the energy in J of the 5s electron in $_{37}Rb$.(1 eV = 6.02×10^{-19}J.)

(c) Use MOT to explain why Be exists as only Be(g) not Be_2 (g) but Li_2 occurs in gas phase.

(d) With respect to the following $[Co(NH_3)_6]^{3+}$, determine:

- (i) the d orbital occupancy
- (ii) the Effective atomic Number (EAN)
- (iii) whether it obeys the 18 electron rule
- (iii) whether this is a low or high spin complex
- (iv) the Ligand Field Stabilization Energy (LFSE)

(e) What is the difference between the Crystal Field Theory (CFT) and Ligand Field Theory (LFT)?

END OF EXAMINATION

Table A.1. The t-distribution

Value of t for a confidence interval of	90%	95%	98%	99%
Critical value of $\lvert t \rvert$ for P values of	0.10	0.05	0.02	0.01
Number of degrees of freedom				
1	6.31	12.71	31.82	63.66
2	2.92	4.30	6.96	9.92
3	2.35	3.18	4.54	5.84
4	2.13	2.78	3.75	4.60
5	2.02	2.57	3.36	4.03
6	1.94	2.45	3.14	3.71
7	1.89	2.36	3.00	3.50
8	1.86	2.31	2.90	3.36
9	1.83	2.26	2.82	3.25
10	1.81	2.23	2.76	3.17
12	1.78	2.18	2.68	3.05
14	1.76	2.14	2.62	2.98
16	1.75	2.12	2.58	2.92
18	1.73	2.10	2.55	2.88
20	1.72	2.09	2.53	2.85
30	1.70	2.04	2.46	2.75
50	1.68	2.01	2.40	2.68
∞	1.64	1.96	2.33	2.58

Table A.2. Critical values of F for a one-tailed test ($P = 0.05$)

ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45
3	10.13	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.745	8.703	8.660
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.858	5.803
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.772	4.735	4.678	4.619	4.558
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.938	3.874
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.511	3.445
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438	3.388	3.347	3.284	3.218	3.150
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	3.006	2.936
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.020	2.978	2.913	2.845	2.774
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.719	2.646
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.617	2.544
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.533	2.459
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.463	2.388
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.588	2.544	2.475	2.403	2.328
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.5[illegible]	2.494	2.425	2.352	2.276
17	4.451	3.592	3.197	2.965	2.810	2.699	3.614	2.548	2.49[illegible]	2.450	2.381	2.308	2.230
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.4[illegible]	2.412	2.342	2.269	2.191
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.4[illegible]	2.378	2.308	2.234	2.155
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.3[illegible]	2.348	2.278	2.203	2.124

ν_1 = number of degrees of freedom of the numerator and ν_2 = number of degrees of freedom of the denominator.

The Periodic Table of Elements with Nonmetals Shown in Green

Atomic numbers appear above the symbols. Atomic masses appear below the symbols and are rounded to three decimals, where available.
See the facing page for a table of all significant figures.

Periods	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** 1.008																1 **H** 1.008	2 **He** 4.003
2	3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
3	11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
4	19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
5	37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.906	46 **Pd** 106.42	47 **Ag** 107.868	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.710	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.904	54 **Xe** 131.29
6	55 **Cs** 132.905	56 **Ba** 137.327	57 **La*** 138.906	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.08	79 **Au** 196.966	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.980	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.025	89 **Ac**† 227.028	104 **Rf** (261)	105 **Ha** (262)	106 **Sg** (263)	107 **Ns** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Uun** (269)	111 **Uuu** (272)	112 **Uub** (277)						

***Lanthanide series**	58 **Ce** 140.115	59 **Pr** 140.908	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.965	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 164.930	68 **Er** 167.26	69 **Tm** 168.934	70 **Yb** 173.04	71 **Lu** 174.967
†**Actinide series**	90 **Th** 232.038	91 **Pa** 231.036	92 **U** 238.029	93 **Np** 237.048	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 225: ANALYTICAL CHEMISTRY I

TIME: **THREE HOURS**

INSTRUCTIONS: ANSWER ALL QUESTIONS

---

1. (a) Write out four major steps in a typical chemical analysis.

   (b) A solution contains 12.6 ppm of dissolved $Ca(NO_3)_2$ (which is a strong electrolyte dissociated into $Ca^{2+} + 2NO_3^-$) Calculate the concentration of NO_3^- in parts per million and parts per billion.

   (c) To prepare a solution of NaCl, you weigh out 2.634 (±0.002) g and dissolve it in a volumetric flask whose volume is 100.00 (±0.08) mL. Express the molarity of the resulting solution, along with its uncertainty, with an appropriate number of significant figures.

   (d) A new flame atomic-absorption spectrometric method of determining antimony in the atmosphere was compared with the recommended colorimetric method. For samples from an urban atmosphere, the following results were obtained(antimony found in mg/m^3):

Sample No.	New method	Standard method
1	22.2	25.0
2	19.2	19.5
3	15.7	16.6
4	20.4	21.3
5	19.6	20.7
6	15.7	16.8

Do the results obtained by the two methods differ significantly?

Table A.1. The t-distribution

Value of t for a confidence interval of	90%	95%	98%	99%
Critical value of $\lvert t \rvert$ for P values of	0.10	0.05	0.02	0.01
Number of degrees of freedom				
1	6.31	12.71	31.82	63.66
2	2.92	4.30	6.96	9.92
3	2.35	3.18	4.54	5.84
4	2.13	2.78	3.75	4.60
5	2.02	2.57	3.36	4.03
6	1.94	2.45	3.14	3.71
7	1.89	2.36	3.00	3.50
8	1.86	2.31	2.90	3.36
9	1.83	2.26	2.82	3.25
10	1.81	2.23	2.76	3.17
12	1.78	2.18	2.68	3.05
14	1.76	2.14	2.62	2.98
16	1.75	2.12	2.58	2.92
18	1.73	2.10	2.55	2.88
20	1.72	2.09	2.53	2.85
30	1.70	2.04	2.46	2.75
50	1.68	2.01	2.40	2.68
∞	1.64	1.96	2.33	2.58

Table A.2. Critical values of F for a one-tailed test ($P = 0.05$)

ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45
3	10.13	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.745	8.703	8.660
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.858	5.803
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.772	4.735	4.678	4.619	4.558
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.938	3.874
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.511	3.445
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438	3.388	3.347	3.284	3.218	3.150
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	3.006	2.936
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.020	2.978	2.913	2.845	2.774
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.719	2.646
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.617	2.544
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.533	2.459
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.463	2.388
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.588	2.544	2.475	2.403	2.328
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.53[illegible]	2.494	2.425	2.352	2.276
17	4.451	3.592	3.197	2.965	2.810	2.699	3.614	2.548	2.49[illegible]	2.450	2.381	2.308	2.230
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.4[illegible]	2.412	2.342	2.269	2.191
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.4[illegible]	2.378	2.308	2.234	2.155
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4	19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
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6	55 **Cs** 132.905	56 **Ba** 137.327	57 **La*** 138.906	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.08	79 **Au** 196.966	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.980	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.025	89 **Ac**† 227.028	104 **Rf** (261)	105 **Ha** (262)	106 **Sg** (263)	107 **Ns** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Uun** (269)	111 **Uuu** (272)	112 **Uub** (277)						

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Actinide series	90 **Th** 232.038	91 **Pa** 231.036	92 **U** 238.029	93 **Np** 237.048	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS SEMESTER I, 2004
C245 INORGANIC CHEMISTRY I

Time Allowed: 3 Hours

Instructions: **Attempt 4 out of 6 Questions.**
Indicate your ID Number.
Periodic Table is attached.
Neatly and orderly work needed.
All Questions carry equal marks.

Physical constants

Quantity	Symbol	Value and Units
Avogadro's Number	N_A	6.022×10^{23} mol^{-1}
Bohr radius	a_o	5.922×10^{-11} m
Electron mass	m_e	9.109×10^{-31} kg
Electronic charge	-e	1.602×10^{-19} C
Planck's constant	h	6.603×10^{-34} Js
Permittivity of free space	ε_o	8.854×10^{-12} C^2N^{-1} m^{-2}
Speed of light	c	$2.998 \times 10^8 ms^{-1}$
Rydberg constant	R	$1.097 \text{ X } 10^7$ m^{-1}

---

1 (a) The energy for a one-electron atom is given by the Bohr equation:

$$E_n = -2.176\times10^{-18}\frac{Z^2}{n^2}J$$

Calculate the wavelength of the radiation that will cause the removal of an electron from the third Bohr orbit of He^+ ion.

(b) Given that the potential energy, V, for a Simple Harmonic Oscillator (SHO) is $\frac{1}{2}kx^2$, where x is displacement and k is force constant. Write the expression for the Hamiltonian and, hence, the Schrödinger Equation for a SHO.

(c) Briefly describe the importance of the contributions to Chemistry of Louis de Broglie

---

2 (a) Calculate the value of the Rydberg Constant, in cm^{-1}, for a hydrogen atom from

$$R_H = \frac{e^4 m}{8\varepsilon_o h^3 c}$$

(b) When a certain photo-electric surface is illuminated with light of different wavelengths the following stopping potentials, are observed:-

λ/Å	3660	4340	5460	5790
Vs/V	1.48	0.93	0.36	0.24

By plotting the stopping potential as y-axis and frequency as x-axis, determine:-

(i) the threshold frequency,
(ii) the photoelectric work function of the material,
(iii) the value of the Planck constant, h.

(c) Briefly discuss the contributions of Heisenberg to Chemistry.

3 (a) For an electron in a certain one-dimensional box the lowest observed transition frequency is $1 \times 10^{14}\ s^{-1}$. Find the length of the box.

(b) Define the '*Basicity of a ligand*'. What factors influences the donor capacity of a ligand?

(c) Distinguish between the characteristics of 'hard and soft' donor atoms of ligands.

---

4 (a) Show how an electron in a Bohr orbit behaving like a wave obeys Bohr's angular momentum condition.

(b) Draw the porphyrin ring ligand. Discuss the nature of bonding and type of hybridization about the nitrogen containing hydrogen atom.

(c) A wave function is written as

$$\Psi = \frac{1}{4\sqrt{2\pi}}\left(\frac{Z}{a_o}\right)^{\frac{3}{2}}\left(\frac{Zr}{a_o}\right)e^{-\frac{Zr}{2a_o}}\sin\theta\sin\phi$$

By identifying and solving the wave function, draw the shape of the radial density distribution function and state the most probable position to spot an electron in this wave function.

---

5 (a) The dipole moment of NF_3 (0.234 Debye) is much lower than the dipole moment of NH_3(1.47 Debye), even though the N-F bond is more polar than the N-H bond. Discuss the above experimental observation.

b) How does Pauling define electronegativity? Give the expression, which relates the electronegativity and bond energy of a molecule. The 'extra bond energy' for HF, HCl and HI is found to be 268, 92 and 5 kJ/mol, respectively. Which species is expected to have the least ionic contribution to the covalent bonding?

c) The C-C distance in cyanogen $(CN)_2$ is about 10% shorter than that in ethane. Support the above statement using necessary arguments.

---

6 (a) Solid PCl_5 is an ionic solid composed of PCl_4^+ cations and PCl_6^- anions, but the vapour is molecular. Describe the structure and bonding in the above three species.

(b) From elementary Molecular Orbital consideration would one expect the molecule FN to be capable of existence? If it should exist, would it be diamagnetic or paramagnetic? Verify the magnetic behaviour using any other concept of your choice.

(c) The formula for allene is $H_2C_x{=}C_y{=}C_zH_2$. What is the hybridization of C_x, C_y, and C_z Carbons. Describe the bonding and stereochemistry of allene.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass

Name of the element
X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 01 ogen																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 i 94 ium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
1 a 00 ium	12 **Mg** 24.31 magnesium											13 **Al** 27.99 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
9 K 10 ium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.65 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypto
7 b 47 ium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Iridum	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
5 s 91 um	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
7 - 02) um	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **unh** 263.12	107 **uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einstienium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

Department of Chemistry-UNZA

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY SEMESTER I 2004 EXAMINATIONS

ORGANIC CHEMISTRY I – C251

JUNE 2004

<u>TIME ALLOWED: THREE (3) HOURS.</u>

INSTRUCTIONS:
1. **This paper has five (5) questions. Answer any four (4) questions.**
2. **Each question carries thirty marks.**
3. **Marks for each part of the question are indicated.**

<u>QUESTION ONE.</u>

(a) In the multi-step synthetic route given below, identify the missing reagents/reagent systems <u>A</u> and <u>F</u>, and products <u>B</u>, <u>C</u>, <u>D</u>, <u>E</u> and <u>G</u> and, provide a reaction mechanism for transforming product <u>D</u> to <u>E</u>. Show clearly the geometry of compound <u>E</u>.

$$\text{1-Butene} \xrightarrow{\underline{A}} C_4H_8Br_2 \xrightarrow[\text{EtOH}]{\text{KOH}} \underline{B} + \underline{C} \xrightarrow[150^\circ C]{NaNH_2} \text{Alkyne}$$

$$\text{Alkyne} \xrightarrow[2.\ \text{EtBr/DMF}]{1.\ NaNH_2/\text{liq. } NH_3} \underline{D} \text{ (Symmetrical alkyne)}$$

$$\underline{D} \xrightarrow{\text{Na/liq. } NH_3} \underline{E} \xrightarrow{\underline{F}} \text{Aldehyde } (C_3H_6O)\ \underline{G}$$

18 marks

(b) Which reaction in each of the following pairs of reactions proceeds at a faster rate? Briefly explain your choice.

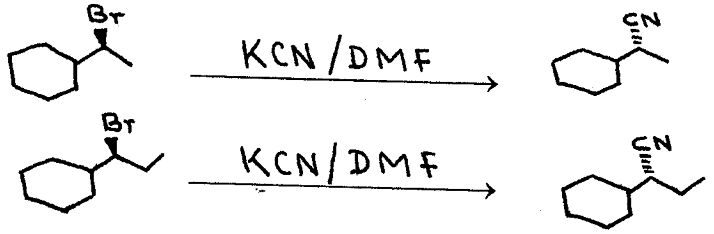
(i) $$CH_3I \xrightarrow{Br^{\ominus}/\text{MeOH}} CH_3Br + I^-$$

$$CH_3I \xrightarrow{Cl^{\ominus}/\text{MeOH}} CH_3Cl + I^-$$

(ii) $CH_3{-}S^{+}(CH_3)_2 \xrightarrow{{}^{\ominus}OH / THF} (CH_3)_2S + CH_3OH$

$CH_3{-}S^{+}(CH_3)_2 \xrightarrow{{}^{\ominus}OH / H_2O} (CH_3)_2S + CH_3OH$

(iii)



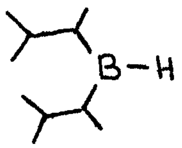
+ Br^-

+ Br^-

4 marks each

QUESTION TWO.

(a) (i) Stereospecificity is an important factor in the synthesis of specific organic compounds. Using a reaction mechanism, show the stereospecificity of hydroboration-oxidation of ethylcyclopentene with bis (1,2-dimethylpropyl) borane; structure is shown

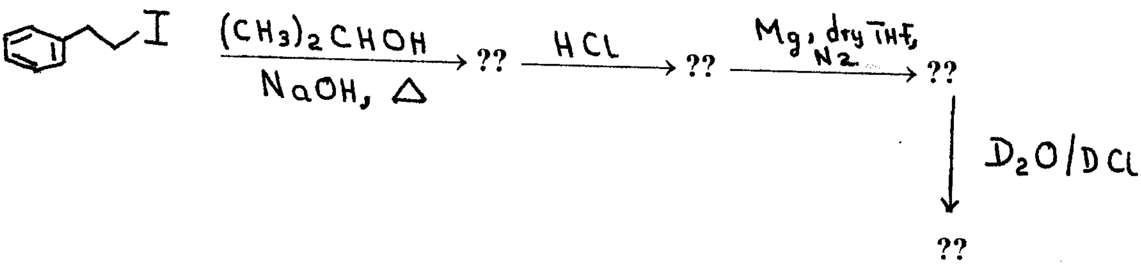


Bis (1,2-dimethylpropyl) borane

(ii) State your reasons briefly why bis (1,2-dimethylpropyl) borane is a much more useful reagent in the stereospecific synthetic reactions than say dimethylborane.

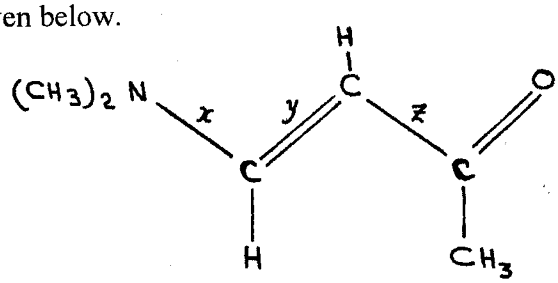
15 marks

(b) Show structures of the products, including pertinent stereochemistry, of the following reaction. **(Note: Reaction mechanisms are not required).**



10 marks

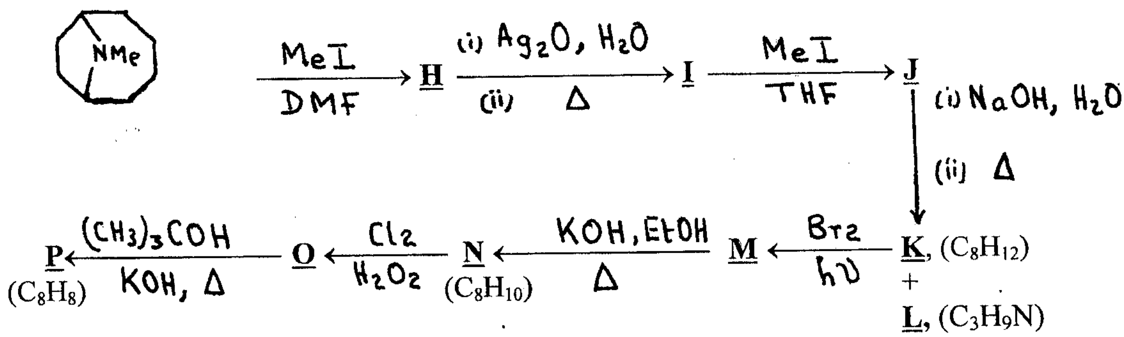
(c) The barrier to free rotation in ethane is 3.0 kcal/mol, which is low enough for the ethane to rotate freely about the C–C single bond. On the contrast, the barrier to free rotation in ethene is 63.0 kcal/mol, which is too high for the ethene to rotate freely about the C=C double bond. Basing on this fact, explain briefly and without calculation of any energy involved, the barriers you would expect at the N–C single bond marked **x**, at the C=C double bond marked **y**, and at the C–C single bond marked **z** in the molecule given below.



5 marks

QUESTION THREE.

A synthetic route for a compound **P**, (C_8H_8), is shown below.



(a) Give the structures of compounds **H** to **O** **14 marks**

(b) Deduce the structure of compound **P** from the above synthesis. **2 marks**

(c) Show the mechanisms of the reactions involved in the formation of:

(i) Compound **H**
(ii) Compound **K** from compound **J**
(iii) Compound **O** from compound **N**

9 marks

(d) Predict the major organic product of the reaction of compound **M** with 5% aqueous sodium hydroxide at 20^0C.

2 marks

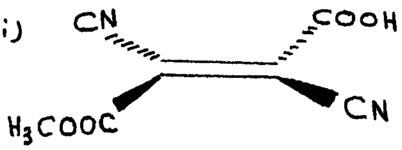
(e) Is it possible to prepare compound **N** from the major organic product obtained from the reaction in Question 3 (d) above? If yes, state the reagents and the reaction conditions for such a reaction.

3 marks

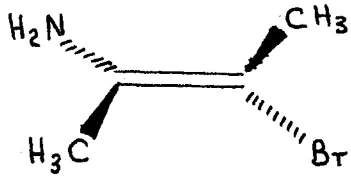
QUESTION FOUR.

(a) Assign E or Z configuration to the following alkenes.

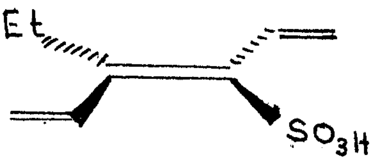
(i)



(ii)



(iii)



9 marks

(b) Hydration of alkenes is usually catalysed by mercury II salts like mercuric trifluoroacetate, Hg $(OCOCF_3)$. Write a mechanism for the hydration of 2-methylpropene and comment briefly on the stereochemistry and regiochemistry of this hydration.

10 marks

(c) When cis-2-butene is reacted with acidified hypohalous acid, HOCl, (HOCl that has been previously treated with a mineral acid like HCl), a mixture of products is obtained which shows no optical activity. Similarly, when trans-2-butene is treated in the same manner as cis-2-butene, an optically inactive product is again obtained. Give a mechanistic explanation to account for the observed optical inactivity in the two reactions.

(Note: You must clearly show and identify the stereochemical structures of all the products obtained in the two reactions).

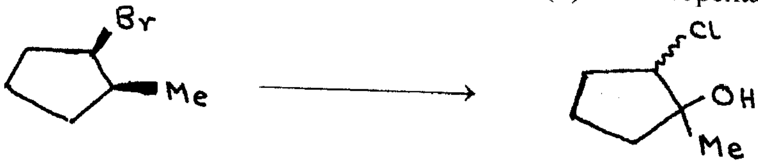
11 marks

QUESTION FIVE.

(a) Propose efficient synthetic routes for each of the following transformations. Show clearly the reagents and the reaction conditions needed for each reaction step of your synthesis. **(Note: Reaction mechanisms are not required).**

(i) (S)-2-Chloropentane $\longrightarrow$ (S)-2-aminopentane

(ii)



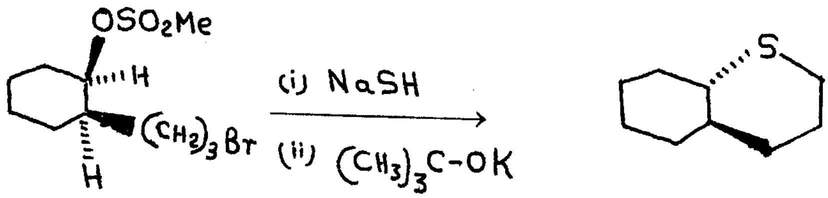
10 marks

(b) Give a brief explanation to account for the fact that t-butyl is energetically much worse in an axial position of cyclohexane than is isopropyl and, yet the two alkyl groups are structurally similar to each other.

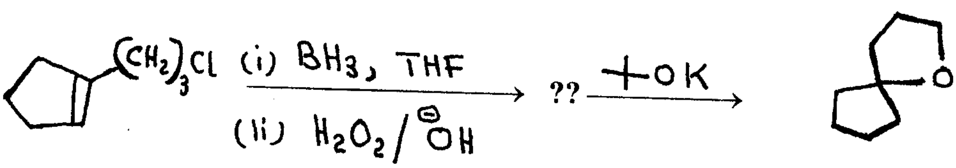
8 marks

(c) Suggest reasonable mechanisms for the following reactions.

(i)



(ii)



12 marks

END OF EXAM

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – June 2004

C311

TIME: THREE HOURS.

ANSWER QUESTIONS AS INDICATED IN EACH SECTION. ALL QUESTIONS ARE OF EQUAL VALUE. YOU ARE TO ANSWER A TOTAL OF **SIX** QUESTIONS.

SECTION I. Basic Facts. Answer **three questions** in this section.

1. Draw the structure of <u>any five</u> of the following and answer the associated questions.
   a. LVAEK. This could be the product of proteolysis catalyzed by what enzyme?
   b. 2,3-BPG. As the concentration of this increases, what happens to Hb O_2 affinity?
   c. *N*-acetylglucosamine. This can bind in which of the six lysozyme sites?
   d. NAD^+. Where is the reactive site on this molecule?
   e. Citrate. Is a prochiral compound, which means what?
   f. PPi. What commonly happens to this molecule and why?
   g. Biotin. Serves as a carrier of what?
   h. cAMP. How does an increase in this affect glycogen breakdown?

2. Give a short answer (50 words or less each answer) to <u>any five</u> of the following.
   a. Why are α-helices found in so many proteins?
   b. What does the proximal histidine in hemoglobin do?
   c. Why does the velocity of an enzyme catalyzed reaction no longer increase with the addition of more substrate when $[S] >> K_M$?
   d. What is the explanation for the difference in specificity of trypsin and chymotrypsin?
   e. How does a decrease in ATP concentration affect the pace of glycolysis?
   f. How is ATP actually synthesized in oxidative phosphorylation?
   g. What pathways would you use to produce NADPH without producing five carbon sugars?
   h. What is the purpose of a cascade control system like that seen in glycogen metabolism?

3. A. How does an enzyme catalyze a reaction?

   B. Describe in detail the specific mechanism by which either lysozyme, chymotrypsin or the HIV protease catalyzes a reaction. Include in your description the nature and function of important catalytic residues.

4. A. Give the reactions and the enzymes for the irreversible steps in glycolysis.

   B. What is the significance of these reactions?

   C. How does gluconeogenesis get around these reactions?

   D. What is the result of incomplete control over cycles that can occur in these pathways?

SECTION II. Applications and Calculatoins. Answer **two questions** in this section.

1. You have been given the task of isolating glycogen phosphorylase from rabbit muscle. After homogenizing the tissue in buffer and centrifuging to remove cellular debris, the remaining protein solution, has an absorbance of 1.2 at 280 nm after dilution by a factor of 10. (Remember, the protein chemist's rule of thumb says that a 1 mg/ml solution of an average protein has an absorbance at 280 nm of 1.) The volume of the protein solution obtained from 500 g of muscle is 830 ml. An initial measurement of phosphorylase activity found 2.27×10^5 units of phosphorylase activity. The unit of activity is 1 μmole of GIP produced per minute, and purified phosphorylase b has a specific activity of 300 units per mg phosphorylase.
   A. How many milligrams of phosphorylase b are present in the original protein solution?
   B. How many milligrams of phosphorylase b are present in each gram of rabbit muscle?
   C. What percent fraction of the total protein is phosphorylase b in the original protein solution?
   D. The final protein solution obtained from the phosphorylase purification procedure contains 453 mg of protein and is 97% phosphorylase (the other 3% are other proteins). How many units of phosphorylase activity are present in this final solution?

2. A. Two enzymes in liver catalyze the phosphorylation of glucose using ATP to produce glucose 6-phosphate. Once phosphorylated, the sugar molecule cannot pass back through the cell membrane and is thus committed to either immediate energy generation via glycolysis or to glucose storage as glycogen. When the activities of these enzymes are measured over a range of glucose concentrations, the following results are obtained. What are the K_M and V_{max} values for these two enzymes?

Glucose (mM)	Phosphorylation rate (μmoles G6P formed min^{-1}) Enzyme 1	Enzyme 2
0.10	1.99	1.54
0.25	4.89	2.34
0.50	8.03	2.74
1.00	18.67	2.99
2.50	36.99	3.36

   B. Which data set likely represents the liver enzyme associated with glycogen biosynthesis? Briefly defend your answer.

   C. Glucose 6-phosphate is an inhibitor of one of these enzymes. Add a line to the graph you produced in A. to show what you would predict to be the double reciprocal plot of this enzyme with and without G6P added to the enzyme assay solution. Clearly label this new line.

3. A. A one liter bottle of a lemon flavored drink concentrate was analyzed for total sugar content using iodometry. Little or no reducing sugar was detected prior to acid hydrolysis. Ten ml of the concentrate was then acid hydrolyzed and diluted to 50 ml for analysis. Five ml of this was titrated to a starch endpoint using 8.3 ml of I_2 (0.045 M) and .45 ml of $S_2O_3^{-2}$ (0.12 M). How many total grams of sugar are present in the 1 liter of drink concentrate?

   B. How many moles of ATP could theoretically be produced by a person who drank a 300 ml portion of the diluted lemon drink (30 ml of concentrate) while seated and at rest?

SECTION III. Imagination. Answer **one question** in this section.

1. Communicating Science to the Public.

A. Your young relative appreciated that paragraph you sent him/her explaining what a protein is, but really couldn't understand what you wrote? Please try again to write this paragraph. Your answer should include specific details of protein structure explained in terms understandable to your young relative who has limited science education. Both details and understandable terms are important in a good answer!

B. You have a growing reputation as a clear, concise communicator of biochemistry. A friend who is not in Natural Sciences has asked you to explain how anti-retrovirals work, especially the protease inhibitors. Write a paragraph for this friend who also has limited science education. Both details and understandable terms are important in a good answer.

2. Understanding Living Systems at the Level of Chemistry.

A. In this course you were told about two mutations more commonly found in human populations that live in locations where malaria is still a significant health risk. Very briefly (one short paragraph) describe one of these mutations.

B. How can the presence of one species, the malaria parasite, change the genes of another species? Be brief (one short paragraph), specific and biochemical!

END OF C311 EXAM

COMPUTER NUMBER: ____________________

Use as necessary, detach and insert in your answer book.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
JUNE 2004

C-321 [Analytical Chemistry II]
[Spectral Analytical Methods].

TIME ALLOWED: THREE(3) HOURS
INSTRUCTIONS: 1. Answer any FOUR questions
2. Each Question carries 25 marks.

---

1. (a) Complete the following table:

	λ[cm]	ν[sec^{-1}]	$\bar{\nu}$ [cm^{-1}]
i.		3.0 x 10^{10}	
ii.			2.5 x 10^{5}

(b) Complete the following table:

	X[M]	A	T(%)	ε[/mol-cm]	b[cm]
a.,			35	1540	2.00
b.,		0.612		250	5.00
c.,	3.8 x 10^{-6}		92	4765	

(c) Calculate the energy in *KJ* at *200 nm, 450nm* and *800* non, per mole respectively.

(d) A solution exhibits *65%* transmittance in a *1.00 cm* cell. What will be its percent transmittance at *455nm* in a *2-cm* cell.

(e) Calculate the molar absorptivity of $K_2Cr_2O_7$

(f) For many spectrophotometers, the lowest relative uncertainty is achieved when the absorbance is about *0.4*. Calculate the optimum concentration (mitigrams per liter) for the following metal ions, assuming a *2.00cm* cell.
(a) Cu^{2+} (as cuproine complex, $\varepsilon = 6.4 \times 10^3$ at *546 nm*)
(b) Ni^{2+}(as dimethylglyoxime complex, $\varepsilon = 3.5 \times 10^3$ at *350nm*)

(g) One compound being considered for utilization of solar energy is *HI*. The bond energy in *HI* is *71 kcal/mol*. What wavelength and frequency of light are sufficiently energetic to break the *HI* bond?

2. (a) Explain the principle of *IR-spectroscopy*.

(b) Explain the principle and difference between Raman and *IR-spectroscopy*. respectly.

(c) Describe Quantum treatment of vibrations.

(d) What type of stretching and bending vibrations do you known? Sketch them.

(e) Calculate the wave number and wavelength (*in* μm) of the fundamental absorption peak due to stretching vibration of $C = C$ and $C \equiv C$ groups respectively [Konstant k $C = C$ = 10dyn/cm and k $C \equiv C$ = 15 dyn/cm.].

(f) Explain different sample handling techniques in *IR-spectroscopy*.

3. (a) Explain the basic principles and differences between flame photometry and atomic absorption spectroscopy respectively.

(b) Describe principle of emission spectroscopy.

(c) Describe type of sources for atomic absorption spectroscopy and emission spectroscopy respectively.

(d) Explain standard addition method for atomic absorption spectroscopy.

(e) Describe, Inductively coupled plasma source. Sketch the diagram.

(f) A *0.570g* sample of an alloy steel is dissolved, the manganese is oxidized to permanganate, and the solution is diluted to *100ml* in a volumetric flask. The absorbance at *525nm* in a *1.00cm* - cell is *0.523*. The molar absorptivity of . MnO_4^- *at 525 nm* is 2.24×10^3
Calculate the percentage of *Mn* in the steel.

(g) A $5.00ml$ sample of blood was treated with trichloroacetic acid to precipitate proteins. After centrifugation, the resulting solution was brought to pH3 and retrected with two $5\text{-}ml$ portion of methylisobutyl ketone containing the organic lead - complexing agent APCD. The retract was aspirated directly into an air/acetylene flame and yielded an absorbance of 0.502 at $283.3\ nm$. Five, milliliter aliquots of standard solutions containing 0.400 and 0.600 ppm of lead were treated in the same way and yielded absorbances of 0.396 and 0.599.

Calculate the parts per million o lead in the sample, assuming that Beer's law is followed.

4. a) Describe the principle of proton magnetic resonance method. Sketch the block diagram of $^1H\ NMR$ instrument.

b) Explain chemical shift in $^1H\ NMR$.

c) Describe spin-spin splitting in of $^1H\ NMR$.

d) Explain integral and derivative spectrum of propanol from of $^1H\ NMR$.

e) Describe $^{13}C\ NMR$ and compare it with $^1H\ NMR$.

f) Explain Fourier transform $^1H\ NMR$.

g) What is meaning decoupling in $^{13}C\ NMR$.

h) i) An $^1H\ NMR$ .instrument employ a magnet that provides a field strength of $1.40T$. At what frequency would hydrogen nuclear absorb in such a field? $[\gamma = 2.68 \times 10^8\ T^{-1}S^{-1}]$.

ii) What magnetic field will be used for $200\ MHz$ apparatus?

l) Predict the appearance of the high resolution proton NMR spectrum of:
i) propanol ii) ethylbenzene iii) methylethylketone.

5. a) Explain the basic principle of mass spectrometry.

b) Write the equation for *m/z*

c) Sketch the graph of basic part of mass spectrometer

d) What accelerating potential will be required to direct a singly charged water $[H_2O = 18.02]$ molecule through the exit slit of a magnetic mass spectrometer if the magnet has a field strength *0.260* tesla and the radius of curvature of the ion through the magnetic field is *12.6cm?*

e) Describe how the following compounds will degradate; write their *m/z:*

$R\text{-}CH_2 - CH_2 - CH_2 - CH_3$ (i)

$R\text{-}CH_2 - CH_2 - NO_2$ (ii)


$-CH_2R$ (iii)

END OF EXAMINATION

THE PERIODIC TABLE

Key

Atomic Number
Symbol
Name
Relative atomic mass

Period	Group 1	Group 2											Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1	1 H Hydrogen 1																	2 He Helium 4
2	3 Li Lithium 7	4 Be Beryllium 9											5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20
3	11 Na Sodium 23	12 Mg Magnesium 24											13 Al Aluminium 27	14 Si Silicon 28	15 P Phosphorus 31	16 S Sulphur 32	17 Cl Chlorine 35.5	18 Ar Argon 40
4	19 K Potassium 39	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84
5	37 Rb Rubidium 85	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Mo Molybdenum 96	43 Tc Technetium (99)	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
6	55 Cs Caesium 133	56 Ba Barium 137	57 La Lanthanum 139 ▶	72 Hf Hafnium 178	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium (210)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227) ▶▶	104 Unq Unnil-quadium (261)	105 Unp Unnil-pentium (262)	106 Unh Unnil-hexium (263)												

▶ Lanthanoid elements

58 Ce Cerium 140	59 Pr Praseo-dymium 141	60 Nd Neodymium 144	61 Pm Promethium (147)	62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 163	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175

▶▶ Actinoid elements

90 Th Thorium 232	91 Pa Protactinium (231)	92 U Uranium 238	93 Np Neptunium (237)	94 Pu Plutonium (242)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (245)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (253)	101 Md Mendelevium (256)	102 No Nobelium (254)	103 Lr Lawrencium (257)

DATA SHEET

PHYSICAL CONSTANTS

Avogadro's constant, N_A	$= 6.02 \times 10^{23}\ mol^{-1}$
Speed of light, c	$= 2.998 \times 10^{8}\ m\ s^{-1}$
Molar volume of gas at S.T.P	$= 22.4\ dm^3$
Universal gas constant, R	$= 8.314\ J\ K^{-1}\ mol^{-1}$
	$= 0.0821\ L\ atm\ K^{-1}\ mol^{-1}$
	$= 8.314\ kPa.\ L.\ K^{-1}\ mol^{-1}$.

1 atm = 760 mmHg = 760 torr =101325 Pa = 101325 Nm^{-2}

THE PERIODIC TABLE IS PRINTED AT THE BACK OF THIS PAGE

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS

SEMESTER I 20004

C341 – Inorganic Chemistry II

Time Allowed: **3 Hours**

Instructions:

Answer any FIVE(5) questions
Each question carries 20 marks

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1. Ammonia is the main raw material for production of dilute Nitric acid.

   a. Describe the industrial method production of dilute Nitric acid.

   b. How do dilute and concentrated Nitric acids react with Cu, Zn, and Fe?

   c. Give three commercial uses of each of the following: Nitric acid, Sulphuric acid, and phosphates.

---

2. The Noble gases group contains He, Ne, Ar, Kr, Xe, and Rn.

   a. Describe the main properties of each of them: density, melting and boiling points.

   b. How do they obtain the Noble gases?

   c. Write down the reactions production of XeF_2, XeF_4, XeF_6, XeO_3, and XeO_4.

---

3. **a.** Describe the sulphuric acid production by contact process if the raw material is sulphur.

   b. Write down the reactions for the production of carbon oxides CO, CO_2, and H_2 from Coal and Natural gas.

c. Discuss the Phosphorous production process, and explain the properties of White, Red, Black and Brown phosphorous.

---

4. a. The complex $[Co(H_2O)_6]^{2+}$ gives two absorption bands at 8000 cm^{-1} and 16000 cm^{-1}. Assign the bands.

   b. Propose a method to prepare Pentaminenitratocobalt (III) nitrate from Hexaaquacobalt(II) nitrate. Give equations.

   c. Give the correct chemical formula of the complex Octaaquo-μ-dihydroxodiiron(III) sulphate.

---

5. a. Account for the color in $[Mn(H_2O)_6]^{2+}$ and $[Co(NH_3)_5Cl]^{2+}$. Comment on the intensity of bands obtained in both cases.

   b. Show why it is to be expected that the MnF_6^{3-} ion should have a distorted rather than a regular octahedral structure. In what manner would the ion be distorted?

   c. Is d-d transition possible in $[CrO_4]^{2-}$ ions? Can it be coloured?

---

6. a. Briefly explain how CO can stabilize low oxidation states of metals?

   b. How many vibrational modes does an SO_3 molecule have? Explain.

   c. Which of the following molecules are rotational active?

   OCS, H_2O, N_2, CO_2, C_6H_6. Explain your answer.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
UNIVERSITY SEMESTER I SESSIONAL EXAMINATIONS
2004 ACADEMIC YEAR

CHEMICAL KINETICS AND NUCLEAR CHEMISTRY - C 361

29 JUNE 20

INSTRUCTIONS: (i). ANSWER FIVE(5) QUESTIONS ONLY
(ii). ANSWER EACH QUESTION IN A SEPARATE ANSWER BOOK

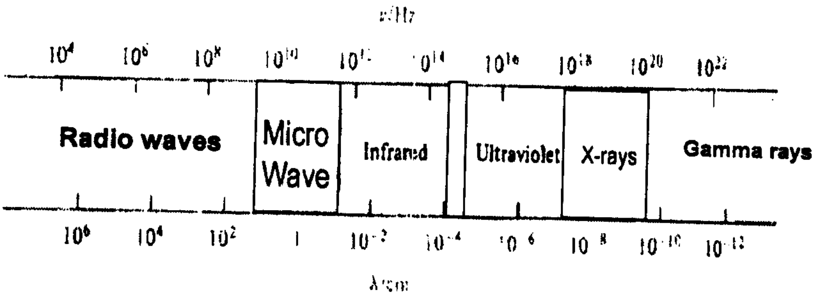
TIME ALLOWED: THREE(3) HOURS

THIS EXAMINATION PAPER IS THREE (3) PAGES LONG

DATA

$R = 8.314$ J mol^{-1} K^{-1}, $k_B = 1.38 \times 10^{-23}$ J K^{-1}, $h = 6.63 \times 10^{-34}$ J s
$N_A = 6.02 \times 10^{23}$ mol^{-1}, amu $= 1.661 \times 10^{-27}$ kg

Electromagnetic spectrum



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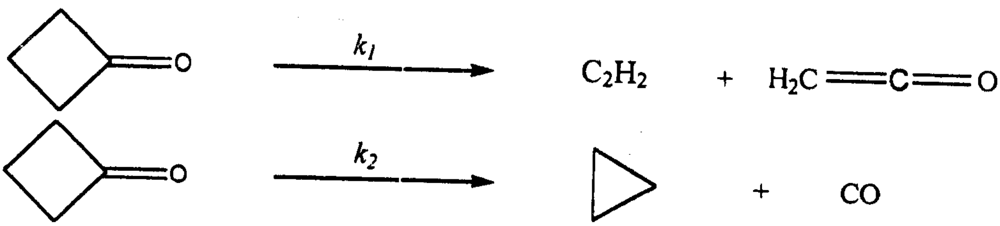
1. The thermal decomposition of cyclobutanone (CB) is elementary and gives a mixture of products as shown by the following competing reactions:



[*Problem 1 continues on page 2*]

a) Write the rate equation for the decomposition of cyclobutanone $_{c\text{-}}C_4H_6O$ and sh that it is first order.

b) The following data were obtained at 383 K with $[_{c\text{-}}C_4H_6O]_o = 6.50 \times 10^{-5}$ *M*

t (*min*)	0.5	1.0	3.0	6.0
$[C_2H_4](M)$	0.31×10^{-5}	0.68×10^{-5}	1.53×10^{-5}	2.63×10^{-5}
$[_{c\text{-}}C_3H_6](M)$	0.21×10^{-7}	0.47×10^{-7}	1.24×10^{-7}	2.20×10^{-7}

Determine k_1, k_2 and the overall rate constant k.

2. Yates, Taylor, and Sinfeldt : *J. Am. Chem. Soc.*, **86** : 2996 (1964) determined that t heterogeneous catalytic reaction between ethylene (Et) and hydrogen

$$C_2H_6 + H_2 \underset{\text{Silica}}{\overset{\text{Ni}}{\rightleftarrows}} 2CH_4$$

obeys a rate law of the form $R = P_{Et}^m P_{H_2}^n$ where m and n are integers. At 464 K t following data were obtained:

p_{H_2} (atm)	0.10	0.20	0.40	0.20	0.20	0.20
p_{Et} (atm)	0.030	0.030	0.030	0.010	0.030	0.10
$\frac{R}{R_o}$	3.10	1.00	0.20	0.29	1.00	2.84

where R_o is the rate when $P_{H_2} = 0.20$ atm and $P_{Et} = 0.030$ atm.

a) Determine the exponents m and n and the order of the reaction.
b) Show that these results are consistent with the following mechanism:

$$C_2H_6 \rightleftarrows (C_2)_{ads} + 3H_2$$
$$(C_2)_{ads} + H_2 \rightarrow 2CH \quad \textit{slowest step}$$
$$CH + \tfrac{3}{2}H_2 \rightarrow CH_4$$

3. The hydrolysis of mitomycin, an antitumour antibiotic, at pH 3.5 is due to catalytic effe of water, the specific contribution of H^+ ions and the effect of the phosphate buffer. A this pH value, the phosphate buffer consists almost exclusively of $H_2PO_4^-$ ions so that th expression for k_{obs} is

$$k_{obs} = k_o + k_{H+}[H^+] + k_{H2PO4}[H_2PO_4^-]$$

...dependence of k_{obs} on the concentration of $H_2PO_4^-$ at constant pH is given below:

$[H_2PO_4^-]$ M	0.01	0.05	0.1	0.2	0.3	0.4
$k_{obs} \times 10^3$ s^{-1}	1.295	1.317	1.344	1.398	1.452	1.56

a) Plot k_{obs} versus $[H_2PO_4^-]$ and compute the catalytic coefficient k_{H2PO4} of H_2P... from the slope.

b) Compute k_{H^+} at pH 3.5 if k_o is 1×10^{-6} s^{-1}

4. The reaction

$$2NO_2 \rightarrow 2NO + O_2$$

obeys bimolecular kinetics with k_2 = 4.45 M^{-1} s^{-1} at 600 K and 0.632 M^{-1} s^{-1} at 5... K. Compute energy, enthalpy, entropy and Gibbs energy of activation. Arrhenius fact... $A = 2.0 \times 10^9$ M^{-1} s^{-1}.

5. Write brief notes on nuclear stability in terms of binding energy, *magic numbers* and t... proton-neutron ratio. Use suitable sketch diagrams to illustrate your point.

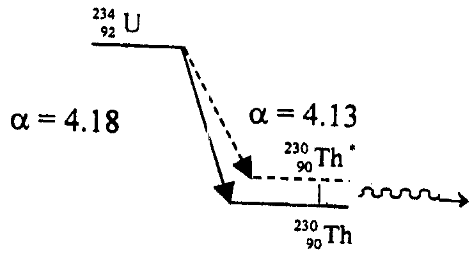
6. (a) ^{90}Sr is both a product of radioactive fallout and radioactive waste in nucle... reactors. This radioisotope is a β^- emitter with a half-life of 27.7 Y. Give reaso... why ^{90}Sr is a potentially hazardous substance.

(b) You are given the following nuclidic masses ${}^6_3Li = 6.0151$ u; ${}^4_2He = 4.00260$ ${}^3_1H = 3.01604$; ${}^1_0n = 1.008665$ u. How much energy is released in the nucle... reaction

$${}^6_3Li + {}^1_0n \rightarrow {}^4_2He + {}^3_1H$$

(c) Of these two isotopes, ^{17}F and ^{22}F, one decays by β^- and the other by β^+ emissio... Which isotope decays by β^- emission and why?

(d) The diagram below depicts the decay of ${}^{234}_{92}U \rightarrow {}^{230}_{90}Th$.



(i) Write nuclear reaction equations for the decay process.
(ii) Determine what type of radiation is released in this process.
(iii) Comment on the characteristics of the radiation identified in 6 d(ii) above.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FRIST SEMESTER FINAL EXAMINATIONS

ADVANCED BIOCHEMISTRY- C411

TIME: **THREE HOURS (3:00 HOURS)**

INSTRUCTIONS TO CANDIDATES:

WRITE YOUR COMPUTER NUMBER ON ALL ANSWER BOOKLETS

THE EXAMINATION CONSISTS OF TWO (2) SECTIONS **A** AND **B.**

SECTION **A: ANSWER ALL QUESTIONS. (40 MARKS)**

SECTION **B. ANSWER ANY THREE QUESTIONS (60 MARKS)**

SECTION A (EACH QUESTION CARRIES 10 MARKS)

1. Explain briefly the principles involved in the following processes.
   i. SDS-PAGE
   ii. Isopycnic and rate zonal centrifugation
   iii. Ion exchange and gel filtration chromatography

---

2. Outline the objectives of protein extraction, purification, concentration and giv possible steps involved.

---

3. A solution of L-glutamic acid -^{14}C (MW 147.1g/mol and uniformly labeled) con 1.0mCi and 0.25mg of glutamic acid per milliter. Calculate the specific activity labeled amino acid in terms of
   i. mCi/mg
   ii. mCi/mmole
   iii. DPM/μmole
   iv. DPM/μmole of carbon at a counting efficiency of 70%

---

4. What factors contribute to membrane fluidity? Using suitable examples, write a note on the asymmetry of membranes with respect to proteins and lipids.

SECTION B (EACH QUESTION CARRIES 20 MARKS)

1. a) Give the structural composition of striated muscle fiber and with the he well labeled diagram, draw its basic functional unit.

   b) Using the models of smooth and striated muscle, elucidate the mechar muscle contraction.

   c) i. Calculate the energy needed to pump Ca^{2+} out of a muscle cell whe the cytosolic concentration is 0.4mM, the extracellular concentration and the membrane potential being -60 mV.
   (R= 1.99×10^{-3}k cal/mol/K, T=298K, F=23.062 k cal/V/mol)

   ii. At 20 °C, a muscle protein has a diffusion coefficient of $6.1 \times 10^{-7} cm^2$/ and a sedimentation coefficient of 4.6S. The density of water at 20 °(0.998. Calculate the proteins MW, assuming a specific volume of 0.7 20°C.

---

2. What is an operon? Using the model of tryptophan polycistronic genes, explai detail the mechanism of attenuation in control of tryptophan metabolism. Starting from chorismate, give the pathway for the synthesis of tryptophan, sho the enzymes involved.

---

3. a) What are hormones? Give the major classes of hormones with suitable examples in each case?

   b) Elucidate the pathway for the synthesis of dopamine, epinephrine and norepinephrine and **give** the function of dopamine as a **hormone**.

   c) Give the structure of **IAA** and any **three** of its functions.

   d) How does ethylene form in plants? What is the major function of ethylen

---

4. a) Nicotine and Bungarotoxin are the natural agonist and antagonist of whi receptor? What is their mode of action?

   b) An activated squid membrane resulted in the following equilibrium concentrations; Na^+ 40:450; K^+ 385:15 and Cl^- 47:530 in (mM) and their permeability constants being 0.04, 1 and 0.45 respectively. Calculate the Nernst potential resulting from the above equilibrium conditions.

END OF EXAMININATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C421: APPLIED ANALYTICAL CHEMISTRY

TIME: 3 HOURS

ANSWER ANY 4 FROM THE 5 QUESTIONS IN THIS PAPER

QUESTION 1

(a) Describe how to determine "Base saturation" and "exchangeable acidity" in soils.(3)
(b) Describe in detail the analysis of 2 nitrogenous compounds in soils.(3)
(c) 0.2g of copper ore is analyzed iodometrically.Cu(11) was reduced to Cu(1) by iodide. $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$. What is the %Cu in the ore if 20ml of 0.2M $Na_2S_2O_3$ is used for liberated iodine.(3).
(d) Discuss 2 procedures used to prepare rock samples for analysis using the determination of Cd as an example. (3)
(e) Discuss how you would determine organic C as well as "alkalinity of ash" in soils. (3)

QUESTION 2

(a) Explain the main steps in atomization of an analyte using the electrothermal furnace including the physical and chemical processes that occur in each step.)
(b) Compare the determination of Au and that of Zn from their ores. (2)
(c) Some alloys tend to have 2 common elements, name any 2 of such alloys and describe the analysis of one of such elements. (3).
(d) Describe any 3 schemes used in the analysis of silicate rocks (3)
(e) What weight of pyrite (impure FeS_2) must be used in analysis so that $BaSO_4$ precipitate formed will be equal to half that of the %S in the sample. (3)

QUESTION 3

(a) Compare the routes by which high molecular mass organic compounds and toxic metals may disperse and re-concentrate in the environment and in organisms. (3)
(b) Most soils contain some exchangeable cations, what are they and explain in detail how any 3 of them can be determined. (3)
(c) A soda ash sample is analyzed by titration with standard HCl. The analysis is done in triplicate with the following results: 93.50, 93.58 and 93.43% Na_2CO_3. Within what range are you 95% confident that the true value lies? (t =4.303). (3)

(d) Routine analysis of water for domestic use is very important why? Define the following and their significance in water analysis: BOD and water hardness. (3)
(e) Describe how to determine K in the presence of sulfates but not phosphates in fertilizers. (3)

QUESTION 4

(a) In your lab., you are presented with a water sample known to have been contaminated with 2 metals (Cu, Na), what instrument(s) and approaches would you use to determine the levels of these 2 metals in this water. (3)
(b) In monitoring SO_2 in the environment absorption train using H_2O_2 as an adsorbent is used rather than West and Gaeke reagent. Discuss advantages and disadvantages of this for large scale monitoring. (3)
(c) Define or describe the terms: bio-concentration factor, eutrophication and green house effect. What do these terms signify? (3)
(d) A substance is known to have a molar absorptivity of 14000 at its wavelength of maximum absorption in a 1cm cell. Calculate what molarity of this substance could be measured in a spectrometer if the absorbance reading is to be 0.850. What % transmittance does this represent?. (3)
(e) An analyst notes that 1ppm solution of Na gives flame emission signal of 110, while the same solution containing 20ppm K gives a reading of 125. It was determined that 20ppm solution of K exhibited no blank reading. Explain the results. (3)

QUESTION 5

(a) A monitoring exercise is planned for Pb deposited on soil close to the roadway. How do you select sampling positions and how would you determine Pb in such samples?
(b) Which techniques would be useful in the analysis of: NO_2 in the external atmosphere at several locations and an organic solvent in a lab atmosphere. (3)
(c) An ore is analyzed for Mn content by converting Mn to MnO_2 and weighing it. If a 2.1g sample yields Mn_3O_4 weighing 0.15g. What would be the $\%Mn_2O_3$ in the sample and %Mn?. (3)
(d) Discuss 4 ways of collecting atmospheric gases for analysis and include the description of the determination of one of such gases (3)
(e) In flame spectrometry, state the differences between emission and absorption spectrometry, giving examples to illustrate such differences. (3)

(Use: Ba = 137.3; Cu = 63.5; I = 126.9; S = 32.1; Fe = 55.8; O = 16.0; Cl = 35.5; Ca = 40.1; Mn = 54.94).

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION
SEMESTER I, JUNE 2004

C445 B io-Inorganic Chemistry

Time Allowed: **3 Hours**

Instructions:

Answer 4 out of 5 questions
Show orderliness and logic in your presentation.
All questions carry equal marks

---

1. (a) State the functions of *non-protein* metallobiomolecules.

   (b) Protein metallobiomolecules can function as enzymes and have found use in transport and storage roles.

   Name the metal(s) associated with the following reactions:
   (i) Isomerases and synthetases
   (ii) Copper metal management
   (iii) Electron carriers
   (iv) Dioxygen management

   (c) What is copper-molybdenum antagonism?

---

2. (a) Discuss the reaction and use of Vitamin B_{12} coenzyme.

   (b) Ligands for biological systems are careful tailored for their functions. Explain with illustrations.

   (c) Write short account on each of the following:

   (i) Entrobactin
   (ii) BSOD mechanism/action
   (ii) Action usefulness of catalases

3. (a) What role(s) does copper play in the human body? What deficiency disorders are associated with copper?

(b) Deferrioxamine B has been used in chelation therapy for excess Al and Fe treatment. What characteristics makes this ligand suitable for this treatment role?

(c) Petrol blending with ethanol is environmental sound compared with the use of TEL (tetraethyllead). By showing the action of the antiknock agent on humans describe the toxic effects of lead.

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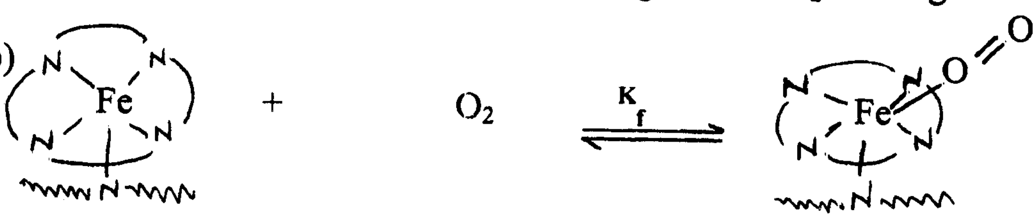
4. (a) At pH 6.7, and at lower dioxygen partial pressures, distinguish the reactivity of myoglobin and hemoglobin to O_2 binding.

(b) 

(i) Using the Weiss explanation describe the above coordination of dioxygen.

(ii) If the binding above is use to derive the Hill equation, show the step involved.

---

5. (a) Discuss the reactions and toxicity of mercury on a phospholipid.

(b) Describe the following:

(i) Cooley's aneamia and its treatment.
(ii) Lewisite poisoning and its treatment

(c) What is the role of magnesium to the body?

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMESTER EXAMINATIONS

GEO 111: INTRODUCTION TO HUMAN GEOGRAPHY I

TIME: Three hours

INSTRUCTIONS: Answer Question 1 (40%) and any other three questions.
Credit will be given for use of relevant illustration.
Use of electronic calculator and a Philips' University atlas is allowed.

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1. Figure 1 illustrates settlements with names and dots representing village locations.

   (a) Calculate the nearest neighbour measure ($R\eta$) for the area given.

   (b) Explain the distribution pattern of the settlements.

2. Give a critical account of three major approaches in Human Geography.

3. Examine the applicability of Central Place Theory in Zambia.

4. Outline the contributions of T. Hagerstrand on the diffusion process.

5. Discuss the applicability of the Von Thunen's Model with reference to the Zambian situation.

6. Write short explanatory notes on each of the following:

   (a) Determinism

   (b) Site of Rural Settlements

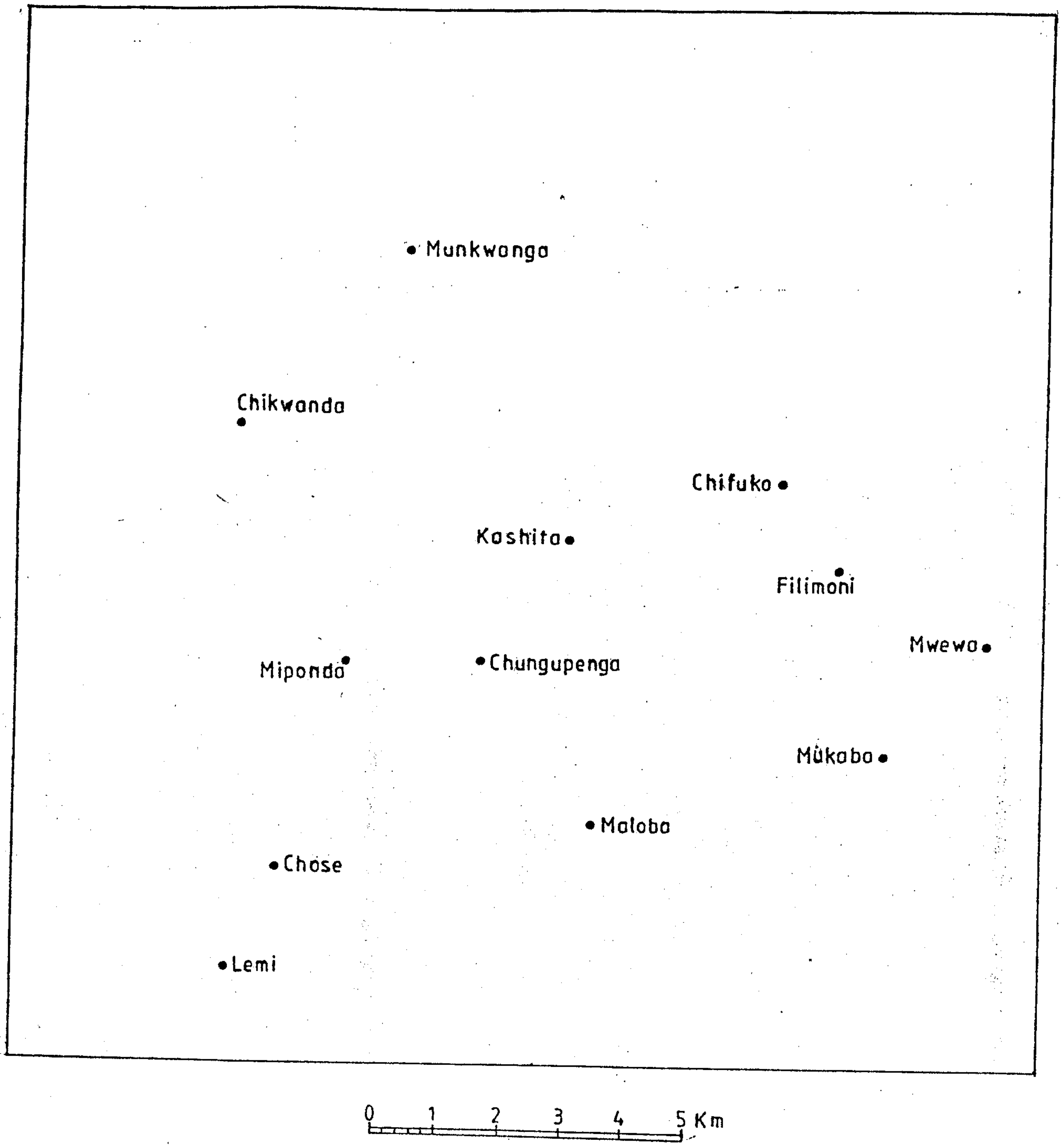
   (c) Rank-Size Rule

   (d) Multiple-nuclear Model in Urban landuse

   (e) Agglomeration Economies

END OF EXAMINATION

Figure 1


Munkwanga
Chikwanda
Chifuko
Koshita
Filimoni
Mwewa
Miponda
Chungupenga
Mukabo
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THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 175: INTRODUCTION TO MAPPING TECHNIQUES

PAPER I: PRACTICAL

TIME: Three hours

INSTRUCTIONS: Answer all questions

The use of a Philips' University Atlas and a Calculator is allowed
You are encouraged to use illustrations wherever appropriate.

SECTION A

1. Write short explanatory notes on all of the following:

   (a) Oblique aerial photographs
   (b) Essential elements of a good map
   (c) Characteristics of a good map symbol
   (d) Grid references
   (e) Types of scale

2. (a) Explain why scale on a vertical aerial photograph is not uniform?

   (b) With the help of an example, explain how you would convert a scale in words to a scale in figures.

   (c) Draw a line scale in metric units for a map drawn at the scale of 1:25 000, given that the maximum space available is 15 centimetres.

   (d) Using the contour method, draw a ridge at 20 metre vertical intervals showing a river flowing on the dip slope with its source near the summit.

   (e) With the help of a diagram, describe a radial drainage pattern and briefly explain the characteristics of the area on which it develops.

SECTION B

Answer all the questions in this section using topographic map sheet 0930 D2 provided.

3. (a) When was map sheet 0930 D2 first published and by whom?

   (b) How many districts are covered by map sheet 0930 D2?

   (c) If you were driving eastwards along the maintained D19 road to Mbala, what other map sheet would you require?

   (d) What is the vertical interval used on map sheet 0930 D2 and what does it mean?

   (e) Using map evidence only, explain how you could read grid references on map sheet 0930 D2.

   (f) What is the direction of the church located at grid reference point 690220 from the trigonometrical station in grid square 7329 as a:
   (i) compass direction
   (ii) bearing from grid north.

   (g) Calculate the average gradient along a straight line between Chimengwa Farm at grid reference 620308 and Kopeka School at grid reference 652333 in degrees.

   (h) What is the approximate size in square kilometres of the area enclosed between the Kawongo and the Nchelenge rivers and state the method that you have used.

   (i) What drainage pattern is generally exhibited by the Nchelenge river and its tributaries west of easting 63?

   (j) Using map evidence only suggest any two reasons which could have influenced the location of settlements on map sheet 0930 D2

4. (a) Using the most appropriate method, draw a map at half the original scale showing the area extending from eastings 59 – 71 and northings 22 – 38 and on it show the following:

   (i) D19 maintained road and the roads to Kopeka and Myangaluba from the D19.
   (ii) The Lufubu and Nchelenge rivers,
   (iii) Kopeka, Kapiya, Mtema and Myangaluba villages and
   (iv) Shade the area above 1540 metres.

(b) Draw a straight-line profile from grid reference point 600271 to grid reference point 665382. On your profile, show the positions of the following:

   (i) the maintained road D19,

(ii) Chimengwa Farm and
(iii) Lufubu river.

(c) Using your profile determine whether or not grid reference point 600271 and Chimengwa Farm are intervisible.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 211:THE GEOGRAPHY OF AFRICA

TIME:THREE HOURS.

INSTRUCTIONS: ANY FOUR QUESTIONS.
CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS AND EXAMPLES WHEREVER APPROPRIATE. USE OF AN APPROVED ATLAS IS ALLOWED

---

1. Write short explanatory notes on **ALL** of the following:
(a) Soils in Africa.
(b) Influence of rainfall on agriculture in Africa.
(c) Continental drift
(d) Early man in Africa
(e) Proverbs and African Philosophy.

2." The African continent constitutes the second largest landmass on this planet after Eurasia" (Best and de Blij, 1977, p3). To what extent is this reality an advantage for economic development rather than a disadvantage?

3. In what ways is the control of water key to Africa's economic development?

4. What are the explanations for the persistent socio-economic crises in Africa and suggest possible solutions.

5. Explain the reasons for the shifts in development strategies that have taken place in Ghana and Tanzania since independence.

6. Evaluate the strategies for socio-economic development that Kenya implemented after independence.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC FIRST SEMESTER FINAL EXAMINATIONS

GEO 271: QUANTITATIVE TECHNIQUES IN GEOGRAPHY 1

TIME	:	Three hours
INSTRUCTIONS	:	Answer any four questions. Use of a Philips University atlas is allowed. Candidates are encouraged to use illustrations wherever appropriate.

---

1. 'The methodology of the subject matter makes it scientific and not its content'. Discuss.

2. Some GEO 271 students were asked by Central Board of Health (CBoH) to evaluate whether or not the following problem statement was of an acceptable standard. The statement read as follows: "The prevalence of HIV/AIDS in peri-urban high density areas is coupled with a number of factors. These manifest themselves in terms of high maternal and infant mortality rates, high morbidity, poor dietary intake and resistance to use of condoms".

   a) Explain the problems which you think the GEO 271 students identified in this statement.

   b) Present a more researchable problem.

   c) What would be four of your objectives of this study?

3. Explain the essence of reviewing literature in research.

4. Ms. Hajoko is to undertake a study to evaluate the impact of water conservation technology called pot-holing on maize yields in Shimabala area of Kafue district. Which evaluation methodology would you recommend and why?

5. Discuss the major categories of processing data.

6. Explain the relevance of a research proposal.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMESTER
GEO 381: ENVIRONMENT AND DEVELOPMENT I

TIME: THREE HOURS

INSTRUCTION: ANSWER QUESTION ONE AND ANY OTHER THREE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

---

1. Write short explanatory notes on ALL of the following:
   a. The concept of resource alienation
   b. The capability perspective of definitions of poverty.
   c. Differentiate between instrumental and intrinsic values of the environment.
   d. Autopoietic systems.
   e. Social ecology and eco-feminism.

2. Show why the interrelationship between the exploitation and degradation of environmental resources, on one hand, and development and poverty, on the other, is most relevant to rural areas in developing countries.

3. Using examples, differentiate between territorial decentralization and technical decentralization, and outline the advantages and disadvantages of both types of decentralisation.

4. Use the concept of the BOMA (i.e. British Overseas Military Administration) centre to show the historical legacy of colonialism on the environment in Africa.

5. Define sustainable development, and outline at least four criteria for sustainability in Africa.

6. "Environmental rights are human rights", Yvonne Dausab (2004). Discuss.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS - JUNE, 2004

GEO 451: LAND RESOURCE SURVEY

TIME: 3 HOURS
INSTRUCTION: ANSWER ALL QUESTIONS **MARKS: 80**

---

1. a. From a land evaluation point of view, what would be wrong with a statement such as "This is good land"?
   (5 marks)

   b. Should land use requirements be determined before or after land resource surveys? Why?
   (5 marks)

   c. Land use planning may be considered to be a three-phase process. With suitable illustrations, where possible, explain what these phases are, clearly indicating what may be involved in each one.
   (6 marks)

2. You have a client who is interested in starting the following projects:

   a. An irrigated sugar plantation on the Kafue Floodplains
   b. A quarry in Lusaka East to mine granite stone for construction purposes
   c. A Game ranch in Chisamba (Lusaka Rural)
   d. A new residential scheme on the outskirts of Lusaka

   In each of the above cases, outline and explain what you would consider as the critical environmental issues that must be addressed.
   (20 marks)

3. a. Land evaluation is not land use planning. Elucidate this statement.
   (6 marks)

   b. Discuss the main approaches commonly used in land evaluation
   (6 marks)

4. Explain why the following land resources are important in land evaluation

   a) Vegetation
   b) Hydrology and water
   c) Land form
   (12 *marks*)

5. With the aid of suitable diagrams, illustrate how matching helps to determine land suitability in land evaluation (*8 marks*)

6. You are involved in the assessment of land suitability for intensive irrigated rice production in Western Province. (*12 marks*)

a. Give four land qualities you would assess in the field

b. For each land quality you have given above indicate the associated land characteristics for each of your stated land qualities in a.

c. Why is working with land qualities usually preferred in land evaluation?

END OF EXAMINATION

UNIVERISTY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS
GEO 481 ENVIRONMENT AND DEVELOPMENT II

TIME: Three (3) hours
INSTRUCTIONS: Answer any four (4) Questions. All questions carry equal marks.

1. Write short explanatory notes on all of the following:
    a. Flood hazards
    b. Urban industrialisation and environment
    c. Logical framework matrix
    d. Rangeland management
    e. Direct anthropogenic process in geomorphology

2. In what ways and to what extent does the upgrading of unplanned settlements contribute to unsustainable development of cities in developing countries?

3. Outline ways in which humankind can integrate development issues into water resources management in the world.

4. Discuss the linkages between energy and environment in relation to the development debate.

5. "An agricultural system is an assemblage of components which are united by some form of interaction and interdependence and which operate within a prescribed boundary to achieve a specified agricultural objective on behalf of the beneficiaries of the system" (Mc Connell and Dillon, 1997, P1.)

Evaluate the above statement in relation to the sustainable development of agriculture in developing countries.

6. "... without better knowledge of where , when and how forest has and has not been lost and transformed, policies aiming to address poverty and degradation will miss their target" (Farihead and Leach, 1998 in Forest, Trees and People Newsletter, August 1999, No. 39, p. 56.)
Discuss.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

GEO 911: POPULATION GEOGRAPHY

TIME: **Three hours**
INSTRUCTIONS: **Answer any four questions**
All questions carry equal marks
Use of a Philips' University Atlas and a calculator is allowed.

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1. Levels of Natural Increase (NI) for Sweden and Zambia are the same. Discuss.

2. Study the 1990 and 2000 selected census data for Zambia which are presented in Table 1 and answer questions a to d.

Table 1: 1980, 1990 and 2000 selected census data for Zambia

Year	Population size
1980	5,661,801
1990	7,818,447
2000	9,885,591

Source: Central Statistical Office, (2004).

a) Calculate the intercensal percentage change,

b) Use any of the mathematical methods of population to extrapolate Zambia's population for 2005,

c) Estimate Zambia's population for 2000 by using the continuous growth method and account for the difference between your figure and the actual census figure and

d) Find the doubling time for Zambia's population.

3. With special reference to Zambia compare and contrast a census and sample survey.

4. Examine the statement that 'The Classical or neo-Classical or Capitalist and the Marxist theories of population size and growth are the same side of the coin.'

5. Write short explanatory notes on all of the following:

   a) Basic features of a Vital Statistics collection system,

   b) Pre-natal and post-natal mortality,

   c) Interaction/Assimilation hypothesis of religion in relation to fertility,

   d) The scope and use of demographic data in Zambia

   e) Demography versus Population Geography.

6. Discuss ways in which religion has been a factor for explaining pro-natalism in any parts of the world since the population debate started.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC FIRST SEMESTER FINAL EXAMINATIONS

GEO 921: ECONOMIC GEOGRAPHY

TIME	:	Three hours
INSTRUCTIONS	:	Answer any four questions. Use of a Philips University atlas is allowed. Candidates are encouraged to use illustrations wherever appropriate.

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1. Discuss Zambia's tourism potential and why it has not been effectively utilised for Socio –Economic Development.

2. 'Small Industries Development Organisation (SIDO) and now Small Enterprises Development Board (SEDB) can be seen as a way of industrialisation in Zambia'. Discuss this statement in relation to the evolution of manufacturing industries.

3. With reference to Figure 1, compute the connectivity and accessibility indices for towns indicated using the Euler's Graph theory and comment on the results.

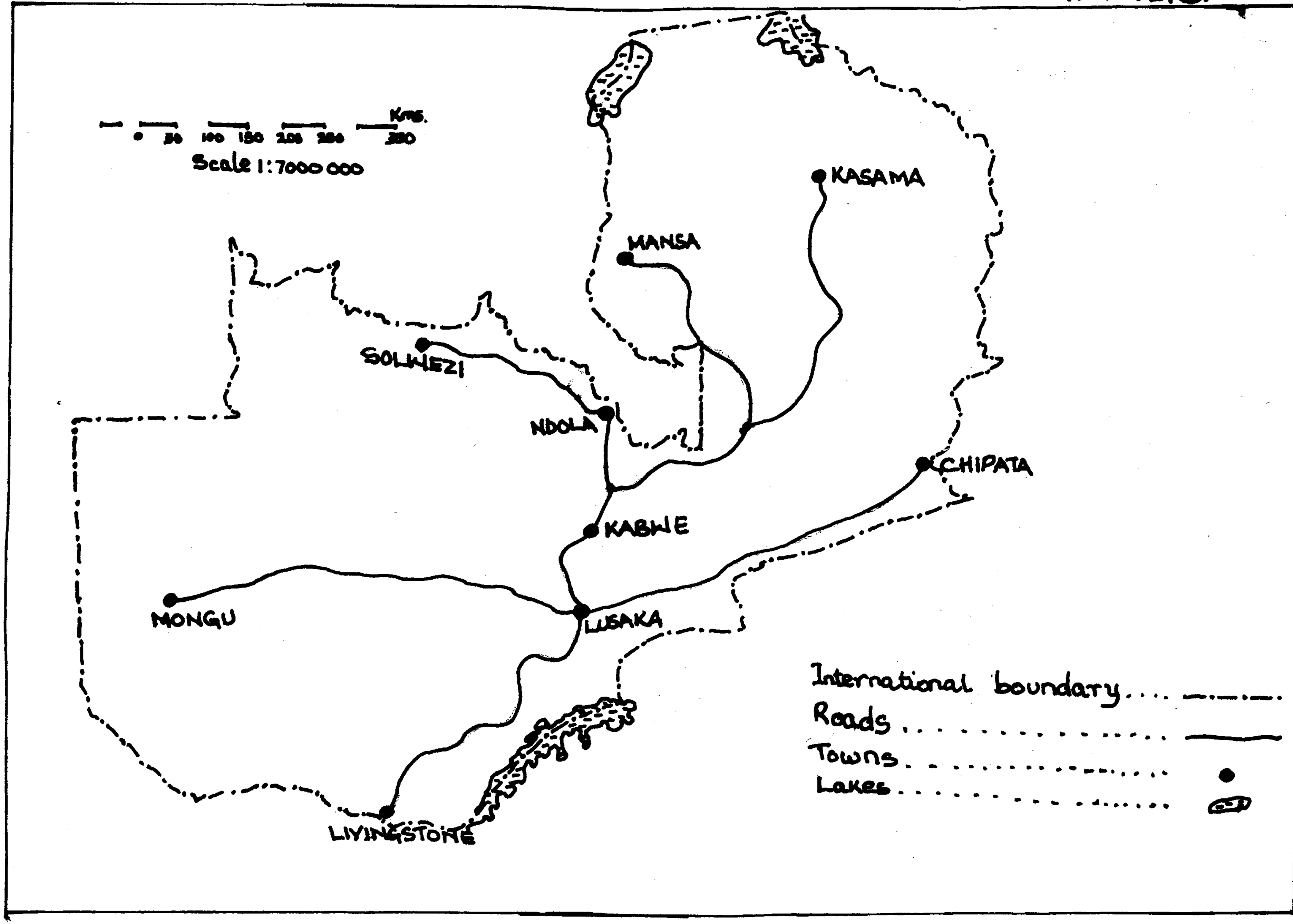
4. To what extent are Smith's criticisms of the Weberian framework valid in the Zambian situation?

5. Use Zambia and any other country of your choice to discuss the concept of 'comparative advantage' in International Trade.

6. Examine how Japan has managed to compete effectively in both internal and external trade with either Britain or the United States of America ?

END OF EXAMINATION

FIGURE 1. MAP OF ZAMBIA SHOWING ROADS TO PROVINCIAL HEADQUARTERS.



THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 931:RURAL GEOGRAPHY

TIME: THREE HOURS.

INSTRUCTIONS:ANSWER ANY FOUR QUESTIONS.
CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS AND EXAMPLES WHEREVER APPROPRIATE. USE OF AN APPROVED ATLAS IS ALLOWED.

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1. Write short explanatory notes on ALL of the following:

(a) Diffusion of agricultural innovations.
(b) Marginal land and diminishing returns.
(c) Supply, Demand and Prices.
(d) The concept of Risk in agriculture.
(e) Indigenous knowledge versus Scientific knowledge.

2. Define Rural Geography and show the relevance of the Participatory Rural Appraisal (PRA) methodology in Rural Research.

3.'Women hold fifty percent of the sky'. Comment on this saying with respect to the role of women in rural dèvelopment programmes in Africa.

4. Account for the location of rural settlements in Zambia and show whether there is dynamism in the housing situation.

5. Evaluate the view that peasants in Sub-Saharan Africa are guided by ' the law of subsistence' rather than by 'the law of value'.

6.'The key to Africa's socio-economic development is transport and the provision of water and sanitation'. Discuss.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR
FIRST SEMESTER FINAL EXAMINATION

GEO 971
AERIAL PHOTOGRAPHY AND AERIAL PHOTO INTERPRETATION

PAPER I

TIME: THREE HOURS.

INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS.

NOTE: ALL QUESTIONS CARRY EQUAL MARKS. CANDIDATES ARE ENCOURAGED TO MAKE USE OF ILLUSTRATIONS WHEREVER APPROPRAITE.

Q1 Outline the various interactions between electromagnetic energy and the surfaces being photographed, with emphasis on relevance to data detection on the photographic film.

Q2 Compare and contrast colour infrared and true colour film on the basis of:

a) Spectral sensitivity.
b) Meanings of colours depicted.
c) Ideal applications.

Q3 Explain the characteristics on aerial photographs that can be used in photo interpretation.

Q4 Compare and contrast image parallax and relief displacement on vertical aerial photographs.

Q5 Using an illustrative case study, outline the application of aerial photography in any ONE aspect of environmental inventory.

Q6 Write short explanatory notes on ALL of the following:

a) Controlled mosaics.
b) Ground truthing.
c) Types of scattering of electromagnetic energy.
d) Panchromatic film.
e) Air photo interpretation keys.

END OF EXAMINATION

THE UNIVERSITY OF UNIVERSITY

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M 111: MATHEMATICAL METHODS I

TIME: THREE (3) HOURS

INSTRUCTIONS:
- (i) ANSWER ANY FIVE (5) QUESTIONS
- (ii) NO CALCULATORS TO BE USED
- (iii) INDICATE THE NUMBER OF EACH QUESTION ANSWERED ON YOUR MAIN ANSWER BOOK.

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1. (a) (i) Express the complex number $Z = \dfrac{(4+3i)(2+i)}{3-2i}$

in the form $a + ib$ where a and b are real numbers.

(ii) Show that $4.3\overline{57}$ is a rational number.

(iii) Draw a Venn diagram showing the following sets:

$C = \{\text{complex numbers}\}$, $R = \{\text{real numbers}\}$
$Q = \{\text{rational numbers}\}$, $Z = \{\text{integers}\}$

(b) (i) If the roots of the equation $x^2 + 5x + K = 0$ are α and $\alpha + 1$, find the value of K.

$(\alpha - x) = 0$ $\quad x = \alpha + 1$ $\quad (x - \alpha + 1) = 0$

(ii) Find the integer m given that

$$\frac{\tan^2\theta}{1+\tan^2\theta} + \frac{\cot^2\theta}{1+\cot^2\theta} = m$$

$(\alpha - x)(x - \alpha + 1) = 0$

$\alpha x - \alpha^2 + \alpha - x^2 + \alpha x - x$

$- x^2 - x - \alpha^2 + \alpha$

(iii) Solve for x given that

$$\frac{x+2}{x-3} \geq 3$$

(c) Simplify as much as possible where A and B are any sets

$$[(A \cap B') \cup (A' \cap B)]'$$

2. (a) Given that $f(x) = \sqrt{-x+4}$

(i) Determine the domain of f(x).

(ii) Sketch the graph of f(x). Indicate on your graph, the y-intercept.

(iii) Determine the range of values of x for which $f(x) < 4 - x$.

(b) Given the polynomial $p(x) = 6x^4 + x^3 - 8x^2 - x + 2$

(i) Factorize p(x) completely.

(ii) Find values of x for which $p(x) = 0$

(iii) Find values of x for which $p(x) < 0$

(c) Let the universal set E be all students registered at UNZA in the first semester 2004 academic year. Given the following sets:

A = Graduate students

B = Students registered in School of Law

C = Undergraduate students

D = Students who are on GRZ sponsorship.

Represent this information in a Venn diagram.

3. (a) Given that $f(x) = 3\cos(2x) + 1$

(i) Solve $f(x) = \frac{5}{2}$, $x \in [-2\pi, 2\pi]$

(ii) Determine the amplitude, period and phase of the graph of f(x).

(iii) Sketch the graph of f(x) on the interval $[0, 2\pi]$.

(b) Let $g(x) = \begin{cases} x^2 - 3x + 3 & \text{if } x \leq 2 \\ \dfrac{2}{x} & \text{if } x > 2 \end{cases}$

(i) Determine whether the function $g(x)$ is continuous at $x = 2$.

(ii) Determine the equations of the horizontal and vertical asymptotes of $g(x)$, if there are any.

(iii) Find the equation of the tangent line to the graph of $g(x)$ at $x = 1$.

(c) Find the equation whose roots are minus the roots of the quadratic equation

$$2x^2 - x + 3 = 0$$

4. (a) Given that $\sin\theta = \dfrac{-3}{5}$ and $\tan\alpha = \dfrac{3}{4}$, where θ is a third quadrant angle and α is acute angle.

(i) Find $\sin\alpha$, $\cos\theta$ and $\cos\alpha$.

(ii) Find $\sin(\theta + \alpha)$.

(iii) Find $\tan(\theta - \alpha)$.

(b) (i) Find the derivative of $f(x) = \dfrac{2}{x}$ from the first principles.

(ii) Solve $\dfrac{2x - 6}{x + 3} < -x - 2$.

(iii) Sketch the graph of

$$g(x) = |x - 3| - |2x - 1|$$

(c) Find the following limits:

(i) $\displaystyle\lim_{x\to 2} \frac{x^2 + x - 6}{x^2 - 4}$

(ii) $\displaystyle\lim_{x\to -\infty} \frac{x^2 + 1}{x^2 + 2x + 1}$

5. (a) (i) Solve for x and y given that

$$\frac{x}{1+3i} + \frac{y}{1-i} = 3$$

(ii) When the polynomial $p(x) = x^3 + kx^2 - 2x + 1$ is divided by $x - k$, the remainder is k. Find the possible values of k.

(iii) Given that α and β are the roots of the equation $3x^2 + x + 2 = 0$, find the equation whose roots are $\frac{1}{\alpha}$ and $\frac{1}{\beta}$.

(b) Differentiate the following:

(i) $y = x^2(2x^2 - 1)^6$.

(ii) $y = \frac{x^2 - 1}{\sqrt{x+1}}$

(iii) $y = \operatorname{cosec}^2 3x$

(c) Prove that $\frac{\sin x \sec x}{\cot x + \tan x} = 1 - \cos^2 x$

6. (a) Given that $f(x) = \sqrt{-x^2 + 4x + 21}$

(i) Determine the domain of $f(x)$.

(ii) Solve for $f(x) \geq 9$.

(iii) Solve for $f(x) = \frac{4}{3}(x - 2)$.

(b) Let $f(x) = \frac{x}{x-1}$ and $g(x) = x^2$.

(i) Find $(fog)(x)$.

(ii) Show whether $(fog)(x)$ is even or not.

(iii) Find $\lim_{x\to\infty}(fog)(x)$.

(c) The Zambia National Service (ZNS) has a rectangular Car Park 20 meters wide and 35 meters long. They plan to increase the area of the car park by 236 square meters by adding a strip of equal width to one side and one end. Find the width of the strip to be added.

7. (a) (i) Given that $\sqrt{3}$ is irrational number prove that $2 + \sqrt{3}$ is irrational number.

(ii) Express the complex number $\frac{1}{(1-i)^2} - \frac{1}{(1+i)^2}$

in the form $a + ib$ where a and b are real numbers.

(iii) Find the general solution for θ for the equation

$$2 \sin^2\theta - 3 \cos \theta = 0.$$

(b) (i) Find $\frac{dy}{dx}$ given that $y = x^2 \cot x$.

(ii) Find the values of x which satisfy the inequality

$$|2x + 5| < 3x - 5.$$

(iii) Find values of x for which $\frac{3}{x+3} < \frac{2}{x-1}$.

(c) The rate of photosynthesis of a plant denoted by $p(I)$ is given by

$p(I) = \frac{I}{a + bI}$, $I \geq 0$ where a, b are costants, and I is the light intersity.

(i) Find $p'(I)$

(ii) Find $p'(0)$

(iii) Find $\lim\limits_{I\to\infty} p'(I)$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

M161: **INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS 1**

TIME: **THREE (3) HOURS**

INSTRUCTIONS:

1. You must write your **Computer Number** on each answer booklet used.
2. Indicate the number of each question attempted in the first column on the main answer booklet.
3. There are **SIX (6)** questions in this paper. Candidates must answer **ANY FIVE (5)** questions only. All questions carry equal marks.
4. Mathematical Tables and Calculators are **NOT** allowed in this examination.

1. (a) Determine the nature of the roots of the following quadratic equations.

(i) $2x^2 - 3x - 5 = 0$ (ii) $x^2 - 4x + 7 = 0$

Hence, sketch the function $f(x) = |2x^2 - 3x - 5|$ and find the minimum or maximum value of f(x).

(b) The Expression $b + ax - 4x^2 + 8x^3$ gives a remainder of -19 when divided by $(x + 1)$ and a remainder of -19 when divided by $(2x - 1)$.

Find the values of a and b.

2. (a) If $A = \{1, 2, 3, 4\}$, $B = \{2, 4, 6, 8\}$, $C = \{3, 4, 5, 6\}$ and the universal set $x = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$

(i) Find $(x - c)' \cap (A - B)$

(ii) State the laws which says $A \cup (A \cap C) = (A \cup B) \cap (A \cap C)$?

(iii) Confirm the law in (ii) using sets A, B, and C above

(b) (i) Show that $\log_y^x = \dfrac{1}{\log_x^y}$

(ii) Solve the simultaneous equations

$$\log_x^y + 2\log_y^x = 3$$

$$\log_9^y + \log_9^x = 3$$

3. (a) If α and β are the roots of the equations $x^2 - x - 3 = 0$, without solving, find the values of

(i) $\alpha^2 + \beta^2$ (ii) $\dfrac{\alpha}{\beta} + \dfrac{\beta}{\alpha}$

(b) (i) The complex number z satisfies $\dfrac{z}{z+2} = 2 - i$. Find the real and imaginary parts of z and the modulus and argument of z.

(ii) Solve $x^2 + 2x + 6 = 0$

4. (a) Given that $f(x) = 3 - 7x + 5x^2 - x^3$,

(i) Show that $3 - x$ is a factor.

(ii) Factorize $f(x)$ completely

(iii) Determine the set of values of $\hat{x}$ for which $f(x) \leq 0$.

(b) Solve (i) $6\cos^2 x - \cos x - 1 = 0, \quad 0^\circ \leq x \leq 360^\circ$. Consider the standard angles only.

(ii) $\sqrt{1-2x} - \sqrt{x+1} = 3$

5. (a) (i) Expand $(1 + x)^{15}$ in ascending powers of x up to and including the term in x^3, and hence

(ii) Evaluate $(1.01)^{15}$ correct to three decimal places.

(b) Express $\dfrac{x^3}{(x+4)(x-1)}$ in partial fractions.

6. (a) Express the following in the form $a + bi$

(i) $\dfrac{2i}{1-i}$ (ii) $\dfrac{(a+ib)^2}{b-ai}$

(iii) $(3 + 4i)(1 - 2i)$ (iv) If $z = -1 - i\sqrt{3}$, find $|z|$.

(b) Show that $a + b$ is irrational if a is irrational and b is rational.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC FIRST SEMESTER
FINAL EXAMINATIONS

M 211 MATHEMATICAL METHODS III

TIME: **THREE (3) HOURS**

INSTRUCTIONS: **(i) Answer any five questions.**

(ii) Indicate the number of each question answered on your main answer book.

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1. The equation of the conic is

$$x^2 + 2xy + y^2 + 6x - 6y = 0$$

(a) Express the equation in standard form.
Hence, or otherwise identify the curve.

(b) Find (i) the focus (foci)

(ii) the vertex (vertices)

(iii) the directrix (directrices)

(c) The orbit of the earth is an ellipse with the sun at one focus. The planet's maximum distance from the sun is 94.56 million miles and its minimum distance is 91.44 million miles.
Find the lengths of the major and minor semi axes of the earth's orbit, and what is its eccentricity?

2. (a) Give the definition of $\lim_{x \to c} f(x) = L$.

Hence, prove that $\lim_{x \to 4}(x^2 - 9) = 7$

(b) Evaluate the limits

(i) $\lim_{x \to 0} x^2 \ln x$

(ii) $\lim_{x \to 0}\left(\frac{1}{x} - \frac{1}{e^x - 1}\right)$

(iii) $\lim_{x \to \frac{\pi}{2}^+} (\tan x)^{\cos x}$

(c) The intrinsic equation of a curve is $s = 12 \sin^2 \psi$ where s is measured from the point (-8, 0). Show that

$$x^{\frac{2}{3}} + y^{\frac{2}{3}} = 4$$

is the cartesian equation of the curve.

3. (a) State Rolle's theorem.

Hence, show that the function f defined by

$$f(x) = x^{\frac{1}{2}} - x^{\frac{3}{2}}$$

on [0, 1] satisfies the hypothesis of Rolle's theorem on the interval, and find the number c that satisfies the conclusion of the theorem.

(b) State the Mean Value theorem.

Hence, use it to approximate the value of $(2.003)^2$.

(c) Find the equation of the circle of curvature of the curve

$$2xy + x + y = 4$$

at the point (1, 1).

4. (a) Find the sum of the series

(i) $\sum_{n=1}^{\infty} \left(\frac{2^{n+1}}{5^n} \right)$

(ii) $\sum_{n=0}^{\infty} \frac{1}{(4n-3)(4n+1)}$

(b) Find the power series $y = \sum_{n=0}^{\infty} c_n x^n$ satisfying the conditions $y = 1$ when $x = 0$, $y' = 1$ when $x = 0$ and $y'' + y = 0$.

(c) Express $\sin x$ as a Taylor's series in powers of $(x - \pi)$.

Hence, find the interval for which the series converges.

5. (a) Evaluate the integrals

(i) $\int x^3 \sqrt{4 + x^2}\, dx$

(ii) $\int \frac{\cos t}{5 - 3\cos t}\, dt$

(iii) $\int_3^5 \frac{5x}{x^2 + x - 6}\, dx$

(b) By revolving the region bounded by the graphs of $y = \ln x$, $y = 0$ and $x = e$ about the x-axis, find the volume of the solid generated.

6. (a) Given that

$$I_n = \int_0^{\pi} \sin^{2n} dx, \qquad n \geq 1,$$

show that

$$I_n = \frac{2n-1}{2n} I_{n-1}$$

Hence or otherwise, find I_3

(b) For the curve with equation

$$y = (1-x)\sqrt{\frac{x}{3}},$$

show that

$$1 + \left(\frac{dy}{dx}\right)^2 = \frac{(3x+1)^2}{12x}.$$

(i) Find the length of the curve from the origin O to the point A(1, 0).

The area of the curve OA is rotated through 360° about the x-axis.

(ii) Find the area of surface generated.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M361: MATHEMATICAL STATISTICS

INSTRUCTIONS:

1. Answer any FIVE (5) questions.
2. Calculators are allowed.
3. You may use statistical tables provided.
4. Show all your work to earn full marks.

TIME: THREE (3) Hours

1. (a) Suppose that the random variable X has a Uniform distribution UNI(-1, 1) and that $Y = X^2$

   (i) Write down the functional form of the probability density function of X

   (ii) Determine the probability density function of Y.

   (b) Let X_1 and X_2 be independent exponential random variables such that $X_i \sim EXP(1)$. Hence, the joint probability density function of X_1 and X_2 is given as

$$f(x_1, x_2) = \begin{cases} e^{-(x_1+x_2)}, & x_1, x_2 > 0 \\ 0 \quad , & \text{elsewhere} \end{cases}$$

   (i) Sketch the region of X_1 and X_2 for which $f(x_1, x_2) > 0$

   (ii) Sketch the region corresponding to the transformation $Y_1 = X_1$ and $Y_2 = X_1 + X_2$

   (iii) Find the joint probability density function for Y_1 and Y_2

   (iv) Find the marginal density function for Y_2

2. (a) Let

$$X_i = \begin{cases} 1 & \text{if an } i^{th} \text{ animal is infected by a disease ,} \qquad i = 1, 2 \ldots, n. \\ 0 & \text{if the } i^{th} \text{ animal is not infected by the disease} \end{cases}$$

   and the probability density function of X_i be given by

$$f(x_i) = \theta^{x_i} (1 - \theta)^{1-x_i}$$

   where $x_i = 0, 1$, and θ is the probability that a randomly selected animal from a herd is infected by the disease.

   (i) Determine the moment generating function of X_i.

   (ii) If $X_1, X_2, \ldots, X_n$ is a random sample representing the status of n animals such that X_i has the distribution above, find the probability density function of $Y = X_1 + X_2 + \ldots + X_n$

   (iii) What does Y in (ii) represent?

   (b) The distribution of the time (in hours) a runner takes to complete a race-track is given by the exponential distribution

$$f(t)=\begin{cases}\frac{1}{2}e^{-\frac{t}{2}} & , \quad t>0 \\ 0 & , \quad \text{elsewhere}\end{cases}$$

$T_1, T_2, \ldots, T_n$ represent a random sample of running times of n runners taking part in a race competiti

(i) State the probability density function of $Y = \text{Maximum}\{T_1, T_2, \ldots, T_n\}$

(ii) A prize is awarded to a runner if he/she completes the race within 2 hours. If a team sends three runners to the competition, find the probability that all three runners will receive prizes. (Hint: m use of your result in (i)).

3. Let $Y_1, Y_2, \ldots, Y_n$ denote a random sample from a probability density function given by

$$f(y)=\begin{cases}\frac{1}{\Gamma(\alpha)\theta^{\alpha}}y^{\alpha-1}e^{-\frac{y}{\theta}} & , \quad y>0 \\ 0 & , \quad \text{elsewhere}\end{cases}$$

(a) (i) Find a sufficient statistic for θ if α is known.

(ii) Find the maximum likelihood estimator $\hat{\theta}_{MLE}$ for θ if α is known.

(iii) Find the method of moments estimator $\hat{\theta}_{MME}$ for θ if α is known. (HINT: $\Gamma(\alpha+1)=\alpha\Gamma(\alpha)$)

(b) (i) How do $\hat{\theta}_{MLE}$ and $\hat{\theta}_{MME}$ compare?

(ii) Find the expected value of $\hat{\theta}_{MLE}$.

(iii) Find the variance of $\hat{\theta}_{MLE}$

(iv) Stating any relevant definition or theorem show that $\hat{\theta}_{MLE}$ is a consistent estimator for θ.

4. Suppose that (X_i, Y_i); $i = 1, 2, \ldots, n$ are independent pairs of a set of measurements between X and Y where we assume X to be fixed and Y to be random. Further, the relationship between X and Y is assumed to be of th form:

$$Y_i = \beta X_i + E_i, \quad i = 1, 2, \ldots, n,$$

where $\mathbf{E}(E_i) = 0$ and Variance of $E_i = \sigma^2$ and E_i s are independent and have an identical normal distribution, and consequently, the distribution of Y_i is

$$f(y_i)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{(y_i-\beta x_i)^2}{2\sigma^2}} \quad , \quad \sigma^2>0, -\infty<y_i<\infty$$

(a) Find the maximum likelihood estimator $\hat{\beta}_{MLE}$ for β

(b) Show that $\hat{\beta}_{MLE}$ can be expressed in the form $\hat{\beta}_{MLE} = \sum_{i=1}^{n} w_i y_i$, where w_i is a function of $x_1, x_2, \ldots, x_n$.

(c) Find the variance of $\hat{\beta}_{MLE}$ by utilizing the form given in (b).

(d) Given that $\lim_{n\to\infty}\frac{1}{n}\sum_{i=1}^{n}x_i^2 = \mu_2' \neq 0$, show that $\lim_{n\to\infty}\text{Var}(\hat{\beta}_{MLE}) = 0$

(e) Based on your result in (d) what can you say about the consistence of $\hat{\beta}_{MLE}$?

5. A random sample $X_1, X_2, \ldots, X_n$ of size 25 is drawn from a normal population believed to have a mean c and a standard deviation of 8. The test: $H_0: \mu = 20$ versus $H_a: \mu = 25$, is of interest.

(a) (i) State the method of moments estimator you would use to carry out the test.

(ii) Determine the size of the test if the critical value is set at $C = 23$

(iii) Determine the power of this test if the critical value is set at $C = 23$

(iv) Which direction should the critical value move to increase the power of the test?

(b) (i) What sample size will yield a power of 80% if the critical value is set at $C = 23$?

(ii) What sample size will be required to achieve a Type I error of 5% and a Type II error of 10%

(iii) Which direction will the sample size in (ii) go if $H_a: \mu = 30$?

6. (a) Let $Y_1, Y_2, \ldots, Y_n$ denote a random sample from a population with mean μ and variance σ^2. Consider the following three estimators for μ:

$$\hat{\mu}_1 = \frac{1}{2}(Y_1 + Y_2), \quad \hat{\mu}_2 = \frac{1}{4}Y_1 + \frac{Y_2 + \ldots + Y_{n-1}}{2(n-2)} + \frac{1}{4}Y_n \quad \text{and} \quad \hat{\mu}_3 = \frac{\sum_{i=1}^{n} Y_i}{n}$$

(i) Show that each of three estimator is unbiased

(ii) Find the efficiency of $\hat{\mu}_3$ relative to $\hat{\mu}_1$ and $\hat{\mu}_2$, respectively.

(iii) Given that the most efficient of the three estimators attains the Cramer-Rao Lower Bound, fin value of the bound. (Note that you are not asked to show that it attains!)

(b) (i) State the Neyman –Pearson Lemma

(ii) Suppose that the random variable X has the probability density function

$$f(x) = \begin{cases} (\gamma+1)x^{\gamma}, & 0 < x < 1 \\ 0, & \text{otherwise} \end{cases}$$

We wish to test $H0: \gamma = \gamma_0$ versus $Ha: \gamma = \gamma_1$ where $\gamma_0 < \gamma_1$ based on a random sample $X_1, X_2, \ldots, X_n$.

Show that the most powerful test of rejecting H_0 is of the form $\sum_{i=1}^{n} \ln(x_i) \geq K$ for some const K.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

DEPARTMENT OF MATHEMATICS AND STATISTICS

UNIVERSITY EXAMINATIONS

FIRST SEMESTER 2004

M411

THEORY OF FUNCTIONS OF A COMPLEX VARIABLES I

TIME: THREE HOURS

ANSWER ANY FIVE QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

TOTAL MARKS: 100

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1. (a) Given Green's theorem

$$\int_C P(x,y)dx + Q(x,y)dy = \iint_R \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right) dxdy$$

where C is a contour enclosing the region R, and $P(x,y)$, $Q(x,y)$, $\frac{\partial Q}{\partial x}$ and $\frac{\partial P}{\partial y}$ are continuous on the contour and in the region R, prove the Cauchy-Goursat theorem

$$\oint f(z)dx = 0$$

where $f(z)$ is an analytic function. [6]

(b) (i) Prove Cauchy's integral formula

$$f(z_0) = \frac{1}{2\pi i}\oint \frac{f(z)}{(z - z_0)}dz \quad [8]$$

(ii) Hence or otherwise, find the value of the integral

$$I = \oint \frac{2z^2 + 7z + 1}{z(z - 2i)}dz$$

around the closed contour $|z| = 1$. [6]

2. (a) Show that for a function $f(z) = u(x,y) + iv(x,y)$ to be analytic, it must satisfy the Cauchy-Riemann equations

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} \text{ and } \frac{\partial v}{\partial x} = -\frac{\partial u}{\partial y} \quad [7]$$

(b) (i) Show that in the curvilinear coordinates (r, θ) where $x = e^r \cos\theta$ and $y = e^r \sin\theta$, the Cauchy-Riemann equations have the form

$$-\sin\theta\frac{\partial u}{\partial \theta} + \cos\theta\frac{\partial u}{\partial r} = \cos\theta\frac{\partial v}{\partial \theta} - \sin\theta\frac{\partial v}{\partial r}$$

and

$$\cos\theta\frac{\partial u}{\partial \theta} + \sin\theta\frac{\partial u}{\partial r} = \sin\theta\frac{\partial v}{\partial \theta} - \cos\theta\frac{\partial v}{\partial r} \quad [10]$$

.(ii) Show that they can be cast in the form

$$\frac{\partial u}{\partial r} = \frac{\partial v}{\partial \theta} \text{ and } \frac{\partial u}{\partial \theta} = -\frac{\partial v}{\partial r} \qquad [3]$$

3. (a) (i) Use the Cauchy integral formula

$$f^{(n)}(z_0) = \frac{n!}{2\pi i} \int_C \frac{f(z)}{(z - z_0)^{n+1}} dz$$

to prove Cauchy's inequality

$$\left| f^{(n)}(z_0) \right| \leq \frac{n! M}{r_0^n}$$

where C is a circular contour of radius r_0 centred on z_0 and M is the maximum value of $|f(z)|$ on C. [10]

(ii) Prove the maximum modulus theorem and the minimum modulus theorem

$$|f(z)| \leq M \text{ and } |f(z)| \geq N$$

where M and N are the maximum and minimum values of $|f(z)|$ on the contour respectively. [3]

(b) Evaluate the integral

$$I = \int_C e^z dz$$

where C is the boundary of the square whose sides lie along the lines $x = \pm 1$ and $y = \pm 1$ and is described in the positive sense. [7]

4. (a) (i) Prove that the real or imaginary part of an analytic function is harmonic. [3]

(ii) Prove that

$$u(x, y) = \sinh x \cos y - y$$

is harmonic and find its harmonic conjugate. [7]

(b) (i) Prove the triangle inequality

$$|z_1 + z_2| \leq |z_1| + |z_2| \qquad [6]$$

(ii) Hence prove that

$$||z_1| - |z_2|| \leq |z_1 - z_2| \qquad [4]$$

5. (a) (i) Prove that the transformation

$$\frac{(w-w_1)(w_2-w_3)}{(w-w_3)(w_2-w_1)} = \frac{(z-z_1)(z_2-z_3)}{(z-z_3)(z_2-z_1)}$$

has the general bilinear form

$$w = \frac{a+bz}{c+dz} \quad [7]$$

(ii) Hence obtain the linear fractional transformation that maps the points i, $-i$ and 1 into 0, 1 and ∞ respectively. [3]

(b) Under the bilinear transformation

$$w = \frac{3i}{z+2}$$

the region $x + y \geq 0$ is transformed into the interior of a circle in the w plane. Find the centre and radius of the circle. [10]

6. (a) (i) Define uniform convergence of a series of complex functions. [3]

(ii) State and prove the Weierstrass M test. [5]

(b) Use the ratio test to obtain the region of convergence of the series

$$z - \frac{z^2}{2} + \frac{z^3}{3} - \frac{z^4}{4} \cdots = \sum_{n=1}^{\infty} (-1)^{n+1} \frac{z^n}{n} \quad [5]$$

(c) Determine the principal value of $(1+i)^{2+3i}$. [7]

7.(a) Determine the value of $\left(\frac{1+\sqrt{3}i}{1-\sqrt{3}i}\right)^8$. [5]

(b) Obtain the value of $\sin^{-1}(\sqrt{3}/2)$ by first deriving a formula for $\sin^{-1} z$. [7]

(c) Let S be the set of all points $a+bi$ where a and b are rational numbers which lie inside the square with vertices at $z = 0, 1, 1+i$ and i. Answer the following, giving reasons for your answers.

(i) Is S bounded? [2]

(ii) What are the limit points of S, if any? [2]

(iii) What are the interior and boundary points of S? [2]

(iv) Is S connected? [2]

*****END OF EXAMINATION*****

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

M421: STRUCTURE AND REPRESENTATIONS OF GROUPS

TIME: THREE (3) HOURS

INSTRUCTIONS: Attempt four (4) questions in all with at least two(2) questions from Section A and at least one question from Section B.

SECTION A (STRUCTURE OF GROUPS)

1. Define each of the following terms:

(i) A normal series of a finite group

(ii) A commutator (derived) subgroup G ′ of a group G.

(a) Prove that

(i) if a group G has a normal series

$$G = G_0 \supseteq G_1 \supseteq \ldots \supseteq G_r = \{e\}$$

Then every subgroup N of G possess a normal series

(ii) if G has anormal subgroup N such that the factor group G/N is abelian, then N contains the commutator (derived) subgroup G ′ of G.

(b) Show that if N is a normal subgroup of a group G such that $N \cap G' = \{e\}$, then N contains the centre Z(G) of G.

2. Let G be a permutation group acting on a set Ω. Then explain the meaning of each of the following terms:

(i) the stabilizer G_α of $\alpha \in \Omega$ in G

(ii) G is a primitive permutation group.

(a) Show that :

(i) the stabilizer G_α is a subgroup of G for each $\alpha \in \Omega$ (ii) and that if G is transitive on Ω then the stabilizers G_α of $\alpha \in \Omega$ are all conjugate in G.

(b) Show that a nontrivial normal subgroup N of a primitive permutation group G is transitive.

3. Define each of the following terms:

(i) A solvable group

(ii) A nilpotent group

(a) Prove that

(i) if a solvable group G contains a normal subgroup N, then the factor group G/N is also solvable.

(ii) if G is a nilpotent group which contains a subgroup H, then H is also nilpotent. Hence deduce that H is solvable.

(b) Show that the symetric group S_5 of degree 5 is not solvable.

SECTION B (REPRESENTATIONS OF GROUPS)

4. What is the meaning of the terms:

   (i) a left regular representation of a group G?

   (ii) the character of a representation

(a) Let $\theta : G \rightarrow S_n$ be a mapping from a finite group G to the symmetric group S_n of degree n given by

$$\theta(g) = \begin{pmatrix} x_1 & x_2 & \ldots & x_n \\ \theta x_1, & \theta x_2, & \ldots, & \theta x_n \end{pmatrix}$$

where $x_i \in G$ and $\theta \in S_n$. Then prove that θ is a representation of G.

(b) Give the left regular representation of the group D_3 defined by

$$D_3 = < a, b / a^3 = b^2 = e,\ ba = a^2 b >$$

Hence give the character values of this representation for each element of the group.

5. Give the meaning of each of the following terms:

   (i) a reducible representation of a group G?

   (ii) a group character X of a group G?

(a) (i) Prove that a group character of a group is a class function on G.

   (ii) State Schur's Lemma

(b) Given that a matrix representation T of a group G over the field of rationals is such that for a certain element x in the Z(G) of G,

$$T(x) = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix},$$

Then

(i) show that the matrix A given by

$$A = I_2 + T(x)$$

Satisfies the condition

$$T(g)\,A = A\,T(g), \text{ for all } g \in G.$$

(ii) deduce that T is a reducible representation of G over Q.

6. What is the meaning of each of the following;

(i) a completely reducible representation of a group G.

(ii) a character table of a group G.

(a) State and prove the Maschke's theorem

(b) (i) Let $T : G \to GL(2, \mathbf{R})$ be a mapping such that

$$T(a) = \begin{pmatrix} 0 & 1 \\ -1 & -1 \end{pmatrix}.$$

Then show that T is an irreducible representation of G.

(ii) Show that the mapping $T^j : G \to C$ given $T^j(g^k) = \omega^{jk}$, $j = 0, 1, \ldots, n - 1$ where $\omega = e^{\frac{2\pi i}{n}}$ is a representation of the group G defined by $G = \langle g / g^n = e \rangle$. Hence obtain a character table for the cyclic group of order 3.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M 431: REAL ANALYSIS V

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS

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1. (a) Define a separable space.

   (b) Prove that the set of real numbers **R** is a separable space.

2. Give the ternary expansion of $x \in [0, 1]$.

3. (a) Let X be a metric space and $A \subset X$.

      (i) Define the interior of A;
      (ii) Define the closure of A;
      (iii) When is A said to be no-where dense?

   (b) (i) Give an example of a no-where dense set.

      (ii) Show that the set in 3. (b)(i) is no-where dense.

4. (a) Define the following:

      (i) equivalent sets;
      (ii) a finite set.

   (b) Suppose A is a finite set and B is a subset of A. Prove that if B is equivalent to A then B = A.

5. (a) Define the following:

(i) For $1 \leq p < \infty$, ℓ^p; and $\| x \|_p$ for $x \in \ell^p$

(ii) ℓ^∞; and $\| x \|_\infty$ for $x \in \ell^\infty$

(b) If $1 \leq p < q < \infty$, show that

(i) $\ell^p \subset \ell^q$
(ii) $\ell^p \subset \ell^\infty$

(c) Let $1 \leq p < \infty$. Prove that for $x, y \in \ell^p$, $x = y$ if and only if $\|x - y\|_p = 0$.

6. (a) If A and B are countable sets, prove that $A \cup B$ is a countable set and deduce that a countable union of countable sets is countable.

(b) Find a bijection $f : [0, 1] \rightarrow (0, 1)$

7. (a) Define a partial order relation in a non-empty set.

(b) Let W be a well-ordered set and suppose $g : W \rightarrow W$ is order preserving and injective. Show the $x \leq g(x)$, $\forall x \in W$.

(c) In the set $\mathbf{N} \times \mathbf{N}$, $(m_1, n_1) \leq (m_2, n_2)$ if and only if one of the following holds

(i) $m_1 < m_2$

(ii) $m_1 = m_2$ and $n_1 \leq n_2$.

Show that $\leq$ is a partial order in $\mathbf{N} \times \mathbf{N}$.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

M461: MULTIVARIATE ANALYSIS

TIME: THREE (3) HOURS **DATE: JULY 22, 2004**

INSTRUCTIONS:
i. ANSWER ANY FIVE (5) QUESTIONS
ii. ALL QUESTIONS CARRY EQUAL MARKS
iii. SHOW YOUR WORKING TO EARN FULL MARKS
iv. CALCULATORS AND TABLES ARE ALLOWED

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1. (a) If x is distributed as $N_5(\mu, \Sigma)$, find the distribution of $\begin{pmatrix} x_2 \\ x_4 \end{pmatrix}$.

(b) Given the random vector $x^T = (x_1, x_2, \ldots, x_5)$ with mean vector $\mu^T = (-1, 2, 1, 4, 1)$ and variance-covariance matrix.

$$\Sigma_x = \begin{pmatrix} 2 & -1 & 0 & 1 & 3 \\ -1 & 2 & 4 & 0 & 1 \\ 0 & 4 & 2 & 1 & 1 \\ 1 & 0 & 1 & -1 & 0 \\ 3 & 1 & 1 & 0 & 5 \end{pmatrix}$$

partition x as $\begin{pmatrix} x_1 \\ x_2 \\ -- \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} x^1 \\ \\ -- \\ \\ \\ x_2 \end{pmatrix}$

Let $A = \begin{pmatrix} 2 & 0 \\ 1 & -1 \end{pmatrix}$ $B = \begin{pmatrix} 1 & 3 & 1 \\ 0 & 1 & -1 \end{pmatrix}$

Find (i) $E(A x^1)$ (ii) $\text{cov}(A x^1)$

(iii) $\text{cov}(A x^1, B x^2)$

(c) Let X be $N_3(\mu, \Sigma)$ with $\mu^T = (-1, 2, -4)$ and $\sum_x = \begin{pmatrix} 3 & 1 & -2 \\ 1 & 1 & 4 \\ -2 & 4 & 4 \end{pmatrix}$

(i) Determine whether (x_1, x_2) and x_3 are independent

(ii) Find a 2 x 1 vector p such that x_2 and $x_2 + p^T \begin{pmatrix} x_1 \\ x_3 \end{pmatrix}$ are independent.

2. (a) Let Σ be the covariance matrix associated with the random vector $x^T = (x_1, x_2, x_3, \ldots x_p)$.

Show that if (λ_1, e_1), (λ_2, e_2) .... (λ_p, e_p) are the eigenvalue - eigen vector of Σ then

(λ_1^{-1}, e_1), (λ_2^{-1}, e_2) .... (λ_p^{-1}, e_p) are the eigen value - eigen vector of Σ^{-1}.

(b) Let X have covariance matrix

$$\sum = \begin{pmatrix} 25 & 0 & 0 \\ 0 & 16 & 0 \\ 0 & 0 & 4 \end{pmatrix}$$

(i) Find

α Σ^{-1}

β the eigen values and eigen vectors of Σ.

γ the eigen values and eigen vectors of Σ^{-1}.

(c) If $x_1, x_2, \ldots x_n$ are mutually independent with $x_i \sim N_p(\mu_i, \Sigma)$ then show that

$$\begin{pmatrix} v_1 \\ v_2 \end{pmatrix} \sim N_{2p} \left[\begin{pmatrix} c_1\mu_1 + \ldots c_n\mu_n \\ b_1\mu_1 + \ldots b_n\mu_n \end{pmatrix} \begin{pmatrix} (c^Tc)\sum & (b^Tc)\sum \\ (b^Tc)\sum & (b^Tb)\sum \end{pmatrix} \right]$$

where $v_1 = c_1x_1 + c_2x_2 + \ldots + c_nx_n$ and

$v_2 = b_1x_1 + b_2x_2 + \ldots + b_nx_2$

3. (a) Define the following terms:

(i) p - dimensional normal density
(ii) p - dimensional Wishart distribution with m degrees of freedom.

(b) Show that if

$$\left(\frac{x_1}{x_2}\right) \sim N_p\left[\left(\frac{\mu_1}{\mu_2}\right), \left(\frac{\Sigma_{11} \quad \Sigma_{12}}{\Sigma_{21} \quad \Sigma_{22}}\right)\right]$$

then the conditional distribution of x_1 given $x_2 = x_2$ is normal with mean $= \mu_{1/2} = \mu_1 + \Sigma_{12}\,\Sigma_{22}^{-1}\,(x_2 - \mu_2)$

and

covariance $= \Sigma_{1/2} = \Sigma_{11} - \Sigma_{12}\,\Sigma_{22}^{-1}\,\Sigma_{21}$

(c) (i) Find the maximum likelihood estimates of the 2 x 1 mean vector μ and the 2 x 2 covariance matrix Σ based on the random sample.

$$x = \begin{pmatrix} 1 & 8 & 9 & 6 \\ 8 & 2 & 10 & 4 \end{pmatrix}$$

from a bivariate normal population.

(ii) If c_1 and c_2 are independent with $c_1 \sim W_p(K_1, \Sigma)$ and $c_2 \sim W_p(K_2, \Sigma)$ with m degrees of freedom,

α) State the distribution of $c_1 + c_2$.

β) Given that B is a q x p matrix, state the distribution of BC_1B^T.

4. (a) Define the following terms

(i) T^2 statistic for testing

$Ho : \mu = \mu_o$ versus $H_1 : \mu \neq \mu_o$

(ii) Wilk's Lambda statistics

(b). Let the data matrix for a random sample of size $n = 4$ from a bivariate population be

$$X = \begin{pmatrix} 4 & 5 & 5 & 6 \\ 11 & 11 & 10 & 12 \end{pmatrix}$$

(i) Evaluate the observed T^2 for $H_o : \mu_o^T = (10, 4)$ at the $\alpha = 0.05$ level.

Comment on the result

(ii) Evaluate the Wilk's Lambda

(iii) Show that T^2 remains unchanged if each observation x_j, $j = 1, 2, 3$ is replaced by cx_j where

$$c = \begin{pmatrix} 2 & -1 \\ 1 & 0 \end{pmatrix}$$

(c) Let the differences $D_1, D_2, \ldots, D_{10}$ be independent $N_2(\delta, \Sigma_d)$ random vectors about two sets of data x_1 and x_2 as shown below:

$$\bar{D} = \begin{pmatrix} \bar{d}_1 \\ \bar{d}_2 \end{pmatrix} = \begin{pmatrix} -6.41 \\ 11.23 \end{pmatrix}, \quad S_d = \begin{pmatrix} 12.02 & 58.14 \\ 58.14 & 318.15 \end{pmatrix}$$

(i) Evaluate T^2.

(ii) Using (i), test $H_o : \delta^1 = [0, 0]$ and $H_a : \delta^1 \neq [0, 0]$ at the $\alpha = 0.05$ level.

Comment on your result.

(iii) Calculate the 95% simultaneous confidence intervals for the mean differences $\mu_1 - \mu_2$.

5. (a) Suppose that $n_1 = 11$ and $n_2 = 12$ observations are made on two random variables x_1 and x_2, where x_1 and x_2 are assumed to have a bivariate normal distribution with a common covariance matrix Σ but possibly different mean vectors μ_1 and μ_2.

The sample mean vectors and pooled covariance matrix are

$$\bar{x}_1 = \begin{pmatrix} -1 \\ 1 \end{pmatrix} \quad \bar{x}_2 = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$$

$$S_{pooled} = \begin{pmatrix} 7.3 & -1.1 \\ -1.1 & 4.8 \end{pmatrix}$$

(i) Test for differences in population mean vectors using Hotelling's two-sample T^2 - statistic at $\alpha = 0.05$ level.

(ii) Construct 95% simultaneous confidence intervals for the differences $\mu_{1i} - \mu_{2i}$, $i = 1, 2$.

(b) (i) State and prove the cauchy-swhartz inequality for two vectors a and b

(ii) Confirm the inequality in part (i) by taking

$$a^1 = (1, -2, -1), \; b^1 = (5, -3, 2)$$

6. The test results for the three tests x_1, x_2 and x_3 for 60 college students were summarized as follows:

$$\bar{x} = \begin{pmatrix} \bar{x}_1 \\ \bar{x}_2 \\ \bar{x}_3 \end{pmatrix} = \begin{pmatrix} 527.74 \\ 54.69 \\ 25.13 \end{pmatrix}$$

$$S = \begin{pmatrix} 5691.34 & & \\ 600.51 & 126.05 & \\ 217.25 & 23.37 & 23.11 \end{pmatrix}$$

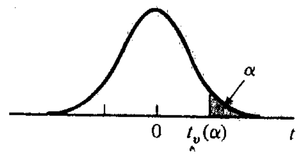
(i) Compute the 95% simultaneous confidence intervals for μ_1 μ_2 and μ_3

(ii) Construct the 95% Bonferroi confidence intervals for μ_1 μ_2 and μ_3

(iii) What advantage, if any, do the T^2 - confidence interval have over the Bonferroi intervals?

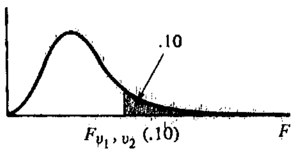
END OF EXAMINATION

TABLE 2 STUDENT'S *t*-DISTRIBUTION CRITICAL POINTS



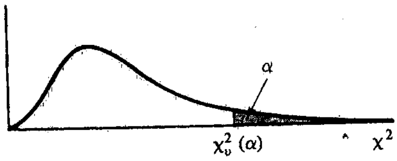
d.f. ν	α .250	.100	.050	.025	.010	.00833	.00625	.005
1	1.000	3.078	6.314	12.706	31.821	38.190	50.923	63.657
2	.816	1.886	2.920	4.303	6.965	7.649	8.860	9.925
3	.765	1.638	2.353	3.182	4.541	4.857	5.392	5.841
4	.741	1.533	2.132	2.776	3.747	3.961	4.315	4.604
5	.727	1.476	2.015	2.571	3.365	3.534	3.810	4.032
6	.718	1.440	1.943	2.447	3.143	3.287	3.521	3.707
7	.711	1.415	1.895	2.365	2.998	3.128	3.335	3.499
8	.706	1.397	1.860	2.306	2.896	3.016	3.206	3.355
9	.703	1.383	1.833	2.262	2.821	2.933	3.111	3.250
10	.700	1.372	1.812	2.228	2.764	2.870	3.038	3.169
11	.697	1.363	1.796	2.201	2.718	2.820	2.981	3.106
12	.695	1.356	1.782	2.179	2.681	2.779	2.934	3.055
13	.694	1.350	1.771	2.160	2.650	2.746	2.896	3.012
14	.692	1.345	1.761	2.145	2.624	2.718	2.864	2.977
15	.691	1.341	1.753	2.131	2.602	2.694	2.837	2.947
16	.690	1.337	1.746	2.120	2.583	2.673	2.813	2.921
17	.689	1.333	1.740	2.110	2.567	2.655	2.793	2.898
18	.688	1.330	1.734	2.101	2.552	2.639	2.775	2.878
19	.688	1.328	1.729	2.093	2.539	2.625	2.759	2.861
20	.687	1.325	1.725	2.086	2.528	2.613	2.744	2.845
21	.686	1.323	1.721	2.080	2.518	2.601	2.732	2.831
22	.686	1.321	1.717	2.074	2.508	2.591	2.720	2.819
23	.685	1.319	1.714	2.069	2.500	2.582	2.710	2.807
24	.685	1.318	1.711	2.064	2.492	2.574	2.700	2.797
25	.684	1.316	1.708	2.060	2.485	2.566	2.692	2.787
26	.684	1.315	1.706	2.056	2.479	2.559	2.684	2.779
27	.684	1.314	1.703	2.052	2.473	2.552	2.676	2.771
28	.683	1.313	1.701	2.048	2.467	2.546	2.669	2.763
29	.683	1.311	1.699	2.045	2.462	2.541	2.663	2.756
30	.683	1.310	1.697	2.042	2.457	2.536	2.657	2.750
40	.681	1.303	1.684	2.021	2.423	2.499	2.616	2.704
60	.679	1.296	1.671	2.000	2.390	2.463	2.575	2.660
120	.677	1.289	1.658	1.980	2.358	2.428	2.536	2.617
∞	.674	1.282	1.645	1.960	2.326	2.394	2.498	2.576

TABLE 4 F-DISTRIBUTION CRITICAL POINTS ($\alpha = .10$)



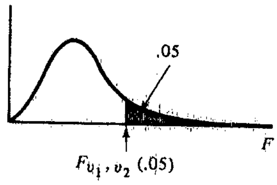
ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	60
1	39.86	49.50	53.59	55.83	57.24	58.20	58.91	59.44	59.86	60.19	60.71	61.22	61.74	62.05	62.26	62.53	62.79
2	8.53	9.00	9.16	9.24	9.29	9.33	9.35	9.37	9.38	9.39	9.41	9.42	9.44	9.45	9.46	9.47	9.47
3	5.54	5.46	5.39	5.34	5.31	5.28	5.27	5.25	5.24	5.23	5.22	5.20	5.18	5.17	5.17	5.16	5.15
4	4.54	4.32	4.19	4.11	4.05	4.01	3.98	3.95	3.94	3.92	3.90	3.87	3.84	3.83	3.82	3.80	3.79
5	4.06	3.78	3.62	3.52	3.45	3.40	3.37	3.34	3.32	3.30	3.27	3.24	3.21	3.19	3.17	3.16	3.14
6	3.78	3.46	3.29	3.18	3.11	3.05	3.01	2.98	2.96	2.94	2.90	2.87	2.84	2.81	2.80	2.78	2.76
7	3.59	3.26	3.07	2.96	2.88	2.83	2.78	2.75	2.72	2.70	2.67	2.63	2.59	2.57	2.56	2.54	2.51
8	3.46	3.11	2.92	2.81	2.73	2.67	2.62	2.59	2.56	2.54	2.50	2.46	2.42	2.40	2.38	2.36	2.34
9	3.36	3.01	2.81	2.69	2.61	2.55	2.51	2.47	2.44	2.42	2.38	2.34	2.30	2.27	2.25	2.23	2.21
10	3.29	2.92	2.73	2.61	2.52	2.46	2.41	2.38	2.35	2.32	2.28	2.24	2.20	2.17	2.16	2.13	2.11
11	3.23	2.86	2.66	2.54	2.45	2.39	2.34	2.30	2.27	2.25	2.21	2.17	2.12	2.10	2.08	2.05	2.03
12	3.18	2.81	2.61	2.48	2.39	2.33	2.28	2.24	2.21	2.19	2.15	2.10	2.06	2.03	2.01	1.99	1.96
13	3.14	2.76	2.56	2.43	2.35	2.28	2.23	2.20	2.16	2.14	2.10	2.05	2.01	1.98	1.96	1.93	1.90
14	3.10	2.73	2.52	2.39	2.31	2.24	2.19	2.15	2.12	2.10	2.05	2.01	1.96	1.93	1.91	1.89	1.86
15	3.07	2.70	2.49	2.36	2.27	2.21	2.16	2.12	2.09	2.06	2.02	1.97	1.92	1.89	1.87	1.85	1.82
16	3.05	2.67	2.46	2.33	2.24	2.18	2.13	2.09	2.06	2.03	1.99	1.94	1.89	1.86	1.84	1.81	1.78
17	3.03	2.64	2.44	2.31	2.22	2.15	2.10	2.06	2.03	2.00	1.96	1.91	1.86	1.83	1.81	1.78	1.75
18	3.01	2.62	2.42	2.29	2.20	2.13	2.08	2.04	2.00	1.98	1.93	1.89	1.84	1.80	1.78	1.75	1.72
19	2.99	2.61	2.40	2.27	2.18	2.11	2.06	2.02	1.98	1.96	1.91	1.86	1.81	1.78	1.76	1.73	1.70
20	2.97	2.59	2.38	2.25	2.16	2.09	2.04	2.00	1.96	1.94	1.89	1.84	1.79	1.76	1.74	1.71	1.68
21	2.96	2.57	2.36	2.23	2.14	2.08	2.02	1.98	1.95	1.92	1.87	1.83	1.78	1.74	1.72	1.69	1.66
22	2.95	2.56	2.35	2.22	2.13	2.06	2.01	1.97	1.93	1.90	1.86	1.81	1.76	1.73	1.70	1.67	1.64
23	2.94	2.55	2.34	2.21	2.11	2.05	1.99	1.95	1.92	1.89	1.84	1.80	1.74	1.71	1.69	1.66	1.62
24	2.93	2.54	2.33	2.19	2.10	2.04	1.98	1.94	1.91	1.88	1.83	1.78	1.73	1.70	1.67	1.64	1.61
25	2.92	2.53	2.32	2.18	2.09	2.02	1.97	1.93	1.89	1.87	1.82	1.77	1.72	1.68	1.66	1.63	1.59
26	2.91	2.52	2.31	2.17	2.08	2.01	1.96	1.92	1.88	1.86	1.81	1.76	1.71	1.67	1.65	1.61	1.58
27	2.90	2.51	2.30	2.17	2.07	2.00	1.95	1.91	1.87	1.85	1.80	1.75	1.70	1.66	1.64	1.60	1.57
28	2.89	2.50	2.29	2.16	2.06	2.00	1.94	1.90	1.87	1.84	1.79	1.74	1.69	1.65	1.63	1.59	1.56
29	2.89	2.50	2.28	2.15	2.06	1.99	1.93	1.89	1.86	1.83	1.78	1.73	1.68	1.64	1.62	1.58	1.55
30	2.88	2.49	2.28	2.14	2.05	1.98	1.93	1.88	1.85	1.82	1.77	1.72	1.67	1.63	1.61	1.57	1.54
40	2.84	2.44	2.23	2.09	2.00	1.93	1.87	1.83	1.79	1.76	1.71	1.66	1.61	1.57	1.54	1.51	1.47
60	2.79	2.39	2.18	2.04	1.95	1.87	1.82	1.77	1.74	1.71	1.66	1.60	1.54	1.50	1.48	1.44	1.40
120	2.75	2.35	2.13	1.99	1.90	1.82	1.77	1.72	1.68	1.65	1.60	1.55	1.48	1.45	1.41	1.37	1.32
∞	2.71	2.30	2.08	1.94	1.85	1.77	1.72	1.67	1.63	1.60	1.55	1.49	1.42	1.38	1.34	1.30	1.24

TABLE 3 χ^2 CRITICAL POINTS



d.f. ν	α .990	.950	.900	.500	.100	.050	.025	.010	.005
1	.0002	.004	.02	.45	2.71	3.84	5.02	6.63	7.88
2	.02	.10	.21	1.39	4.61	5.99	7.38	9.21	10.60
3	.11	.35	.58	2.37	6.25	7.81	9.35	11.34	12.84
4	.30	.71	1.06	3.36	7.78	9.49	11.14	13.28	14.86
5	.55	1.15	1.61	4.35	9.24	11.07	12.83	15.09	16.75
6	.87	1.64	2.20	5.35	10.64	12.59	14.45	16.81	18.55
7	1.24	2.17	2.83	6.35	12.02	14.07	16.01	18.48	20.28
8	1.65	2.73	3.49	7.34	13.36	15.51	17.53	20.09	21.95
9	2.09	3.33	4.17	8.34	14.68	16.92	19.02	21.67	23.59
10	2.56	3.94	4.87	9.34	15.99	18.31	20.48	23.21	25.19
11	3.05	4.57	5.58	10.34	17.28	19.68	21.92	24.72	26.76
12	3.57	5.23	6.30	11.34	18.55	21.03	23.34	26.22	28.30
13	4.11	5.89	7.04	12.34	19.81	22.36	24.74	27.69	29.82
14	4.66	6.57	7.79	13.34	21.06	23.68	26.12	29.14	31.32
15	5.23	7.26	8.55	14.34	22.31	25.00	27.49	30.58	32.80
16	5.81	7.96	9.31	15.34	23.54	26.30	28.85	32.00	34.27
17	6.41	8.67	10.09	16.34	24.77	27.59	30.19	33.41	35.72
18	7.01	9.39	10.86	17.34	25.99	28.87	31.53	34.81	37.16
19	7.63	10.12	11.65	18.34	27.20	30.14	32.85	36.19	38.58
20	8.26	10.85	12.44	19.34	28.41	31.41	34.17	37.57	40.00
21	8.90	11.59	13.24	20.34	29.62	32.67	35.48	38.93	41.40
22	9.54	12.34	14.04	21.34	30.81	33.92	36.78	40.29	42.80
23	10.20	13.09	14.85	22.34	32.01	35.17	38.08	41.64	44.18
24	10.86	13.85	15.66	23.34	33.20	36.42	39.36	42.98	45.56
25	11.52	14.61	16.47	24.34	34.38	37.65	40.65	44.31	46.93
26	12.20	15.38	17.29	25.34	35.56	38.89	41.92	45.64	48.29
27	12.88	16.15	18.11	26.34	36.74	40.11	43.19	46.96	49.64
28	13.56	16.93	18.94	27.34	37.92	41.34	44.46	48.28	50.99
29	14.26	17.71	19.77	28.34	39.09	42.56	45.72	49.59	52.34
30	14.95	18.49	20.60	29.34	40.26	43.77	46.98	50.89	53.67
40	22.16	26.51	29.05	39.34	51.81	55.76	59.34	63.69	66.77
50	29.71	34.76	37.69	49.33	63.17	67.50	71.42	76.15	79.49
60	37.48	43.19	46.46	59.33	74.40	79.08	83.30	88.38	91.95
70	45.44	51.74	55.33	69.33	85.53	90.53	95.02	100.43	104.21
80	53.54	60.39	64.28	79.33	96.58	101.88	106.63	112.33	116.32
90	61.75	69.13	73.29	89.33	107.57	113.15	118.14	124.12	128.30
100	70.06	77.93	82.36	99.33	118.50	124.34	129.56	135.81	140.17

TABLE 5 *F*-DISTRIBUTION CRITICAL POINTS ($\alpha = .05$)



ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	60
1	161.5	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	246.0	248.0	249.3	250.1	251.1	252.2
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.46	19.46	19.47	19.48
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.63	8.62	8.59	8.57
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.52	4.50	4.46	4.43
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.83	3.81	3.77	3.74
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.40	3.38	3.34	3.30
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.11	3.08	3.04	3.01
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.89	2.86	2.83	2.79
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.73	2.70	2.66	2.62
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.60	2.57	2.53	2.49
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.50	2.47	2.43	2.38
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.41	2.38	2.34	2.30
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.34	2.31	2.27	2.22
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.28	2.25	2.20	2.16
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.23	2.19	2.15	2.11
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.18	2.15	2.10	2.06
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.14	2.11	2.06	2.02
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.07	2.04	1.99	1.95
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.02	1.98	1.94	1.89
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.00	1.96	1.91	1.86
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.97	1.94	1.89	1.84
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.94	1.90	1.85	1.80
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.92	1.88	1.84	1.79
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.89	1.85	1.81	1.75
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.88	1.84	1.79	1.74
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.78	1.74	1.69	1.64
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.69	1.65	1.59	1.53
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.60	1.55	1.50	1.43
∞	3.84	3.00	2.61	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.51	1.46	1.39	1.32

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

M911: MATHEMATICAL METHODS V

TIME: THREE (3) HOURS

INSTRUCTIONS:

1. You must write your **Computer Number** on each answer booklet used.
2. Indicate the number of each question attempted in the first column on the main answer booklet.
3. There are **SIX (6)** questions in this paper. Candidates must answer **ANY FIVE (5)** questions only. All questions carry equal marks.
4. Mathematical Tables and Calculators are **NOT** allowed in this examination.

1. (a) Determine the flow lines and sketch the vector fields of the following fields:

(i) $F(x,y) = -3i + 4j$

(ii) $F(x,y) = xi + x^2j$

(b) Using the second partial derivative test, discuss the relative extrema of

$$f(x,y) = -x^3 + 4xy - 2y^2 + 1$$

2. (a) Verify that the vector field $F(x,y) = \dfrac{yi}{x^2+y^2} - \dfrac{xj}{x^2+y^2}$ is incompressible. Sketch the physical interpretation of this result?

(b) State the first order Taylor's Theorem. Derive the explicit value of the remainder $R_1(h,x_o)$. Hence, find the first order Taylor's formula for the function $f(x,y) = (x^2 + y^2 + 1)^{-1}$ at $x_o = 0$, $y_o = 0$.

3. (a) Determine whether the vector field is conservative. If it is , find the potential function for the vector field $F(x,y) = xe^{x^2y}(2yi + xj)$

(b) Find the arc length function s for the line segment given by $r(t) = 2ti + t^2j - \frac{1}{3}t^3k$, $0 \le x \le 1$. Hence, find the curvature of the curve.

4. (a) Let $D = [0,1]X[0,1]$ be the image of D* which is a parallelogram bounded by the lines $y = \frac{1}{2}x$, $y = \frac{1}{2}x + 2$, $y = 3x - 4$ and $y = 3x$ under some transformation T. Find T such that D is the image of D* under T.

(b) Apply the second derivative test to study the nature of the relative extrema of f, subject to the stated constraint.

$$f(x,y) = x, \quad x^2 + 2y^2 = 3.$$

5. (a) Classify and sketch the trace of the surface $z^2 - 2x^2 - 2y^2 = 12$. Hence, find the equation of the tangent plane to the given surface above at the point (1,-1,4). Show this tangent plane on your sketch. Express the given surface and the given point in cylindrical co-ordinates.

(b) Design a cylindrical can with a lid which can hold 1 litre of water, using the minimum amount of materials.

6. (a) Let T be a transformation under a 2x2 matrix $A = \begin{pmatrix} \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} \end{pmatrix}$,

and let D be the square whose vertices are (1,0) ,(0,1) , (-1,0) and (0,-1). Find D* with T(D*) = D. Hence, show that T is one-to-one , if and only if Det. A $\neq$ 0.

(b) Find the unit Tangent vector and principal unit Normal at t = 1 for the curve represented by $r(t) = ti + t^2 j + \frac{t^2}{2} k$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS
UNIVERSITY EXAMINATIONS
2004 ACADEMIC YEAR FIRST SEMESTER

MP415-MATHEMATICAL METHODS FOR PHYSICS

TIME: THREE (3) HOURS **MAX. MARKS 100**

INSTRUCTION: ATTEMPT ANY **FOUR (4)** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

You may use the following information

$$\int_{-\infty}^{+\infty} e^{-2\alpha x^2}\,dx = \sqrt{\frac{\pi}{2\alpha}} \qquad \int_{0}^{+\infty} x e^{-2\alpha x^2}\,dx = \frac{1}{4\alpha}$$

$$\int_{-\infty}^{+\infty} x^2 e^{-2\alpha x^2}\,dx = \frac{1}{4\alpha}\sqrt{\frac{\pi}{2\alpha}}$$

Q.1(a) The classical Hamiltonian for a mass-spring harmonic oscillator system is given by

$$H = \frac{p^2}{2m} + \frac{kx^2}{2}.$$

Express this Hamiltonian as a product of a complex number and its complex conjugate.
(3 marks)

(b) Use the integral representation

$$f^n(a) = \frac{1}{2\pi i}\int_C \frac{f(z)dz}{(z-a)^{n+1}}$$

to prove that

$$\left(\frac{x^n}{n!}\right)^2 = \frac{1}{2\pi i}\int_C \frac{x^n e^{xz}}{n!\,z^{n+1}}dz.$$
(4 marks)

(c) From your result in (b) above show that

$$\sum_{n=0}^{\infty}\left(\frac{x^n}{n!}\right)^2 = \frac{1}{2\pi}\int_0^{2\pi} e^{2x\cos\theta}\,d\theta$$
(5 marks)

(d)(i) Use the identity

$$(\exp ix)^3 = (\exp 3ix)$$

to show that

$$\cos 3x = 4\cos^3 x - 3\cos x$$
(8 marks)

(ii) Employ the Cauchy-Riemann equations to prove that

$$f(z) = r^3(\cos 3\theta + i\sin 3\theta)$$

is not only analytic for all $z \neq 0$ but is also analytic at $z = 0$. (5 marks)

Q.2 When calculating the dependence of the current density upon the distance ρ from the axis of a straight long current-carrying wire, the following scalar equation in cylindrical coordinates is normally obtained:

$$\frac{\partial^2 u}{\partial \rho^2} + \frac{1}{\sigma}\frac{\partial u}{\partial \rho} = \frac{4\pi\sigma\mu}{c^2}\frac{\partial u}{\partial t}.$$

(a) Reduce this equation to a Bessel's differential equation of zeroth order in its simplest form by assuming that u is a periodic function of the time given by

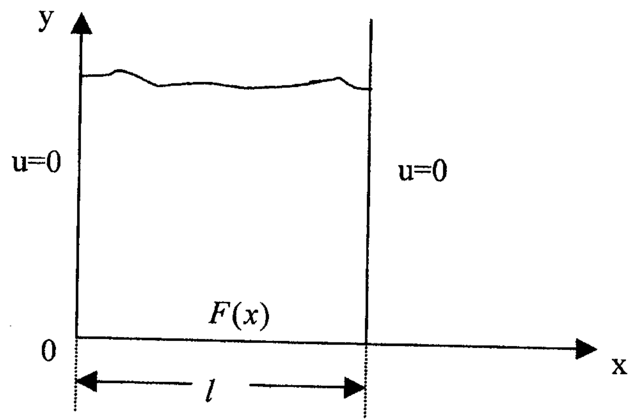
$$u = \phi(\rho)e^{i\omega t}$$
(8 marks)

(b) By assuming an appropriate power series solution of your equation in (a) above,

(i) Obtain the power series identity equation. (7 marks)

(ii) Find the recurrence relations for the expansion coefficients a_r. (10 marks)

Q.3(a) Use the method of separation of variables to determine the steady state temperature distribution in a thin plate bounded by the lines $x = 0$, $x = l$ $y = 0$ and $y = \infty$ assuming that heat cannot flow from either surface of the plates. The edges $x = 0$ and $x = l$ are kept at zero temperature and the lower edge $y = 0$ is kept at a temperature $F(x)$ with the edge $y = \infty$ also at zero temperature as depicted in the figure below: (20 marks)



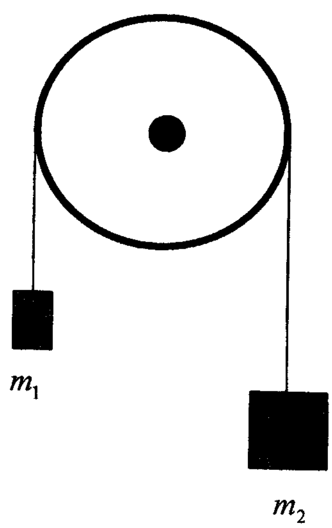
(b) Apply the method of residues to perform the following integral

$$\int_{-\infty}^{\infty} \frac{\cos sx}{k^2 + x^2} dx .$$

(5 marks)

Q.4(a) Employ the variational principle to estimate the ground state energy of the Schrodinger equation having the potential $V(x) = g|x|$ where g is positive. Use the Gaussian function $\Phi(x) = \exp(-\alpha x^2)$ as the trial function, treating α as a variational parameter. (13 marks)

(b) Consider the Atwood's machine shown in the figure below. Obtain the expressions for the kinetic energy and the potential energy and hence the Lagrangian and the equation of motion for the system when $m_2 > m_1$. (12 marks)



Q.5(a) The matrix

$$Q = \begin{pmatrix} 67 & 266 & -30 & 64 \\ -24 & -91 & 12 & -20 \\ -6 & -42 & 10 & -12 \\ 42 & 126 & -21 & 21 \end{pmatrix}$$

has three known eigen-values namely $\lambda_1 = 7$, $\lambda_2 = -7$ and $\lambda_3 = 21$.

(i) Calculate the fourth eigen-value. (3 marks)

(ii) Calculate the determinant of the matrix. (2 marks)

(b) Calculate the eigen-values and eigen-vectors of the matrix

$$B = \begin{pmatrix} 3 & -2 \\ 4 & -1 \end{pmatrix}.$$

(8 marks)

(c) The Schrodinger equation for spin a $\frac{1}{2}$ particle placed in a constant magnetic field B pointing in the $z-$direction is given in matrix form is given by

$$i\hbar \frac{\partial}{\partial t}\begin{bmatrix} \alpha_+(t) \\ \alpha_-(t) \end{bmatrix} = \frac{e\hbar B}{2mc}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}\begin{bmatrix} \alpha_+(t) \\ \alpha_-(t) \end{bmatrix}$$

(i) Find two possible values of ω and their corresponding eigen-vectors.

(4 marks)

(ii) By choosing an appropriate exponentially time varying solution to the equation above, write down the state wave function $\psi(0)$ of the particle in column vector form at time $t = 0$.

(2 mark)

(d) The spin S_x is measured at time $t = 0$ and is found to be $\frac{\hbar}{2}$. Calculate the expectation value of S_x at a later time t given that the spin matrix representation in the $x-$ direction is

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}.$$

(6 marks)

Q.6 Consider an axial distribution of charge concentrated along the z – axis and given by

$$\rho(\vec{r}) = \sigma(z')$$

where $\sigma(z')$ may represent a continuous or δ – function charge of discrete nature.

(a) Show that at any point $P(\vec{r},\theta)$ in space, the potential is given by

$$\Phi(\vec{r},\theta) = \sum_{l=0}^{\infty} \frac{M_l P_l(\cos\theta)}{r^{l+1}}$$

where the coefficients M_l given by

$$M_l = \int \sigma(z') z'^l dz'$$

are called the axial multipole moments of the system and the potential for $r > z_0$ is determined by them.

(12 marks)

(b) From your result in (a) above write down the expression for the generator of the Legendre polynomial $P_l(\cos\theta)$ for this problem.

(2 marks)

(c) Use your result in (a) or (b) above to show that $P_l(\cos\theta)$ ($l = 0,1,2$) form an orthogonal set of functions in the interval $-1 \le x \le +1$ where $x = \cos\theta$.

(11 marks)

Q.7(a) Generate the first four Hermite polynomials ($H_n(x)$)by using the generator

$$e^{x^2}(-1)^n \frac{d^n}{dx^n} e^{-x^2}$$

(4 marks)

(b)(i) Show that the differential equation

$$\frac{d^2\psi}{dx^2} + (\lambda - x^2)\psi = 0$$

reduces to the Hermite differential equation under the substitution

$$\psi = e^{-\frac{x^2}{2}} y.$$

(8 marks)

(ii) Predict the solution to the differential in b(i) above if the constant λ is of the form $1 + 2n$ with n being a positive integer.

(2 marks)

(c) By assuming an appropriate solution to the Laguerre differential equation

$$xy'' + (1 - x)y' + \nu y = 0$$

obtain the series identity equation and hence the expression for the recurrence relation.

(11 marks)

END OF THE EXAMINATION

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The University of Zambia
School of Natural Sciences
Department of Physics
2004 Academic Year First Semester
Final Examinations
P-191 : Introductory Physics - I

Question 1 is compulsory. Attempt only four more questions. Clearly indicate on the answer script which questions you have attempted. All questions carry equal marks. The marks are shown in brackets.

Time : Three Hours. **Maximum Marks : 100.**

Write your computer number clearly on the answer script !!

Wherever necessary use :

$G = 9.8 m/s^2$: $P_A = 1.01 \times 10^5 N/m^2$: 1 cal. = 4.2 J : $\rho_{water} = 1000 kg/m^3$
Specific heat capacity of water = 4200J/kg.K : $G = 6.67 \times 10^{-11} N.m^2/kg^2$: 1 pascal = 1 N/m^2 :

Some equations you may find useful :

$v_f = v_o + at$: $v_f^2 = v_o^2 + 2ax$: $x = v_o t + (½)at^2$: $f = \mu F_N$: work = F.s.cos θ

$Ft = m(v_f - v_o)$: kin. Energy = $(½)mv^2$: grav. pot. energy = mgh : W = mg

$x = v_{avg.}t$: $\mathbf{Ft} = \Delta \mathbf{p} = m(v_f - v_o)$: $\Delta PE + \Delta KE + \Delta TE = 0$: power = work/time

$v_{avg.} = (½)(v_o + v_f)$: $\omega_f = \omega_o + \alpha t$: $\omega_f^2 = \omega_o^2 + 2\alpha\theta$: $\theta = \omega_o t + (½)\alpha t^2$: P = Fv

$\mathbf{p} = m\mathbf{v}$: $a_T = \alpha r$: $L = I\omega$: $\tau = I\alpha = Fr$: $[\text{Kin. Energy}]_{total} = (½)mv^2 + (½)I\omega^2$

1 rev = 360° = 2π radians : $F_c = (mv^2)/r$: $I = \Sigma mr^2 = mk^2$: $F = (Gm_1m_2)/r^2$:

$Y = (F/A)/(\Delta L/L_o)$: $B = -\Delta P/(\Delta V/V_o)$: $W_{app.} = mg$ - B.F. : $P = \rho gh$: $v_T = \omega r$

$W_{app.} = W[1 - (\rho_f/\rho)]$: $[(½) mv^2]_{avg.} = (3/2)kT$: $\Delta Q = mc\Delta T = nC\Delta T$: $\Delta Q = mH_f$

$\Delta L = \alpha L\Delta T$: $\Delta V = \gamma V\Delta T$: $\Delta W = P\Delta V$: $P_1V_1^\gamma = P_2V_2^\gamma$: PV = nRT : F = -kx

$\Delta Q = \Delta U + \Delta W$: $\Delta W = nRT.\ln(V_f/V_i)$: $R = (2u^2 \sin\theta \cos\theta)/g$: $t = (2u \sin\theta)/g$

$(½)kx^2 + (½)mv^2 = (½)kx_o^2$: $\omega = \sqrt{(k/m)}$: $v = \pm\sqrt{[(k/m)(x_o^2 - x^2)]}$: $v_T = \omega r$:

$v = \sqrt{(Y/\rho)}$: $f = (1/2\pi)\sqrt{(k/m)}$: $f = (1/2\pi)\sqrt{(g/L)}$: $v = \sqrt{[T/(m/L)]}$: $v = \sqrt{(B/\rho)}$

$v = \sqrt{(\gamma RT/M)}$: $f = 1/\tau$: $\omega = 2\pi f$: $I_1\omega_1 = I_2\omega_2$: ΔT.E. = f.s : a = - kx/m

area of a sphere = $4\pi r^2$: area of a right cylinder = $2\pi rL$: 0K = 273°C

$a_{max.} = kx_o/m$: $a_c = \omega^2 x_o$: P.E. = $(½)kx^2$: volume of a sphere = $(4/3)\pi r^3$

Question 1 : Sample answers : F(a), G(d).... etc. DO NOT guess the answer. For each correct answer, 2 marks will be awarded. For each wrong answer, (0.67) will be deducted. No answer, zero mark. No deduction of marks for not attempting. Minimum total marks for Question 1 is zero. [$10 \times 2 = 20$]

(A) The resultant of two vectors acting at 120^0 is perpendicular to the smaller vector. If the larger vector is of magnitude 10 units, the smaller vector is of magnitude :

(a) 8.66 units (b) 5 units
(c) 6.88 units (d) none of the above.

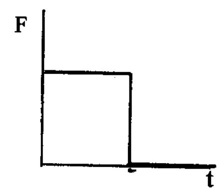
(B) Which one of the following statements is incorrect ?

(a) the velocity of an object can change while the speed remains the same
(b) the speed of an object can change while the velocity remains the same
(c) the velocity of an object can change direction while the acceleration remains the same
(d) the velocity of an object can be zero while the acceleration is non-zero.

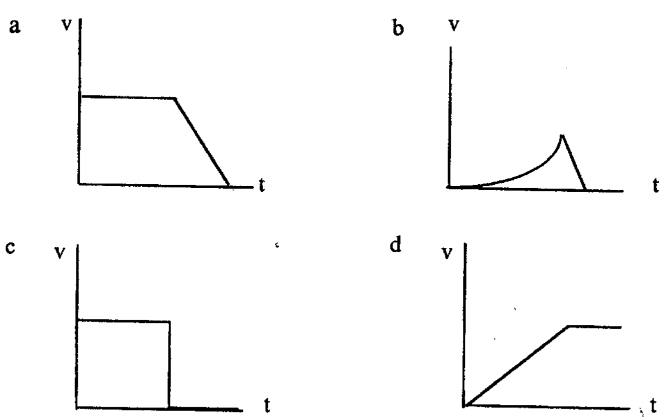
(C) A ball is thrown at a 30° angle above the horizontal at 3m/s. After 0.50s the horizontal component of its velocity will be

(a) 5.5m/s
(b) 4.9m/s
(c) 1.5m/s
(d) 2.6m/s

(D) A body is acted upon by a force F which varies with time t as shown in the figure at right :



Which of the following graphs best represents the velocity-time variation of the body ?



(E) A 2kg book is held 1m above the floor for 50s. The work done is :

(a) 980J
(b) zero
(c) 10.2J
(d) 100J

(F) An object that has momentum must also have :

(a) impulse
(b) acceleration
(c) kinetic energy
(d) potential energy

(G) A quantity not directly involved in the rotational motion of an object is :

(a) torque
(b) angular speed
(c) moment of inertia
(d) mass.

(H) An object in equilibrium may not have :

(a) any acceleration
(b) any forces acting on it
(c) any torques acting on it
(d) any velocity.

(I) The stress on a wire supporting a load does not depend on :

(a) the acceleration of gravity
(b) the wire's diameter
(c) the wire's length
(d) the mass of the load

(J) Evaporation cools a liquid because :

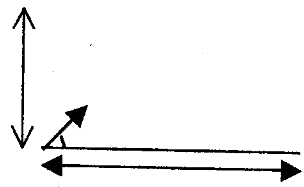
(a) the slowest molecules tend to escape
(b) the fastest molecules tend to escape
(c) the pressure on the liquid increases
(d) the pressure on the liquid decreases

Attempt any four questions only from below :

Q 2 (a) Vector **A** has a magnitude of 50m at $\theta = 175^0$. If we want to subtract vector **A** from another vector **B** so as to produce a resultant along the negative y-axis that has a magnitude of 30m, what must be the direction and magnitude of vector **B** ? [10]

b) A helicopter is climbing vertically at 8.0m/s when it drops a pump near a leaking boat. The pump reaches the water 4.0 sec afterward. How high was the helicopter from the water when the pump was dropped ? [10]

Q3(a) A ball is thrown with a speed of 40m/s at a certain angle θ with the horizontal.



(i) What is the maximum horizontal distance it can go given that the maximum height reached is 30 meters ?

(ii) Find also this angle. [10]

(b) In some canals, barges are lifted from a low level of the canal to a higher level by means of wheeled carriages. In a certain canal, barges of 70 metric tons are placed on a carriage of 35 metric tons which is pulled by a wire rope to a height of 12m along an inclined track 500m long. [1 metric ton = 1000kg]

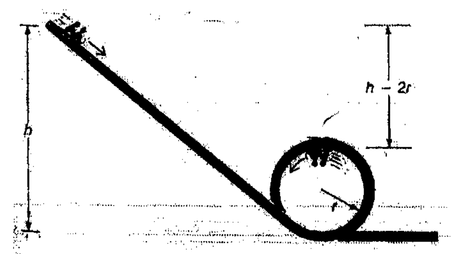
(i) What is the tension in the wire rope ?

(ii) How much work is done to lift the barge and the carriage ?

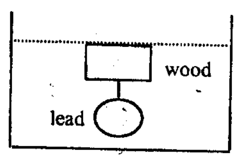
(iii) If the cable breaks just as the carriage reaches the top, what would be the final speed of the carriage when it would crash at the bottom ? Ignore friction. [8]

(c) Explain in short what you mean by a "conservative force". [2]

Q4 (a) A mass m is released from rest from a height h. It slides down a frictionless track as shown. If r = 15m, what is the minimum value of h so that the mass m loops the track without falling off ? [8]

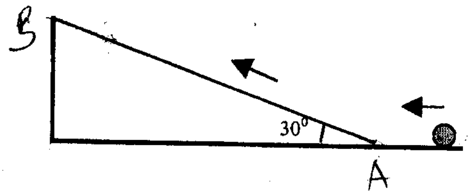


(b) A piece of wood is 0.5m long, 0.2m wide and 0.02m thick. Its density is $600 kg.m^{-3}$. What volume of lead (density $11300 kg/m^3$) must be fastened underneath the wood to sink it in calm water so that its top is just even with the water level ? [9]



(c) State Archimedes' principle of buoyancy. [3]

Q5(a) A 3kg solid ball rolling on a horizontal surface at 25m/s comes to the bottom of an inclined plane and starts to move up the incline; the incline makes an angle of 30^0 with the horizontal.



Calculate :

(i) the total kinetic energy of the ball when it is at the bottom of the incline,

(ii) how far up the incline the ball rolls ? [Neglect friction. Moment of inertia of a solid sphere $I = (2/5)mb^2$] [9]

(b) A 15kg mass fastened to the end of a steel wire of unstretched length 0.5m is whirled in a vertical circle with an angular velocity of 2rev/s at the bottom of the circle. The cross section of the wire is $0.02cm^2$.

Calculate the elongation of the wire when the mass is at the lowest point of the path. Given : Young's modulus for steel = 2.0×10^{11} Pa. [9]

(c) Write a short note on "radius of gyration" of a rotating object. [2]

Q6(a) A billiard ball at rest is struck by another ball of the same mass coming in from the left with a speed of 5.0m/s. After an elastic collision, the striking ball goes off at an angle of 40^0 counter-clockwise with respect to its original direction of motion. The struck ball goes off at an angle of 50^0 clockwise with respect to this direction. Find the final speeds of the two balls. [11]

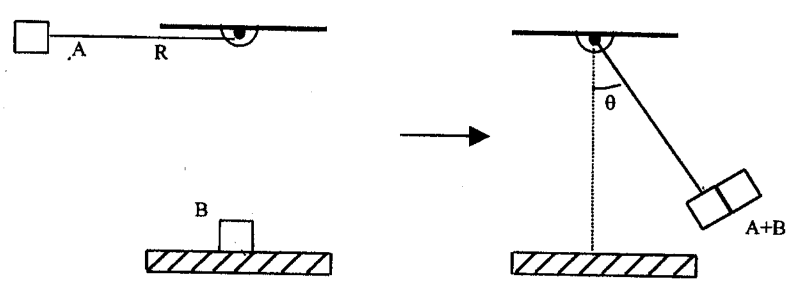
(b) An electric motor is turned off and its angular velocity decreases from 1000 rev/minute to 400 rev/minute in 5 seconds.

(i) Find the angular acceleration (rad/s^2), and the number of rotations (radians) made by the motor in 5 seconds.

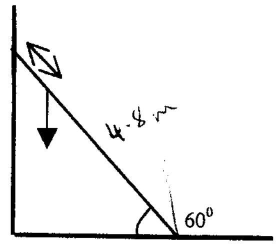
(ii) How many seconds are required for the motor to come to rest after being turned off ? [7]

(c) Define centripetal force. [2]

Q7(a) A magnet *A* attached to a string R is pulled out to one side so that the string is horizontal. When the magnet is let go, it swings downward and strikes an iron cube B of the same mass that is resting on a frictionless surface. The two stick together and swing upward on the other side. What is the maximum value of θ, the angle between the string and the vertical ? [11]



(b) A weightless ladder 6m long rests against a frictionless wall at an angle of 60^0 above the horizontal. A 75kg person is 1.2m from the top of the ladder.



Calculate :

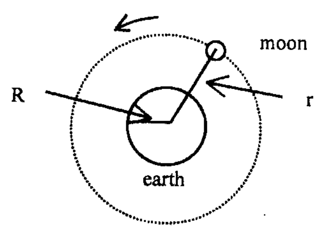
(i) the horizontal force required at the bottom of the ladder to keep it from slipping,

(ii) the coefficient of friction between the ladder and the floor. [7]

[Hint : Since the ladder rests against a frictionless wall, the only force the wall can exert on the ladder is a horizontal force.]

(c) Define (i) torque and (ii) lever arm of an applied force. [2]

Q8(a) If the moon describes a circular orbit of radius r round the earth with a uniform angular velocity ω, show that $\omega^2 r^3 = gR^2$, where R is the radius of the earth. [8]



(b) A fish at the depth of 10m in a fresh-water lake exhales an air bubble of volume V_0. Find the volume of the bubble just before it reaches the surface. Let the temperature of the water at the surface be 25^0C and that at 10m depth be 20^0C. [9]

(c) What are the necessary conditions for a satellite to appear stationary ? [3]

== End of P-191 Examination==

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

P-231 PROPERTIES OF MATTER AND THERMAL PHYSICS

TIME : THREE HOURS MAXIMUM MARKS: 100

Instructions

Attempt any five questions.
All questions carry equal marks.
Marks are indicated for each question.

USEFUL DATAS

$1W = 1J/S$ $\qquad K = \frac{dP}{dV} \cdot V$ $\qquad C = \frac{Q}{m \cdot \Delta T}$ $\qquad Q = mL$

Bending moment of a beam $= \frac{E}{R} \times I_a$ $\qquad$ y$= \frac{WL^3}{48EI_a}$

$Q = K \times \frac{A(T_1 - T_2)}{x} t$ $\qquad Q = K 4\pi r_1 r_2 (T_1 - T_2)/(r_2 - r_1)$

$C_V = \left(\frac{\Delta Q}{\Delta T}\right)_V$ $\qquad C_P = \left(\frac{\Delta Q}{\Delta T}\right)_P$ $\qquad C_P - C_V = R$

$W = \frac{1}{1-\gamma}[P_2V_2 - P_1V_1]$ $\qquad W = RT \log_e \frac{V_2}{V_1}$ $\qquad dT = \frac{T}{C_X}\left(\frac{\delta x}{\delta T}\right)_X dX$

$\left(P + \frac{a}{V^2}\right)(V - b) = RT$

Q1 (a) (i) Explain the term viscosity of a liquid. (1)
(ii) Define coefficient of viscosity of a liquid. (1)

(b) Derive an expression for the rate of flow of a viscous fluid with coefficient of viscosity η, flowing through a narrow tube of length l, radius a, under a pressure difference ΔP between its ends. (10)

(c) A wide vertical tube has a short capillary tube fixed horizontally at its lower end. When it is filled with glycerin it takes 45 seconds for the level to fall between two fixed marks. When the tube is filled with oil it takes 67.5 seconds for the level to fall between the same two fixed marks. Calculate the coefficient of viscosity of oil. (Given, density of glycerin 1.2×10^3 kg/m^3, density of oil 0.8×10^3 kg/m^3, viscosity of glycerin 0.85N-S/m^2). (8)

Q2 (a) Describe Jaeger's method for determining the surface tension of a liquid. (7)

(b) Derive an expression for the excess pressure inside a spherical bubble blown within a liquid. (8)

(c) A spherical soap bubble of radius 0.01m is formed inside another soap bubble of radius 0.02m. Calculate the radius of a single soap bubble which will have an excess of pressure equal to the difference in pressure between the inside of the inner bubble and the outside of the larger bubble. (5)

Q3 (a) The rubber cord of a catapult has a cross sectional area of 1 mm^2 and a total unstretched length of 10 cm. If it is stretched to 15 cm and then released to project a missile of mass 5 g. Calculate (i) the energy stored in the rubber (ii) the velocity of the projection and (iii) the maximum height that the missile could reach (Young's modulus of rubber is 5×10^8 N/m^2). (8)

(b) Compare the loads required to produce equal depressions for two beams supported at the ends, made of the same material and having the same length and weight, the only difference is that while one has a circular cross-section, the cross section of the other is square. (7)

(c) If the pressure p of a gas varies with volume v so that pv^{γ} = constant when the temperature is not constant (adiabatic), show that the bulk modulus of a gas under this condition is equal to γ times its pressure. $(\gamma = \frac{C_P}{C_V})$ (5)

Q4 (a) A bar of length 40 cm and uniform cross section 5 cm^2, consists of two equal halves, AB of copper and BC of Brass welded together at B. The end A is maintained at

200°C and end C is at 0°C and the sides are thermally insulated. Find the radii of flow of heat along the bar when the steady state has been reached (Given thermal conductivity for copper 400 W/Km and for Brass 105 W/Km). (7)

(b) A steel wire 2 mm in diameter is just stretched between two fixed points at a temperature 0f 20^0 C. Determine its tension when the temperature falls to 10^oC. (Coefficient of linear expansion of steel is 0.0000011 deg^{-1} and Young's modulus for steel is 2.1×10^{12} N/m^2). (7)

(c) Two thin concentric spherical shells of radii 5 cm and 10 cm respectively have their annular cavity filled with charcoal powder. When energy is supplied at the rate of 10.5 watts to a heater at the center, a temperature difference of 60^oC is set up between the shells. Find the thermal conductivity of charcoal. (6)

Q5 (a) Prove that the work done by an ideal gas with constant heat capacity during a quasi-static adiabatic expansion is equal to $W = \frac{P_iV_i}{\gamma-1}\left[1-\left(\frac{P_f}{P_i}\right)^{\frac{\gamma-1}{\gamma}}\right]$ (9)

(b) The pressure on 20g of water at 0^oC is increased adiabatically from 0 to 500 atmospheres. Calculate the change in temperature of the water. (Coefficient of volume expansion of water = -0.67×10^{-6} deg^{-1}, C_p = $4.2\times$ 10^3J/kg °C, density of water=1000kg/m^3). (6)

(c) An ideal gas of volume 1 liter and pressure 8 atm. undergoes a quasi-static adiabatic expansion until the pressure drops to 1 atm.

What is the final volume? (1atm.=10^5N/m^2, 1litre=10^{-3} m^3, $\gamma = 1.66$) (5)

Q6 (a) A mass m of a liquid at temperature T_1 is mixed with an equal mass of the same liquid at temperature T_2. The system is thermally insulated. Show that $\Delta S = 2mC_P \log_e \frac{(T_1+T_2)}{2\sqrt{(T_1T_2)}}$ (8)

(b) Regarding the internal energy of a hydrostatic system to be a function of T and p, derive the equations,

$$dQ = \left[\left(\frac{\partial u}{\partial T}\right)_p + p\left(\frac{\partial v}{\partial T}\right)_p\right]dT + \left[\left(\frac{\partial u}{\partial p}\right)_T + p\left(\frac{\partial v}{\partial p}\right)_T\right]dp \quad (7)$$

$$\left(\frac{\partial u}{\partial T}\right)_p = C_p - pv\beta \quad (5)$$

Where β is the coefficient of volume expansion.

Q7 (a) For a gas, the Van der Waals constants are a =1.32 litre^2-atoms mole^{-2}, b = 3.12×10^{-2} litre mole^{-1}. Calculate the temperature at which 5 mole gas at 5 atmospheric pressure will occupy a 20 liter volume. Calculate also the pressure of the gas at the same temperature when the volume is reduced to 2.0 liters (Given R =8.4 Joules mole^{-1}deg^{-1}). (8)

(b) Define entropy. Show that, for n kg –moles of an ideal gas, the entropy S is given by

$$S = C_v \ln T + (C_p - C_v) \ln V + const$$

(7)

(c) A Carnot engine whose low temperature reservoir is at 7°C has efficiency 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of the high temperature reservoir be increased? (5)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF PHYSICS

2004 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

P251: CLASSICAL MECHANICS I

TIME: THREE (3) HOURS

ANSWER ANY FIVE QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

MAXIMUM MARK: 100

Universal gravitational constant, $G = 6.67\times10^{-11}$ m^{3}kg^{-1}s^{-2}

Acceleration due to the earth's gravity, $g = 9.8$ ms^{-2}

Speed of light in free space, $c = 3.0 \times 10^8$ ms^{-1}

The earth's planetary year, $T = 3.15 \times 10^7$ s.

Mass of the earth, $m_e = 5.95\times10^{24}$ kg

Mass of the sun, $m_s = 1.989\times10^{30}$ kg

Radius of the earth $r = 6.4 \times10^6$ m

Radius of the sun $R = 7.0 \times10^8$ m

$(\vec{A}\times\vec{B})\times\vec{C} = (\vec{C}\bullet\vec{A})\vec{B} - (\vec{C}\bullet\vec{B})\vec{A}$

Q1 (a) State the Newtonian law of addition of relative velocities. [3]

(b) A river is 0.8 km wide and is flowing at 8 km/h. A person in a boat, which has a speed of 8 km/h at 30° **relative to the flow of the river** (not the bank), wishes to cross the river to a point directly opposite from the starting point. To do this he crosses the river to some place on the opposite bank and runs at 4 km/h to the point directly opposite from the starting point. Find the angle at which the boat must head out relative to the bank, and also find the time taken to reach the point directly opposite. [10]

(c) Show that the two parametric equations $x = v\cos\theta t$ and $y = -\frac{1}{2}gt^2 + v\sin\theta t$ represent a parabolic trajectory in the x-y plane. Give the range and maximum height. [7]

Q2 (a) The usual expressions for the radial and transverse components of velocity and acceleration can be obtained by differentiating the equation $x = r\cos\theta$ and evaluating the resulting expressions for $\dot{x}$ and $\ddot{x}$ when $\theta = 0$ and. Explain this result without derivation. [3]

(b) Two rods AB and BC, each of length 4m, are hinged at B. C approaches A with a speed of 16 m/s relative to A. Find the velocity and acceleration of B relative to A at the instant when the angle between the rods is 120°. (The required velocity and acceleration can be written in terms of components parallel to AC and perpendicular to AC.) [9]

(c) A rod AB of length L moves with its ends A and B always lying on two mutually perpendicular axes Ox and Oy. The speed v of A relative to O is constant. Find, in terms of the angle $\theta = O\hat{B}A$, the cartesian components of the velocity and acceleration relative to O of the point P lying on the rod a distance βL from B. [8]

Q3 (a) With the help of a sketch of a potential energy function explain what turning points of motion are and distinguish between the two possible types of equilibrium positions. [3]

(b) A particle of mass 4 kg moves in a straight line under the action of a force whose potential energy is given by

$$V(x) = 2x^2 (x-3).$$

(i) Find an expression for the force on the mass. [2]

(ii) Plot the graph of $V(x)$ against x. [5]

(iii) If the particle starts from $x = 2m$ with velocity $\dot{x} = -v_0$, what is the condition on v_0 if it should not escape to $x = -\infty$. [3]

(c) A body of mass 2 kg falls through a resisting medium. If the resistance force at a speed v is given by $4v^2$ and assuming the displacement to be 0.3m when $v = 0$,

(i) what is the displacement when the speed of the particle is 2.2 m/s, and [5]

(ii) what is the maximum possible speed attainable? [2]

Q4 (a) What is a Syncom satellite? [3]

(b) Show that the orbit of a syncom satellite must lie in the equatorial plane and find a numerical value for the radius of the orbit. [4]

(c) The cartesian co-ordinates (x,y,z) of a moving particle of mass m are given at any time t by the equations

$$x=x_0+at, \quad y=y_0+bt^2 \quad \text{and} \quad z=z_0+ct^3$$

where (x_0,y_0,z_0) and $(a,0,0)$ are respectively the co-ordinates and the components of the velocity of the particle at time $t = 0$. The mass of the particle is m. Find expressions for,

(i) the force acting on the particle, [3]

(ii) the moment of this force about the origin, and [4]

(iii) the angular momentum of the particle about the origin. [4]

(iv) Verify that the moment of the force is equal to the rate of change of the angular momentum. [2]

Q5 (a) What is termed the 'effective potential energy' in a gravitational field? [3]

(b) (i) Draw a graph of the effective potential energy $U(r)$ of a particle of mass m moving with angular momentum L under the action of an attractive central force $F(r) = -\lambda/r^5$. [8]

(ii) Determine the radius of any possible circular orbit in which the above particle can move and discuss the stability of this orbit. [3]

(c) A particle P of mass m is moving on a smooth horizontal table in a circle of radius a with angular velocity ω. The particle is constrained to move in the circle by being attached to one end of a light inextensible string, the other end of the string being slotted through a hole in the table. A further length $a/3$ of the string is pulled down through the hole. Find an expression for the new angular velocity of the particle in terms of m, a and ω. [6]

Q6 (a) Distinguish between internal and external forces for a system of particles. [2]

(b) A particle of mass m_1 and linear momentum p_1 collides elastically with a stationary particle of mass m_2. After collision the two particles are scattered at angles θ_1 and θ_2 from the direction of p_1 and with linear momenta P_1 and P_2 respectively.

(i) Draw a vector triangle relating quantities which describe the above collision in the lab frame of reference and the centre of mass frame. [3]

(ii) Relate the angles of scatter θ_1 and θ_2 in the lab frame to the scattering angle θ in the centre of mass frame. [5]

(c) A wheel of mass m is formed from a uniform circular disc of radius a by cutting n circular holes of radius a' from the disc, the centre of the holes being symmetrically situated at a distance $a/2$ from the centre of the disc. Show that the moment of inertia of the wheel about its centre is given by

$$I = \frac{ma^2}{2} + \frac{mna'^2(a^2 - 2a'^2)}{4(a^2 - na'^2)}.$$ [10]

Q7 (a) What do you understand by the expression 'moment of inertia tensor' in rigid bodies? [3]

(b) Let O be some point fixed in a given rigid body with $\hat{i}$, $\hat{j}$ and $\hat{k}$ as the unit vectors in the direction of the rectangular cartesian axes Ox, Oy and Oz respectively, the unit vectors and axes being fixed in the body. If ϖ is the angular velocity vector of the body, show that $\dot{\hat{i}} = \varpi \times \hat{i}$, $\dot{\hat{j}} = \varpi \times \hat{j}$ and $\dot{\hat{k}} = \varpi \times \hat{k}$. [7]

(c) Show that the angular velocity vector of a rigid body is independent of the choice of origin. [3]

(d) Given that the moment of inertia of a spherical shell of mass m and radius r about any diameter is given by $I = \frac{2}{3}mr^2$, find the moment of inertia of a uniform solid sphere of mass M and radius a about any diameter. [7]

END OF EXAMINATION

The University of Zambia

Physics Department

University Examinations 2004

P261

Electricity and Magnetism

Time: Three (3) Hours **Marks:**100

Instructions

ATTEMPT ANY FIVE (5) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. MARKS ARE INDICATED FOR EACH OF THE QUESTIONS

USEFUL DATA

$\epsilon_o = 8.85 \times 10^{-12}$ coul^2/newton-m^2
$\mu_o = 4\pi \times 10^{-7}$ webers/amp-m

1. (a) i. As you penetrate a uniform sphere of charge, **E** should decrease because less charge lies inside a sphere drawn through the observation point. On the other hand, **E** should increase because you are closer to the centre of the charged sphere. Which effect predominates and why?

ii. A certain charge Q is to be divided into two parts q and $Q - q$. What is the relationship of Q to q if the two parts, placed a given distance apart, are to have maximum Coulomb repulsion?

[10 marks]

(b) i. A positive charge q is distributed uniformly throughout a non-conducting spherical volume of radius R. Show that the potential a distance a from the centre, where $a < R$ is given by

$$V = \frac{q(3R^2 - a^2)}{8\pi\epsilon_o R^3}$$

ii. Is it reasonable that according to this expression, V is not zero at the centre of the sphere?

[10 marks]

2. (a) A system of two particles is described as consisting of a positive charge Q fixed at a position P and a second particle of mass m with a negative charge $-q$ moving at a constant speed in a circle of radius R_1 centred at P. Derive an expression for the work that must be done by an external agent on the second particle in order to increase the radius of the circle of motion, centred at P, to R_2.

[10 marks]

(b) Figure 1 shows a set of two conducting balls carrying similar charges q. The balls are of mass m and are hung from silk threads of length l. Assume that Φ is so small that tanΦ can be replaced by its approximate equal sinΦ. To this approximation:

i. Show that the separation between the balls is

$$x = \left(\frac{q^2 l}{2\pi\epsilon_o mg}\right)^{1/3}$$

ii. Assume that each ball is losing charge at the rate of 1.0×10^{-9} C/s. At what instantaneous relative speed do the balls approach each other initially?

[10 marks]

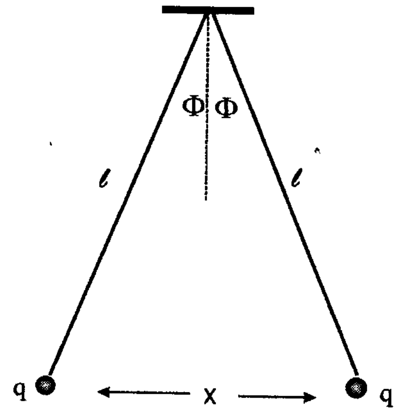


Figure 1: *A system of two particles for question* 2b

3. (a) Shown in Figure 2 is the Wheatstone bridge. If points a and b are connected by a wire of resistance r, show that the current in the wire is

$$i = \frac{\epsilon(R_s - R_x)}{(R + 2r)(R_s + R_x) + 2R_sR_x}$$

where ϵ is the emf of the battery. Assume that $R_1 = R_2 = R$ and that R_o=0.

[10 marks]

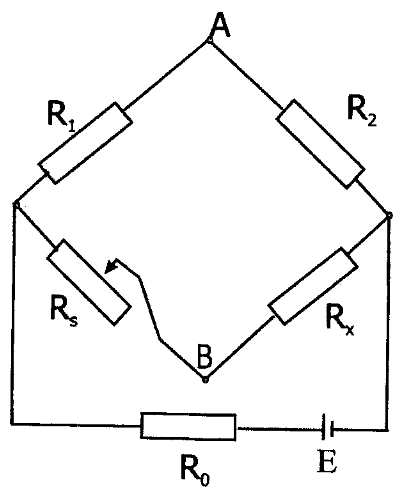


Figure 2: *The Wheatstone bridge for question* 3a

(b) Conductors A and B, having equal lengths of 40 m and a cross-sectional area of 0.10 m^2, are connected in series. A potential of

60V is applied across the terminal points of the connected wires. The resistances of the wires are 40 Ω and 20 Ω respectively. Determine

i. the resistance of the two wires
ii. the magnitude of the electric field in each wire
iii. the current density
iv. the potential difference applied to each conductor

[10 marks]

4. (a) i. Describe the differences among the electric vectors **E**, **D** and **P**.

ii. Write the expressions for the vectors **D** and **P** in terms of **E** and define the constants that appear in the expressions. State the value of vector **P** in vacuum, giving reasons.

[5 marks]

(b) Figure 3 shows two capacitors in series, the rigid centre section of length b being movable vertically. Show that the equivalent capacitance of the series combination is independent of the position of the centre section and is given by

$$C = \frac{\epsilon_o A}{a - b}$$

[5 marks]

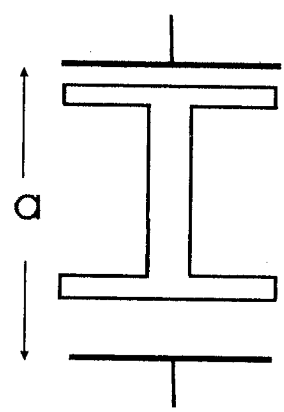


Figure 3: *Two capacitors in series for question* 4b

(c) The plates of a thin parallel plate capacitor are separated by a distance d. The maximum voltage that can be applied to this capacitor before a spark occurs in the air inside the capacitor is V_o. A dielectric plate of dielectric constant K and thickness $t < d$ is laid on the inner surface of one of the capacitor's plates. Show that the maximum voltage that can now be applied to the capacitor before a spark in the air inside the capacitor occurs is only

$$V = V_o[1 - \frac{t}{d}(1 - \frac{1}{K})]$$

[10 marks]

5. (a) A length l of wire carries a current i. Show that if the wire is formed into a circular coil, the maximum torque in a given magnetic field is developed when the coil has one turn only. The maximum torque is given by

$$\tau = \frac{l^2 iB}{4\pi}$$

[10 marks]

(b) i. Discuss analogies and differences between Coulomb's law and the Biot-Savart law.

ii. A single layer solenoid 20 cm long of radius 2 cm is wound uniformly with 3000 turns of wire. A current of 2 A flows through the coil.

A. Derive the value of **B** on the axis of the solenoid, at the middle.

B. What is the value of **B** on the axis of the solenoid, at the end?

C. What is the value of **B** on the axis of the solenoid, at a point 10 cm from one end?

[10 marks]

6. (a) Explain the meaning of the terms *self-inductance* and *mutual inductance.* [2 marks]

(b) Two long parallel wires whose centres are a distance d apart carry equal currents in opposite directions. Show that, neglecting the flux within the wires themselves, the inductance of length l of such a pair of wires is given by

$$L = \frac{\mu_o l}{\pi} \ln \frac{d-a}{a}$$

[10 marks]

(c) A long wire carries a current i uniformly distributed over a cross-section of the wire. Calculate the magnetic energy per unit length stored within the wire.

[8 marks]

7. (a) In a semiconductor, what is the effect of doping with donor atoms on electron density? On hole density? Consider three specimens a pure metal, a pure semiconductor and an insulator at room temperature. Predict the effect on the conductivity of each specimen of an increase in absolute temperature.

[6 marks]

(b) A circuit consisting of resistor-capacitor-inductor(R_1, C_1, L_1) connected in series exhibits resonance at the same frequency as a second, separate combination R_2, C_2, L_2. If the two combinations are connected in series in a single circuit, at what frequency would the combined circuit resonate?

[8 marks]

(c) A circuit consists of an iron-cored coil of 2 H and 50 Ω placed in series with a resistor of 1000 Ω. An alternating e.m.f of 12 V (r.m.s) and frequency 50 Hz is applied. Find

i. the current flowing in the circuit,

ii. the voltage across the inductor and

iii. the phase angle between the applied e.m.f and the current.

[6 marks]

End of P261 Examination

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

P-341 INTRODUCTORY ANALOGUE ELECTRONICS

TIME ALLOWED: **THREE** HOURS

INSTRUCTIONS: ANSWER **ANY FOUR** QUESTIONS ONLY. ALL QUESTIONS ARE OF EQUAL MARKS.

Q1 (a) State the superposition theorem as understood in electronic theory [2 marks]

(b) In Figure 1, find the values of currents I_1, I_2, and I using the superposition theorem. Hence find the voltage drop across the 6 Ω resistor. [12 marks]

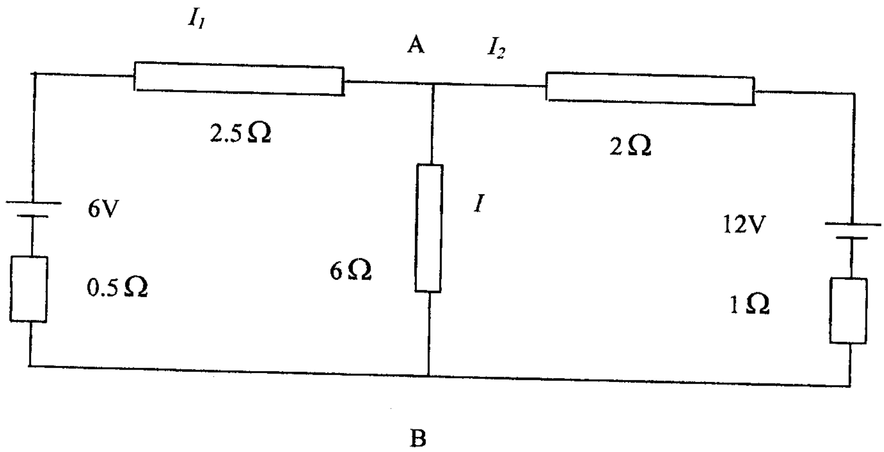


Figure 1

(c) Using Thevenin's theorem, calculate the potential difference across the terminals A and B in figure 2. [11 marks]

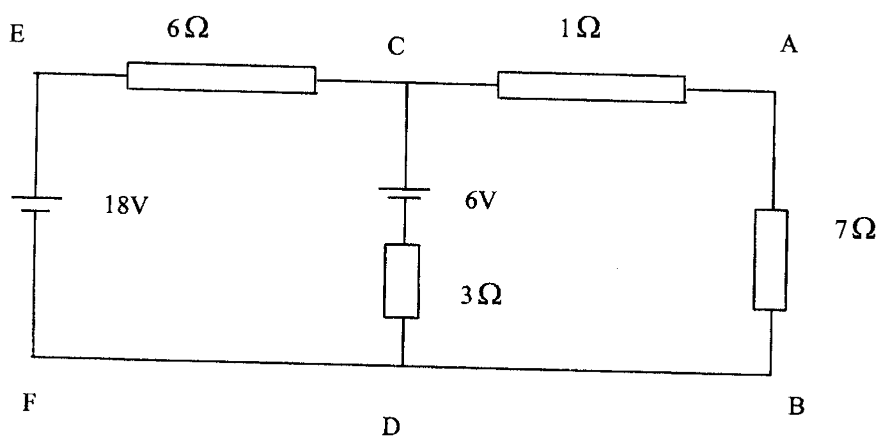


Figure 2

Q2 (a) An alternating current of frequency 50Hz has a minimum value of 100A. Calculate

(i) Its value $\frac{1}{600}$ s after the instant the current is zero and its value decreasing thereafter. [4 marks]

(ii) the time in seconds after the instant the current is zero (increasing thereafter-

wards) when the current attains the value of 86.6A . Assume no phase angle.
[4 marks]

(b) (i) Determine the **average** and **r.m.s** values of the saw-tooth wave form in figure 3.
[8 marks]

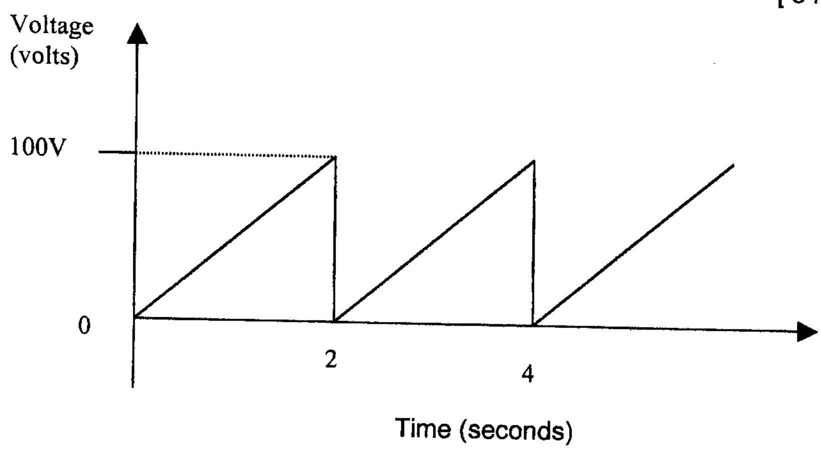


Figure 3

(ii) In the following circuit figure 4, write expressions for Z_1, Z_2 and Z_3 in cartesian co-ordinates and find the values of the voltages V_1, V_2 and V_3. [8 marks]

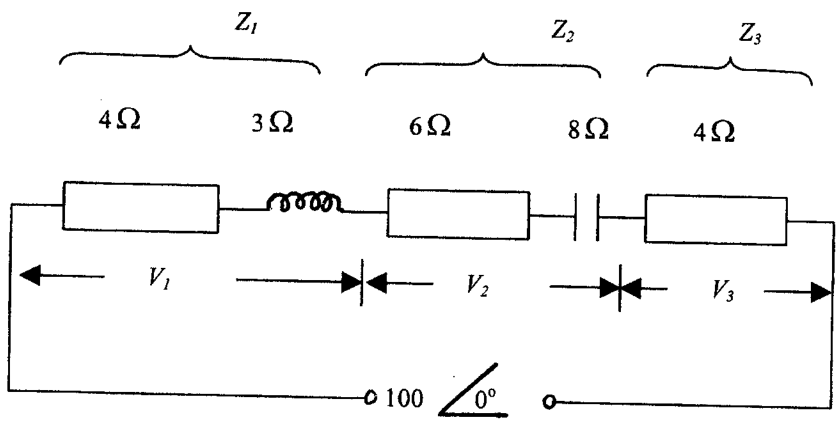


Figure 4

Q3 (a) (i) Distinguish between minority and majority carriers in semiconductor materials
[2 marks]

(ii) In p-type semiconductors, it is usually assumed that the number concentration of positive charge carriers is essentially the same as the number concentration of acceptor atoms and that in n-type semiconductors, the number concentration of negative charge carriers, n, is also essentially the same as the number concentration of donor atoms. Explain. [3 marks]

(b) (i) The resistivity of intrinsic silicon at 270° is 3000 Ω. Calculate the intrinsic carrier density from this data. Take the mobilities as $\mu_e = 0.17$ m²/V.s and $\mu_p = 0.035$ m²/V.s. Electronic charge e =1.6X10^{-19}C [4 marks]

(ii) Mobilities of electrons and holes in a sample of intrinsic germanium at room temperature are 0.36 m²/V.s and 0.17 m²/V.s respectively. If the electron and hole densities are each equal to 2.5X10^{-19} /m³, calculate the conductivity. [2 marks]

(c) (i) Distinguish between an ordinary diode and a Zener diode in relation to the following:

- operating principle
- current growth
- major use

[6 marks]

(ii) In the following circuit, figure 5, implemented with a Zener diode, find the range of input voltages over which the diode maintains a 30V output across the 2000 Ω load resistor given that the series resistance R = 200 Ω. Take the maximum Zener current rating to be 25 mA. [8 marks]

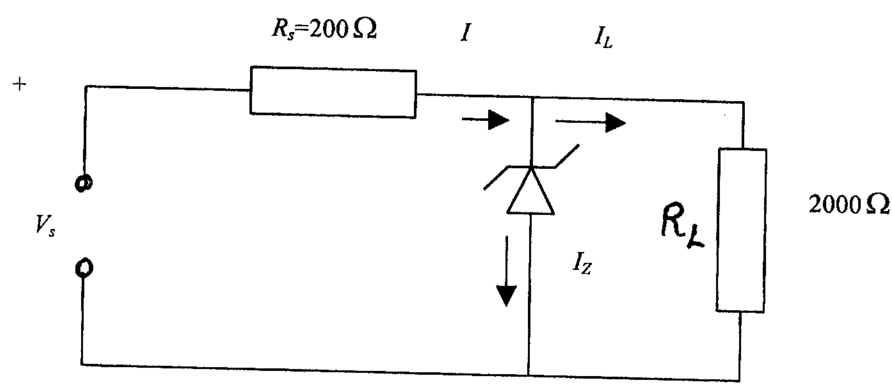


Figure 5

Q4 (a) (i) What do you understand by the term "reverse saturation current or I_s" Explain the reason why it is temperature dependent. [4 marks]

(ii) The following diagram, figure 6, shows the output characteristic of a bipolar junction transistor. Derive the input characteristic plot of the transistor using this diagram and calculate the amplification factor β. [7 marks]

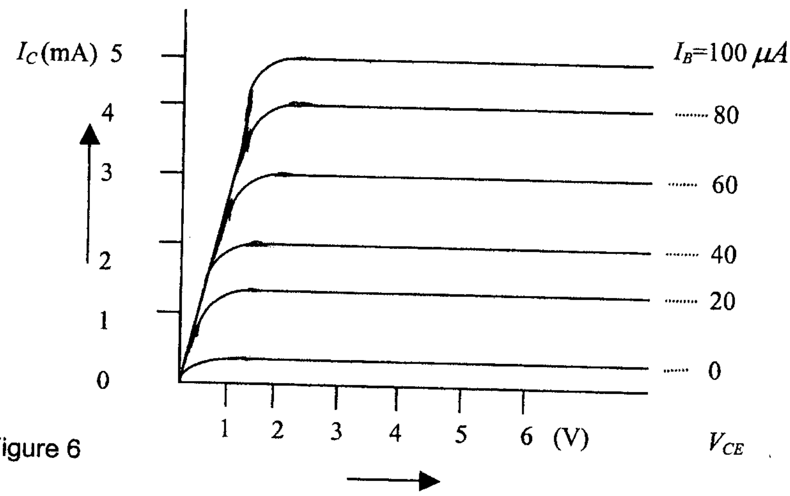


Figure 6

(b) For the circuit in figure 7, find the values of (i) $I_{C(sat.)}$, (ii) V_{CE}, (iii) V_C and (iv) V_E. Take $\beta = 100$. Use the approximate method. [6 marks]

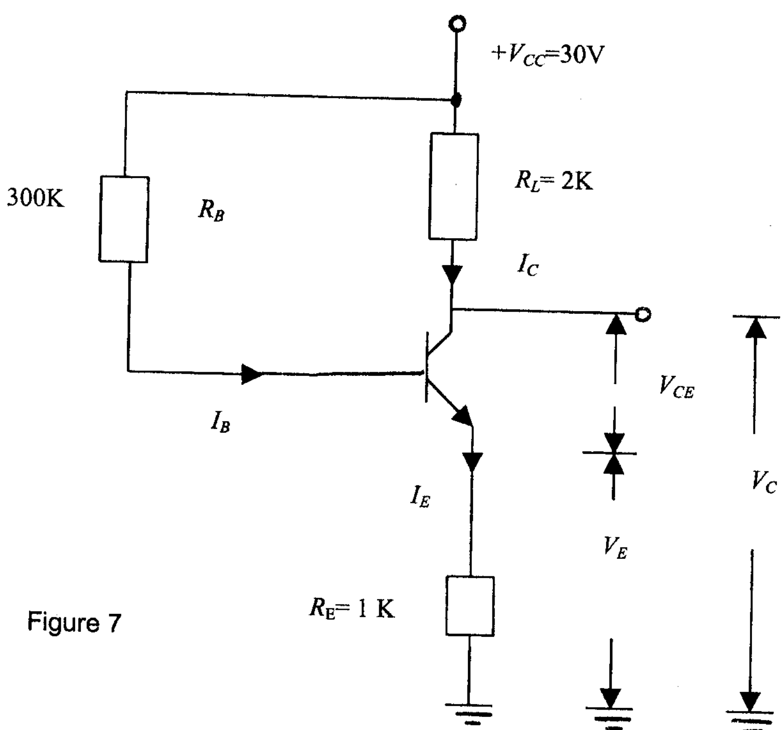


Figure 7

Q4 (c) Determine the quiescent values of V_{GS}, I_D and V_{DS} for the JFET circuit in the figure given that I_{DSS} = 10mA, R_S = 5K, R_L = 2K and V_P = -5V [8 marks]

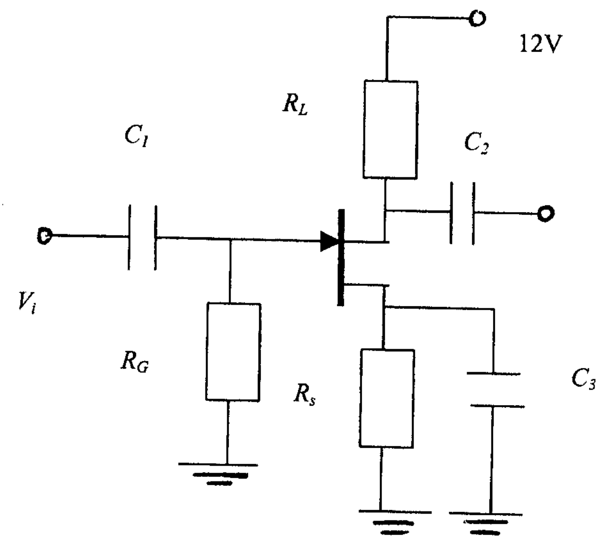


Figure 8

Q5 (a) Distinguish between a.c. and d.c. load lines. [2 marks]

(b) A transistor with β =100 is used in the circuit of figure 9. Using the output characteristics given, [23 marks]

(i) draw the load-line and mark the quiescent point Q;

(ii) determine the up- and –down shift of the Q-point if an a.c. signal voltage injects a sinusoidal base current of peak value 10 μA into the circuit. Mark these variations on the output characteristics.

(iii) determine the corresponding swing in V_{CE} and I_C using the results in part (ii). Mark these variations on the output characteristics as well

(iv) Show that the voltage variations across R_L are the same as the voltage variations in V_{CE} but are 180° out of phase.

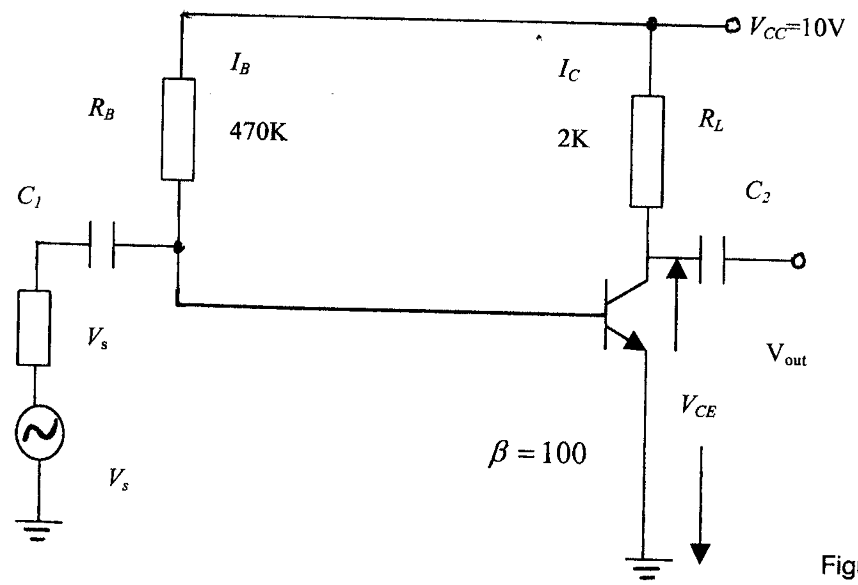


Figure 9

Q6. (a) State four advantages of negative feed-back. [4 marks]

(b) (i) Differentiate between **positive** and **negative** feedback. [4 marks]

(ii) Draw a well labeled block diagram of a feedback amplifier and hence show that if A is the open loop gain of the amplifier and A' is the closed gain of the same amplifier, then the two are related by

$$A' = \frac{A}{1+\beta A} \quad \text{where } \beta \text{ is the feedback factor}$$

[8 marks]

(c) An amplifier has a gain of 500 without feedback. When negative feedback is applied, the gain is reduced to 100.

(i) Calculate the fraction of the output voltage that was fed back to the input; [4 marks]

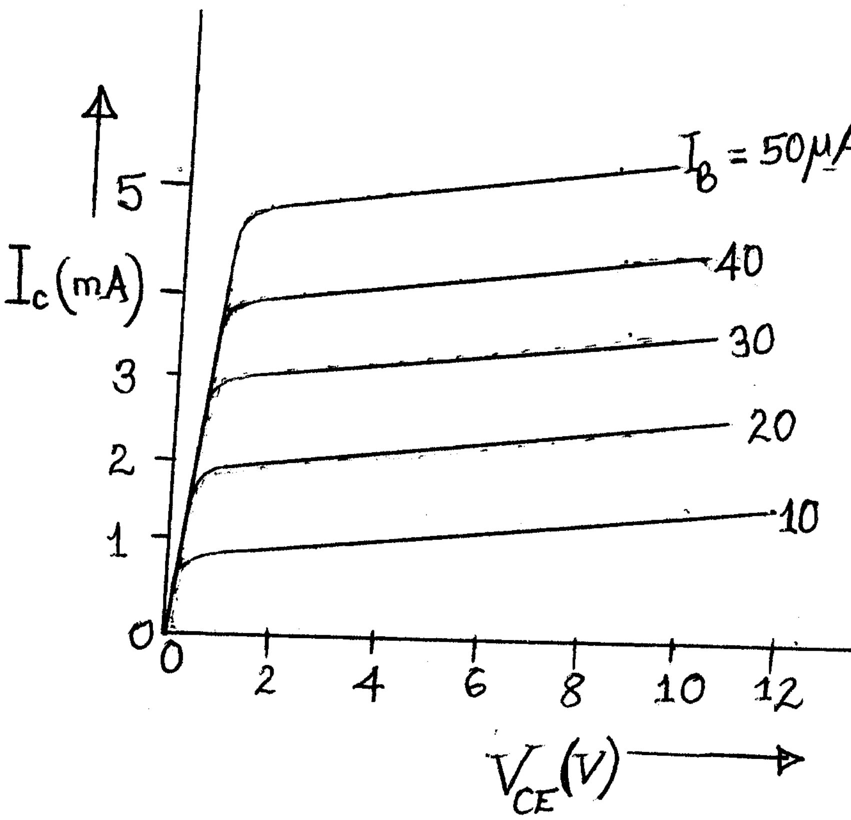
(ii) If, due to ageing of components, the gain without feed-back falls by 20%, calculate the percentage fall in gain with feed-back.

[5 marks]

END OF EXAMINATION

Q5(b)

Output characteristics
for transistor in figure 9



UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2004
P351
INTRODUCTION TO QUANTUM MECHANICS

TIME: THREE HOURS
ANSWER ANY FOUR QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS
TOTAL MARKS: 100

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6. A certain hydrogen atom has the wave function

$$\psi = Bre^{-r/2a_0}\cos\theta$$

where B is a constant and

$$a_0 = \frac{4\pi\varepsilon_0\hbar^2}{\mu e^2}$$

is the Bohr radius.

(i) Calculate the normalisation constant B. [6]

(ii) Obtain the values of the z component of the angular momentum, the square of the angular momentum and the energy of the system in that order. [17]

(iii) Hence specify the quantum numbers of this state. [2]

Note the following:
For the hydrogen atom

$$H = -\frac{\hbar^2}{2\mu}\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{\mathbf{L}^2}{2\mu r^2} - \frac{e^2}{4\pi\varepsilon_0 r},$$

$$\mathbf{L}^2 = -\hbar^2\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial}{\partial\theta}) + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial^2\phi}\right],$$

$$L_z = -i\hbar\frac{\partial}{\partial\phi}$$

and

$$E_n = -\frac{\mu}{2\hbar^2}\left(\frac{e^2}{4\pi\varepsilon_0}\right)^2\frac{1}{n^2},\ n = 1, 2, 3, ...$$

The volume element in spherical polar coordinates is $dV = r^2\sin\theta dr d\theta d\phi$.
You will need the integral:

$$\int_0^\infty x^n e^{-\mu x}dx = \frac{n!}{\mu^{n+1}},\quad \mu > 0.$$

*******END OF EXAMINATION*******

$$[S_x] = \frac{\hbar}{2}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad [S_y] = \frac{\hbar}{2}\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} \quad \text{and} \quad [S_z] = \frac{\hbar}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

(i) Prove that these matrices are Hermitian. [3]

(ii) The eigenvalues of $[S_z]$ are $\pm\frac{\hbar}{2}$. Explain why $[S_x]$ and $[S_y]$ have the same eigenvalues. [2]

(iii) Prove explicitly that $[S_y]$ has the eigenvalues $\pm\frac{\hbar}{2}$ and show that the eigenvectors corresponding to them are

$$[\chi_+] = \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ i \end{pmatrix} \quad \text{and} \quad [\chi_-] = \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ -i \end{pmatrix}$$

for eigenvalues $+\frac{\hbar}{2}$ and $-\frac{\hbar}{2}$ respectively. [10]

Q 5. (a) (i) Give two reasons for the importance ascribed to angular momentum in quantum mechanics. [2]

(ii) Obtain the components in Cartesian coordinates of the angular momentum operator $\mathbf{L} = -i\hbar\mathbf{r} \times \nabla$. [2]

(iii) Hence prove that $[L_x, L_y] = i\hbar L_z$ [4]

(iv) Given that the commutation relations for the three components are $[L_i, L_j] = i\hbar L_k$ with i, j and k taken in cyclic order, show that $[L^2, L_z] = 0$. [4]

(v) Explain the significance of the results in parts (iv) and (v). [2]

(b) The wave function of a certain harmonic oscillator at time $t = 0$ is

$$\Phi(x, t = 0) = A[\sqrt{2}\psi_1 + \frac{1}{\sqrt{2}}\psi_2 + \psi_3]$$

where ψ_n is the stationary-state eigenfunction of the oscillator for the nth state and A is a normalisation constant.

(i) Compute A. [4]

(ii) Compute the eigenfunction $\Phi(x, t)$ for all values of t. [4]

(iii) Obtain the expectation value of the energy at time t. [3]

Note that the allowed energy values are given by

$$E_n = (n + \frac{1}{2})\hbar\omega, \quad n = 0, 1, 2, ...$$

(iii) Obtain the energy, the degree of degeneracy and the eigenfunctions for the two lowest energy states of the system. [6]

3.(a) A particle of mass m is incident from the right on a potential of the form

$$\begin{aligned} V(x) &= 0, \quad x \leq 0 \\ &= V_1, \; 0 \leq x \leq a \\ &= V_2, \quad x \geq a \end{aligned}$$

The energy of the particle is such that $E > V_2$ and $V_2 > V_1$.

(i) Obtain the wave function of the particle everywhere, identifying each term. [8]

(ii) Obtain expressions for the reflection and transmission coefficients in terms of the constants of integration. [4]

(iii) Write down and justify the equations that would be used to determine the constants of integration in terms of one of them. [4]

(b) The wave function of a certain system is

$$\psi(x) = \sum c_n \phi_n(x)$$

where $\phi_n(x)$ are the orthonormal non-degenerate solutions of the time-independent Schroedinger equation of the system.

(i) Interpret the expansion coefficients c_n and obtain an expression for them. [4]

(iii) Obtain the expectation value of the energy of the system. [5]

4. (a) The time-independent Schrödinger equation for the one-dimensional harmonic oscillator is

$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\psi(x) + \frac{1}{2}kx^2\psi(x) = E\psi(x)$$

Show that the eigenfunctions of this oscillator must be of definite parity. Recall that eigenfunctions are never degenerate in one dimension. [6]

(b) The matrix representation of the harmonic oscillator is obtained by using the harmonic oscillator eigenfunctions as basis functions. Use the results of the previous problem to identify which of the matrix elements of the matrix representation of the operator x vanish. [4]

(c) The operators for spin-1/2 are

1. **(a)** **(i)** Explain why the operators representing dynamical variables in quantum mechanics are Hermitian. [2]

(ii) Show that the Hamiltonian operator for the linear harmonic oscillator

$$H = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + \frac{1}{2}kx^2$$

is Hermitian. Assume that the functions on which the operator acts vanish at $x = \pm\infty$. [7]

(b) **(i)** Explain the physical significance of the wave function. [2]

(ii) Show that if the potential energy acting on a particle is independent of the time, the time-dependent Schroedinger equation

$$-\frac{\hbar^2}{2m}\nabla^2\Psi(\mathbf{r},t) + V(\mathbf{r})\Psi(\mathbf{r},t) = i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t)$$

separates into two equations. [10]

(iii) Show that for such potential, the probability density is time-independent. [4]

2. A system consists of two particles, each of mass m, moving independently in the potential well

$$V(x) = \begin{cases} \infty \text{ for } x \le 0,\ x \ge L, \\ 0 \text{ for } 0 \ge x \le L \end{cases}$$

(i) Using x_1 for the coordinate of one particle and x_2 for the coordinate of the other, write down the Hamiltonian for the system. [2]

(ii) Hence show that the eigenfunctions of the system are given by

$$\Psi_{n_1,n_2}(x_1,x_2) = \frac{2}{L}\sin\frac{n_1\pi x_1}{L}\sin\frac{n_2\pi x_2}{L}, \quad n_1, n_2 = 1, 2, 3, ...$$

while the energy eigenvalues are given by

$$E_{n_1,n_2} = \frac{\hbar^2\pi^2}{2mL^2}(n_1^2 + n_2^2) \qquad [15]$$

(ii) Obtain the total wave function of the system. [2]

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS
UNIVERSITY EXAMINATIONS
2004 ACADEMIC YEAR FIRST SEMESTER

P361-ELECTROMAGNETISM

TIME: THREE (3) HOURS **MAX MARKS: 100**

INSTRUCTIONS: ATTEMPT ANY **FOUR (4)** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

You may use the following information:

$$\varepsilon_0 = 8.85\times 10^{-12}\ \text{farad/meter}$$
$$\mu_0 = 4\pi\times 10^{-7}\ \text{N/A}^2$$
$$\int \sec\theta d\theta = \ln(\sec\theta + \tan\theta)$$

The vector identities

$$\vec{\nabla}(fg) = f(\vec{\nabla}g) + g(\vec{\nabla}f)$$
$$\vec{\nabla}\cdot(f\vec{A}) = f\vec{\nabla}\cdot\vec{A} + \vec{A}\cdot\vec{\nabla}f$$
$$\vec{\nabla}\cdot(\vec{A}\times\vec{B}) = \vec{B}\cdot(\vec{\nabla}\times\vec{A}) - \vec{A}\cdot(\vec{\nabla}\times\vec{B})$$
$$\vec{\nabla}\times(f\vec{A}) = (\vec{\nabla}f)\times\vec{A} + f(\vec{\nabla}\times\vec{A})$$
$$\vec{\nabla}(V\cdot\vec{\nabla}V) = (\vec{\nabla}V)^2 + V\vec{\nabla}^2 V$$

The vector $\vec{r}$ is directed from $P'(x',y',z')$ to $P(x,y,z)$. If P' is fixed and P is allowed to move, then the gradient under this condition is given by

$$\vec{\nabla}'\left(\frac{1}{r}\right) = -\frac{\hat{r}}{r^2}$$

If P and P' is allowed to move, then the gradient is

$$\vec{\nabla}'\left(\frac{1}{r}\right) = \frac{\hat{r}}{r^2}$$

In cylindrical coordinates

For any arbitrary vector $\vec{A}$ and a surface bounding a volume τ

$$\int_{\tau}(\vec{\nabla}\times\vec{A})d\tau = -\int_{s}\vec{A}\times d\vec{a}$$

Poisson's equation

$$\vec{\nabla}^2 V = -\frac{\rho}{\varepsilon_0}$$

The vector potential at a point due to a current carrying conductor

$$\vec{A} = \frac{\mu_0 I}{4\pi}\oint\frac{d\vec{l}}{r}$$

The magnetic induction

$$\vec{B} = \frac{\mu_0 I}{4\pi}\oint\frac{d\vec{l}\times\hat{r}}{r^2}$$

$$\vec{B} = \vec{\nabla}\times\vec{A}$$

The Maxwell equations are:

$$\vec{\nabla}\cdot\vec{D} = \rho_f$$

$$\vec{\nabla}\cdot\vec{B} = 0$$

$$\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$$

$$\vec{\nabla}\times\vec{H} = \vec{J}_f + \frac{\partial\vec{D}}{\partial t}$$

Q.1(a) A metal sphere of radius a carries a charge Q. It is surrounded out to radius b by linear dielectric of permittivity ε.

(i) Find the potential at the center of the sphere relative to infinity (7 marks)

(ii) Find the bound charge in the dielectric at the outer surface and at the inner surface. (4 marks)

(b) A long cylindrical shell has inner and outer radii of a and b respectively. The space between the two radii is filled with a class A dielectric of relative permittivity ε_r. A charge of uniform linear density λ Coulomb per meter is distributed along its axis

(i) Use the generalized form of Gauss' law to calculate $\vec{E}$ and $\vec{D}$ within the dielectric material and also outside the cylindrical shell. (6 marks)

(ii) Calculate the bound surface charge density on the inner as well as the outer surface of the cylindrical shell. (5 marks)

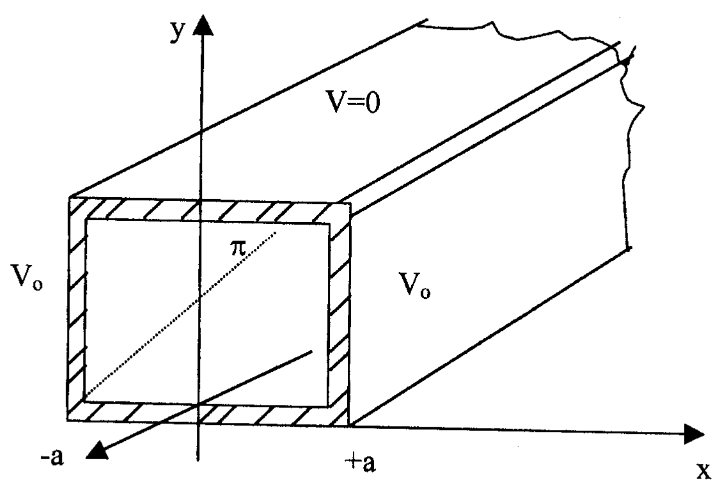
(iii) Calculate the bound volume charge density within the dielectric. (3 marks)

Q.2 Two infinitely long grounded metal plates at $y = 0$ and $y = \pi$ are connected at $x = \pm a$ by metal strips maintained at potential V_0, as shown in the figure below. (A thin silver of insulation at each corner prevents them from shorting out).

(a) Write down the boundary conditions for the problem. (4 marks)

(b) Solve Laplace's equation for this problem using the method of separation of variables. (10 marks)

(c) Find an expression for the general solution of the potential inside the resulting rectangular pipe satisfying the boundary conditions in (a) above. (11 marks)



Q.3(a) Use Poisson's and Laplace's equations to obtain the expression for electric the field $\vec{E}$ at a point

(i) inside and (6 marks)

(ii) outside (5 marks)

a uniform spherical charge distribution ρ.

(b) The energy density associated with an electric field is given by

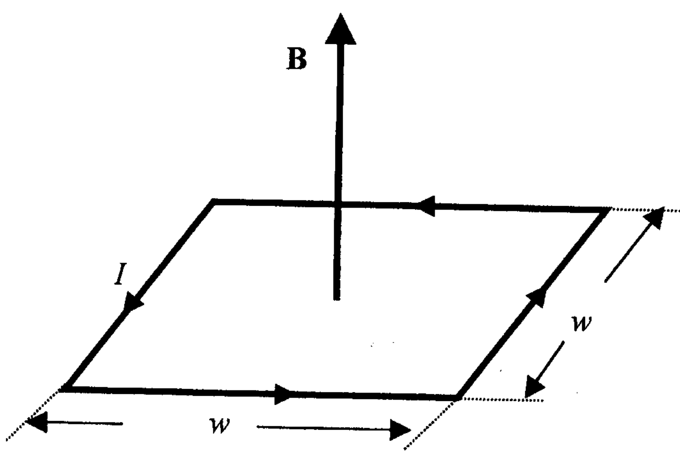
$$\frac{dW}{d\tau} = \frac{1}{2}\varepsilon_0 E^2 ..$$

Use this expression to calculate the electrostatic potential of a spherical shell having a charge Q uniformly distributed over its surface. (6 marks)

(c) A thin conducting plate carries a surface charge density σ. Calculate the electric field intensity E at a point situated z meters from the surface of the plate due to the charge located on the plate within a radius $\sqrt{3}\, z$. (8 marks)

Q.4 A square loop as shown below with sides w carries a current I. The loop lies in the horizontal plane a distance d from the $y-$axis. There is a vertical magnetic field whose magnitude varies linearly in the $x-$direction according to the expression:

$$B(x) = ax + b.$$



(a) Determine (symbolically) the force on each side of the loop. (21 marks)

(b) Calculate the net force on the loop. (4 marks)

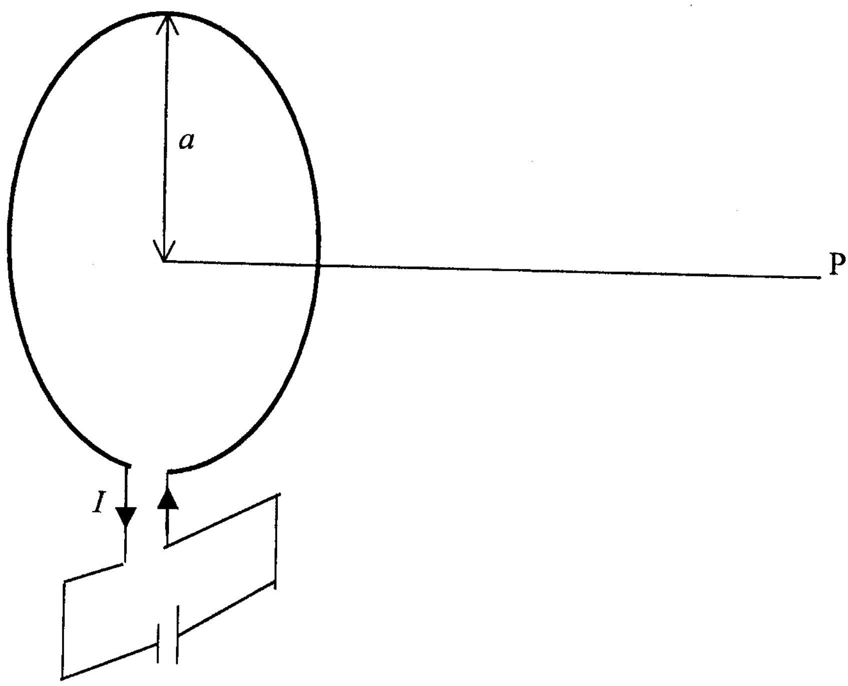
Q.5(a) State Ampere's circuital law.

(3 marks)

(b) Use the law stated in (a) above to obtain an expression for the magnetic induction at a point P a distance ρ ($\rho < R$) from the axis of a cylindrical wire of radius R carrying a current I and show that your expression reduces to the expected result at the surface of the cylinder.

(6 marks)

(c) Determine the magnetic induction at a point P on the axis of a circular loop of radius a carrying a current I and show that your expression reduces to the expected result at the centre of the loop depicted in the figure below. (8 marks)



(d) A conducting sphere of radius R having a charge Q uniformly distributed over its surface is spun about a diameter at an angular frequency ω. If the diameter of rotation points in the z-direction and θ is the angle (in spherical coordinates) of any point on the sphere, find the magnetic induction at the center of the sphere.

(8 marks)

Q.6 In a homogenous, linear, isotropic and stationary medium, the electric vector $\vec{E}$ obeys the following wave equation:

$$\nabla^2 \vec{E} - \varepsilon\mu \frac{\partial^2 \vec{E}}{\partial t^2} - \sigma\mu \frac{\partial \vec{E}}{\partial t} = 0 \cdot$$

(a) Using complex notation for a plane sinusoidal wave travelling along the positive z – direction, show that in a good conductor the wave number is complex and is equal to

$$\left(\frac{\omega\sigma\mu}{2}\right)^{\frac{1}{2}}(1-j)$$

(11 marks)

(b) Use the equation given above to obtain an expression for the electromagnetic wave equation in a charge-free space and hence deduce the speed of electromagnetic waves in free space in terms of the parameters μ_0 and ε_0.

(5 marks)

(c) (i) Define mutual inductance.

(3 marks)

(ii) Obtain the mutual inductance of two coils a and b in terms of their current carrying line elements and hence show that

$$M_{ab} = M_{ba}$$

(6 marks)

END OF EXAMINATION

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THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF PHYSICS
FIRST SEMESTER EXAMINATION 2004

P401: COMPUTATIONAL PHYSICS

TIME:	3 HOURS
INSTRUCTIONS:	ANSWER ANY FOUR QUESTIONS
	TOTAL MARKS 100
	ALL QUESTIONS CARRY EQUAL MARKS

$$a_k \approx \frac{2\Delta}{T}\sum_{i=0}^{N-1} f(t_i)\cos w_k t_i$$

$$b_k \approx \frac{2\Delta}{T}\sum_{i=0}^{N-1} f(t_i)\sin w_k t_i$$

$$\Delta = 0.1, T = N \times \Delta, w = 2\pi / T, w_k = kw$$

Q1. a) A radioactive process produces beta and alpha particles in ratios of 1:2 respectively. A certain detector is capable of measuring both types of particles one at a time. Let X = the number of beta particles detected when 5 particles are detected. Find

i) the probability function $f(x)$ of X.
ii) the mean μ of the probability function.
iii) The variance σ of the probability function.

[15]

b) Write an algorithm to simulate this experiment assume that the random number generator is provided as a Library function rand() which returns an integer.

[10]

Q.2. a) Draw the block diagram of a 4 point Fast Fourier Transform in time decimation.

[7]

b) Given the function whose discreet form is given below, find the Fourier coefficients a_k and b_k using the Discreet Fourier Transform. Calculate values of $k = 0$, 1 and 2.

[18]

t_i	0	0.1	0.2	0.3	0.4	0.5	0.6
$f(t_i)$	1	0	-1	1	0	-1	1

Q.3 The data given below is expected to follow a function of the form

$$f(x) = ke^{-\alpha(x-\mu)^2}.$$

Find k, α and μ using the method of least squares up to three decimal points precision.

x	-1	0	1	2	3
$f(x)$	0.54	2.40	4.02	2.42	0.53

[25]

Q.4. a) Find an eigenvalue (common) for the matrix below using

i) The Analytical method [8]
ii) A Numerical method (4 steps) with initial trial vector of $[1\ 0]^T$

$$\begin{bmatrix} 10 & 2 \\ 2 & 7 \end{bmatrix}$$ [8]

b) Calculate the expected error bounds and verify that the analytical result falls within the error bounds. [4]

c) Hence find the corresponding eigenvector associated with the matrix. Use the analytically derived eigenvalue. [5]

Q.5. a) Explain briefly the major steps taken to perform simulations of many particle systems such as a gas of molecules. [7]

b) Find the basis of the matrix given below and diagonalize. [18]

$$A = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 2 & 0 \\ 3 & 0 & 0 \end{bmatrix}$$

Q.6. a) Write an algorithm that will perform a Monte-Carlo style simulation of alpha decay. In the algorithm to be provided use the following,

- i) Assume that the original sample has N_o unstable nuclei.
- ii) The output of should be the number (n) of undecayed unstable nuclei at any particular time.
- iii) the probability of decay on each time step is given by p.
- iv) the array data structure is used to identify and represent each nuclei's status.
- v) Assume that the random number generator function is provided as a library function *rand()*.

[12]

b) Put comments in the program provided below and hence explain what the program performs.

[13]

```
#include <fstream.h>

float  x;
int    n;

main(){
ofstream    output;
output.open("lampi.txt");
if(output.fail())
       cout<<"failed to open output file";
    ifstreaminput;
input.open("ex.txt");
if(input.fail())
       cout<<"failed to open input file";

while(1){
       input>>x;
       if(x==0)
             break;
       n = x;
       output<<n<<"\n";
}
output.close();
input.close();
return 0;
}
```

End of Examination

Answer sheet

```
#include <fstream.h>

float x;
int   n;

main(){
      ofstream  output;
      output.open("lampi.txt");
      if(output.fail())
           cout<<"failed to open output file";
      ifstream  input;
      input.open("ex.txt");
      if(input.fail())
           cout<<"failed to open input file";

      while(1){
           input>>x;
           if(x==0)
                break;
           n = x;
           output<<n<<"\n";
      }
      output.close();
      input.close();
      return 0;
}
```

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

P441: ANALOGUE ELECTRONICS II

TIME: THREE HOURS **MAXIMUM MARKS = 100**

INSTRUCTIONS:

Answer any four questions.
All questions carry equal marks.
The marks are shown in brackets.

Q1 (a) Derive an expression for the input resistance of a voltage series feedback amplifier. [7]

(b) Determine the output voltage in each of the following cases for the open loop differential amplifier of figure 1. Draw the output waveform in each case. [4]

(i) $V_{in1} = 5$ mV dc $\quad V_{in2} = -7$ mV dc
(ii) $V_{in1} = 10$ mV rms $\quad V_{in2} = 20$ mV rms

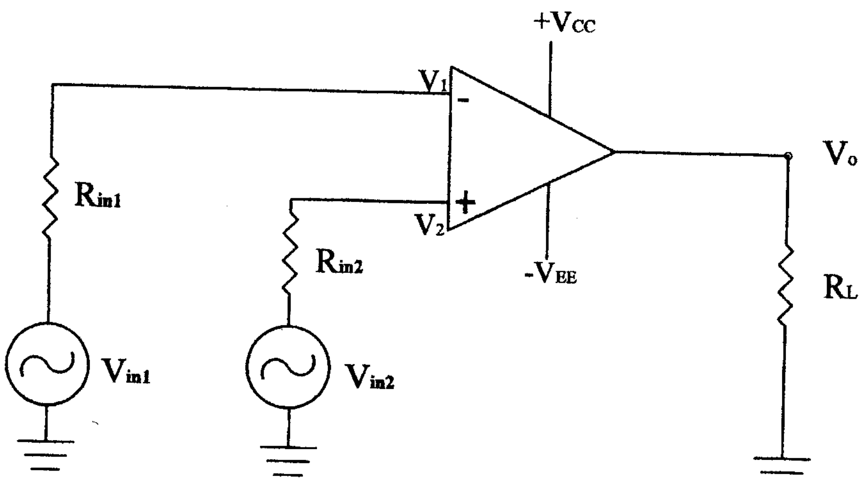

Figure 1

The operational amplifier is a 741C with the following specifications:
$A = 200{,}000$, $R_i = 2\ M\Omega$, $R_o = 75\ \Omega$, $+V_{CC} = 15$ V, $-V_{EE} = -15$ V, $R_{in1} = 0$
$R_{in2} = 0$, $R_L = 3\ k\Omega$ and output voltage swing = ± 14 V.

(c) Discuss the effect of input offset voltage on inverting and non-inverting feedback amplifiers.

[14]

Q 2 (a) Design a second order low pass Butterworth filter at a cutoff frequency of 2 kHz. Using the frequency scaling technique, convert this filter to have a cutoff frequency of 3 kHz.

[8]

(b) Draw the schematic diagram of a Wien bridge oscillator. What are the two requirements for oscillation? A certain Wien bridge oscillator uses $R = 4.7\ k\Omega$, $C = 0.01\ \mu F$ and $R_F = 2R_1$. Determine the frequency of oscillation. [10]

(c) The following specifications are given for the amplifier circuit of figure 2. $R_1 = R_3 = 680\ \Omega$, $R_F = R_2 = 6.8\ K\Omega$, $V_x = -1.5$ V pp and $V_y = -2$ Vpp sine waves at 1kHz.The operational amplifier is a 741C with $A = 200{,}000$ and $R_i = 2M\Omega$.
Calculate the
(i) Voltage gain
(ii) input resistance
(iii) output voltage of the amplifier.
Assume that the output is intially nulled.

[7]

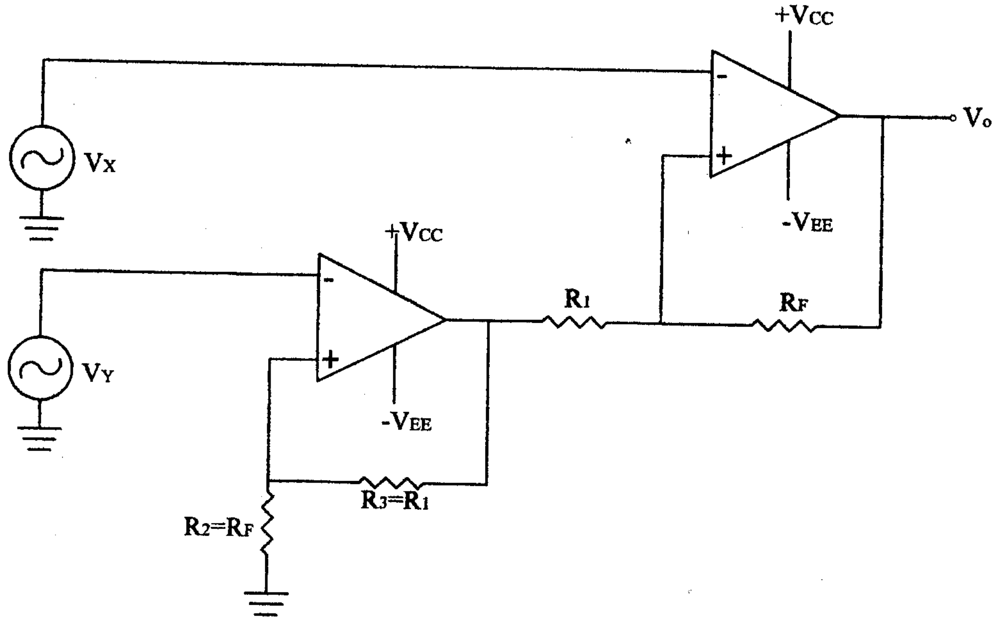

Figure 2

Q3 (a) Design a narrow band pass filter so that $f_c = 2$ kHz, $Q = 20$ and $A_F = 10$. What modifications are necessary in the filter circuit to change the center frequency f_c to 2.5 kHz, keeping the gain and bandwidth constant? [10]

(b) In the circuit of figure 3a, $R_1 C_F = 1$ second, and the input is a step (dc) voltage as shown in figure 3b. Determine the output voltage and sketch it. Name the waveform and find the slope. Assume that the op-amp is initially nulled. [5]

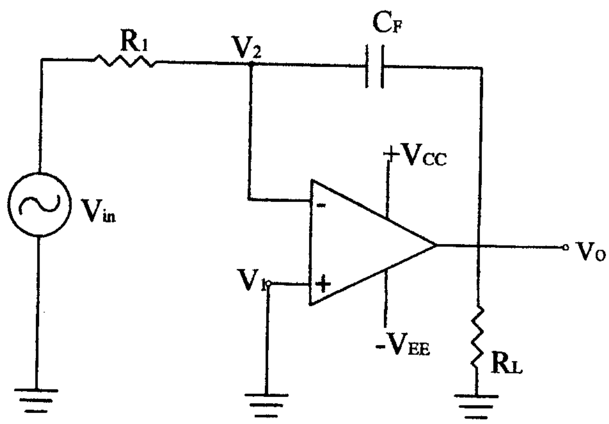

Figure 3a

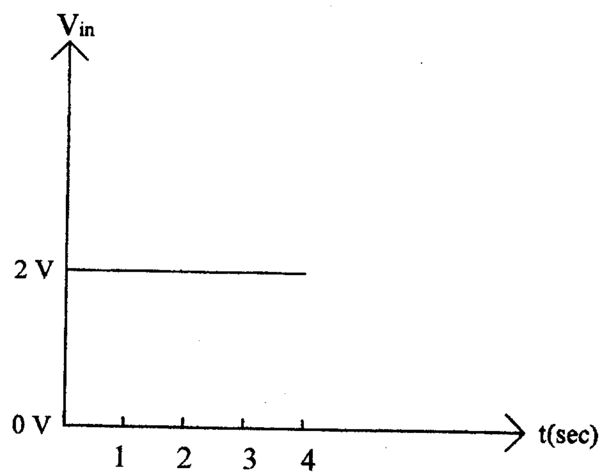

Figure 3b

(c) Write short notes on (i) CMRR (ii) slew rate (iii) SVRR (iv) input offset current (v) voltage follower. [10]

Q4 (a) Design a wide band pass filter with $f_L = 200$ Hz, $f_H = 1$ kHz and a pass band gain = 4. [11]

(b) Draw the frequency response plot of the filter. [12]

(c) Calculate the Q value for the filter. [2]

Q5 (a) Draw the schematic diagram of a peaking amplifier. What determines the peak frequency f_p in the peaking amplifier? Determine the values of all components of the peaking amplifier to provide a gain of 10 at a peak frequency of 16 kHz. [12]

(b) For the circuit given below, $R_{in} = 50\ \Omega$, $C_i = 0.01\ \mu F$, $R_1 = 1K\Omega$, $R_{OM} = 820\ \Omega$, $R_F = 5.6\ k\Omega$ and $R_L = 10\ k\Omega$. The op-amp is a 741C with A = 200,000 and UGB = 1 MHz. Determine
(i) The gain and [2]
(ii) The bandwidth of the amplifier. [5]

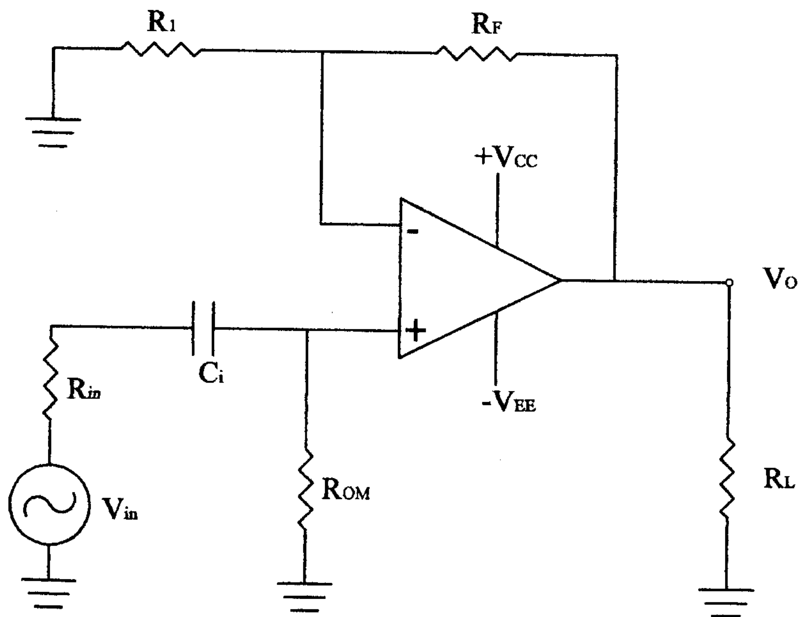

Figure 4

(c) What is a comparator? Draw the input and output waveforms of the comparator when +4V is applied at the inverting input and a sinusoidal signal of 6V peak at the non-inverting input [6]

Q6 (a) Briefly describe how an operational amplifier in inverting configuration can be used as a (i) Summing amplifier (ii) Scaling amplifier and (iii) Averaging amplifier. [13]

(b) Draw the circuit diagram of a Schmitt trigger using an op-amp and explain its operation. [12]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M221: LINEAR ALGEBRA

TIME: **THREE HOURS**

INSTRUCTIONS: ATTEMPT ANY FOUR QUESTIONS.

---

1. What is the meaning of each of the following terms

   (i) the *row-echelon form of a matrix* A?
   (ii) a *consistent system of equations*?

   (a) Reduce the matrix

$$\begin{pmatrix} 1 & -1 & 2 & 1 \\ 2 & 1 & -1 & 1 \\ 1 & -2 & 1 & 1 \end{pmatrix}$$

   to its echelon form.

   (b) Determine the values of μ such that the system of equations

$$\begin{aligned} \mu x + y + z &= 1 \\ x + \mu y + z &= 1 \\ x + y + \mu z &= 1 \end{aligned}$$

   (i) has a unique solution
   (ii) has no solution
   (iii) has more than one solution.

2. Define each of the following terms

(i) a *subspace* U of a vector space V

(ii) a *basis* of a subspace U of a vector space V

(a) Show that the subset U of $V_4(\Re)$ which is given by

$$U = \{(\alpha, \beta, \gamma, \delta) \mid \gamma = -\delta\}$$

is a subspace of $V_4(\Re)$, hence determine its dimension over $(\Re)$.

(b) Find an $\Re$ - basis for a subspace U of $V_4(\Re)$ which is generated by the vectors

$$v_1 = (1, 1, 0, 0), \quad v_2 = (0, 0, 1, 1),$$
$$v_3 = (-2, 0, 2, 2), \quad v_4 = (0, -3, 0, 3)$$

3. Define each of the following terms

(i) a *linear transformation* $T: U \rightarrow V$

(ii) a *matrix of a linear transformation* T

(a) Let $T: V_3((\Re) \rightarrow V_3(\Re)$ be a map which is given by

$T(\alpha, \beta, \gamma) = ((\alpha - \beta, (\alpha + 2\beta - \gamma, 2\alpha + \beta + \gamma)$

Prove that T is a linear transformation on $V_3(\Re)$ relative to the standard basis

$$\{(1,0,0), (0,1,0), (0,0,1)\}$$

for $V_3(\Re)$.

(b) The matrix of a linear transformation on $V_3(\Re)$ relative to the standard basis of $V_3(\Re)$ is given by

$$\begin{pmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{pmatrix}$$

find the matrix of T relative to the $(\Re)$ - basis $\{v_1, v_2, v_3\}$ of $V_3(\Re)$, where $v_1 = (-1, 1, 2)$, $v_2 = (0, 1, 1)$, $v_3 = (2, 5, 7)$

4. Define the following terms

   (i) the *rank* of a linear transformation $T: U \rightarrow V$

   (ii) a *non-singular linear transformation*

(a) Show that a linear transformation T on $V_3(\Re)$ given by

$$T(x, y, z) = (-x + 2y - z, 3x - y, x - y + z)$$

Is non-singular, hence determine rank(T)

(b) The matrix of a linear transformation

$T: V_3(\Re) \rightarrow V_3(\Re)$ relative to the standard basis is given by

$$\begin{pmatrix} 2 & 4 & -2 \\ 4 & -2 & 2 \\ 6 & 2 & 2 \end{pmatrix}$$

Find the rank and nullity of the linear transformation T.

Deduce that the system of equations

$$2x_1 + 4x_2 - 2x_3 = 0$$

$$4x_1 - 2x_1 + 2x_3 = 0$$

$$6x_1 + 2x_2 + 2x_3 = 0$$

does not have a non-trivial solution.

5. Let $U \to V$ be a linear transformation then define

(i) the *kernel*, ker T of T
(ii) the *image*, im T of T

(a) Prove that the kernel of T and the image of T are subspaces of U and V respectively

(b) If T has the matrix

$$A = \begin{pmatrix} 1 & 1 & 2 \\ -1 & -3 & 8 \\ 4 & -3 & -7 \\ 1 & 12 & -3 \end{pmatrix}$$

then find a basis for ker T and a basis for im$T$.

6. What is the meaning of each of the following terms

(i) an *elementary row operation* on a matrix A?

(ii) the *inverse* A^{-1} of a matrix A?

(a) Let

$$\begin{bmatrix} 1 & 0 & 1 \\ 2 & -1 & 0 \\ 1 & 1 & 0 \end{bmatrix}$$

be a matrix. Then

(i) define the row operations on A that may reduce A to te identity matrix I_3 of degree 3.

(ii) Apply the row operations defined in (a) (i) above to the matrix I_3 to obtain the matrix B.

(b) Let A be the matrix defined in 6(a) (ii) above. Then deduce that $B = A^{-1}$, the inverse of A.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER DEFERRED EXAMINATIONS

M221: LINEAR ALGEBRA

TIME: **THREE HOURS**

INSTRUCTIONS: ATTEMPT ANY FOUR QUESTIONS.

---

1. What is the meaning of each of the following terms

   (i) the *row-echelon form of a matrix* A?
   (ii) a *consistent system of equations*?

   (a) Reduce the matrix

$$\begin{bmatrix} 1 & 1 & -1 \\ 1 & -1 & 2 \\ 2 & 0 & 2 \\ 2 & 1 & -1 \end{bmatrix}$$

   to its echelon form.

   (b) Determine the values of μ such that the system of equations

$$\mu x + y + z = 1$$
$$x + \mu y + z = 1$$
$$x + y + \mu z = 1$$

   (i) has a unique solution
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$$U = \{(\alpha, \beta, \gamma, \delta) \mid \gamma = -\delta\}$$

is a subspace of $V_4(\Re)$, hence determine its dimension over $(\Re)$.

(b) Find an $\Re$ - basis for a subspace U of $V_4(\Re)$ which is generated by the vectors

$$v_1 = (1, -2, 5, 3),$$
$$v_2 = (2, 3, 1, -4),$$
$$v_3 = (3, 8, -3, -5).$$

3. Define each of the following terms

(i) a *linear transformation* $T: U \to V$

(ii) a *matrix of a linear transformation* T

(a) Let $T: V_3((\Re) \to V_3(\Re)$ be a map which is given by

$T(\alpha, \beta, \gamma) = (\alpha + 2\beta - \gamma,\ \beta + \gamma,\ \alpha + \beta - 2\gamma)$

Prove that T is a linear transformation on $V_3(\Re)$ relative to the standard basis

$$\{(1,0,0), (0,1,0), (0,0,1)\}$$

for $V_3(\Re)$.

(b) The matrix of a linear transformation on $V_3(\Re)$ relative to the standard basis of $V_3(\Re)$ is given by

$$\begin{pmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{pmatrix}$$

find the matrix of T relative to the $(\Re)$ - basis $\{v_1, v_2, v_3\}$ of $V_3(\Re)$, where $v_1 = (-1, 1, 2)$, $v_2 = (0, 1, 1)$, $v_3 = (2, 5, 7)$

4. Define the following terms

(i) the *rank* of a linear transformation $T: U \to V$

(ii) a *non-singular linear transformation*

(a) Show that a linear transformation T on $V_3(\Re)$ given by

$$T(x, y, z) = (-x + 2y - z, 3x - y, x - y + z)$$

Is non-singular, hence determine rank(T)

(b) The matrix of a linear transformation

$T: V_3(\Re) \to V_3(\Re)$ relative to the standard basis is given by

$$\begin{pmatrix} 2 & 4 & -2 \\ 4 & -2 & 2 \\ 6 & 2 & 2 \end{pmatrix}$$

Find the rank and nullity of the linear transformation T.

Deduce that the system of equations

$$2x_1 + 4x_2 - 2x_3 = 0$$

$$4x_1 - 2x_1 + 2x_3 = 0$$

$$6x_1 + 2x_2 + 2x_3 = 0$$

does not have a non-trivial solution.

5. Let $U \rightarrow V$ be a linear transformation then define

(i) the *kernel*, ker T of T
(ii) the *image*, im T of T

(a) Prove that the kernel of T and the image of T are subspaces of U and V respectively

(b) If T has the matrix

$$A = \begin{pmatrix} 1 & 1 & 2 \\ -1 & -3 & 8 \\ 4 & -3 & -7 \\ 1 & 12 & -3 \end{pmatrix}$$

then find a basis for ker T and a basis for imT.

6. What is the meaning of each of the following terms

(i) an *elementary row operation* on a matrix A?

(ii) the *inverse* A^{-1} of a matrix A?

(a) Let

$$\begin{bmatrix} 1 & 0 & 1 \\ 2 & -1 & 0 \\ 1 & 1 & 0 \end{bmatrix}$$

be a matrix. Then

(i) define the row operations on A that may reduce A to te identity matrix I_3 of degree 3.

(ii) Apply the row operations defined in (a) (i) above to the matrix I_3 to obtain the matrix B.

(b) Let A be the matrix defined in 6(a) (ii) above. Then deduce that $B = A^{-1}$, the inverse of A.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M231: REAL ANALYSIS I

TIME: **THREE (3) HOURS**

INSTRUCTIONS:

THERE ARE TWO SECTIONS IN THIS PAPER.

(i) Answer **four** questions, **two from each sections.**

(ii) Indicate the question number of any question answered on the main answer book.

---

1. (a) Define

(i) a function $f: X \to Y$

(ii) a direct image of a set $A\ (\subset X)$ under a function $f: X \to Y$

(iii) an inverse image of a set $C(\subset Y)$ under a function $f: X \to Y$

(b) If $f: \mathbf{R} \to \mathbf{R}$ is a function and if X, Y are subsets of **R**, prove that

(i) $f(X \cap Y) \subset f(X) \cap f(Y)$

(ii) $f^{-1}(X^c) = \left[f^{-1}(X)\right]^c$

(iii) $X \subset f^{-1}(f(X))$

(c) The function f is defined by $f(x) = \log_e x$. If $A = [0, 1]$ and $B = [1, 3]$, find

(i) $f(A)$
(ii) $f^{-1}(A)$
(iii) $f^{-1}(B)$
(iv) $f^{-1}(A \cup B)$
(v) $f^{-1}(A \cap B)$

2. (a) Define

(i) least member of a set S ($\subset$ **R**)

(ii) least upper bound (supremum) of a set S ($\subset$ **R**)

(iii) completeness axiom for subsets of **R**

(b) (i) Prove that a non-empty set of real numbers which is bounded below has an infimum.

(ii) Let A, B be subsets of **R**, which are bounded above, and let A + B be defined by

$$A + B = \{x + y : x \in A \text{ and } y \in B\}$$

Prove that

$$\text{Sup}\,(A + B) = \sup A + \sup B$$

(c) Determine for each set the <u>supremum</u> and <u>infimum</u> if they exist.

(i) $R = \left\{1 - \frac{(-1)^n}{n} : \ n \in \mathbf{N}\right\}$

(ii) $S = \left\{\frac{n}{n+1} : \ n \in \mathbf{N}\right\}$

(iii) $T = \{5^{-m} + 3^{-n} + 4 : \ m, n \in \mathbf{N}\}$

3. (a) (i) Define a bounded set S ($\subset$ **R**).

State

(ii) Dedekinds property of **R**.

(iii) Density property of **R**

(b) Prove the following :

(i) Between any two district real numbers there exist infinitely many rational numbers.

(ii) Dedekind's property implies that every bounded set has a supremum.

(c) Prove that there is a positive real number c such that $c^2 = 2$

SECTION B

4. (a) Define

(i) a sequence (a_n) which converges to a limit ℓ.

(ii) a sequence (a_n) which diverges to $+\infty$ as $n \to \infty$

(iii) a bounded sequence (a_n) in **R**.

(b) Prove

(i) If (a_n) is a convergent sequence of real numbers and if $a_n \geq 0$ for all $n \in \mathbf{N}$ then $\lim_{n\to\infty} a_n \geq 0$

(ii) If (a_n) and (b_n) are convergent sequences of real numbers and if $a_n \leq b_n$ for all $n \in \mathbf{N}$, then

$$\lim_{n\to\infty} a_n \leq \lim_{n\to\infty} b_n$$

(iii) If (a_n) and (b_n) are two sequences of real numbers and if $a_n \leq b_n$ for all $n \in \mathbf{N}$, then

$$\lim_{n\to\infty} a_n = \infty \quad \text{implies} \quad \lim_{n\to\infty} b_n = \infty$$

(c) Using your definition in (a) (i) show that the sequence $a_n = \dfrac{n^2+n+1}{4n^2+3} \to \dfrac{1}{4}$ as $n \to \infty$.

5. (a) Define

(i) a monotone increasing sequence (a_n)

(ii) a subsequence of a sequence (a_n) of real numbers.

State

(iii) the Monotone Convergence theorem for sequences.

(b) The sequence (a_n) is defined by $a_1 = 1$, $a_{n+1} = \sqrt{1+\dfrac{a_n^2}{2}}$, $(n = 1, 2, 3, \ldots)$

Show that (i) $a_n^2 - 2 < 0$

(ii) $a_{n+1}^2 - a_n^2 > 0$

Deduce that (a_n) converges and find its limit

5. (c) By using the fact that $\left(1+\frac{1}{n}\right)^n \to e$ as $n \to \infty$ show that the sequences are convergent and find their limits in terms of e.

(i) $\left(\left[1+\frac{1}{3n}\right]^n\right)$

(ii) $\left(\left[1-\frac{1}{n}\right]^n\right)$

6. (a) Let (a_n) be a sequence of real numbers.

Define

(i) lim sup a_n

(ii) lim inf a_n

(iii) a Cauchy sequence (a_n)

(b) Prove

(i) If (a_n) and (b_n) are bounded sequences of real numbers and if $a_n \le b_n$ for all $n \in \mathbf{N}$, then $\lim\limits_{n\to\infty} \sup a_n \le \lim\limits_{n\to\infty} \sup b_n$

(ii) A bounded sequence (a_n) in **R** is convergent if and only if

$$\lim_{n\to\infty} \sup a_n = \lim_{n\to\infty} \inf a_n = \lim_{n\to\infty} a_n$$

(iii) Every Cauchy sequence is convergent in **R**.

(c) A sequence is defined by $a_n = \left(1+\frac{1}{n}\right)\cos n\pi$

Find (i) $\lim\limits_{n\to\infty} \sup a_n$

(ii) $\lim\limits_{n\to\infty} \inf a_n$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M261: INTRODUCTION TO STATISTICS

INSTRUCTIONS:

1. Answer any FIVE (5) questions.
2. Calculators are allowed.
3. You may use statistical tables provided.
4. Show all your work to earn full marks.

TIME: THREE (3) Hours

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1. (a) Mention <u>three</u> steps necessary for constructing a frequency distribution

(b) The price (in dollars) of a certain popular coat was studied across a certain city, a sample of 50 prices of the same was collected and is shown below.

36	38	40	41	42	43	43	44	45	46
46	47	48	49	50	50	50	51	51	53
53	54	55	55	56	56	57	58	58	59
63	69	71	73	73	75	77	78	79	80
82	83	84	87	88	91	92	96	100	110

(i) Prepare a frequency distribution in which the lowest value for the lowest class is 30 and each class has a class-interval of 10 units.

(ii) <u>Briefly</u> comment on the adequacy of the class interval

(iii) Mention <u>two</u> things that stand out about the distribution of the price of the coat.

(c) (i) Construct a stem-and –leaf plot of the data

(ii) What are the immediate advantages the plot offers over the frequency distribution?

2. In 1999, George Kawila et. al., a student in M261 class at the time, carried out a survey among the disabled students enrolled at the University of Zambia (UNZA). His objective was to find out the problems the students faced with regard to a number of issues. He collected a total of 30 variables and data for four of those variables are given below:

Student ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gender 1 = Male, 2= Female	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	2
Age (years)	24	23	31	23	23	33	24	21	25	26	40	30	39	24	23	33	22	42	23
Did your situation limit your choice of study programme? 1= Yes, 2 = No	2	2	2	2	1	2	2	2	2	1	2	2	2	1	2	2	2	2	2
Has the University Community been accommodative to you? 1= Yes, 2 = No, * = Missing	2	1	1	1	1	2	1	1	1	2	2	1	1	1	1	1	1	2	*

Source: M261 Project 1999, UNZA, George Kawila.

(a) (i) Determine the mean and standard deviation of age by gender

(ii) What proportion of disabled students did females represent?

(b) (i) What proportion of disabled students were limited in their choice of programmes due to their disability?

(ii) What proportion of male disabled students were limited in their choice of programmes due to their disability?

(iii) What proportion of female disabled students were limited in their choice of programmes due to their disability?

(iv) What can you say about the limitation in choice of programmes for disabled students that year? In one line or two.

(v) What proportion of disabled students found UNZA un-accommodative?

(c) A cross tabulation of limitation in the choice of programmes and accommodation of UNZA community is as follows

		Has the University Community been accommodative to you? Yes	No	Total
Did your situation limit your choice of study programme?	Yes	2	1	3
	No	11	4	15
	Total	13	5	18

(i) What proportion of disabled students were not limited in their choice of programmes among the students who found UNZA community accommodative?

(ii) What proportion of disabled students were not limited in their choice of programmes among the students who found UNZA community un-accommodative?

(iii) What conclusion can you make based on your results in (i) and (ii)? In one line or two.

3. The Government has been studying six areas with potential for tourism development. Economic activities in there areas seem to vary. A survey utilizing stratified sampling design was carried out. Among the variables collected was income, below is a summary of the findings.

Region (Strata)	Stratum Size N_n	Sample Size n_n	Weight $W_n=N_n/N$	$\frac{N_n - n_n}{N_n}$	Average Income	Standard Deviation
1	340,000	270,000	0.18	0.21	216,200	123,140
2	500,000	280,000	0.27	0.44	183,621	90,000
3	50,000	30,000	0.03	0.40	190,040	120,000
4	49,000	25,000	0.03	0.49	219,048	130,000
5	700,000	300,000	0.38	0.57	273,556	99,000
6	200,000	80,000	0.11	0.60	191,417	80,000

Note: N = 1,839,000 n = 985,000

You may find the formulae provided useful.

(a) Obtain the average income of the six regions using simple random sampling design

(b) Obtain the average income of the six regions using stratified simple random sampling

(c) How do the two estimates compare?

(d) Obtain the standard error of the estimate in (b).

(e) What proportion of the data was samples?

$\boxed{1.}$ $\bar{x} = \frac{\sum x_i}{n}$ $\boxed{2.}$ $\hat{SE}(\bar{x}) = \frac{s}{\sqrt{n}}\sqrt{\frac{N-n}{N}}$ $\boxed{3}$ $\bar{x} = \sum_{n=1}^{k} W_n \bar{X}_n$, $\boxed{4}$. $\hat{SE}(\bar{x}) = \sqrt{\sum_{n=1}^{k} W_n^2 \left(\frac{N_n - n_n}{N_n}\right)\frac{s_n^2}{n_n}}$

4. (a) A chemical process has produced, on the average, 800 tons of chemical per day. A sample of size 5 yields an average of 795 and a standard deviation of 8.34 tons. When the supervisor is informed of this production he made the following statement, "I wonder whether these data indicate that the average yield is less than 800 tons and, hence, that something is wrong with the process".

At the 5% level of significance carry out a test to answer the supervisor's query. Be sure to state the null and alternative hypotheses based on the supervisor's remark. Assume a normal distribution.

(b) The braking ability was compared for two types of cars. Random samples of 64 cars were tested for each type. The recorded measurement was the distance (metres) required to stop when the brakes were applied at 40 miles per hour. The computed sample means and variance were as follows

	n	Sample mean	Sample variance S^2
Type 1	64	$118 = \bar{y}_1$	$102 = s_1^2$
Type 2	64	$109 = \bar{y}_2$	$87 = s_2^2$

Do the data provide sufficient evidence to indicate a difference in the mean stopping distance for the two types of cars? Be sure to state the hypotheses, tests and decision rule.

5. An agricultural company has trained its workers using three methods of packing cotton in bags. There were six trainees for each method. Below are the number of bags picked by trainees using each method.

SUMMARY STATISTICS

							N	Mean	Standard Deviation
Method 1	45	40	50	39	53	44	6	45.17	5.4924
Method 2	59	43	47	51	39	49	6	48.00	6.8993
Method 3	41	37	43	40	52	37	6	41.67	5.5737

(a) (i) Determine the total sums of squares (SST)

(ii) Determine the within sums of squares (SSW)

(iii) Write down an ANOVA table

(b) Based on the ANOVA table carry out the test to determine whether the true means for the three methods differ at $\alpha = 0.05$.

(c) Is it necessary to carry out pair-wise comparisons of means here? Defend your answer briefly.

6. In economics, the demand function for a product is often estimated by regressing the quantity sold (Q) on the price (P). A company is trying to estimate the demand function for its new family-size drink and has collected the following data:

P(x)	20	17.5	16.0	14.0	12.5	10.0	8	6.5
Q(y)	125	156	183	190	212	238	250	276

The model postulated is:

$$Q_i = \alpha + \beta P_i + \text{Error}$$

(a) (i) Write down expressions for the Least Squares Estimators for α and β.

(ii) Obtain the Least Squares Estimates $\hat{\alpha}$ and $\hat{\beta}$ using the data above given that $\Sigma xy = 19642$.

(iii) Write down an estimated regression line.

(b) An ANOVA table for the regression line in (a) is shown below.

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17480.795	1	17480.795	475.226	.000[a]
	Residual	220.705	6	36.784		
	Total	17701.500	7			

a. Predictors: (Constant), PRICE

b. Dependent Variable: QUANTITY

Is the relationship between quantity and price significant at $\alpha = 0.05$? Support your answer.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

M 325: INTRODUCTION TO ABSTRACT ALGEBRA

TIME: THREE (3) HOURS **DATE: JUNE 28, 2004**

INSTRUCTIONS: ATTEMPT ANY FIVE QUESTIONS

Q.1. (a) Let G be a group. Define a subgroup H of a group G.

(b) Consider the four permutations

$$V = \{(1),\ (1\ 2)(3\ 4),\ (1\ 3)(2\ 4),\ (1\ 4)(2\ 3)\}$$

Show that V is a subgroup of S_4.

(c) Let $A = \{1, 2, 3, 4, 5, 6, 7, 8\}$. Define a function $f: A \to A$ by

$$f(n) = \text{remainder after dividing } 11n \text{ by } 9$$

(i) Show that f is a permutation

(ii) How many permutations in S_8 have the same cycle structure as f?

(iii) Find the order, inverse and the parity of f.

Q.2 (a) Let X be a set. Define an equivalence relation $x \equiv y$ on X.

(b) Suppose that G is a group acting on a set X as follows: if $x, y \in X$, define $x \equiv y$ i there exists $g \in G$ such that $y = gx$. Show that this relation is an equivalence relation on X.

(c) Let x be an integer such that $1 < x \leq 20$. Solve the congruence $x^2 \equiv 1 \mod 21$.

Q.3. (a) State the Euclid's Lemma.

(b) Let p be a prime number. Show that $p \left| \binom{p}{j} \right.$ for all j such that $0 < j < p$.

(c) Show that if p is prime then the cyclotomic polynomial

$$x^{p-1} + \binom{p}{1}x^{p-2} + \binom{p}{2}x^{p-3} + \ldots + \binom{p}{p-1}x + p$$

is irreducible in $Z[x]$ and in $Q[x]$.

Q.4. (a) Find the g c d (343, 63) and express it in the form $343t + 63w$ where t and w a
integers.

(b) Let $U(Z_m)$ denote the multiplicative group of units in Z_m

(i) List $U(Z_9)$

(ii) Hence show that $U(Z_9) \cong Z_6$

(c) Suppose that G is a group, and let $a, b \in G$ be commuting elements of orders m and n respectively. If $(m, n) = 1$. Show that the element $ab \in G$ has order m

Q.5. (a) Let p be prime and let G be a group of order p. Suppose $a \neq 1$ is an element of G and $H = \langle a \rangle$ is a subgroup of G generated by a, show that $H = G$.

(b) Let the circle group $S^1 = \{z \in C : |z| = 1\}$ where the operation is the multiplication of complex numbers, and let **R** be the additive group of real numbers.

Consider the function $f: \mathbf{R} \to S^1$ defined by $f(x) = e^{2\pi i x}$

Show that **R**/Z if isomorphic to S^1, $\mathbf{R}/Z \cong S^1$. (You may use the formular $e^{ix} = \cos x + i \sin x$).

(c) Show that $Q(\sqrt{2}] = \{a + b\sqrt{2} : a, b \in Q\}$ is a field.

Q.6. (a) (i) State the Lagrange's Theorem.

(ii) Define the Class equation of finite group G.

(b) Let G be a finite group with subgroups H and K. Suppose further that H is a subgroup of K, show that

$$[G : H] = [G : K]\,[K : H]$$

(c) Suppose that G is a p-group for some prime number p. Show that the center of G is not trivial, $Z(G) \neq \{1\}$.

Q.7. (a) Let $f(x) = 2x^5 - 6x^3 + 9x^2 - 15 \in Z[x]$.

Show that f(x) is irreducible in Q[x].

(b) Suppose that R is a commutative ring such that the only ideals in R are {0} and R itself, show that R is a field.

(c) Find the roots of $f(x) = x^4 + x^2 + 1$ in Z_3. Hence obtain the factorization into irreducibles of $f(x) = x^4 + 16x^2 + 1$ in $Z_3[x]$ and in $Z_5[x]$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

M 331: REAL ANALYSIS III

TIME: THREE (3) HOURS **DATE: JULY 2, 2004**

INSTRUCTIONS: ATTEMPT ANY FIVE QUESTIONS

Q.1 (a) Let $f: X \to Y$, $A \subset X$ and $B \subset Y$.

Define

(i) the direct image of A under f
(ii) the inverse image of B under f
(iii) the simple discontinuity of f at the point $x_o \in X$.

(b) Consider the function $f: \mathbf{R} \to \mathbf{R}$ defined by

$$f(x) = \sin x$$

Find

(i) the direct image $f\left(\left[\frac{-\pi}{2}, \frac{\pi}{2}\right]\right)$

(ii) the inverse image $f^{-1}([0,1])$

(c) Show that the function defined by

$$f(x) = \begin{cases} \sin \frac{1}{x} & \text{if } x \neq 0 \\ 0 & \text{if } x = 0 \end{cases}$$

has a non simple discontinuity at the origin.

Q.2. (a) State

(i) The Lindelof's covering Theorem.

(ii) The Heine-Borel Theorem.

(b) Let $A = [a, b]$, and $A_n = \left(a + \frac{1}{n},\ b - \frac{1}{n}\right)$ $n = 1, 2, 3, \ldots.$

Show that $\beta = \{A_1, A_2, \ldots, A_n, \ldots\}$ is not an open covering of A.

(c) let A be a closed and bounded subset of **R** and let $f: A \to \mathbf{R}$ be defined and continuous on A. Prove that f is bounded on A.

Q.3. (a) Let $A = [a, b]$ and let $f: A \to \mathbf{R}$. Define

(i) continuity of the function f at a point $d \in A$.

(ii) the variation of the function f on A.

(b) Let $f: \mathbf{R} \to \mathbf{R}$ be a real valued function. Suppose further that f is a continuou function on **R**, prove that for every open subset B of **R**, the inverse image $f^{-1}[B]$ is also open.

(c) Let $f(x) = \begin{cases} x\cos\frac{1}{x} & \text{if } 0 < x \leq 1 \\ 0 & \text{if } x = 0 \end{cases}$

Show that f is not of bounded variation.

Q.4. (a) Let $A \subseteq \mathbf{R}$ be a set of real numbers, and for each natural number n let

$f_n: A \to \mathbf{R}$ denote a function defined on A. Define

(i) pointwise convergence of the sequence $\{f_n\}$.

(ii) uniform convergence of the sequence $\{f_n\}$

(b) Consider the sequence of bounded functions $\{f_n)$ defined on $A \subseteq \mathbf{R}$. Suppose that $f_n : A \to \mathbf{R}$ converges uniformly on A to a function f, show that

$$\lim_{n\to\infty}\left[\sup_{x\in A} |\ f_n(x) - f(x)\ |\right] = 0$$

(c) Let $f_n(x) = \dfrac{2 + x^n}{3 + x^n}$, $0 \leq x < 1$. Show that the sequence $\{f_n\}$ converges pointwise, and determine whether the sequence converges uniformly on [0, 1).

Q.5. (a) Let $A \subseteq \mathbf{R}$ and let $f: A \to \mathbf{R}$. Define

(i) uniform continuity of f on A

(ii) Lipschitz function f on A

(iii) The path connectedness of A

(b) The function

$$F: \left[\frac{-1}{2}, \frac{1}{2}\right] \to \mathbf{R} \text{ is defined by } F(x) = \frac{x}{1-x^2}$$

Show that F is a Lipschitz function on $\left[\frac{-1}{2}, \frac{1}{2}\right]$.

(c) Suppose $A \subseteq \mathbf{R}$ is a connected set and $f: A \to \mathbf{R}$ is continuous on A. Show that f(A) is a connected set.

6. (a) Let $I = [a, b]$ be a closed and bounded subset of $\mathbf{R}$. Define

(i) a simple function $S: I \to \mathbf{R}$

(ii) a piecewise linear function $g : I \to \mathbf{R}$

(b) Consider a continuous function $f : I \to \mathbf{R}$ where I is closed and bounded. Show that for every $\varepsilon > 0$ there exists a step function $S_\varepsilon : I \to \mathbf{R}$ such that for every $x \in I$

$$| f(x) - S_\varepsilon(x) | < \varepsilon$$

(c) Let $f : \mathbf{R} \to \mathbf{R}$ be a function defined by

$$f(x) = \begin{cases} 3 & \text{for } x < 3 \\ x & \text{for } x > 3 \\ 1 & \text{for } x = 3 \end{cases}$$

(i) Sketch the graph of f in the interval $0 \le x \le 5$.

(ii) Find $\lim_{x \to 3} f(x)$ if it exists.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOLL OF NATURAL SCIENCE
DEPARTMENT OF COMPUTER STUDIES

END OF 1ST SEMESTER EXAM

NETWORKING AND DATA COMMUNICATION

J.K. CHANDA (MSC)

The Exam consists of two section's

Section 1 is compulsory

In section 2. You choose 4 out of 6 questions

You have three hours in which to complete

SECTION 1 COMPULSORY

1. Which command, that is used to test address configuration uses Time-To-Live TTL value to generate messages from each router?

   (a) Trace
   (b) Ping
   (c) Telnet
   (d) Boot

2. What is the maximum number of subnets that can be assigned to networks when using the address 172.16.0.0 with a subnet mask of 255.255.240.0

   (a) 16
   (b) 32
   (c) 30
   (d) 14
   (e) it is an invalid subnet mask for the network

3. The clock rate on DEC device is set in bits per second, the Bandwidth is set in _______

   (a) Kbps
   (b) Kbits
   (c) Mbits
   (d) Mbytes

4. Which statement about switched and routed data flow is correct

   (a) Switches create a single collision domain and a single Broadcast domain Route provide separate broadcast domain
   (b) Switches create separate collision domain but a single Broadcast domain, Router provide a separate broadcast domain
   (c) Switches create a single collision domain and a separate Broadcast domain, Routes provide a separate Broadcast domain as well
   (d) Switches create separate collision domain and separate Broadcast domains, Router provide separate collision domain

5. What was the key reason the international organisation for standardization released the OSI model

   (a) Users could access network servers faster
   (b) Different vendors networks could work with each other
   (c) The industry could create a standard for how computers work
   (d) The network administration could increase the overall speed of their network

6. One of the best way to understand how to build a network is to understand the method in which traffic is passed across the network. One of the reason the OSI mode was created to help you understand how a network operates. Which of these devices operate at all seven layers of OSI model, (choose three)

   (a) Network host
   (b) Network management Station
   (c) Transceiver
   (d) Bridge
   (e) Web server
   (f) Switch

7. Using the following address and subnet mark195.106.14.0/24 bits for the network portions, what is the total number of networks and the total number of host per network

   (a) 1 network with 254 host
   (b) 2 network with 128 host
   (c) 4 network with 64 host
   (d) 6 network with 30 host

8. You have assigned the IP address of 201.222.5.0. you need to have 20 subnets with 5 hosts per subnet, the subnet mask is 255.255.255.248 which address are valid host addresses, choose three

   (a) 201.222.5.17
   (b) 201.222.5.18
   (c) 201.222.5.16
   (d) 201.222.5.19
   (e) 201.222.5.31

9. You are given the following address 128.16.32.13/30 bits for the network portion. Determine the subnet mask address class, subnet address and broadcast address

   (a) 255.255.255.252 B. 128.16.32.12,128.16.35.15
   (b) 255.255.255.252 C. 128.16.32.12,128.16.32.15
   (c) 255.255.255.252 B. 128.16.32.12,128.16.32.12
   (d) 255.255.255.248 B. 128.16.32.12, 128,16,32,15

10. LAN protocols typically use which of the following two methods to access the physical network medium, choose two

   (a) UTP
   (b) CSMA/CD
   (c) FDDI
   (d) Token passing

11. What layers does a given layer in the OSI mode generally communicate with, choose the best three answers

(a) The layer directly above it
(b) All the layers above or below it
(c) All the layers above it
(d) The layer directly below it
(e) It's peer layer in other networked computer systems

12. Match up the following OSI layers with it's corresponding encapsulation

(a) Physical	1. Segments
(b) Transport	2. Packets of Datagrams
(c) Data link	3. Bits
(d) Network	4. User data
(e) Application, presentation and session	5. Frames

13. LAN protocol function at which two layers of the OSI reference mode? Choose two

(a) Application
(b) Presentation
(c) Network
(d) Data link
(e) Physical

14. What is the destination address of an ARP request

(a) Broadcast IP address
(b) Broadcast MAC address
(c) The Default gateway IP address
(d) The default gateway MAC address

15. When is a RARP request made

(a) When a source knows its MAC address but not its IP address
(b) When a source knows its IP address but not its address
(c) When a source knows the destination MAC address but not the IP address
(d) When a source knows the destination IP address but not the MAC address

16. Which of the following is cause of crosstalk

(a) Poorly terminated network cabling
(b) The loss of signals ground reference
(c) AC line noise coming from a nearby video monitor or hard disk drive
(d) FM Radio signals, TV signals, various types of office equipment

17. What are the three distinct kinds of crosstalk, choose three

(a) NEXT
(b) FEXT
(c) ANEXT
(d) SPNEXT
(e) PSNEXT

18. Which of the following are network interconnecting devices, choose 3

(a) Web server
(b) Bridge
(c) Router
(d) End user device
(e) Network device

19. Which of the following is an example of a broadcasting address for a class B network with a 16 bit subnet mask

(a) 147.1.1.1
(b) 147.13.0.0
(c) 147.14.255.0
(d) 147.14.255.255

20. Which protocol data units are forwarded by the switch

(a) Bit
(b) Frames
(c) Packets
(d) Segments

SECTION 2

CHOOSE FOUR OUT OF SIX QUESTIONS

1. (a) What are the characteristics and application of a straight through, crossover and rollover cables

   (b) Draw a wire map for each of the cables

   (c) (1) Describe multmode and single mode fibre in terms of characteristics, application and Data transmission

   (2) What is optical link loss budget

2. Think of any class B address then borrow 3 bits from the host portion to come up with subnets.

   (i) What will be the subnet mask

   (ii) How many useable subnets

   (iii) For each subnet write down the address, the range of host address and broadcast dress

3. (a) Identify each of the seven layers of the OSI model and describe the functions of each layer. What is the data encapsulation of each layer

   (b) Identify the four layers of TCP/IP model

4. (a) Explain VPNs and their advantages

   (b) Describe the difference between intranets and extranets

   (d) List 4 WAN Technologies that you know

5. (a) What are SAN'S and what features do they offer

   (b) What is the difference between digital bandwidth and analogy bandwidth

   (c) Describe how crosstalk and twisted pair help reduce noise

6. Describe the ten copper cable test defined in TIA/EIA-568-B

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATION – JUNE 2004

CST3031

INTRODUCTION TO SOFTWARE ENGINEERING

INSTRUCTIONS:

1. Time: **Three (3) hours.**
2. There are Three (3) Sections in this examination paper, Section A, Section B, and Section C.
3. Answer All questions in Section A and Section B and any Two (2) questions in Section C.
4. Each question carries equal marks.

Section A – Multiple Choice. Attempt All questions in this Section

1. ____________ are structure approaches to software development that include system models, rules, design advice and process guidance. [2 marks]

a) Software process models

b) Software engineering methods

c) Attribute of good software

d) None of the above

2. This approach interleaves the activities of specification, development and validation? [2 marks]

a) System assembly from reusable components

b) Formal transformation

c) Waterfall approach

d) Evolution development

3. In the software environment, the term verification can succinctly expressed as: [2 marks]

a) Software specification

b) Are we building the product right?

c) Are we building the right product?

d) Software life cycle.

4. ___________ are constraints on the services or functions offered by the system. They include timing constraints , constraints on the development process and standards. [2 marks]

a) Domain requirements.

b) Functional requirements.

c) Non-functional requirements.

d) Non of the above.

5. Which of the following does not best fall under management activities? [2 marks]

a) proposal writing.

b) project costing.

c) report writing.

d) project coding.

6. _________ describe the logical system entities and their classification and aggregation. [2 marks]

a) Context models.

b) Object models.

c) Semantic models.

d) State machine models.

7. Which of the following are the **strategies** in the testing process? [2 marks]

a) Top down testing, bottom up testing and acceptance testing.

b) Black box testing, white box testing and system testing.

c) Black box testing, white box testing and stress testing.

d) Black box testing, white box testing and acceptance testing.

8. Software should be written in such a way that it might evolve to meet the changing needs of customers. [2 marls]

a) Efficiency

b) Dependability

c) Maintainability

d) Usability

9. More time and money is spent in the ___________ phase than any other phase. [2 marks]

a) maintenance

b) implementation

c) integration

d) requirements

10. __________ maintains information about the entities used in a system design. [2 marks]

a) Data dictionary

b) DFD

c) Functional requirements

d) Non-functional requirements

Section B - Answer All questions in this Section

1. (a) What is a structure chart? [3 marks]

(b) Discuss the difference between cohesion and coupling. [5 marks]

(c) Construct the Structure Chart from the DFD given in Figure 1. The DFD is for a system, which receives student's marks and calculates the marks range and stores top marks. Thereafter, it displays the top marks and generates the graph. [12 marks]

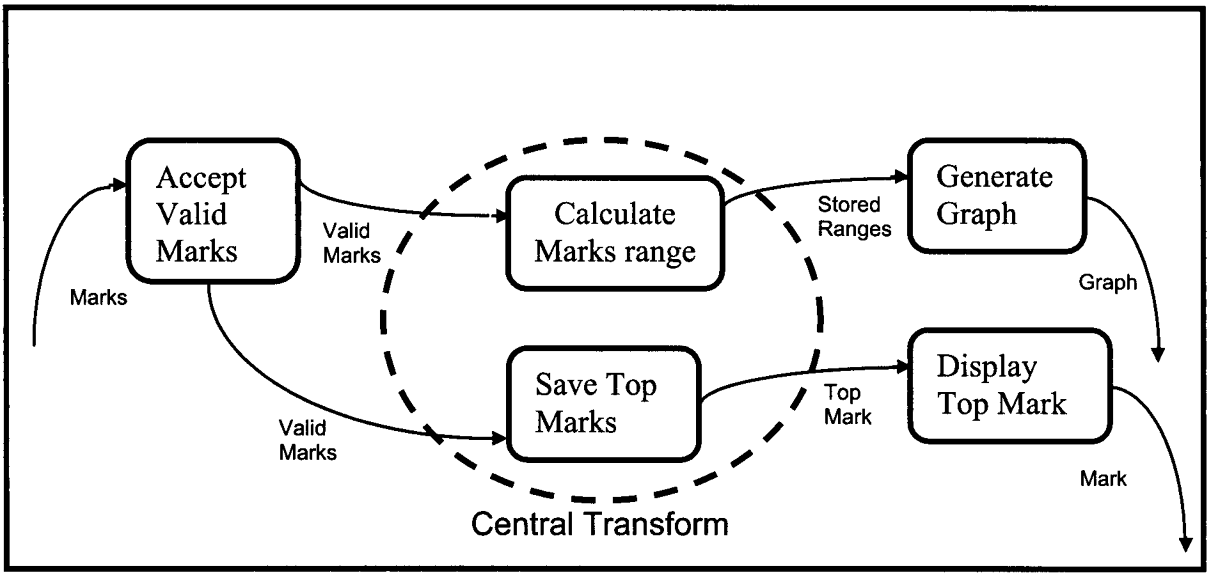

Figure 1. DFD for Student Marks

2. (a) What are the advantages of a Software Engineer maintaining the milestones and deliverables throughout the system development? [4 marks]

(b) Discuss how bar charts and activity networks are important tool for a project schedule. [4 marks]

(c) Figure 2 sets out a number of activities, durations and dependencies. Draw an activity chart showing the project schedule. In addition, determine the minimum time required to finish the project. [12 marks]

Task	Duration (days)	Dependencies
T1	10	
T2	15	
T3	10	T2
T4	20	T2, T3
T5	10	T1
T6	20	T3, T4
T7	15	T1, T4
T8	20	T6

Figure 2. An Activity Network

Section C - Answer Any Two (2) questions in this Section

1. (a) How is UML relevance to both Software Engineer and Programmer? [3 marks]

(b) The term generalisation has been widely used or applied under objects, object classes and UML topics. Define generalisation by giving an example. [4 marks]

(c) What is multiplicity? [3 marks]

(d) An employee has a name, address, phone number, date of birth and job title. Employees can be appointed and can leave, and are either monthly paid employees or weekly paid employees.

Monthly paid employees have a bank sort code and bank account number, while weekly paid employees are paid in cash on a specified day of the week - their payday. Weekly paid employees may be promoted to monthly paid.

All employees are entitled to use the Sports Centre if they register to do so. The Sports Centre is made up of two parts: a swimming pool and bar.

The bar can be booked for special events, and has three rates of hire - a working hours' rate, an evening rate and a weekend rate. The Sports Centre holds a list of employees who have registered.

Draw an UML class diagram for the above system. All the key words you need to include are underlined – do *not* invent any details additional to those given above. [10 marks]

2. (a) What is an object class? [3 marks]

(b) What do you understand by encapsulation and information hiding in the context of object oriented design? [3 marks]

(c) In the context of object-oriented design, describe by giving some examples the concepts: "derived attributes" and "composition". You may illustrate by using diagrams. [4 marks]

(d) Given Car and Driver as two object classes, with some computerised system in mind that it could fit into, for each class draw a graphical representation (object) encapsulating seven major attributes and seven operations that apply to it. [10 marks]

3. (a) How relevance is a successful defect testing to a Software Engineer? [3 marks]

(b) As a Software Engineer, how would you comprehensively explain to the system developers the detailed techniques of defect testing process? [5 marks]

(c) Given two testing strategies: "black box" and "white box", which one would you recommend to the system development team to use? Give reasons to your answer. [4 marks]

(d) Illustrate the five-stage testing processing? [8 marks]

4. (a) What do you understand by the following terms: software specification; software development; software validation and software evolution? [4 marks]

(b) What is the significance of process models during the system development? [4 marks]

(c) Identify and illustrate the principle stages of the "water fall" model. [12 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF COMPUTER STUDIES
SECOND SEMESTER EXAMINATION 2003

CST 4251: ELECTRONICS FOR COMPUTING III

TIME: 3 HOURS
INSTRUCTIONS: There are three sections. **Follow instructions for each section.**

Section I Multiple choice

(***Answer all, 1.5 Marks each***)

1. How many electron guns are housed in a typical color CRT?
   a. one
   b. three
   c. five
   d. nine

2. The thin plate of metal in a CRT that contains thousands of microscopic perforations is called...
   a. the pixel mask
   b. the color mask
   c. the electron mask
   d. the shadow mask

3. A monitor's high-voltage is developed by...
   a. the horizontal drive circuit
   b. the power supply
   c. the CRT grid voltage circuit
   d. the color adjustment circuit

4. What is the very first step in a typical PC boot process?
   a. the CPU fetches an instruction from address FFFF:0000h
   b. the BIOS checks memory and executes its sequence of POST routines
   c. the motherboard receives a "power good" signal from the power supply
   d. none of the above

5. If the final two bytes of the master partition boot sector are not 55h and AAh, you'll probably see what error message?
   a. XXXX ROM Error
   b. C000 ROM Error
   c. Diskette boot record error
   d. No boot device available

6. When backing up for disaster preparation, where should the backup(s) best be stored?
   a. as close to the backed up system as possible
   b. as far from the backed up system as possible
   c. in a metal container somewhere on-site
   d. in a fire-proof safe/cabinet in a secure off-site location

7. A typical BIOS occupies how much memory space in the UMA?
   a. 256KB
   b. 32KB
   c. 512KB
   d. 640KB

8. A BIOS "checksum" error typically means that...
   a. the BIOS code on the chip has become corrupted
   b. the BIOS code is conflicting with a driver or TSR
   c. the BIOS code needs to be updated to a later version
   d. the BIOS code is operating properly

9. A typical compact disc (CD) holds up to...
   a. 600MB
   b. 623MB
   c. 650MB
   d. 705MB

10. Which of the following companies do NOT produce PC chipsets?
    a. Intel
    b. Microsoft
    c. VIA
    d. SiS

11. The most effective means of upgrading a chipset to expand a system's capabilities is to...
  a. upgrade the motherboard
  b. upgrade the BIOS
  c. upgrade the CPU
  d. upgrade the RAM

12. The CPU's attention can be obtained by asserting which type of signal?
  a. an interrupt (IRQ)
  b. an I/O address
  c. a DMA channel
  d. none of the above

13. Which of the following symptoms do NOTsuggest the possibility of a hardware/software conflict?
  a. the system locks up during the POST or operating system initialization
  b. the system locks up during a particular application
  c. the system locks up when a particular device (i.e. a TWAIN scanner) is used
  d. none of the above

14. The CPU rating system which equates AMD/Cyrix processors to Intel processors is called...
  a. the SysOpt rating system
  b. the iCOMP rating system
  c. a "benchmark"
  d. the P-rating (PR) system

15. Intel's architecture intended to accelerate 3D and other multimedia processing is called...
  a. MMX
  b. 3DNow
  c. SSE
  d. MPC

16. Which of these facts is not true about the Pentium II
  a. uses a 32KB L1 cache
  b. provides 512KB of L2 cache
  c. 16 bit architecture
  d. clock speeds of 233MHz, 266MHz, and 300MHz are available.

17. What is NOT a common causes of data loss?
  a. hardware or system failures
  b. human error
  c. memory diagnostics
  d. computer viruses

18. Hard drive performance is dependent upon...
  a. seek time
  b. data transfer rates
  c. file fragmentation
  d. all of the above

19. In order to indicate a serious error before the video system is initialized, the BIOS will...
  a. generate a beep code
  b. generate a POST code to port 80h
  c. generate an error message to the printer
  d. halt and fail to boot at all

20. How many data bits are on a 72 pin SIMM?
  a. 64
  b. 32
  c. 16
  d. 48

21. Which memory type has valid outputs on any part of the clock cycle?
    a. SRAM
    b. SDRAM
    c. DRAM
    d. EDO RAM

22. What is the size of a sector in a Hard Disk
    a. 512 bytes
    b. 1024 bytes
    c. 256 bytes
    d. 8 bytes

23. Lightning strikes are notorious for causing...
    a. blackouts
    b. spikes
    c. surges
    d. brownouts

24. Which of the following components is NOT required to establish a working PC?
    a. a motherboard
    b. a video card
    c. a processor
    d. a sound card

25. In today's motherboards, a regular 168-pin DIMM constitutes...
    a. half of a bank
    b. one banks
    c. two banks
    d. three banks

26. A destructive program disguised as a useful utility or program is called a...
    a. bug
    b. worm
    c. Trojan horse
    d. infection

27. A "time bomb" type of virus delivers its payload based on...
    a. date
    b. time
    c. repetitions
    d. all of the above

28. The USB interface offers a maximum data transfer rate of...
    a. 1.5Mb/s
    b. 3Mb/s
    c. 6Mb/s
    d. 12Mb/s

29. Which of the following does not refer to a CD ROM terminology?
    a. pits
    b. lands
    c. islands
    d. tracks

30. Which of these is not part of the CD drive electronics?
    a. SCSI controller
    b. D/A converter
    c. Memory
    e. Actuator Driver

Section II ***Short Answer (One to two sentences)***
(Answer all, 2.5 Marks each)

1. What does FAT mean and why is it important?
2. What does COMAND.COM perform and ŵhat is its significance?
3. What is the EFM encoding technique and why is it useful?
4. What are the major components of the floppy disk assembly?
5. Why is the ECC technique better than the Parity checking technique when dealing with memory integrity?
6. Give two reasons why INTEL is ideally positioned to produce chipsets?
7. What are the major parameters when evaluating a bus?
8. What is the difference between RISC and CISC Processors?
9. What is the advantage of using a switch mode power supply for a PC?
10. Draw the pin layout of a USB port.

Section III ***Short Essay***
Choose two topics to write a short essay on (approx. 200 words)
(15+15 marks)

1. Memory organization of the PC.
2. The use of DMA to handle data transfers.
3. The motherboard and its components.
4. Basic MODEM Construction and Operation.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC FIRST SEMESTER
FINAL EXAMINATIONS

EM 211 : ENGINEERING MATHEMATICS I

TIME: **THREE (3) HOURS**

INSTRUCTIONS: **(i) Answer any five questions.**
(ii) Indicate the number of each question answered on your main answer book

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1. (a) Find the convergence set for the series

$$\sum_{n=1}^{\infty} \frac{1}{n!}\left(\frac{x-1}{x}\right)^n$$

(b) (i) Write the first five terms of the series $\sum_{n=1}^{\infty} (-1)^{n+1}\frac{e^n}{n^3}$

(ii) Show that the series in (b) (i) is divergent.

2. (a) (i) Let r be the ratio of the minor axis to the major axis in an ellipse. Prove that $r = \sqrt{1-e^2}$, where e is the eccentricity.

(ii) Let $K > 0$. Show that the graph of $xy = K^2/2$ is a hyperbola by showing that this is the equation of the hyperbola with foci at (K, K) and (-K, -K) and distance difference 2K.

(b) Rotate the axes through a suitable angle to remove the xy-term and put the resulting equation in standard form.

$$4x^2 - 4xy + y^2 + 5x + 10y = 0$$

3. A curve in space is described by

$$\overline{R}(t) = 6t\hat{i} + 3\sqrt{2}t^2\hat{j} + 2t^3k$$

For $t = 1$

(i) Find a unit vector $\hat{T}$, tangent to the curve pointing in the positive direction along the curve.

(ii) Find the curvature κ, of the curve.

(iii) Find a unit vector $\hat{N}$, normal to the curve.

4. (a) Use partial fractions to decompose the function

$$\frac{10}{x^2 - x - 6}$$

and then find a Maclaurin series for this function.

(b) Given the polynomial

$$f(x) = 3 + 2x - x^2 + 4x^3 - 2x^4,$$

find constants a_0, a_1, a_2, a_3 and a_4 so that

$$f(x) = a_0 + a_1 (x - 1) + a_2 (x - 1)^2 + a_3 (x - 1)^3 + a_4 (x - 1)^4$$

5. (a) Prove that for each fixed $M > 2$ the ellipse

$$\frac{(x-M)^2}{M^2} + \frac{y^2}{2M} = 1$$

has centre at $(M, 0)$ and vertices at $(0, 0)$, $(2M, 0)$.

(b) For the ellipse in (a) show that $e = \sqrt{1 - 2/M}$ and the foci are at $\left(M \pm \sqrt{M^2 - 2M}, 0\right)$.

(c) For $M = 5000$, sketch the ellipse in (a).

6. (a) Let $Ax + By + Cz = D$ be an equation of a plane and $P_0 (x_0, y_0, z_0)$, $P(x, y, z)$ be two points on the plane. Show that the vectors

$A\hat{i} + B\hat{j} + C\hat{k}$ and $(x - x_0)\hat{r} + (y - y_0)\hat{j} + (z - z_0)\hat{k}$ are perpendicular.

(b) (i) Find the point of intersection of the line through $P(-1, 5, 1)$ and $Q(-2, 8, -1)$ with the plane $2x - 3y + z = 10$

(ii) Find $\sin \theta$ for the angle between the line and the plane in (b) (i).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2004 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

EM 311 : ENGINEERING MATHEMATICS III

TIME: THREE (3) HOURS **DATE: JUNE, 2004**

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

FULL WORKING MUST BE SHOWN

Q.1. (a) Given the differential equation $xy'' - y' + 4x^3y = x^5$

Find a suitable transformation $z = f(x)$, which reduces the above differential equation into a second order linear differential equation with constant cc fficients. Hence find a general solution of the given differential equation.

(b) Reduce the differential equation $y'' - 4xy' + (4x^2 - 1)y = -3e^{x^2}\sin 2x$ into Normal form. Hence find a general solution.

Q.2 (a) (i) State the general form of the Euler-Cauchy equation of the second order.

(ii) Find a general solution of the differential equation

$$x^2y'' - 3xy' + 4y = 0$$

(b) solve for x and y

$$\frac{dx}{dt} + \frac{2dy}{dt} - 2x + 2y = e^t$$

$$\frac{3dx}{dt} + \frac{dy}{dt} + 2x + y = 0$$

Q.3. (a) Define a singular point of the differential equation $y'' + p(x)y' + q(x)y = 0$

Show that $x = 0$ and $x = -1$ are singular points of

$$x^2 (x+1)^2 y'' + x(x^2 - 1) y' + 2y = 0$$

Determine whether the singular point $x = 0$ is regular or irregular.

(b) Find the general series solution of the differential equation $4xy'' + 6y' + y = 0$ and show that it can be expressed in the form $\left(A\cos\sqrt{x} + B\sin\sqrt{x}\right)/\sqrt{x}$

Q.4. (a) (i) Given $f(t) = \sin 3t$

State $L(f(t))$, $L(tf(t)$ without deriving from the definition.

(ii) Find the function $f(t)$ whose inverse transform is

$$F(s) = \frac{12Se^{-4s}}{(S^2+9)^2}$$

(b) (i) Using definition of Laplace transform, show that

$$L\big(U_a(t)\big) = \frac{e^{-as}}{S}$$

where $U_a(t)$ is a unit step function.

(ii) Solve

$$y'' + 4y = U_0(t) - U_{\frac{\pi}{2}}(t) \quad \text{given that } y(o) = 1,\ y'(o) = 0$$

Q.5. (a) A periodic function of period 4 is defined as

$$F(x) = |x|, \quad -2 < x < 2$$

Find its Fourier series expansion

(b). By using Sine fourier series representation, prove that

$$\frac{1}{2} - x = \frac{1}{\pi}\sum_{n=1}^{\infty} \frac{1}{n}\sin 2n\pi x, \quad 0 < x < 1$$

Q.6. (a) (i) Verity that $e^{-n^2 t} \sin\left(\frac{nx}{c}\right)$

is a solution of heat equation $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$

(ii) Find a general solution of the partial differential equation $U_{xy} = U_x$

(b) (i) if $f(x) = 0$ when $x < 0$ and $f(x) = e^{-x}$ when $x > 0$, $f(0) = \frac{1}{2}$

show that f satisfies all the conditions of the Fourier integral representation.

(ii) Show that the Fourier integral representation of f(x) defined in part (i) is

$$f(x) = \frac{1}{\pi} \int_0^{\infty} \frac{\cos wx + w \sin wx}{1 + w^2} dw, \quad -\infty < x < \infty.$$

Hence find the value of $\int_0^{\infty} \frac{dw}{1+w^2}$

END OF EXAMINATION