UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

FIRST SEMESTER EXAMINATIONS

2010-2011 ACADEMIC YEAR

1. BIO 1011 - Cell and Biomolecules
2. BIO 2041 - Basic physiology theory paper
3. BIO 2042 – Basic physiology practical paper
4. BIO 2051 – Diversity of plants theory paper
5. BIO 3141 – Ecological methods theory paper
6. BIO 3161 – Ethnology of birds and mammals
7. BIO 3171 – Evolutionary biology theory paper
8. BIO 3251 – Parasitology theory paper
9. BIO 3211 – Introduction to entomology theory paper
10. BIO 3231 – Molecular biology theory paper
11. BIO 3301 – Virology theory paper
12. BS 425 - Immunology
13. BS 441 - Advanced molecular biology theory paper
14. BS 475 - Population ecology theory paper
15. BS 491 - Freshwater biology theory paper
16. BS 935 - Plant pathology practical paper
17. C 101 - Introduction to Chemistry I
18. C 205 - Analytical and inorganic chemistry
19. C 245 - Inorganic Chemistry I
20. C 251 - Organic Chemistry I
21. C 225 - Analytical Chemistry I
22. C 311 - Biochemistry I
23. C 321 - Analytical Chemistry II
24. C 241 - Inorganic Chemistry II
25. C 351 - Organic Chemistry III
26. C 411 - Advanced Biochemistry I
27. CAV 251 – Chemistry for Agricultural and Veterinary students
28. C445 - Inorganic Chemistry I
29. C 481 - Inorganic industrial chemistry
30. CS 3231 - Electronics for computing I
31. CST 2011 – An introduction to programming using Java
32. CST 2021 – Introduction to computer systems

33. CST 2041 – Introduction to operating systems
34. CST 3011 – Data structure and algorithms
35. CST 3031 – Introduction to software engineering
36. CST 3061 – Computer networks and communications
37. CST 3141 – Object oriented analysis and design
38. CST 4131 – Advanced object oriented programming
39. CST 4141 - Multimedia and human computer interaction
40. CST 4251 – Electronics for computing III
41. EM 211 - Engineering mathematics I
42. EM 411 - Engineering mathematics I
43. GEO 155 - Introduction to physical geography
44. GEO 211 - The geography of Africa
45. GEO 271 - Quantitative techniques in geography I
46. GEO 381 - Environment and development I
47. GEO 481 - Environment and development II
48. GEO 495 - Environmental Hazards and disasters
49. GEO 911 - Population geography
50. GEO 921 - Economic geography
51. GEO 931 - Rural geography
52. GEO 951 - Climatology
53. GEO 961 - Soils geography
54. GEO 971 - Aerial photography and aerial photo interpretation paper II
55. M 111 - Mathematical methods I
56. M 161 - Introduction to mathematics, probability and statistics I
57. M 211 - Mathematical methods III
58. M 231 - Real analysis I
59. M 331 - Real analysis III
60. M 335 - Topology
61. M 361 - Mathematical statistics
62. M 411 - Functions of a complex variable I
63. M 461 - Multivariate analysis
64. M 465 - Non- parametric statistics
65. M 911 - Mathematical methods V
66. MG 319 - Computer techniques
67. MI 461 - Geo statistics
68. MP 413 - Mathematical methods for physics
69. P 191 - Introductory physics I
70. P 231 - Properties of matter and thermal physics
71. P 251 - Classical mechanics
72. P 261 - Electricity and magnetism

73. P 341 - Analogue electronics I
74. P 331 - Introduction to quantum mechanics
75. P 361 - Electromagnetic theory and waves
76. P 401 - Computational physics II
77. P 411 - Nuclear experimental techniques
78. P 421 - Solid state physics I
79. P441 - Analogue electronics II

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

2010-2011 ACADEMIC YEAR

FIRST SEMESTER EXAMINATIONS

BIO 1011: CELLS AND BIOMOLECULES

THEORY PAPER

TIME: THREE HOURS

Instructions:

Answer **all** questions

All questions carry equal marks

1. Use the answer sheet provided to record the answers
2. A correct answer carries +4 marks
3. A wrong answer carries –1 mark
4. The option "I do not know" carries 0 marks
5. Use ink to record the answers on the mark sheet
6. Cross out a wrong entry and write the correct one by the side

1. Provide reasons for cells being so small.
   1. So that they can fit within an organism.
   2. So that they can efficiently move metabolites within the cell
   3. Cells must remain small in order for them to be able to accommodate the nucleus.
   4. Cells with a size range of 2.5 – 5.0u
   5. Eukaryotic cells
   6. I do not know

2. Identify the **false** statement.
   1. Respiration in bacteria takes place in the plasma membrane.
   2. Hereditary materials are found in both prokaryotes and eukaryotes.
   3. Ribosomes are found in all cells.
   4. Lysosomes are found in all cell types.
   5. Bacterial cell walls are more complex than plant cell walls.
   6. I do not know

3. Explain why some bacteria are Gram negative.
   1. They are made of protein mainly and protein does not stain.
   2. Their cells walls are made of cellulose and starch.
   3. Some bacterial do not cause disease and therefore cannot stain.
   4. Their cell walls are made of lipids, which wash away together with the ethanol during staining.
   5. Some bacterial cells are too virulent and therefore cannot stain.
   6. I do not know

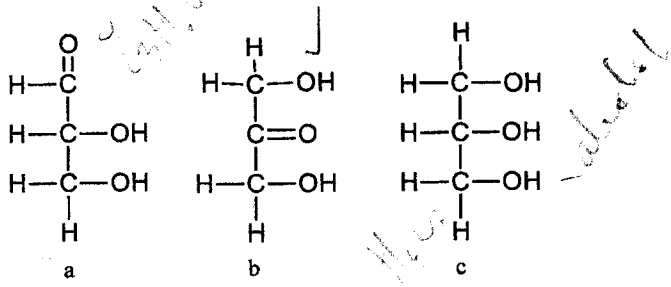
4. Which of the following terms are **not correctly** matched?
   1. Flagellum is for movement.
   2. DNA can replicate.
   3. Cytoskeleton suspends organelles.
   4. Lysosomes are for digestion of organic debris in a cell.
   5. Animal cells do not have vacuoles
   6. I do not know.

5. Where in mitochondria of eukaryotic cells are respiratory enzymes located?
   1. Stroma
   2. Mitochondrial matrix
   3. Stalked particles
   4. In the intracristal space
   5. Granum
   6. I do not know.

6. Name two organelles that can synthesise their own proteins.
   1. Chloroplasts and mitochondria
   2. DNA and the nucleus
   3. Ribosomes and chloroplasts.
   4. Chlorophyll and chloroplasts.
   5. Endoplasmic reticulum and Golgi apparatus.
   6. I do not know.

7. The first amino acid and the termination codons during transcription are … and … respectively.
   1. Glycine, TUA.
   2. Valine, CUU.
   3. Serine, CTU.
   4. Cysteine, CTC.
   5. Methionine, UAA.
   6. I do not know.

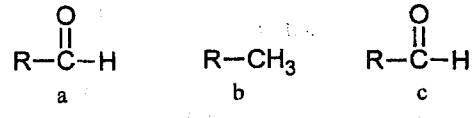
8. Which of the following molecules is not a carbohydrate?



a b c

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

9. Which of the following functional groups of compounds will dissolve in water?



a b c

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

10. The two nitrogenous bases with two rings in their structures are …
    1. Guanine and Cytocine.
    2. Adenine and Guanine.
    3. Thymine and Uracil.
    4. Uracil and Cytocine.
    5. Thymine and Cytocine
    6. I do not know.

11. Determine the number of amino acids in the base sequence of – AAUCGAAACGGU would code for.
    1. 2
    2. 3
    3. 4
    4. 5
    5. 6
    6. I do not know

12. Which of the following compounds is an aldehyde?

    1. triglyceride
    2. glucose
    3. fructose
    4. ATP
    5. purines
    6. I do not know.

13. In an amino acid, the portion (s) of the molecule not involved in making peptide pond is…..
    1. amino group
    2. the side chain group (R-group)
    3. carboxyl group
    4. the side chain groups (R-group and hydrogen atom)
    5. the hydroxyl group
    6. I do not know

14. A glycosidic bond forms between two …
    1. glucose molecules.
    2. amino acids.
    3. nitrogenous bases
    4. Glycerol molecules.
    5. Phosphate groups.
    6. I do not know

15. A pentose sugar covalently bonded to a nitrogenous base is called ...
    1. nucleoside
    2. nucleotide
    3. Adenosine dinucleotide
    4. ATP
    5. ADP
    6. I do not know.

16. The formation of a covalent bond between a nucleoside and phosphate group leads to the synthesis of a ...
    1. nucleotide.
    2. nucleosome.
    3. phosphodiester bond
    4. nuleoside.
    5. fatty acid
    6. I do not know.

17. Which of the following substances would easily pass through the plasmamembrane and why?
    (a) Water (b) Oxygen (c) Carbon dioxide /
    1. (a), it is hydrophilic
    2. (a) and (b), both are hydrophilic
    3. (a), (b) and (c), water is small enough, while O_2 and CO_2 are hydrophobic.
    4. (a) and (c), one is hydrophilic and the other is hydrophobic.
    5. (b) and (c), both are hydrophobic.
    6. I do not know.

18. The contours of DNA are the same length between them because ...
    1. DNA carries hereditary information.
    2. the nitrogenous bases occur in pairs.
    3. two base pairs are used each time.
    4. base pairs are held together by hydrogen bonds
    5. bases are matched to fit the same width.
    6. I do not know.

19. Identify a fibrous protein from the following list of proteins.
    (a)Collagen (b) Beta pleated sheet (c) Insulin
    1. (a)
    2. (a) and (c)
    3. (a), (b) and (c)
    4. (b) and (c)
    5. (a) and (b)
    6. I do not know.

20. A triple hydrogen bond is usually formed between ...
    1. Adenine and thymine
    2. Guanine and uracil
    3. Uracil and cytosine
    4. Cytosine and guanine
    5. Thymine and uracil
    6. I do not know

21. Which of the following statements is correct?
    1. The products of a catalysed and non catalysed chemical reaction have the same energy.
    2. An enzyme gets modified after a chemical reaction.
    3. The energy required to bring two reacting substances together is more in an enzyme catalysed chemical reaction.
    4. The energy given out during a chemical reaction is equivalent to the amount of enzyme in a solution.
    5. Coenzymes are always necessary in a chemical reaction
    6. I do not know.

22. Identify the class of carbohydrates that are used in the synthesis of nucleic acids.

    1. Trioses
    2. Tetroses
    3. Hexoses
    4. Aldehydes
    5 Pentoses
    6. I do not know

23. Some proteins differ from carbohydrates because they contain ...
    1. carbon, oxygen and hydrogen.
    2. glycosidic bonds.
    3. sulphur.
    4. double bonds.
    5. covalent bonds.
    6. I do not know

24. The two carbon atoms in hexose sugars that commonly participate in condensation reactions are ...
    1. carbons one and two
    2. carbons two and three
    3. carbons two and four
    4. carbons one and four
    5. carbons one and five
    6. I do not know

25. Which one of these environmental factors does not affect general enzyme activity?
    1. Temperature.
    2. Inhibitors.
    3. Humidity
    4. PH.
    5. Co-enzymes.
    6. I do not know

26. The hydrolysis of lipids may produce
    1. glucose.
    2. glycerol.
    3. fatty acids.
    4. amino acids.
    5. (2) and (3) above
    6. I do not know.

27. Which of the following are components of a phospholipid?
    1. Cholesterol, glycerol, fatty acids
    2. Phosphate group and a hydrocarbon chain,
    3. Glycerol, amino acids, phosphate group
    4. Phosphate group, cholesterol, monosaccharides
    5. Two fatty acids, glycerol, phosphate group, and a large polar group
    6. I do not know.

28. An unsaturated oil could be converted to a saturated fat by doing one of the following things;
    1. Breaking some peptide bonds.
    2. Removal of hydrogen atoms.
    3. Addition of hydrogen atoms.
    4. Increasing the hydrocarbon chain.
    5. Removal of Glycerol molecule.
    6. I do not know.

29. Atoms joined by a ...
    1. single bond cannot twist and rotate about its long axis
    2. double bond can twist and rotate because the extra bond facilitates rotation
    3. triple bond can easily rotate
    4. single bond can twist and rotate about its long axis
    5. double bond cannot twist because the extra bond prevents rotation.
    6. I do not know

30. Structural isomers have …
1. the same number and type of atoms in a molecule, but the atoms are connected differently
2. different number of atoms but the atoms are connected in the same way as the original molecule
3. different number of atoms with different connections
4. different reactive groups
5. the same number and type of atoms in a molecule and all the atoms are connected in the same way but the two molecules cannot be superimposed
6. do not know

31. Globular proteins …
1. are insoluble in water.
2. serve as structural materials.
3. are involved in physiological processes.
4. are made up of three polypeptide chains that are tightly wound around each other.
5. contain more alpha helical structures than beta pleated sheet arrangement.
6. I do not know

32. the great strength and resistance to hydrolysis of cellulose are due to …
1. its branched chains.
2. its short strands that are linked at particular points to yield a strong fibrilar structure.
3. long chains of glucose attached to nitrogen.
4. parallel arrangement of fibres and lack of branching.
5. the straight chain portion that is associated with 1-6 glycosidic bonds.
6. I do not know.

33. Water dissolves ionic compounds because water molecules …
1. are non polar.
2. have partially charged ends that interact with ions.
3. do not contain atoms.
4. have a pH value of 14.
5. are hydrophobic.
6. I do not know.

34. A substance that forms hydrogen ions when dissolved in water is called a(n) …
1. atom
2. amphoteric.
3. zwitterion
4. base.
5. acid.
6. I do not know.

35. The energy needed to start a chemical reaction is called ...
    1. electrical energy
    2. heat energy..
    3. mechanical energy.
    4. activation energy.
    5. chemical energy.
    6. I do not know.

36. The maximum size of a cell is determined by the ratio between the cell's ...
    1. surface area and volume.
    2. circumference and surface area
    3. number of Golgi apparatus and mitochondria
    4. cytoplasm and nucleus
    5. length of the internal and external membrane systems.
    6. I do not know.

37. Prokaryotic cells differ from eukaryotic cells in that prokaryotic cells ...
    1. have DNA but not ribosomes.
    2. are larger than eukaryotic cells.
    3. lack internal compartments.
    4. lack a cell wall.
    5. lack cell membranes.
    6. I do not know.

38. In the cell membrane the fatty acids of phospholipid molecules ...
    1. face the cytoplasm.
    2. face the outside of the cell.
    3. are on both sides of the membrane.
    4. are in the interior of the membrane.
    5. are rigidly fixed in one half of the lipid bi-layer
    6. I do not know.

39. Cell membrane proteins include ...
    1. enzymes.
    2. markers.
    3. transporters
    4. receptors
    5. all of the above
    6. I do not know

40. The energy generating organelle of a eukaryotic cell is ...
    1. nucleus
    2. ribosomes.
    3. Endoplasmic reticulum.
    4. Golgi apparatus.
    5. mitochodrion.
    6. I do not know.

41. proteins are produced by ...
    1. vesicles
    2. lysosomes
    3. smooth endoplasmic reticulum.
    4. ribosomes.
    5. nucleus
    6. I do not know

42. One function of the Golgi apparatus is to ...
    1. store DNA.
    2. make carbohydrates.
    3. modify proteins.
    4. digest and recycle the cell's wastes.
    5. sythesise ATP
    6. I do not know

43. the thylakoid membranes of a chloroplast are the sites where ...
    1. ATP is produced.
    2. carbohydrates are produced.
    3. chlorophylls are located.
    4. plant respiration takes place.
    5. energy for the cell is generated.
    6. I do not know.

44. Chromatids are ...
    1. dense patches within the nucleus.
    2. bacterial chromosomes.
    3. mixture of DNA and proteins
    4. two exact copies of DNA that make up each chromosome.
    5. threads that are made from centrioles in animal cells.
    6. I do not know.

45. DNA nucleotide does not include a ...
    1. five carbon sugar.
    2. phosphate group
    3. nitrogen base
    4. histone
    5. double helix
    6. I do not know.

46. If the sequence of nucleotides on one strand of a DNA molecule is 3' – GCCATTG-5' is used as a template, the sequence of mRNA molecule is ...
    1. 5'- CGGTAAC-3'.
    2. 5'-CGGUAAC-3'.
    3. 5'-GGGUAAC-3'.
    4. 5'-CCCUAAC-3'.
    5. 3'-CGGTAAG-5'.
    6. I do not know.

47. The enzymes that add complementary nucleotides during DNA replication are called.
    1. DNA helicases
    2. DNA ligases
    3. DNA polymerases
    4. DNA primase
    5. Topoisomerases
    6. I do not know.

48. Replication forks along the DNA are to ...
    1. correct replication errors.
    2. allow for a smooth replication of DNA.
    3. signal DNA polymerase to stop
    4. ensure that the new and old DNA strands are complementary
    5. all of the above
    6. I do not know

49. Protein containing **10** amino acids could form any of ... different amino acid sequences.
    1. 10^1
    2. 10^2.
    3. 20^1
    4. 20^{10}.
    5. 10^{20}.
    6. I do not know.

50. When two nonpolar peptide chains in a protein molecule are very close to each other, they form an attraction force called ...
    1. hydrogen bonds.
    2. hydrophobic bonds.
    3. Van der Waals bonds.
    4. hydrophilic bonds.
    5. covalent bonds.
    6. I do not know

51. Protein's tertiary structure exists in one of the following forms
    1. globular or fibrous.
    2. brush.
    3. helical.
    4. beta pleated sheet .
    5. quaternary
    6. I do not know

52. Name types of non-covalent bonds that are involved in protein folding
    1. ionic, hydrogen and hydrophobic bonds
    2. Van der Waals forces, ionic, hydrogen and hydrophobic bonds.
    3. hydrogen bonds
    4. Van der Waals forces and hydrogen bonds.
    5. ionic and hydrophobic bonds.
    6. I do not know

53. Anticodons are found on ... molecules
    1. mRNA
    2. DNA
    3. tRNA
    4. rRNA
    5. Ribosomes
    6. I do not know

54. A ... is an extra ring of hereditary material in bacteria.
    1. ribonucleic acid
    2. gene
    3. plasmid
    4. DNA segment
    5. nucleosome
    6. I do not know.

55. Unlike eukaryotes, bacteria ...
    1. have a nucleus.
    2. lack motility.
    3. have a protein outer coat.
    4. have mitochondria.
    5. have flagella
    6. I do not know.

56. The cell wall of all plant cells are made of ...
    1. peptidoglycan
    2. cellulose.
    3. Chitin.
    4. Glycoprotein
    5. lipoprotein.
    6. I do not know.

57. The primary function of carbohydrates is to ...
    1. hydrolyse proteins.
    2. aid in digestion in the intestines.
    3. supply the body with energy.
    4. regulate the flow of fluids.
    5. function as enzymes.
    6. I do not know.

58. The organelle that combines proteins with carbohydrates and packages them into vesicles is the ...
    1. rough endoplasmic reticulum.
    2. smooth endoplasmic reticulum.
    3. ribosomes.
    4. vacuole
    5. Golgi apparatus.
    6. I do not know

59. Which one of the following statements about mRNA is false?
    1. It is produced as a large pre-mRNA
    2. It codes for the synthesis of specific proteins.
    3. It forms associations with ribosomes.
    4. It is made in the nucleus.
    5. Its base triplets are called anticodon
    6. I do not know.

60. tRNA is synthesised ...
    1. form ribonucleic acid template.
    2. on a DNA template
    3. from a ribosome template.
    4. in the nucleolus
    5. in the cytoplasm.
    6. I do not know.

61. Which one of the following is an example of a fibrous protein?
    1. haemoglobin
    2. insulin
    3. enzymes
    4. the alpha helix
    5. a quaternary structure
    6. I do not know

62. A gene is ...
    1. a complete molecule of DNA.
    2. a short segment of DNA.
    3. made of many chromosomes.
    4. a sequence of amino acids.
    5. a complete molecule of RNA..
    6. I do not know.

63. The majority of enzymes work best at pH of ...
    1. 1.
    2. 3.
    3. 7
    4. 10.
    5. 14.
    6. I do not know

64. The difference between Deoxyribose and Ribose sugar is based on the number of ... in the compound.

    1. Oxygen atoms
    2. Hydrogen atoms
    3. double bonds
    4. covalent bonds
    5. hydrogen bonds
    6. I do not know

65. State the carbohydrate that bears branches and is found in starch granules.

1. Amylose
2. Amylopectin
3. cellobiose
4. Sucrose
5. cellulose
6. I do not know

66. Which of the following compounds would you recommend in a diet of a person who wants to avoid the risk of getting cardiovascular disease?

1. Foods that contain solid lipids
2. Food prepared with vegetable oils
3. A diet of carbohydrates
4. Bread with butter
5. A combination of fat with carbohydrates
6. I do not know

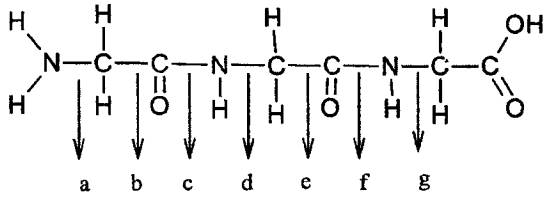
67. The general formula of a fatty acid is …

1. $(CH)nCH_2\ nCOOH$
2. $CH_3(CH_2)nCOOH$
3. $R(CH_2)nCOOH$
4. $R(COOH)nCOOH$
5. $CH_2CH_2CH_3$
6. I do not know

68. Explain why insects can walk on the surface of water.

1. Water is able to adhere to polar surfaces
2. Water is dipolar and therefore prevents insects from sinking
3. Water molecules stick to each other creating an elastic layer at the surface
4. Because water is a liquid at ordinary temperature and pressure
5. Water is dense and therefore can support the insect
6. I do not know

69. Given the molecular structure below, identify the peptide bond in the molecule.



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

70. The molecule in Question 69 will yield ... amino acids upon hydrolysis.

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

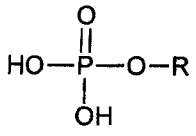
71. In what form would an amino acid exist in milk which is known to have a pH of 8

1. Zwitterion ion
2. The amino acid will have a net charge of zero
3. It will become positively charged.
4. The amino acid will become an anion.
5. it will become dipolar
6. I do not know

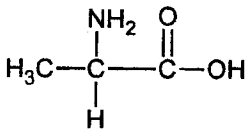
72. All condensation reactions have one common by product called ...

1. ATP
2. hydrogen atoms
3. enzymes
4. water
5. monomer units
6. I do not know

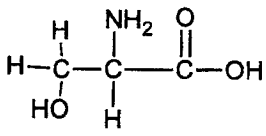
73. Identify the non polar amino acid from the following structures



a



b



c

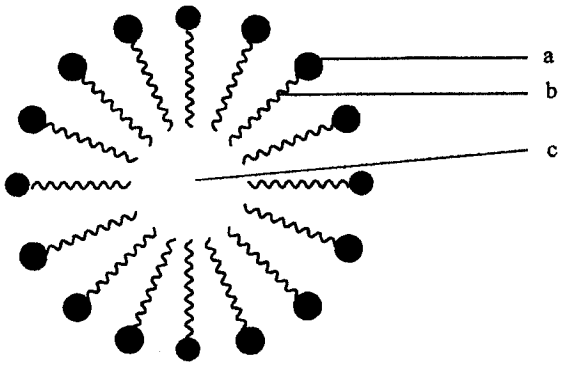
1. a and b
2. a and c
3. b
4. c
5. a
6. I do not know.

74. Hydrogen bonds in a secondary structure of protein molecules are found between … and …..
1. Carboxylic group of one amino acid and thiole (SH) group of another amino acid
2. Carboxylic group of one amino acid and amine group of another amino acid.
3. One alkyl group of one amino acid and another alkyl group of a second amino acid.
4. Phosphate of one amino acid and an alkyl group of the second amino acid.
5. Amino group of one amino acid and a hydroxyl group of another amino acid.
6. I do not know.

75. When two cysteine side chains are involved in chemical bonding in proteins they form …
1. Disulphide bridges
2. Phosphodiester bond
3. A polar bond
4. Glycosidic bond
5. Ionic bond
6. I do not know

76. Given the following mRNA base sequence, determine the anticodon for tRNA for the highlighted codon.
5'-AGCUGACUA-3'
1. TCT-5'
2. ACT-3'
3. AGA-3'
4. TCT-3'
5. ACU-5'
6. I do not know.

77. Identify the labelled parts.



1. Polar head (b), hydrocarbon tail (a), fatty droplets (c)
2. Polar head (a), hydrocarbon tail (c), fatty droplets (b)
3. Polar head (a), hydrocarbon tail (b), fatty droplets (c)
4. Polar head (c), hydrocarbon tail (b), water droplets (a)
5. Polar head (a), hydrocarbon tail (b), water droplets (c)
6. I do not know.

78. Identify the statement that is not correct.

1. The hydrocarbon tails of lipids dominate their character.
2. Lipids are oils because they are hydrophilic
3. Lipids like proteins are also a source of energy
4. Lipids are chemical compounds that cushion delicate organs in the body.
5. Lipids are not a structural form of enzyme.
6. I do not know

79. In a ketose, a double bond is found on the ... carbon

1. first
2. outer
3. middle
4. all
5. second last
6. I do not know

80. The functional carbon in fructose is found at carbon ...
    1. one
    2. two
    3. three
    4. five
    5. six
    6. I do not know

81. Dehydration synthesis is involved in the making of all the following except ...
    1. DNA
    2. proteins
    3. monosaccharides
    4. lipids
    5. polysaccharides
    6. I do not know.

82. Which one of the following is a co-factor?
    1. FAD
    2. Haem
    3. NAD+
    4. NADP+
    5. ATP
    6. I do not know

83. Which one of the following is not a polymer?
    1. DNA
    2. RNA
    3. Starch
    4. Oleic acid
    5. glycogen
    6. I do not know

84. A water body in a pond evaporates very slowly because ...

    1. the specific heat capacity of water is very low

    2. it requires a lot of energy to separate water molecules

    3. it is easy to raise the temperature of water.

    4. water freezes at O°C

    5. water dries up when it is in the form of ice.

    6. I do not know

85. Protein histones carry positive charges due to...
    1. The positive phosphate groups on them.
    2. The presence of carboxyl groups on them.
    3. The abundance of its basic amino acid.
    4. Aromatic side chains.
    5. Non polar methyl groups
    6. I do not know.

86. Which one of the following molecules is a monosaccharide?
    1. lactose.
    2. glycerol
    3. maltose
    4. dihydroxyacetone
    5. amylose
    6. I do not know.

87. During the condensation process of two glucose molecules, carbon ... of one glucose molecule donates a hydrogen atom while carbon ... of the next glucose molecule donates a hydroxyl group to form water.
    1. Four; four
    2. Two; two.
    3. Three; four
    4. One; four
    5. Four; one
    6. I do not know.

88. Phosphate diester bonds in the formation of DNA strands are between ...
    1. Nitrogenous bases
    2. The two strands of DNA
    3. The 3' and 5' carbon atoms in the sugar phosphate back bone
    4. 2' and 4' carbon atoms in the sugar phosphate back bone
    5. The oxygen bridge and carbon one
    6. I do not know.

89. Which of the following is **not** true?
    1. Actin filaments are in the muscle cells.
    2. Microtubules arise from the ER.
    3. Microtubules are made of a globular protein called tubulin.
    4. Intermediate filaments sometimes contain keratin.
    5. There is no cytoskeleton in bacteria.
    6. I do not know.

90. Which molecules yield more energy per unit weight?
    1. polysaccharides.
    2. polypeptides.
    3. proteins.
    4. triglycerides.
    5. oligosaccharides.
    6. I do not know.

91. Cellulose is made from ...
    1. Beta glucose monomers
    2. Alpha and beta glucose monomers
    3. Alpha glucose monomers
    4. Alpha glyceraldehydes monomers
    5. Alpha amino acid monomers
    6. I do not know.

92. Which one of the following macromolecules is amphipathic?
    1. Proteins
    2. Fatty acids
    3. Polysaccharides
    4. DNA
    5. RNA
    6. I do not know.

93. Which one of the following polymers is not a protein?

    1. Human hair
    2. Nails
    3. Lipase
    4. Amylase
    5. Cotton
    6. I do not know.

94. An ester bond is a characteristic of ...
    1. glycerides
    2. fatty acids
    3. glycerol
    4. proteins
    5. disaccharides
    6. I do not know

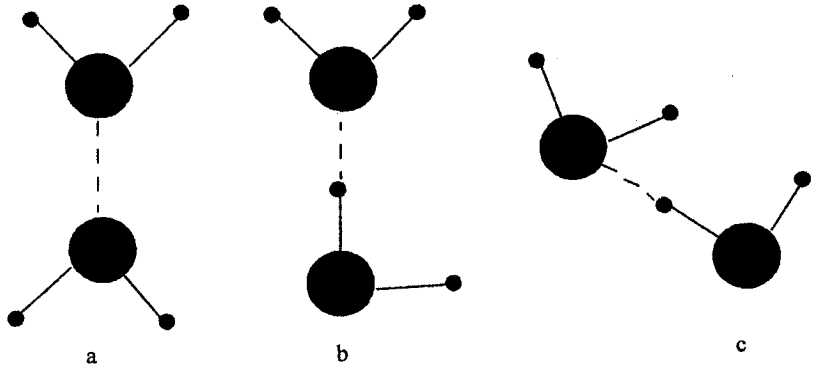
95. $C_3H_8O_3$ is ...
    1. a lipid
    2. a fatty acid
    3. an alcohol
    4. a steroid
    5. a triose
    6. I do not know.

96. Oleic acid ($C_{17}H_{33}COOH$) is an example of ... because it's ...
    1. an oil; completely saturated
    2. an unsaturated fat; no double bond in it.
    3. a saturated fat; a solid at room temperature
    4. a fat; one double bond in its fatty acid tail
    5. an oil; unsaturated
    6. I do not know.

97. The empirical formula of polysaccharides is ...
    1. $(CH_3O)n$
    2. $(C_6H_{12}O_6)n$
    3. $(C_5H_{10}O5)n$
    4. $(C_5H_{12}O_5)n$
    5. $(C_{12}H_{22}O_{11})n$
    6. I do not know.

98. In sucrose, the two sugar molecules are connected by ...
    1. Beta (1-2) linkage
    2. Alpha (1-4) linkage
    3. Alpha (1-2) linkage
    4. Beta (1-4) linkage
    5. Alpha (1-6) linkage
    6. I do not know.

99. In which of the following figures is a hydrogen bond at its strongest force?



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

100. A triple bond holding two bases together in a DNA helix are found between …

1. two purines.
2. Guanine and Cytosine.
3. pyrimidines and a purines.
4. Cytosine and adenine.
5. Thymine and adenine.
6. I do not know.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 – 2011 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

BIO 2041: BASIC PHYSIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, WITH **AT LEAST TWO QUESTIONS FROM EACH SECTION**. USE ILLUSTRATIONS WHERE NECESSARY. USE **SEPARATE ANSWER BOOKS** FOR EACH SECTION.

SECTION A: Plant Physiology

1. (a) In the anaerobic reduction of pyruvate by NADH to form lactate as per equation:
   Pyruvate + NADH + H^+ → Lactate

   Relevant reduction potentials are as follows - NAD^+ : NADH $E_0' = -0.32$ V
   Pyruvate: Lactate $E_0' = -0.019$ V
   (i) Write the partial reactions for the reduction of pyruvate by NADH.
   (ii) Calculate the free energy change for the reduction of pyruvate under standard conditions. Faraday constant is 96485 joules / V/ mole.
   (b) Summarise the mechanism of photophosphorylation in chloroplasts.

2. Explain polar movement of auxin in coleoptiles in terms of chemiosmosis.

3. Outline the major chemical reactions of the Calvin cycle, distinguishing carboxylation, reduction and regeneration phases.

4. (a) Discuss the roles of Gibberellin (GA1) in the physiology of plant growth in respect of stems.
   (b) Discuss any two regulatory roles of Abscisic Acid in plant growth and development.

SECTION B: Animal Physiology

5. Discuss the roles of sensor, central control and effector systems in regulating ventilation in a human.

6. (a) Describe the composition of pancreatic secretion and discuss its physiological roles in protein and carbohydrate digestion in a human.
   (b) (i) Define enterohepatic circulation.
   (ii) Discuss the significance of enterohepatic circulation in nutrient digestion in animals.

TURN OVER

7. (a) Define osmoregulation.
   (b) Describe the various osmoregulatory mechanisms employed by animals in various environments.

8. (a) Summarise the main physiological roles of the mammalian kidney.
   (b) Discuss the circumstances under which the mammalian kidney produces concentrated or dilute urine.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 2042: BASIC PHYSIOLOGY
PRACTICAL PAPER

TIME: ONE AND HALF HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. USE **SEPARATE ANSWER BOOKS** FOR EACH SECTION.

SECTION A: Plant Physiology

1. Consider a cell with surface area 2.5×10^{-2} mm^2, initial water potential of -0.3MPa and membrane hydraulic conductance of 10^{-6} m s^{-1} MPa^{-1}. The cell is placed in freshwater having a solute potential of -0.15 MPa.
   (a) Calculate the driving force for water movement into the cell.
   (b) Determine the initial flow rate of water into the cell in volumetric terms.

2. Describe the changes which occur in cell water potential, solute potential and pressure potential during water uptake from a bathing solution by a cell until full turgor is attained. State all the assumptions you make.

SECTION B: Animal Physiology

3. Examine slide preparation specimen **A** and do the following:
   (a) Draw and label the different types of cells present.
   (b) State the main functions of each of the cell types identified.
   (c) Discuss the significance of differential cell count.
   (d) Define serum and distinguish between plasma and serum.
   (e) Outline the factors which may prolong bleeding time.

4. (a) Perform qualitative tests for the presence of urea, ammonia and glucose on specimens **B** and **C**. Describe the methods used for the tests and record your results and observations in a Table.
   (b) Explain the differences in the results for the two specimens.
   (c) Contrast the nature of the major nitrogenous waste products by fish, terrestrial mammals and birds and explain how these nitrogenous waste products are related to the environments in which the organisms live.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 2051: DIVERSITY OF PLANTS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTION **ONE** AND **ANY OTHER FOUR** QUESTIONS.

1.Summarise any **four** of the following:
(a) Heterospory.
(b) Amphivasal vascular bundles.
(c) Sporangiophores in *Equisetum*.
(d) Dioecious plants.
(e) Angiosperm male gametophyte.
(f) Conjugation in *Spirogyra*.

2. (a) Outline the life cycle of the green algal genus *Volvox*.
(b) State the type of life cycle and its major feature.

3. Describe the vegetative and reproductive structure of *Chara*. Explain the evolutionary significance the reproductive structures among the green Algae.

4. Give an account of the vegetative and reproductive features characteristic of the genus *Isoetes*.

5. Describe the typical structure of a moss and indicate which structures belong to the different generations and their ploidy levels.

6. Discuss the probable steps involved in the evolution of the seed and highlight the significance of heterospory in this process.

7. Give an illustrated account of the life cycle of an angiosperm and highlight the process of double syngamy. State the type of life cycle is exhibited by Angiosperms.

8. (a) Describe the characteristic vegetative and floral features of a named Angiosperm family.
(b) Summarise the economic importance of angiosperms.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3141: ECOLOGICAL METHODS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, TWO QUESTIONS FROM EACH SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. **USE SEPARATE ANSWER BOOKS** FOR EACH SECTION.

SECTION A: Sampling, Experimental Methods and Design

1. Increases in weight of guinea pigs (g) fed on basic and supplemented diets were assessed. The dietary supplementations included the following factors: bran, vitamins and antibiotics. Each diet was fed to four animals, one in each of the four pens in a Randomized Block Design, giving the following results (Table 1) and ANOVA table (Table 2):

Table 1. Increases in weight (g) of guinea pigs fed on basic and supplemented diets.

Diet	Basic	+ Anti-biotics (A)	+ Bran (B)	+ Vita-mins (V)	+ A & B	+ A & V	+ B & V	A,B & V	Totals
Treatments	⊕	a	b	v	ab	av	bv	abv	(R_j)
Pen I	7	8	11	10	12	12	15	16	91
II	8	10	11	11	15	16	16	15	102
III	6	8	13	12	14	12	13	15	93
IV	7	8	12	10	14	14	17	16	98
Totals (T_i)	28	34	47	43	55	54	61	62	384

TURN OVER

Table 2. ANOVA Table of the results of increases in weight of guinea pigs fed on basic and supplemented diets.

Source of variation	d.f.	SS	MS	F-Ratio
Pens (Replications)	3	9.25	3.08	2.42
Treatments	7	268.00	38.29	30.06
Error	21	26.75	1.27	
Total	31	304.00		

Test the null hypothesis (Ho) that there are no interactions among the dietary factors in this study.

2. Given the following data of an experiment involving a Completely Randomized Design (Table 3), test the H_o that there are no significant differences among the treatment means.

Table 3. Results of a Completely Randomised Design experiment.

	Treatment			
Replicate	A	B	C	D
1	2.0	1.7	2.0	2.1
2	2.2	1.9	2.4	2.2
3.	1.8	1.5	2.7	2.2
4.	2.3		2.5	1.9
5.	1.7		2.4	

3. In an auto mobile exhaust emission study, four cars and four drivers were used to test the possible differences among four petrol additives (A, B, C & D) in reducing the amount of oxides of nitrogen emitted in exhaust gases. Results of the study are presented below (Table 4) with one missing value.

CONTINUE TO NEXT PAGE

Table 4. Results of an auto mobile exhaust emission study conducted.

	CAR			
Driver	1	2	3	4
I	A = 21	B = 26	D = 20	C = 25
II	D = 23	C = 26	A = -	B = 27
III	B = 15	D = 13	C = 16	A = 16
IV	C = 17	A = 15	B = 20	D = 20

(a) Deduce from the layout of the results in table 4 above, the kind of experimental design used in the experiment.
(b) Estimate the missing value in the results.
(c) Conduct an ANOVA to test the Ho that there are no significant differences in the emission levels of nitrous oxides among the additives.

4. State when each of the following kinds of sampling designs are used and explain how the population mean and variance are estimated in each one of them:

(a) Simple Random Sampling Design
(b) Systematic Sampling Design
(c) Stratified Sampling Design.

SECTION B: Data Analysis Methods and Research Proposal Writing

5. In an effort to determine the effect of diet and environmental living conditions on the weight gain in guinea pigs, twenty animals were randomly allocated to four diets differing in protein and carbohydrate content. The five animals allocated to each diet were then randomly allocated to five cages differing in environmental conditions (temperature, relative humidity and light). The weight gain (in grams) of each animal after two weeks was determined. The data obtained was analysed by two-factor ANOVA without replication using MSEXCEL© to test the following null hypotheses (H_0):

H_0: The mean weight gain of guinea pigs is the same on each of the four diets.
H_0: The mean weight gain of guinea pigs is the same under different environmental living conditions.

TURN OVER

In the analysis, the four diets constituted the columns whereas the environmental living conditions (blocks) constituted the rows on the spreadsheet. The output of the analysis is given in Table 5a and 5b.

Table 5a ANOVA Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Block 1	4	7.6	1.9	0.4
Block 2	4	7.5	1.875	0.715833
Block 3	4	7	1.75	0.363333
Block 4	4	7.5	1.875	0.689167
Block 5	4	8.7	2.175	0.809167
Diet 1	5	6.9	1.38	0.012
Diet 2	5	14	2.8	0.2
Diet 3	5	11.2	2.24	0.043
Diet 4	5	6.2	1.24	0.038

Table 5b ANOVA results

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.393	4	0.09825	1.513479	0.259720464	3.259167
Columns	8.1535	3	2.717833	41.8665	1.24098E-06	3.490295
Error	0.779	12	0.064917			
Total	9.3255	19				

(a) Summarise the mean weight gain under different diets and living conditions using bar diagrams.
(b) Discuss whether living conditions and diet influence weight gain in guinea pigs.

6. The wing length (cm) and tail length (cm) of twelve birds belonging to the same species were measured in order to determine whether wing length in birds influences the tail length. A correlation and linear regression analysis was done on the data obtained using MSEXCEL© and the output of the analysis is as shown in table 6a and 6b.

CONTINUE TO NEXT PAGE

Table 6a Summary output of correlation and regression analysis

Regression Statistics	
Multiple R	0.870354561
R Square	0.757517062
Adjusted R Square	0.733268769
Standard Error	0.180705199
Observations	12

Table 6b ANOVA results

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.020122977	1.020123	31.24002	0.000231106
Residual	10	0.326543689	0.032654		
Total	11	1.346666667			

	Coefficients	*Standard Error*	*P-value*
Intercept	-0.66883495	1.474369854	0.659773
Wing length	0.770873786	0.137920131	0.000231

(a) Describe the nature of the relationship between wing length and tail length.
(b) Determine whether there is significant regression of wing length on tail length.
(c) Summarise the relationship between wing length and tail length in the form of an equation.
(d) Determine the tail length of a bird with a wing length of 11.0cm.

7. The data in table 7 shows the weight (in kg) of ten male students selected at random at the University of Zambia Great East Road Campus and the deviation of the observations from the mean weight.

TURN OVER

Table 7. Weight (kg) of ten male students on campus and the deviation from the mean weight

Weight (kg)	**Deviation from the mean**
72.5	1.77
71.7	0.97
60.8	-9.93
63.2	-7.53
71.4	0.67
73.1	2.37
77.9	7.17
75.7	4.97
72	1.27
69	-1.73

Determine:

(a) The sum of squares (SS) using the deviation method.
(b) The variance.
(c) The standard deviation.
(d) The confidence limits of the mean at 95% confidence level.

8. The following excerpt was obtained from an article in the Zambia Daily Mail. "Over 10,000 hectares of defoliation of Mukwa *Pterocarpus angolensis* Jacq. DC in the Western Province of Zambia has resulted in over 100 million kwacha in economic loss to the income of the province over the last five years". Insect **A** is suspected as a primary defoliator in the area although its role in defoliation of Mukwa has not been investigated. As a biology student interested in researching this topic, propose:

(a) A title for the research.
(b) Statement of the problem.
(c) Objective.
(d) Hypothesis to be tested.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3161: ETHOLOGY OF BIRDS AND MAMMALS
THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER QUESTION **ONE** AND ANY OTHER **FOUR** QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

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1. Charles Darwin proposed that evolution by natural selection was the basis for the differences in similar organisms. Discuss in detail any **two** of the following:
   (a) The theory of evolution by Natural Selection as presented by Darwin.
   (b) Natural Selection and antibiotic-resistant bacteria.
   (c) Speciation and its limitations.

2. Briefly discuss the following:
   (a) Konrad Lorenz.
   (b) Handicap Principle.
   (c) Genetic drift.
   (d) Cooperative breeding.

3. Briefly discuss the following terms as used in ethology:
   (a) Associative learning.
   (b) Kin selection.
   (c) Ritualized combat.
   (d) Territory.

4. Describe the main features of chemical communication in animal species, and explain how such communication could be an essential mechanism in sexual behaviour in birds.

5. Discuss how imprinting behavior could be useful in both offspring and parents in precocial species such as ducks and geese.

6. 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) Cerebral cortex.

TURN OVER

7. Discuss the main differences between Lamarckism and Darwinism as they relate to the evolution of altruistic behaviour in mammalian species.

8. Compare and contrast Character Displacement and Habituation as they relate to the evolution of aggressive behaviour in social species.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3171: EVOLUTIONARY BIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTION **ONE** AND ANY OTHER **FOUR** QUESTIONS

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1. Discuss the major concepts in evolutionary biology and explain how the human immunodeficiency virus illustrates these concepts.

2. Outline Charles Darwin's four postulates and how they have been restated in the light of the modern synthesis of evolutionary biology.

3. Discuss four of the pieces of evidence presented for the theory of biological evolution.

4. Discuss two of the arguments presented by proponents of Intelligent Design against the theory of evolution and explain the counter evidence that has been presented by evolutionary biologists.

5. Summarise the role of mutation as the ultimate source of variation in populations, stating the sources of the four types of mutations that are most significant for evolution and their evolutionary importance.

6. Give an account of frequency dependent selection with the help of some empirical examples and state the significance of this pattern of selection.

7. Briefly discuss the species concept and outline the various mechanisms of speciation.

8. Comment on the following:
   (a) Reinforcement in speciation
   (b) Muller's ratchet
   (c) Intersexual selection
   (d) Red queen hypothesis

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR first SEMESTER
FINAL EXAMINATIONS

BIO 3251: PARASITOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. **TWO** QUESTIONS FROM EACH SECTION AND THE **FIFTH** FROM EITHER SECTION. USE ILLUSTRATIONS WHERE POSSIBLE AND USE SEPARATE BOOKLETS FOR EACH SECTION.

SECTION A

1. (a) Discuss immunity in malaria in relation to stable and unstable malaria transmission.
   (b) Summarise recrudescence in falciparum malaria.

2. Describe transmission and life cycle of the following:
   (a) Leishmania species causing visceral Leishmaniasis
   (b) Trypanosomes causing African human trypanosomiasis

3. Describe transmission, life cycle, pathogenesis, clinical symptoms and diagnosis of bovine babesiosis.

4. Summarise the following:
   (a) Types of symbiosis.
   (b) Types of hosts.
   (c) Ultra structure of a parasitic cell

SECTION B

5. Describe the process of autoinfection in the life cycles of the following parasites:
   (a) *Enterobius vermicularis*
   (b) *Strongyloides stercoralis*
   (c) *Taenia solium*

6. Describe the following:
   (a) Diagnosis of *Trichinella spiralis*
   (b) Morphology of *Ancylostoma duodenale*

(c) Pathogenesis from Tick infestation
(d) Periodicity of *Wuchereria Bancrofti* microfilariae in peripheral blood

7. (a) Describe the general trematode life cycle.
   (c) Contrast the life cycles of *Schistosoma haematobium* and *Schistosoma Mansoni.*

8. Describe the following:
   (a) The feeding habits of phlebotomine sand flies
   (b) The breeding sites of *Anopheles*, *Culex* and *Aedes* mosquitoes.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3211: INTRODUCTION TO ENTOMOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, TWO QUESTIONS FROM EACH SECTION AND THE LAST QUESTION FROM EITHER SECTION

SECTION A: Insect Morphology, Anatomy and Orders

1. Compare and contrast tagmatization and evolutionary success in the following arthropod classes:

   (a) Archnida.
   (b) Chilopoda.
   (c) Pterygota.
   (d) Diplopoda.

2. Compare and contrast the organization of the tracheal system in the abdominal, thoracic and head tagmata of the insect body.

3. Describe the organization of the nervous system in insects and explain the function of the stomatogastric nervous subsystem in the insect body.

4. Discuss the phylogenetic relationships of the present insect orders and state the major events that occurred at specified times in their evolutionary history.

SECTION B: Insect Physiology and Biochemistry

5. Describe the kinds of metamorphosis exhibited by the following insect groups:

   (a) Apterygota.
   (b) Orthopteroid insects.
   (c) Lepidoptera.

6. Discuss the roles of imaginal discs in the development of adult features in hemimetabolous and holometabolous insects.

7. Distinguish the modes of action of ecdysone and Juvenile hormone during postembryonic development in insects.

TURN OVER

8. With the aid of well labelled diagrams, describe steps involved in an insect moult and tanning.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3241: MYCOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. ILLUSTRATE YOUR ANSWERS WHEREVER POSSIBLE.

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1. Distinguish Sporangiospores from arthrospores. Describe the formation of conidia in *Neurospora crassa.*

2. Describe wall bonding properties of *Candida albicans*. Explain how an environment rich in glucose levels contributes to the morphological transformation of the fungus from a filamentous form to a unicellular form.

3. Describe the main distinguishing features of the Basidiomycotina, their sexual reproduction and ecological significance.

4. Discuss the involvement of hormones in sexual reproduction of the Zygomycotina, using a named example.

5. Describe the structure of the growing tip of a hypha. Explain how fungi have partly depended on it for their success.

6. Summarise the following hyphal modifications:
   (a) Rhizomorphs
   (b) Sclerotia
   (c) Mycelial strands

7. *Saccharomyces cerevisiae* at 30° C has a μmax of $0.45h^{-1}$ and a g of 1.54h. Discuss the given information with reference to kinetics of growth of the fungus. Explain why μmax of any fungus can never be sustained indefinitely in a batch culture.

8. Discuss the different mechanisms for spore discharge in *Podospora fimicola*, *Pilobolus* spp. and *Sphaerobolus* spp.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3301: VIROLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS WITH TWO QUESTIONS FROM EACH SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. USE SEPARATE ANSWER BOOKS FOR EACH SECTION.

SECTION A: Plant viruses

1. Describe the characteristics, diversity and forms of plant viruses giving appropriate examples.

2. Describe the range of disease symptoms caused by plant viruses.

3. Discuss the various interesting and unusual strategies for plant virus transmission in nature.

4. Describe the fate of viruses inside the host plant cells once the infection process is over.

SECTION B: Animal viruses

5. Describe the characteristics and explain the pathogenesis of the Papillomaviruses.

6. Discuss the various types of vaccines against animal viruses.

7. Explain the various mechanisms of animal virus pathogenesis.

8. Summarise the following with respect to influenza viruses:
   (a) Distinguishing biological characteristics.
   (b) Antigenic variation within the group.
   (c) Clinical features.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
FIRST SEMESTER DEFERRED EXAMINATIONS
2010-2011 ACADEMIC YEAR

BS 425: IMMUNOLOGY
THEORY PAPER
TIME: THREE HOURS
INSTRUCTIONS: ANSWER ANY **FIVE** QUESTIONS AND USE ILLUSTRATIONS WHEREEVER POSSIBLE

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1. Draw a schematic diagram of the basic structure of the lymphatic system in humans. Indicate the network of vessels that penetrate every tissue of the body and a collection of tissues and organs that produce immune cells.

2 (a) List and describe the functions of the lymphatic system in humans.
(b) Explain how Lymph is formed and returned to the blood stream.

3. (a) Name the major types of cells in the human lymphatic system and state their functions.
(b) Describe the form and function of red bone marrow and thymus.

4. Write short notes on the following:
(a) Opsonization
(b) the potent biological activity of Immunoglobulin E(IgE)
(c) Cytolysis
(d) Haptens and hapten – Carrier conjugate

5. Discuss the process of inflammation under the following sub-questions:
(a) Define an inflammation
(b) Describe the general purposes of the inflammation.
(c) State the different agents of inflammation and their functions
(d) List its cardinal signs
(e) Explain how its purposes are achieved.

6. (a) Describe the life history of a T-lymphocyte beginning with a precursor cell in the bone-marrow and ending with a clone of active cells and memory cells.
(b) Draw schematic diagrams of the T-cell receptor (TCR), CD3, CD4 and CD8 coreceptors.

TURNOVER

7. (a) Define specific immunity
   (b) Name the three types of lymphocytes that are involved in Cellular immunity and describe the roles they play.
   (c) Contrast Cellular and humoral immunity.

8. (a) Explain why IgM has a stronger power of agglutination than antibody of any other class.
   (b)Explain why the secondary immune response prevents a pathogen from causing diseases while the primary immune response does not.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BS 475: POPULATION ECOLOGY
THEORY PAPER

TIME: THREE (3) HOURS

INSRUCTIONS: ANSWER QUESTIONS ONE AND FOUR OTHERS. ILLUSTATE YOUR ANSWER WHERE NECESSARY

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1. Using the Lotka-Volterra equations based on the logistic curve,
   (a) describe the interaction of two species, that is Sp_1 and Sp_2 are competing for food or space
   (b) describe the interaction by predation of Sp_1 (prey) and Sp_2(predator)

2. If success in passing on genes determines the evolution of a population, explain why not all organisms grow rapidly, reproduce shortly after birth, produce many offspring, reproduce frequently, and take extensive care of young.

3. In the regulation of species populations, consider the views of Andrewartha and Birch (1954, 1974) and discuss these in contrast with those expressed by;
   (a) Wynne-Edwards (1964).
   (b) Christian and Davis (1964).

4. Discuss the parameters $\mathbf{l_x}$ and $\mathbf{m_x}$ in population growth as applied to a single population model, and discuss the difficulties associated with their application.

5. Discuss this expression and its limitations in estimating population growth.

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

6. American Cicadas: insects whose nymphs live underground living off roots juices emerge every 17 years (Northern sp) or 13 years (Southern sp) into adults to breed and lay eggs. The life span is greater than the life span of their predators. Explain why 13 or 17 years.

7. Compare and contrast between the semelparous and iteroparous strategies in the life history a population of a vertebrate species.

TURN OVER

8. Compare the life table of a vertebrate species such as that of a rodent, a Giant Rat(*Cricetomys gambianus* Waterhouse) and that of:

(a) An insect such as a mosquito and
(b) A perennial plant such as *Cynadon dactylon*

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR: FIRST SEMESTER
DEFERRED FINAL EXAMINATIONS

BS 491: FRESHWATER BIOLOGY
THEORY PAPER:

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTIONS **1 AND 2** AND ANY OTHER **THREE** QUESTIONS. USE **ILLUSTRATIONS** WHERE NECESSARY

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1. Discuss the following in relation to relative productivity of aquatic ecosystems:
   (a) Mean depth.
   (b) Shoreline development.
   (c) Water turbidity.
   (d) Salinity.
   (e) Lake mixing.

2. Discuss the significance of measuring vertical distribution of dissolved oxygen concentrations in depth profiles for determining the relative productivity of aquatic ecosystems.

3. Provide a detailed description of the effect of silicon compounds in both the seasonal and vertical distributions of the Bacillariophyceae in a warm monomictic lakes.

4. Assess the significance of hypolimnetic carbon dioxide (CO_2) in determining the relative productivity of lakes.

5. Discuss the circulation, distribution and dynamics of nitrogen in aquatic ecosystems.

6. Compare and contrast lontic and lentic ecosystems.

7. Discuss factors that determine the distribution and abundance of pelagic zooplankton in cold dimictic lakes.

8. Discuss the four methods that are commonly used in assessing absolute primary productivity of aquatic ecosystems highlighting shortcomings of each one.

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 -2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BS 935: PLANT PATHOLOGY
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS.

---

1. You are provided with specimens **A1** to **A5** of plant diseases. For each specimen:

   (a) State the common name of the disease.
   (b) Describe the characteristic disease symptom.
   (b) Name the causal organism of the disease.
   (d) State whether the pathogen is a biotroph or a necrotroph.

2. You are provided with **B1** and **B2**. For each specimen:

   (a) State the common name of the disease.
   (b) Describe the disease symptom.
   (c) Identify the host by its scientific name.
   (d) Identify the causal organism by its scientific name.

3. Examine specimens **C1** to **C5** and describe the following in respect of each specimen:

   (a) State the common name of the disease.
   (b) Describe the disease symptom.
   (c) Identify the causal organism by its scientific name.
   (d) State the scientific name of the host.

4. You are provided with specimens **D1** to **D5**. For each specimen:

   (a) Identify the diagnostic structure.
   (b) State the pathogen.
   (c) State the common name of the disease caused by the pathogen.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C101: INTRODUCTION TO CHEMISTRY I

TIME: THREE (3) HOURS

INSTRUCTIONS:

1. Indicate your **student ID number** (computer number) and **TG number** on **ALL** your answer booklets.

2. This examination paper consists of two **(2)** sections: **A** and **B**

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

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

5. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORKING CLEARLY AND LOGICALLY.**

6. **ENSURE** that you have seven (7) printed pages.

Information to the candidates:

1. **Useful data** is printed on **page 2.**

2. **Periodic Table** is printed on the **page 3** of this question paper.

DATA

Avogadro's constant, N_A	6.022×10^{23} mol^{-1}
Molar volume of gas at S.T.P	22.4 dm^3 mol^{-1}
Universal gas constant, R	8.314 J K^{-1} mol^{-1}
	0.0821 L atm K^{-1} mol^{-1}
	8.314 k Pa L K^{-1} mol^{-1}
Planck's constant, h	6.63×10^{-34} J s
Rydberg constant, R_H	109678 cm^{-1}
Velocity of light, c	3.00×10^8 ms^{-1}
Electron volt, 1 eV	1.602×10^{-19}J
Faraday, 1F	96485 C mol^{-1}
Joule, 1 J	1 kg m^2 s^{-2}
Mass of proton, m_p	1.00727 amu
Mass of Neutron, m_n	1.008665 amu
Mass of electron, m_e	0.000548593 amu

Standard Electrode Potentials:

$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$;	$E^o = -0.40$ V
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$;	$E^o = -1.19$ V

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
				KEY													
				Atomic number **X** Atomic mass Name of the element X													
																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
1 **H** 1.01 Hydrogen												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
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											13 **Al** 26.98 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
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium																
19 **K** 39.10 Potassium	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** 63.55 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 Seleniu m	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	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 Inidum	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Telluriu m	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	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
87 **Fr** (223.02) Francium	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 Gadoliniu m	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 Lawrenciu m

SECTION A **ANSWER ALL QUESTIONS**

QUESTION A 1

An isotope of a naturally occurring element X contains 12 neutrons, 11 protons, and 10 electrons.

(a) Use the Periodic Table to identify the element.

(b) Write its isotopic notation, ${}^{A}_{Z}X$.

(c) What can you see, one molecule of water or one mole of water. Explain in one sentence.

[4 Marks]

QUESTION A 2

A 0.1000 g sample of nicotine, $C_xH_yN_z$, (molar mass of 162.26 g/mol) has the composition shown below. Copy and complete the table and,

	C	H	N
Mass in grams	0.07402	0.008714	0.01727
n (in mol)			
Mole ratio			

(a) determine its empirical formula,

(b) calculate its molecular formula.

[4 Marks]

QUESTION A 3

An ideal gas is a gas that can be described using the ideal gas equation.

(a) Describe the three postulates or assumptions in the Kinetic Molecular Theory of gas for a gas to behave as an ideal gas.

(b) What is the total pressure, in atmospheres, when a mixture of non-reactive gases of 0.01 mol of CO and 0.005 mol CO_2 gas are contained in a total volume of 2.00 L at 25 °C.

[4 Marks]

QUESTION A 4

Calculate the energy associated with the blue emission line (410 nm) in the hydrogen spectrum.

[4 Marks]

QUESTION A 5

Write the electron configuration for a magnesium atom following the ejection of an electron via the photoelectric effect.

[4 Marks]

QUESTION A 6

Construct a Lewis structure for the molecule $CHCl_3$ and determine whether the molecules is polar or non polar.

[4 Marks]

QUESTION A 7

Camphor ($C_{10}H_{16}O$) has a heat of combustion of - 5903.6 kJ/mol. A sample of camphor with a mass of 0.1204 g is burned in a bomb calorimeter. The temperature increases by 2.28 °C. What is the heat capacity (kJ / °C) of the calorimeter?

[4 Marks]

QUESTION A 8

The enthalpy of solution, $\Delta H°_{sol}$ is the enthalpy change that accompanies the dissolution of 1.00 mol of a solid in large excess of water. In an experiment 8.00 g of ammonium nitrate was dissolved in 50.0 g water in a coffee cup calorimeter. The temperature fell by 10.1 °C.

(a) Is the change endothermic or exothermic? Explain.

(b) Calculate the Enthalpy of solution of ammonium nitrate.

[4 mks]

QUESTION A 9

Both dichromate(VI) ions and manganate(VII) ions need hydrogen ions in order to act as oxidising agents in titration experiments. Explain, by calculating $E°_{cell}$ values, whether hydrochloric acid could be used to provide the H^+ ions for these oxidations.

	E° / V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+ 0.77
$½\ Cl_2(g) + e^- \rightleftharpoons Cl^-(aq)$	+1.36
$MnO_4^-(aq) + 8H^+ + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+ 1.52

[4 mks]

QUESTION A 10

A galvanic cell uses following reaction:

$$Mn(s) + 2\ Cd^{2+}(aq) \rightleftharpoons Mn^{2+}(aq) + 2Cd(s)$$

(a) Calculate the standard cell potential and change in Gibb's free energy, $\Delta G°$.

(c) In which direction will the current flow?

[4 mks]

SECTION B **ANSWER B1 AND ANY OTHER THREE QUESTIONS**

QUESTION B1

In Experiment V on simple titration, 5.00 mL of household ammonia with100.00 mL water added to it was titrated using a standardized HCl solution. The titration required 10.37 mL of 0.08555 M standardized HCl solution to reach the methyl orange end-point according to the reaction:

$$HCl(aq) + NH_3(aq) \rightarrow NH_4Cl(aq)$$

(a) What is an indicator, and what was the colour change at the end-point in that titration.

(b) The reaction above is an acid-base reaction. Indentify the acid/conjugate base pair and the base/conjugate acid pair in the above reaction.

(c) Calculate percent ammonia in household ammonia. Assume the density of ammonia solution was 1.00 g/mL.

[TOTAL = 15 mks]

QUESTION B 2

Magnesium sulphate forms a hydrate known as Epsom salts, $MgSO_4.xH_2O$. A student dissolved 1.2400 g of the hydrate in water and added $BaCl_2$ solution until the precipitation of $BaSO_4$ was complete. The precipitate was filtered, dried and found to weigh 1.1740 g . The precipitation reaction is:

$$MgSO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + MgCl_2(aq)$$

(a) Write an ionic reaction when $MgSO_4.xH_2O$ dissolves in water.

(b) What is the net ionic reaction involving the precipitation reaction above?

(c) Determine moles of water of hydration in Epsom salts.

[TOTAL = 15 mks]

QUESTION B 3

(a) (i) The yellow colour commonly used for qualitative determination of element sodium is due to the transition from the 3p to 3s. Write the electron configuration of the sodium atom in its excited state giving rise to this transition.

(ii) Calculate the first ionization energy for a sodium atom in its ground state.

(b) Predict the trend in atomic radius for the following ions: Li^+, Na^+, K^+ and Cs^+.

(c) (i) Construct a Lewis structure of the ammonium molecules and show its electron-pair geometry

(ii) Use the hybridization theory to justify the geometry describe in c (i) above.

[TOTAL =15 mks]

QUESTION B 4

(a) From the following enthalpies of formation calculate the standard reaction enthalpy for the photosynthesis reaction,

$6\,CO_2(g) + 6\,H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6\,O_2(g)$

$\Delta H_f^o\ (CO_2(g)) = -393.5$ kJ/mol,

$\Delta H_f^o\ (H_2O(l)) = -285.8$ kJ/mol,

$\Delta H_f^o\ (C_6H_{12}O_6(s)) = -1274.5$ kJ/mol

(b) Construct the Born-Haber cycle and compute the lattice enthalpy change of $MgCl_2(s)$ from the following data.

$Mg\ (g) \rightarrow Mg^{2+}(g) + 2e^-$	$\Delta H° = 2170$ kJ
$Mg\ (s) \rightarrow Mg\ (g)$	$\Delta H° = 132$ kJ
$Cl_2(g) \rightarrow 2Cl(g)$	$\Delta H° = 236$ kJ
$Cl(g) + e^- \rightarrow Cl^-(g)$	$\Delta H° = -342$ kJ
$Mg\ (s) + Cl_2(g) \rightarrow MgCl_2(s)$	$\Delta H° = -652$ kJ

[TOTAL = 15 mks]

QUESTION B5

(a) What is meant by the term electrolysis?

(b) Sketch a cell for the electrolysis of a molten NaCl using inert electrodes. Show the direction in which the ions move in the internal circuit and the electron in the external circuit.

(c) Write the electrode reactions in above electrolytic cell.

(d) In a certain electrolysis experiment 1.44 g of Ag were deposited in one cell (containing silver nitrate) while 0.120 g of an unknown metal X was deposited in another cell (containing aqueous solution of XCl_3 in series. Identify the metal X.

[TOTAL = 15 mks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 205: ANALYTICAL AND INORGANIC CHEMISTRY
TIME: THREE (03) HOURS.

INSTRUCTIONS:

1. **THIS PAPER CONTAINS FIVE (05) QUESTIONS.**
2. **ANSWER FOUR (04) QUESTIONS; EACH QUESTION CARRIES 15 MARKS**
3. **SHOW ALL YOUR WORKING CLEARLY.**
4. **ESSENTIAL DATA TABLES ARE ATTACHED TO THE QUESTION PAPER.**

Question 1.

a).

In 1964, a new compound composed of potassium, molybdenum and cyanide, with formula $K_xMo_y(CN)_z$ was reported. Chemical analyses showed the presence of 25.51% K and 31.54% Mo. Calculate the empirical formula of the compound.

b).

The oxygen-oxygen bond is observed in many molecules where two oxygen atoms occur as a bonding unit; e.g. O_2, Na_2O_2, KO_2. Apply molecular orbital energy level consideration to extract information regarding relative order of (a) bond length (b) bond energy (c) magnetic moments.

c).

A study is being performed to see if there is a correlation between the concentration of chromium in the blood and a suspected disease. The results of analysis of blood samples from a control group and a diseased group were as follows:

Control Group (ppb Cr): 15, 23, 12, 18, 09, 28, 11, 10

Diseased Group (ppb Cr): 25, 20, 35, 32, 15, 40, 16, 10, 22, 18

Determine, at 95% confidence level, whether the differences between the two groups can be ascribed to chance or whether they are real.

Question 2.

a).

According to Bohr's theory, the electronic energy of Hydrogen atom in the n^{th} orbit is given by

$$E_n = -\frac{21.76 \times 10^{-19}}{n^2} \text{ J.}$$

Calculate the longest wavelength of light that would be needed to remove an electron from the 3^{rd} orbit of He^+ ion.

b).

i). What is a buffer solution?
ii). Calculate the pH of a buffer solution prepared by adding 10.0 ml of 0.20 M acetic acid to 40.0 ml of 0.50 M sodium acetate. $K_a = 1.75 \times 10^{-5}$

c.

A pair of C205/C225 students, Sovi Kajila/ Anxious Muleya, obtained the following results for replicate determinations of calcium in food samples: 14.35%, 14.41%, 14.40%, 14.32% and 14.37%. Calculate the confidence interval at the 95% confidence level.

Question 3.
a.

Li forms oxide, sodium the peroxide and potassium the superoxide. Explain their properties using equations.

b.

An iron ore is analysed for iron content by dissolving in acid, converting the iron to Fe^{2+}, then titrating with standard potassium dichromate (0.0150 M) solution. If 35.6 mL titrant is required to titrate the iron in 1.85 g of an ore sample, how much iron is in the sample expressed as milligrams of Fe_2O_3 correct to 3 significant figures?

c.

A wholesaler purchased a track load of baby milk from the Manufacturers. The analysis certificate made out while the track was being loaded showed 46.70% protein with a standard deviation of 0.07% for five (5) measurements. When the baby milk arrived at the wholesaler's warehouse, it was analysed with the following results, %protein: 45.58, 45.61, 45.69 and 45.64. Should the wholesaler accept the baby milk?

Question 4.
a.

When the strong cleaning agent "trisodium phosphate" is mixed with household vinegar, which contains acetic acid, the following equilibrium is established:
$PO_4^{3-}{}_{(aq)} + HC_2H_3O_{2(aq)} \rightarrow HPO_4^{2-}{}_{(aq)} + C_2H_3O_{2(aq)}^-$. Identify the pairs of conjugate acids and bases involved.

b.

Show the crystal field splitting diagram of $Fe(H_2O)_6]^{3+}$ and $[Fe(CN)_6]^{3-}$; and then compute their magnetic moments.

c.

The Manager of a Food Processing Company was trying to decide whether or not to keep a young recently hired scientist. The Manager decided to see if the new scientist's work was of the same quality as that of the other staff. She asked both a senior scientist and the new scientist to analyze the same food sample using the same procedure, reagents and instruments. They obtained the following results:

Senior Scientist (% Ca)	**New Scientist** (%Ca)
18.89	20.10
19.20	20.50
19.00	18.65
19.70	19.25
19.40	19.40
	19.99

Determine if there is a significant difference in the precision of the data at 95% confidence level.

Question 5.

a.

Complete and balance the following redox reactions which occur in acid aqueous solution:

i). $Cr_2O_7^{2-} + BrO_4^- + H_2O \rightarrow Br_2 + Cr^{+3} + H_2O$ given that E^0 for $Cr_2O_7^{2-}/Cr^{3+} = 1.33v$; and, E^0 for $BrO_4^- / Br_2 = 1.52v$.

ii). $NO_3^- + Cu \rightarrow NO_2 + Cu^{2+} + H_2O$

b.

Discuss the formation of $[Zn(NH_3)_4]^{2+}$ and $[FeCl_4]^-$ complex ions using valence bond theory.

c.

i). Describe the steps involved in a sampling operation of ground nut sample.
ii). Explain the difference between accuracy and precision.
iii). Distinguish between determinate and indeterminate errors.

END OF EXAMINATION

Universal Statistical Tables:

1. Rejection Quotient, Q, at Different Confidence Limits.

Number of Observations	Confidence Level Q_{90}	Q_{95}	Q_{99}
3	0.941	0.970	0.004
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568
15	0.338	0.384	0.475
20	0.300	0.342	0.425
25	0.277	0.317	0.393
30	0.260	0.298	0.372

2. Values of t for v Degrees of Freedom at Different Confidence Limits.

Number of Degrees of Freedom	Confidence Level 90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.441	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	2.060	2.787	3.078
Infinite	1.645	1.960	2.576	2.807

3. Values of F at the 95% Confidence Level

v_1 =		2	3	4	5	6	7	8	9	10	15	20	30
v_2 =	2	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.42.	19.4	19.4	19.4	19.5
	3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
	4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
	5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
	6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
	7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
	8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
	9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
	10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
	15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
	20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
	30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

C 251: ORGANIC CHEMISTRY I

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer any FOUR questions.
2. Present your answers in a logical and orderly manner.
3. Mark allocation for questions is shown, **[x]**.

Max. Marks: 120

Question 1

(a) (i) Write mechanisms showing how CH_3CH_2Cl might be formed when methane is chlorinated. **[8]**

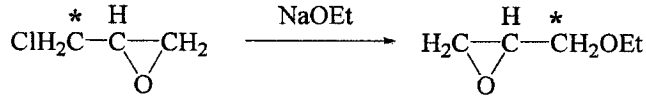
(ii) How would you minimize the formation of polychlorinated products? **[2]**

(b) An alkane with molecular formula C_5H_{12} reacts with chlorine to give four isomeric **mono**-chlorinated products.

(i) Write the structural formulas of the four mono-chlorinated products. **[4]**

(ii) Given that the relative reactivities of the 1^0: 2^0: 3^0 hydrogens to chlorination are 1: 4: 5. Calculate the relative amounts of all the products and the percentages of the different products. **[6]**

(c) (i) When sodium ethoxide reacts with 1-(chloromethyl) oxirane, labeled with ^{14}C, as shown by the asterisk in **A**, the major product is an epoxide bearing the label as shown in **B**. With the aid of an appropriate reaction mechanism, provide an explanation for this reaction. **[6]**

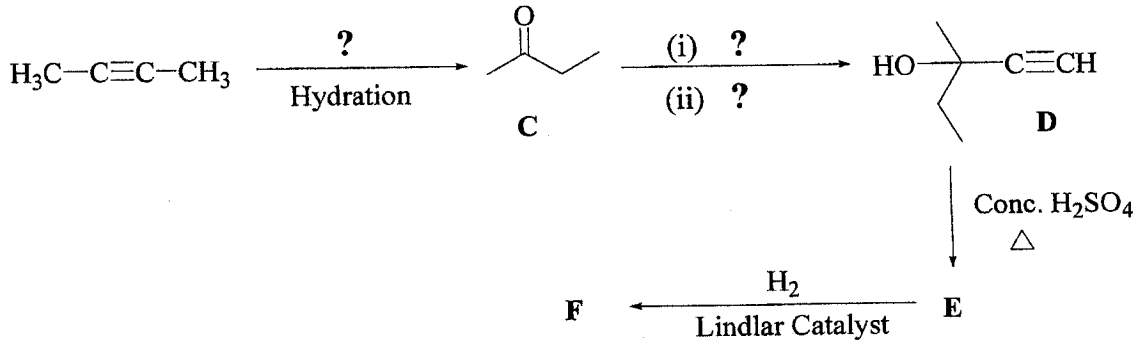


A **B**

(ii) Give a synthesis for the oxirane **A**, shown above, from propene, labeled with ^{14}C at C-3, $H_3{}^*CCH{=}CH_2$. **[4]**

Question 2

(a) A synthesis for the compound **F**, a starting material used in the manufacture of synthetic rubber, is shown below:



(i) Show the missing reagents, including solvents, if any, needed for formation of **C** and **D.**

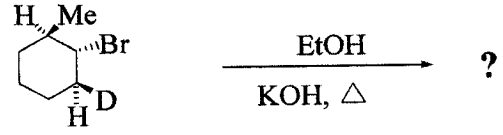
[4]

(ii) Give the structures of the major intermediate **E** and the compound **F.**

[4]

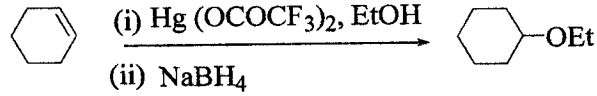
(b) Predict the major organic product(s) and give mechanisms of the following reactions:

(i) 

(ii) 

[12]

(c) Suggest a mechanism to account for the following ether synthesis:



[10]

Question 3

(a) Each of the following reactions can be carried out in a mixed water-ethanol solvent. Would you expect the reaction rate to increase or decrease as the percentage of water is increased? Give reason(s) for your choice.

(i) $NH_3 + CH_3I \xrightarrow[CH_3CH_2OH]{H_2O} CH_3CH_2NH_3^{\oplus} + I^{\ominus}$

(ii) $CN^{\ominus} + CH_3Br \xrightarrow[CH_3CH_2OH]{H_2O} CH_3CN + Br^{\ominus}$

(iii) $(CH_3)_3CBr + OH^{\ominus} \xrightarrow[CH_3CH_2OH]{H_2O} (CH_3)_3COH + (CH_3)_3COC_2H_5$

[9]

(b) Provide a brief explanation for the following experimental observations:

(i) Hydrolysis of methylbromide takes place much faster in presence of sodium iodide in an S_N2 reaction.

(ii) The compounds $CH_3CH{=}CHCH_2Cl$ and $CH_3CH(Cl)CH{=}CH_2$ yield the same product with aqueous sodium hydroxide in an S_N1 reaction.

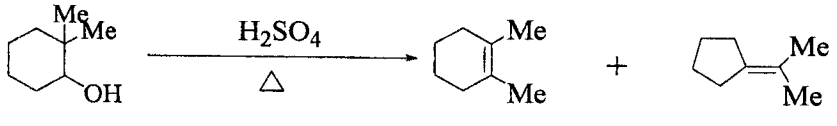
(iii) Doubling the concentrations of reactants in an S_N2 reaction increases the rate of reaction four fold.

(iv) Chloroethene is very unreactive towards nucleophiles in an S_N2 reaction.

(v) Changing the leaving group from $^-OCH_3$ to $^-O_2CCH_3$ in an S_N2 reaction decreases the reaction rate.

[11]

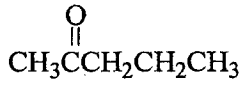
(c) Provide a mechanistic explanation to account for the products of the following reaction:



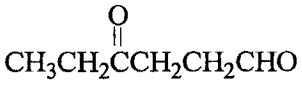
[10]

Question 4

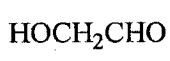
(a) Pheromones are substances secreted by insects that produce a specific behavioral response in other insects. A sex attractant pheromone of the codling moth has the molecular formula $C_{13}H_{24}O$. On catalytic hydrogenation, one mole of the pheromone absorbs two molar equivalents of hydrogen to give 3-ethyl-7-methyl-1-decanol. On treatment with ozone followed by treatment with zinc and acetic acid, the pheromone gives 2-pentanone, 2-hydroxyethanal and 4-oxo-hexanal, structures shown below:



2-pentanone



4-oxohexanal



2-hydroxyethanal

(i) Suggest a structure for this pheromone that is consistent with the above experimental results. Show your logic.

[8]

(ii) From other experiments, the double bonds were found to be (2*Z*, 6*E*). Write a stereo-chemical structure for this pheromone.

[2]

(b) Propose a synthesis of compounds **G** and **H**, structures shown below, from the indicated starting materials and any needed reagents. Show the reagents, including solvents, if any, and the reaction conditions for each step of your proposed synthesis. Pay due attention to stereochemistry of the molecules, where relevant.

(i) **G:** $HOCH_2COCH_2OH$ **From** $HOCH_2CH(OH)CH_2OH$

(ii) **H:** *trans*- 2-pentene **From** *cis*- 2-pentene

[12]

(c) Predict the expected position of the labeled oxygen, ^{18}O, in the product, if you carried out Fischer esterification of benzoic acid, C_6H_5COOH, with ^{18}O-labeled methanol, $CH_3\,^{18}OH$, in presence of concentrated sulphuric acid. Write a detailed mechanism to account for your answer.

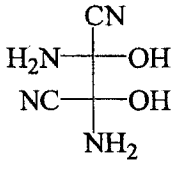
[8]

Question 5

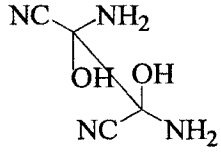
(a) An open chain compound **I**, molecular formula $C_5H_{10}O$, has four isomers that are chiral. All stereoisomers decolorize bromine. Draw all the four stereoisomers of compound **I** and give their complete IUPAC names.

[8]

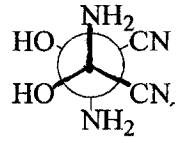
(b) Given below are three different kinds of three dimensional representations of a compound with molecular formula $C_4H_6N_4O_2$.



J



K



L

What are the stereochemical relationships between the following pairs?

(i) **J** and **K**
(ii) **J** and **L**
(iii) **K** and **L**

[12]

(c) Given that the specific rotation of a mixture of (+)-(R) and (-)-(S) enantiomers is -18.4^0 and its optical purity is 80 %.

(i) What percentages of each enantiomer are contained in the mixture?

(ii) Calculate the specific rotation of each enantiomer.

[10]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 225: ANALYTICAL CHEMISTRY 1
TIME: 3 HOURS

INSTRUCTIONS:

1. **THIS PAPER CONTAINS FIVE (05) QUESTIONS.**
2. **ANSWER ANY FOUR (04) QUESTIONS.**
3. **EACH QUESTION CARRIES 15 MARKS.**
4. **SHOW ALL YOUR WORKING CLEARLY.**
5. **ESSENTIAL DATA TABLES ARE ATTACHED TO THE QUESTION PAPER.**

Question 1.

a.

A cell is established between two half-reactions: $H_3AsO_4 + 2H^+ + 2e \rightarrow H_3AsO_3 + H_2O$, ($E^0 = +0.559$v) and $Zn \rightarrow Zn^{2+} + 2e$ ($E^0 = -0.763$v). Write a balanced equation for the overall redox reaction; and, calculate the cell voltage.

b.

A new method of determining iron gave 99.35% recovery (variance 0.185). The standard method gave 99.53% recovery (variance 0.152). In each case three replicate measurements were made. Test whether the two means differ significantly at the 95% confidence level.

c.

The three ionisation constants for citric acid, $HO(CH_2COOH)_3$, are $Ka_1 = 7.42 \times 10^{-4}$; $Ka_2 = 1.75 \times 10^{-5}$ and $Ka_3 = 3.99 \times 10^{-6}$. Determine the equilibrium concentration of the molecular acid species at pH 2 in a 0.500 M citric acid solution.

Question 2.

a.

i). What is a buffer solution?

ii). What will be the pH of a 0.10 M solution of acetic acid, HOAc, which has been made 0.02 M in sodium acetate, NaOAc.

b.

A calibration curve for the colorimetric determination of phosphorus in urine is prepared by reacting standard solutions of phosphate with molybdenum (IV) and reducing the phosphomolybdic acid complex to produce a characteristic blue colour. The measured absorbance (A) is plotted against the concentration of phosphorus. From the following data determine the linear least squares line and calculate the phosphorus concentration in the urine sample.

Phosphorus (ppm)	Absorbance
1.0	0.205
2.0	0.410
3.0	0.615
4.0	0.820
Urine sample	0.625

c.

Use the half reaction method to balance the following redox reaction which occurs in acidic aqueous medium: $IO_3^- + I^- \Rightarrow I_2$ (for I_2/I^-, $E^0 = +0.5345$ v and IO_3^-/I_2, $E^0 = +1.20$ v)

Question 3.

a.

When chlorine is added to drinking water to kill bacteria, some of the chlorine is changed into ions by the following equilibrium: $Cl_{2(aq)} + H_2O \rightarrow H^+_{(aq)} + Cl^-_{(aq)} + HOCl_{(aq)}$
Use the Oxidation Number method on the forward reaction to determine, which is the reductant, in the reverse reaction,

b.

A pair of C205/C225 students, Sovi Kajila/ Anxious Muleya, obtained the following results for replicate determinations of calcium in food samples: 14.35%, 14.41%, 14.40%, 14.32% and 14.37%. Calculate the confidence interval at the 95% confidence level.

c.

A 0.1M solution of a weak monoprotic acid (HA) is found to be 3.5% ionized. Calculate the ionisation constant (Ka) of the acid; and, the pH of the solution.

Question 4.

a.

i). Describe the steps involved in a sampling operation of ground nut sample.
ii). Explain why and how would you prepare a protein free filtrate sample?
iii). Explain the difference between accuracy and precision.
iv). Name three sources of systematic errors.

b.

Given that 0.420 g potassium permanganate, $KMnO_4$, is reduced by exactly 40.0 cm^3 of an acidified solution containing Fe^{2+}. Calculate the molarity of the Fe^{2+} ions in the standard solution.

c.

i). What is the overall complex formation equilibrium constant (K_f) for the reactions:
$Fe^{3+} + SCN^- \rightarrow Fe(SCN)^{2+}$ $K_{f1} = 890$
$Fe(SCN)^{2+} + SCN^- \rightarrow Fe(SCN)_2^+$ $K_{f2} = 2.6$
ii). Calculate the value of K_d for the above equilibrium

Question 5.

a.

Complete and balance the following redox reaction which occurs in acid aqueous solution; then proceed to calculate the cell voltage for the overall reaction:

$Cr_2O_7^{2-} + BrO_4^- + H_2O \rightarrow Br_2 + Cr^{+3} + H_2O$

(Given that E^0 for $Cr_2O_7^{2-}/Cr^{3+} = +1.33v$; and, E^0 for $BrO_4^- / Br_2 = +1.52v$).

b.

The Manager of a Food Processing Company was trying to decide whether or not to keep a young recently hired scientist. The Manager decided to see if the new scientist's work was of the same quality as that of the other staff. She asked both a senior scientist and the new scientist to analyze the same food sample using the same procedure, reagents and instruments. They obtained the following results:

Senior Scientist (% Ca)	**New Scientist** (%Ca)
18.89	20.10
19.20	20.50
19.00	18.65
19.70	19.25
19.40	19.40
	19.99

Determine if there is a significant difference in the precision of the data at 95% confidence level.

c.

i). Distinguish between the solubility and solubility product of silver chloride.

ii). Determine whether a precipitate will form if 10 mL of 0.0001 M $AgNO_3$ is added to 90 mL of 0.000045 M NaCl (K_{sp} for AgCl = 1.0×10^{-10}).

END OF EXAMINATION

Universal Statistical Tables:

1. Rejection Quotient, Q, at Different Confidence Limits.

Number of Observations	Confidence Level Q_{90}	Q_{95}	Q_{99}
3	0.941	0.970	0.004
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568
15	0.338	0.384	0.475
20	0.300	0.342	0.425
25	0.277	0.317	0.393
30	0.260	0.298	0.372

2. Values of t for v Degrees of Freedom at Different Confidence Limits.

Number of Degrees of Freedom	Confidence Level 90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.441	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	2.060	2.787	3.078
Infinite	1.645	1.960	2.576	2.807

3. Values of F at the 95% Confidence Level

v_1 =		2	3	4	5	6	7	8	9	10	15	20	30
v_2 =	2	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.42.	19.4	19.4	19.4	19.5
	3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
	4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
	5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
	6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
	7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
	8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
	9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
	10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
	15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
	20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
	30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 **H** 1.01 Hydrogen				KEY Atomic number **X** Atomic mass Name of the element X												1 **H** 1.01 Hydrogen
3 **Li** 6.94 Lithium	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
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine
19 **K** 39.10 Potassium	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
37 **Rb** 85.47 Rubidium	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 Indium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine
55 **Cs** 132.91 Caesium	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
87 **Fr** (223.02) Francium	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 Thallium	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 Einsteinium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATION

C311: BIOCHEMISTRY I
TIME: THREE HOURS

1. Answer any **FOUR (4)** questions
2. There are **TWO (2)** printed pages in this examination

Question 1

Consider a protein identified only as **X**.

a) i) If denatured, **how** might this protein be renatured?
ii) If renaturation does not occur, **what** might be the explanation?

b) **Calculate** the molar extinction coefficient of protein **X** if the absorbance at 280 nm was 0.850 and the molecular weight was determined to be is 42 000 Dalton. Assume that path length = 0.5 cm and the concentration of protein **X** calculated from quantitative amino acid analysis was 460 μg/ml.

c) Purified protein **X** was subjected to N-terminal determination using Sanger's reagent and *DNP-gly* and *DNP-ser* were identified. **What** explanation can you give for this result?

[25 marks]

Question 2

If radioactive glucose, labeled in position 5 with ^{14}C, was incubated with a cell-free liver homogenate under anaerobic conditions, **what** position(s) in lactate produced would be labeled with ^{14}C? **Show** all steps with reactions incorporating structures of all key compounds except coenzymes.

[25 marks]

PLEASE TURNOVER THE PAGE

Question 3

a) In eukaryotic cells, the enzymes for the Krebs cycle are located in the _____, and those for the electron transport system are located in the _____.

b) In the TCA cycle, oxaloacetate reacts with acetyl CoA to give citrate which then undergoes two (2) decarboxylation steps giving rise succinate. If the methyl group in acetyl CoA is labeled with ^{14}C, the radioactive atom does not leave as carbon dioxide molecule in the first round. Using appropriate structures, **explain** why this is so.

[25 marks]

Question 4

Explain in detail using a neat well labeled diagram why a molecule of $FADH_2$ only yields 2 ATP molecules on complete oxidation in the mitochondrion (**DO NOT WRITE AN ESSAY**).

[25 marks]

Question 5

a) Use the Michaelis-Menten Equation to **calculate** the missing values of [S] given below if V_{max} = 5 mmol/min.

[S] (mM)	v (mmol/min)
10	1.2
?	1.7
?	2.1
?	2.2
?	2.5

b) After a preincubation with *p*-chloromercuribenzoate, the binding of an enzyme with its substrate was no different from that of the untreated enzyme, but the catalytic activity of the treated enzyme was found to be 29 % less. **What** conclusion can be drawn from this type of observation?

[25 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATION

C321 ANALYTICAL CHEMISTRY II

TIME: **Three (3) Hours**

INSTRUCTIONS: Answer **any four** questions in this examination paper. Questions carry equal marks.

Question 1

(a) The instrumental reading for a sample solution was 35.0. An instrumental reading of 60.0 was obtained with a solution of the sample containing an additional 3.0×10^{-4}M of the substance being analyzed. Calculate the concentration of the substance in the sample solution. (3marks)

(b) Describe the essential features of a conventional single beam UV-visible spectrophotometer capable of measuring absorbance at any wavelength in the range 200 – 800 nm.(4marks)

(c) (i) Distinguish between fluorescence and phosphorescence. (2marks)

(ii) What is the chemical shift of a proton whose NMR signal is observed at 320Hz downfield from TMS in a spectrometer whose basic resonance frequency for hydrogen is 90MHz? (2marks)

(d) A bottle of tonic water is to be analyzed for its quinine content by fluorescence spectrometry with excitation at 350nm and emission intensity measured at 450nm. One milliliter of tonic water is diluted to 100ml with 0.05M H_2SO_4; its emission intensity is 8.44 (arbitrary units). A series of quinine standards, in 0.05M H_2SO_4, is prepared and the emission intensities measured (in parentheses): 100ppm (293 units), 10.0ppm (52.3), 1.00ppm (12.0), 0.100ppm (1.26), 10ppb (0.158) and 1.0ppb (0.015). Plot the calibration curve for quinine fluorescence, and determine the quinine content of the original tonic water sample. (5marks)

Question 2

(a) (i) If a 0.0100M solution exhibits 45.0%T at some wavelength, what will be the percent transmittance for a 0.0200M solution of the same substance? (2marks)

(ii) Discuss the instrumentation and applications of nephelometry and turbidimetry. (3marks)

(b) The following data were collected in a continuous variations study of a coloured complex. Determine the combining ratio of M and L in this complex. (5marks)

Concentration ($Mx10^3$)		
M	**L**	**Absorbance of ML_x**
0	10.0	0.002
0.50	9.50	0.202
1.00	9.00	0.397
1.50	8.50	0.596
2.50	7.50	0.828
3.50	6.50	0.783
4.50	5.50	0.704
5.50	4.50	0.597
6.50	3.50	0.460
7.50	2.50	0.326
8.50	1.50	0.194
9.50	0.50	0.059
10.0	0	0.001

(c) An NMR signal is observed at 7.3ppm downfield from TMS in a spectrometer operating at 100MHz. Calculate the position in Hz of that same signal in a spectrometer operating at 60MHz. (3marks)

(d) If the wavelength of a particular form of emr in a vacuum is 522nm; calculate the frequency and the energy of the radiation. Given that Planck's constant, $h = 6.62x10^{-34}JS$ and the speed of light in vacuum, $C = 3.0x10^8m/s$. (3marks)

Question 3

(a) A solution containing a mixture of tetracycline and epitetracycline was found to have an absorbance of 0.670 at 254nm and 0.720 at 267nm (b=1.00cm). If the molar Absorptivities of tetracycline are 16000 at 254nm and 19000 at 267nm and the molar Absorptivities of epitetracycline are 16000 at 254nm and 15000 at 267nm, calculate the concentrations of tetracycline and epitetracycline in the mixture. (5marks)

(b) Nitrite ion, NO_2^-, is used as a preservative for bacon and other foods. This practice has been a source of controversy because the ion is potentially carcinogenic. A spectrophotometric determination of NO_2^- was performed on a sample. To 50 mL of unknown solution containing nitrite was added 1.00 mL sulfanilic acid solution. After 10 minutes, 2.00 mL of 1-aminonaphthalene solution and 1.00 mL of buffer were added. After 15 minutes the absorbance was read at 520 nm in a 5.00-cm cell. The absorbance was 0.622. The molar absorptivity,γ, of the colored product was 4.97×10^4 $M^{-1}cm^{-1}$. How many micrograms of NO_2^- were present in 50.0 mL of food extract? (RAM: N = 14.01; O = 16.00). (4marks)

(c) (i) When performing UV spectroscopy, what is the effect of increasing the wavelength bandwidth (by increasing monochromator slit width) on sensitivity and specificity? (2 marks)

(ii) Many fluorimeters can readily be used as nephelometers. Discuss the modifications required when switching from fluorimetry to nephelometry. (3marks)

(d) A proton has resonance 90 Hz down field from tetra methyl silane (TMS) when the field strength is 14100 gauss and the oscillator frequency is 60 MHz. what will its shift in Hz be if the field strength is increased to 28200 gauss and the oscillator frequency to 120 MHz? (2marks)

Question 4

(a) (i) A 100.0ml solution of a drug gave an instrumental reading of 24.5. A 10.2mg sample of the pure drug (MW 848) was added to the solution and dissolved. The new solution gave an instrumental reading of 65.0. Calculate the concentration of the drug in the original solution. (3marks)

(ii) Show that the difference between two absorbance values, A_1-A_2, is equal to the log of the inverse ratio of their transmittances, log (T_2/T_1). (2marks)

(b) The absorbances of a series of standard solutions of a compound were measured; they are recorded below. The absorbance of an unknown solution of the same compound was 0.480. Determine the concentration of the unknown. (4marks)

Concentration, $x10^{-4}M$	**Absorbance**
1.0	0.080
3.0	0.232
5.0	0.379
7.0	0.524
9.0	0.672
11.0	0.820

(c) For a compound given below, suggest a structure which is consistent with its NMR data. (4marks)

Compound	**NMR Data**
$C_7H_{14}O$	σ 1.0 (d, 6H)
	1.5 (m, 1H)
	2.3 (d, 2H)
	2.4 (d, 3H)
	5.8 (d, 1H)
	6.2 (m, 1H)

(d) A proton has resonance 90 Hz down field from tetra methyl silane (TMS) when the field strength is 14100 gauss and the oscillator frequency is 60 MHz. what will its shift in Hz be if the field strength is increased to 28200 gauss and the oscillator frequency to 120 MHz? (3marks)

Question 5

(a) You need to determine the concentration of an analyte in a food sample using UV/visible spectroscopy. At what wavelength would you analyze the sample and what precautions would you take when determining the concentration of the analyte? (3marks)

(b) The absorbances of a series of standard solutions of a compound were measured; they are recorded below. The absorbance of an unknown solution of the same compound was 0.480. Determine the concentration of the unknown. (4marks)

Concentration, x10^{-4}M	**Absorbance**
1.0	0.080
3.0	0.232
5.0	0.379
7.0	0.524
9.0	0.672
11.0	0.820

(c) Sulphate in natural waters is often analyzed by using the barium sulphate turbidimetric method. The dissolved sulphate is reacted with a solution containing excess barium chloride to form the barium sulphate suspension. The turbidity measurements are made in a spectrometer at 450nm. The percent transmittance of a series of standards and the unknown are listed in the following table. Calculate the turbidance of each solution and the concentration of the unknown. (5marks)

Sulphate concentration, mg/litre	**Percent transmittance**
10.2	94
19.8	80
32.2	60
45.1	40
65.6	20
79.6	13
Unknown	34

(d) (i) Describe the principles of phosphorescence. Why are phosphorescence measurement frequently made at liquid nitrogen temperatures? (3marks)

(ii) For a compound given below, suggest a structure which is consistent with its NMR data. (2marks)

Compound	**NMR Data**
$C_6H_{13}Cl$	σ 1.0 (t, 6H) 1.3 (q, 4H) 1.1 (s,3H)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 351: ORGANIC CHEMISTRY III

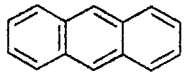
TIME: THREE HOURS

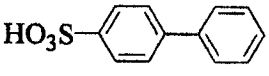
INSTRUCTIONS:
1. Answer any FOUR questions.
2. Present your answers in a logical and orderly fashion.
3. Mark allocation for questions is shown, **[x]**

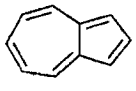
Max. Marks: 120

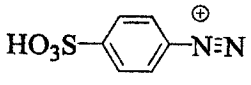
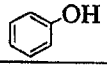
Question 1

(a) Predict the major organic product(s) of the following reactions:

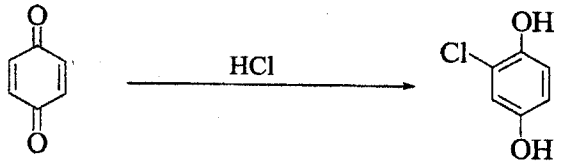
(i)  (i) CO, HCl, anhydrous $AlCl_3$; (ii) $H_3O^{\oplus}$ → **A** **[2.5]**

(ii)  (i) $Cl{-}CH_2{-}COCl$; (ii) $H_3O^{\oplus}$ → **B** **[2.5]**

(iii)  ICl → **C** **[2.5]**

(iv)   → **D** **[2.5]**

(b) When p-benzoquinone is treated with HCl, there is obtained 2-chlorohydroquinone:



p-benzoquinone **2-chlorohydroquinone**

It has been suggested that the product arises via an initial 1, 4-Michael addition. On this basis, suggest a plausible mechanism for this reaction.

[10]

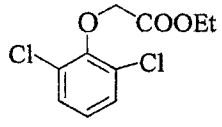
(c) Two isomeric compounds, **E** and **F**, both of molecular formula $C_{10}H_{12}O$, are isolated from oil of bay leaf. Both are insoluble in water, dilute acid and dilute base. Both give positive tests with dilute potassium permanganate and solution of bromine in carbon tetrachloride. Upon vigorous oxidation with alkaline permanganate followed by acidification, both yield anisic acid, p-methoxybenzoic acid. Catalytic hydrogenation of both **E** and **F** gives the same compound **G**, $C_{10}H_{14}O$. What are the possible structures for **E**, **F** and **G**? Explain your answer.

[10]

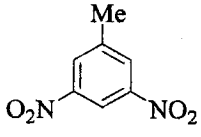
Question 2

(a) Propose a synthesis of *any TWO* of the following compounds from benzene/toluene/phenol. Show the reagents, including solvents, if any, and the reaction conditions for each step of your proposed synthesis.

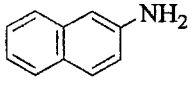
(i) **Compound H**



(ii) **Compound I**



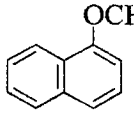
(iii) **Compound J**



[18]

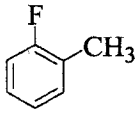
(b) Predict the major organic product(s) and give mechanisms of the following reactions:

(i)



(i) Me_2NCHO, $POCl_3$
(ii) H_2O
→ ?

(ii)



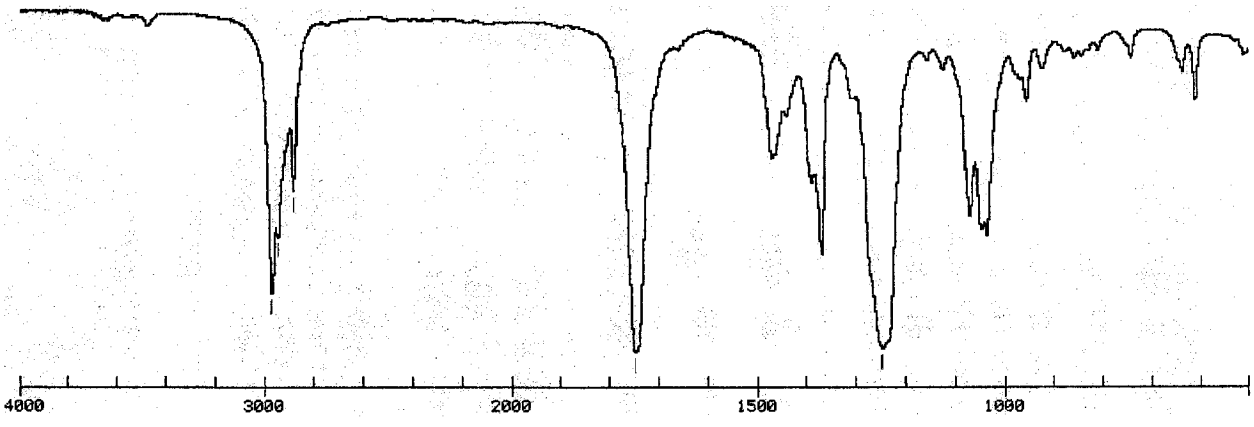
(i) PhLi, dry ether
(ii) CO_2
(iii) H_2O
→ ?

[12]

Question 3

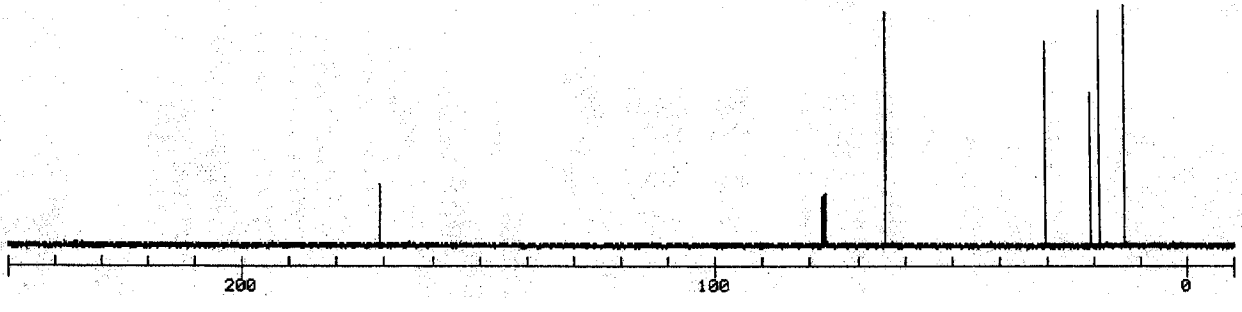
Analyze the spectra and deduce the structure of compound **K**, $C_6H_{12}O_2$, whose **IR**, ^{13}**CNMR** and ^{1}**HNMR** spectra are given below. The mass spectrum shows peaks at m/e: 101, 41 and 15.

IR Spectrum

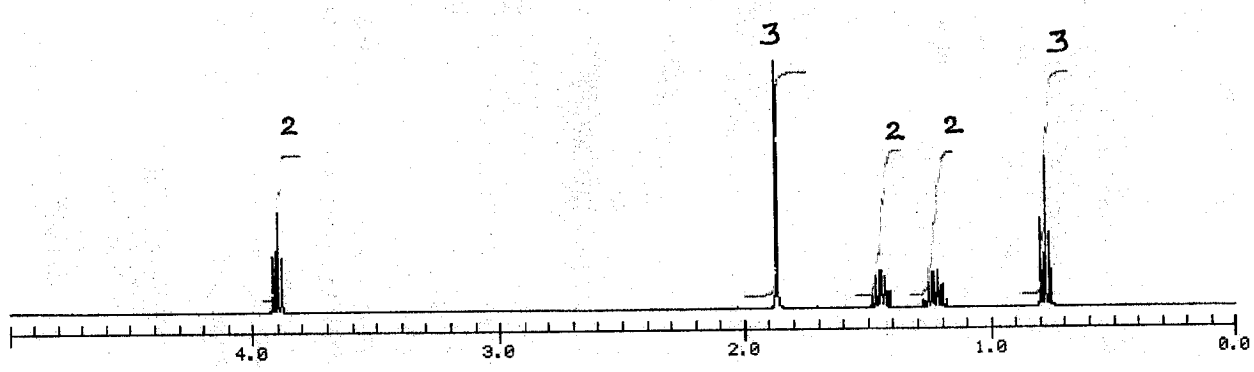


^{13}C NMR Spectrum

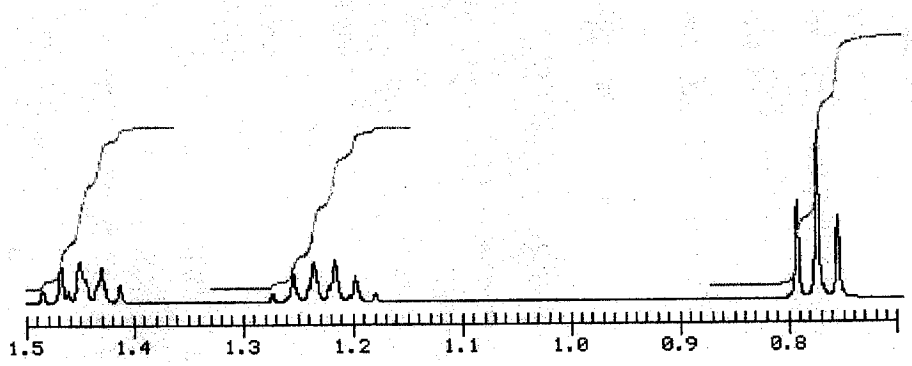
The chemical shifts for peaks are as follows: 171(s), 66.1(t) 32.1(t), 19.3(t), 17.3(q), 13(q)

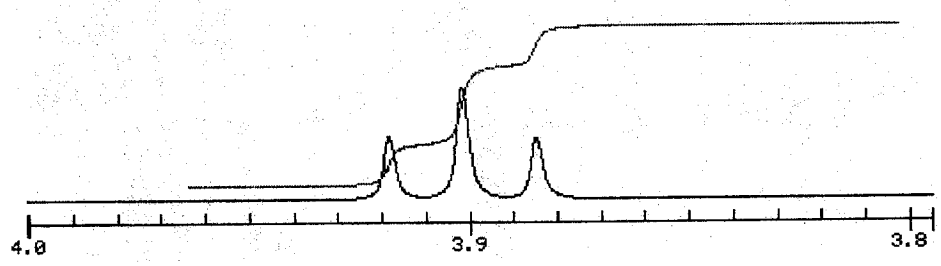


^{1}H NMR Spectrum



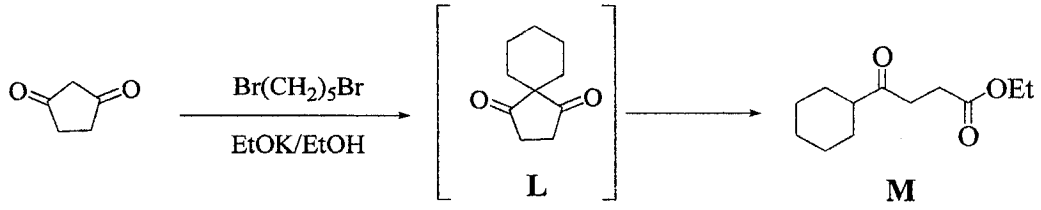
Below are the expanded spectra from 0.7 ppm to 1.5 ppm and 3.8 ppm to 4.0 ppm.





Question 4

(a) Reaction of 1,3-cyclopentanedione with 1,5-dibromopentane in presence of sodium ethoxide in ethanol gave a compound **M**. The reaction proceeds via an intermediate **L**. Propose a mechanism for this reaction.



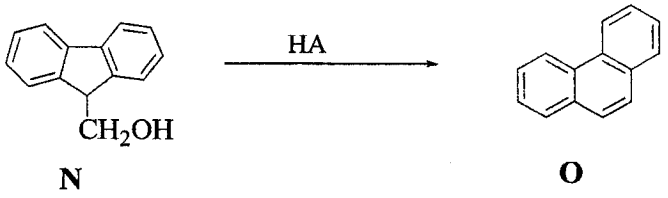
(i) Give the mechanisms of the reactions involved in the formation of the intermediate **L**

[3]

(ii) Suggest a mechanism for the formation of compound **M** from the intermediate **L**

[3]

(b) Phenanthrenes can be prepared from appropriately substituted flourines, as shown below:

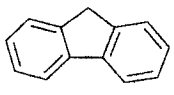


(i) Given that the reaction involves carbocationic as well as arenium ion intermediates. Propose a plausible mechanism for this reaction.

[6]

(ii) How would you prepare compound **N** from flourine, structure shown below?

[3]

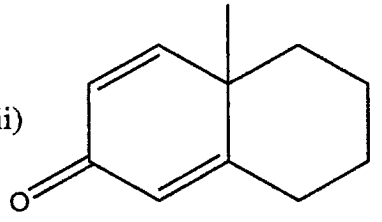
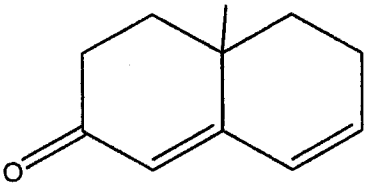
Flourine: 

(c) (i) A compound has λ_{max} 235 nm in ethanol when its concentration 8.58 x 10^{-5} M in 1.0 cm cuvette and its absorbance is 1.03. What is its extinction coefficient?

[2]

(ii) Clearly and briefly state how you would distinguish between pairs of isomers given below using UV spectroscopy.

(i) Ethyl ethanoate and 2-butenoic acid **(1 mark)**

(ii)  and 

(4 marks)

(iii) The majority of the pleasant smelling hydrocarbons found in plants have ten carbons and are referred to as monoterpenes. β-ocimene is a pleasant smelling monoterpene found in leaves of herbs. It has a molecular formula of $C_{10}H_{16}$ and has a λ_{max} of 232 nm. On hydrogenate on it gives 2, 6-dimethyloctane and on ozonolysis followed with reductive work-up it produces four fragments: acetone, methanal (formaldehyde), 2-methylpropanedial (pyruvaldehyde) and ethanedial(malonaldehyde).

(a) What is the index of hydrogenation for β-ocimene? **[1]**
(b) How many double bonds does β-ocimene have? **[1]**
(c) How many double bonds are conjugated in β-ocimene? **[1]**

(iv) Using only the information from UV and hydrogenation data draw five possible structures of β-ocimene.

[3]

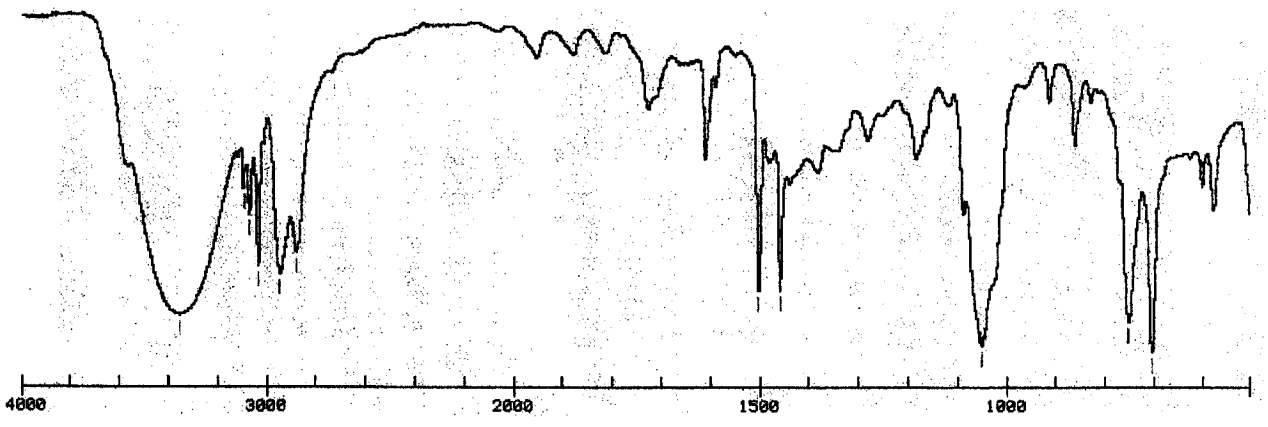
(v) What is the correct structure of β-ocimene when the ozonolysis data is considered? Clearly show which component of the β-ocimene gives the obtained ozonolysis products.

[2]

Question 5

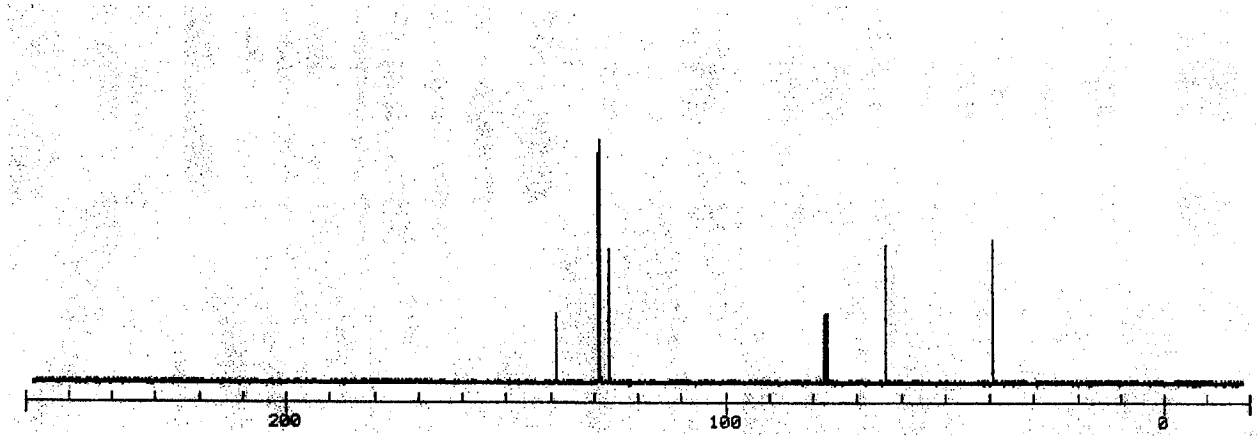
Given below are the **IR**, ^{13}**CNMR** and ^{1}**HNMR** spectra of compound **P** with molecular formula $C_8H_{10}O$. The mass spectrum shows peaks at m/e: 121, 105 and 91. Analyze the spectra and deduce the structure of compound **P**.

IR Spectrum

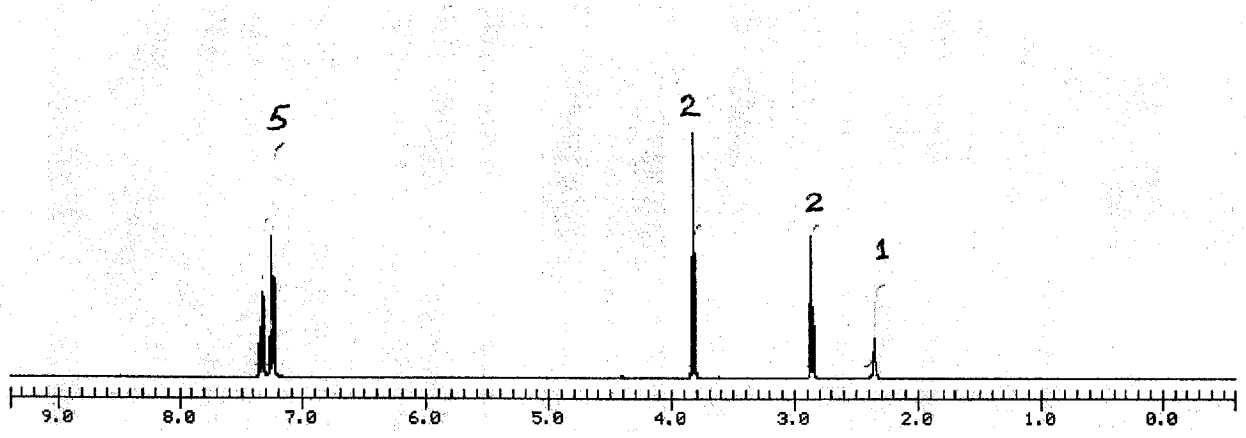


^{13}C NMR Spectrum

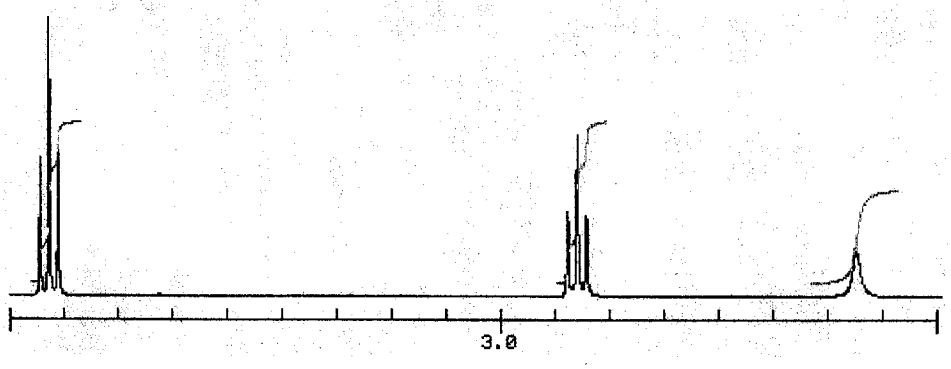
The chemical shifts for peaks are as follows: 140.2(s), 128.4(d), 127.9(d), 125.7(d), 65.1(t), 38.7(t).

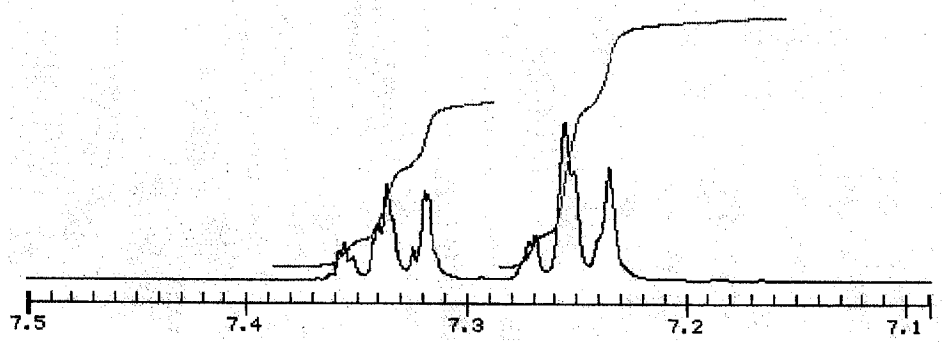


^{1}H NMR Spectrum



Below are the expanded spectra from 2.2 ppm to 3.9 ppm and 7.1 ppm to 7.5 ppm.





END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

C411: Advanced Biochemistry I

TIME: THREE HOURS

ATTEMPT ANY FOUR (4) QUESTIONS

MAKE SURE YOU HAVE THREE (3) PRINTED PAGES

Question 1

i) Four pure proteins were used as standards to construct a standard curve for a molecular weight analysis via SDS-gel electrophoresis. Protein 1, with molecular weight of 15,000, was the smallest. Protein 2 (MW = 35,000) moved only 39 % as far as protein 1. Protein 3 (MW =25,000) moved only 63 % as far as protein 1. Protein 4 (MW = 20,000) moved only 81 % as far as protein 1.

Construct the standard curve, and then **determine** the molecular weight of the unknown protein that had a mobility (under the same conditions) midway between that of proteins 2 and 3.

[15 marks]

PLEASE TURNOVER THE PAGE

ii) A different protein (**X**) was divided into 2 aliquots. One aliquot was subjected to regular PAGE and the other to SDS-PAGE giving the results shown in figure 1 below.

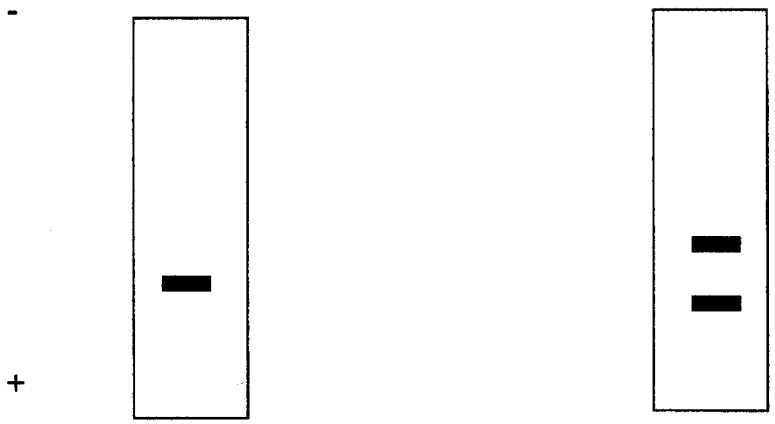


Figure 1 Regular (a) and SDS-PAGE (b) of protein **X**

What conclusion can you make regarding the structure of the protein X?

[10 marks]

Question 2

a) A sample of radioisotope has an activity of 450 μCi after 2 days. If the rate constant for the isotope is 0.056 day^{-1}, what was the activity of the sample 2 days ago?

b) A sample of wood taken from an ancient palace had an activity of 20.0 mCi. A similar sample of freshly cut wood of the same type of tree had an activity of 25 mCi. **Estimate** the age of the wood taken from the palace. (Half-life of Carbon-14 = 5720 yr)

c) A container having 10 μCi of L-glutamic acid – ^{14}C (uniformly labeled) in 1 mL of solution was found to have a specific activity of 15 μCi/mmol. **Calculate** the concentration of L-phenylalanine in g/ml.
(H = 1.0, N = 14.0, O = 16.0)

[25 marks]

TURN TO THE NEXT PAGE PLEASE

Question 3

What are the roles of ATP and Ca^{++} in allowing muscle contraction? **What** specific step provides the energy for muscle contraction? **Give** experimental evidence to support your answer.

[25 marks]

Question 4

Discuss in detail how change in membrane potential can lead to change in protein conformation so that ions can enter or leave a motor neuron. **Cite** an example.

[25 marks]

Question 5

Describe and critically **discuss** the biochemical basis for the development of cholera.

[25 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

CS3251: ELECTRONICS FOR COMPUTING I

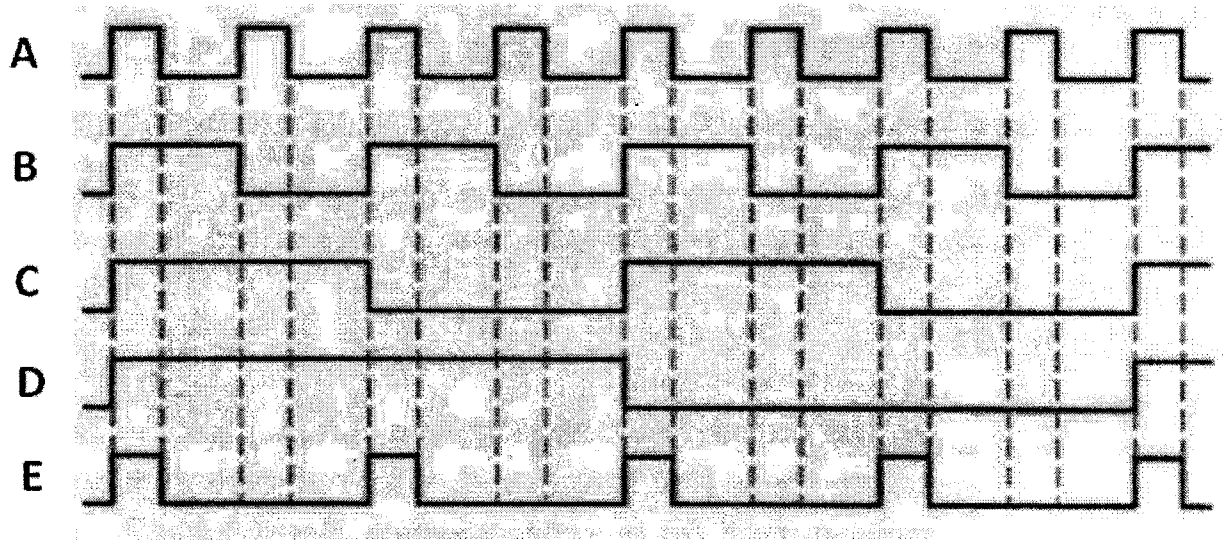
SEMESTER 1 EXAM **9th NOVEMBER 2010**

TIME: THREE HOURS

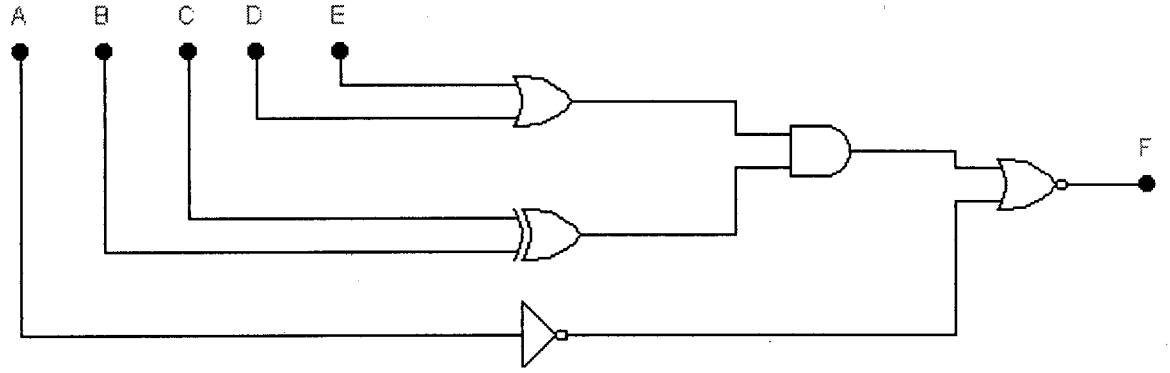
ANSWER: ALL QUESTIONS

QUESTION 1

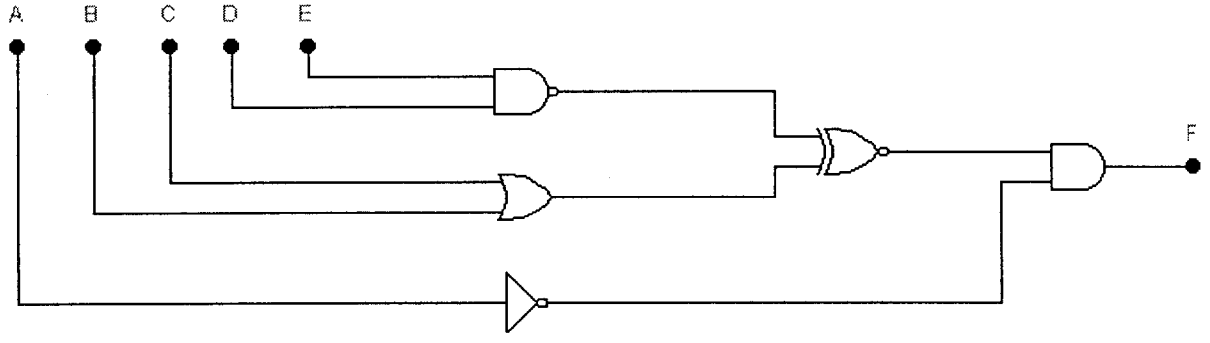
Using the input signal (A, B, C, D and E) below, determine the output signal F for two (2) of the digital circuit diagrams 1, 2 and 3. (Choose any two diagrams)



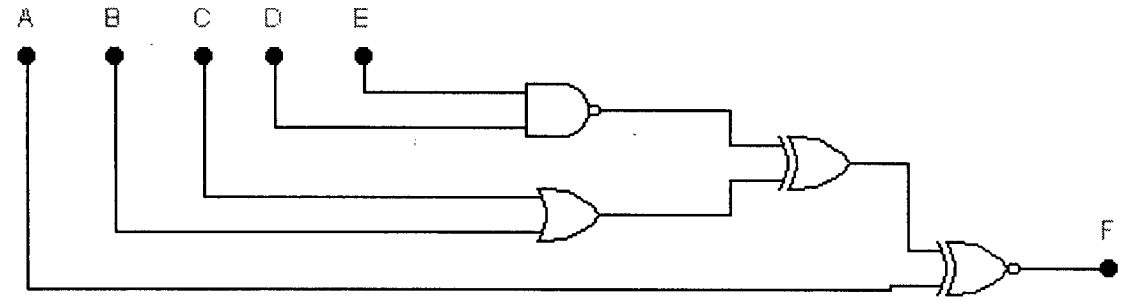
1



2



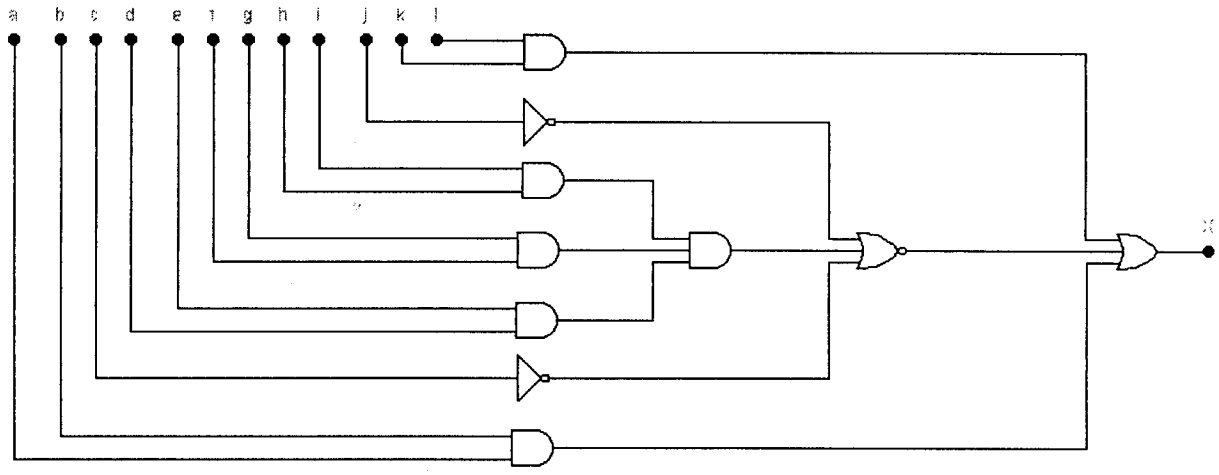
3



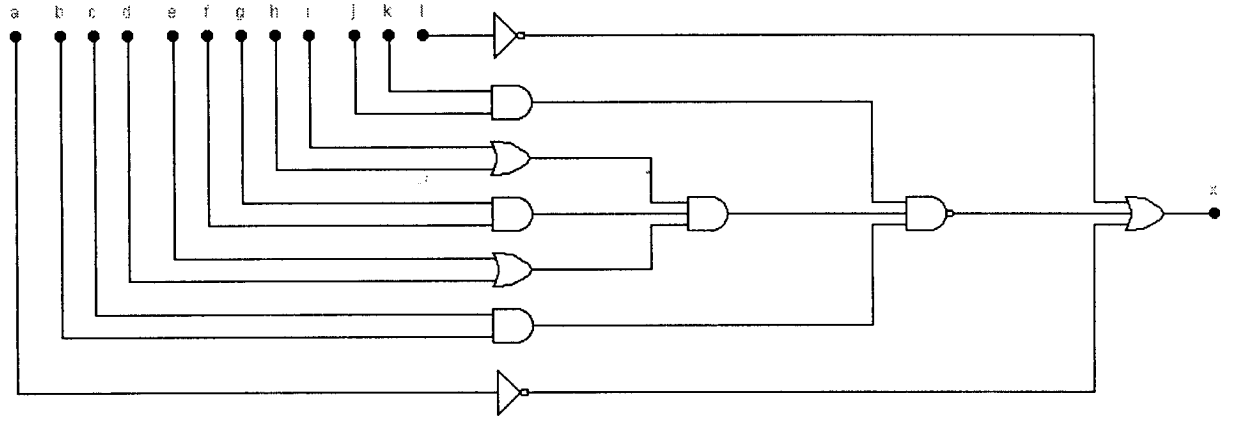
QUESTION 2
Using the kanaugh maps and your output F in question1, redesign the circuit diagram (removing exclusive elements / excluding the use of exclusive or/nor) to produce the same signal F.

QUESTION 3
Write the Boolean expression for two digital circuit diagrams below. (Choose any two diagrams)

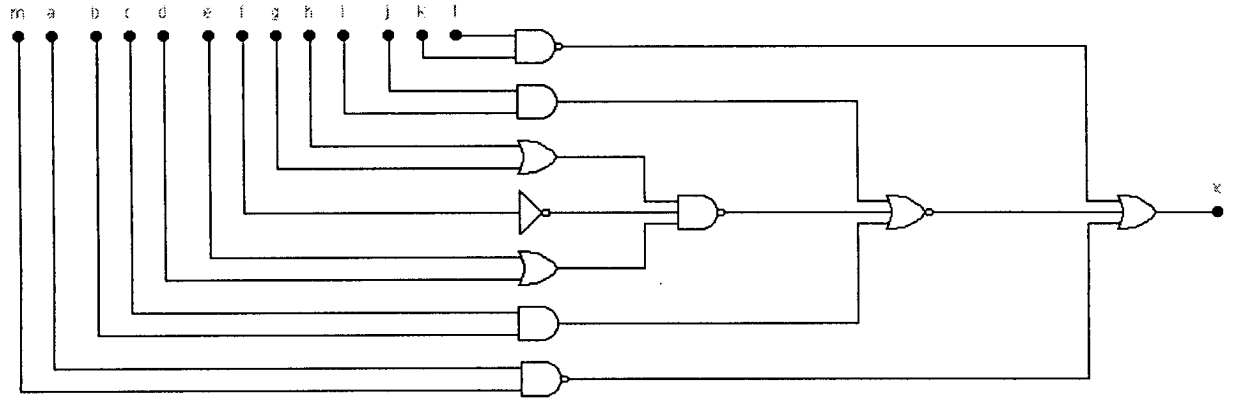
1.



2.



3.



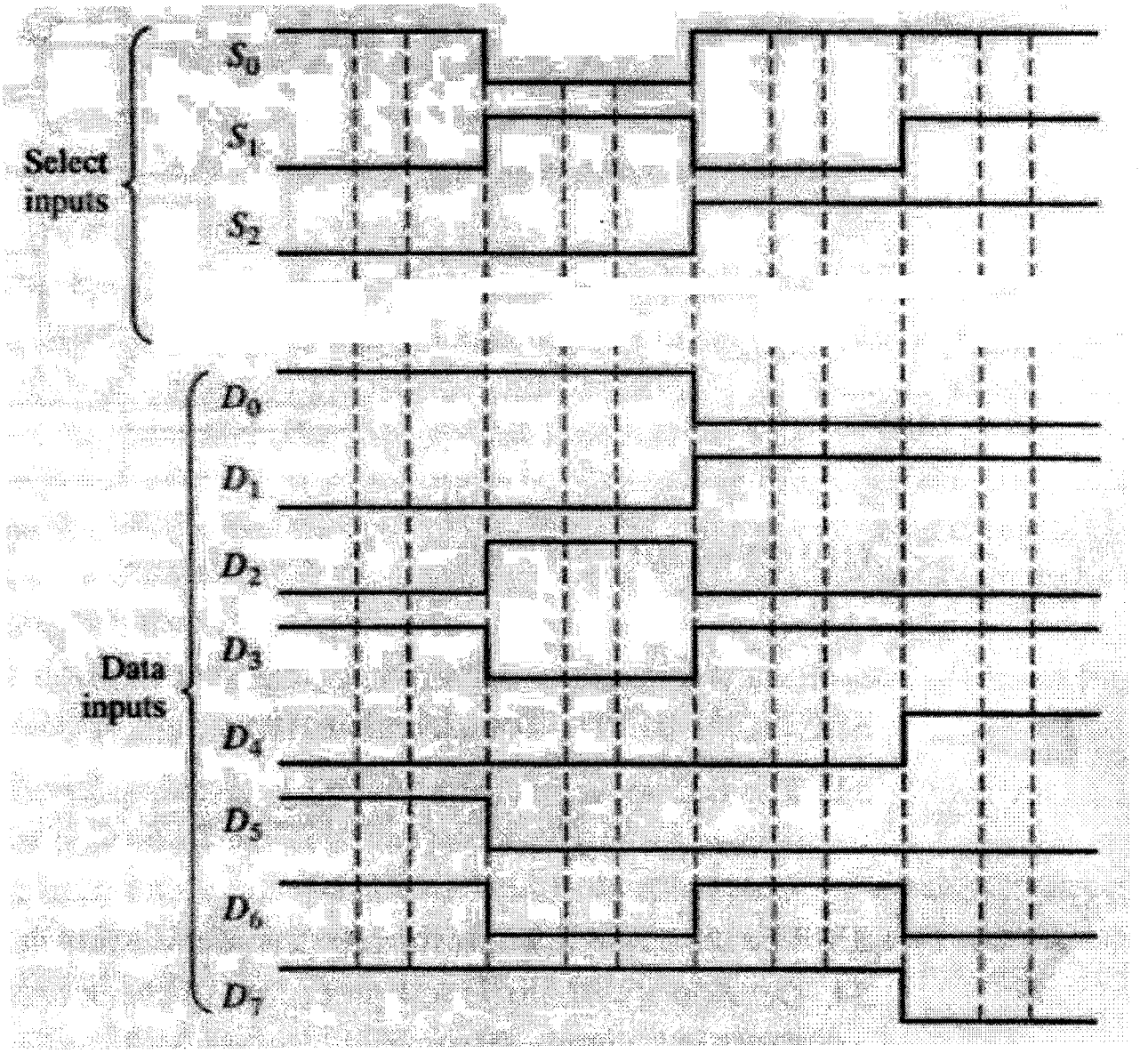
QUESTION 4

If in question3 e=g, d=h, c=I, b=j, a=k and m=l reduce the Boolean expressions accordingly to come up with a simplified expression.

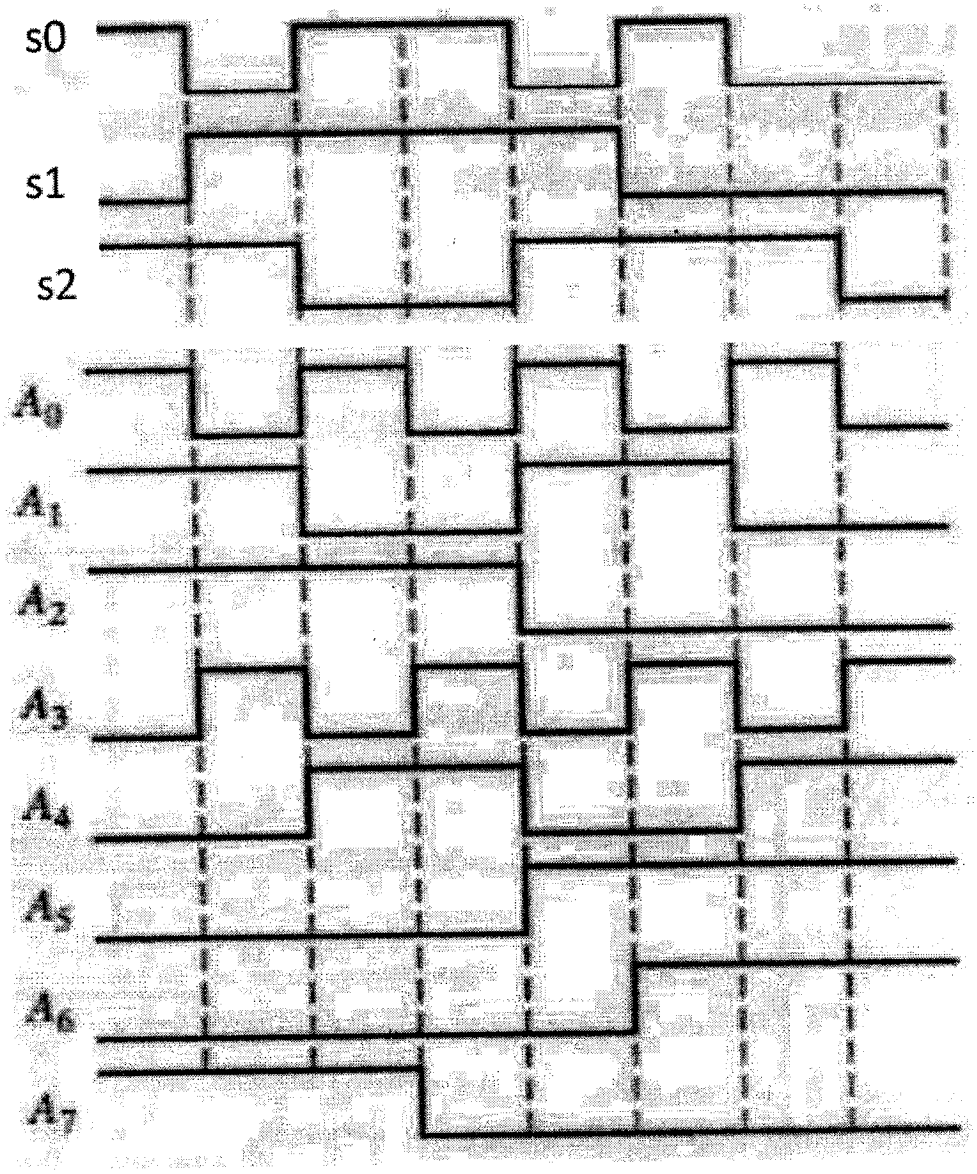
QUESTION 4

Design a multiplexor and determine the output using one of the input pulse lines below. (Choose one)

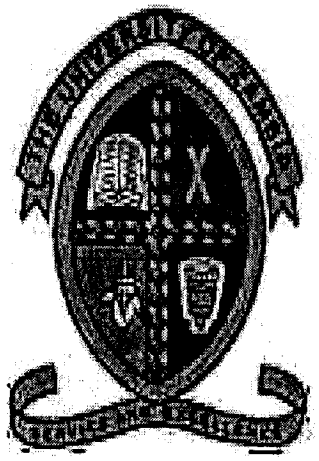
1.



2.



END OF EXAM



University of Zambia

School of Natural Sciences

Department of Computer Studies

CST2011 Final Exam

An Introduction to Programming using Java

This exam has four sections. Section A, B and C has compulsory questions and each Section carries 30, 20 and 20 points respectively. Section D has three questions and you are expected to answer any two of the three Questions. Each question in Section D carries 15 points.

A. Short answer section (30 points)

1. What is wrong with the following code?

```
switch (x)
{
case 1:
n1 = 10;
n2 = 20;
case 2:
n3 = 30;
break;
n4 = 40;
}
```

2. What will be the output of the following program code?

```
int m = 100;
int n = 300;
while(++m < --n);
System.out.println(m);
```

3. What does the following fragment display?

```
String s = "six:" + 3 + 3;
System.out.println(s);
```

4. What is the output of the following code?

```
String s;
System.out.println("s = " + s);
```

5. What is the output of the following code?

```
String s = new String();
System.out.println("s = " + s);
```

6. What will be the output of the following code snippet?

```
int x = 10;
int y = 20;
if((x||(x=5)>10)
System.out.println(x);
else
System.out.println(y);
```

7. Show the output of the following code:

```
int a, b;
a = 5;
b = 10;
if(a > 5)
if(b > 5)
{
System.out.println("b is " +b);
}
else
System.out.println("a is " +a);
```

8. State the output of the following code:

```
int a = 10;
int b = 5;
if(a > b)
{
if(b > 5)
System.out.println("b is " +b);
}
else
System.out.println("a is " +a);
```

9. What is the output of the following code:

```
int m = 100;
while(true)
{
if(m < 10)
break;
m = m - 10;
}
System.out.println("m is " +m);
```

10. What is the output of the following code:

```
int m = 100;
while(true)
{
if(m < 10)
continue;
m = m - 10;
}
System.out.println("m is " +m);
```

11. Given a package named **EDU.Student**, how would you import a class named Test contained in this package? Write one line statement.

12. Consider the following class definition:

```
class Student
{
abstract double result( )
}
```

This code will not compile since a keyword is missing in the first line. What is the keyword?

13. Consider the following class file:

```
import java.awt.*;
import java.io.*;
package studentBase;
class Test
{
void display( )
{
```

```
System.out.println("RESULTS");
}
}
```

Will it compile? Yes or No. Give reason, if No.

14. Consider the following code:

```
class Product
{
public static void main(String args[ ])
{
int x = 10, y = 20;
System.out.println(mul(x, y));
}
int mul(int a, int b)
{
return(a * b);
}
}
```

Will it compile? Yes or No. Give reason, if No.

15. Given below are two files:

File Employee.java

```
package purchase
public class Employee
{
protected double age = 35.00;
}
```

File Company.java

```
import purchase.Employee;
public class Company
{
public static void main(String arg[ ])
{
Employee e = new Employee( );
System.out.println("Age =" + e.age);
}
}
```

Will it compile? Yes or No. Give reason, if No.

16. Consider the following code:

```
class A
{
void method(int x)
{ System.out.println("x =" + x); }
}
class B extends A
{
```

```
void method(int y)
{ System.out.println("y =" + y); }

void method(String s)
{ System.out.println("s =" + s); }
public static void main(String args[ ])
{
A a1 = new A( );
A a2 = new B( );
a1.method(10);
a2.method(20);
}
}
```

What will be the output, when executed?

17. Given a valid File object reference, we can create a new file using two classes defined in java.io package. One is FileOutputStream class. Which is the other one?

18. What will be the output of the following program when it is executed with the command line

    java Command Java is wonderful

```
class Command
{
public static void main(String args[ ])
{
for(int i = 1; i < args.length; i++)
{
System.out.print(args[i]);
if( i != args.length )
System.out.print(" ");
}
System.out.println(" ");
}
}
```

19. What will be the output of the following code snippet when combined with suitable declarations and run?

```
StringBuffer city = new StringBuffer("Madras");
StringBuffer string = new StringBuffer( );
string.append(new String(city));
string.insert(0, "Central ");
String.out.println(string);
```

20. Consider the following application:

```
class Max
{
public static void main(String args[ ])
{
int max = 10;
max(max, 20, 30);
```

```
System.out.println(max);
}
static void max(int max, int x1, int x2)
{
if(x1 > x2)
max = x1;
else
max = x2;
}
}
```

What value is printed out, when executed?

21. State the output of the following program:

```
class Recur
{
public static void main(String args[ ])
{
int Result = result(10);
System.out.println("Result = " + Result);
}
static int result(int m)
{
if(m <= 2)
return m;
else
return m + result(m-2);
}
}
```

22. Consider the class definition:

```
class Default
{
public static void main(String args[ ])
{
int m;
System.out.println("m is " + m);
}
}
```

Will this code compile? Yes or No. Give reason, if No.

23. What is the output of the following program?

```
class Static
{
static int m = 0;
static int n = 0;
public static void main(String args[ ])
{
int m = 10;
int x = 20;
{
System.out.println("m + n = " + m + n);
```

```
}
x = m + n;
System.out.println("x = " + x);
}
}
```

24. Consider the following class definitions:

```
class Square
{
private Square() { }
int area(int side)
{
return(side * side);
}
}
class Constructor
{
public static void main(String args[ ])
{
Square S1 = new Square();
int area = S1.area(10);
System.out.println(area);
}
}
```

Will the code above compile and run successfully? Yes or No. Give reason, if No.

25. What is the output of the following program:

```
class MainString
{
public static void main(String args[ ])
{
StringBuffer s = new StringBuffer("String");
if(s.length()>5) &&
(s.append("Buffer").equals("X")
; // empty statement
System.out.println(s);
}
}
```

26. Consider the following program:

```
class Number
{
int x;
void store(Number num)
{
num.x++;
}
}
class MainNumber
{
public static void main(String args[ ])
```

```
{
Number n = new Number();
n.x = 10;
n.store(n);
System.out.println(n.x);
}
}
```

What is the output?

27. Given the code:

```
class Continue
{
public static void main(String args[ ])
{
int m = 0;
loop1: for(int i=0; i<10; i++)
loop2: for(int j=0;j<10;j++)
loop3: for(int k=0;k<10;k++)
{
System.out.println(++m);
if( (k%10) == 0)
continue loop2;
}
}
}
```

What is the last value printed?

28. Can an abstract method be declared final? Yes or No. If No, give reason.

29. Can an abstract method be declared static? Yes or No. If No, give reason.

30. Consider the following **try .... catch** block:

```
class TryCatch
{
public static void main(String args[ ])
{
try
{
double x = 0.0;
throw(new Exception("Thrown"));
return;
}
catch(Exception e)
{
System.out.println("Exception caught");
return;
}
finally
{
System.out.println("finally");
}
```

```
}
}
```
What will be the output?

B. True or False Section (20 points)

1. A value must always be assigned to String object when it is created, and cannot be modified later.
2. The expression *str.length* returns the length (number of characters) contained in str, a String object.
3. The *System.in* and *System.out* objects are created by default and need not be created explicitly.
4. An instance of the java.io.File class can be used to delete a file.
5. The modulus operator (%) in Java can be used only with variables of integer type.
6. Declarations must appear at the start of the body of a Java method.
7. Whenever the "&&" operator is used, such as in:
   exp1 && exp2
   where exp1 and exp2 are boolean expressions, both the boolean expressions are not always evaluated.
8. The "switch" selection structure must end with the *default* case.
9. For the expression (y >= z && a == b) to be true, at least one of (y >= z) and (a == b) must be true.
10. A *break* statement must always be present in the *default* case of a "switch" selection structure.
11. Variables declared inside a *for* loop are limited in scope to the loop.
12. An array in the Java programming language has the ability to store many different types of values.
13. An individual array element from an array of type int, when passed to a method is passed by value.
14. Objects of a super class can always be assigned to a subclass reference.
15. Objects of a subclass can be assigned to a super class reference.
16. The == operator can be used to compare two *String* objects. The result is always true if the two strings are identical.
17. Java does not allow a method with the same signature in a subclass, as a method in the super class.
18. When a method or a variable in a class is declared as *private*, it can only be accessed by the methods within the same class.
19. A method declared as *final* can be overridden by subclasses if it is also declared as *static*.

C. Multiple Choice Section (20 points).

1. Which of the following statements are valid array declarations?
   a) int number();
   b) float average[];
   c) double[] marks;
   d) counter int[];

2. Consider the following code
   int number[] = new int[5]; After execution of this statement, which of the following are true?
   a) number[0] is undefined
   b) number[5] is undefined
   c) number[4] is null
   d) number[2] is 0
   e) number.length() is 5

3. Which of the following classes are available in the **java.lang** package?
   a) Stack
   b) Object
   c) Math
   d) Random
   e) String
   f) StringBuffer
   g) Vector

4. Which of the following are the wrapper classes?
   a) Random
   b) Byte
   c) Vector
   d) Integer
   e) Short
   f) Double
   g) String

5. Which of the following methods belong to the **String** class?
   a) length()
   b) compareTo()
   c) equals()
   d) substring()

6. Given the code
   ```
   String s1 = "yes";
   String s2 = "yes";
   String s3 = new String(s1);
   ```
   Which of the following would equate to true?
   a) s1 == s2
   b) s1 = s2
   c) s3 == s1
   d) s1.equals(s2)

e) s3.equals(s1)

7. Suppose that s1 and s2 are two strings. Which of the statements or expressions are valid?
   a) String s3 = s1 + s2;
   b) String s3 = s1 - s2;
   c) s1 <= s2
   d) s1.compareTo(s2);
   e) int m = s1.length();

8. Given the code
   ```
   String s = new String("abc");
   ```
   Which of the following calls are valid?
   a) s.trim()
   b) s.replace('a', 'A')
   c) s.substring(3)
   d) s.toUppercase()
   e) s.setCharAt(1,'A')
   f) s.append("xyz")

9. Given the following code:
   ```
   class Base { int x = 10; }
   class Derived extends Base
   { int x = 20; }
   Base b = new Base();
   Derived d = new Derived ( );
   Base bd = new Derived();
   ```
   The statement
   ```
   System.out.println(b.x + " " + d.x + " " + bd.x);
   ```
   will produce the output
   a) 10 20 20
   b) 20 10 20
   c) 10 20 10
   d) 20 20 10

10. Given the class definitions
    ```
    class Base
    {
    void display ()
    { System.out.println("Base"); }
    }
    class Derived extends Base
    {
    void display ()
    { System.out.println("Derived"); }
    }
    ```
    and objects

```
Base b = new Base();
Derived d = new Derived();
Base bd = new Derived;
```

then the print statements

```
System.out.print(b.display() + " ");
System.out.print(d.display() + " ");
System.out.print(bd.display() + " ");
System.out.println();
```

will display:

a) O Base Derived Derived
b) Base Base Derived
c) Base Derived Base
d) Derived Derived Derived

11. Which of the following statements about abstract methods/classes in Java are true?
    1. An abstract class cannot be instantiated.
    2. Constructors cannot be abstract.
    3. A subclass of an abstract class must define the abstract methods.
    4. Static methods may be declared abstract.

    a) Line 1, line 2 and line 3 only
    b) Line 1 only
    c) Line 1 and line 2 only
    d) Line 2 only
    e) All are true

12. Which keyword can protect a class in a package from accessibility by the classes outside the package?
    a) don't use any keyword at all (make it default)
    b) private
    c) protected
    d) final

13. Which of the following are not keywords?
    a) NULL
    b) Implements
    c) Protected
    d) Extended
    e) string

14. A package is a collection of
    a) classes and interfaces
    b) classes
    c) interfaces

d) editing tools

15. Which of the following defines a legal abstract class?
    a) abstract class Vehicle { abstract void display(); }
    b) class Vehicle { abstract void display(); }
    c) abstract Vehicle { abstract void display(); }
    d) class abstract Vehicle { abstract void display(); }
    e) abstract class Vehicle { abstract void display(); { System.out.println("Car"); }}

16. The concept of multiple inheritance is implemented in Java by
    a) extending two or more classes
    b) extending one class and implementing one or more interfaces
    c) implementing two or more interfaces
    d) all of these

17. Which lines of the following will produce an error?
    a) byte a1 = 2, a2 = 4, a3;
    b) short s = 16;
    c) a2 = s;
    d) a3 = a1 * a2;

18. Determine the output when the value of x is zero:

```
if(x >= 0)
if(x > 0)
System.out.println("x is positive");
else
System.out.println("x is negative");
```

    a) "x is negative"
    b) "x is positive"
    c) "x is positive" and "x is negative"
    d) None of these

19. To print the value of a variable "x" of type int, which of the following expressions can be used:
    a) System.out.println("x = " + x);
    b) System.out.println("x = " + String.valueOf(x));
    c) System.out.println("x = " + Integer.toString(x));
    d) System.out.println("x = " + (new Integer(x)).toString());

20. With javadoc, which of the following denotes a javadoc comment?
    a) /**
    b) //#
    c) /*
    d) //**

D. Coding Section

Answer any two questions. Each question carries 15 points.

1. Write a java program that has a method that can calculate an employee's housing allowance given that each employee gets 20% of their salary as housing allowance. In addition if the employee gets an allowance which is more than K3, 000,000 it is taxed at a rate of 20% and if more than K3, 500,000 it is taxed at a rate of 35%.
2. Write a java program that gets user input and echoes it out back on the screen. When the user enters the command exit the program should then terminate.
3. Write a java program that copies entries from one array into another array and sorts out the entries in alphabetical order.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Computer Studies

EXAM: 2010 - SEMESTER ONE FINAL

COURSE: CST2021 – INTRODUCTION TO COMPUTER SYSTEMS

DURATION: 3 HOURS

DATE: 5TH NOVEMBER, 2010

TIME: 14:00-17:00 HOURS

INSTRUCTIONS

- ***This paper has seven (7) questions, answer a total of five (5) questions***
  - ***There are two (2) sections, A and B.***
  - ***Answer everything in section A, i.e., QUESTION one (1) and two (2)***
  - ***Answer any three(3) QUESTIONS from section B***

- *All questions carry equal marks(**20 marks each**)*
- ***Clearly number** your answers*
- ***Use the marks** as a guide to the **detail required** in your answers while keeping your answers **concise and relevant.***

GOOD LUCK!!

SECTION A

QUESTION ONE

1. Define the following terms precisely; **[10 marks]**

   i. Computer
   ii. Data
   iii. Program
   iv. Micro-operations
   v. Memory Cell
   vi. Compiler
   vii. Database
   viii. Switch flooding
   ix. Network collision domain
   x. Broadcast domain

2. A semiconductor memory system is subject to errors. Explain two classes of errors mentioning possible causes of each. **[3 marks]**
3. Explain the syndrome characteristics in memory error correction. **[3 marks]**
4. Explain the roles of the following compiler phases; lexical and syntax analysis. **[4 marks]**

QUESTION TWO

1. Draw the following models; **[9 marks]**

   i. ALU Inputs and Outputs
   ii. Control Unit Inputs and Outputs
   iii. External Device Block Diagram

2. Discuss the concept of zoned bit recording with regards to hard disks. **[8 marks]**
3. A word of data in cache memory is updated by the CPU; what problems may this cause? **[3 marks]**

SECTION B

QUESTION THREE

1. With regards to Multi-user DBMS architectures, explain the mode of operation in the following architectures. **[9 marks]**

    i. Teleprocessing

    ii. File- Server

    iii. Traditional two-tier client-server

2. Outline any two objectives of the ANSI-SPARC three-level architecture. **[2 marks]**

3. Suppose that a disk unit has the following parameters: block size B = 2048 bytes, interblock gap size = 256 bytes. An employee file has the following fields; NRC 15 bytes, firstname 50 bytes, lastname 50 bytes, department 15 bytes. The employee file has r = 100,000 records, fixed-length format, and unspanned blocking. Write the appropriate formulas and calculate the following values for the above employee file:

    i. The record size R, the blocking factor bfr and the number of disk blocks b needed to store the file. **[3 marks]**

    ii. Calculate the wasted space in each disk block because of the unspanned organization. **[3 marks]**

    iii. Calculate the total wasted space to store the entire file. **[3 marks]**

QUESTION FOUR

1. Computer networks. **[10 marks]**

    i. The hierarchical design has three basic layers: name and state the functions of each of these layers.

    ii. Define the term unlike devices; provide two examples of such devices and state the cable used to connect them.

    iii. Define the term like devices; provide two examples of such devices and state the cable used to connect them.

iv. Complete the following statements;

a. On a local Ethernet network, a NIC only accepts a frame if the destination address_____

b. The sending host can use an IP protocol called ARP to discover____

c. A table on the switch, called a _____ , contains a list of all of the ____

2. Consider a disk drive with the following characteristics: **[10 marks]**

There are 6 surfaces, each with 700 tracks.

Tracks hold 500 sectors of 512 bytes each.

12% of each track is used by inter-sector gaps.

The disk rotates at 7200 rpm

The time needed to move the read/write head through n tracks is 1+0.001n milliseconds.

i. What is the total useful capacity of the disk in KB?

ii. What is the maximum seek time?

iii. What is the maximum rotational latency?

iv. What is the average rotational latency?

v. If a block contains 4 sectors, what is the transfer time of a block?

vi. For a single block read or write, what is the (1) best time? (2) the worst time?

QUESTION FIVE

1. Computer networks. **[10 marks]**

i. Explain the mode of operation of the following devices; Hub, Switch and Router

ii. Outline the physical features of the following cables; UTP, Coaxial and Fiber Optic.

2. Compilers.

i. Briefly describe why one may wish to split a compiler into modules corresponding to the phases. **[3 marks]**

ii. Discuss the context of a compiler **[7 marks]**

QUESTION SIX

1. Computer networks. **[10 marks]**

   i. What is physical topology

   ii. What are the features of the following topologies; Point-to-Point, Ring and Star

   iii. Explain Ethernet architecture

   iv. List the seven layers of the OSI model

2. Consider a disk with the following characteristics: block size B = 512; interblock gap size G = 128 bytes; number of blocks per track = 20; number of tracks per surface = 400. A disk pack consists of 15 double-sided disks. **[10 marks]**

   i. What is the total capacity of a track and what is its useful capacity?

   ii. How many cylinders are there?

   iii. What are the total capacity and the useful capacity of a cylinder?

   iv. What are the total capacity and the useful capacity of a disk pack?

   v. Suppose that the disk drive rotates the disk pack at a speed of 2400 rpm; what are the transfer rate in bytes/msec and the block transfer time in msec?

   vi. Suppose that the average seek time is 30 msec. How much time does it take (on the average) in msec to locate and transfer a single block, given its block address?

QUESTION SEVEN

1. Suppose the CPU encounters an instruction relating to I/O, outline the sequence of events for each of the following techniques;

   i. Programmed I/O

   ii. Interrupt Driven I/O

   iii. DMA I/O

   [9 marks]

2. Explain the mechanism used by contemporary rigid disk systems to read data. **[4 marks]**
3. Explain the flying head mechanism in the Winchester hard disk **[4 marks]**
4. External devices fall into three broad categories. Define each category and give an example of a peripheral in each category. **[3 marks]**

THE END

The University of Zambia
School of Natural Sciences

Semester 1 Final Examinations – November 2010

CST2041 : Introduction to Operating Systems

Instructions:
Answer FOUR (4) questions
Duration: Three Hours

Question One
The availability of various operating systems demand a comprehensive understanding on the underlying principles and architectures on which these systems are founded.
a) Distinguish between
   i) general purpose and special purpose operating system
   ii) client server system and virtual system design of the operating system (8 Marks)
b) Explain the significance of the layered structure in operating system design (10 Marks)
c) List a number of operating system facilities used in computer program development. (7 Marks)
(Total 25 Marks)

Question Two
a) Describe three services offered by a
   i) Single user operating system
   ii) Network operating system
   Give an example of a single user and network operating system.
(8 Marks)
b) With the help of a diagram, explain the five states of a process. (10 Marks)
c) Given the following program statements
   S1: a = x+y;
   S2: b = z+1;
   S3: c = a-b;
   S4: w = c+1;
   Using Bernstein's conditions, show which statements
   i) can be executed concurrently
   ii) cannot be concurrently (7 Marks)
(Total 25 Marks)

Question Three

a) Distinguish between a program and a process, explain why the use of the process concept is necessary in studying operating systems. (6 Marks)

b) List five objectives of the scheduler (5 Marks)

c) Explain how:

i) a short CPU-bound process

ii) a long CPU-bound process and

iii) an I/O bound process

would perform in a multi-level feedback system. (6 Marks)

d) Discuss how any two strategies for dealing with deadlocks (8 Marks)

(Total 25 Marks)

Question 4

a) Compare and Contrast

i) Swapping and virtual memory

ii) global and local allocation

iii) segmentation and paging

iv) Multi-programming with a variable number of tasks (MVT) and Multi-programming with a fixed number of tasks (MFT)

(20 Marks)

b) Discuss ~~how~~ contents in each memory partition can be protected.(5 Marks)

(Total 25 Marks)

Question Five

a) A file can be considered as a collection of related information stored in storage devices in the form of a sequence of bits, bytes, or record. Outline any three properties of a file and three properties of a directory. (6 Marks)

b) Explain the addressing scheme with regard to a disk. (4 Marks)

c) Describe five operations that can be made on a file. (10 Marks)

d) Explain what is meant by the term device independence and indicate the difference made by device drivers in this respect. (5 Marks)

(Total 25 Marks)

End of Examination

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Computer Studies

EXAM: 2010 - SEMESTER ONE FINAL

COURSE: CST3031 – INTRODUCTION TO SOFTWARE ENGINEERING

DURATION: 3 HOURS

DATE: 29th OCTOBER, 2010

TIME: 14:00-17:00 HOURS

INSTRUCTIONS

- ***This paper has five (5) QUESTIONS.***
  - ***Answer everything in QUESTION one (1) and two (2)***
  - ***Answer either A OR B in QUESTIONS three (3) to five (5)***

- *All questions carry equal marks(**20 marks each**)*
- ***Clearly number** your answers*
- ***Use the marks** as a guide to the **detail required** in your answers while keeping your answers **concise and relevant**.*

GOOD LUCK!!

QUESTION ONE

Define the following terms precisely; **[20 marks]**

1. Software Engineering
2. Software Process
3. Software Engineering method
4. Upper-CASE
5. Requirements
6. Cohesion
7. Sub-system
8. Statistical testing
9. Bespoke software product
10. Alpha testing

QUESTION TWO

1. Draw the following models; **[12 marks]**

   i. V-model of development process

   ii. Re-use oriented development process

   iii. Viewpoint Oriented Requirements Definition method

2. Architectural Control Models **[8 marks]**

   i. What is centralized based control?

   ii. Describe the nature of control and applicability of the call-return and manager models.

QUESTION THREE

Answer either A **OR** B

A

The ATM (Automatic Teller Machine) software of a bank allows a customer to check his account balance, withdraw cash, request for a new cheque book, and prints a statement of the activities in his account. Access to the machine is done using an ATM card and a PIN (Personal Identification Number).

i. Write the context-level processing narrative (Not more than 1 page)
[10 marks]

ii. Explain the perspective from which Data-flow diagrams model a system.
[2 marks]

iii. Draw a data flow diagram modeling the data processing involved when a customer checks his account balance from the ATM software.
[8 marks]

B

Consider a system for administering the lending of books at a university library. A person must be a member of the university's community and must be in good standing– that is, not have any outstanding fines or overdue books – to borrow books. A book may be borrowed for up to two weeks at a time. A book loan may be renewed if the book is returned before the loan's due date and if no other library member has expressed an interest in borrowing the book. If a book is returned after the loan's due date, the borrower will be charged a fine of K5000 for each late day. Fines are paid to the library staff at the circulation desk, where books are returned. Heavily-used books may be put on reserve, meaning that members can read them only in the library and cannot borrow them. The library has terminals that members use to search for books, to determine the loan status of a book, or to express interest in borrowing a book that is currently out on loan. Members also use the terminals to check out books from the library and to renew book loans. The terminals have scanners for scanning the member's library card and for scanning the barcodes on books. The terminals will authenticate the member and check his or her standing before processing book loans or renewals.

i. Provide a context diagram for the library lending system.
[6 marks]

ii. Provide a use-case diagram that depicts only those use cases that are initiated by library members. **[6 marks]**

iii. Draw a data-flow diagram modeling the data processing involved when a member first steps up to the terminal and ends when the terminal issues a receipt (a slip of paper with the loan's due date) for the book loan. Assume that the use case applies to the loan of a single book.
[8 marks]

QUESTION FOUR

Answer either A **OR** B

A

1. Explain requirements elicitation and analysis in the software engineering process, particularly in the context of a contract for bespoke (custom) software under the following headings;

    i. Its role and who does it?
    ii. What the inputs are and who provides them?
    iii. Differentiate between user requirements, system requirements and system specification, in terms of content and language.
    iv. List at least five possible users of a requirements document and state how they use it.

    [12 marks]

2. You are eliciting requirements for a new release of an existing product. For each of the elicitation problems described below, list a distinct elicitation technique that would best address that problem. **[4 marks]**

    i. You want to understand how users really use the existing system, as opposed to how they tell you they use the system.

    ii. You want to invent new requirements or features to be added to the new release.

    iii. You want to understand the original requirements of the existing system.

    iv. You want to get a quick sense of the most popular features of the existing system.

3. Explain the phases involved in carrying out a feasibility study. **[4 marks]**

B

1. What are the inputs and outputs of the RE process? **[6 marks]**
2. Explain prototype ethnography as a technique for requirements elicitation and analysis.

    [4 marks]

3. Consider a requirements specification for a simple scientific calculator application, intended to run on a palmtop Personal Digital Assistant (PDA). Give, in appropriate language, a plausible example of each of the following, first as a user requirement, (1 mark each) and then as it might be refined into a system requirement. **[10 marks]**

   i. A functional requirement
   ii. A usability requirement
   iii. A domain requirement
   iv. A performance requirement
   v. An interoperability requirement

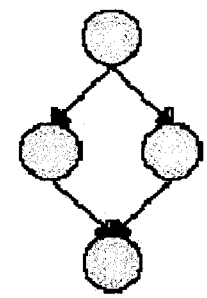
QUESTION FIVE

Answer either A **OR** B

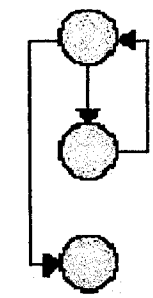
A

Given the following code fragment and notation for representing control flow,

```
1:  WHILE NOT EOF LOOP
2:        Read Record;
2:        IF field1 equals 0 THEN
3:      Add field1 to Total
3:      Increment Counter
4:    ELSEIF field2 equals 0 THEN
5:        Print Total, Counter
5:        Reset Counter
6:      ELSE
6:        Subtract field2 from Total
7:      END IF
8:    END IF
8:    Print "End Record"
9:  END LOOP
9:  Print Counter
```



If



While

i. Define path testing. **[2 marks]**

ii. Using the code, draw the corresponding flow graph. **[6 marks]**

iii. Determine the cyclomatic complexity of the flow graph. **[4 marks]**

iv. Determine a basis set of independent paths. **[4 marks]**

v. Prepare a test case that will force execution of one of the paths in the basis set. **[4 marks]**

B

Given the following code fragment

```
public double calculate(int amount)
{
        double rushCharge = 0;

  if (nextday.equals("yes") )
  {
        rushCharge = 14.50;
  }
        double tax = amount * .0725;

   if (amount >= 1000)
   {
      shipcharge = amount * .06 + rushCharge;
   }

   else if (amount >= 200)
   {
     shipcharge = amount * .08 + rushCharge;
   }
   else if (amount >= 100)
   {
    shipcharge = 13.25 + rushCharge;
   }
   else if (amount >= 50)
   {
     shipcharge = 9.95 + rushCharge;
   }
   else if (amount >= 25)
   {
     shipcharge = 7.25 + rushCharge;
   }
    else
   {
    shipcharge = 5.25 + rushCharge;
   }
   total = amount + tax + shipcharge;
   return total;
```

//end calculate

i. Using the code, draw the corresponding flow graph. **[10 marks]**

ii. Determine the cyclomatic complexity of the flow graph. **[5 marks]**

iii. Determine a basis set of independent paths. **[5 marks]**

THE END

THE UNIVERSITY OF ZAMBIA
Department of Computer Studies

UNIVERSITY EXAMINATION

CST3141 –OBJECT - ORIENTED ANALYSIS & DESIGN

Wednesday 27 October 2010

Instructions: This examination consists of six (6) questions. You are required to answer only **five (5)** of them according to the instructions given for each question. All questions have the same weight. ***Good Luck!***

Duration: 3 Hours

1.

a. What do you understand by object oriented analysis and design?[6 Marks]
b. Explain the following object oriented concepts and describe the UML artifacts that denote them.[6 Marks]
    i. Interface
    ii. Inheritance
    iii. Package
c. How is a subsystem different from a package?[2 Marks]
d. Describe the following and how UML models them[6 Marks]
    i. Association
    ii. Aggregation
    iii. Dependency

2.

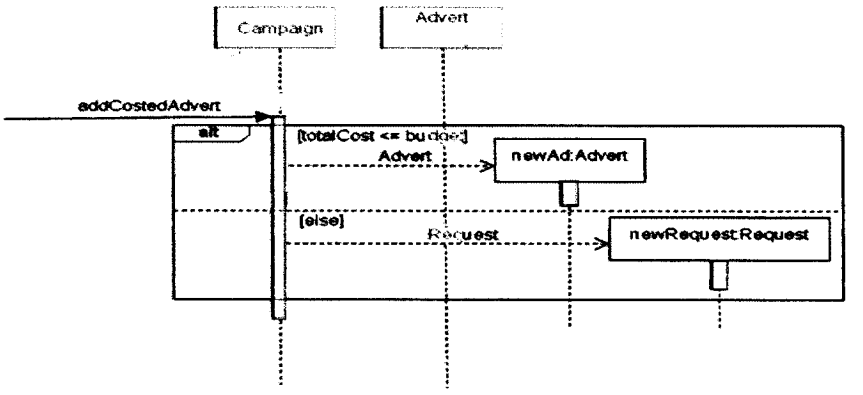
a. Give two objectives of use-case modeling during the development process?[2 Marks]
b. Precisely define the following:[4 Marks]
    i. Actor
    ii. Use case
c. Using a labeled diagram, illustrated the components of a use case diagram including as many relationships that can exist between actors and use-cases as possible.[8 Marks]
d. Differentiate between the following:
    i. <<extend>> and <<include>> stenotypes of use cases[2 Marks]
    ii. High-level use case and extended use case[2 Marks]
    iii. Essential use case and real use case[2 Marks]

3. There are two types of interaction diagrams that are supported by UML: sequence diagrams and collaboration (communication) diagrams

a. Give two major reasons why it is so necessary to model the interaction amongst objects during the development process. [4 Marks]

b. What is the major difference between the two sequence and collaboration diagrams in UML?[2 Marks]

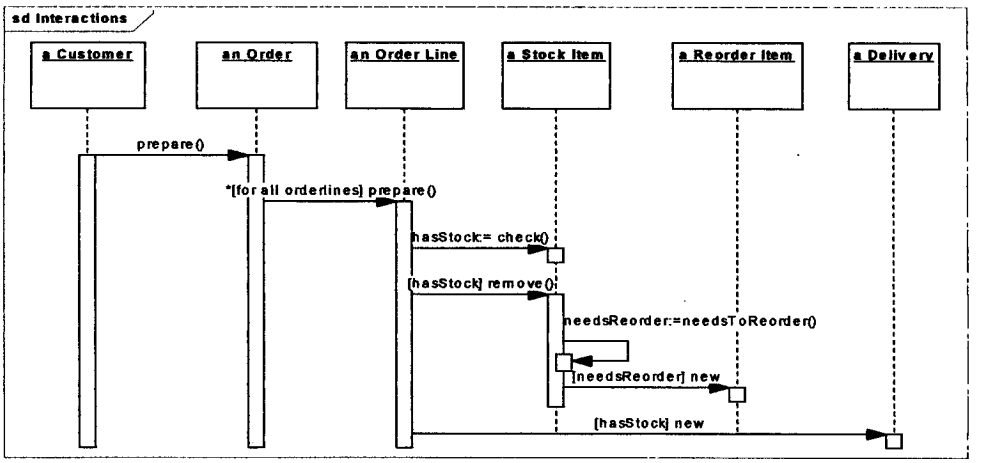
c. Consider the sequence diagram below



i. What does the rectangle with caption **alt** indicate?[2 Marks]

ii. Briefly describe what this interaction diagram is expressing. It starts when the campaign object receives a request/message to add a new advert. [You do not need to understand the environment domain to answer this question][4 Marks]

d. Consider the diagram below



i. What does the asterisk in the message *[for all arderlines]prepare() indicate?[2 Marks]

ii. What methods are to be implemented in the StockItem class?[3 Marks]

iii. Convert this interaction diagram into a collaboration diagram[3 marks]

4. The key ideas behind the Rational Unified process are use case driven, architectural centric and iterative and development.
    a. Explain, briefly, what each of these terms mean [8 Marks]
        i. Use-case driven
        ii. Architectural centric
        iii. Iterative
        iv. Incremental

    b. How do the use cases influence the iterative and incremental nature of the unified process? Use the development of simple illustrative example using a real system e.g. a library or an ATM machine [4 Marks]

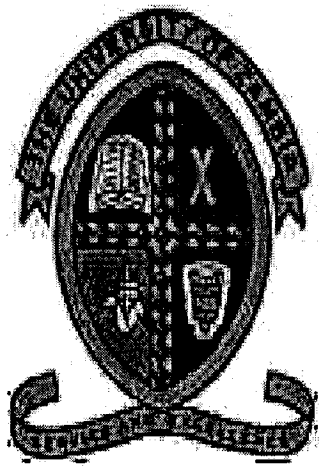
    c. RUP is divided into four phases. Briefly outline the sequence of each of these phases and explain, briefly, stating the significance of each phase. [8 Marks]

5.
    a. What does the acronym UML, with respect to object-oriented modeling, stand for?[2 Marks]
    b. Briefly describe what the UML is?[4 Marks]
    c. UML has up 13 different types of diagrams. Describe the following types of diagrams in UML giving two examples for each category:[12 Marks]
        i. Static/structure diagrams
        ii. Behavior diagrams
        iii. Interaction diagrams
    d. Which UML diagram is most likely used for design modeling?[2 Marks]

6. A local library wishes to invest in a new computerised library system. The requirements of this system are as follows:
    - A library lends books and magazines to borrowers, who are registered in the system, as are the books and magazines.
    - A library handles the purchase of new titles for the library. Old books and magazines are removed when they are out of date or in poor condition.
    - The librarian interacts with the customers (borrowers) and whose work is supported by the system
    - A borrower can reserve a book or magazine that is not currently available in the library, so that when it's returned or purchased by the library, that person is notified. The reservation is cancelled when the borrower checks out the book or magazine or through an explicit cancelling procedure.
    - The library can easily create, update, and delete information about the titles, borrowers, loans, and reservations in the system.
    - Borrowers can search for titles and make/cancel reservations online via a website.

    a. Draw the use-case model for this system[10 Marks]
    b. Draw the design class diagram[10 Marks]

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



University of Zambia

School of Natural Sciences

Department of Computer Studies

CST4131 Final Exam

Advanced Object Oriented Programming

This exam has four sections. Section A, B and C has compulsory questions and each Section carries 20, 20 and 20 points respectively. Section D has three questions and you are expected to answer any two of the three Questions. Each question in Section D carries 20 points.

Section A (20 points)

1) Which three of these are valid contructors of a Thread object?
   a) public Thread(Object obj)
   b) public Thread(String name)
   c) public Thread(Runnable trgt)
   d) public Thread(ThreadGroup grp, Runnable trgt, String name)
   e) public Thread(ThreadGroup grp, Object ob)
2) If you had an array of the following type stored in the variable theArray, which cannot be sorted with Arrays.sort(theArray)?
   a) String
   b) int
   c) BigDecimal
   d) URL
3) Which of the following puts "Hello" starting at X=20 Y=50? Assume that graph holds a Graphics object reference.
   a) drawString("Hello", 20, 50);
   b) graph.drawString(20, 50, "Hello");
   c) graph.println("Hello");
   d) graph.drawString("Hello", 20, 50);
4) Can an *object* be a subclass of another object?
   a) Yes---as long as single inheritance is followed.
   b) No---inheritance is only between classes.
   c) Only when one has been defined in terms of the other.
   d) Yes---when one object is used in the constructor of another.
5) Which of the following is NOT an advantage to using inheritance?
   a) Code that is shared between classes needs to be written only once.
   b) Similar classes can be made to behave consistently.
   c) Enhancements to a base class will automatically be applied to derived classes.
   d) One big superclass can be used instead of many little classes.
6) What restriction is there on using the *super* reference in a constructor?

a) It can only be used in the parent's constructor.

b) Only one child class can use it.

c) It must be used in the last statement of the constructor.

d) It must be used in the first statement of the constructor.

7) How many objects of a given class can there be in a program?

a) One per defined class.

b) One per constructor definition.

c) As many as the program needs.

d) One per *main()* method.

8) Which of the following is true about HashMap and Hashtable?

a) Both require their keys to be strings

b) Both maintain key-value pair references in insertion order

c) Both provide synchronized access

d) Both can directly hold primitive and object values

e) None of the above

9) Which of the following is not in the same class hierarchy?

a) Map

b) List

c) Collection

d) Set

10) What must be imported to get class Applet

a) java.applet.Applet

b) java.util

c) java.awt.*

d) java.java

11) What method of your applet is called by the browser when it wishes to display it on the monitor?

a) paint()

b) drawLine()
c) setBackground(0
d) setColor()

12) Which of the following is NOT an advantage to using inheritance?

a) Code that is shared between classes needs to written only once.
b) Similar classes can be made to behave consistently.
c) Enhancements to base class will automatically be applied to derived classes.
d) One big superclass can be used instead of many little classes.

13) In which class is the wait() method defined. Select the one correct answer.

a) Applet
b) Runnable
c) Thread
d) Object

14) What HTML tags should begin and end an applet section in a web page?

a) <applet> </applet>
b) <body> </body>
c) <h1> </h1>
d) <html> </html>

15) What class must be extended when you code an applet?

a) AWT
b) JDK
c) Applet
d) Graphics

16) A simple distributed application uses the Java classes Socket and ServerSocket to communicate between the client and server. The following code fragments are taken from the client and the server. Indicate (using 1, 2, 3, 4) the time sequence in which they must occur for successful communication.

```
theServerSocket.accept(); (i)
Socket theClientSocket = new Socket( HOST, PORT ); (ii)
ServerSocket theServerSocket = new ServerSocket( PORT ); (iii)
theClientSocket.getOutputStream().println("Hello" ); (iv)
```

a) i, ii, iii, iv
b) ii, i, iii, iv
c) iii, ii, I, iv
d) iii, i, ii, iv

17) Which method doesn't map to the respective interface?

a) Comparable - compareTo()

b) Comparator - equals()
c) ListIterator - getPrevious()
d) Iterator - remove()

18) Which of the following is in the same hierarchy

a) Map
b) List
c) Collection
d) Set

19) Say that there are three classes: Computer, AppleComputer, and IBMComputer. What are the likely relationships between these classes?

a) Computer is the superclass, AppleComputer and IBMComputer are subclasses of Computer.
b) IBMComputer is the superclass, AppleComputer and Computer are subclasses of IBMComputer.
c) Computer, AppleComputer and IBMComputer are sibling classes.
d) Computer is a superclass, AppleComputer is a subclasses of Computer, and IBMComputer is a sublclas of AppleComputer

20) Assume that class A extends class B, which extends class C. Also all the three classes implement the method test(). How can a method in a class A invoke the test() method defined in class C (without creating a new instance of class C). Select the one correct answer.
a) test();
b) super.test();
c) super.super.test();
d) ::test();
e) C.test();
f) It is not possible to invoke test() method defined in C from a method in A.

Section B (20 points)

True or False

1. All methods in an abstract superclass must be declared abstract.
2. A class declared final cannot be subclassed. Every method of a final class is implicitly final.
3. A redefinition of a superclass method in a subclass need not have the same signature as the superclass method. Such a redefinition is not method overriding but is simply an example of method overloading.
4. A constructor is a special method with the same name as the class that is used to initialize the members of a class object. Constructors are called when objects of their classes are instantiated.

5. A method declared static cannot access nonstatic class members. A static method has not his reference because static class variables and static methods exist independent of any objects of a class.
6. A map is an interface?
7. In a map, can the same key be associated with several different values?
8. Why Java collections are called "generic"? answer this in yes/no
9. Iterator has a method called getValue()?
10. Applets can open any remote socket?
11. Consider the following class
    public class Test implements Runnable{
    public void run(){}
    }
    Creating an instance of this class and calling its run() method will spawn a new thread.
12. A Thread object has a method called notify().
13. This code compiles without error.

```
class MyButton extends Button implements MouseListener{
 public MyButton(String lbl) {
  super(lbl);
  addMouseListener(this);
 }
 public void mousePressed(MouseEvent e){
 //do something
  }
 }
```

14. A Dialog is a subclass of Frame.
15. When using the GridBagLayout manager, each new component requires a new instance of the GridBagConstraints class.
16. You can only obtain a mutually exclusive lock on methods in a class that extends Thread or implements runnable.
17. You can obtain a mutually exclusive lock on any object.
18. A thread can obtain a mutually exclusive lock on an object by calling a synchronized method on that object.
19. It is possible to call an abstract method from a non abstract method.
20. A subclass inherits both member variables and methods.

Section C (20 points)

1. Define the major aspects of an object oriented model?
2. Illustrate how classes and objects are represented in UML models.

3. What are the major principles are of object oriented programming?
4. What is polymorphism and how is it related to inheritance?
5. What relationships can be defined between objects in an object oriented model?
6. Illustrate the life cycle of an applet in a diagram.
7. Illustrate the life cycle of a thread in a diagram.
8. What are the major properties of an Object?
9. Explain the principle of sandboxing and how it relates to applets.
10. What type of sockets does java support and how are they implemented.

Section D (40 points)

Answer any two

1. Cats and cattle are mammals and so is a whale. However a whale does not live on land like cats and cattle. Interestingly enough a whale leaves in water like a shark which is a fish just like tiger fish. All these are animals. You can eat cattle and tiger fish but not a whale nor a cat. Illustrate the relationship between these organisms in a UML class diagram. Write skeleton code by translating the UML class diagram in java code.

2.

   a. Create an array of **double** and **fill( )** it with random doubles. Print the results.
   b. Create a new class called **Gerbil** with an **int gerbilNumber** that's initialized in the constructor. Give it a method called **hop( )** that prints out which gerbil number this is, and that it's hopping. Create an **ArrayList** and add a bunch of **Gerbil** objects to the **List**. Now use the **get( )** method to move through the **List** and call **hop( )** for each **Gerbil**.
   c. Modify the previous steps so you use an **Iterator** to move through the **List** while calling **hop( )**.
   d. Take the **Gerbil** class in step 2 and put it into a **Map** instead, associating the name of the **Gerbil** as a **String** (the key) for each **Gerbil** (the value) you put in the table. Get an **Iterator** for the **keySet( )** and use it to move through the **Map**, looking up the **Gerbil** for each key and printing out the key and telling the **gerbil** to **hop( )**.

e. Create a **List** (try both **ArrayList** and **LinkedList**) and fill it with **Gerbils.** For each List print the first and last items and then remove them and reprint the first and last items.

3. *In a quest to expand its clientele Company-Z has decided to go the e-commerce way focusing on B2B kind of architecture. To this vain one of the things targeted by Mr. Chibuta the Chief Information officer is an introduction of Web services. One of the Web services should be able to interface with a custom designed server over a network. This custom designed server is to be used to manipulate a database backend. The IT department has decided to recruit 4th Year UNZA students to build this custom server. The functionality of the server was analyzed and the following are the programming requirements it should meet*
   i. It should store session information in an appropriate data structure. This data structure should allow accessing the session information using session names and the solution should be scalable. Identify the appropriate data structure to use.
   ii. The server is to handle transactions and as a result it requires the usage of a reliable protocol. The critical factor, to quote Mr. Chibuta, is "transaction integrity over response time". Identify the appropriate transport layer protocol to be used.
   iii. The server is to serve multiple clients at the same time. Which java programming concept is to be used?
   iv. Realizing that the server will be servicing the Web service over a network which java programming concept will be used to establish the remote connection.
   v. Since a session oriented approach is being used it is possible that while a request is being served the server may also need to modify the session data. This introduces the Consumer/Producer problem. How does java solve this problem?
   vi. Write complete java code to illustrate these concepts in the server implementation. You do not need to outline the detailed implementation. Just the sections outlined above.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER STUDIES

CST 4141

(Multimedia and Human Computer Interaction)

FINAL EXAMINATION

Test Instructions:
Answer FOUR questions
Time allowed: 3 Hours

Question One
Multimedia applications require new systems mechanisms to enable them to handle large volumes of time-dependant data.
a) Distinguish between Web Multimedia and hypermedia (4 Marks)
b) Outline some hardware and software needs of a multimedia system. (8 Marks)
c) Many applications make use of multimedia
   i) Explain the use of multimedia in software development
   ii) What are the benefits of using multimedia in education
(8 Marks)
d) Evaluate the possible directions in which multimedia is likely to develop over the next years. (5 Marks)
(Total 25 Marks)

Question Two
a) Discuss how the existing internet-based audio and video streaming applications achieve acceptable quality of service management. (10 Marks)
b) Explain what you understand by MPEG, MIDI and JPEG multimedia standards
(9 Marks)
c) Explain why text is still not outdated even with modern applications (3 Marks)
d) Discuss how incompatibility affects applications based on different formats. (3 Marks)
(Total 25 Marks)

Question Three

a) Explain with examples the significance of the following development tools in multimedia systems

i) Multimedia authoring programs

ii) Visual object oriented programming languages

iii) Scripting languages

(9 Marks)

b) Outline FIVE objectives of a multimedia database management system (MDBMS) (5 Marks)

c) Distinguish between

i) media data and meta data

ii) descriptive search methods and content based retrieval.

Give an example for each data item and search method respectively. (8 Marks)

d) Give THREE challenges faced by multimedia query processing systems (3 Marks)

(Total 25 Marks)

Question Four

When developing systems, the Human Computer Interface (HCI) should also be considered.

a) Define the term Human Computer Interface (HCI). (3 Marks)

b) Outline FIVE principles that can be used in the design of a good interface (10 Marks)

c) Discuss components of a Graphical User Interface (GUI). (8 Marks)

d) Describe the significance of a good HCI in both systems and applications software (4 Marks)

(Total 25 Marks)

Question five

a) Why are both the human users and computer systems said to be complex systems? (4 Marks)

b) Discuss the relevance and application of THREE subject areas that have an input into HCI (6 Marks)

c) What is the significance of each of the human senses in Human Computer interface? (5 Marks)

d) Explain how fast, high density memory devices and quick processors have

i) influenced recent developments in HCI

ii) expanded the range of applications of computer systems.

(5 Marks)

d) What is the role ergonomics in HCI? (5 Marks)

(Total 25 Marks)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER STUDIES

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(5 Marks)

d) What is the role ergonomics in HCI? (5 Marks)

(Total 25 Marks)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

CS4251: ELECTRONICS FOR COMPUTING III

SEMESTER 1 EXAM **4th NOVEMBER 2010**

TIME: THREE HOURS

ANSWER: ANY FIVE (5) QUESTIONS

ANSWER ANY FIVE (5) QUESTIONS

QUESTION 1

Build a 1bit ALU with a zero (0) carryin input [10 Marks]

QUESTION 2

(i) Describe the four step protocol of operation when a victim cache is incorporated in a multilevel cache system [4 Marks]

Define the Inclusion Policy on the following:

(ii) Inclusive multilevel cache, [3 Marks]

(iii)Exclusive multilevel caches, [3 Marks]

QUESTION 3

With the help of sketches, describe any three of the touch screen technologies. [10 Marks]

QUESTION 4

In a capacitive touch pad technology, how are the following processes achieved:

(i) Sensing finger presence, [3 Marks]

(ii) Filtering position data, [3 Marks]

(iii) Sensing motion. [4 Marks]

QUESTION 5

With the help of detailed sketches, describe the process of image formation in a:

(i) TFT-LCD monitor. [5 Marks]

(i) CRT monitor. [5 Marks]

QUESTION 6

The EEPROM is a basic component of a flash drive. With the help of schematics describe the following EEPROM modes, giving details of the inputs and outputs of each associated wire {array ground, row(0), col(0), VERASE, I/O(0)..I/O(7)}.

(i) Erase mode of the 1 byte array. [3 Marks]

(i) Programming the 1 byte array to 01110101. [4 Marks]

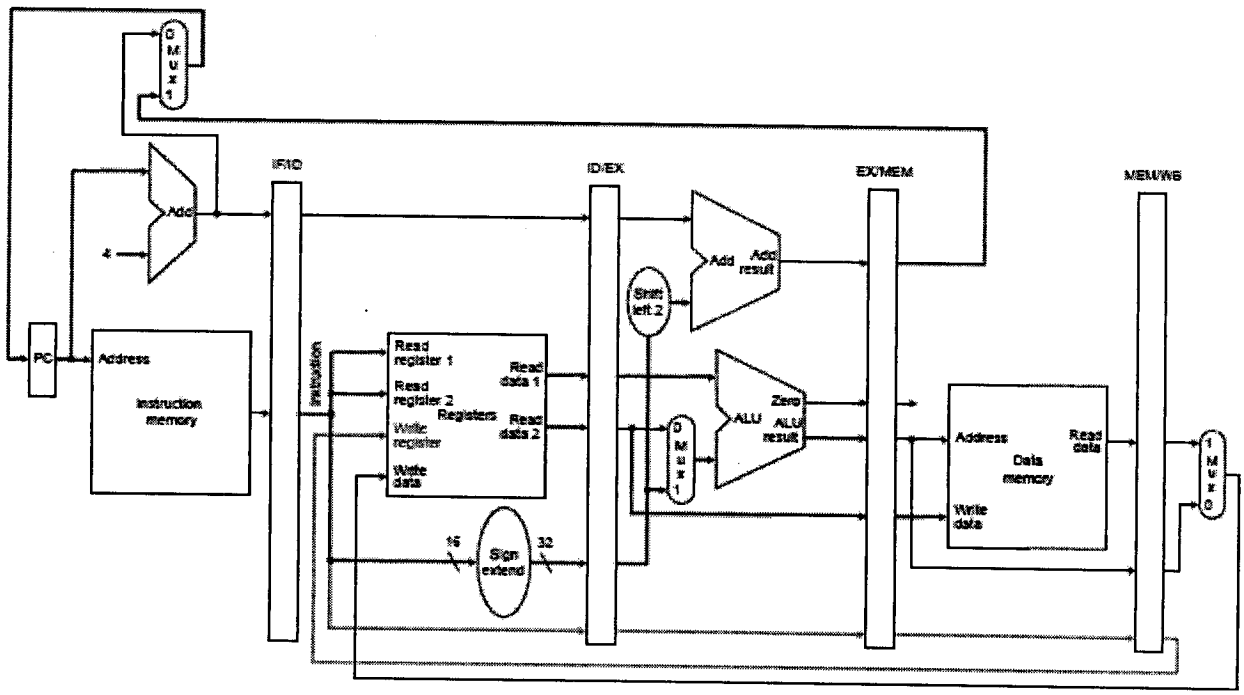
(i) Reading the 1 byte array. [3 Marks]

QUESTION 7

Using the data path diagrams and by way of shading, describe the stages of pipelining the following instructions.

(i) sw $30, $10 [5 Marks]

(ii) add $20, $40 [5 Marks]



END OF EXAM

The University of Zambia

School of Natural Sciences

Department of Mathematics & Statistics

First Semester Examinations - October/November 2010

EM411 - Engineering Mathematics V

Time allowed : Three (3) hrs Full Marks : 100

Instructions: • Attempt **any five (5)** questions. All questions carry equal marks.

• **Full credit** will only be given when **necessary work** is shown.

• Indicate your **computer number** on all answer booklets.

This paper consists of 4 pages of questions.

---

1. a) (i) By sketching the graphs of the curves $y = \ln x$ and $y = x^2 - 1$ on the same plot, determine the number of real solutions of the equation $\ln x = x^2 - 1$.

(ii) Show that the function $g(x) = e^{x^2-1}$ has a fixed point in the interval $(0, 0.5)$.

(iii) Use part (i) and (ii) and perform three iterations of the fixed point iteration method to find the root of the equation $\ln x = x^2 - 1$ starting with the initial approximation $x_0 = 0.45$. State the approximate relative error of your approximated root.

b) Show that the equation

$$\cos\left(\frac{\pi(x+1)}{8}\right) + 0.148x - 0.9062 = 0$$

has a root in the interval $(-1, 0)$. Starting with $x_0 = -0.5$, perform one iteration of the Newton-Raphson method to estimate the root.

c) (i) Suppose that p^* approximates a number p to three significant digits. Find the interval in which p^* must lie if p is 900.

(ii) Find the absolute error and relative error in approximating π by 3.1 .

2. a) The system of equations $y\cos(xy) + 1 = 0$, $\sin(xy) + x - y = 0$ has one solution close to $x = 1$, $y = 2$. Perform one iteration of Newton-Raphson method to approximate this solution.

b) The following system of linear equations represents the distribution of current flow in a circuit :-

$$\begin{aligned} I_1 + I_2 - I_3 &= 0 \\ 2I_1 - 4I_2 &= 4 \\ 2I_1 + 5I_3 &= 6 \end{aligned}$$

Initial estimates of the solutions are $I_1 = 1$ ampere (A), $I_2 = 0$ and $I_3 = 1$. Apply the Gauss-Seidel method to obtain a solution with maximum absolute error of 0.25.

c) Consider the following system of equations :-

$$\begin{aligned} 30i_1 - 20i_2 - 10i_3 &= 0 \\ -20i_1 + 55i_2 - 10i_3 &= 0 \\ -10i_1 - 10i_2 + 50i_3 &= 200 \end{aligned}$$

(i) Show that the above order of equations meet the diagonal dominance condition.

(ii) Find the solution of the system by the Gauss elimination method.

3. a) The percentage of light (L) passing through the sea surface that penetrates to specific depths (D) in clean ocean water is as follows :-

$D(m)$	0	1	2	10	50	100
$L(\%)$	100	45	39	22	5	0.5

Approximate the value of L at a depth of $75m$ using Gregory Newton interpolation polynomial.

b) The data in the following table are the short wave radiation flux (R) at the outer limit of the atmosphere in gram-calories per square centimeter per day for the month of December.

R	891	856	719	494	219
Latitude ($^\circ N$)	0°	20°	40°	60°	80°

Use an appropriate Newton interpolation polynomial to estimate R at a latitude of 35°.

c) Suppose that the Lagrange interpolating polynomial of degree three was used to approximate $\cos 0.75$ using the following values :-

$$\begin{aligned} \cos 0.698 &= 0.7661 \\ \cos 0.733 &= 0.7432 \\ \cos 0.768 &= 0.7193 \\ \cos 0.803 &= 0.6946 \end{aligned}$$

Find a bound on the error.

4. a) The complete elliptical integral of the first kind is

$$K(\theta) = \int_0^{\frac{\pi}{2}} \frac{d\phi}{\sqrt{1 - \sin^2 \phi \sin^2 \theta}} .$$

Compute $K(\frac{\pi}{6})$ using Simpson's rule with four intervals.

b) Given the following equally spaced data

x	1.20	1.30	1.40
$f(x)$	11.59006	14.04276	16.86187

Find $f'(1.20)$, $f'(1.30)$ and $f''(1.30)$ using difference representations which are $\mathcal{O}(h^2)$.

5. a) Apply Milne's four-step method to obtain the numerical solution to the initial-value problem

$$y' = x^2 + y, \qquad y(0) = -1 ,$$

performing one step with $h = 0.1$. The method is given by

$$w_0 = \alpha , \qquad w_1 = \alpha_1 , \qquad w_2 = \alpha_2 , \qquad w_3 = \alpha_3 ,$$

$$w_{i+1} = w_{i-3} + \frac{4h}{3} [2f(t_i, w_i) - f(t_{i-1}, w_{i-1}) + 2f(t_{i-2}, w_{i-2})]$$

(Use a method of $\mathcal{O}(h^4)$ for the necessary start.)

b) Use the Simpson's three step method

$$w_{i+1} = w_{i-1} + \frac{h}{3} [f(t_{i+1}, w_{i+1}) + 4f(t_i, w_i) + f(t_{i-1}, w_{i-1})]$$

as corrector to improve the solution obtained in part a).

6. a) Given that $f(0.25) = f(0.75) = \alpha$, find α if the composite Trapezoidal rule with $n = 2$ gives the value 2 for $\int_0^1 f(x)\,dx$ and gives the value 1.75 with $n = 4$.

b) If u and v are harmonic in a region R, show that

$$\left(\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}\right) + i\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right)$$

is analytic in R.

c) In aerodynamics and fluid mechanics, the functions ϕ and ψ in $f(z) = \phi + i\psi$, where $f(z)$ is analytic, are called the *velocity potential* and *stream function*, respectively. If $\phi = x^2 + 4x - y^2 + 2y$

(i) find ψ

(ii) find $f(z)$ in terms of z

END!

The University of Zambia

Department of Mathematics and Statistics

END OF SEMESTER I EXAMINATIONS 2009/2010

EM 211 - ENGINEERING MATHEMATICS I

Time allowed: Three (3) hrs

Instructions: (i) Answer any **FIVE** questions
(ii) All questions carry equal marks
(iii) Show all essential working to earn full marks

1.(a)(i) Sketch the region bounded by the graphs of

$$y = \frac{1}{\sqrt{1+x^2}},\ x = 0 \text{ and } x = 1.$$

(ii) Determine the area of this region.
(iii) The region is revolved about the x-axis. Find the volume of the resulting solid.

(b) By removing the xy term using rotation of axes, determine the type of conic section represented by the equation

$$73x^2 - 72xy + 52y^2 + 30x + 40y - 75 = 0.$$

2. (a) Suppose that the position of a golf ball is given by

$$r(t) = 90\sqrt{2}ti + 90\sqrt{2}tj + (64t - 16t^2)k \text{ for } t \geq 0.$$

(i) Find the initial position and initial velocity of the golf ball.
(ii) Show that the golf ball strikes the ground at time $t = 4$, and determine the distance from its initial position.

(b) Find the interval of convergence of the series

(i) $\sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)!}$

(ii) $\sum_{n=0}^{\infty} \frac{x^n}{2^n}$

(iii) $\sum_{n=0}^{\infty} \frac{x^n}{\sqrt{n}3^n}$

3. (a) Find the values of x and y such that the point $(x, y, 1)$ lies on the line passing through $(2, 5, 7)$ and $(0, 3, 2)$.

(b) In mountaineous areas, reception of radio and TV signals is sometimes poor. Consider an idealised case in which a hill is represented by the graph of the parabola $y = x - x^2$, a transmitter is located at the point $(-1, 1)$, and a reciever is located on the other side of the hill at the point $(x_0, 0)$. What is the nearest the reciever can be to the hill so that the reception is unobtstructed?

(c) Determine whether the given series converges or diverges

(i) $\sum_{n=1}^{\infty} \frac{\sin n}{n^2+1}$

(ii) $\sum_{n=0}^{\infty} \frac{\ln n}{n}$

4. (a) (i) Find the Taylor series for the function $f(x) = \cos x$ about $x = 0$.
(ii) Determine the interval of convergence of the Taylor series.

(b) A circular helix is represented parametrically by

$$r(t) = 2\cos t i + 2\sin t j + 3tk.$$

(i) Determine the curvature of the helix.

(ii) Find the principal unit normal vector to the helix at the point corresponding to $t = \frac{\pi}{4}$.

5. (a) Find the arc length of the cycloid given parametrically by

$$x = 2(t - \sin t) \text{ and } y = 2(1 - \cos t)$$

over the interval $0 \leq t \leq 2\pi$.

(b) show that the curves parametrized by

$$r_1(t) = ti + 2tj + t^2k \text{ and } r_2(t) = t^2i + (1 - t)j + (2 - t^2)k,$$

(i) intersect at $(1, 2, 1)$ and that (ii) the vectors tangent to the two curves at $(1, 2, 1)$ are perpendicular.

6. (a)(i) Find the number d such that the line $x + y = d$ is tangent to the parabola $x^2 = 2y$.
(ii) Determine the point of tangency and sketch the graph of the parabola and the tangent.

(b) Determine whether the series converges or diverges

(i) $\sum_{n=1}^{\infty} \frac{(-1)^{n+1}\sqrt{n}}{2n+1}$

(ii) $\sum_{n=3}^{\infty} \frac{\arctan n}{n^2+1}$

(iii) $\sum_{n=1}^{\infty} \frac{(-1)^n(\ln n)^p}{n}$, where p is any positive integer.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 155: INTRODUCTION TO PHYSICAL GEOGRAPHY

TIME : **THREE HOURS**

INSTRUCTIONS : **ANSWER ANY FOUR QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.**

---

1. Write short explanatory notes on **ALL** of the following:
   a) Climatic factors
   b) Time as soil forming factor
   c) Continental drift
   d) Spatial heterogeneity
   e) Biomes

2. Show how the study of physical geography is significant to human populations' use of the environment.

3. Describe how the incoming solar radiation is disposed in the earth-atmosphere system.

4. Sketch the rock cycle of and describe the processes that act within it.

5. Describe the influence of climate and geology on the type of soil that would form in a particular area.

6. Discuss the factors that influence the distribution pattern of plants and animals on the earth's surface.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 211 : THE GEOGRAPHY OF AFRICA

TIME: **THREE HOURS**

INSTRUCTIONS : **Answer any four questions.**
Candidates are advised to make use of illustrations and examples wherever appropriate.

---

1. 'Africa's natural resource endowment can be the basis for sustainable socio-economic development , but so far this seems to be elusive'. Discuss.

2. Describe the contributions that were made by the Mande people of Western Sudan and ancient Egyptians, to the Neolithic Revolution.

3. Discuss the challenges that African people face in promoting national unity in view of racial and linguistic diversity.

4. Compare and contrast the development strategies that Ghana and Kenya implemented after the attainment of political independence.

5. Explain the factors that influence the diversity of climates in Africa.

6. Describe the soils of Africa based on D'Hoore's soil classification system and comment on their utilization.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 271: QUANTITATIVE TECHNIQUES IN GEOGRAPHY I

TIME: **THREE HOURS.**

INSTRUCTIONS: **Answer Question 1 and any other three. Question 1 carries 40 marks while the others carry 20 marks each.**

---

1. Given the below statement of the research problem answer the questions that follow:

   'District X almost always experiences flooding during the rainy season. Recognising this problem, the National HIV/AIDS Program, working with the Ministry of Health, established a new supply logistics system for the district. Just before the rainy season, each health centre and post in the district is given a four-month supply of medication to cover TB and other AIDS-related opportunistic infections. In addition, the Ministry of Health maintains several small motorboats in the district that can be used to transport supplies across rivers where there is either no bridge or the bridge has been destroyed. Despite these new measures, this year's service statistics from Kalabo District indicate that a large number of PLHA (People Living with HIV/AIDS) enrolled in the DOTS program failed to receive daily medication for TB. Consequently, the mortality in PLHA has been observed to be higher than before.'

   (a) Outline the discrepancy in that exists between what is and what should be;
   (b) Provide a research question that elaborates why there is a discrepancy;
   (c) Provide at least two possible answers to the question;
   (d) Provide a research hypothesis.

2. It has been observed that a number of fishermen and their families live on the beach of Lake Bangweulu especially during the legalised fishing period. Discuss any three data collection methods that a researcher would use in order to ascertain the pros and cons of this type of life.

3. Outline the steps used in scientific inquiry.

4. Define pattern, and using examples show how pattern can be used to explain geographic phenomena.

5. Discuss any five factors a researcher should bear in mind if they intend to collect good data in their research.

6. 'Multistage sampling can be used concurrently with stratified random sampling'. Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURALSCIENCES
2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS
GEO 381
ENVIRONMENT AND DEVELOPMENT I

TIME : Three Hours
INSTRUCTIONS: Answer any FOUR questions. All questions carry equal marks.

---

1. 'The atmospheric concentrations of carbon dioxide and methane have increased by 31% and 149%, respectively, above pre-industrial levels since 1750 causing global warming and climate change'. What are the characteristic manifestations of this trend?

2. Based on Environmental Sustainability Index (Population Growth and Density, Quality of Governance (institutional capacity) and Economic performance), evaluate Zambia's environmental situation.

3. Explain the major concepts of Environmental Planning and the importance of physical, biological, cultural and political factors.

4. Why do Sustainable Development approaches look at the issue of environment and development as an interlocking crisis?

5. One way to ensure that development projects pay greater attention to the environment is through the application of the Environmental Impact Assessment (EIA). Elucidate.

6. What are the likely ecological, social and economic effects of cultural pollution of water bodies in Zambia?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 481: ENVIRONMENT AND DEVELOPMENT II

TIME : **THREE HOURS**

INSTRUCTIONS : **ANSWER ANY FOUR QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.**

---

1. The poverty trap thesis states that 'the necessities of the poor, and their living and working conditions drive them to *over-exploit* the environment, leading to *forced* environmental degradation'. Discuss this thesis with respect to the urban-rural dichotomy of environmental degradation.

2. Outline and explain the major characteristics of the ecological footprint of human decision processes in urban environments of the developing world.

3. 'Agricultural sustainability involves the mediation between ecology and technology, and relies on culturally appropriate attitudes and behaviour'. Discuss.

4. Discuss the four (4) hypotheses that Angelsen and Kaimowitz (2001) argue to be significant in understanding the 'win-win' assumption in the agricultural technologies and deforestation nexus.

5. 'In many developing countries where provision of water is seriously inadequate, there is little or no overall shortage of freshwater resources'. Discuss.

6. Compare and contrast the management and utilisation of natural forest resources and urban forest resources in the world.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 495: ENVIRONMENTAL HAZARDS AND DISASTERS

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. The use of a Philips University Atlas and a certified calculator is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

---

1. With the help of specific examples, discuss Smith's (1992:271) contention that "All technological innovation creates risks as well as benefits".

2. With the aid of examples, discuss one of the major global environmental concerns and the extent to which it is manifested in Zambia.

3. Misisi and Kuku compounds in Lusaka experienced one of the worst floods during the 2009/2010 rainy season. Briefly, explain the effectiveness of the mitigation measures undertaken during and after the event.

4. 'The earth has vast resources for human survival, yet the rate of population growth and threat of global warming paint a gloomy picture'. Discuss.

5. With the help of a simple matrix, explain the relationships between physical exposure to hazard (risk) and human vulnerability to disaster (insecurity).

6. "Despite the welcome fall in fatalities for some hazards in many of the wealthier countries, the world trend is probably towards more disaster related deaths and damages" (Smith, 1992:38). Explain why this should be so, even if the frequency of events is not growing and despite the many positive steps being taken to reduce disasters.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 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 scientific calculator is allowed.

1(A) The current population of Norway is 4,968, 040 (Population Reference Bureau, 20100). Assuming Norway's population growth rate will remain constant between October, 2010 and October 2016 what would be the population of Norway in October 2016 based on the following equations:

a) Arithmetic or Simple Population Growth model (10 Marks)

a) Exponential Population Growth model (8 Marks)

(B) Examine the merits and demerits of using each one of the above formulae for projecting population. (7 Marks)

2. Explain why some countries in Sub-Saharan Africa fail to conduct good Population censuses.

3. 'Although the Demographic Transitional Theory is not universally accepted by some scholars it is still useful for explaining Fertility, Mortality and Population transition in many countries in the world today'. Discuss the assertion of this statement.

4, The Population Reference Bureau (2010) associates poverty with high Total Fertility Rates in the majority of countries in sub-Saharan countries. Elucidate.

5. Compare and contrast population policies in the Developed and Low Developed Countries.

6. Assess why the majority of both Kenyan and Zambian women still have pronalist tendencies.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 921: ECONOMIC GEOGRAPHY

TIME: **Three Hours**

INSTRUCTIONS: **Answer any FOUR questions. All questions carry equal marks.**

---

1. Compare and contrast Smith's Variable Cost Model and Pred's Behavioural Matrix with regard to industrial location.

2. Discuss the impact of industrial clusters on economic development in Africa.

3. In what ways and to what extent is Economic Geography a hybrid science between Geography and Economics?

4. Account for the low competitiveness of Zambia's tourism industry in Southern Africa despite the industry having comparative advantage.

5. 'The clothing industry in Zambia has significantly shrunk during the past two decades'. Discuss.

6. Explain the importance of the Heckscher-Ohlin Model in relation to international trade.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 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.**

---

1. Describe the steps that can be undertaken in conducting rural research using the Participatory Rural Appraisal (PRA) methodology, and explain the advantages of the methodology.

2. (a) Define Rural and Agricultural Geography .(10 marks).

   (b)Explain any five factors that influence agricultural production in developing countries (15 marks).

3. Describe the Intensity and Crop Theories in Von Thunen's model of land use and show whether they are applicable to Zambia.

4. 'Some indigenous agronomic systems in Africa can be considered as being sustainable land use systems'. Discuss.

5. Suggest ways in which women small-scale farmers can be empowered in order to promote sustainable agricultural development and ensure household food security in rural Africa.

6. Account for the location of rural settlements in Africa and show whether the settlements are temporary or permanent.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATION

GEO 951: CLIMATOLOGY

TIME: THREE HOURS
INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS,
ALL QUESTIONS CARRY EQUAL MARKS

---

1. Write short explanatory notes on **ALL** of the following:

a. Scales of motion

b. ENSO and Walker circulation system

c. Airmass and Front

d. The importance of the stratospheric ozone

e. Weather systems of the middle and high latitudes

2. 'Climate change and variability is a developmental issue and is a threat to the attainment of Millennium Developmental Goals (MDGs) especially for developing countries like Zambia'. Discuss.

3. 'The hydrological cycle is an integral part of all the components of the global climate system'. Discuss.

4. Describe the boundary layer climate processes and explain their importance.

5. Compare and contrast frontogenesis and cyclogenesis.

6. Define air pollution and discuss the implications of air pollution on urban climate and ecosystems.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 961: SOILS GEOGRAPHY

Time: Three hours

Instructions: Answer any four questions. All questions carry equal marks. The use of a Philips University Atlas and a certified electronic calculator is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

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1. Write short explanatory notes on **ALL** of the following:
   (a) Argillic in a Vertisol
   (b) Length – Slope factors in the Universal Soil Loss Estimation Equation (USLE)
   (c) Nutrient retention in 1:1 and 2:1 soil colloids
   (d) Measurement of plant available water in soil
   (e) Benefits and hazards of manures as ameliorants for soil fertility.

2. When water is poured on a dry soil, preferably in the field and where the soil is undisturbed, one would observe the production of air bubbles. Explain their origin and briefly discuss the factors that determine the air capacity of any given soil.

3. With the help of an annotated diagram, explain the parts of a soil profile that an agriculturalist or horticulturalist would be most interested in, and which parts they would prefer to leave undisturbed.

4. Explain the processes that are active during the formation of soils.

5. Explain how a Soil Surveyor uses the knowledge of factors of soil formation during aerial photo interpretation.

6. Describe measurable and observable parameters of a soil that are important for it to be classified as an Ustult.

End of Examination

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 971: AERIAL PHOTOGRAPHY AND AERIAL PHOTO INTERPRETATION - PAPER II

TIME: Three hours
INSTRUCTIONS: Answer all questions

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1. (a) Draw an idealized cross-section of the colour infrared film and explain its electromagnetic radiation sensitivity. [10 Marks]

   (b) Explain how green vegetation and reddish soils will appear in colour infrared film. [15 Marks]

2. Using the provided aerial photograph number 20:35, answer the following questions:

   (a) What film type was used to produce this photographic product? [4 Marks]

   (b) If you had to carry out an interpretation exercise, explain and justify the photo-interpretation technique you would use. [20 Marks]

   (c) Provide at least three advantages and disadvantages of the technique you have chosen? [6 Marks]

3. (a) List the requisites and explain the steps you would undertake in establishing the 'effective area' in aerial photo-interpretation. [15 Marks]

   (b) Under what circumstances would the 'effective area' vary? (5 Marks)

4. In an effort to monitor Buffalo movements and feeding practices in Kafue National Park, Zambia Wildlife Authority (ZAWA) intends to carry out a habitat mapping project, with emphasis on showing grassland and woodland areas. As an aerial photography expert assigned to the project, explain the steps you would carry out before producing a final Buffalo habitat map. [25 Marks]

END OF EXAMINATION


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THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Mathematics and Statistics

2010 Academic Year

Semester I

M111 Mathematical Methods I

FINAL EXAMINATION

Time Allowed: Three (3) Hours **26th October, 2010.**

Instructions:

1. You must write your **Computer Number**, and your **TG Number** on each answer booklet you have used.

2. There are Seven (7) questions in this paper, Attempt **Any Five (5)** questions. All questions carry equal marks

3. Calculators are **Not** allowed.

4. Should you have any problem or if you need more answer booklet, put up your hand an invigilator will come to attend to you.

1. (a) (i) Express $2.5\overline{90}$ in the form $\frac{a}{b}$ where a and b are integers and $\frac{a}{b}$ is in its lowest terms.

(ii) Express $\frac{\sqrt{3}+1}{\sqrt{3}-1}+\sqrt{3}-1$ in the form $a+b\sqrt{3}$ where a and b are rational numbers.

(iii) Express $\frac{3-i}{4i}$ in the form $a+ib$ where a and b are rational numbers.

(b) Let $f(x)=\frac{x-3}{x+2}$ be a function.

(i) Find the domain and the range of $f(x)$.

(ii) Find also the inverse $f^{-1}(x)$ of $f(x)$.

(iii) Given also that $g(x)=\frac{1}{x+1}$, solve the equation $f(g(x))=1$.

(c) A binary operation $*$ is defined on the set of real numbers as follows:

$a*b=2^{-a}+b, \qquad a, b \in \mathbf{R}$

(i) Is the operation $*$ commutative? If not give a counterexample.

(ii) Find the value of $-1*(0*1)$ and $(-1*0)*1$, and state whether $*$ is associative.

2. (a) The function $f(x)=\frac{a}{x}+b$ is such that $f(-1)=\frac{3}{2}$ and $f(2)=9$.

(i) Find the values of a and b.

(ii) State the domain of f.

(iii) Determine whether $f(x)$ is a one – to – one function.

(b) Let **R**, the set of real numbers be the universal set. If $A=[-7, 8)\cup[11, \infty)$ and $B=[0, 20]$, find the following sets and display them on the numberline:

(i) A'.

(ii) $A\cap B$.

(iii) $(A\cup B)'$.

(c) Sketch the graph of the function $g(x)=-\sqrt{1-2x}$. Hence find the solution set of the inequality $\sqrt{1-2x}>1$.

3. (a) (i) Solve the following inequality $\frac{2x}{x+1} \leq \frac{1}{2}$.

(ii) Differentiate from the first principle $f(x) = \sqrt{x}$.

(b) Given the quadratic function $f(x) = 6x^2 + x - 2$

(i) Find the y – intercept and the x – intercept.

(ii) Determine the maximum or the minimum point of the function.

(iii) Sketch the graph of $f(x) = 6x^2 + x - 2$ and the graph of $g(x) = |6x^2 + x - 2|$.

(c) The remainder when the polynomial $P(x) = x^3 - px + q$ is divided by $x^2 - 3x + 2$ is $4x - 1$.

(i) Find the constants p and q.

(ii) Hence express the polynomial in the form $P(x) = (2x-1)Q(x) + R$ where $Q(x)$ is the quotient and R is the remainder when $P(x)$ is divided by $2x-1$.

4. (a) Solve the following equations for all values of x in the interval $[\,0\,, 360^0\,]$

(i) $2\sin x \cos x + \sin x = 0$.

(ii) $\sin^2 x + 5\cos^2 x = 3$.

(b) Given that the roots of the equation $x^2 - 21x + 4 = 0$ are α^2 and β^2, where both α and β are positive, find

(i) $\alpha\beta$.

(ii) $\alpha + \beta$.

(iii) an equation whose roots are $\frac{\alpha}{\beta}$ and $\frac{\beta}{\alpha}$.

(c) Let $f(x) = x^3 - 5x^2 + 2x + 8$ be a polynomial.

(i) Show that $x+1$ is a factor of the polynomial $f(x)$

(ii) Factorize the polynomial $f(x)$ completely.

(iii) Calculate the range of values of x for which $2x + 8 > 5x^2 - x^3$.

5. (a) Let $f(x) = |2x-3| - 1$ be a function.

(i) Is the function f ,even , odd or neither? Justify your answer.

(ii) State the range of $f(x)$.

(iii) Sketch the graph of $f(x)$.

(b) Given that X and Y are subsets of some universal set U, simplify the following:

(i) $X \cap (X' \cup Y)$.

(ii) $[(X \cap Y)' \cap (X' \cup Y)]'$.

(c) Let $f(x) = 2\cos 2x$ be a function.

(i) State the amplitude and the period of the function $f(x)$.

(ii) Sketch the graph of $f(x) = 2\cos 2x$ for values of x in the interval $0 \le x \le \pi$.

(iii) On the same diagram draw the graph of $g(x) = 1 + \sin 2x$ for values of x in the interval $0 \le x \le \pi$.

(iv) Hence state the number of solutions to the equation $1 + \sin 2x = 2\cos 2x$ in the interval $0 \le x \le \pi$.

6. (a) Evaluate the following limits

(i) $\lim_{x \to 3} \dfrac{3-x}{2x^2 - 5x - 3}$.

(ii) $\lim_{x \to \infty} \dfrac{3x^2 - 2x + 1}{5 - 8x^2}$.

(b) (i) Express the complex numbers $\dfrac{x+iy}{y+ix}$ in the form $a + ib$.

(ii) Find p and q given that $2p + 3iq + \dfrac{1}{1+i} = (2+i)^2$.

(iii) Solve the inequality $|x+2| > 3$.

(c) (i) Prove the identity $\sin 2\theta = \dfrac{2\tan\theta}{1 + \tan^2\theta}$.

(ii) Show that $\dfrac{1 - \cos 2A}{3 + \cos 2A} = \dfrac{\sin^2 A}{1 + \cos^2 A}$.

(iii) Hence solve the equation $\dfrac{1 - \cos 2A}{3 + \cos 2A} = \dfrac{1}{7}$ for values of A in the interval $0 \le A \le 180^0$.

7. (a) Solve each of the equations below for real values of x.

(i) $x = \sqrt{\frac{1}{2}(5x+3)}$.

(ii) $\frac{x-3}{x^2+2} = \frac{1}{x+1}$.

(b) (i) Given that $\lim_{\theta \to 0} \frac{1-\cos\theta}{\theta} = 0$ and $\lim_{\theta \to 0} \frac{\sin\theta}{\theta} = 1$ differentiate the function $f(x) = \frac{1}{x} - \sin 2x$ from the first principle.

(ii) The curve $g(x) = \frac{1}{x}$ passes through the point $P(a, g(a))$. Find in terms of a the equation of the tangent to the curve at P.

(c) Find $\frac{dy}{dx}$ given that

(i) $y = (3x^3 + 1)^3$.

(ii) $y = \tan x$.

(iii) $y = x^{\frac{3}{2}} \cos x$.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS AND STATISTICS

2010 ACADEMIC YEAR
FIRST SEMESTER EXAMINATIONS

M161: INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS I

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS:
1. Answer any **Five** (5) Questions
2. Show All Essential Working
3. Calculators are NOT allowed

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1. (a) Given the universal set E = { 1, 2, 3, 4, 5, 6, 7, 8 } and the sets A = { 1, 5, 6, 7 }, B = { 2, 4, 5, 6 }, C = { 3, 4, 6, 7 }.

   (i) Represent the sets A, B and C in a venn diagram.

   (ii) Find $(A \cup B)' \cap C$

   (iii) Find $A' \cup (B' \cap C)$

   (b) Solve the following :

   (i) $4x^4 - 5x^2 + 1 = 0$

   (ii) $\frac{1}{x-2} \leq \frac{1}{x+3}$

   (c) Express $\frac{5x+4}{(x-1)(x+2)^2}$ into partial fractions.

2. (a) (i) Express $1.7\overline{2}$ in the form $\frac{a}{b}$ in its lowest terms where a and b are real numbers.

   (ii) Simplify $x - \frac{x^2}{x-1} + \frac{2}{x^2-1}$

   (b) Given that $z_1 = 3 - 2i$, $z_2 = 1 - i$ and $z_3 = x^2 + yi$. Find

   (i) $(z_1 - z_2)^2$

   (ii) $\frac{z_1 + |z_2|^2}{z_1}$

   (iii) the values of x and y if $\bar{z}_1 + 6z_2 = z_3$

(c) Prove that $\dfrac{\cos\theta\csc\theta}{\tan\theta+\cot\theta}=1-\sin^2\theta$

3. (a) (i) Evaluate $\dfrac{2^{-4}+4^{-3}}{2^{-3}}$.

(ii) Find the range of values of k for which the equation $4x^2-kx+k=0$ has no real roots.

(b) An orange farmer has 400 crates of fruit ready for the market and will have 20 more for each day the farmer waits. The present price in \$60 per crate and will drop an estimated \$2 per day for each day waited. Let x be the number of days waited.

(i) Show that the income function is given by $P(x)=-40x^2+400x+24000$

(ii) Find the number of days the farmer should wait to maximize his income.

(iii) Find the maximum income possible.

(c) Solve

(i) $2\sin^2\theta=3\cos\theta+3$ for $0\le x<2\pi$

(ii) $\begin{aligned}2x-3y&=4\\6y&=4x-8\end{aligned}$

4. (a) The roots of the equation $2x^2+4x-1=0$ are α and β. Without solving the equation, find the

(i) value of $\dfrac{1}{\alpha^3\beta}+\dfrac{1}{\alpha\beta^3}$.

(ii) equation whose roots are $\alpha-2$ and $\beta-2$.

(b) Given the function $f(x)=-2x^2+4x+6$,

(i) find the points at which $f(x)$ meets the x – axis and y – axis.

(ii) find its vertex and axis of symmetry.

(iii) sketch the graph of $f(x)$.

(c) Solve the equations

(i) $8e^{-x}-e^{x}=2$

(ii) $\cos2\theta+\cos\theta=0$ for $0°\le\theta<360°$

5. (a) Given that $f(x) = 1 + \dfrac{x-2}{x+1}$ and $g(x) = x^3 - 1$.

(i) State the domain and range of $g(x)$.

(ii) Find $f^{-1}(x)$ and state its domain.

(iii) Find $(f \circ g)(-1)$.

(b) If $\tan A = \dfrac{12}{5}$ and $\cos B = \dfrac{3}{5}$, where A and B are both reflex angles, find

(i) $\tan(A - B)$

(ii) $\sin\dfrac{B}{2}$

(c) Solve

$$\begin{aligned} 2x - y + z &= 0 \\ 3x - 2y + 4z &= 11 \\ 5x + y - 6z &= -32 \end{aligned}$$

6. (a) Solve the equations

(i) $\log x + \log(3x+1) = 1$

(ii) $\tan\theta = 2\cos\theta\tan\theta$ for $0° \le \theta < 360°$

(b) (i) Find the term in x in the expansion of $\left(x^2 + \dfrac{1}{x}\right)^{11}$

(ii) Find the first four terms in the expansion of $(1-2x)^{-\frac{1}{4}}$. State the range of values of x for which the expansion is valid.

(c) Given that $f(x) = x^3 - 2x^2 - x + 2$.

(i) If $f(x) = (x^2 + x + 1)q(x) + r(x)$, find $q(x)$ and $r(x)$.

(ii) Solve the equation $f(x) = 0$.

END OF EXAMINATION

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics

2010/11 ACADEMIC YEAR
FISRT SEMESTER FINAL EXAMINATIONS

M211 – MATHEMATICAL METHODS III

11th November, 2010

INSTRUCTIONS: (1) Answer any **five (5)** questions only.

(2) Show all essential working to avoid loss of marks.

(3) Indicate the **question number** of each question attempted on the cover of the main answer book.

TIME ALLOWED: Three (3) hours.

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1. (a) Sketch the graph of the conic whose equation is given by

$$9x^2 - 4y^2 + 36x + 8y + 68 = 0.$$

Hence, state its vertex (or vertices), focus (or foci) and directrix (or directices)

(b) Identify the conic section described by

$$r = \frac{15}{5 - 4\sin\theta},$$

and sketch its graph indicating

(i) the polar coordinates of points where the curve cuts the axes.

(ii) the Cartesian equation(s) of directrix (or directrices);

(iii) the focus (or foci) in polar form;

(c) On the same diagram, sketch the graph of curves defined by

$$y = 9 - x^2; \quad y = x + 3,$$

stating their points of intersection.

Hence, find the area of the region bounded by the curves.

2. (a) The equation of a conic section is given by

$$4x^2 + 4xy + y^2 - 60x + 120y = 0$$

(i) Use a suitable rotation of axes to transform the equation in its standard form.
Hence, identify the conic.

(ii) State its axes of symmetry

(ii) Find its vertex (or vertices), focus (or foci) and the directrix (or directrices) of the conic.

(iii) Sketch the curve.

(b) Find the polar equation of the conic with a focus at the pole, eccentricity, $e = \frac{3}{2}$ and one directrix with polar equation $r = -3\csc\theta$.

3. (a) Use the formal definition of limits to prove that

$$\lim_{x\to 2}\frac{3}{x} = \frac{3}{2}.$$

Hence, find the value of δ corresponding to $\varepsilon = 0.0009$.

(b) Determine whether each of the following series converges. If so, find the sum.

(i) $\sum_{n=1}^{\infty}\left(\frac{2}{3}\right)^n$

(ii) $\sum_{n=1}^{\infty}\frac{1}{n(n+1)}$

(iii) Examine the series for conditional or absolute converges: $\sum_{n=1}^{\infty}\frac{(-1)^{n-1}}{(n+1)^2}$

(c) Evaluate the integral $\int_1^{13}\frac{x^2}{\sqrt{x+3}}dx$

4. (a) (i) State Rolle's theorem.

(ii) Show that the hypotheses Rolle's theorem are satisfied by the function

$$f(x) = x^{\frac{1}{2}} - x^{\frac{3}{2}},$$

in the interval [0,1].

(iii) For the function $f(x) = x^{\frac{1}{2}} - x^{\frac{3}{2}}$, find the value of c which satisfies the conclusion of Rolle's theorem.

(b) (i) Evaluate the integral $\int \frac{1}{\sqrt{x^2 + 2x}} dx$

(ii) Find the unknown coefficients a_0, a_1, a_2, a_3, a_4, given that

$$\int x^4 e^{3x} dx = e^{3x}(a_0 x^4 + a_1 x^3 + a_2 x^2 + a_3 x + a_4).$$

(c) Evaluate the limit $\lim_{x \to \frac{\pi}{2}} (\tan x)^{\cos x}$

5. (a) (i) State the Mean Value theorem.

(ii) Use the Mean value theorem to approximate $\sqrt{3.999}$.

(b) Evaluate each of the following integrals

(i) $\int x^2 \tan^{-1} x dx$

(ii) $\int \frac{d\theta}{1 + \cos\theta} d\theta$

(c) Find the interval of convergence of the series $\sum_{n=0}^{\infty} \frac{(-1)^n (x+1)^n}{2^n}$.

6. (a) Express the function $f(x) = \ln x$ as a series in powers of $(x-1)$. Hence, ignoring the term in $(x-1)^5$ and higher powers, find the approximate value for $\ln 0.9$, correct to 5 decimal places.

(b) A curve is given by

$$3y^2 + x^2y^3 - 5x^2 + 3 = 0.$$

Find

(i) the equation of the tangent, and

(ii) the equation of the normal

to the curve at $(1,-1)$.

(c) Given the curve $x^2 - y^2 = 16$, where $4 \le x \le 8$, find the volume generated when the area bounded by the curve and the $x-$ axis is rotated about the $x-$ axis.

7. (a) Evaluate the integral $\int \sin 3x \cos 4x \, dx$

(b) Given that $I_n = \int_0^{\frac{\pi}{2}} \cos^n x \, dx$, where $n \ge 2$, show that

$$I_n = \frac{n-1}{n} I_{n-2}.$$

Hence find I_3.

(c) Find the length of the arc of the curve $y = 3x^{3/2} - 1$, from $x = 0$ to $x = 1$.

END OF EXAMINATION

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics

2010/11 ACADEMIC YEAR
FISRT SEMESTER FINAL EXAMINATIONS

M211 – MATHEMATICAL METHODS III

11th November, 2010

INSTRUCTIONS: (1) Answer any **five (5)** questions only.

(2) Show all essential working to avoid loss of marks.

(3) Indicate the **question number** of each question attempted on the cover of the main answer book.

TIME ALLOWED: Three (3) hours.

---

1. (a) Sketch the graph of the conic whose equation is given by

$$9x^2 - 4y^2 + 36x + 8y + 68 = 0.$$

Hence, state its vertex (or vertices), focus (or foci) and directrix (or directices)

(b) Identify the conic section described by

$$r = \frac{15}{5 - 4\sin\theta},$$

and sketch its graph indicating

(i) the polar coordinates of points where the curve cuts the axes.

(ii) the Cartesian equation(s) of directrix (or directrices);

(iii) the focus (or foci) in polar form;

(c) On the same diagram, sketch the graph of curves defined by

$$y = 9 - x^2; \quad y = x + 3,$$

stating their points of intersection.

Hence, find the area of the region bounded by the curves.

2. (a) The equation of a conic section is given by

$$4x^2 + 4xy + y^2 - 60x + 120y = 0$$

(i) Use a suitable rotation of axes to transform the equation in its standard form.
Hence, identify the conic.

(ii) State its axes of symmetry

(ii) Find its vertex (or vertices), focus (or foci) and the directrix (or directrices) of the conic.

(iii) Sketch the curve.

(b) Find the polar equation of the conic with a focus at the pole, eccentricity, $e = \frac{3}{2}$ and one directrix with polar equation $r = -3\csc\theta$.

3. (a) Use the formal definition of limits to prove that

$$\lim_{x\to 2}\frac{3}{x} = \frac{3}{2}.$$

Hence, find the value of δ corresponding to $\varepsilon = 0.0009$.

(b) Determine whether each of the following series converges. If so, find the sum.

(i) $\sum_{n=1}^{\infty}\left(\frac{2}{3}\right)^n$

(ii) $\sum_{n=1}^{\infty}\frac{1}{n(n+1)}$

(iii) Examine the series for conditional or absolute converges: $\sum_{n=1}^{\infty}\frac{(-1)^{n-1}}{(n+1)^2}$

(c) Evaluate the integral $\int_1^{13}\frac{x^2}{\sqrt{x+3}}dx$

4. (a) (i) State Rolle's theorem.

(ii) Show that the hypotheses Rolle's theorem are satisfied by the function

$$f(x) = x^{\frac{1}{2}} - x^{\frac{3}{2}},$$

in the interval [0,1].

(iii) For the function $f(x) = x^{\frac{1}{2}} - x^{\frac{3}{2}}$, find the value of c which satisfies the conclusion of Rolle's theorem.

(b) (i) Evaluate the integral $\int \frac{1}{\sqrt{x^2 + 2x}} dx$

(ii) Find the unknown coefficients a_0, a_1, a_2, a_3, a_4, given that

$$\int x^4 e^{3x} dx = e^{3x}(a_0 x^4 + a_1 x^3 + a_2 x^2 + a_3 x + a_4).$$

(c) Evaluate the limit $\lim_{x \to \frac{\pi}{2}} (\tan x)^{\cos x}$

5. (a) (i) State the Mean Value theorem.

(ii) Use the Mean value theorem to approximate $\sqrt{3.999}$.

(b) Evaluate each of the following integrals

(i) $\int x^2 \tan^{-1} x dx$

(ii) $\int \frac{d\theta}{1 + \cos\theta} d\theta$

(c) Find the interval of convergence of the series $\sum_{n=0}^{\infty} \frac{(-1)^n (x+1)^n}{2^n}$.

6. (a) Express the function $f(x) = \ln x$ as a series in powers of $(x-1)$. Hence, ignoring the term in $(x-1)^5$ and higher powers, find the approximate value for $\ln 0.9$, correct to 5 decimal places.

(b) A curve is given by

$$3y^2 + x^2y^3 - 5x^2 + 3 = 0.$$

Find

(i) the equation of the tangent, and

(ii) the equation of the normal

to the curve at $(1,-1)$.

(c) Given the curve $x^2 - y^2 = 16$, where $4 \le x \le 8$, find the volume generated when the area bounded by the curve and the $x-$axis is rotated about the $x-$axis.

7. (a) Evaluate the integral $\int \sin 3x \cos 4x \, dx$

(b) Given that $I_n = \int_0^{\frac{\pi}{2}} \cos^n x \, dx$, where $n \ge 2$, show that

$$I_n = \frac{n-1}{n} I_{n-2}.$$

Hence find I_3.

(c) Find the length of the arc of the curve $y = 3x^{3/2} - 1$, from $x = 0$ to $x = 1$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS 2010/2011

M231 – REAL ANALYSIS I

Time Allowed: **Three (3) hours**

Instructions : **Attempt any five (5) questions**
All questions carry equal marks

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1. (a) Let A and B be statements. B is a logical consequence of A if for each assignment of truth values to the variables of A (and of B) such that A has a truth value T, then B also has a truth value T. Prove that B is a logical consequence of A if and only if "$A \Rightarrow B$" is a tautology.

   (b) Let A and B be non-empty sets and $f \subset A \times B$ be a function. Prove that f^{-1} is a function if and only if f is a bijection.

2. (a) Let A and B be sets. What does it mean that A and B are equivalent sets?

   (b) Let A be the set {r, s, t, u, v} and B be the set {1, 2, 3, 4, 5}, Prove that A and B are equivalent sets.

3. (a) Define a finite set.

   (b) Let A be an infinite set. Show that there exists a subset B of A, $A \neq B$ such that A and B are equivalent sets.

4. (a) Define a countable set.

   (b) Prove that the union of two countable sets is countable

   (c) If $\forall\, n \in \mathbf{N}$, A_n is a countable set, prove that $\bigcup_{n \in \mathbf{N}} A_n$ is countable.

5. (a) Define a totally ordered field.

(b) Let $(\mathbf{F},+,\cdot,P)$ be a totally ordered field. Prove the following

(i) If $x \in P$ then $x^{-1} \in P$,

(ii) If $0 \neq 1$ then $1 \in P$

(c) Let $(\mathbf{F},+,\cdot,P)$ be a totally ordered field. Suppose $a, b \in \mathbf{F}$. Prove that $a \leq b$ and $b \leq a \Rightarrow a = b$

6. Let $(\mathbf{F},+,\cdot,P)$ be a totally ordered field and S be a subset of $\mathbf{F}$.

(a) Define the following:

(i) Least upper bound of S, (l.u.b.S)

(ii) Greatest lower bound of S, (g.l.b.S)

(b) Let $u \in \mathbf{F}$ be the least upper bound of S. Show that u is an upper bound of S and $\forall\ x \in \mathbf{F},\ x < u \Rightarrow \exists\, s \in S \ni x < s \leq u$.

(c) Let $l \in \mathbf{F}$. Suppose $\forall \varepsilon > 0$,

(i) $\forall\ s \in S,\ l - \varepsilon < s$ s, and

(ii) $\exists\, s \in S \ni s < l + \varepsilon$.

Prove that l = g. l. b. S

7. (a) If $a \in \mathbf{R}$, define the absolute value of a denoted by $|a|$.

(b) Let $a, c \in \mathbf{R}$ with $c \geq 0$. Prove that $|a| \leq c$ if and only if $-c \leq a \leq c$.

(c) Let $a, b \in \mathbf{R}$. Prove the following:

(i) $|a+b| \leq |a| + |b|$

(ii) $\big||a| - |b|\big| \leq |a-b|$.

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics

2010/11 ACADEMIC YEAR
FISRT SEMESTER FINAL EXAMINATIONS

M331 – REAL ANALYSIS III

10th November, 2010

INSTRUCTIONS: 1. Answer any **Five (5)** Questions Only.

2. All questions carry equal marks.

3. Indicate the question number for each question attempted on the cover of the main answer book.

TIME ALLOWED: **Three (3)** hours.

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1. (a) Let **R** be the set of all real numbers.

(i) When is a point $x \in \mathbf{R}$ a limit point of a subset of **R**

(ii) When is a set said to be a closed set in **R**

(iii) When are two sets said to be separated.

(b) Prove

(i) Let A be a subset of **R**. A real number x is a limit point of $A \Leftrightarrow \exists$ a sequence $\{x_n\}_{n=1}^{\infty}$ in $A \ni x_n \to x$ as $n \to \infty$.

(ii) The closure of A, $\overline{A}$ is a closed set.

(c) Prove that two closed subsets F_1 and F_2 of **R** are separated $\Leftrightarrow$ they are disjoint.

2. (a) Let **R** be a set of all real numbers. Give the definition of each of the following:

(i) interior point a subset of **R**

(ii) open set in **R**

(iii) disconnected set of **R.**

(b) Prove

(i) A subset A of **R** is open $\Leftrightarrow$ its complement is closed.

(ii) The intersection of any finite number of open sets is open.

(c) Prove that if two connected sets are not separated, their union is connected.

3. (a) Let **R** be a set of all real numbers. Define

(i) open covering of a subset of **R**

(ii) finite subcovering of a subset of **R**

(iii) compact subset of **R**

(b) (i) Let $A = \{x\} \cup \{x_n : n \in \mathbf{N}\}$, where $x_n \to x$ as $n \to \infty$. Prove that if $\mathscr{C}$ is an open covering of A, then A is covered by finitely many of the sets in $\mathscr{C}$.

(ii) Let $A = (1,3)$. Prove that A is not compact..

(c) Prove that every nonempty compact set $A \subset \mathbf{R}$ has a largest element and smallest element.

4. Suppose that f is a function with domain $D(f)$ and range in the set of real numbers **R.**

(a) When is f said to be continuous at $a \in D(f)$?

(b) Let $a \in D(f)$. Prove that f is continuous at a if and only if

$\forall\, \varepsilon > 0, \exists\, \delta(\varepsilon) > 0 \ni$ if $x \in D(f)$ and $|x - a| < \delta(\varepsilon)$ then

$|f(x) - f(a)| < \varepsilon$.

(c) Let $a \in D(f)$ and $\{x_n\}_{n=1}^{\infty}$ a sequence in $D(f)$ such that $\lim_{n\to\infty} x_n = a$. If f is continuous at a, prove that $\lim_{n\to\infty} f(x_n) = f(a)$.

5. (a) Let f have domain $D(f)$ and range in the set of real numbers **R**. Let $A \subset D(f)$. When is f said to be uniformly continuous on A?

(b) Let f be a continuous function with domain $D(f)$ and range in the set of real numbers **R**. If $K \subset D(f)$ is compact prove that f is uniformly continuous on K.

(c) Let $h:[0,1) \to \mathbf{R}$ be defined by $h(x) = \dfrac{x}{1-x}$. Prove that h is continuous on $[0,1)$ but that h is not uniformly continuous on $[0,1)$.

6. (a) Define each of the following:

(i) pointwise convergence of a sequence of real valued functions;

(ii) uniform convergence of a sequence of real valued functions.

(b) Let $\{f_n\}_{n=1}^{\infty}$ be a sequence of functions such that $\forall\, x \in I \subset \mathbf{R}$, $\lim_{n\to\infty} f_n(x) = f(x)$ and $M_n = l.u.b.\{|f_n(x) - f(x)| : x \in I\}$. Prove that $\{f_n\}_{n=1}^{\infty}$ converges uniformly to f if and only if $\lim_{n\to\infty} M_n = 0$.

(c) If $f_n(x) = \dfrac{x^n}{n}$ in $0 < x < 1$, prove that $\{f_n\}_{n=1}^{\infty}$ converges uniformly in $[0,1]$.

7. (a) Let $f:[a,b] \to \mathbf{R}$.

(i) When is f said to be of bounded variation?

(ii) If f is of bounded variation, define the total variation of f on $[a,b]$.

(b) Let $f:[a,b] \to \mathbf{R}$ be of bounded variation and $V_f(a,b)$ be the total variation of f on $[a,b]$. Define $V:[a,b] \to \mathbf{R}$ by $V(x) = V_f(a,x)$ if $a < x \le b$ and $V(a) = 0$. Prove the following:

(i) V is an increasing function on $[a,b]$;

(ii) $V - f$ is an increasing function on $[a,b]$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

MATHEMATICS AND STATISTICS DEPARTMENT

2010 ACADEMIC YEAR

FIRST SEMESTER FINAL EXAMINATIONS

M335: TOPOLOGY

Time Allowed: Three (3) hours

Instructions: Answer **any** four (4) Questions
Full Credit will only be given where necessary work is given.

1. a) Define the following:
   (i) Product of n sets

   (ii) Indexed family of sets

   (iii) Countable set

   b) Prove the following:

   (i) If f: A $\longrightarrow$ B is a function and V and W are subsets of B,

   then $f^{-1}(V - W) = f^{-1}(V) - f^{-1}(W)$

   (ii) Let $\{A_\lambda : \lambda \in \Omega\}$ be a collection of sets where $\Omega \neq \emptyset$ and D be any set

   $$then \left(\bigcap_{\lambda\epsilon\Omega} A_\lambda\right) \bigcap D = \bigcap_{\lambda\epsilon\Omega} \left(A_\lambda \bigcap D\right).$$

   (iii) If the topological spaces $(X, £_x)$ and $(Y, £_y)$ are homeomorphic, then X is compact if and only if Y is compact.

   c) (i) State the fixed point theorem.

   (ii) Prove the fixed point theorem.

2. a) Define the following in a topological space :

(i) Neighbourhood of a point

(ii) Interior of a set

(iii) Boundary point of a set

b) Prove the following:

(i) The intersection of any collection of closed sets in a topological space is closed.

(ii) If A and B are subsets of X and (X, £) is a topological space,

then int (A∩B) = int (A) ∩ int (B).

(iii) If A and B are subsets of X and (X, £) is a topological space

then $\overline{A \cup B} = \bar{A} \cup \bar{B}$.

c) Let f(x) = $|x - 2| - |x + 2|$, find the following:

(i) Range of f

(ii) Image of A = (-3, 1]

(iii) Inverse image of B = [-2, 5)

3. a) Define the following in a metric space:

(i) Open sphere

(ii) Open set

(iii) limit point of a set

b) Prove the following:

(i) If (X, d) is a metric space and E_1, E_2, ... E_n is a finite number of open sets, then their intersection is open.

(ii) An open sphere in a metric space is an open set

(iii) If (X, d) is a metric space, and x_0 is a limit point of A a subset of X, then every neighbourhood of x_0 contains infinitely many points of A

c) Let X = {a, b, c, d, e} and the topology on X be

$£_x$ = {Ø, {a}, {c}, {e}, {a, c}, {a, e}, {c, e}, {a, c, e}, X}

Y = {1, 2, 3, 4}, and the topology on Y be

$£_y$ = {Ø, {1}, {3}, {4}, {1, 3}, {1, 4}, {3, 4}, Y}

Let f(a) = 1, f(b) = f(d) = 2, f(c) = 3, f(e) = 4

(i) Is f continuous? Justify your answer

(ii) Is (X, $£_x$) connected? Justify your answer

(iii) Find the relative topology of Z = {a, d, e}

4. a) Define the following:

(i) Continuity of a function f : (A, $£_A$) ⟶ (B, $£_B$) at a point $x_0 \in A$

(ii) Homeomorphism

(iii) Subspace of a topological space

b) Prove the following:

(i) If f: (x, $£_x$) ⟶ (Y, $£_y$) is a continuous function and B is a compact subset of X, then the image of B under f is compact.

(ii) If f: [a, b] ⟶ IR is a continuous function and f(a) ≠ f(b), then for each $y \in$ IR, in between f(a) and f(b), there is a point $x \in [a, b]$ such that f(x) = y

(iii) A function f: (x, $£_x$) ⟶ (Y, $£_y$) is a continuous if and only if the inverse image of every closed set in (Y, $£_y$) is closed in (X, $£_x$).

c) Let $P_1 = (x_1, y_1)$ and $P_2 = (x_2, y_2)$ *in* IR^2,

Define $d(P_1, P_2) = \begin{cases} 1 & \text{if } y_1 \neq y_2 \text{ or } |x_1 - x_2| \geq 1 \\ |x_1 - x_2|, & \text{if } y_1 = y_2 \text{ and } |x_1 - x_2| < 1 \end{cases}$

(i) Prove that (IR^2, d) is a metric space

(ii) Describe the open sphere S_r(P), where $r = \frac{3}{4}$ and P = (0, 0)

5. a) Define the following:

(i) Hausdorff space

(ii) Connected topological

(iii) Compact topological space

b) Prove the following:

(i) If (X, £) is a compact topological space, then each closed subset of X is compact

(ii) If f: $(X, £_x) \longrightarrow (Y, £_y)$ is a continuous function, and A is a connected subset of X, then the image of A under f is a connected subset of Y.

(iii) If f: $(X, £_x) \longrightarrow (Y, £y)$ is a one-one onto function where X is compact and $(Y, £_y)$ is a Hausdorff space, then f is a homeomorphism.

c) Let A = {a, b, c, d, e, f} and the topology on A be
£ = {Ø, {b}, {a, f}, {a, b, f}, {c, d, e}, {b, c, d, e}, {a, c, d, e, f}, A}
Let B = {b, d, f}

(i) Find int (B)

(ii) Find $\bar{B}$

(iii) Is B connected? Justify your answer.

END

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS AND STATISTICS
SEMESETER I EXAMINATIONS – 2010

M361 – MATHEMATICAL STATISTICS

INSTRUCTIONS: 1 Answer any **four (4)** questions.
2. Write down the questions attempted on the front page of the main booklet.
3. Calculators are allowed.

TIME ALLOWED: Three **(3)** hours.

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1 **(a)** Define the following:

(i) Joint distribution function of random variables $Y_1, Y_2, Y_3 \ldots\ldots Y_k$

(ii) Joint moment generating function of random variables $Y_1, Y_2, Y_3 \ldots\ldots Y_k$.

(b) Prove the following:

(i) If $\overline{X}$ is a sample mean of a random sample of size n from $N(\mu, \sigma^2)$ then $\overline{X}$ has a normal distribution with mean μ and variance $\frac{\sigma^2}{n}$.

(ii) If $X_1, X_2, X_3 \ldots\ldots\ldots, X_n$ are independent identically distributed random variables with distribution probability density function $f_X(x)$ and the cumulative distribution $F_X(.)$ then

$f_{Y_n}(y) = n[(F_X(y)]^{n-1} f_X(y)$ where $Y_n = \max(X_1, X_2, \ldots\ldots\ldots, X_n)$

(iii) If X and Y are jointly distributed continuous random variables with density function $f_{xy}(x, y)$ where $Z = X + Y$ then

$$f_Z(z) = \int_{-\infty}^{\infty} f_{X,Y}(x, z-x)\, dx .$$

(c) **(i)** Let $X_1, X_2 \ldots\ldots, X_n$ be a random sample of size n from a geometric distribution with parameter p.
Derive the cumulative distribution function of the minimum Y_1, and hence find the $P[Y_1 \leq 1]$.

(ii) Suppose that system components are connected in series and that the life times of the components $T_1, T_2, T_3 ..., T_n$ are independent random variables that are exponentially distributed with parameter λ. Find the distribution of T that represents the length of time the system operates and find the probability that it will operate for more than two hours.

2 **(a)** Define the following terms:

(i) the estimator $\hat{\theta}$ is a UMVUE

(ii) Relative efficiency of T_1 with respect to T_2 of unbiased estimators of θ.

(b) The n independent and identically distributed random variables $X_1, X_2, ..., X_n$ each have density function

$$f(x,\theta) = 3\theta x^2 \exp\{-\theta x^3\}, \quad x > 0, \theta > 0$$

(i) Show that the function belongs to the exponential family of distributions and find the sufficient statistics of the distribution.

(ii) Find the maximum likelihood estimator $\hat{\theta}$.

(iii) Show that $\hat{\theta}$ is a UMVUE.

(c) **(i)** The random variable X has a probability distribution function given by

$$f_X(x, \theta) = \frac{1}{\theta} e^{-\frac{x}{\theta}} \quad x > \theta.$$

Show that the two estimators $T_1 = \frac{1}{n}\sum_{i=1}^{n} X_i$ and $T_2 = X_i$, the ith observation, are unbiased and find the $RE(T_1, T_2)$.

(ii) Let $X_1, X_2, X_3 ....., X_n$ be random variables with distribution probability density function $f_X(x,\theta)$ where

$$f(x,\theta) = \frac{1}{\theta}, -\frac{\theta}{2} \leq x \leq \frac{\theta}{2}$$

Find a sufficient statistic for θ.

(d) Suppose that X has a Weibull distribution with probability distribution function given by $f(x,\lambda) = (\lambda\alpha) x^{\alpha-1} \exp(-\lambda x^{\alpha}), \quad x > 0$ with known α.

Find the maximum likelihood estimate of λ based on a sample of size n.

3 **(a)** State without proof the theorem concerning the theoretical lower bound for the variance of an estimator $T(X_1, X_2 ... X_n)$ based on the sample of size n.

(b) Let X_1 , X_2 , ..., X_n be a random sample from the probability density function

$$f(x,\theta) = \frac{2x}{\theta} e^{-\frac{x^2}{\theta}}, \quad x > 0$$

(i) Show that $\hat{\theta} = \frac{\sum_{i=1}^{n} x_i^2}{n}$ is an unbiased estimator of θ and find its variance.

(ii) Show that the variance in (i) is the least possible for any an unbiased estimator of θ.

(iii) Find its efficiency.

(c) **(i)** The random variable X has a cumulative distribution function $F_X(.)$ and that $Y = g(X)$. Show that the probability density function of Y is given by

$$f_y(y) = f_x[g^{-1}(y)] \left| \frac{\partial}{\partial y} g^{-1}(y) \right|$$

(ii) Suppose X and Y are independent standard normals.

Find the joint density of r and θ where $r = \sqrt{x^2 + y^2}$ and $\theta = \tan^{-1}\left(\frac{y}{x}\right)$.

(d) The joint density of two discrete random variables X and Y is given by the table below

		Y			
		1	2	3	4
X	1	0.1	0.05	0.02	0.02
	2	0.05	0.2	0.05	0.02
	3	0.02	0.05	0.2	0.04
	4	0.02	0.02	0.04	0.1

Find the density function for W = X – Y.

4 **(a)** Define the following terms:

(i) the likelihood function of $f_X(x,\theta)$.

(ii) an estimator $\hat{\theta}$.

(b) The crushing strength of concrete samples, in kilograms per square centimeter is modeled as a gamma distributed random variable with probability distribution function given by

$$f(x,\theta) = \frac{1}{\theta^2} \text{ x e}^{-\frac{x}{\theta}}, \quad \text{x} \geq 0$$

where θ is unknown.
Find the maximum likelihood estimate of θ based on the observations 5.4, 7.1, 6.2, 6.4 and 4.9.

(c) Prove that if U and V are independent chi-square random variables with m and n degrees of freedom respectively, then

$$X = \frac{u/m}{v/n}$$

has F – distribution with m and n degrees of freedom.

(d) Let $X_1, X_2, ..., X_n$ be a uniformly distributed random sample over the interval $(0,\theta)$.
Show that $T = \max(X_1, X_2.., X_n)$ is asymptotically unbiased estimator of θ.

5 **(a)** Define the following:

(i) Order statistics of a random sample $X_1, X_2, X_3 ..., X_n$

(ii) Power function of a rest.

(b) Prove the following:

(i) The mean squared error of an estimator is equal to the sum of the variance of the estimator and its bias squared.

(ii) If $X_1, X_2, X_3 ..., X_n$ is a sample mean of a random sample of size n from $N(\mu, \sigma^2)$ then

$$\frac{\overline{X} - \mu}{\frac{s}{\sqrt{n}}}$$ where S^2 = sample variance,

has a t distribution with $n-1$ degrees of freedom.

(c) Consider a random sample of size n from a distribution with probability density function given by

$$f_X(x) = e^{-x}, \quad x > 0,$$

Find the

(i) Joint density function of the order statistics.

(ii) density function of the smallest order statistic, Y_1

(iii) density function of the largest order statistic, Y_n

(d) Construct a power function test for testing

$H_0 : \mu = 10 \quad vs \quad H_a : \mu > 10$

where $X_1, X_2, X_3 ..., X_{16}$ is a random sample $N(\mu, 16)$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Mathematics & Statistics

FIRST SEMESTER FINAL EXAMINATIONS

12th November, 2010.

M411—Functions of a Complex Variable I

Time allowed : THREE(3) HOURS

Instructions : There are seven(7) questions. Answer **ANY FIVE (5)** questions. All questions carry equal marks. Show all your working to earn full marks.

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1. (a) Let z, z_1, z_2 be complex numbers.

(i) Show that $\overline{z_1 + z_2} = \overline{z_1} + \overline{z_2}$.

(ii) Show that $z\overline{z} = |z|^2$.

(iii) Show that $|z_1 + z_2| \leq |z_1| + |z_2|$.

(b) Let z be a complex number. Denote the real and imaginary parts of z by Rez and Imz, respectively. Prove that

$$\sqrt{2}|z| \geq |\text{Re}z| + |\text{Im}z|.$$

(c) Show that if z is any n^{th} root of unity other than unity itself then

$$1 + z + z^2 + \ldots\ldots + z^{n-1} = 0.$$

2. (a) Let z be a complex number, then we define $e^z = \exp z = \sum_{n=0}^{\infty} \frac{z^n}{n!}$; $\cos z = \sum_{n=0}^{\infty} \frac{(-1)^n z^{2n}}{(2n)!}$; and $\sin z = \sum_{n=0}^{\infty} \frac{(-1)^n z^{2n+1}}{(2n+1)!}$. Using these definitions

(i) derive the formula $\cos z = \frac{e^{iz}+e^{-iz}}{2}$.

(ii) derive the fromula $\sin z = \frac{e^{iz}+e^{-iz}}{2i}$.

(iii) deduce that $e^{iz} = \cos z + i \sin z$.

(b) Where in the complex plane is the function

$$\tan z = \frac{\sin z}{\cos z}$$

defined and analytic?

(c) Determine all the values of $(-1)^{2i}$.

3. (a) Show that the function $f(z) = |z|^2$ has a derivative only at the origin.

(b) Assuming that $f'(z)$ exists, find the differentiation formula for

$$\frac{d}{dz}(c^{f(z)}),$$

where c is a constant.

(c) The function $u(x, y) = e^x(x \cos y - y \sin y)$ is harmonic. Find a corresponding analytic function

$$f(z) = u(x, y) + iv(x, y).$$

4. (a) By writing $w - a^2 + r^2 = \rho \exp(i\phi)$, where a and r are real numbers and $r > 0$, show that the mapping $w = z^2$ transforms the circle $z = a + r\exp(i\theta)$ into a limacon $\rho = 2r(a + r \cos \phi)$.

(b) Find the image of the infinite strip $0 < y < \frac{1}{2c}$ under the transformation $w = \frac{1}{z}$. Sketch the strip and its image.

5. (a) Define a Möbius transformation.

(b) Let $z_1, z_2, z_3, z_4 \in \mathbb{C}_\infty$. Define the cross ratio (z_1, z_2, z_3, z_4).

(c) (i) Evaluate the cross ratios $(z, 2, 1, 0)$ and $w, 1, 0, i)$

(ii) Hence or otherwise, find a Möbius transformation that maps the points $2, 1, 0$ into the points $1, 0, i$, respectively.

6. (a) (i) Let γ be a closed rectifiable path in $\mathbb{C}$. Prove that for each $w \in \mathbb{C} - \gamma^*$, there is an integer

$$n(\gamma; w) = \frac{1}{2\pi i} \int_\gamma \frac{dz}{z - w}.$$

(ii) Hence, or otherwise, show that if G is a region, $f : G \to \mathbb{C}$ is analytic and γ is a closed rectifiable path with $\gamma^* \in G$, then for $w \in \mathbb{C} - \gamma^*$,

$$n(\gamma; w) f(w) = \frac{1}{2\pi i} \int_\gamma \frac{f(z)}{z - w} dz.$$

(b) Let $1 < \rho < 3$, $\gamma(t) = \rho e^{it}$, for $t \in [0, 2\pi]$. Evaluate

$$\int_\gamma \frac{4z + 3}{z(z + 2)(z - 3)} dz.$$

7. (a) Let G be an open set in $\mathbb{C}$, $f : G \to \mathbb{C}$ analytic and $R = \sup\{|z - a| : z \notin G\}$. Prove that there exists a sequence $\{a_n\}_{n=1}^\infty$ such that

$$f(w) = \sum_{n=0}^{\infty} a_n (w - a)^n, \text{for } |w - a| < R.$$

(b) Give the power series expansion of $\log z$ about the point $z = i$ and find its radius of convergence.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

2010 ACADEMIC YEAR
FIRST SEMESTER EXAMINATIONS

M461: MULTIVARAITE ANALYSIS

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS:

1. **ALL** questions carry equal marks.
2. Answer any **FOUR** (4) Questions.
3. Show All your working.
4. Calculators are **Allowed**.
5. Statistical TABLES are provided.

---

1. (a) Let $\mathbf{X}$ be distributed as $N_3(\mu, \Sigma)$, where

$$\mu = \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix} \text{ and } \Sigma = \begin{bmatrix} 4 & 0 & -1 \\ 0 & 5 & 0 \\ -1 & 0 & 2 \end{bmatrix}$$

   i. Investigate the independence of the following:
      A. (X_1, X_3) and X_2;
      B. X_2 and $X_1+3X_2-2X_3$.

   ii. Find the vector $\mathbf{a} = \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$ such that $X_1 + X_3$ and $X_2 - \mathbf{a}' \begin{bmatrix} X_1 \\ X_3 \end{bmatrix}$ are independent.

   iii. Find the distribution of $3X_1 - 2X_2 + X_3$.

   (b) Let $\mathbf{X}_1, \mathbf{X}_2, \mathbf{X}_3, \ldots, \mathbf{X}_{60}$ be a random sample from a 4-variate normal distribution with mean vector μ and covariance matrix Σ. Show that the distribution of

$$(\mathbf{X} - \mu)' \Sigma^{-1} (\mathbf{X} - \mu)$$

   is approximately Chi-square with 4 degrees of freedom (χ^2_4).

(c) A researcher considered three indices measuring severity of heart-attacks. The values of these indices for $n = 40$ patients of heart-attack arriving at a hospital emergency room produced the following summary statistics.

$$\overline{\mathbf{X}} = \begin{bmatrix} 46.1 \\ 57.3 \\ 50.4 \end{bmatrix} \text{ and } \mathrm{S} = \begin{bmatrix} 101.3 & & \\ 63.0 & 80.2 & \\ 71.0 & 55.6 & 97.4 \end{bmatrix}$$

i. All three indices are evaluated for each patient. Test the equality of indices with $\alpha = 5\%$.

ii. Judge the differences in pairs of mean indices using the simultaneous confidence interval.

2. (a) State the main objectives of classification.

(b) Let $\mathbf{X}_1$, $\mathbf{X}_2$, $\mathbf{X}_3$, $\mathbf{X}_4$, $\mathbf{X}_5$ be independent and identically distributed p-variate normal random vectors with mean vector μ and covariance matrix Σ.

i. Find the marginal distributions of the random vectors

$$\tfrac{1}{5}\mathbf{X}_1 + \tfrac{1}{5}\mathbf{X}_2 + \tfrac{1}{5}\mathbf{X}_3 + \tfrac{1}{5}\mathbf{X}_4 + \tfrac{1}{5}\mathbf{X}_5 \text{ and } \mathbf{X}_1 - \mathbf{X}_2 + \mathbf{X}_3 - \mathbf{X}_4 + \mathbf{X}_5.$$

ii. Find the joint density of the random vectors in Part (i).

(c) Improved anesthetics are often developed by first studying their effects on animals. In one such study, 19 dogs were initially given the drug Pentobarbitol. Each dog was then administered CO_2 at each of the two pressure levels, low and high. Then Halothane was added and administration of CO_2 was repeated. The response, millimseconds between heartbeats, was measured for the treatment combination. The data produced the following summary statistics:

$$\overline{\mathbf{X}} = \begin{bmatrix} 368.21 \\ 404.63 \\ 479.26 \\ 502.89 \end{bmatrix} \text{ and } \mathrm{S} = \begin{bmatrix} 2819.29 & & & \\ 3568.42 & 7963.14 & & \\ 2943.49 & 5303.98 & 6851.32 & \\ 2292.35 & 4065.44 & 4499.63 & 4878.99 \end{bmatrix}$$

i. Identify the treatments for each subjects.

ii. Using information in Part (i), derive the contrasts of all the treatment effects and hence the contrast matrix C.

iii. Show that

$$\mathrm{C}\overline{\mathbf{X}} = \begin{bmatrix} 209.31 \\ -60.05 \\ -12.79 \end{bmatrix} \text{ and } \mathrm{CSC}' = \begin{bmatrix} 9432.32 & & \\ 1098.92 & 85195.84 & \\ 927.62 & 914.54 & 7557.44 \end{bmatrix}$$

where C is the contrast matrix.

iv. Using the simultaneous confidence intervals, deduce the conclusion of the hypothesis of no treatment effect at 5% level of significance.

v. Does CO_2 and Halothane have any anesthetizing effect on the subjects?

3. (a) Let $\mathbf{X}$ be a vector random variable with mean vector $\mu_{\mathbf{X}}$ and covariance matrix $\Sigma_{\mathbf{X}}$. Show that

$$E(\mathbf{X}\mathbf{X}') = \mu_{\mathbf{X}}\mu_{\mathbf{X}}' + \Sigma_{\mathbf{X}}.$$

(b) Using Moody's rating, samples of 20 A (middle-high quality) corporate Bonds and 20 B (top-medium quality) corporate Bonds were selected. For each of the corresponding companies the ratios,

$$\begin{aligned} X_1 &= \text{Current ratio} \\ X_2 &= \text{Long term interest rates} \\ X_3 &= \text{Debt-equity ratio} \\ X_4 &= \text{Rate of return on equity} \end{aligned}$$

were recorded. The summary statistics are as follows:

$$\overline{\mathbf{X}}_A = \begin{bmatrix} 2.287 \\ 12.600 \\ 0.347 \\ 14.830 \end{bmatrix}, \overline{\mathbf{X}}_B = \begin{bmatrix} 2.404 \\ 7.155 \\ 0.524 \\ 12.840 \end{bmatrix}, \mathrm{S}_A = \begin{bmatrix} 0.459 & & & \\ 0.254 & 27.465 & & \\ -0.026 & -0.589 & 0.030 & \\ -0.244 & -0.267 & 0.102 & 6.854 \end{bmatrix} \text{ and}$$

$$\mathrm{S}_B = \begin{bmatrix} 0.944 & & & \\ -0.089 & 16.432 & & \\ 0.002 & -0.004 & 0.024 & \\ -0.719 & 19.044 & -0.094 & 61.854 \end{bmatrix}$$

i. Compute the common covariance matrix, assuming populations with the same covariance matrices.

ii. Construct the 95% simultaneous confidence intervals for mean differences of financial characteristics.

iii. Are the financial characteristics of firm with A bonds generally different from those with B bonds?

4. (a) Evaluate T^2, for testing H_0: $\mu' = [7, 11]$, using the data

$$\mathbf{X}' = \begin{bmatrix} 2 & 8 & 6 & 8 \\ 12 & 9 & 9 & 10 \end{bmatrix}$$

i. What is the distribution of T^2?

ii. Test H_0 at $\alpha = 0.05$ level.

iii. If each observation $\mathbf{X}_j$, $j = 1, 2, 3, 4$ is replaced by $\mathbf{CX}_j + \mathbf{d}$, where

$$\mathbf{C} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \text{ and } \mathbf{d} = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix}$$

Show that the T^2 is invariant under affine transformations.

(b) In an experimental program to determine bone loss, 24 subjects are studied. Measurements of bone mineral contents were taken from the subjects at the begining of the program and a year later. For each subject the bone mineral contents measurements on,

$$\begin{aligned} X_1 &= \text{Dominant radius} \\ X_2 &= \text{Radius} \\ X_3 &= \text{Dominant humerus} \\ X_4 &= \text{Humerus} \\ X_5 &= \text{Dominant ulna} \\ X_6 &= \text{Ulna} \end{aligned}$$

were recorded. The following summary statistics computed:

$$\overline{\mathbf{d}} = \begin{bmatrix} 0.00012 \\ -0.00325 \\ -0.00717 \\ -0.01233 \\ 0.01513 \\ 0.00017 \end{bmatrix}, \mathrm{S}_d = \begin{bmatrix} 0.0023 & & & & & \\ 0.0003 & 0.0008 & & & & \\ 0.0036 & 0.0007 & 0.0106 & & & \\ 0.0014 & 0.0005 & 0.0037 & 0.0039 & & \\ 0.0006 & -0.0001 & -0.0002 & -0.0003 & 0.0009 & \\ -0.0001 & -0.0001 & -0.0006 & -0.0004 & 0.0003 & 0.0022 \end{bmatrix}$$

i. Construct the 95% Boniferroni confidence intervals for the mean differences.

ii. Determine whether there has been bone loss at 5% level of significance.

5. (a) State two important features of an "optimal" classification method or technique.

(b) A researcher want to determine a procedure for discriminating between two multivariate populations. The researcher has enough data available to estimate the density function of $f_1(\mathbf{x})$ and $f_2(\mathbf{x})$ associated with populations π_1 and π_2, respectively. Let $c(2|1) = 50$ and $c(1|2) = 100$. Further, it is known that 20% of all possible items belong to π_2.

i. Give the minimum Expected Cost of Misclassification (ECM) rule for assigning a new item to one of the two populations.

ii. Measurement recorded on a new item yield the density values $f_1(\mathbf{x}_o) = 0.3$ and $f_2(\mathbf{x}_o) = 0.7$. To which population does $\mathbf{x}_o$ belong?

(c) In the first phase of a study of the cost of transporting milk from farms to dairy plants, a survey was taken of firms engaged in milk transportation. Cost data on

$$\begin{aligned} X_1 &= \text{Capital} \\ X_2 &= \text{Repairs} \\ X_3 &= \text{Fuel}, \end{aligned}$$

all measured on a per-mile basis, were recorded for 36 and 23 gasoline and diesel trucks respectively. Summary statistics are given below:

$$\overline{\mathbf{X}}_D = \begin{bmatrix} 10.11 \\ 10.76 \\ 18.17 \end{bmatrix}, \overline{\mathbf{X}}_G = \begin{bmatrix} 12.22 \\ 8.11 \\ 9.59 \end{bmatrix}, \mathrm{S}_D = \begin{bmatrix} 4.36 & & \\ 0.76 & 25.85 & \\ 2.36 & 7.69 & 46.65 \end{bmatrix} \text{ and}$$

$$\mathrm{S}_G = \begin{bmatrix} 23.01 & & \\ 12.37 & 17.54 & \\ 2.91 & 4.78 & 13.96 \end{bmatrix}$$

i. Construct 99% simultaneous confidence intervals for the pairs of mean components.

ii. Which components, if any, appear to be quite different?

iii. On the basis of the results in Part (i) and (ii), what is the conclusion of the test of the hypothesis of no difference in the mean costs vectors?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

MATHEMATICS AND STATISTICS DEPARTMENT

M465: Non-Parametric Statistics

First Semester Final Examinations November, 2010

Time Allowed: Three (3) hours

Instructions:
- Answer **any four (4)** Questions
- Full Credit will only be given where **all necessary** work is shown.

---

1. a) (i) What are the assumptions made to use Wilcoxon signed rank test for location.

(ii) Derive the mean and variance for the Wilcoxon signed rank test statistics.

b) On the survival lifetime after infection with the TB germ, a study involved lifetimes of 24 guinea pigs infected with tubercle bacilli (TB germ). The animals were observed over a period and their times of death in days were recorded are as follows :

76	93	97	107	108	113	114	119	136	166	119	168
137	164	125	169	127	181	182	132	134	183	190	99

Test the hypothesis at 0.05 level of significance that the median lifetime is more than 110 days.

(I) Use the sign test.
(II) Use Wilcoxon signed rank test.

c) An environment impact study examined the relationship between the depth of a stream and the rate of its flow. The data on ten randomly selected points were collected and are given below.

	1	2	3	4	5	6	7	8	9	10
Depth	3.4	2.9	2.8	4.2	2.9	4.1	7.6	7.3	4.6	4.0
Flow rate	63.6	31.9	73.4	132.7	48.7	92.4	735.0	589.0	197.9	112.4

(I) Compute Spearman rank correlation coefficient.
(II) Compute Kendall's Tau.

2) a) Records of 317 patients who were diagnosed as having endometrial carcinoma (some form of cancer) were obtained from two hospitals. Matched controls for each case were obtained. Each control was matched for major possible confounding variables. The table below gives the number of cases and controls who had taken estrogen for at least a year and those that hadn't taken estrogen.

	Cases (Cancer)		
Controls	Estrogen used	Estrogen not used	**Totals**
Estrogen Used	39	15	54
Estrogen Not used	113	150	263
Totals	152	165	317

Is there a significant relationship between estrogen use and endometrial cancer?

b) (i) What are the assumptions made to use the median test.

(ii) For the median test a = $\sum_{j=1}^{k} 0_{1j}$, $b = \sum_{j=1}^{k} 0_{2j}$, $N = \sum_{j=1}^{k} n_j$, and a + b = N. Show that if a = b, then

$$\frac{N^2}{ab}\sum_{j=1}^{k}\frac{\left(0_{1j} - n_j\frac{a}{N}\right)^2}{n_j} = \sum_{j=1}^{k}\frac{\left(0_{1j} - 0_{2j}\right)^2}{n_j}$$

c) The life times to failure (in hours) of 16 strands tested at a specified stress level are given below.

1.5 13.0 30.5 0.5 9.5 15.0 0.5 9.5 15.5

9.0 11.0 13.0 16.0 9.0 21.5 1.5

The mean for the data is 11.03.

Can one conclude at 0.05 level of significance that the data came from an exponential distribution.

3) a) Two methods (A and B) were used in the determination of latent heat of fusion of ice. The investigators wished to find out whether the two methods differed. The following data, the change in total heat from ice to water in calories per gram mass.

Method A: 79.9 80.4 80.2 80.4 80.3 80.3 80.4 79.8 80.5 80.3 80.2 80.0 80.2

Method B: 80.2 79.7 80.0 79.9 79.6 80.3 80.1 80.4

Is there significance difference between the two methods in determining the latent heat o fusion?

b) An experiment was performed to determine whether three forms of iron (A, B, C) are retaine differently. The investigators randomly divided 29 mice into three groups of 8, 10 and 11. Th mice were given iron orally. The iron was radioactively labeled so that a counter could be use to measure the initial amount given. At a later time, another counter was taken for eac mouse, and the percentage of iron retained was calculated. The data is given below:

A:	1.6	0.7	2.4	3.3	3.7	2.1	2.6	3.1		
B:	2.2	5.8	3.9	6.8	3.8	4.2	2.5	5.5	6.2	5.6
C:	4.4	4.9	4.2	5.8	6.1	5.4	5.6	5.7	6.0	4.3 4.8

(I) Use kruskall-walis test to determine whether the three forms of iron are retaine differently at $\alpha = 0.05$.

(II) Do a multiple comparison test if necessary.

c) For the data given in b) above analyse it using the median test (Do <u>not</u> perform multiple comparison).

4) a) A Marketing research consultant evaluated the effects of fee schedule (A_1, A_2, A_3), Scope of work (B_1, B_2) and type of supervisory control (c_1, c_2, c_3, c_4), on the quality of work performed under contract by independent marketing research agencies. The quality of work was measured by an index taking into account several characteristics of quality. The data was as follows:

	B_1			B_2		
	A_1	A_2	A_3	A_1	A_2	A_3
C_1	124	119	91	113	114	79
C_2	121	118	95	110	109	81
C_3	122	125	89	114	108	84
C_4	123	121	92	109	112	77

(I) Are there differences among the fee schedules on quality of work?

(II) Are there differences among the type of supervisory control on quality of work.

b) Two different brands of Nokia cell-phone batteries were studied for battery life-time. The lifetime (in months) of each type is given below.

Brand A:	45	38	52	47	45	42	43	39	44	50
Brand B:	54	48	46	40	50	46	43	48	57	48

Can one conclude that the distributions of the lifetimes of the two brands of batteries are the same.

C) A nutrition status survey of 200 under five years old children found that 60 children were from female headed households, while the remaining 140 were from male headed households. Among the children from female headed households, 30 were malnourished while 49 children from male headed households were malnourished. Can one say that a child from a female headed household is more at risk of being malnourished?

5. a) Fat content for twenty randomly selected cup serving of chocolate ice-cream brand gave the following data:

9.5	8.5	7.8	9.3	8.6	10.0	10.6	9.6	8.1	10.5
9.5	8.5	9.6	9.3	9.3	10.6	8.1	9.2	9.2	9.6

The mean and standard deviation for the data are 9.27 and 0.81 respectively. Can one say that the distribution of fat content per cup serving of chocolate ice-cream is normal.

b) Show that if there are no ties the Kruskal – Wallis test statistic reduces to

$$\frac{\sum_{j=1}^{k} \frac{R_j^2}{n_j} - \frac{N(N+1)^2}{4}}{\frac{1}{N-1}\left(\sum_{j=1}^{k}\sum_{i=1}^{n_j} R^2(x_{ij}) - \frac{N(N+1)^2}{4}\right)} = \frac{12}{N(N+1)}\sum_{j=1}^{k}\frac{R_j^2}{n_j} - 3(N+1)$$

c) The concentrations (in monograms per milliliter) of plasma epinephrine were measured fo twelve dogs under isofluorane and cyclopropane anesthesia. The measurements are giver below. Is there a difference in the median concentration of plasma epinephrine at 0.05 leve of significance?

Dog	1	2	3	4	5	6	7	8	9	10	11	12
Isofluorance	2.8	5.1	10.0	2.9	3.6	8.8	6.9	1.7	3.3	2.9	6.8	3.9
Cycropropane	10.7	13.5	6.9	12.4	15.3	4.9	5.6	10.2	3.0	3.8	3.9	5.1

(i) Use sign test.

(ii) Use Wilcoxon signed rank test.

END

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Mathematics and Statistics

2010 Academic Year

Semester I

M911 Mathematical Methods V

FINAL EXAMINATION

Time Allowed: Three (3) Hours **4th November, 2010.**

Instructions:

1. You must write your **Computer Number**, on each answer booklet you have used.

2. There are Six (6) questions in this paper, Attempt **Any Five (5)** questions. All questions carry equal marks

3. Should you have any problem or if you need more answer booklet(s), put up your hand, an invigilator will come to attend to you.

1. (a) The equation $x^2+2y^2+3z^2-2xy-2yz=2$ defines z as a function of x and y say $z=\Phi(x,y)$.

(i) Find the partial derivatives $\frac{\partial\Phi}{\partial x}$ and $\frac{\partial\Phi}{\partial y}$

(ii) Hence find the points $(x\,,\,y)$ at which Φ has a local maximum or a local minimum.

(b) (i) A surface is given by the equation $4y^2+z^2-x-16y-4z+20=0$. Reduce the equation to one of the standard forms and classify the surface.

(ii) Find the Taylor polynomial of degree two which approximates the function $f(x,y)=e^x\sin y$ at the point $\left(2\,,\frac{\pi}{4}\right)$.

2. (a) (i) The temperature distribution on a metal plate is given by $T(x,y)=50-x^2-2y^2$. Find the path of a heat – seeking particle which starts at the point $(4\,,3)$ on the metal plate as it continuously moves in the direction of maximum temperature increase.

(ii) Find the relative extreme points of the function $f(x,y)=-x^3+4xy-2y^2+1$.

(b) The transformation $u=x^2-y^2$, $v=2xy$ maps the region $D=\{(x\,,\,y);0\le x\le 2\,,0\le y\le 2\}$ onto the region R and is one – to – one.

(i) Find the area of the region R by integrating over D.

(ii) Find the value of the integral $\iint_R v\,du\,dv$

3. (a) Let r and h be positive numbers. A helix is given parametrically by $\mathbf{X}(t)=r\cos t\,\mathbf{i}+r\sin t\,\mathbf{j}+ht\,\mathbf{k}$ for $0\le t\le 6\pi$.

(i) Find in terms of r and h the arc length of the helix in the interval $0\le t\le 6\pi$.

(ii) Obtain a reparametrization of the helix by arc length.

(b) (i) Find the traces of the surface $-x^2+4y^2-z^2=4$ in the planes $x=k$, $y=k$ and $z=k$. Identify the surface.

(ii) A rectangular box, open at the top, is to have a volume of 32cm^3. Find the dimensions of the box so that the total surface area is minimum.

4. (a) Let $\mathbf{F}(x,y,z) = ye^z\mathbf{i} + xe^z\mathbf{j} + xye^z\mathbf{k}$ be a vector field.

(i) Show that $\mathbf{F}$ is exact.

(ii) Find the potential function $f(x,y,z)$ such that $\nabla f = \mathbf{F}$

(b) (i) Let $f(x,y,z) = x^2y^2 + y^2z^2$. Find $\nabla \bullet (\nabla f)$ and $\nabla \times (\nabla f)$

(ii) Show that the functions below are functionally dependent and find a relation that connects them.

$h(x,y,z) = x + y + z$

$f(x,y,z) = x^2 + y^2 + z^2$

$g(x,y,z) = xy + yz + xz$

5. (a) Find the directional derivative of the function $F(x,y,z) = x^2yz^3$,

(i) in the direction of $\mathbf{v} = \mathbf{i} - 2\mathbf{j} - 2\mathbf{k}$ at the point $(2, -1, 1)$

(ii) along the curve given parametrically by $x = e^{-t}$, $y = 2\sin t + 1$, $z = t - \cos t$ at the point where $t = 0$.

(b) (i) Find the angle between the normal lines to the surface $xy = z^2$ at the points $(1, 4, 2)$ and $(-3, -3, 3)$.

(ii) Use a suitable transformation to evaluate the integral $\iint_R (x+y)e^{x^2-y^2}\,dxdy$ where R is the rectangle enclosed by the lines $x - y = 0$, $x - y = 2$, $x + y = 0$ and $x + y = 3$

6. (a) (i) Find the tangent plane and the unit normal to the surface $z = x^2 + y^2$ at the point $(1, -2, 5)$.

(ii) Given that $\mathbf{r} = x\,\mathbf{i} + y\,\mathbf{j} + z\,\mathbf{k}$ and that $r = \|\mathbf{r}\| = \sqrt{x^2 + y^2 + z^2}$, find *div grad* r^m

(b) (i) Find the Jacobian, $\dfrac{\partial(x,y,z)}{\partial(r,\theta,z)}$, of the transformation $x = r\cos\theta$, $y = r\sin\theta$, $z = z$.

(ii) Find the mass of the ellipsoidal solid Ω given by the equation $4x^2 + 4y^2 + z^2 = 16$ lying above the xy – plane if the density at any point in the solid is given by $\rho(x,y,z) = kz$ where k is a constant.

End of Exam.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Mathematics and Statistics

2010 Academic Year

Semester I

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End of Exam.

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

OCTOBER 2010

MI 461: GEOSTATISTICS

TIME : THREE [3] HOURS FULL MARKS : 100
INSTRUCTIONS: ANSWER QUESTION 5 AND ANY OTHER THREE (3)

QUESTION 1

a) Clearly define the following terms commonly used in geostatistics with suitable formulae where necessary:

- **i.** Coefficient of variation (CV)
- **ii.** Skewness (σ^3)
- **iii.** Kurtosis (σ^4)
- **iv.** Isotropy
- **v.** Anisotropy
- **vi.** Nugget
- **vii.** Spatial variance
- **viii.** Correllogram **[8 Marks]**

b) Why is it important to check whether the company has surveyed its drillholes to ensure that they are indeed vertical (consider also, that the data is to be used later for geostatistical analysis **[7 Marks]**

c) State **five** characteristics for **vein deposits** **[10 Marks]**

[Total: 25 Marks]

QUESTION 2

a) Briefly describe the following estimation methods with the aid of suitable diagrams:

- **i.** Method of sections
- **ii.** Polygonal methods (site one method)
- **iii.** Random stratified grid (RSG)
- **iv.** Inverse distance weighting **[12 Marks]**

b) State three disadvantages associated with polygonal methods and method of sections **[6 Marks]**

c) Define **grade** and explain ~~how~~ its significance in grade tonnage-relationship **[5 Marks]**

d) Differentiate between accuracy and precision in quality analysis **[2 Marks]**

[Total: 25 Marks]

QUESTION 3

a) Briefly explain the problems encountered during structural analysis **[5 Marks]**

b) Construct a robust **experimental variogram** at 10m vector lag distance up to lag 6 for grade values obtained from a diamond drilling campaign shown in **Table 1**, and **fit** with a suitable variogram model **[10 Marks]**

c) Determine the values for nugget, spatial variance, range and sill? **[5 Marks]**

[Total: 25 Marks]

QUESTION 4

Figure 1 shows directional semi-variogram for the initial data obtained from diamond drilling for a newly discovered Zinc deposit.

a) Briefly discuss how tolerances can be used to help construct robust directional variograms **[5 Marks]**

b) Construct a **ROSE DIAGRAM** for the directional variograms given in **Figure 1** **[10 Marks]**

c) What do the values in **(b)** tell you about the nature and continuity of mineralisation in the deposit? **[5 Marks]**

[Total: 25 Marks]

QUESTION 5

a) Calculate the grade and tonnages associated with blocks A, B and C and use these to calculate global grade and tonnage for the blocks in Figure 3 and Table 2 given that ore bulk density factor is **2.74t/m^3**. **[8 Marks]**

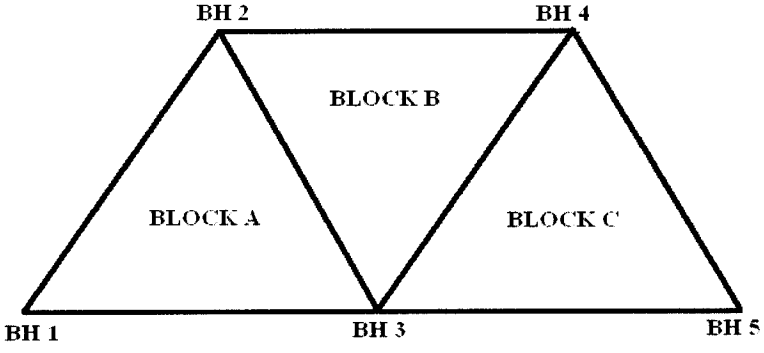


Figure 3: Triangulated blocks

Table 2: Diamond drill assay data

Drillhole	Intercept (m)	Average grade (% Cu)
BH1	2.25	4.99
BH2	8.18	2.92
BH3	6.60	2.72
Bh4	3.15	5.60
BH5	3.05	4.97

Block	Plan area (m^2)
A	7750
B	9375
C	6575

b) Kriging is also called BLUE. Why is kriging also called **BLUE** and what does the acronym **BLUE** stand for? **[3 Marks]**

c) State the Cokriging matrix equation of the form C x W = D **[4 Marks]**

d) Determine unbiased kriging weights $\mathbf{W_1}$, $\mathbf{W_2}$ and $\mathbf{W_3}$ using locations 2, 3 and 5 for the data given in **Figure 2** and **Table 3** **[9 Marks]**

[Total: 25 Marks]

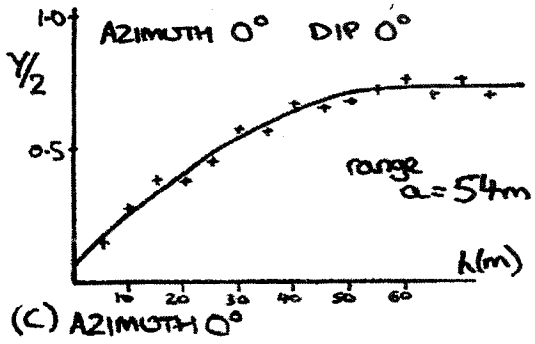
APPENDICES

QUESTION 3 TABLE

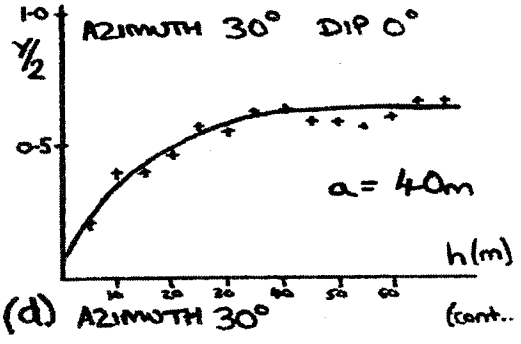
TABLE 1: GRADE VALUES FOR QUESTION 3 (TO BE READ COLUMN WISE)

Sample number	Eastings (X)	Northings (Y)	Grades
1	45000	77200	9.14
2	45500	77700	8.01
3	46000	78200	7.19
4	46500	78700	7.95
5	47000	79200	6.68
6	47500	79700	6.82
7	48000	80200	8.77
8	48500	80700	3.44
9	49000	81200	4
10	49500	81700	2.6
11	50000	82200	2.93
12	50500	82700	4.28
13	51000	83200	4.91
14	51500	83700	1.61
15	52000	84200	1.74

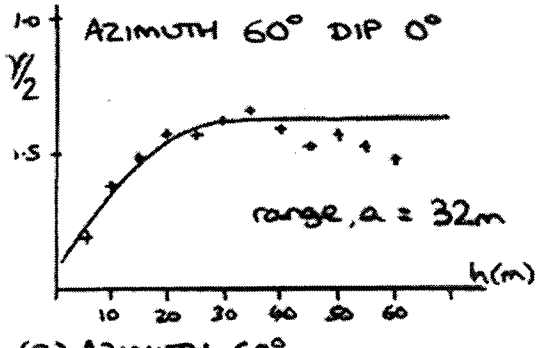
QUESTION 4 FIGURES



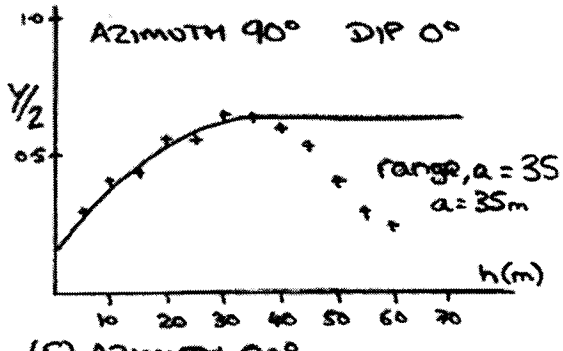
(c) AZIMUTH 0°



(d) AZIMUTH 30° (cont..



(e) AZIMUTH 60°



(f) AZIMUTH 90°

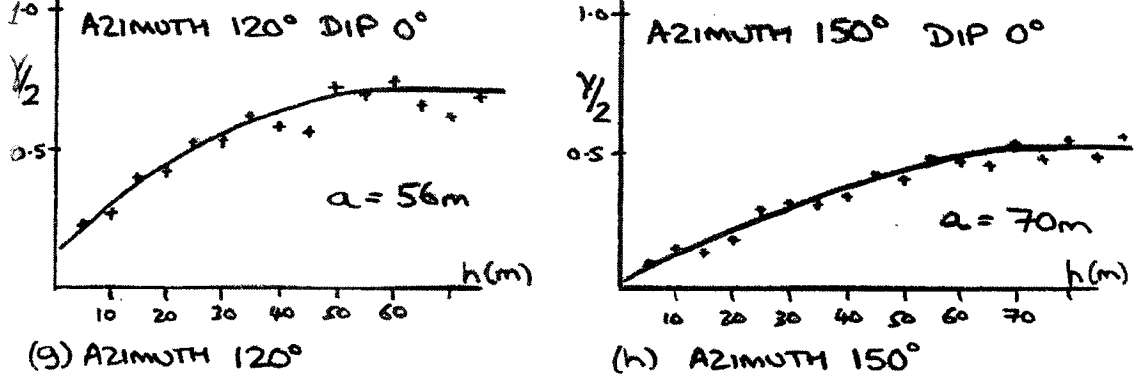


FIGURE 2 SHOWING VAROGRAMS FOR QUESTION 4

QUESTION 5 FIGURES AND TABLES

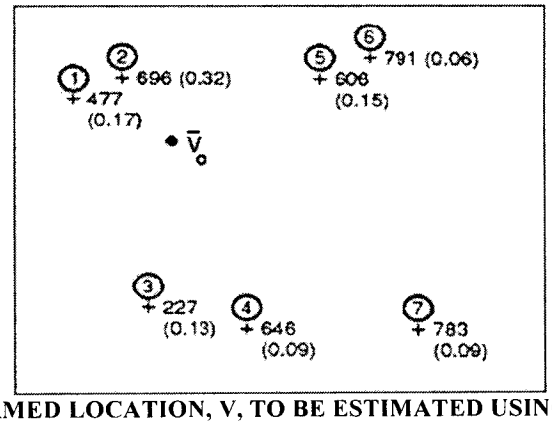


FIGURE 2: UNINFORMED LOCATION, V, TO BE ESTIMATED USING SEVEN INFORMED LOCATIONS FOR QUESTION 5C

TABLE 3 FOR QUESTION (5C): DISTANCES BETWEEN ALL POSSIBLE PAIRS FOR 7 DATA LOCATIONS

Distance between every pair of locations								
Location	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0	0	4.47	3.61	8.06	9.49	6.71	8.94	13.45
1	4.47	0	2.24	10.44	13.04	10.05	12.17	17.8
2	3.61	2.24	0	11.05	13	8	10.05	16.97
3	8.06	10.04	11.05	0	4.12	13.04	15	11.05
4	9.49	13.04	13	4.12	0	12.37	13.93	7
5	6.71	10.05	8	13.04	12.37	0	2.24	12.65
6	8.94	12.17	10.05	15	13.93	2.24	0	13.15
7	13.45	17.8	16.97	11.05	7	12.65	13.15	0

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
2010 FIRST SEMESTER UNIVERSITY EXAMINATIONS

MP415
MATHEMATICAL METHODS FOR PHYSICS

DURATION: Three hours.

INSTRUCTIONS: Answer any four questions from the six given. *Each question carries 25 marks with the marks for parts of questions indicated.*

MAXIMUM MARKS: 100

DATE: Tuesday 26th October 2010.

Formulae that may be needed:

1. Derivative of an analytic function:

$$f^{(n)}(z_0) = \frac{n!}{2\pi i}\oint_C \frac{f(z)}{(z-z_0)^{n+1}}\,dz \qquad (n = 1, 2, \ldots).$$

2. The geometric series

$$\sum_{m=0}^{\infty} q^m = 1 + q + q^2 + \ldots$$

converges with sum $1/(1-q)$ when $|q| < 1$.

3. Ratio test 1: Series converges if $|\frac{z_{n+1}}{z_n}| \leq q < 1$, and diverges if $|\frac{z_{n+1}}{z_n}| \geq 1$ for n greater than some N.

4. Ratio test 2:

$$\lim_{n\to\infty}\left|\frac{z_{n+1}}{z_n}\right| = L.$$

5. Root test 1: Series converges if $\sqrt[n]{|z_n|} \leq q < 1$, and diverges if $\sqrt[n]{|z_n|} \geq 1$.

6. Root test 2:

$$\lim_{n\to\infty}\sqrt[n]{|z_n|} = L.$$

7. Radius of convergence of a power series:

$$\begin{aligned} R &= \frac{1}{L^*}, \quad L^* = \lim_{n\to\infty}\left|\frac{a_{n+1}}{a_n}\right| \\ R &= \frac{1}{\tilde{L}}, \quad \tilde{L} = \lim_{n\to\infty}\sqrt[n]{|a_n|} \\ R &= \frac{1}{\tilde{l}}, \quad \tilde{l} = \text{largest limit of } \lim_{n\to\infty}\sqrt[n]{|a_n|} \end{aligned}$$

8.

$$(\cosh z)' = \sinh z, \qquad (\sinh z)' = \cosh z.$$

9. Formula 1 for residue at a simple pole:

$$\operatorname*{Res}_{z=z_0} f(z) = \lim_{z\to z_0}(z-z_0)f(z).$$

10. Formula 2 for the residue at a simple pole:

$$\operatorname*{Res}_{z=z_0} \frac{p(z)}{q(z)} = \frac{p(z_0)}{q'(z_0)}.$$

11. Formula for residues of any order:

$$\operatorname*{Res}_{z=z_0} f(z) = \frac{1}{(m-1)!}\lim_{z\to z_0}\left\{\frac{d^{m-1}}{dz^{m-1}}[(z-z_0)^m f(z)]\right\}.$$

12. Residue theorem:

$$\oint_C f(z)\,dz = 2\pi i\sum_{j=1}^{k}\operatorname*{Res}_{z=z_j} f(z).$$

13. Improper integrals of rational functions of $\sin\theta$ and $\cos\theta$ (integration taken counterclockwise)

$$\int_0^{2\pi} f(z)\,\frac{dz}{iz} = 2\pi i\sum \text{Res}\left[\frac{f(z)}{iz}\right],$$

where $f(z)$ is obtained from $f(\cos\theta,\sin\theta)$ by the substitutions

$$\cos\theta = \frac{1}{2}\left(z+\frac{1}{z}\right), \qquad \sin\theta = \frac{1}{2i}\left(z-\frac{1}{z}\right).$$

14. Improper integrals of rational functions:

$$\int_{-\infty}^{\infty} f(x)\,dx = 2\pi i\sum \text{Res} f(z).$$

15.

$$e^x = 1+\frac{x}{1!}+\frac{x^2}{2!}+\frac{x^3}{3!}+\frac{x^4}{4!}+\dots$$

16. Frobenius method:

Case 1. Distinct roots not differing by an integer

$$\begin{aligned} y_1(x) &= x^{r_1}(a_0+a_1x+a_2x^2+\dots) = x^{r_1}\sum_{m=0}^{m=\infty} a_m x^m, \\ y_2(x) &= x^{r_2}(A_0+A_1x+A_2x^2+\dots) = x^{r_2}\sum_{m=0}^{m=\infty} A_m x^m. \end{aligned}$$

Case 2. Double root

$$y_1(x) = x^{r_1}(a_0 + a_1x + a_2x^2 + ...) = x^{r_1}\sum_{m=0}^{m=\infty} a_m x^m,$$

$$y_2(x) = y_1(x_2)\ln x + x^r(A_0 + A_1x + A_2x^2 + ...) = y_1(x_2)\ln x + x^{r_2}\sum_{m=0}^{m=\infty} A_m x^m, \quad (x > 0).$$

Case 3. Roots differing by an integer

$$y_1(x) = x^{r_1}(a_0 + a_1x + a_2x^2 + ...) = x^{r_1}\sum_{m=0}^{m=\infty} a_m x^m,$$

$$y_2(x) = ky_1(x)\ln x + x^{r_2}(A_0 + A_1x + A_2x^2 + ...), \quad (x > 0), \quad r_1 > r_2.$$

QUESTION 1

(a) Test whether or not the following functions are harmonic:

$$v = (x^2 - y^2)^2, \quad \text{and} \quad v = x^2 - 3xy^2$$

If it is, find the corresponding analytic function. (18 marks)

(b) Evaluate the following integral

$$\oint_C = \frac{e^{z^2}}{(2z - i)}\, dz$$

with C the unit circle in the counterclockwise sense. (7 marks)

QUESTION 2

(a) Use the method of integration by path to integrate $f(z)$ counterclockwise around the square with vortices 0, i, $1 + i$, and 1, where $f(z)$ is

$$f(z) = z.$$

Check your answer by direct integration. (14 marks)

(b) Find all the Taylor and Laurent series with center $z = 0$ and determine the precise region of convergence of each :

$$\frac{4}{1 - z^4}.$$

(6 marks)

(c) Determine the location and type of singularities of the following function:

$$f(z) = \frac{z^3 + 3z}{z^2 + 1}.$$

(5 marks)

QUESTION 3

Evaluate the following improper integral

$$\int_{-\infty}^{\infty} \frac{x}{(x^2 - 2x + 2)^2}\, dx.$$

State the conditions that must be satisfied for any formulae you may use. (25 marks)

QUESTION 4

Find the eigenvalues and eigenfunctions of the following matrix

$$A = \begin{bmatrix} 13 & 0 & -15 \\ -3 & 4 & 9 \\ 5 & 0 & -7 \end{bmatrix}.$$

(25 marks)

QUESTION 5

(a) Use the power series method to solve the following differential equation:

$$(1 - x^2)y' = 2xy.$$

(9 marks)

(b) Consider the differential equation

$$y'' + \frac{1}{2x}y' + \frac{1}{4x}y = 0.$$

(i) Obtain the indicial equation and solve it to confirm that the roots are $r_1 = \frac{1}{2}$ and $r_2 = 0$. (7 marks)

(ii) Show that the recursion relation for the coefficients is

$$a_{s+1} = -\frac{a_s}{(2s + 2r + 2)(2s + 2r + 1)}, \qquad (s = 0, 1, 2, 3, \ldots)$$

(6 marks)

iii You are given that for the root r_1 the recursion relation of part (b) becomes $a_m = [a_0(-1)^m]/(2m+1)!$ and for the root r_2 it becomes $A_m = [A_0(-1)^m]/(2m)!$. Write down the two basis solutions.

(3 marks)

QUESTION 6

(i) Beginning with the functional

$$I = \int_a^b F[y(x), \dot{y}(x)]\, dx,$$

derive the Euler-Lagrange equation. (18 marks)

(i) Show that if F does not depend on x, i.e. $F = F(y, \dot{y})$ the Euler-Lagrange equations reduce to

$$F - \dot{y}(x)\frac{\partial F}{\partial \dot{y}(x)} = constant.$$

(7 marks)

END

The University of Zambia
School of Natural Sciences
Department of Physics
2010 Academic Year First Semester
Final Examinations
P-191: Introductory Physics - I

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script cover page which questions you have attempted.

Time: Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together!!

==========

Wherever necessary use:

$g = 9.8 m/s^2$

$P_A = 1.01 \times 10^5 N/m^2$

1 cal. = 4.18 J

$\rho_{water} = 1000 kg/m^3$

1 hp = 746W

1 Pascal =1 N/m^2

$G = 6.67 \times 10^{-11} Nm^2/kg^2$

1 metric ton = 1000 kg

Question 1: Sample answers: F (a), G (d).... etc. **DO NOT guess** the answer. For each correct answer, **2 marks** are given. For each wrong answer, **0.67** will be deducted. For no answer, zero mark. The minimum total mark for Question 1 is zero. [10 × 2 = 20]

(A) A cricket ball of mass 50 g strikes a bat with a velocity of 100 ms^{-1} and rebounds with the same velocity within 0.01 seconds. The force exerted on the bat is:

a) 100 N b) 1000 N c) 10 N d) 500 N

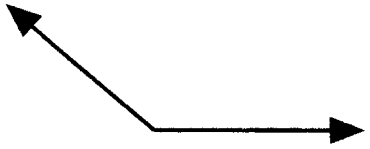
(B) When a mass is rotating in a plane about a fixed point its angular momentum is directed along:

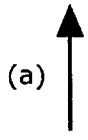
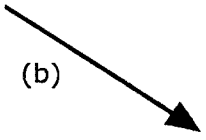
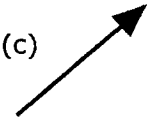
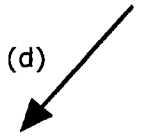
(a) the radius
(b) the tangent to the circular path
(c) the axis of rotation
(d) the centre of rotation

(C) If two bodies of unequal masses are thrown vertically upwards with the same velocity, the ratio of the time taken by both to reach the ground is equal to:

(a) the ratio of the masses
(b) one
(c) the ratio of the inverse of the masses
(d) the product of the masses

(D) Which vector represents the direction of the sum of the two concurrent vectors shown below:



(a)  (b)  (c)  (d) 

(E) A bomb of 12 kg explodes into two pieces of masses 4 kg and 8 kg. The velocity of the 8 kg mass is 6 ms^{-1}. The kinetic energy of the other is

(a) 48 J (b) 32 J (c) 24 J (d) 288 J

(F) It is easier to pull a wooden block along the inclined plane than to raise it vertically, because:

(a) Friction is decreased
(b) Only part of the weight is to be overcome
(c) g is decreased
(d) the statement is false

(G) In a javelin throw an athlete has greater probability of winning if he throws the javelin:

(a) At an angle of 45° to the ground
(b) At an angle slightly less than 45° to the ground
(c) At an angle slightly greater than 45° to the ground
(d) In the horizontal direction

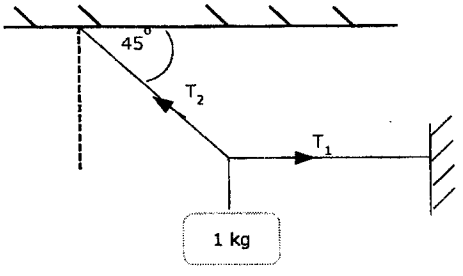
(H) When a bicycle is in motion, the force of friction exerted by the ground on the two wheels is such that it acts:

(a) in the backward direction on the front wheel and in the forward direction on the rear wheel
(b) in the forward direction on the front wheel and in the backward direction on the rear wheel
(c) in the backward direction on both the front wheel and the rear wheel
(d) in the forward direction on both the front wheel and the rear wheel

(I) Two identical wires of substances *A* and *B* are subjected to equal stretching forces along their length. It is observed that elongation of wire *A* is more than wire *B*. Then:

(a) *A* is more elastic than *B*
(b) *B* is more elastic than *A*
(c) *A* and *B* are equally elastic
(d) *A* is elastic and *B* is more plastic

(J) A mass of 1 kg is suspended as shown in the diagram below. The tension T_1 in the horizontal cord will be:



(a) 4.9 N
(b) 509.6 N
(c) 9.8 N
(d) 19.6 N

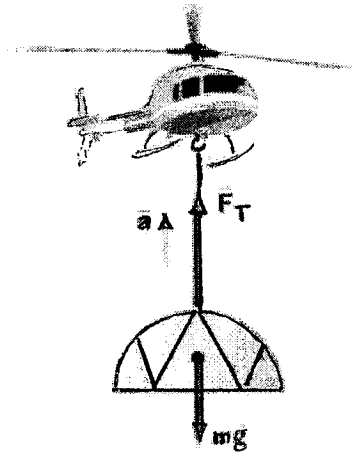
ATTEMPT ANY FOUR QUESTIONS FROM BELOW:

Q.2 (a) A force **A** is added to another force **B** that has *x*- and *y*-components equal to -10 N and 8 N respectively. The resultant of the forces is in the positive *x*-direction and has a magnitude of 12 N.

i) Find the *x*- and *y*-components of the force **A**, and
ii) the angle it makes with the positive *x*-axis. **[8]**

(b) A 7650 kg helicopter accelerates upward at 0.80 ms^{-2} while lifting a 1250 kg frame at a construction site as shown below.

i) What is the lift force exerted by air on the helicopter rotors?
ii) What is the tension in the cable (ignore its mass) that connects the frame to the helicopter?
iii) What force does the cable exert on the helicopter? **[8]**



(c) A rifle shoots a bullet with a muzzle velocity of 500 ms^{-1} at a small target 50 m away. How high above the target must the rifle be aimed so that the bullet will hit the target? **[4]**

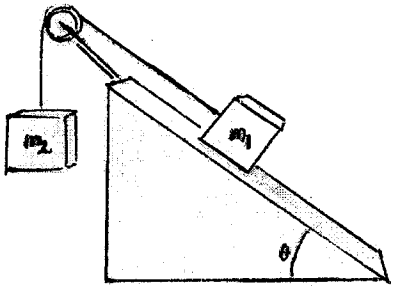
Q.3 (a) A billiard ball A of mass m_A = 0.400 kg moving with a speed v_A = 1.80 ms^{-1} strikes another ball B initially at rest of mass B = 0.500 kg. As a result of the collision, the ball A is deflected off at an angle of 30° with a speed of v'_A = 1.10 ms^{-1}.

i) Taking the *x*-axis to be the original direction of ball A, write down the equations expressing the conservation of momentum in the *x* and *y* directions separately.
ii) Solve these equations for the speed v'_B and angle θ_B of ball B. Do not assume the collision is elastic. **[10]**

(b) A mass m_1 lying on a frictionless inclined plane is connected to a mass m_2 by a massless string passing over a frictionless pulley as shown.

i) Determine a formula for the acceleration of the system of the two masses in terms of m_1, m_2 and g

ii) What conditions apply to the masses m_1 and m_2 for the acceleration to be in one direction (say, m_1 down the incline plane) or in the opposite direction?



[10]

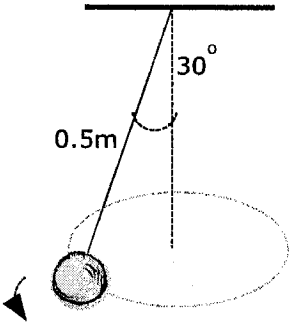
Q.4 (a) A fish takes a bait and pulls on the line with a force of 2.1N. The fish reel a disk of mass 0.84kg and radius 0.055m has a friction clutch that exerts a restraining torque of 0.047N on it. ($I_{disk} = \frac{1}{2}mr^2$)

(i) What is the angular acceleration of the reel?

(ii) How much line (string) does the fish pull from the reel in 0.25secs?

(iii) How many revolutions has the reel turned through in the 0.25sec time interval? **[9]**

(b) A bob of mass 50g is suspended from a string 0.5m long. It is made to rotate in a horizontal circle with the string making an angle of 30° with the horizontal as shown below.



Calculate:

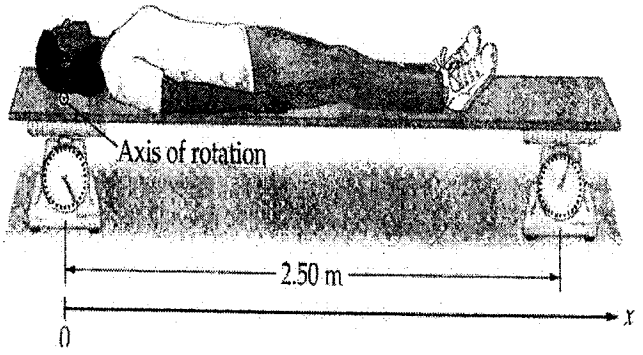
(i) the angular speed of the bob; and

(ii) the tension in the string. **[6]**

(c) To determine the location of her center of mass, a physics student lies on a light-weight plank supported by two scales placed 2.5m apart as shown in the diagram below. If the scale reads 290N and the right scale reads 122N, find:

i) the student's mass; and

ii) the distance from the student's head to her centre of mass. **[5]**



Q.5 (a) Define the following terms:

(i) Young's modulus

(ii) Shear modulus

(iii) The Compressibility **[6]**

Note: definition can be either in words or in mathematical equation as long as you define the symbols used.

(b) A steel ball (density = 7860kgm^{-3}) with a diameter of 6.4 cm is tied to an aluminium wire 82cm long and 2.5mm in diameter. The ball is whirled in a vertical circle with a tangential speed of 7.8ms^{-1} at the top of the circle and 9.3ms^{-1} at the bottom of the circle.

Find the amount of stretch in the wire

(i) at the top and

(ii) at the bottom of the circle.

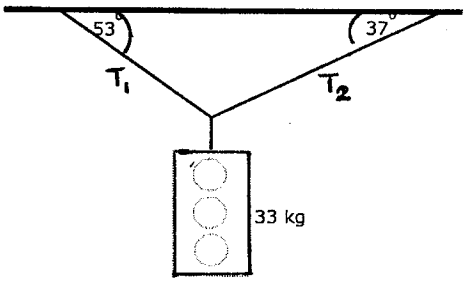
(Young's modulus for aluminium, $Y_{Alum} = 6.9 \times 10^{10}$ Nm^{-2}) **[8]**

(c) A model rocket blasts off and moves upward with an acceleration of 12ms^{-2}. until it reaches a height of 20m, at which point its engine shuts off and it continues its flight in free fall

What is the maximum height attained by the rocket? **[6]**

Q.6 (a) A 2.8 g rifle bullet travelling at 230 ms^{-1} buries itself in a 3.6 kg pendulum hanging on a 2.8 m long string, which makes the pendulum swing upward in an arc. Determine the vertical and horizontal components of the pendulum's displacement. **[11]**

(b) Find the tension in the two wires supporting the traffic lights as shown below. **[9]**



Q.7. (a) A jet plane is flying in a horizontal direction relative to the ground with a velocity of 600 km/h and at a height of 1960 m. When it is vertically over a point *A*, on the ground, an object drops from it. The object strikes the ground at a point *B*. Calculate the distance *AB*. **[7]**

(b) A car of mass 1000 kg travelling at 20 ms^{-1} on a horizontal road is brought to rest by the action of its brakes in a distance of 25 m. Find:

i) the average retarding force; and
ii) if the same car travels up a slope of 1/20 at a constant speed of 20 ms^{-1}, what power does the engine develop if the frictional resistance is 100 N?

[10]

(c) When we stretch a wire, is there any work done? If so, what happens to the energy given to the wire? **[3]**

Q.8 (a) You throw a stone vertically into the air from ground level. You observe that when it is 15.0 m above ground level, it is travelling at 25.0 ms^{-1} upward. Use the work-energy theorem to find:

i) the stone's speed just as it left the ground; and
ii) its maximum height. **[8]**

(b) A wheel of weight 392 N comes off a moving truck rolls without slipping along a highway. At the bottom of the hill it is rotating at 25.0 rad/s. The radius of the wheel is 0.600 m, and its moment of inertia about the rotation axis is 0.800 MR^2. Friction does work on the wheel as it rolls up the hill to a stop, at a height *h* above the bottom of the hill; this work has an absolute value of 3500 J. Calculate the height *h*.

(c) Why is a ladder more likely to slip when you are high up on it than when you just begin to climb? **[2]**

END OF EXAMINATION

Equations

Uniformly accelerated motion:

$x = \bar{v}t \qquad \bar{v} = \frac{1}{2}(v_f + v_i) \qquad v_f = v_i + at \qquad v_f^2 = v_i^2 + 2ax$

$x = v_i t + \frac{1}{2}t^2$

Projectile motion:

$v_x = v_i \cos\theta_i = \text{constant} \qquad v_y = v_i \sin\theta_i - gt \qquad y = (v_i \sin\theta_i)t - \frac{1}{2}gt^2$

$y = (\tan\theta_i)x - \left[\frac{g}{2v_i^2(\cos^2\theta_i)}\right]x^2 \qquad R = \frac{v_i}{g}\sin 2\theta \qquad t = \frac{2v_i \sin\theta}{g}$

Force and motion:

$F = ma \qquad w = mg \qquad F_{AB} = -F_{BA} \qquad F_f = \mu F_N$

Energy:

$PE = wh = mgh \qquad KE = \frac{1}{2}mv^2 \qquad W = Fx\cos\theta \qquad P = \frac{W}{t} = Fv\cos\theta$

Linear momentum:

$p = mv \qquad F\Delta t = \Delta mv$

Circular motion and gravitation:

$T = \frac{2\pi r}{v} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r} \qquad F_{grav} = G\frac{m_A m_B}{r^2}$

Rotational motion and angular momentum:

$\theta = \frac{s}{r} = \left(\frac{\omega_i + \omega_f}{2}\right)t \qquad \omega = \frac{\theta}{t} \qquad \theta = \omega_i t + \frac{1}{2}\alpha t^2 \qquad \omega_f = \omega_i + \alpha t$

$v = \omega r \qquad \omega_f^2 = \omega_i^2 + 2\alpha\theta \qquad \alpha = \frac{\Delta\omega}{\Delta t} = \frac{a_T}{r} \qquad I = \sum mr^2$

$KE_{rot} = \frac{1}{2}I\omega^2 \qquad \tau = FL = I\alpha \qquad W = \tau\theta \qquad P = \tau\omega \qquad L = I\omega$

Properties of matter:

$\rho = \frac{m}{V} \qquad F = -kx \qquad \frac{\Delta L}{L_i} = \frac{1}{Y}\frac{F}{A} \qquad \phi = \frac{s}{d} = \frac{1}{s}\frac{F}{A}$

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS

UNIVERSITY EXAMINATION 2010

P231 (PROPERTIES OF MATTER AND THERMAL PHYSICS)

TIME: **THREE HOURS** **MAX. MARKS 100**

ANSWER: **FIVE QUESTIONS**

QUESTION 1

(a) Show that the deflection Y of the free end of a cantilever of length L, clamped horizontally at one end, when its own weight is effective, is given by the formula

$$Y = \left[W + \tfrac{3}{8}W_1\right]\frac{L^3}{3YI}$$ **[10 Marks]**

where W is the load.
L is the length of the cantilever.
Y is the Young's modulus of the material of the cantilever.
I is the geometrical moment of inertia of the material of the cantilever.
W_1 is the weight of the cantilever

(b) A gas with a volume of 0.014 m^3 at a pressure of $2.07 \times 10^6 N.m^{-2}$ expands to a pressure of $2.07 \times 10^5 N.m^{-2}$ according to the law $PV^{1.35} = C$. Determine the work done by the gas during the expansion. **[5 Marks]**

(c) A copper vessel of mass 2 kg contains 6 kg of water. If the initial temperature of the vessel plus water is 20^0 C and the final temperature is 90^0 C, how much heat is transferred to accomplish this change assuming that there is no heat loss?

Note that specific heat capacity of water is $4181.6\,J.kg^{-1}.K^{-1}$. Specific heat capacity of water at 90^0 C is $4204.8\,J.kg^{-1}.K^{-1}$. The specific capacity of water in the temperature range 20^0 C to 90^0 C is $4193.2\,J.kg^{-1}.K^{-1}$ **[5 Marks]**

QUESTION 2

(a) Show that if a clean narrow-bore glass tube is placed vertically with one end below the surface of a liquid, the surface tension T is given by the formula

$$T = \frac{\rho g r}{\cos\theta}\left(h + \frac{r}{3}\right)$$

where T is the surface tension of the liquid
g is the acceleration due to force of gravity
r is the radius of the glass tube
θ is the angle of contact between the solid surface and the tangent plane to the liquid surface measured through the liquid, and
h is the height to which the liquid rises **[10 marks]**

(b) A U-tube with limbs of diameters 5.0 mm and 2.0 mm respectively contains water of surface tension $7.0\times10^{-2}\ N.m^{-1}$, angle of contact zero and density $1000\,kg.m^{-3}$. Find the difference in levels in the two limbs ($g = 9.81\ m.s^{-2}$) **[7 Marks]**

(c) Estimate the height to which water with surface tension of $7\times10^{-2}\ N.m^{-1}$ will rise in a glass capillary tube of radius 1 mm. **[3 Marks]**

QUESTION 3

(a) A gas whose original volume and temperature were 0.015 m^3 and 28.5^0C respectively is expanded according to the law $PV^{1.35} = C$ until its volume is 0.09m^3. Determine the temperature of the gas. **[10 Marks]**

(b) Show that the equation

$$S_2 - S_1 = C_V \ln\frac{T_2}{T_1} + R\ln\frac{V_2}{V_1}$$

determines the change of specific entropy of a gas from the knowledge of temperature and volumes. **[10 Marks]**

QUESTION 4

(a) Show that the depression d of a beam of length L and of uniform cross-section supported on two knife-edges at its two ends and loaded in the middle with a weight W is

$$d = \frac{WL^3}{48YI_g}$$

where
Y is the Young's modulus of the material of the beam, and

I_g is the geometrical moment of inertia of the beam. **[10 Marks]**

(b) Calculate the twisting couple on a solid shaft of length 1.5m and diameter 120mm when it is twisted through an angle of 0.6^0. The coefficient of rigidity for the material of the shaft may be taken to be $93 \times 10^9 N.m^{-2}$ **[5 Marks]**

(c) Find the work done in stretching a wire of cross-section 1 mm^2 and length 2m through 0.1 mm, if Young's modulus for the material of the wire is $2 \times 10^{11} N.m^{-2}$ **[5 Marks]**

QUESTION 5

(a) Describe the static method for determining the modulus of rigidity of a wire. **[7 Marks]**

(b) A square bar 2.51 cm wide, 37.95 cm long, and weighing 826 grams is suspended by a wire 37.85 cm long and 0.0501 cm radius. It is observed to make 50 complete swings in 335.7 seconds. What is the rigidity coefficient of the wire? The moment of inertia about the suspension wire axis is given as

$$I = mass \times \left[\frac{l^2 + b^2}{12}\right]$$ **[7 Marks]**

(c) A power station output is 500×10^6 watts. During a test it is found that this represents 28% of the energy put into the plant by means of burning coal in the boilers. The coal used liberates $29.5 J.kg^{-1}$. Determine the mass of the coal burnt by the power station in 1 hour. **[6 Marks]**

QUESTION 6

(a) Explain what is understood by the terms;

(i) Longitudinal stress **[2 Marks]**

(ii) Tangential stress and **[2 Marks]**

(iii) Shear strain **[1 Marks]**

(b) Show that a small and uniform strain v is equivalent to three linear strains $\frac{v}{3}$, in any three perpendicular directions. **[8 Marks]**

(c) Show that the bulk modulus for a gas at constant temperature is equal to its pressure. **[7 Marks]**

QUESTION 7

(a) A composite wall of area A is made of n layers of thickness x_1, x_2, x_3, and x_n respectively. The coefficients of thermal conductivity for the layers are k_1, k_2, k_3, and k_n respectively. The interface temperature between the first layer and the second layer is t_2. The interface temperature between the second layer and the third layer is t_3. The interface temperature between the n^{th} layer and air is t_{n+1}.

Show that the heat transferred per second to the composite wall is

$$\frac{\partial Q}{\partial t} = \frac{A(t_1 - t_{n+1})}{\sum \frac{x}{k}}$$

[10 Marks]

(b) A quantity of gas has an initial pressure, volume, and temperature of $140 \times 10^3\ N.m^{-2}$, $0.14 m^3$ and 25^0 C respectively. It is compressed to a pressure of $1.4 \times 10^6\ N.m^{-2}$ according to the law $PV^{1.25}$ = constant.

Determine the change of entropy.

Take $C_p = 1.041\ kJ.kg^{-1}.K^{-1}$

$C_v = 0.743\ kJ.kg^{-1}.K^{-1}$

$R = C_p - C_v = 0.298\ kJ.kg^{-1}.K^{-1}$

$m = \frac{P_1 V_1}{R T_1} = 0.221$ kg

[10 Marks]

== End of P-231 2010 Exams ==

The University of Zambia

School of Natural Sciences

Department of Physics

First Semester University Examination - 2010/2011

Classical Mechanics I – P251

Duration: 3 Hr (180 min)

Date: 15th November 2010

Full Marks: 100 (100%)

Time: 14:00 – 17:00 Hr

Instructions

- **Use only your COMPUTER NUMBER on your answer sheets and NOT your name.**
- **This paper contains Seven (7) questions. Each question carries 20 marks.**
- **Attempt any Five (5) out of the Seven (7) questions given in this examination paper.**
- **This paper has a total of 100 marks. All questions carry equal marks.**
- **Show all your work clearly. Omission of essential work will result in a loss of marks.**
- **Marks allocated for each question are indicated in square brackets [ ].**

Where necessary, you may need the following formulae:

$$\vec{r}_{CM} = \frac{\sum_i m_i \vec{r}_i}{\sum_i m_i},\quad \vec{F} = -Gm\int_V \frac{\rho(\vec{r}')}{r^2}\vec{e}_r dV',\quad \vec{F} = -\nabla U,\quad \Phi = -G\int_V \frac{\rho(\vec{r}')}{r} dV',\quad U = m\Phi$$

$$h = r^2\dot{\theta},\quad \frac{d^2u}{d\theta^2} + u = -\frac{1}{mu^2h} f(u^{-1}),\quad \int \frac{dx}{a^2+x^2} = \frac{1}{a}\tan^{-1}\left(\frac{x}{a}\right)$$

1. **(a)** The centre of gravity of a system of particles is the point about which external gravitational forces exert no net torque. Letting $\vec{r}_i$ = position vector of the i^{th} particle, m_i = mass of the i^{th} particle, $M = \sum_i m_i$ = total mass and g = acceleration due to gravity, show that for a uniform gravitational force, the centre of gravity is identical to the centre of mass $\vec{r}_{CM}$, i.e.,

$$\vec{r}_0 = \frac{1}{M}\sum_i m_i \vec{r}_i = \vec{r}_{CM}$$

Hint: Determine the torque about $\vec{r}_0$. **[10 Marks]**

(b) One smooth sphere collides with another sphere which is at rest. After the collision they move off at right angles to each other. Neglecting rotation and assuming that the collision is elastic, show that the spheres are of equal mass. **[10 Marks]**

2. **(a)** The force acting on a particle of mass m is given by

$$F = kvx$$

where k is a positive constant. The particle passes through the origin with speed v_0 at time $t = 0$. Find $x(t)$. **[13 Marks]**

(b) A particle moves in a plane elliptical orbit described by the position vector

$$\vec{r} = 2b\sin(\omega t)\hat{i} + b\cos(\omega t)\hat{j}$$

where b and ω are constants.

i) Find the velocity $\vec{v}$, acceleration $\vec{a}$ and speed v of the particle. **[5 Marks]**

ii) Find the angle between $\vec{v}$ and $\vec{a}$ at the time $t = \frac{\pi}{2\omega}$. **[2 Marks]**

3. **(a)** A particle in a central field moves in a spiral orbit

$$r = c\theta^2.$$

i) Determine the form of the force function. **[6 Marks]**

ii) Determine how the angle θ varies with time t. **[4 Marks]**

(b) A particle is placed on top of a smooth sphere of radius r. If the particle is slightly perturbed, at what point of the vertical axis will it leave the sphere? **[10 Marks]**

4. **(a)** For the motion of a projectile where air-resistance is proportional to the square of the speed of the projectile

i) Write the equations of motion for x- and y-directions. **[2 Marks]**

ii) show that the x and y components of the velocity are given by

$$\dot{x} = \dot{x}_o e^{-\gamma x} \text{ and } \dot{y} = \dot{y}_o e^{-\gamma y}$$

where x and y are the distances travelled by the projectile, $\dot{x}_o$ and $\dot{y}_o$ are the initial velocities and $\gamma = c/m$. **[8 Marks]**

(b) Consider a thin uniform disk of mass M and radius a. Find the gravitational force on a mass m located along the axis of the disk.

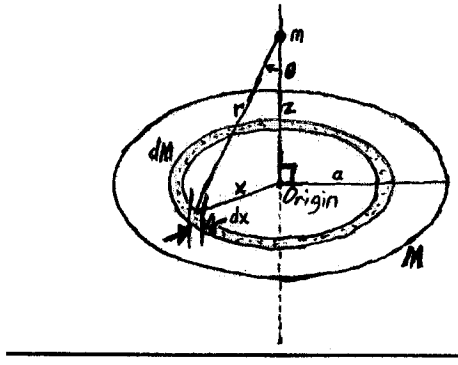


Figure 1: Geometry to find the gravitational force on a point mass m due to thin uniform disk with mass M

[10 Marks]

5. **(a)** A particle of mass m moves in a straight line, say along the x-axis, under the action of the position-dependent force $F(x)$.

i. Show that the equation of motion of the particle leads to the conservation of energy equation,

$$\frac{1}{2}mv^2 + U(x) = E.$$

where $U(x)$ is the potential energy and E is the total energy. **[6 Marks]**

ii. From your result in (i) above, show that the connection between the position of the particle and time is

$$t = \int \frac{dx}{\sqrt{\frac{2}{m}[E - U(x)]}} + t_0.$$

where t_0 is the initial time of the motion. **[4 Marks]**

(b) Show that a body of mass at a distance x from the earth's surface experiences a force given by

$$F = \frac{-r_e^2 mg}{(r_e + x)^2}$$

where r_e is the radius of the earth. Explain how you would proceed to obtain the maximum height from the expression you find if the body is thrown with a velocity v_o from the earth's surface. **[10 Marks]**

6. **(a)** A particle is under the influence of a force $F = -kx + \frac{kx^3}{\alpha^2}$, where k and α are constants with k being positive. Determine $U(x)$ and discuss the motion. What happens when $E = (1/4)k\alpha^2$? **[13 Marks]**

(b) The speed of a particle of mass m varies with distance x as $v(x) = \alpha x^{-n}$. Assume $v(x = 0) = 0$ at $t = 0$.

i) Find the force $F(x)$ acting on the particle. **[3 Marks]**

ii) Determine $x(t)$. **[4 Marks]**

7. **(a)** Determine whether the force

$$F_x = ayz + bx + c,\ F_y = axz + bz,\ F_z = axy + by.$$

is conservative. If it is conservative, find its attendant potential energy $U(\vec{r})$. **[10 Marks]**

(b) i) Assuming a circular orbit, show that Kepler's Third Law follows directly from Newton's Second Law and his law of gravity

$$GMm/r^2 = mv^2/r.$$

where G is the gravitational constant, M and m are two different masses for two bodies involved, r is the bodies' separation distance, and v is the velocity. **[4 Marks]**

ii) Find the force law for a central-force field that allows a particle to move in a logarithmic spiral orbit given by $r = ke^{\alpha\theta}$, where k and α are constants. **[6 Marks]**

END OF EXAMINATION

The University of Zambia
School of Natural Sciences
Department of Physics
2010 Academic Year First Semester Final Examinations
P-261: Electricity & Magnetism

Attempt <u>any five</u> questions. All questions carry equal marks. The marks are shown in brackets.

Time: Three hours. **Maximum marks = 100.**

Write clearly your computer number on the answer book.

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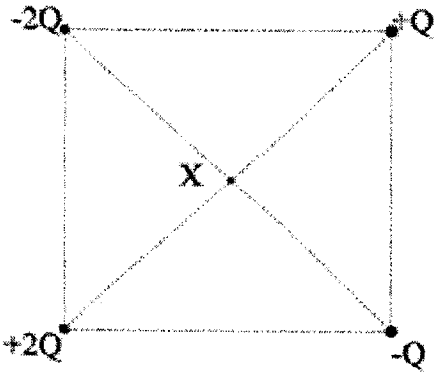
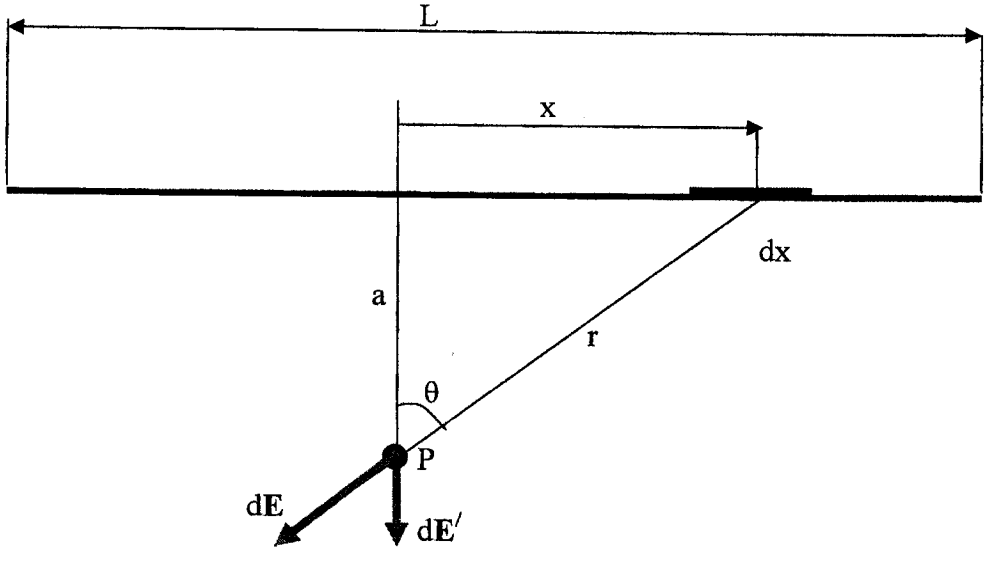
Wherever necessary use:

g = 9.8m/s^2	$N_{Av.}$=6.02 × 10^{23} per mole
e = 1.6 × 10^{-19}C	1 eV = 1.6 × 10^{-19}J
$\mu_0 = 4\pi\times10^{-7}$ Wb/A-m	$\varepsilon_0 = 8.85\times10^{-12}$ C^2/N.m^2
m_e =9.1 × 10^{-31} kg	c = 3 x 10^8 m/s
$B=\mu_0\dfrac{i}{2\pi d}$, $B=\mu_0\dfrac{i\,dl\sin\theta}{4\pi r^2}$, $\mu = iA$	$k=\dfrac{1}{4\pi\varepsilon_0}=9\times10^9$ N.m^2/C^2
$\int\vec{E}.\vec{dl}=0$, $\nabla.\vec{E}=\dfrac{\rho}{\varepsilon_0}$, $\oint\vec{B}.\vec{dl}=\mu_o i$	$F=\mu_0\dfrac{I_1I_2l}{2\pi r}$, $I=I_0(1-e^{-t/\tau})$
$E_r=-\dfrac{\partial V}{\partial r}$, $E_\theta=-\dfrac{1}{r}\dfrac{\partial V}{\partial\theta}$, $E_\phi=\dfrac{1}{r\sin\theta}\dfrac{\partial V}{\partial\phi}$	$V=\int\vec{E}.\vec{dr}$, $\vec{D}=\varepsilon\vec{E}$; $L=N\dfrac{\phi}{i}$
$\varepsilon=\oint E.dl=-\dfrac{d\phi}{dt}$, $i=\dfrac{V}{R}\left[1-\exp\left(-\dfrac{R}{L}\right)t\right]$	$V=L\dfrac{di}{dt}+ri$, $R=\rho\dfrac{L}{A}$
$V_C=V_0e^{-t/RC}$, $q=q_0e^{-t/RC}$, $i=i_0e^{-tR/L}$ $X_L=2\pi fL$; $X_C=1/2\pi fC$; $\tan\phi=(X_L-X_C)/R$	$\int_{CS}\vec{E}.\vec{dS}=\dfrac{\int dq}{\varepsilon_0}$; $F=k\dfrac{q_1q_2}{r^2}$
$C=k\,\varepsilon_0\dfrac{A}{d}$; $dB=\dfrac{\mu_0 i}{2}\dfrac{a^2}{(a^2+b^2)^{3/2}}$	$E=\dfrac{D}{\varepsilon_0K}$; $\chi=\varepsilon_0(K-1)$;

Q1(a) Figure below shows four point charges at the corners of a square of side 2 cm. Find the magnitude and direction of the electric field at the centre (X) of the square if Q = 0.02 μC. (Use $\frac{1}{4\pi\varepsilon_0} = 9\times10^9\ \text{Nm}^2\ \text{C}^{-2}$) [6]

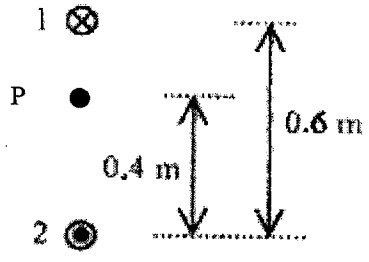


(b) Show that electric field out from a long uniform charged rod calculated along the perpendicular bisector is given by $\frac{2}{4\pi\varepsilon_0}\frac{\mu}{a}$ N/C, where μ is the linear charge density. [8]



(c) Two long parallel wires (1 and 2) separated by 0.60m carry anti-parallel currents of 7.0 amperes each.

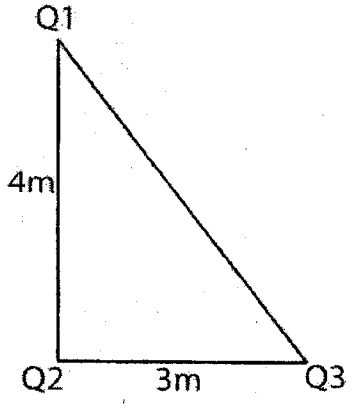
What is the resulting field at *P* along the line between the wires and 0.40m from the lower wire? [6]



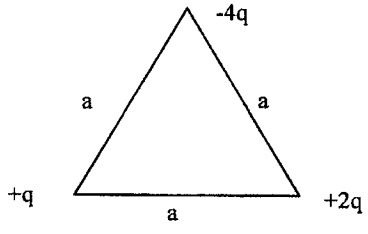
Q2 (a) Three point charges, Q_1, Q_2, and Q_3 are at the vertices of a right-angled triangle, as shown below.

(i) What is the absolute electric potential of Q_3 due to the presence of Q_1 and Q_2 if $Q_1 = -4.0\ 10^{-6}$ C, $Q_2 = 3.0 \times 10^{-6}$ C, and $Q_3 = 2\ 0 \times 10^{-6}$C.

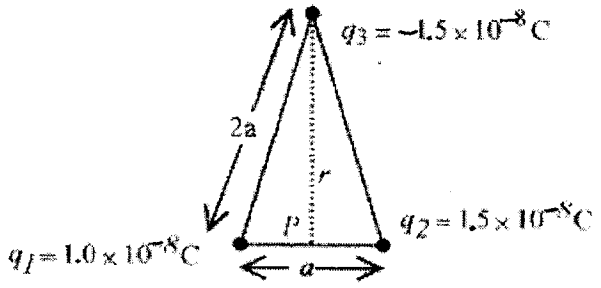
(ii) If Q_3, which is initially at rest, is repelled to infinity by the combined electric field of Q_1 and Q_2, which are held fixed, find the final kinetic energy of Q_3. [10]



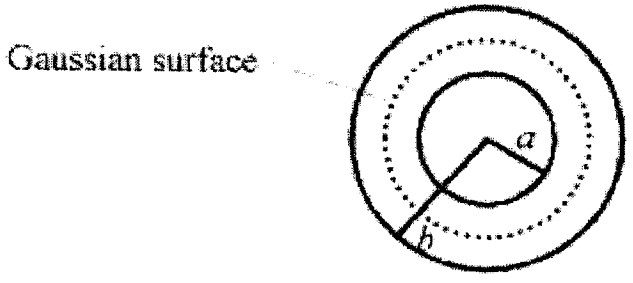
(b) Three charges are arranged as shown. Calculate their mutual potential energy. Given, $q = 1.0 \times 10^{-7}$ C and $a = 10$ cm. [6]



(c) Calculate the potential midway between q_1 and q_2 for the array of charges given. [4]



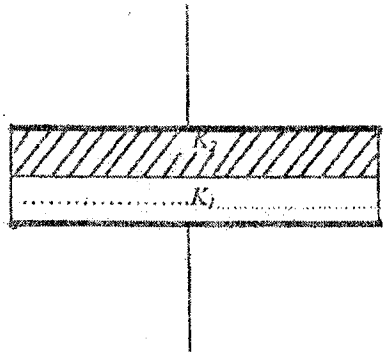
Q3(a) Calculate the capacitance of a spherical capacitor with inner radius *a* and outer radius *b*. A charge *Q* is placed on the inner sphere. [8]



(b) A parallel-plate capacitor is filled with two dielectrics of equal thickness *d*. Show that the capacitance of this configuration is given by

$$C = \frac{2\varepsilon_0 A}{d}\frac{(K_1 K_2)}{(K_1 + K_2)},$$

where *A* is the area of the plate. [6]



(c) A parallel-plate capacitor has a capacitance of 100 x 10^{-12} F, a plate area of 100 cm^2 each, and a mica dielectric (K = 5.4).

At 50 volts potential difference between the plates, calculate:

(i) The electric field intensity **E** in the mica [2]

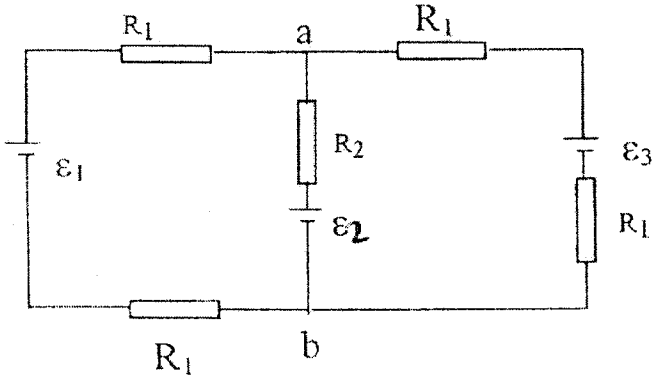
(ii) The magnitude of the free charge on the plates, and [2]

(iii) The magnitude of the induced surface charge. [2]

Q4(a) (i) Find the three currents in the figure. [8]

(ii)Find the potential difference V_{ab} between *a* and *b*.

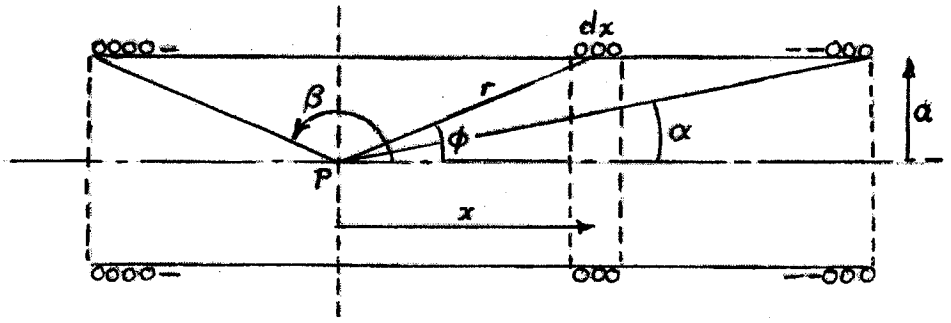
Assume that $R_1 = 1.0\Omega$, $R_2 = 2\Omega$, $\varepsilon_1 = 2.0V$, and $\varepsilon_2 = \varepsilon_3 = 4.0V$ [4]



(b) Two resistors R_1 and R_2 are connected in series or in parallel across a (resistanceless) battery with emf ε. It is desired that the Joule heating for the parallel combination be four times that for series combination.

If R_1 = 100 Ω, what is R_2? [8]

Q5(a). Show that the magnetic field strength at the end of a long solenoid is just one-half that at the centre. [15]

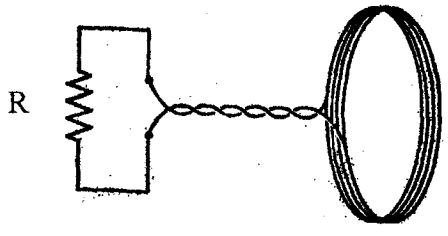


(b) Two closely wound coils are spaced close to each other and sharing the same axis. The coils have N_1 and N_2 number of turns with currents i_1 and i_2 respectively. The coils are electrically insulated from each other.

Calculate the mutual inductance of the coils if $N_1 \neq N_2$ [5]

Q6(a). Figure below shows a coil of *N* turns connected to a resistor *R*.

Prove that if the flux of magnetic induction through the coil changes in anyway from ϕ_1 to ϕ_2, then the charge that flows through the circuit of total resistance *R* is given by $q = \frac{N(\phi_1 - \phi_2)}{R}$ [6]

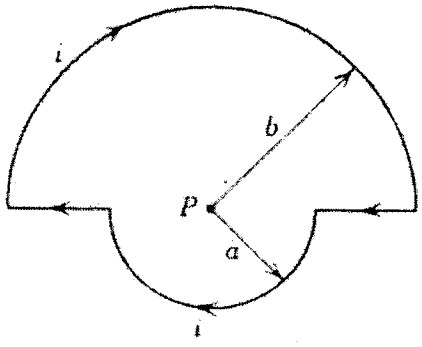


(b). Figure below shows a closed circuit with radii *a* and *b* carrying a current *i*.

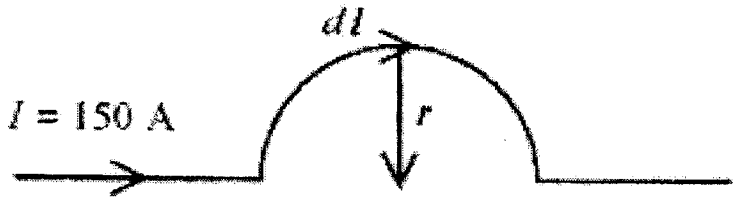
(i) Find the magnitude and direction of the magnetic field **B** at point *P*. [6]

(ii) Find the magnetic dipole moment of the circuit. [4]

[Hint: Consider the two semi-circles separately]



(c) What is the magnetic field at the centre of a semi-circular piece of wire with radius of 0.20m and carrying 150 amperes current? [4]



Q7(a). A capacitor of capacitance $C = 3.5\,\mu F$, a resistance $R = 250\Omega$ and an inductance $L = 0.5H$ are connected in series with a peak voltage of 150V whose frequency is 60 Hz.

Calculate,

(i) The capacitive and inductive reactance, and the impedance of the circuit.

(ii) The peak current and the phase angle between the current and voltage.

(iii) The peak voltages across each element *R*, *L*, and *C*. [13]

(b) An *RC*-circuit is observed during discharge to have an initial capacitor potential of 100 volts and after 3.0s have a potential of 20 volts. How long will it take for the capacitor to discharge to 1.0 volt? [7]

==End of P-261 2010 Exam==

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

P341: ANALOG ELECTRONICS I

TIME: **THREE HOURS** **MAXIMUM MARKS - 100**

Attempt any four questions.
All questions carry equal marks.
The marks are shown in brackets.

Q1. (a) (i) State Norton's Theorem in network analysis with figure. [4]

(ii) Obtain the Norton equivalent of the network shown in figure 1. [11]

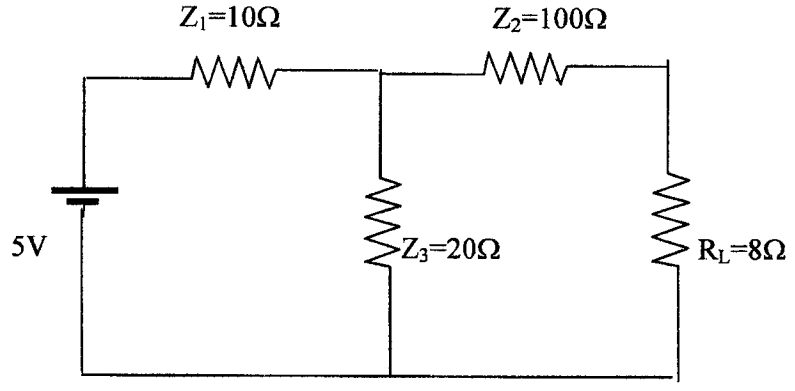


Figure 1

(b) The leakage current of a silicon diode is 5μA at 30°C and the ideality factor is 2. Calculate the diode current at 100°C at an applied forward bias of 0.6V. Charge of an electron=1.602×10^{-19} Coulomb and Boltzman's constant = 1.38×10^{-23} Joule.sec. [5]

(c) Discuss the working of an enhancement MOSFET with suitable figure. [5]

Q2. (a) The forward resistance of each diode in a centre tap full wave rectifier is 16Ω. The transformer secondary voltage from the centre tap to each end of the secondary is 40V (rms) and the load resistance is 900Ω. Find [8]

(i) the average load current
(ii) the rms value of the load current
(iii) d.c output power
(iv) input a.c. power
(v) rectification efficiency

(b) Draw the circuit of a two stage direct coupled transistor amplifier. Show the input and output waveforms. [5+2]

(c) (i) Explain the formation of depletion layer across a pn junction. [5]

(ii) Explain what happens to the pn junction under conditions of forward and reverse bias. [5]

Q3. **(a)** In the zener diode circuit shown in figure 2, series resistance R is 11kΩ and load resistance is 2kΩ. Input voltage = 30V, V_z = 16V and $I_{Z\,max}$ = 10mA. Find [4]

(i) zener current and
(ii) maximum power rating of the diode.

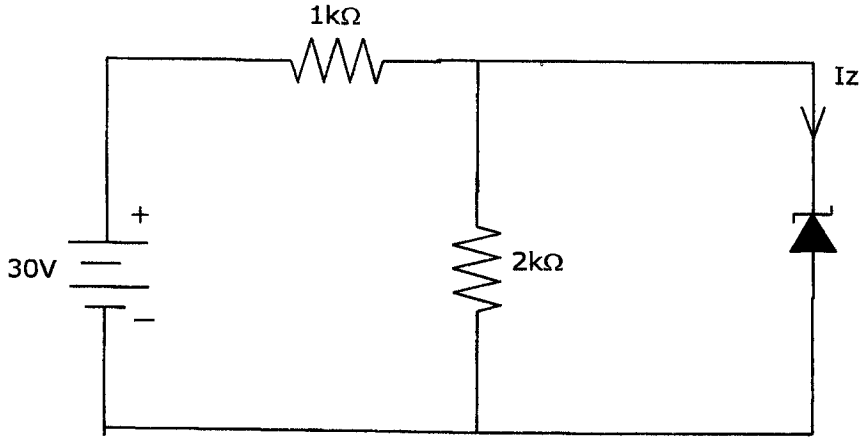


Figure 2

(b) For the circuit shown below, the operating point is chosen such that I_C = 2mA and V_{CE} = 3V. If R_C = 2.2kΩ, V_{CC} = 9V and β = 50, determine the values of R_1, R_2 and R_E. Take V_{BE} = 0.3V and $I_1 = 10I_B$. [12]

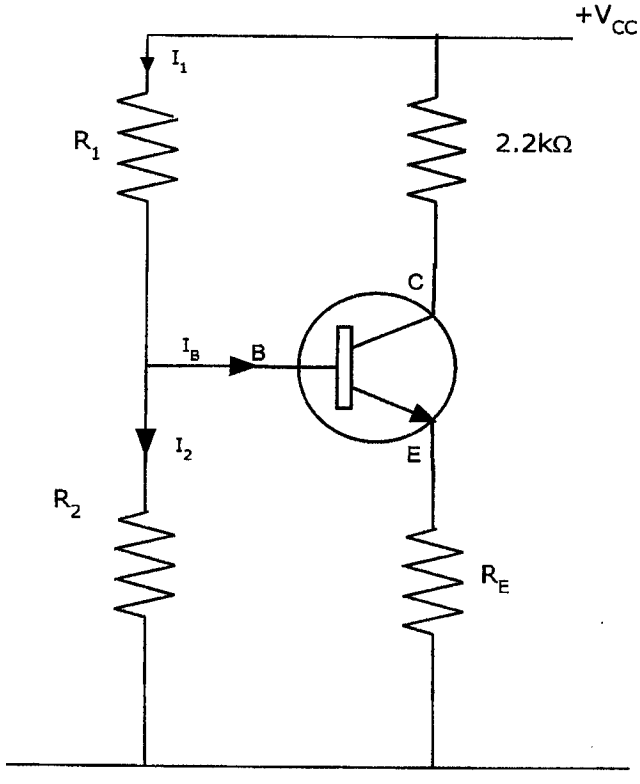


Figure 3

(c) Explain the working of an npn transistor with figure. [9]

Q4. (a) Explain what is meant by positive feedback. Derive an expression for the gain of a positive voltage feedback amplifier. Use a figure to explain the symbols used. [10]

(b) For the circuit shown below, calculate I_A, I_B and I_C with phase angle. [15]

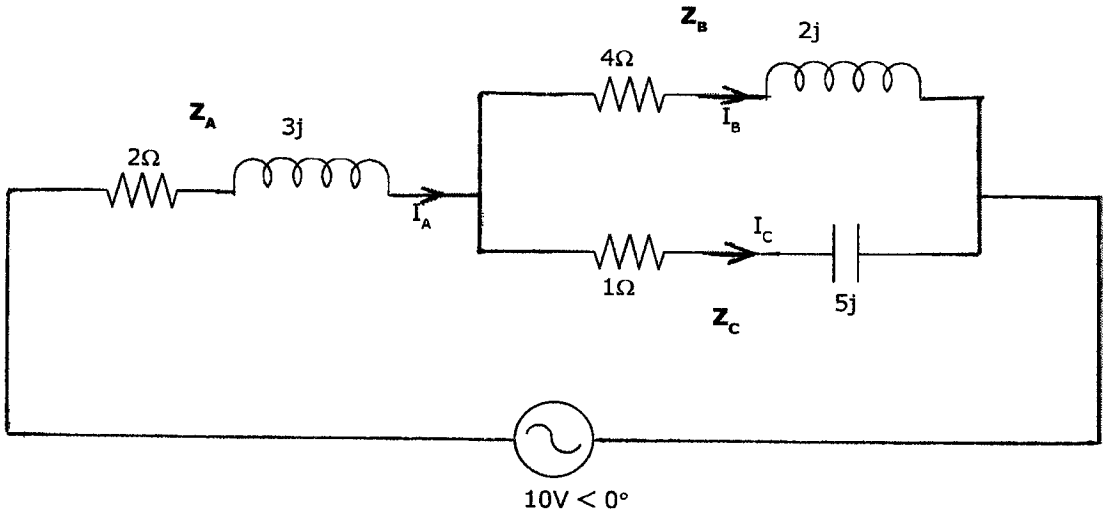


Figure 4

Q5. (a) Consider the circuit shown in the figure below. Find the value of the voltage measured by the voltmeter. [7]

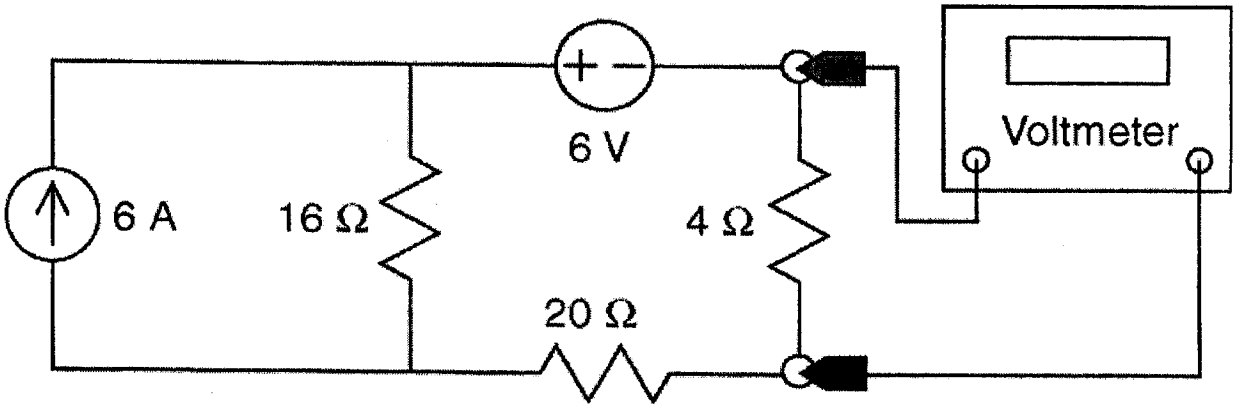


Figure 5

(b) In a circuit, the equations of instantaneous voltage and current are given by [7]

$$v = 141.4\sin\left(\omega t - \frac{2\pi}{3}\right) \text{ volt} \quad \text{and} \quad i = 7.07\sin\left(\omega t - \frac{\pi}{2}\right) \text{ amp}$$

where ω=314 rad/sec.

(i) Use polar notation to calculate impedance with phase angle.

(ii) Calculate average power and power factor.

(iii) Calculate the instantaneous power at the instant t=0.

(c) (i) An amplifier gives 1V output with 1mV input. What will be the output if 10% of the output is fed to the input as negative feedback? [4]

(ii) What do you understand by transistor biasing? What is meant by stabilization of operating point? [7]

Q6. (a) Draw a first order high pass RC filter and explain how it works. Draw the frequency response curve of the filter. [6]

(b) A transistor with α=0.998 is connected in CE mode. The potential difference across 10kΩ resistance connected in the collector circuit is 10V. Draw a circuit diagram indicating the direction of currents in the diagram. Find [7]

(i) collector current (ii)base current (iii)emitter current and (iv)current gain.

(c) Write short notes on [12]

(i) Shunt capacitor filter (ii) Forbidden energy gap

(iii) Voltage regulation (iv) Avalanche breakdown

END OF P341 EXAMINATION

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2010
P351
INTRODUCTION TO QUANTUM MECHANICS

TIME: THREE HOURS
ANSWER ANY FOUR QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS
TOTAL MARKS: 100

Question 1. (a) (i) In treating a system in quantum dynamics, one solves the Schroedinger equation

$$H\Psi(\mathbf{r},t) = i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t)$$

while in classical dynamics one solves the equation of motion from Newton's second law

$$m\,\ddot{\mathbf{r}} = F(\mathbf{r})$$

Contrast the information one gets from the wave function $\Psi(\mathbf{r},t)$ to the information one gets from $\mathbf{r}(t)$. [4 marks]

(ii) When the force is not a function of time or velocity in classical mechanics, the equation of motion leads

$$E = \frac{1}{2}mv^2 + V(\mathbf{r})$$

What general result follows from the time-dependent Schroedinger equation in quantum dynamics under the same circumstances? [3 marks]

(b) A particle of mass m is in an infinite symmetric potential well with walls at $x = \pm a$.

(i) State the boundary conditions that must apply to the motion of the particle and justify them. [4 marks]

(ii) Show that its normalised eigenfunctions are

$$\phi_n(x) = \frac{1}{\sqrt{a}}\cos\frac{n\pi}{2a}x, \qquad n = 1, 3, 5, ...$$

and

$$\phi_n(x) = \frac{1}{\sqrt{a}} \sin \frac{n\pi}{2a} x, \qquad n = 2, 4, 6, ...$$

with energy eigenvalues

$$E_n = \frac{\hbar^2}{8m} \frac{\pi^2 n^2}{a^2}, \qquad n = 1, 2, 3, ... \qquad \text{[14 marks]}$$

Question 2. (**a**) Explain why the harmonic oscillator problem crops up so frequently in physics. [2 marks]

(**b**) The potential energy of a three-dimensional harmonic oscillator of mass m is given by

$$V(x, y, z) = \frac{1}{2} m(\omega_x^2 x^2 + \omega_y^2 y^2 + \omega_z^2 z^2)$$

where ω_x, ω_y and ω_z are angular frequencies. The time-independent Schroedinger equation for the oscillator is

$$-\frac{\hbar^2}{2m} \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right) \psi(x, y, z) + V(x, y, z)\psi(x, y, z) = E\psi(x, y, z)$$

(**i**) Show that because the energy levels of a one-dimensional (linear) harmonic oscillator are given by

$$E_n = (n + \frac{1}{2})\hbar\omega, \qquad n = 0, 1, 2, ...$$

then the energy levels of this three-dimensional oscillator are given by

$$E_{n_x n_y n_z} = (n_x + \frac{1}{2})\hbar\omega_x + (n_y + \frac{1}{2})\hbar\omega_y + (n_z + \frac{1}{2})\hbar\omega_z, \quad n_x,\ n_y,\ n_z = 0, 1, 2, ...$$

[10 marks]

(**ii**) Give the expression for the eigenfunctions of this oscillator in terms of the eigenfunctions ψ_n of the linear harmonic oscillator. [2 marks]

(**iii**) Explain why some of the energy levels of the oscillator may be degenerate if $\omega_x = \omega_y = \omega_z = \omega$ and deduce the degeneracy of the first excited state. [4 marks]

(**b**) The wave function of a free particle moving along a straight line is

$$\psi(x, t) = Ae^{i(kx - \omega t)}$$

(**i**) Determine the energy eigenvalues and explain why they are not quantised. [4 marks]

(**ii**) Normalise the wave function by assuming that it moves along a closed path of length L. [2 marks]

(**iii**) Suggest why it makes some kind of sense that the wave function cannot be normalized over the interval $[-\infty, \infty]$. [1 mark]

Question 3. (**a**) The Hermitian conjugate or the adjoint of an operator A is the operator B such that

$$\int \psi^* A\phi d\tau = \int (B\psi)^* \phi d\tau$$

where ψ and ϕ are square-integrable functions (this means that they vanish at $\pm\infty$), and is denoted by $B = A^\dagger$.

(**i**) Use this information to give the definition of a Hermitian operator. [2 marks]

(**ii**) Show that a Hermitian operator has real eigenvalues and thus justify the use of these operators in quantum mechanics. [5 marks]

(**iii**) Prove that the Hamiltonian operator

$$H = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V(x)$$

is Hermitian. Assume that the functions on which it acts, as well as their derivatives, vanish at $\pm\infty$. [5 marks]

(**iv**) Show that if two Hermitian operators have simultaneous eigenfunctions, then they commute. [3 marks]

(**c**) A linear harmonic oscillator is in the state

$$\Psi = \frac{1}{\sqrt{14}}[\phi_0 + 2\phi_1 + b_3\phi_3]$$

where $\{\phi_n\}$ are the orthonormal eigenfunctions of the harmonic oscillator with energy eigenvalues $E_n = (n + \frac{1}{2})\hbar\omega$.

(**i**) If this state is normalized, obtain the value of b_3. [4 marks]

(**ii**) Obtain the probability that a measurement of the value of energy in this state gives $\frac{3}{2}\hbar\omega$. [2 marks]

(**iii**) Obtain the expectation value of the energy in this state. [4 marks]

Question 4. (**a**) A particle of energy E approaches a potential step from the left. The potential step is

$$V(x) = \begin{cases} 0 \text{ for } x < 0 \\ -V_0 \text{ for } x \geq 0 \end{cases}$$

where V_0 is a positive constant.

(**i**) Sketch the potential step. [2 marks]

(**ii**) Starting from first principles, show that the reflection coefficient is

$$R = \left(\frac{k-q}{k+q}\right)^2$$

while the transmission coefficient is

$$T = \frac{4kq}{(k+q)^2}$$

where

$$k = \left(\frac{2mE}{\hbar^2}\right)^{1/2} \text{ and } q = \left(\frac{2m}{\hbar^2}(E+V_0)\right)^{1/2}$$

[14 marks]

(**iii**) Prove that these coefficients add up to unity and explain the meaning of this. [3 marks]

(**iv**) Show that the transmission coefficient can be written as

$$T = \frac{4\left(1+V_0/E\right)^{1/2}}{\left(1+\left(1+V_0/E\right)^{1/2}\right)^2}$$

[3 marks]

(**v**) Obtain the transmission coefficient if $E = 2$ eV and $V_0 = 16$ eV.[2 marks]

(**vi**) Explain in what way the results you have obtained differ from the corresponding classical results. [2 marks]

(**vii**) Suppose that in the problem above the energy of the particle was below the height of the potential step. What "unclassical" behaviour does quantum mechanics exhibit in this case? [2 marks]

Note that

$$j = \frac{\hbar}{2mi}(\psi^* \frac{\partial}{\partial x}\psi - \psi \frac{\partial}{\partial x}\psi^*)$$

Question 5. (**a**) The operator for the z component of the angular momentum is given in spherical polar coordinates as

$$\widehat{L}_z = -i\hbar\frac{\partial}{\partial\phi}$$

(**i**) Show that this operator is linear, and explain why this is necessarily so. [2 marks]

(**ii**) Show that the normalized eigenfunctions of this operator are

$$\Phi(\phi) = \frac{1}{\sqrt{2\pi}}e^{im\phi}, \quad m = 0, \pm1, \pm2, ...$$

with corresponding eigenvalues

$$(L_z)_m = m\hbar$$

[12 marks]

(**b**) Given that the operator for the square of the total angular momentum is

$$\mathbf{L}^2 = -\hbar^2\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial}{\partial\theta}) + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial^2\phi}\right],$$

show directly or otherwise that

$$[\mathbf{L}^2, L_z] = 0$$

and explain the importance of this result. [5 marks]

(**c**) Show that the function

$$Y = A\sin\theta e^{i\phi}$$

is an eigenfunction of both L_z and L^2 and obtain the eigenvalues and their corresponding quantum numbers for this eigenfunction. [6 marks]

Question 6. (**a**) The radial Schroedinger equation for the hydrogenlike atom leads to

$$\left(\frac{d^2}{d\rho^2} - \frac{l(l+1)}{\rho^2} + \frac{\lambda}{4} - \frac{1}{4}\right)w_{el}(\rho) = 0$$

(**i**) Show that for large values of ρ, the solution behaves like $e^{-\rho/2}$. [5 marks]

(**ii**) Show that for small values of ρ, the solution behaves like ρ^{l+1}. [5 marks]

(**iii**) The substitution $w_{\varepsilon l} = e^{-\rho/2}\rho^{l+1}f(\rho)$, where $f(\rho) = \sum_{k=0}^{\infty} c_k\rho^k$ yields the recursion relation

$$c_{k+1} = \frac{k+l+1-\lambda}{(k+1)(k+2l+2)}c_k$$

Given that

$$\lambda = \frac{Ze^2}{4\pi\epsilon_0\hbar}\left(-\frac{\mu}{2E}\right)^{1/2}$$

use this information to obtain the energy eigenvalues. [5 marks]

(**b**) The normalised wave function for the ground state of the hydrogen atom has the form

$$u = Ae^{-\beta r}$$

where A is a normalisation constant, $\beta = \dfrac{\mu e^2}{4\pi\epsilon_0\hbar^2}$, and r is the distance between the electron and the proton. Show the following:

(**i**) The normalisation constant is

$$A = \sqrt{\frac{\beta^3}{\pi}}$$

[4 marks]

(**ii**) The energy of this state is

$$E = -\frac{\mu^2}{2\hbar^2}\left(\frac{e^2}{4\pi\epsilon_0}\right)^2$$

[6 marks]

Note that since the given wave function depends only on r, the Hamiltonian is effectively

$$H = -\frac{\hbar^2}{2\mu}\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d}{dr}\right) - \frac{e^2}{4\pi\epsilon_0 r}$$

Remember that the volume element is

$$dV = r^2\sin\theta dr d\theta d\phi$$

with $0 \leq r \leq \infty$, $0 \leq \theta \leq \pi$ and $0 \leq \phi \leq 2\pi$.

You may need the integral

$$\int_0^\infty r^n e^{-\alpha r}dr = n!\alpha^{-n-1}, \text{ if } \alpha \text{ is real}$$

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

The University of Zambia

Department of Physics

First Semester University Examinations – 2010

Electromagnetic Theory and Waves – P361

Duration: Three (3) Hours **Marks: 100**

Instructions

- This paper contains six (6) questions. All questions carry equal marks.
- Attempt any four (4) questions of your choice.
- Show all your work clearly. Omission of essential work will result in a loss of marks.
- Marks allocated for each question are indicated in square brackets [ ].
- Vector definitions, identities and theorems can be found in appendix 1, 2 and 3 and the end of this paper

Physical Constants

- Gravitational constant, $G = 6.6720 \times 10^{-11}\ \mathrm{Nm^2.kg^{-2}}$.
- Permittivity of free space, $\varepsilon_0 \approx 8.854 \times 10^{-12}\ \mathrm{Fm^{-1}}$.
- Permeability of free space, $\mu_0 = 4\pi \times 10^{-12}\ \mathrm{Hm^{-1}}$.
- Elementary charge, $e \approx 1.602 \times 10^{-19}\ \mathrm{C}$.
- Speed of light in vacuo, $c \approx 3.0 \times 10^{8}\ \mathrm{ms^{-1}}$.
- Coulomb's constant, $k = \dfrac{1}{4\pi\varepsilon_0} \approx 9 \times 10^{9}\ \mathrm{Nm^2.C^{-2}}$.

Formulae You May Find Useful

$\mathbf{F} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{qQ}{r^2}\hat{\mathbf{r}}$	$\mathbf{E} = \hat{\mathbf{r}}\dfrac{1}{4\pi\varepsilon_0}\int_\tau \dfrac{\rho d\tau}{r^2}$	$V_b - V_a = -\int_a^b \mathbf{E}\cdot\mathbf{dl}$	$V = \dfrac{1}{4\pi\varepsilon_0}\int_\tau \dfrac{\rho d\tau}{r}$
$\mathbf{F} = q\mathbf{E}$	$\int_S \mathbf{E}\cdot\mathbf{dA} = \dfrac{1}{\varepsilon_0}\int_\tau \rho d\tau$	$\nabla\cdot\mathbf{E} = \dfrac{\rho_f + \rho_b}{\varepsilon_0}$	$\nabla^2 V = -\dfrac{\rho_f + \rho_b}{\varepsilon_0}$
$C = Q/V$	$\int_S \mathbf{J}\cdot\mathbf{dA} = -\dfrac{d}{dt}\int_\tau \rho d\tau$	$\rho_b = -\nabla\cdot\mathbf{P}$	$\sigma_b = \mathbf{P}\cdot\hat{\mathbf{n}}$
$\mathbf{P} = \varepsilon_0\chi_e\mathbf{E}$	$\mathbf{D} = \varepsilon_0\mathbf{E} + \mathbf{P}$	$\varepsilon = \varepsilon_0\varepsilon_r$	$\nabla\cdot\mathbf{D} = \rho_f$
$\int_S \mathbf{D}\cdot\mathbf{dA} = \int_\tau \rho_f d\tau$	$\dfrac{\partial\mathbf{D}}{\partial t} = \dfrac{\partial}{\partial t}\varepsilon_0\mathbf{E} + \dfrac{\partial\mathbf{P}}{\partial t}$	$\mathbf{B} = \dfrac{\mu_0 I}{4\pi}\oint \dfrac{\mathbf{dl}\times\hat{\mathbf{r}}}{r^2}$	$\nabla\cdot\mathbf{B} = 0$
$\mathbf{B} = \nabla\times\mathbf{A}$	$\mathbf{A} = \dfrac{\mu_0}{4\pi}\oint \dfrac{I\mathbf{dl}}{r}$	$\int_C \mathbf{A}\cdot\mathbf{dl} = \Phi$	$\oint_C \mathbf{B}\cdot\mathbf{dl} = \mu_0\int_S \mathbf{J}\cdot\mathbf{dA}$
$\mathbf{F} = Q(\mathbf{E} + \mathbf{v}\times\mathbf{B})$	$\oint \mathbf{E}\cdot\mathbf{dl} = -\dfrac{d\Phi}{dt}$	$\mathbf{E} = -\nabla V - \dfrac{\partial\mathbf{A}}{\partial t}$	$\nabla\times\mathbf{E} + \dfrac{\partial\mathbf{B}}{\partial t} = 0$
$\oint_b \mathbf{E}\cdot\mathbf{dl} = -M\dfrac{dI_a}{dt}$	$\oint \mathbf{E}\cdot\mathbf{dl} = -L\dfrac{dI}{dt}$	$\mathbf{J}_e = \nabla\times\mathbf{M}$	$\mathbf{J}_t = \mathbf{J}_\mathrm{m} + \varepsilon_0\dfrac{\partial\mathbf{E}}{\partial t}$
$\nabla\times\mathbf{H} = \mathbf{J}_f + \dfrac{\partial\mathbf{D}}{\partial t}$	$\nabla\times\left(\dfrac{\mathbf{B}}{\mu_0} - \mathbf{M}\right) = \mathbf{J}_f$	$\mathbf{B} = \mu_0(\mathbf{H} + \mathbf{M})$	$\nabla\times\mathbf{H} = \mathbf{J}_f$
$\oint_C \mathbf{H}\cdot\mathbf{dl} = I_f$	$\mathbf{B} = \mu_0(1 + \chi_\mathrm{m})\mathbf{H}$	$\nabla\times\mathbf{B} - \varepsilon_0\mu_0\dfrac{\partial\mathbf{E}}{\partial t} = \mathbf{J}_\mathrm{m}$	$\mathbf{J}_\mathrm{m} = \mathbf{J}_f + \dfrac{\partial\mathbf{P}}{\partial t} + \nabla\times\mathbf{M}$

Vector Definitions

Divergence of a vector:

$$\nabla\cdot\mathbf{A}=\frac{\partial A_x}{\partial x}+\frac{\partial A_y}{\partial y}+\frac{\partial A_z}{\partial z},\quad \text{where}\quad \mathbf{A}=A_x\hat{\mathbf{x}}+A_y\hat{\mathbf{y}}+A_z\hat{\mathbf{z}}.$$

$$\nabla\cdot\mathbf{A}=\frac{1}{r}\frac{\partial}{\partial r}\left(rA_r\right)+\frac{1}{r}\frac{\partial A_\varphi}{\partial\varphi}+\frac{\partial A_z}{\partial z},\quad \text{where}\quad \mathbf{A}=A_r\hat{\mathbf{r}}+A_\varphi\hat{\boldsymbol{\varphi}}+A_z\hat{\mathbf{z}}.$$

$$\nabla\cdot\mathbf{A}=\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2A_r\right)+\frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}\left(A_\theta\sin\theta\right)+\frac{1}{r\sin\theta}\frac{\partial A_\varphi}{\partial\varphi},\quad \text{where}\quad \mathbf{A}=A_r\hat{\mathbf{r}}+A_\theta\hat{\boldsymbol{\theta}}+A_\varphi\hat{\boldsymbol{\varphi}}.$$

Curl of a vector:

$$\nabla\times\mathbf{A}=\left(\frac{\partial A_z}{\partial y}-\frac{\partial A_y}{\partial z}\right)\hat{\mathbf{x}}+\left(\frac{\partial A_x}{\partial z}-\frac{\partial A_z}{\partial x}\right)\hat{\mathbf{y}}+\left(\frac{\partial A_y}{\partial x}-\frac{\partial A_x}{\partial y}\right)\hat{\mathbf{z}},\quad \text{where}\quad \mathbf{A}=A_x\hat{\mathbf{x}}+A_y\hat{\mathbf{y}}+A_z\hat{\mathbf{z}}.$$

$$\nabla\times\mathbf{A}=\left(\frac{1}{r}\frac{\partial A_z}{\partial\varphi}-\frac{\partial A_\varphi}{\partial z}\right)\hat{\mathbf{r}}+\left(\frac{\partial A_r}{\partial z}-\frac{\partial A_z}{\partial r}\right)\hat{\boldsymbol{\varphi}}+\frac{1}{r}\left[\frac{\partial}{\partial r}\left(rA_\varphi\right)-\frac{\partial A_r}{\partial\varphi}\right]\hat{\mathbf{z}},\quad \text{where}\quad \mathbf{A}=A_r\hat{\mathbf{r}}+A_\varphi\hat{\boldsymbol{\varphi}}+A_z\hat{\mathbf{z}}.$$

$$\nabla\times\mathbf{A}=\frac{1}{r\sin\theta}\left[\frac{\partial}{\partial\theta}\left(A_\varphi\sin\theta\right)-\frac{\partial A_\theta}{\partial\varphi}\right]\hat{\mathbf{r}}+\frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial A_r}{\partial\varphi}-\frac{\partial}{\partial r}\left(rA_r\right)\right]\hat{\boldsymbol{\theta}}+\frac{1}{r}\left[\frac{\partial}{r}\left(rA_\theta-\frac{\partial A_r}{\partial\theta}\right)\right]\hat{\boldsymbol{\varphi}},$$

where $\mathbf{A}=A_r\hat{\mathbf{r}}+A_\theta\hat{\boldsymbol{\theta}}+A_\varphi\hat{\boldsymbol{\varphi}}$.

Vector Identities and Theorems

1. $\mathbf{A}\times\left(\mathbf{B}\times\mathbf{C}\right)=\mathbf{B}\left(\mathbf{A}\cdot\mathbf{C}\right)-\mathbf{C}\left(\mathbf{A}\cdot\mathbf{B}\right)$
2. $\nabla\left(fg\right)=f\nabla g+g\nabla f$
3. $\nabla\cdot\left(f\mathbf{A}\right)=\left(\nabla f\right)\cdot\mathbf{A}+f\left(\nabla\cdot\mathbf{A}\right)$
4. $\nabla\cdot\left(\mathbf{A}\times\mathbf{B}\right)=\mathbf{B}\cdot\left(\nabla\times\mathbf{A}\right)-\mathbf{A}\cdot\left(\nabla\times\mathbf{B}\right)$
5. $\nabla\times\left(f\mathbf{A}\right)=\left(\nabla f\right)\times\mathbf{A}+f\left(\nabla\times\mathbf{A}\right)$
6. $\nabla\times\nabla\times\mathbf{A}=\nabla\left(\nabla\cdot\mathbf{A}\right)-\nabla^2\mathbf{A}$
7. $\nabla\left(\frac{1}{r}\right)=\frac{1}{r^2}\hat{\mathbf{r}}$, where the gradient is calculated at the source point $\left(x',y',z'\right)$ and $\hat{\mathbf{r}}$ is the unit vector from the source point $\left(x',y',z'\right)$ to the field point $\left(x,y,z\right)$.
8. **Divergence theorem:**
   $\int_s\mathbf{A}\cdot\mathbf{da}=\int_\tau\nabla\cdot\mathbf{A}d\tau$, where s is the closed surface that bounds the volume τ.
9. **Stokes's theorem:**
   $\oint_c\mathbf{A}\cdot\mathbf{dl}=\int_s\left(\nabla\times\mathbf{A}\right)\cdot\mathbf{da}$, where c is the closed curve that bounds the surface s.

1. (a) (i) State Coulomb's law in vector form and write down the corresponding equation. **[4]**

(ii) Two up-quarks, each with electric charge $Q=(2/3)e$ where e is the elementary charge, are separated by 10^{-16} metres. Use Coulomb's law to show that the magnitude of the electric force between the two quarks is $F=1.03\times10^{4}$ N. **[2]**

(b) (i) Write down the integral form of Gauss's law for electrostatics. **[1]**

(ii) A sphere carries a volume charge density proportional to the distance from the origin, $\rho=kr$, for some positive constant k.

a. Show that the total charge enclosed in a sphere of radius r is $Q_{\text{enc}}=k\pi r^{4}$. **[5]**

b. use Gauss' law for electrostatics to show that the electric field at a point distance r from the centre of the sphere is given by $\mathbf{E}=\dfrac{kr^{2}}{4\varepsilon_0}\hat{\mathbf{r}}$. **[3]**

(c) Prove that the electric field a distance z above the centre of a flat circular disk of radius R which carries a uniform surface charge density σ is given by

$$\mathbf{E}_{\text{disc}}=\frac{\sigma z}{2\varepsilon_0}\left[\frac{1}{z}-\frac{1}{\sqrt{R^2+z^2}}\right]\hat{\mathbf{z}},$$

where the unit vector $\hat{\mathbf{z}}$ points in the direction of increasing values of z. **[10]**

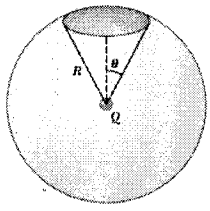
2. (a) (i) Write down the differential form of Gauss's law for electrostatics. **[1]**

(ii) The electric field contained in a certain spherical geometry is found to be $\mathbf{E}=kr^{3}\hat{\mathbf{r}}$, where k is a positive constant, r is the radial distance from the origin and $\hat{\mathbf{r}}$ is a unit vector in the radial direction.

a. Use the differential form of Gauss' law to show that the volume charge density is $\rho=5\varepsilon_0 kr^{2}$. **[6]**

b. Show that the total charge contained in a sphere of radius R and centred at the origin is given by $Q=4\pi\varepsilon_0 kR^{5}$. **[6]**

(b) A sphere of radius R surrounds a point charge Q located at its centre.



(i) Show that the differential surface element of a circular cup of half-angle θ is given by

$$dA = 2\pi R^2 \sin\theta d\theta$$ **[4]**

(ii) Using the result in (i), show that the total area of the circular cup is

$$A = 2\pi R^2 (1-\cos\theta)$$ **[3]**

(iii) Use Gauss' law to show that the electric flux through the circular cup is

$$\Phi_E = \frac{Q}{2\varepsilon_0}(1-\cos\theta).$$ **[5]**

3. (a) The electric potential of some configuration is given by the expression

$$V(\mathbf{r}) = A\frac{e^{-\lambda r}}{r},$$

where A and λ are positive constants, while $\mathbf{r} = r\hat{\mathbf{r}}$ where $\hat{\mathbf{r}}$ is a unit vector. Show that the electric field is given by

$$\mathbf{E} = \frac{Ae^{-\lambda r}(1+\lambda r)}{r^2}\hat{\mathbf{r}}.$$ **[4]**

(b) Two coaxial metal tubes of length L and having radii a and b (where $b > a$) are separated by a material of uniform electric conductivity σ.

(i) If λ is the electric charge per unit length on the inner tube, show that the electric field between the tubes at is given by

$$\mathbf{E} = \frac{\lambda}{2\pi\varepsilon_0 s}\hat{\mathbf{s}},$$

where $a < s < b$. **[5]**

(ii) Use the result in (i) to verify that the current density is given by

$$\mathbf{J} = \frac{\lambda\sigma}{2\pi\varepsilon_0 s}\hat{\mathbf{s}}.$$ **[2]**

(iii) Use the fact that $I = \int \mathbf{J}\cdot d\mathbf{A}$ and the result in (ii) to show that the current flowing between the tubes is given by

$$I = \frac{\sigma\lambda L}{\varepsilon_0}.$$ **[3]**

(iv) If the tubes are maintained at a constant electric potential V, show that the current flow from one tube to another is

$$I = \frac{2\sigma L}{\ln(b/a)}V.$$ **[7]**

(v) Sketch the graph of I against V. **[2]**

(vi) Hence show that the resistance of the material separating the tubes is

$$R = \frac{1}{2\sigma L}\ln\left(\frac{b}{a}\right).$$ **[2]**

4. (a) An electron in a television picture tube moves towards the front of the tube with a speed of 8×10^6 ms^{-1} along the x-axis. Surrounding the neck of the tube are coils of wire that create a magnetic field of magnitude 0.025 T, directed at an angle 60° to the x-axis and lying in the xy plane.

(i) Write down the vector expression $\mathbf{v}$ for the velocity of the electron. **[1]**

(ii) Show that the vector expression for the magnetic field is

$$\mathbf{B} = \left(0.013\hat{\mathbf{x}} + 0.022\hat{\mathbf{y}}\right)\text{T},$$

where $\hat{\mathbf{x}}$ and $\hat{\mathbf{y}}$ are unit vectors in the positive x- and y-axes, respectively. **[1]**

(iii) Compute $\mathbf{v}\times\mathbf{B}$. **[6]**

(iv) Hence show that the magnetic force is given by

$$\mathbf{F}_\text{B} = \left(-2.8\times10^{-14}\,\text{N}\right)\hat{\mathbf{z}},$$ **[1]**

where $\hat{\mathbf{z}}$ is a unit vector along the positive z-axis. **[1]**

(b) A charge $q = 3.20\times10^{-19}\,\mathrm{C}$ moves with a velocity $\mathbf{v} = (2\hat{\mathbf{x}} + 3\hat{\mathbf{y}} - \hat{\mathbf{z}})\,\mathrm{ms}^{-1}$ through a region where both a uniform magnetic field and a uniform electric field exist. Given that $\mathbf{B} = (2\hat{\mathbf{x}} + 4\hat{\mathbf{y}} + \hat{\mathbf{z}})\,\mathrm{T}$ and $\mathbf{E} = (4\hat{\mathbf{x}} - \hat{\mathbf{y}} - 2\hat{\mathbf{z}})\,\mathrm{Vm}^{-1}$,

(i) Write down the Lorenz formula. **[2]**

(ii) Use the Lorenz formula to show that the net force on the moving charge is

$$\mathbf{F} = (3.52\hat{\mathbf{x}} - 1.60\hat{\mathbf{y}})\times10^{-18}\,\mathrm{N},$$ **[5]**

(ii) What angle does the net force make with the positive x-axis? **[2]**

(c) (i) State Ampere's law and write down the corresponding equation in terms of the magnetic field intensity $\mathbf{H}$. **[3]**

(ii) Use Ampere's law to show that for an infinitely long straight current filament

$$\mathbf{H} = \frac{I}{2\pi r}\hat{\boldsymbol{\varphi}},$$

where $\hat{\boldsymbol{\varphi}}$ is a unit vector in the azimuthal direction. **[3]**

5. (a) A sphere of radius R carries a polarisation $\mathbf{P} = k\mathbf{r}$, where k is a constant and $\mathbf{r}$ is a vector from the centre.

(i) Show that the surface bound charge density is $\sigma_b = kR$. **[2]**

(ii) Show that the volume bound charge is $\rho_b = -3k$. **[3]**

(b) Starting with the Biot–Savart law, namely

$$\mathbf{B} = \frac{\mu_0 I}{4\pi}\oint\frac{\mathbf{dl}\times\hat{\mathbf{r}}}{r^2},$$

show that the vector potential of a static magnetic circuit is given by

$$\mathbf{A} = \frac{\mu_0}{4\pi}\oint\frac{I\mathbf{dl}}{R}.$$ **[10]**

(c) A long circular cylinder of radius R carries a magnetisation $\mathbf{M} = ks^2\hat{\boldsymbol{\varphi}}$, where k is a constant, s is the distance from the axis of the cylinder and $\hat{\boldsymbol{\varphi}}$ is the azimuthal unit vector. Prove that

$$\mathbf{B} = \mu_0 ks^2\hat{\boldsymbol{\varphi}} \ ,$$

for $a \le s \le R$ where μ_0 is the permeability of free space. **[10]**

6. (i) Write down Maxwell's equations in vacuo in terms of the electric field $\mathbf{E}$ and magnetic field $\mathbf{B}$ vectors. **[4]**

(ii) Show that in vacuum the electric field vector $\mathbf{E}$ and magnetic field vector $\mathbf{B}$ satisfy the general wave equations

$$\nabla^2\mathbf{E} = \mu_0\varepsilon_0\frac{\partial^2\mathbf{E}}{\partial t^2} \qquad \text{and}$$

$$\nabla^2\mathbf{B} = \mu_0\varepsilon_0\frac{\partial^2\mathbf{B}}{\partial t^2}. \qquad \textbf{[20]}$$

(iii) Hence write down the expression for the magnitude of the velocity, in terms of μ_0 and ε_0 for electromagnetic waves in vacuo. **[1]**

END OF P361 EXAMINATION - 2010

The University of Zambia

Department of Physics

University Examination

2010/11 Academic Year

P 401

Computational Physics II

Instructions **Max. Marks 100**

- ***Time allowed:*** *Three (3) Hours.*
- ***All questions carry equal marks.***
- *Marks for each question are shown in the square brackets [ ].*
- *Whenever necessary, use the information given in the* ***appendix.***
- ***Answer any four (4) questions.***

Q.1 **(a)** Give short answers to the following questions;

i) What is a pointer variable? **[2 Marks]**

ii) If `x` is pointer variable pointing to an initized variable `y`, what is the difference between `&x` and `*x`? **[2 Marks]**

iii) Can the address operator act upon an arithmetic expression such as `2*(u+v)`? Explain the reasons for your answer. **[2 Marks]**

iv) Explain the difference between passing an argument to a function by reference and passing an argument to a function by value. Illustrate by an example in each case. **[2 Marks]**

v) What is the relationship between an array name and a pointer? **[2 Marks]**

(b) $\mathbf{X}$ is a two dimensional integer matrix,

$$\mathbf{X} = \begin{bmatrix} 3 & 5 & 11 & 16 & 18 & 25 & 56 & 70 & 23 \\ 41 & 92 & 27 & 33 & 75 & 19 & 71 & 87 & 90 \\ 1 & 15 & 6 & 66 & 29 & 38 & 2 & 81 & 3 \\ 22 & 17 & 39 & 45 & 92 & 65 & 88 & 72 & 58 \\ 41 & 84 & 49 & 93 & 67 & 86 & 53 & 39 & 47 \end{bmatrix}$$

What is the value of the following

i) $**\mathbf{X}$

ii) $**(\mathbf{X}+2)$

iii) $*(*\mathbf{X}+2)$

iv) $*(*(\mathbf{X}+4)+8)$

v) $*(*\mathbf{X}+8)$

[10 Marks]

(c) How can you declare the matrix in **(b)** using pointer declaration and later on assign a block of memory large enough to store all the quantities? **[5 Marks]**

Q.2 **(a)** What is the difference between the probability density function and the probability distribution function?

[5 Marks]

(b) Let X (milimeters) be the thickness of washers a machine turns out. Assume that X has the density function $f(x) = kx$ if $1.9 < x < 2.1$ and 0 otherwise.

i) Find k, **[5 Marks]**

ii) What is the probability that a washer will have thickness between 1.95 mm and 2.05 mm? **[5 Marks]**

(c) Consider an experiment that consists of counting the number of α-particles given off in a one-second interval by one gram of radioactive material. If we know from past experience that, on average, 3.2 such α-particles are given off, what is a good approximation to the probability that no more than 2 α-particles will appear? **[10 Marks]**

Q.3 **(a)** An example of a Monte Carlo simulation is one used to find the approximate value of pi (π). This is done by considering a unit square that has a circle inscribed in it as shown below.

Given that the ratio

$$\frac{\text{Area of circle}}{\text{Area of square}} = \frac{\pi}{4},$$

write a C program that uses Monte Carlo simulation to find the ratio $\frac{\text{Area of circle}}{\text{Area of squre}}$ and to approximate the value of π. Assume that the random number generator `rand()` generates real random numbers between 0 and 1. **[15 Marks]**

(b) Consider a one dimensional random walk problem in which a dot sitting in the center of the number line takes a step either forward or backward, with equal probability. Show that the average positive distance d away from the center after N steps – each step is either equal to $+1$(forward step) or -1 (backward step) – is given by

$$d = \sqrt{N}$$

[10 Marks]

Q.4 Consider an expriment of 50 trials in which a drunk is allowed to take 100 steps , with an equal probability of moving in any four directions (north, south, east and west). A random number generator is called upon to generate the direction: if between 0 and 0.25 (inclusive), move north; between 0.25 and 0.5 (inclusive), move east; between 0.5 and 0.75 (inclusive), move south; and between 0.75 and 1.0 (inclusive), move west. Write a C program to determine the mean distance travelled by the drunk. Assume that the average step-size is 1m and that the random number generator `rand()` generates real random numbers between 0 and 1.. **[25 Marks]**

Q.5 **(a)** The product data from a simple chemical reaction is given below

$$\mathbf{x} = [0.00 \quad 0.50 \quad 1.00 \quad 1.50 \quad 2.00]$$

$$\mathbf{y} = [0.00 \quad 0.19 \quad 0.26 \quad 0.29 \quad 0.31]$$

Find the least-squares quadratic function for these points. **[15 Marks]**

(b) Find the second order Lagrange polynomial $P_2(x)$ for the Runge Function

$$f(x) = \frac{1}{1 + 25x^2}$$

using three equally spaced points in the interval $[-1, 1]$. Find $P_2(-0.8)$. **[10 Marks]**

Q.6 **(a)** Given the matrix

$$\mathbf{H} = \begin{bmatrix} 1 & 2 \\ 2 & 4 \end{bmatrix}$$

i) Find the eigenvalues of $\mathbf{H}$, **[6 Marks]**

ii) Find the eigenvectors of $\mathbf{H}$, **[6 Marks]**

iii) What is the contribution of the dominant eigenvalue to the trace of $\mathbf{H}$. **[3 Marks]**

(b) Let $f(x) = x^2 \sin(x)$. Determine the trigonometric interpolating polynomial $P_2(x)$ of degree 2, using the direct method, for the data $\{(x_i, y_i)\}_{i=0}^{3}$, where $x_i = \frac{i}{4}$ and $y_i = f(x_i)$. Note that data requires a transformation of the interval $[0, 1]$ to $[-\pi, \pi]$. **[10 Marks]**

$\star\star\star\star\star\star\star$ **End of Examination** $\star\star\star\star\star\star\star$

Appendix

Least-Squares:

Approximation of data using a quadratic function $f(x) = ax^2 + bx + c$

$$a\sum_{i=1}^{n} x_i^4 + b\sum_{i=1}^{n} x_i^3 + c\sum_{i=1}^{n} x_i^2 = \sum_{i=1}^{n} x_i^2 y_i$$

$$a\sum_{i=1}^{n} x_i^3 + b\sum_{i=1}^{n} x_i^2 + c\sum_{i=1}^{n} x_i = \sum_{i=1}^{n} x_i y_i$$

$$a\sum_{i=1}^{n} x_i^2 + b\sum_{i=1}^{n} x_i + c[n] = \sum_{i=1}^{n} y_i$$

Fourier polynomial: For $x \in [-\pi, \pi]$

$$f(x) = \frac{a_0}{2} + a_1\cos(x) + a_2\cos(2x) + \cdots + a_m\cos(mx) + b_1\sin(x) + b_2\sin(2x) + \cdots + b_m\sin(mx)$$

where

$$a_i = \frac{2}{n}\sum_{k=0}^{n-1} f(x_k)\cos(ix_k), \quad \text{and} \quad b_i = \frac{2}{n}\sum_{k=0}^{n-1} f(x_k)\sin(ix_k)$$

n is the number of data points and m is the degree of the polynomial.

Discrete Fourier Transform:

n complex data values z_k evenly spaced on $[0, 2\pi)$ is a set of complex numbers

$$g_j = \sum_{k=0}^{n-1} z_k e^{ijk\omega}, \qquad \text{for} \qquad j = 0, \cdots, n-1$$

Fast Fourier Transform:

$$g_j = \sum_{k=0}^{n-1} z_k w^{jk}, \qquad \text{for} \qquad j = 0, \cdots, n-1$$

where $w = e^{i\omega}$ with $\omega = 2\pi/n$. For $n = 6$ we have

$$\begin{aligned} s_0 &= z_0 + z_3 \\ s_1 &= z_0 + z_3 w^3 \\ s_2 &= z_1 + z_4 \\ s_3 &= z_1 + z_4 w^3 \\ s_4 &= z_2 + z_5 \\ s_5 &= z_2 + z_5 w^3 \end{aligned}$$

$$\begin{aligned} g_0 &= s_0 + s_2 + s_4 \\ g_1 &= s_1 + s_3 w + s_5 w^2 \\ g_2 &= s_0 + s_2 w^2 + s_4 w^4 \\ g_3 &= s_1 + s_3 w^3 + s_5 w^6 \\ g_4 &= s_2 + s_2 w^4 + s_4 w^8 \\ g_5 &= s_1 + s_3 w^5 + s_5 w^{10} \end{aligned}$$

The University of Zambia
School of Natural Sciences
Department of Physics
2010 Academic Year First Semester
Final Examinations
P-411: Nuclear Experimental Techniques

Attempt <u>any four</u> questions. All questions carry equal marks. The marks are shown in brackets.

Time: Three hours. **Maximum marks = 100.**

Write clearly your computer number on the answer book.

==========

Wherever necessary use:

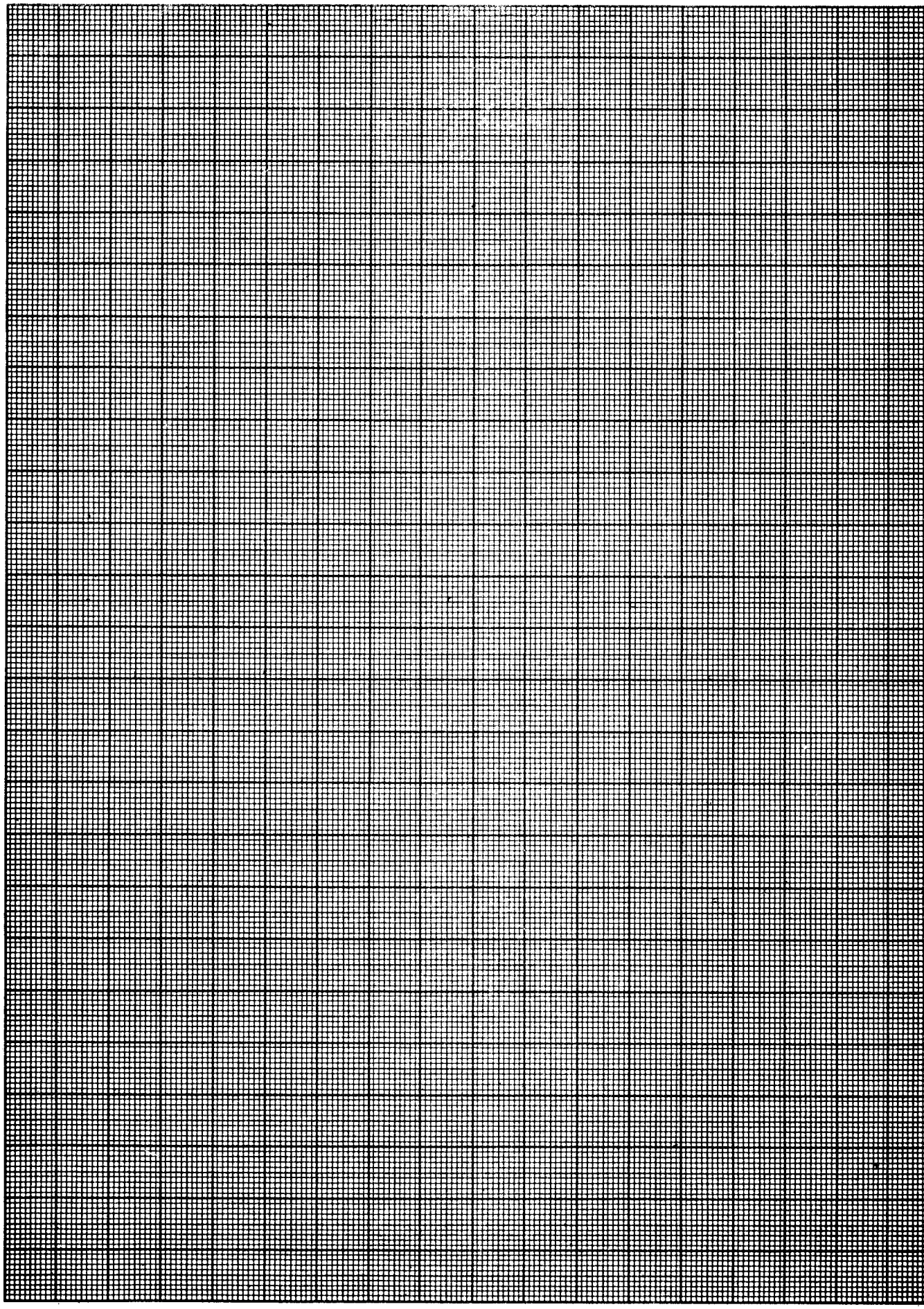
g =	$9.8 m/s^2$
charge of an electron =	$1.6 \times 10^{-19} C$
1 barn =	$10^{-24} cm^2$
mass of an electron =	$9.1 \times 10^{-31} kg$
1 eV =	$1.6 \times 10^{-19} J$
1 a.m.u. =	931.5 MeV $= 1.66 \times 10^{-27}$ kg
$N_{Av.}$ =	6.02×10^{23} per mole
1 curie =	3.7×10^{10} disintegrations/s
Planck's constant h =	6.63×10^{-34} J.s

$$\mu_a = \mu / N = \frac{\mu A}{\rho N_A}$$

Some equations you may find useful:

$$h\upsilon' = \frac{h\upsilon}{1 + \frac{h\upsilon}{m_0 c^2}(1 - \cos\theta)} \qquad \Omega = \frac{\pi a^2}{d^2} \qquad N = N_0 e^{-\Sigma_t x} \qquad m = \frac{n}{1 + n\tau}$$

$$\mu_m = \frac{\mu}{\rho} = \frac{\sigma N}{\rho} = \frac{N_A \sigma}{atomic\ mass} \qquad n - m = n m \tau \qquad E_r = \frac{V_0}{r \ln(b/a)}$$



Q 1. (a) Consider a nuclide *A* that decays into a nuclide *B* which in turn decays into a stable nuclide *C*. If N_1^0 is the number of atoms of *A* initially present and the initial number of atoms *B* is zero, derive an expression giving the number of atoms *B* present at any time ($t > 0$) explaining all the symbols you use. [10]

(b) Draw on the same graph the curves showing the decay of *A* and the growth and decay of *B*. [5]

(c) Hence show by calculation or otherwise, that if N_1^0 is the number of parent atoms *A* initially present, the time at which the number of radioactive daughter atoms *B* is maximum is t_{max} where [10]

$$t_{\max} = \frac{\ln(\lambda_B / \lambda_A)}{(\lambda_B - \lambda_A)}$$

given λ_A = decay constant of the parent nuclide, and λ_B = decay constant of the daughter nuclide *B*.

Q2. (a) Mention two types of neutron sources and briefly describe how neutrons are produced in each case. [6]

(b) Neutrons do not interact with matter in the same way as charged particles do; explain why this is so, and describe briefly the type of interactions that neutrons may undergo. [6]

(c) The nuclide ^{76}As emits four groups of beta particles, with end-point energies (E_{max}) of 2.97, 2.41, 1.76 and 0.36 MeV respectively. Associated with the beta particles are gamma rays of energies 0.561, 0.643, 1.200, 1.490 and 2.05 MeV.

Construct a decay scheme based on this data. [7]

(d) An ion chamber is connected to an electrometer of capacitance 0.5×10^{-12} farad and voltage sensitivity of 4 divisions/volt. A beam of alpha particles causes a deflection of 0.8 division. Calculate the number of ion pairs required and the energy of the alpha particles. [1 ion pair ≡ 35eV, $e = 1.6 \times 10^{-19}$ C]. [6]

Q3(a) State the three major differences in the properties of organic and inorganic scintillation materials. [6]

(b) Explain the function of the *activator* in a *NaI(Tl)* scintillator. [4]

(c) (i) Explain under what conditions the Binomial, the Poisson, or the Gaussian distribution functions can be used to predict the probability distribution function for binary processes. [9]

(ii) What are the applications of statistical models in experimental nuclear physics? [2]

(d) Explain the following statement: In a windowless proportional counter, the output pulse height from an alpha particle source will increase with increasing alpha energy, whereas for beta particles the opposite is usually true. [4]

Q4.(a) A portion of a pulse height spectrum taken with a Multi Channel Analyzer using a High Purity Germanium detector is given below:

Channel	Counts	Channel	counts	Channel	counts
27	162	34	511	41	430
28	199	35	506	42	418
29	251	36	550	43	366
30	301	37	599	44	329
31	347	38	590	45	295
32	432	39	510	46	232
33	434	40	491	47	159

(i) Plot the data and find the number of counts under the peak by direct summation assuming that the data consists of a constant background plus a Gaussian-shaped peak.
(ii) Estimate the constant background level.
(iii) If the energy calibration is 0.1513 keV/channel, what is the energy of the peak and its FWHM in keV? [12]

[Write your computer number on the graph paper and attach it firmly with the answer book]

(b) Gamma rays of energy 3.0 MeV are incident on a *small* sized *NaI(Tl)* detector.

(i) Draw the idealized response function; explain its various features. [3]

(ii) Describe how the various regions of the spectrum are related to the three well-known interaction processes of gamma rays with matter. [4]

(iii) For each process, sketch the variation of the interaction cross section with the gamma ray energy E_γ and the atomic number Z of the material. [6]

Q5. (a) A block of *aluminium* 2cm thick is used in an experiment to measure the total neutron cross section with a well-collimated neutron beam. If the neutron detector registers 1000 counts/second with the cylinder removed from the neutron beam, and 100 counts with the cylinder inserted in the beam, calculate the total cross section of a*luminium* for these neutrons.

Density of aluminium = 2.7 g/cm^3 and the mass of a mole of aluminium is 27 grams. [13]

(b) Calculate the pulse amplitude from the anode of a PM tube used with a *NaI(Tl)* scintillator under the following conditions:

A 1MeV electron loses all its energy in the scintillators. The absolute scintillation efficiency of *NaI(Tl)* is 13%, and 4 eV of energy is required to produce each photon.

Efficiency of light collection to the photocathode is 50%, average quantum efficiency of the photocathode is 20%; 80% of the photo-electrons are collected at the first dynode.

Assume that the PM tube has 10 stages with a multiplication factor δ = 2.5 per stage. The anode load resistance is 100kΩ, and the anode capacitance is 100pF. [12]

Q6. (a) Write short notes on *full-energy peak efficiency*, *relative efficiency*, and *intrinsic efficiency* of a radiation detector. [6]

(b) Define *dead time* and *energy resolution* of a detector. [4]

(c) A Cs-137 source emitting 0.662 MeV gamma rays is placed in front of a *NaI(Tl)* detector of size 5cm x 5cm. The source-to-detector distance is 25cm.

(i) If the number of counts in the photopeak for a 2-minute counting period is 15,000, calculate the *intrinsic photopeak efficiency* of the detector.

(ii) Calculate also the *absolute efficiency* of the detector if the number of counts outside the photo-peak for the same period of counting is 25,000.

Given, the activity of the source is 1 micro-curie; Cs-137 emits a 662 keV gamma ray in 92% of its emissions. [12]

(d) When a fast neutron is captured by a heavy nuclide, the following reactions are possible: *(n,α)*, *(n,γ)* and *(n,p)*. If the probability of the reaction is determined by the height of the potential barrier, write these equations according to their decreasing order of probability of occurrence. [3]

==End of P-411 2010 Exam==

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF PHYSICS

UNIVERSITY EXAMINATIONS: SEMESTER I

P 421: SOLID STATE PHYSICS I

DATE: NOVEMBER 4, 2010

DURATION: THREE HOURS

TOTAL MARKS: 100

ANSWER ANY FOUR (4) QUESTIONS

ALL WORKING SHOULD BE SHOWN CLEARLY TO EARN FULL CREDIT.

A SHEET OF FORMULAE IS ATTACHED AT THE BACK OF THE QUESTION PAPER.

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QUESTION ONE

(a) (i) Explain the concepts of lattice, basis and crystal structure. How are they related? **[4]**

(ii) What is a Wigner-Seitz cell and how is it constructed? Illustrate. **[4]**

(b) Show that the volume of the first Brillouin zone is

$$V_G = \frac{(2\pi)^3}{V_c}$$

where V_c is the volume of a crystal primitive cell.

Hint: The volume of a Brillouin zone is equal to the volume of the primitive parallelepiped in Fourier space. **[10]**

(c) Silver (FCC) has an atomic radius of 0.144 nm. Assuming silver to be a monovalent metal, calculate the

(i) Fermi energy, **[5]**

(ii) Fermi temperature and **[1]**

(iii) Fermi velocity. **[1]**

QUESTION TWO

(a) What binds inert crystals together? Describe in detail the origin of the bonds **[6]**

(b) The potential energy U of a system of two atoms varies as a function of their distance of separation R as $U = -\frac{A}{R^2} + \frac{B}{R^{10}}$. A stable molecule is formed with the release of 8 eV energy when the interatomic distance is 0.28 nm.

(i) Evaluate the values of A and B **[6]**

(ii) When the atoms are pulled apart, they dissociate. Find the interatomic distance at which the dissociation occurs. **[3]**

(iii) Find the force needed to dissociate this molecule into atoms. **[3]**

(c) NaCl has the same structure as KCl. The Debye temperatures of NaCl and KCl are 281 K and 230 respectively. If the lattice heat capacity of NaCl at 5 K is 1.6×10^{-2} $Jmol^{-1}K^{-1}$, estimate the heat capacity of KCl at 10 K.

[7]

QUESTION THREE

(a) (i) State the Dulong and Petit law. **[3]**

(ii) How does the Debye model differ from the Einstein model of lattice heat capacity? Discuss the consequences of this difference explaining the low temperature behavior of specific heat in each case. **[5]**

(b) (i) Show that for a cubic lattice, the lattice constant a is given by

$$a = \left[\frac{nM_A}{N_A \rho}\right]^{1/3}$$

where n is the number of atoms per unit cell, M_A is the atomic mass, N_A is Avogadro's number and ρ is the density of the crystal material.

[5]

(ii) Determine the packing efficiency and density of sodium chloride from the following data: radius of sodium ion = 0.098 nm, radius of chloride ion = 0.181 nm, atomic mass of sodium = 22.99 amu and atomic mass of chlorine = 35.45 amu. **[5]**

(c) From the dispersion relation

$$\omega = \left|\omega_m \sin\frac{1}{2}ka\right|$$

for a monatomic linear lattice of *N* atoms with nearest neighbour interactions, show that the density of modes is

$$D(\omega) = \frac{2N}{\pi}\frac{1}{(\omega_m^2 - \omega^2)^{1/2}}$$

where ω_m is the maximum frequency. **[7]**

QUESTION FOUR

(a) Explain qualitatively and if possible quantitatively, why the X-ray diffraction (XRD) lines observed from small crystallites become broadened. Base the discussion on one dimensional (1-D) finite array of atoms. **[5]**

(b) Determine the structure factor of an FCC crystal with identical basis. The reciprocal vector is

$$\vec{G} = \frac{2\pi}{a}\left(n_1\hat{x} + n_2\hat{y} + n_3\hat{z}\right)$$ **[8]**

(c) In a powder diffraction experiment, using Cu k-alpha radiation of wavelength 0.154 nm, the first lines are observed from a monatomic cubic crystal when the angle 2θ = 38.0, 44.4, 64.4, 77.2 and 81.4°. Determine

(i) the crystal structure and **[8]**

(ii) lattice parameter. **[4]**

QUESTION FIVE

(a) There are more than six consequences that arise because of neglecting anharmonic effects in solids. Give three of these. **[3]**

(b) From the account of energy quantization of a simple harmonic oscillator given by Planck,

(i) Show that the Einstein model of a mole of solid gives the heat capacity as

$$C_v = 3R\left(\frac{\exp\left[\frac{\hbar\omega}{k_BT}\right]}{\left(\exp\left[\frac{\hbar\omega}{k_BT}\right]-1\right)^2}\left(\frac{\hbar\omega}{k_BT}\right)^2\right)$$

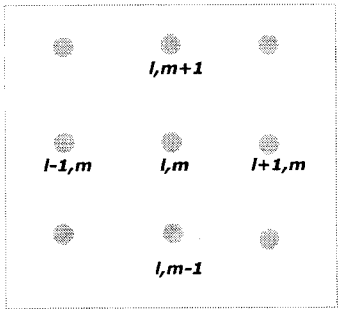
where $R = k_B N_A$ and N_A is the Avogadro's number. **[8]**

(ii) Show that $C_V \to 3R$ at higher temperatures but at low temperatures, C_V increases as

$$\exp\left[-\frac{\hbar\omega}{k_BT}\right]$$

rather than T^3 required. **[4]**

(c) Consider transverse vibrations of a planar lattice of rows and columns of identical atoms, and let $u_{l,m}$ denote the displacement normal to the plane of the lattice of the atom in the lth column and mth row. The mass of each atom is M, and C is the force constant for the nearest neighbour atoms.



(i) Show that the equation of motion is

$$M\frac{d^2u_{lm}}{dt^2} = C\left[\left(u_{l+1,m} + u_{l-1,m} - 2u_{lm}\right) + \left(u_{l,m+1} + u_{l,m-1} - 2u_{lm}\right)\right]$$

[2]

(ii) Assume solutions of the form

$$u_{lm} = u\exp\left[i\left(lk_x a + mk_y a - \omega t\right)\right]$$

where a is the spacing between the nearest neighbour atoms. Show that the equation of motion is satisfied if

$$\omega^2 M = 2C\left(2 - \cos k_x a - \cos k_y a\right) \qquad \textbf{[6]}$$

(iii) For $ka << 1$, show that

$$\omega = \left(Ca^2/M\right)^{\frac{1}{2}}\left(k_x{}^2 + k_y{}^2\right) = \left(Ca^2/M\right)^{\frac{1}{2}}k^2 \qquad \textbf{[2]}$$

So that in this limit the velocity is constant

QUESTION SIX

(a) What are normal and umklapp processes? Explain with the help of vector diagrams. **[6]**

(b) How does a free electron gas differ from an ordinary gas? **[4]**

(c) (i) The energy at the Fermi surface of the sphere is $\varepsilon_F = \frac{\hbar^2}{2m} k_F{}^2$ Derive an expression for the density of states of a free electron Fermi gas in three dimensions. **[10]**

(ii) Find an expression for the velocity and energy of electrons in a free electron Fermi gas at the Fermi surface.

[5]

END OF EXAM

FORMULAE AND CONSTANTS THAT MAYBE NEEDED

Planck's constant $h = 6.626 \times 10^{-34}$ Js^{-1}

Boltzmann constant $k_B = 1.381 \times 10^{-23}$ JK^{-1}

Avogadro's number $N_A = 6.022 \times 10^{23}$ per g mole

Ratios of $(h^2 + k^2 + l^2)$ values for allowed reflections from cubic crystals as obtained from extinction rules are

SC: 1:2:3:4:5:6:8...

BCC: 2:4:6:8:10:12...

Or 1:2:3:4:5:6...

FCC 3:4:8:11:12:16:19...

DC 3:8:11:16:19...

Structure factor = $S_G = \sum f_j \exp\left(-i\vec{G} \bullet \vec{r}\right)$

$$\varepsilon_F = \frac{\hbar^2}{2m} k_F{}^2$$

Fermi function: $$f(\varepsilon) = \frac{1}{\exp[(\varepsilon - \mu)/k_B T] + 1}$$

Planck's discrete energy values of an oscillator: $\varepsilon_n = \left(n + \frac{1}{2}\right)\hbar\omega$

$$\omega = \frac{2v_s \omega_{ph} n}{c} \sin\frac{\varphi}{2}$$

where $\omega \equiv$ frequency of the phonon

$\omega_{ph} \equiv$ frequency of the incident photon

Total internal energy of a metal at low temperatures is

$$E = \frac{3}{5}\pi^4 N k_B \frac{T^4}{\theta_D{}^3}$$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS

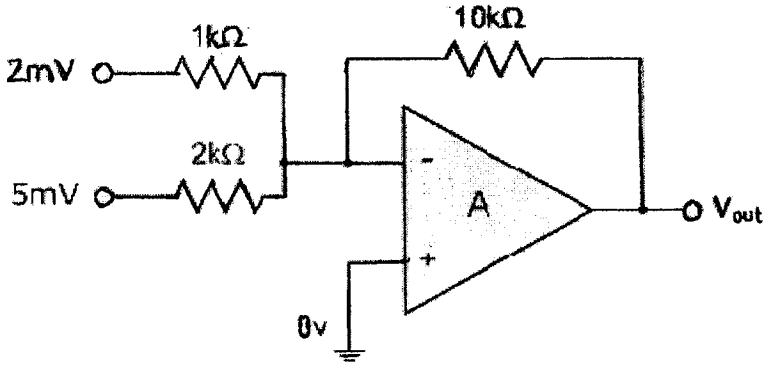
2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

P441: ANALOG ELECTRONICS II

TIME: **THREE HOURS** **MAXIMUM MARKS - 100**

Attempt any four questions.
All questions carry equal marks.
The marks are shown in brackets.

Q1. (a) Find the output voltage of the following operational amplifier circuit. [4]



(b) For an inverting amplifier, suppose that the circuit is nulled when the voltage across terminals $+V_{CC}$ and $-V_{EE}$ measures 24V dc. Because of poor regulation, the voltage across terminals $+V_{CC}$ and $-V_{EE}$ varies with time from 20V to 28V. Determine

(i) the change in the input offset voltage caused by the change in dc supply; [4]

(ii) the total output voltage V_o if V_{in}= 5 mV dc. [2]

The operational amplifier is MC1741 with R_1=100Ω, R_F=4.7kΩ and $\frac{\Delta V_{io}}{\Delta V} = 15.85\mu V/V$.

(c) (i) Design a wide band pass filter with lower cut off frequency of 450 Hz and upper cut off frequency of 2.5 kHz. The total pass band gain of the filter is 4. [13]

(ii) Determine the cut off frequency and bandwidth of the above filter. [2]

Q2. (a) The 714C is configured as a noninverting amplifier. The following data are given for the circuit.

A = 400, 000, $R_1 = 200\ \Omega$, $R_i = 33M\Omega$, $R_F = 3.3\ k\Omega$, $R_o = 60\ \Omega$,
Supply voltages = ± 15V, Maximum output voltage swing = ± 13V,
UGB = 0.6 MHz.

Compute the following closed loop parameters: [10]

(i) Gain
(ii) Input resistance
(iii) Output resistance
(iv) Bandwidth
(v) Total output offset voltage
(vi) Output voltage if V_{in} = 500 mV pp sine wave at 2 KHz.

(b) Show that the characteristic of a differential amplifier with one operational amplifier is the same as that of the non-inverting amplifier. [9]

(c) The 741 operational amplifier is used as an inverting amplifier. Determine the maximum possible output offset voltage due to [6]

(i) input offset voltage V_{io}

(ii) input bias current I_B

(iii) What value offset minimizing resistor is needed to reduce the effect of input bias current I_B?

Given that V_{io} max = 6mV dc, I_B max = 500nA dc, $V_S = \pm 15V$, $R_1 = 470\Omega$ and $R_F = 47k\Omega$.

Q3. (a) What is a Schmitt trigger? Draw the circuit diagram and explain its operation. [10]

(b) For a Schmitt trigger circuit, if $R_1 = 150\Omega$, $R_2 = 68k\Omega$, $V_{in} = 500mV$ peak-to-peak sine wave and the saturation voltages = $\pm 14V$, [5]

(i) Determine the threshold voltages V_{ut} and V_{lt}

(ii) What is the value of hysteresis voltage?

(c) Design an input voltage compensating network for the μA715 operational amplifier for which V_{io}= 6 mV maximum. The operational amplifier uses ±15V supply voltages and is to be used as a non inverting amplifier. [10]

Q4. (a) Explain the operation of producing electric oscillations using a tank circuit. [11]

(b) With a neat diagram, explain the action of a transistor crystal oscillator. [9]

(c) The ac equivalent circuit of a crystal is shown below. Given L=1H, C_1=0.01pF, R=1000Ω and C_2=20pF. Calculate the series resonant and parallel resonant frequencies of the crystal. [5]

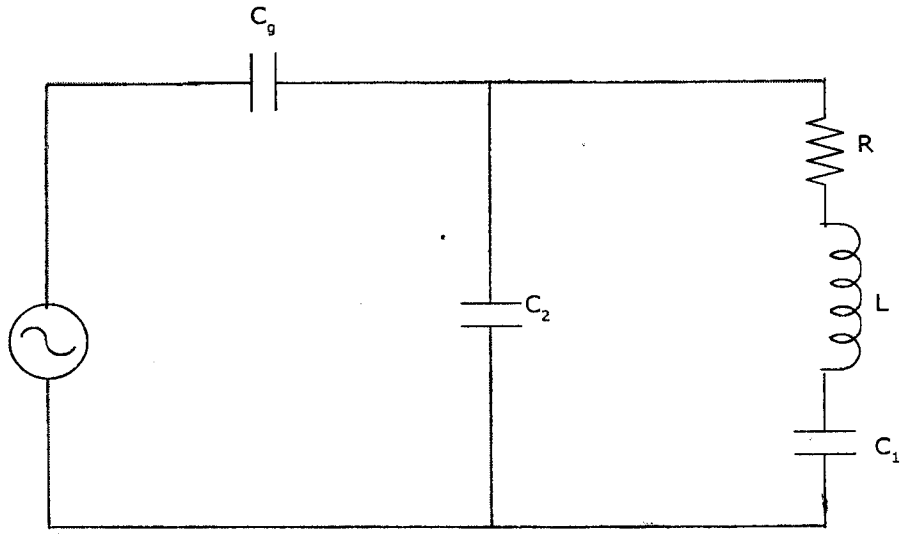
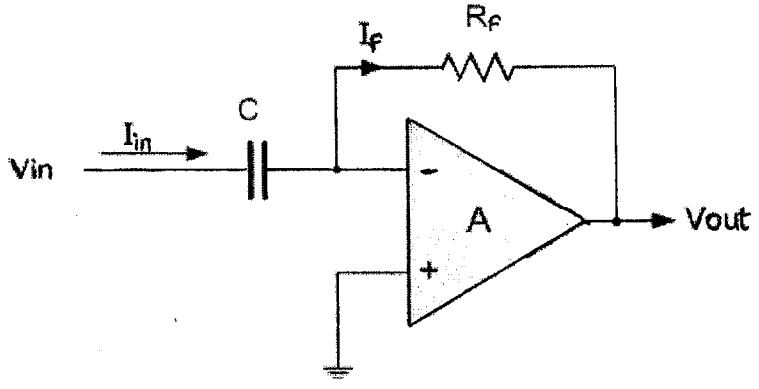


Figure 1

Q5. (a) Explain the difference between slew rate and transient response. [5]

(b) Identify the circuit and derive an expression for the output voltage of the following operational amplifier circuit. [6]



(c) The operational amplifier 741C has open loop gain of 200,000 and break frequency 5Hz.

(i) Write the open loop gain and phase angle equation as a function of break frequency. [3]

(ii) Prepare the frequency response data (magnitude and phase angle) for the following frequencies. [11]

0Hz 5Hz 200Hz 2000Hz 20kHz 100kHz 1MHZ

Q6. (a) For an inverting comparator, V_{in}= 1V peak-to-peak sine wave at 500Hz and supply voltages=±15V. Draw the output waveform if

(i) V_{ref}= 0.2V **(ii)** V_{ref}= -0.6V and **(iii)** V_{ref}= 0V. [6]

(b) (i) Define circuit stability of a system. What are the methods used to check the stability of a circuit. [5]

(ii) Explain how an operational amplifier can be used as a current-to-voltage converter. [6]

(c) Write short notes on [8]

(i) Thermal voltage drift
(ii) Peaking amplifier
(iii) CMRR
(iv) Voltage follower

END OF EXAMINATION