(4)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS -2000
SECOND SEMESTER EXAMINATIONS
SCHOOL OF NATURAL SCIENCES

1.	BS 112-	Systems Biology
2.	BS 212-	Plant And Animal Physiology
3.	BS 221-	Form, Function And Diversity of Plants
4.	BS 222-	Form, Function And Diversity of Animals
5.	BS 319 - BS 332-	Animal Physiology
6.	BS 352-	Parasitology
7.	BS 362-	Genetics
8.	BS 375-	Paper I Theory
9.	BS 412	- Insect Behaviour And Ecology
10.	BS 412-	Applied Entomology
11.	BS 425-	Immunology
12.	BS 432-	Advanced Parasitology
13.	BS 442-	Advanced Molecular Biology Ii
14.	BS 455-	Wild Life Ecology Paper Ii (Practical)
15.	BS 492-	Fisheries Biology
16.	BS 533-	Diseases of Local Crops
17.	BS 536-	Plant Nematology
18.	BS 537-	Seed Pathology
19.	BS 925-	Terrestrial Vertebrate Biology

43.	GEO 272	-	Quantative Techniques in Geography Ii
44.	GEO 912	-	Geography of Migration And Refugees
45.	GEO 922	-	The Geography of Regional Planning And Development
46.	GEO 932	-	Urban Geography
47.	GEO 952	-	Geographical Hydrology
48.	GEO 962	-	Biogeography
49.	GEO 972	-	Satellite Remote Sensing And Geographic Information System
50.	GEO 975	-	Cartography
51.	GEO 995	-	Environment And Natural Resources Management I
52.	M 111	-	Mathematical Methods I
53.	M 112	-	Mathematical Methods II
54.	M 114	-	Mathematics
55.	M 162	-	Introduction to Mathematics, Probability And Statistics II
56.	M 211	-	Mathematical Methods III
57.	M 212	-	Mathematical Methods IV
58.	M 222	-	Linear Algebra II
59.	M 232	-	Real Analysis
60.	M 242	-	Advanced Computer Programming
61.	M 292	-	Introduction to Probability
62.	M 332	-	Real Analysis
63.	M 362	-	Linear Models And Design of Experiments
64.	M 412	-	Functions of A Complex Variable
65.	M 422	-	Mathematics
66.	M 462	-	Bayesian Inference And Discrete Analysis

67.	M 912	-	Mathematics
68.	M 962	-	Time Series Analysis
69.	M 982	-	Numerical Analysis II
70.	P 192	-	Introductory Physics (Option A)
71.	P 198	-	Introductory Physics II (Option B)
72.	P 212	-	Atomic Physics
73.	P 231	-	Properties of Matter And Thermal Physics
74.	P 252	-	Classical Mechanics II
75.	P 272	-	Geometrical And Physical Optics
76.	P 302	-	Computational Physics I
77.	P 332	-	Statistical And Thermal Physics
78.	P 342	-	Introductory Digital Electronics
79.	P 361	-	Electromagnetism
80.	P 401	-	Computational Physics Ii
81.	P 442	-	Digital Electronics 2
82.	P 455	-	Quantum Mechanics Ii
83.	P 485	-	Physics of Renewable Energy Resources And Environment
84.	P Physics	-	For Partial Entry.

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

MAY 2000

BS 112 SYSTEMS BIOLOGY

THEORY PAPER

TIME: Three Hours

ANSWER: ALL Questions using the ANSWER SHEET provided.

MARKS: Correct answer = 4; Wrong answer = -1; I do not know = 0.

NOTE: Submit this question paper; along with your answer sheet, to the Invigilator in the Examination Room.

SECTION A:

PLANT BIOLOGY COMPONENT

1. In most vascular plants the branch roots originate from a meristematic tissue called

   1. the pericarp
   2. the periderm
   3. the pericycle
   4. the protoderm
   5. the endodermis
   6. I do not know.

2. A many-seeded dry fruit which dehisces along one sature at maturity is botanically referred to as

   1. the legume
   2. the capsule
   3. the follicle
   4. the drupe
   5. the berry
   6. I do not know.

3. The funiculus is a structure which is known to connect

   1. the inflorescence to the stem apex
   2. the fruit to the stem axis
   3. the flower to the inflorescence
   4. the ovule to the ovary
   5. the ovary to the floral receptacle
   6. I do not know.

4. A meteorological station at Mfuwe International Airport recorded the following data at 12.00 Hrs. on Monday 21st July 1997: air temperature at normal atmospheric pressure, 25°C; amount of water vapour in 5.0 litres of air sample, 60 mg; amount of water vapour in 1.0 litre of air saturated with water vapour at 25°C and same pressure, 72 mg. Therefore, the relative humidity (R.H.) recorded for Mfuwe Airport was computed to read as follows:

1. R.H. = 65.55%
2. R.H. = 72.75%
3. R.H. = 60.43%
4. R.H. = 8.33%
5. R.H. = 16.67%
6. I do not know.

5. A weather condition in which the relative humidity is very high tends to bring about

1. an increase in the rate of transpiration
2. a reduction in the rate of transpiration
3. a dense development of diffusion shells
4. a sparse development of diffusion shells
5. a significant increase in root pressure.
6. I do not know.

6. The condition of a flower where the stigma becomes receptive to pollen before the maturation of its own stamens is a special type of dichogamous development termed

1. androgyny
2. protogyny
3. protandry.
4. metagyny
5. homogamy
6. I do not know.

7. The positive aspect of Robert Hill's historical experiment was attributed to the incorporation of the so called 'Hill reagent' to a suspension of isolated chloroplasts illuminated by light. This artificial electron acceptor was

1. ferredoxin reducing substance
2. the water molecule
3. NADPH
4. adenosine triphosphate
5. potassium ferricyanide
6. I do not know.

8. A combination of both anticlinal and periclinal mitotic division of cells in the region of the stem apex usually gives rise to the formation of

1. a volume of apical tissue
2. the apical endosperm
3. the apical endodermis
4. the apical epidermis
5. the apical cuticle
6. I do not know.

9. The carrier hypothesis stipulates that some proteinaceous carrier compounds can only function effectively under a physiological condition where

1. each carrier has the affinity for several species of mineral and organic ions
2. each carrier has the affinity for a specific ion species supported by an abundant supply of oxygen in the soil
3. each carrier has the affinity for a specific ion species under anaerobic conditions
4. each carrier exhibits a greater affinity for a specific ion species only when the root organ undergoes a photosynthetic process
5. all the above conditions are correct
6. I do not know.

The following experimental data applies to Questions 10 and 11.:

Two vegetative shoots of the same age and same fresh weights were obtained from the perennial species of a *Hibiscus* plant and a *Solanum* plant for use in a comparative determination of transpiration rates. Given that the internal diameter of the potometer's capillary tube measured 2.4 mm, the rate of transpiration was calculated to the nearest first decimal point.

Plant Name	**Length attained by air bubble (cm)**	**Experimental Time (minutes)**	**Temperature °C**
Hibiscus sp.	11.5	13.0	25°
Solanum sp.	13.6	18.0	25°

10. The transpiration rate exhibited by a shoot of *Hibiscus* sp. was computed as

1. 21.2 mm^3 per min.
2. 15 mm^3 per min.
3. 36.6 mm^3 per min.
4. 40.1 mm^3 per min.
5. 48.6 mm^3 per min.
6. I do not know.

11. As for *Solanum* sp., the transpiration rate was computed as

1. 34.5 mm^3 per min.
2. 30.5 mm^3 per min.
3. 40.8 mm^3 per min.
4. 56.6 mm^3 per min.
5. 43.4 mm^3 per min.
6. I do not know.

12. The phenomenon of hay fever, which is most prevalent in temperate regions of the world, is a manifestation of a pollination type attributed to

1. ornithophily
2. hydrophily
3. entomophily
4. chiropterophily
5. anemophily
6. I do not know.

13. Flowering plants are unique members of the Kingdom Plantae in that they are noted for exhibiting a mode of fertilization in which

1. two sperm nuclei simultaneously fuse with the egg and antipodal nuclei
2. two sperm nuclei simultaneously fuse with the egg cell and the polar nuclei
3. two sperm nuclei simultaneously fuse with the egg cell and the egg apparatus
4. two sperm nuclei simultaneously fuse with endosperm cell and the antipodal nuclei
5. one sperm cell successively fuse with the egg cell and finally fuses with the polar nuclei
6. I do not know.

14. In eukaryotic organisms the molecular structure of membranes that envelop the inherent organelles reveal a transverse section in which

1. a single layer of protein molecules is externally coated by a single layer of phospholipid molecules
2. a single layer of protein molecules is externally coated by two layers of phospholipid molecules
3. a single layer of phospholipid is externally coated by two layers of protein molecules
4. two layers of protein molecules are externally coated by two layers of phospholipid molecules
5. two layers of phospholipid molecules are externally coated by a single layer of protein molecules
6. I do not know.

Questions 15 to 21 should be attempted with reference to illustrations given in **Appendix 1** attached at the end of the examination paper.

15. Carefully examine **Fig.1** and note that the organ labeled as '**a**' is botanically referred to as

1. the achene
2. the follicle
3. the legume
4. the capsule
5. the samara
6. I do not know

16. The longitudinal section of the organ displayed in **Fig. 2** is usually described as

1. a perigynous flower
2. a hypogynous flower
3. an epigynous flower
4. a gamopetalous flower
5. an apetalous flower
6. I do not know.

17. The feature labeled as '**d**' in **Fig. 3** is known as

1. the hypha, typical of members of of Basidiomycetes
2. the hypha, typical of members of the Ascomycetes
3. the stipe, typical of members of the Ascomycetes
4. the stipe, typical of members of the Basidiomycetes
5. the seta, typical of members of the Basidiomycetes
6. I do not know.

18. The developmental stages exhibited in **Fig. 4** are the reproductive features characteristic of organisms that are members of

1. the Class Oomycetes
2. the Class Zygomycetes
3. the Class Ascomycecetes
4. the Class Basidiomycetes
5. the Class Muscid
6. I do not know.

19. The structure labeled as '**b**' in **Fig. 5** is termed

1. the basidiocarp
2. the ascocarp
3. the ascospores
4. the conidiophore
5. the basidium
6. I do not know.

20. The anatomical feature illustrated in **Fig. 6** is a feature that is characteristic of

1. the transverse section of a thick succulent dicot leaf
2. the transverse section of a thick monocot leaf
3. the transverse section of a dicot stem
4. the transverse section of a monocot stem
5. the transverse section of a monocot root
6. I do not know.

21. The feature labeled as '**b**' in **Fig. 7** can be described as

1. the hypodermis
2. the bulliform cells
3. the bundle sheath extension
4. the palisade cells
5. the stomatal complex
6. I do not know.

22. The tissue that is involved in the selective absorption of mineral ions by the roots of vascular plants is

1. the endodermis
2. the exodermis
3. the epidermis
4. the root hairs
5. the pericyle
6. I do not know.

23. It has now been established that in leaves of C_3 plants ribulose 1,5-biphosphate is the initial CO_2 acceptor known to be localised in

1. the bundle sheath cells only
2. the subsidiary cells of the stomatal complex only
3. the mesophyll cells ~~only~~ mainly
4. the cells that constitute the hypodermis
5. the cells that constitute the lower epidermis
6. I do not know.

24. The first detectable compound resulting from the assimilation of carbon dioxide in C_3 plants during the dark reaction of a photosynthetic process is called

1. 3-Phospoglyceraldehyde
2. 3-Phosphoglyceric acid
3. Oxaloacetic acid
4. Aspartic acid
5. Malic acid
6. I do not know.

25. Prior to the event of fertilization in flowering plants, calcium is known to play the role of directing the growth of the pollen tube along a concentration gradient from the stigma towards the ovules. Therefore, calcium is considered to be

1. an osmotic agent
2. a heliotropic agent
3. a growth hormone
4. a chemotropic agent
5. a geotropic agent
6. I do not know.

26. Gaseous exchange involving the movement of carbon dioxide and oxygen through the stomata is achieved by a physiological concept best described as

1. the independent diffusion pressure
2. the dependent diffusion pressure
3. the independent osmotic pressure
4. the dependent osmotic pressure
5. effected by osmotic flow of water
6. I do not know.

27. The mere transfer of pollen grains from the anther to the stigma is a reproductive mechanism usually termed

1. the fertilization process
2. the compatibility process
3. a stage of incompatibility
4. the fusion of sexual gametes
5. a pollination process
6. I do not know.

28. A form of botanical short-hand used in describing the arrangement of flower parts is referred to as

1. the floral formula
2. the floral diagram
3. the floral symmetry
4. the floral design
5. the aestivation of floral parts
6. I do not know.

29. The flowers of the *Hibiscus* species, in which the arrangement of petals of same size is radially symmetrical when viewed from above, is a condition known to be

1. strongly zygomorphic
2. partially zygomorphic
3. strongly actinomorphic
4. partially actinomorphic
5. radially asymmetrical
6. I do not know.

30. The component of the seed called the testa is made up of the protective cells termed

1. the sclereids
2. collenchyma
3. the epidermis
4. the fibres
5. the cuticle
6. I do not know.

31. A plant growth substance which brings about and maintains dormancy in seeds of most plant species is called

1. indole-3-acetic acid
2. indole butyric acid
3. abscisic acid
4. gibberellic acid
5. cytokinin
6. I do not know.

32. When the maize seed imbibes water, this physical event tends to lead to the synthesis of mRNA which, as a consequent, is vital in the immediate synthesis of

1. starch molecules
2. lipid molecules
3. chlorophyll molecules
4. protein molecules
5. glucose molecules
6. I do not know.

33. The heterocyst is a special type of cell found in the filament of the blue-green algae and is involved in

1. the release of oxygen to the atmosphere
2. the release of nitrogen to the atmosphere
3. the release of carbon dioxide to the atmosphere
4. the fixation of carbon dioxide from the atmosphere
5. the fixation of nitrogen from the atmosphere
6. I do not know.

34. Plants which flower at any time of the year, regardless of the nature of photoperiod, are said to be

1. short-day plants
2. evergreen plants
3. day neutral plants
4. perennial plants
5. long-day plants
6. I do not know.

35. An inflorescence which bears several sessile flowers along a single central axis is referred to as

1. the umbel
2. a simple panicle
3. a simple raceme
4. the capitulum
5. a simple spike
6. I do not know.

36. The botanical name for the cultivated crop commonly known as cassava is *Manihot esculenta*. This scientific system of naming plants, as devised by the *International Code of Botanical Nomenclature*, is referred to as the

1. botanical nomenclature
2. biological nomenclature
3. polynomial nomenclature
4. trinomial nomenclature
5. binomial nomenclature
6. I do not know.

37. The aleurine layer is a living tissue located immediately under the seed coat and is known as the site where

1. indole-3-acetic acid is synthesised
2. gibbereilic acid is synthesised
3. abscisic acid is synthesised
4. enzymes of hydrolysis are synthesised
5. products of hydrolysis found in the endosperm tissue are synthesised
6. I do not know.

38. A flattened stem of a xerophytic plant, which has assumed the photosynthetic function of leaves, is termed

1. a cladophyll
2. a cataphyll
3. a phyllode
4. a thallus
5. a spine
6. I do not know.

39. The transverse section of a dicot root clearly shows that the tissue which separates the vascular system from the cortex is

1. the endodermis
2. the pericycle
3. the vascular cambium
4. the hypodermis
5. the phloem
6. I do not know.

40. In most ornamental shrubs the main shoots tend to grow vertically, but the horticultural practice of pruning tends to bring about

1. the inducement of apical dominance and suppression of lateral growth
2. the inducement of both apical and lateral growth
3. the suppression of apical dominance and inducement of lateral growth
4. the suppression of lateral growth and induce apical growth
5. the suppression of lateral dormancy and thus induce apical growth
6. I do not know.

41. A leaflet is an organ of the vascular plant which

1. arises from the axil of the leaf
2. arises from the midrib of a simple leaf
3. arises from the base of the petiole in the form of stipules
4. arises from the rhizome
5. arises from the rachis
6. I do not know.

42. Plasmolysis of the cell is a physiological state in which

1. water molecules osmotically move into the cell due to the high solute concentration of the cytoplasm compared to the surrounding aquatic medium
2. water molecules osmotically move into the cell due to high solute concetration of the surrounding aqueous medium compared to the cytoplasm
3. water molecules osmotically move in out of the cell because the solute concentration of the surrounding aqueous medium is equal to that of the cytoplasm
4. water molecules osmotically move out of the cell due to the high solute concentration of the cytoplasm compared to the surrounding aqueous medium
5. water molecules osmotically move out of the cell due to the high solute concentration of the surrounding aqueous medium compared to the cell cytoplasm
6. I do not know.

43. The greater amount of water lost by plants through a transpiration process is by way of

1. a cuticular pathway
2. a lenticular pathway
3. a stomatal pathway
4. the hydathode pathway
5. the transfusion tissue
6. I do not know.

44. Guttation is a phenomenon that is brought about by a process of

1. a transpiration stream facilitated by anaerobic respiration of the root
2. a transpiration stream facilitated by the passive absorption of water by roots
3. the osmotic passive absorption of water through the apoplast region of the root
4. an active absorption of water later followed by the uptake of mineral ions by roots
5. an active uptake of mineral ions followed later by the osmotic inflow of water into the roots
6. I do not know.

45. In male gametogenesis the developmental process is such that

1. the meiotic division of the spore mother cell leads to the production of one functional daughter cell while three degenerate
2. the meiotic division of the spore mother cell leads to the production of three functional daughter cells and one abortive cell
3. the meiotic division of the spore mother cell leads to the formation of two viable daughter cells and two abortive cells
4. the meiotic division of the spore mother cell leads to the formation of four functional daughter cells
5. the mitotic division of the spore mother cell leads to the formation of four functional daughter cells
6. I do not know.

46. An ovule that is ready for fertilization contains a total of eight nuclei in which

1. two nuclei are located near the micropyle, three nuclei near the chalazal region and another set of three located in the centre of the ovule
2. two nuclei are located near the chalazal region, three nuclei near the micropyle and another set of three nuclei in the centre of the ovule
3. three nuclei are located near the chalazal region, three nuclei near the micropyle and a set of two nuclei in the centre of the ovule
4. the egg apparatus is located in the centre of the ovule
5. the egg apparatus is located near the chalazal region of the ovule
6. I do not know.

47. One of the essential major elements which is incorporated to constitute the nucleus of the chlorophyll molecule is

1. Nitrogen
2. Magnesium
3. Potassium
4. Calcium
5. Carbon
6. I do not know.

48. The event of fertilization triggers one of the following post-fertilization developmental processes

1. a process of anthesis
2. a process of pollination
3. the growth of pollen tube
4. the wilting of petals
5. the transformation of the seed into an ovule
6. I do not know.

49. The open vascular bundles are usually found in

1. herbaceous dicot stems
2. herbaceous dicot leaves
3. herbaceous monocot stems
4. herbaceous monocot leaves
5. leaves of perennial dicot plants
6. I do not know.

50. The African potato is currently being harvested as a popular medinal plant in Zambia. The organ that is being exploited is botanically referred to as

1. the corm
2. the stem tuber
3. the root tuber
4. the rhizome
5. the bulb
6. I do not know.

SECTION B:

ANIMAL BIOLOGY COMPONENT

51. A tissue that receives stimuli and transmits impulses is

1. epithelial
2. connective
3. muscle
4. nervous
5. smooth
6. I do not know.

52. Higher organisms, like the vertebrate animals, contain many different structures which can be ranked in order of complexity. Choose the correct alternative that shows the structures in order of DECREASING complexity:

1. molecules – cells – tissues – organs
2. cells – molecules – tissues – organs
3. cells – molecules – organs – tissues
4. tissues – molecules – organs – cells
5. organs – tissues – cells – molecules
6. I do not know.

53. In the nervous system, the most abundant cell type is

1. motor neuron
2. sensory neuron
3. prepanglionic parasympathetic neuron
4. glial cell
5. prepanglionic sympathetic neuron
6. I do not know.

54. Within the nerve cell, information moves from

1. dendrite to cell body to axon
2. axon to cell body to dendrite
3. cell body to axon to dendrite
4. axon to dendrite to cell body
5. dendrite to axon to cell body
6. I do not know.

55. Which of the following is a function of the liver?

1. bile secretion
2. homeostasis maintenance
3. stores iron
4. synthesis of glucose to glycogen
5. all the above
6. I do not know.

56. Which of the following statements is **not** true?

1. sensory afferents carry information of which we are consciously aware
2. visceral afferents carry information about physiological functions of which we are not consciously aware
3. the voluntary motor division of the efferent side of the peripheral nervous system executes conscious movements
4. the cranial nerves and spinal nerves are parts of the peripheral nervous system
5. afferent and efferent axons never travel in the same direction
6. I do not know.

57. Which of the following blood cells is nucleated and lack haemoglobin?

1. leucocyte
2. erythrocyte
3. platelets
4. plasma
5. fibrinogen
6. I do not know.

58. Which of the following statements accurately describes an action potential?

1. Its magnitude increases along the axon.
2. Its magnitude decreases along the axon
3. All action potentials in a single neuron are of the same magnitude.
4. During an action potential the neuron remains constant.
5. It permanently shifts a neuron's transmembrane potential away from its resting place.
6. I do not know.

59. Urea is the form in which most nitrogenous waste is expelled from the bodies of mammals. The chemical compounds in the body from which this product is derived are:

1. fats
2. vitamins
3. mineral salts
4. amino acids
5. sugars
6. I do not know.

60. The axial skeleton includes

1. the skull
2. the vertebral column
3. the ribs
4. the sternum
5. all the above ✓
6. I do not know.

61. The insoluble protein that gives the skin mechanical strength is

1. keratin ✓
2. sebum
3. oil
4. cuticle
5. actin
6. I do not know.

62. Which of the following statements about skeletons is true?

1. They can consist of any cartilage.
2. Hydrostatic skeletons can be used only for amoeboid locomotions.
3. An advantage of exoskeleton is that they can continue to grow throughout the life of the animal.
4. External skeletons must remain flexible, so they never include calcium carbonate crystals.
5. Internal skeletons consist of four different bones: compact, cancellous, dermal
6. I do not know.

63. The HIV is not a 'perfect' pathogen in terms of its mode of transmission. It slowly but surely kills any one who goes for it. Currently world famous scientists have not yet found the cure. The best way to control and stop the spread of HIV is by:

1. using condoms whenever you are having sexual intercourse
2. using condoms whenever you are having sexual intercourse with someone for the first time
3. change our moral behaviour
4. having so much publicity and education about HIV and its consequences
5. use the African potato
6. I do not know.
7. masturbation ✓
8. Wear six condoms pack time you have sex with a mama at unza. and 2 condoms when you import from Kalingalinga

Both answers, if anyone did UNZA answer, you must be excluded NDBC.

64. From what we learnt in BS112 Animal Biology, the functional cell units of the kidney are called:

1. axons
2. nephrons.
3. neurons
4. dendrons
5. ganglions
6. I do not know.

65. In mammals, which of the following is the most prominent part of the brain?

1. medulla
2. cerebellum
3. cerebrum
4. brain stem
5. pons
6. I do not know.

66. Homeostatic mechanisms in the body .

1. typically depend on negative feedback
2. involve blood sugar levels
3. depend on maintenance of appropriate internal environment
4. are often referred to as stressors
5. the options (3) and (4) are correct
6. I do not know.

67. The pancreas is:

1. an exocrine gland
2. an endocrine gland
3. an organ of true digestive system
4. a hormone producing organ
5. all of the above
6. I do not know.

68. An open circulatory system is characterised by

1. the absence of the heart
2. the absence of the blood vessels
3. blood with a composition different from that of interstitial fluid
4. the absence of capillaries
5. a higher pressure circuit through gills than to other organs
6. I do not know.

69. Which of the following statements about the human heart is true?

1. The walls of the right ventricle are thicker than the walls of the left ventricle.
2. Blood flowing through atroventricular valves is always deoxygenated fluid.
3. The second heart sound is due to the closing of the aortic valve.
4. Blood returns to the heart from the lungs in the vena cava.
5. During systole the aortic valve is open and the pulmonary valve is closed.
6. I do not know.

70. Which of the following statements about essential amino acids is true?

1. They are found in vegetarian diets.
2. They are stored by the body for use when they are needed.
3. All animals require the same ones.
4. Without them one is undernourished.
5. Humans can acquire all of them by eating milk, eggs and meat.
6. I do not know.

71. The digestive enzymes of the small intestine

1. do not function best at a low pH
2. are produced and released in response to circulating secretin
3. are produced and released under neutral control
4. are all secreted by the pancreas
5. are all activated by an acidic environment
6. I do not know.

72. Pepsin, an enzyme which is produced in the stomach mucosa, works best at a pH value of about

1. pH = 2.0
2. pH = 7.4
3. pH = 8.0
4. pH = 14.0
5. None of the above
6. I do not know.

73. The bacteria species that produce vitamin K is found in the

1. mouth
2. oesophagus
3. stomach
4. small intestine
5. large intestine
6. I do not know.

74. Food leaving the stomach next enters the

1. liver
2. pancreas
3. duodenum
4. colon
5. oesophagus
6. I do not know.

75. When we eat excessively, the amount of urea excreted in the urine increase considerably because we ingest

1. nitrate salts in excess
2. carbohydrates in excess
3. fats in excess
4. proteins in excess
5. Nucleic acids in excess
6. I do not know.

76. The structure in an insect that can be considered analogous to a mammalian kidney is the

1. fat body
2. interstinal caeca
3. tracheal system
4. cloaca
5. Malpighian tubules
6. I do not know.

77. Which of the following are not found in a renal pyramid?

1. collecting ducts
2. vas recta
3. peritubular capillaries
4. convoluted tubules
5. Loops of Henle
6. I do not know.

78. The inner surface layer of the kidney is called

1. the bilus
2. the renal artery
3. the medulla
4. the cortex
5. the epithelium
6. I do not know.

79. Sponges belong to the phylum

1. Annelida
2. Mollusca
3. Porifera
4. Cnidaria
5. Arthropoda
6. I do not know.

80. Whether it is the long neck of the giraffe or the short neck of the cat, the number of cervical vertebrae in all mammals is

1. Seven
2. Five
3. Four
4. Twelve
5. Ten
6. I do not know.

81. You are given Fick's formula which reads as follows:

$$\frac{M}{t} = AD\frac{C_1 - C_2}{d}$$

The diffusion constant for oxygen is 2.0×10^{-9} m^2 s^{-1} and the difference in oxygen concentration between the lung lumen and the pulmonary arteries is 10,000 ml/m^3. It therefore follows that the calculation for the rate of oxygen diffusion would give the value of:

1. 0.002 ml/s
2. 0.24 ml/s
3. 2.0 ml/s
4. 200 ml/s
5. 2,000 ml/s
6. I do not know.

82. Elephantiasis is caused by a vector-carrying insect called

1. tsetse fly
2. mosquito
3. horse fly
4. sand fly
5. none of these
6. I do not know.

83. Which of the following does not increase blood flow through a capillary bed?

1. high concentration of CO_2
2. high concentration of lactate and hydrogen ions
3. histamine
4. vasopressin
5. increase in arterial pressure
6. I do not know.

84. The functions of lymphatic systems are:

1. to collect and return blood fluid to the body
2. to defend the body against pathogenic organisms
3. to absorb lipids from the digestive system
4. only (2) and (3) above options are correct
5. none of the above is correct
6. I do not know.

85. The epiglottis

1. seals off the larynx during swallowing
2. is a cavity in the bones of the skull
3. is one of the structures through which gas exchange takes place
4. covers the lungs
5. two of the preceding answers are correct
6. I do not know.

86. The larynx

1. can initiate a cough reflex
2. is a cavity in the bones of the skull
3. is one of the structures through which gas exchange takes place
4. covers the lungs
5. two of the preceding answers are correct
6. I do not know.

87. The surface area of the stomach is increased by the presence of

1. the villi
2. the microvilli
3. the rugae
4. answers (1), (2) and (3) are correct
5. only answers (1) and (2) are correct
6. I do not know.

88. Most carbohydrates are degraded to

1. minerals
2. amino acids
3. glucose
4. glycerol and fatty acids
5. cholesterol
6. I do not know.

89. Which of the following statements about vitamins is true?

1. They are essential inorganic nutrients
2. They are required in larger amounts than are essential amino acids
3. Many serve as co-enzymes
4. Vitamin D can be acquired only by eating meat or dairy products
5. When vitamins C is eaten in large quantities, the excess is stored in fat for later use
6. I do not know.

90. Consider the following statements:

(i) The air that enters the lungs causes an increase of their volume

(ii) The relaxing of the muscles of the diaphragm causes a reduction of lung volume and, therefore, the expulsion of air from the lungs.

Choose the correct alternative.

1. statement (i) is wrong, statement (ii) is correct
2. both statement (i) and statement (ii) are wrong
3. statement (i) is correct, statement (ii) is wrong
4. both statement (I) and statement (ii) are correct
5. none of the above is correct
6. I do not know.

91. During the dissection practical of the rat, where was the liver found?

1. below the lungs in the chest cavity
2. beside the lungs in the chest cavity
3. under the larger and small intestine in the abdominal cavity
4. below the diaphragm in the chest cavity
5. below the diaphragm in the abdominal cavity
6. I do not know.

92. If you were provided with a taxonomical key, to which phylum would you assign an animal with the following diagnostic features:

Body segmented into three divisions, the head, thorax and abdomen

1. Phylum Echinodermata
2. Phylum Porifera
3. Phylum Arthropoda
4. Phylum Annelida
5. Phylum Mollusca
6. I do not know.

93. During the rat dissection, where were the biceps muscles attached?

1. The scapula and humerus bones.
2. The humerus and ulnar bones.
3. The femur and the tibia.
4. The femur and the radius.
5. The humerus and the radius.
6. I do not know.

94. During the rat dissection, which anatomical structures were seen passing through the diaphragm?

1. The aorta and the posterior vena cava
2. The oesophagus and the internal jugular veins
3. The posterior vena cava and the oesophagus.
4. The oesophagus, the anterior vena cava and the aorta
5. The oesophagus, the posterior vena cava and the aorta
6. I do not know.

95. During the animal diversity practical, one of the Classes you looked at was Myriapoda. Which of the following statements is true about members of this Class?

1. They are mostly aquatic animals with gills and many pairs of appendages for swimming.
2. Some of the members have biting mouth parts, poison mandibles and feed on insects while others have chewing mouth parts and feed on plants.
3. The body is divided into a cephalothorax and abdomen, and have four pairs of legs.
4. These are generally elongate, terrestrial arthropods with many segments and appendages.
5. Both (2) and (4) are correct.
6. I do not know.

96. Animals that have a four-chambered heart (two atria and two ventricles) include:

1. lancelets
2. amphibians
3. birds
4. mammals
5. (2) and (4) are correct
6. I do not know.

97. In the circulatory system, gas exchange takes place in

1. veins
2. arterioles
3. capillaries
4. arteries
5. venules
6. I do not know.

98. How are lymphatic vessels like veins?

1. Both have nodes they join
2. Both carry blood under low pressure
3. Both are capitance vessels
4. Both have valves
5. Both carry fluids rich in plasma
6. I do not know.

99. Blood flow through capillaries is slow because

1. lots of blood volume is lost from the capillaries
2. the pressures in venules is high
3. the total cross-sectional area of capillaries is larger than that of arterioles
4. the osmotic pressure in capillaries is very high
5. red blood cells are bigger than capillaries and must squeeze through
6. I do not know.

100. Assimilation can be best described as

1. the incorporation of absorbed nutrients into body tissues
2. the conversion of large molecules of food into smaller units
3. the absorption of digested food
4. the taking in of food
5. none of the above
6. I do not know.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

MAY 2000

BS 112

SYSTEMS BIOLOGY

THEORY PAPER

APPENDIX 1

Fig. 1

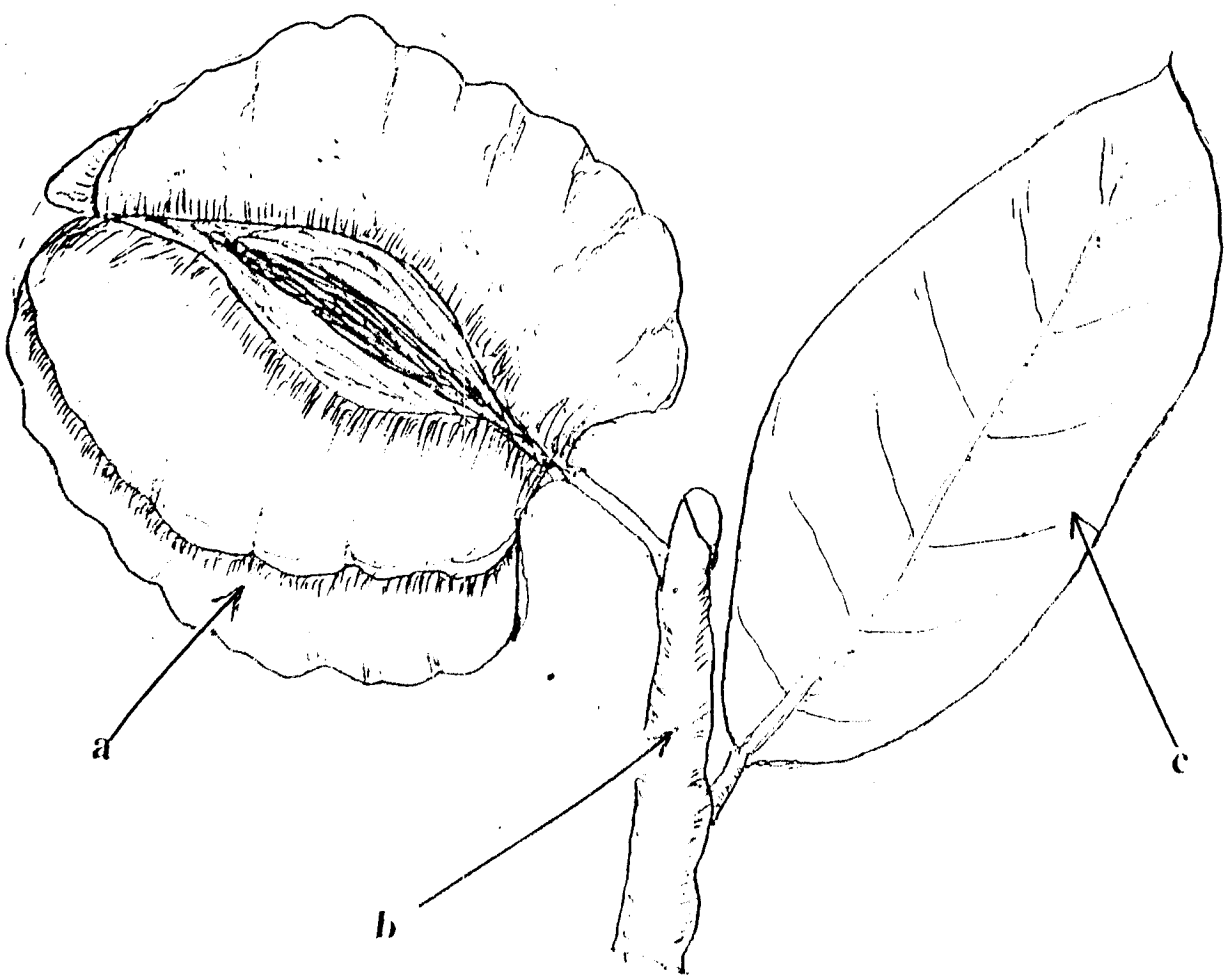


Fig. 2

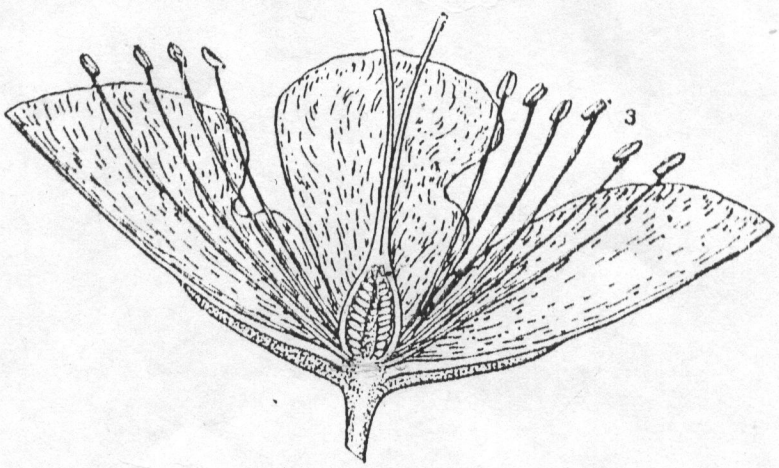


Fig. 3

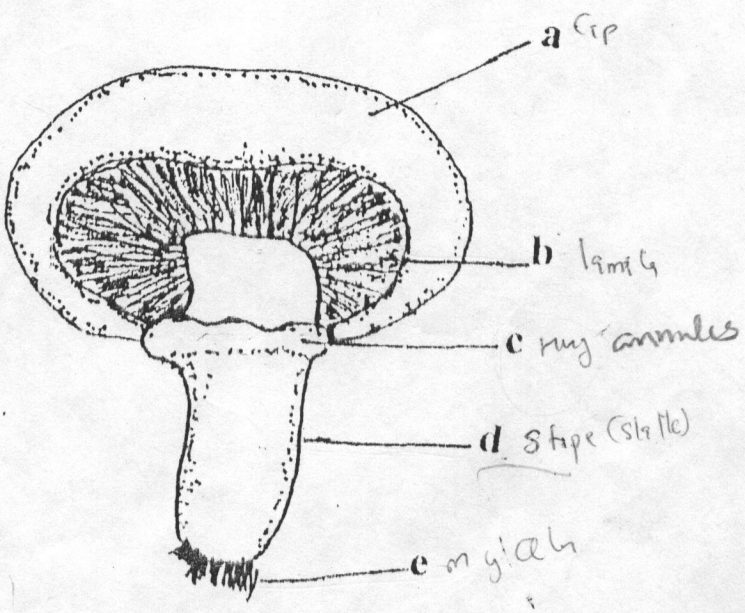


Fig. 4

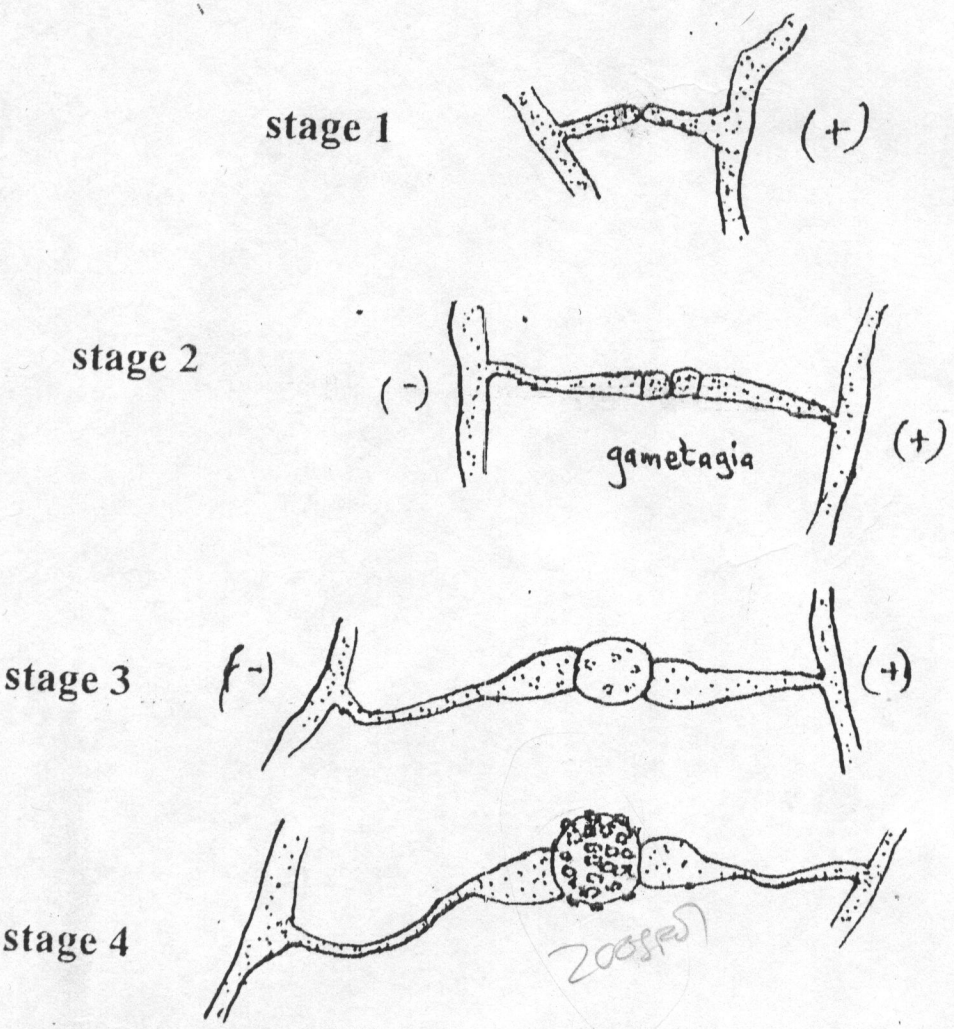


Fig. 5

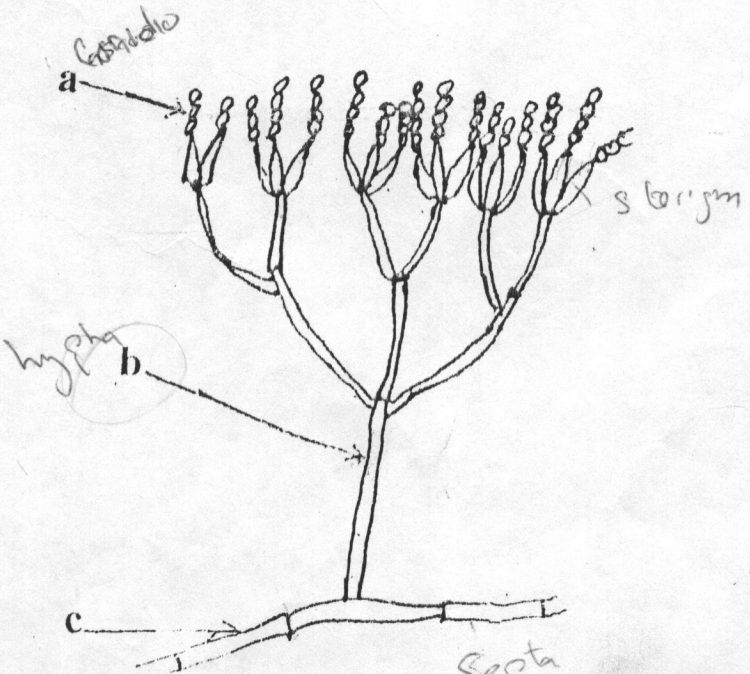


Fig. 6

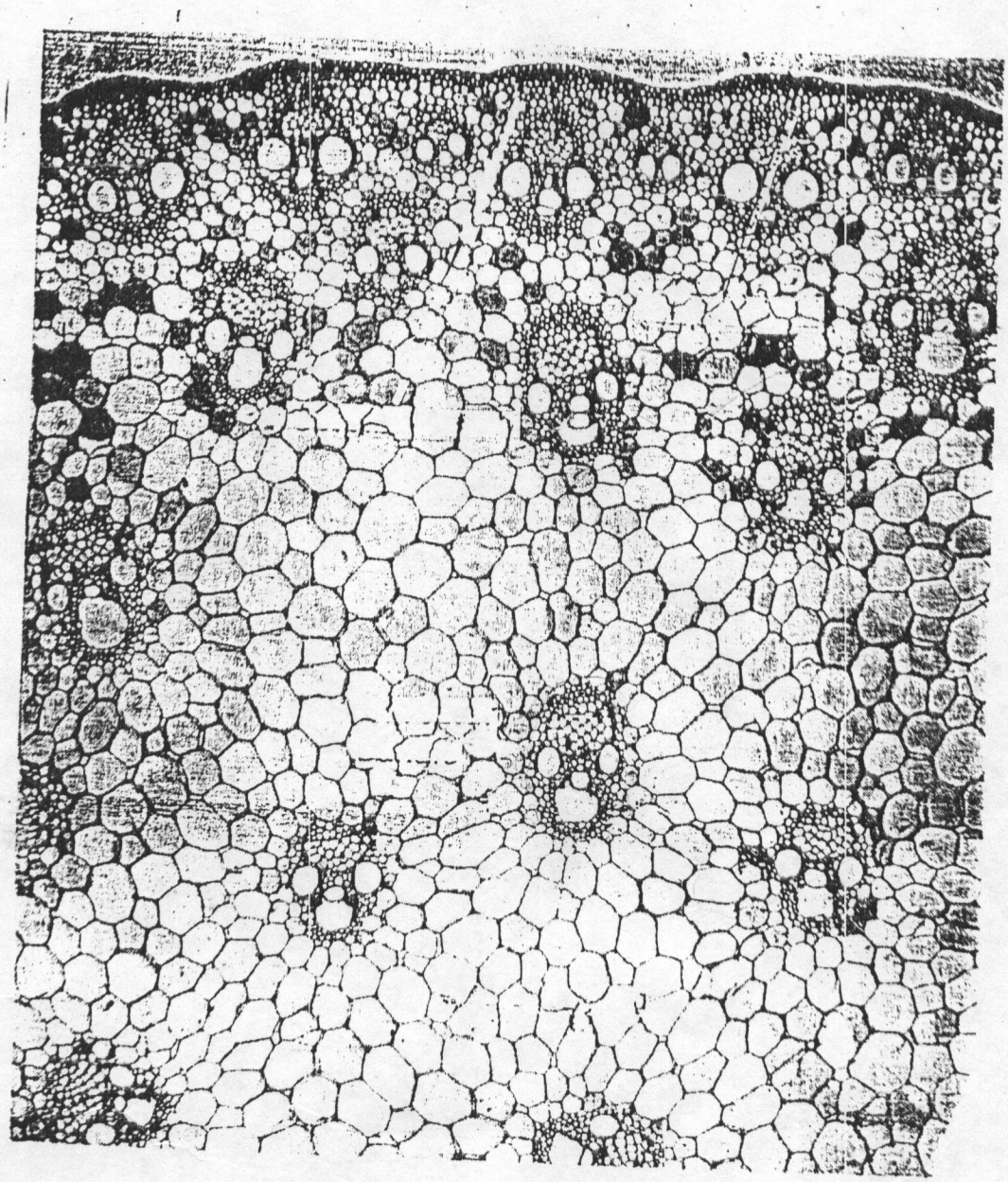
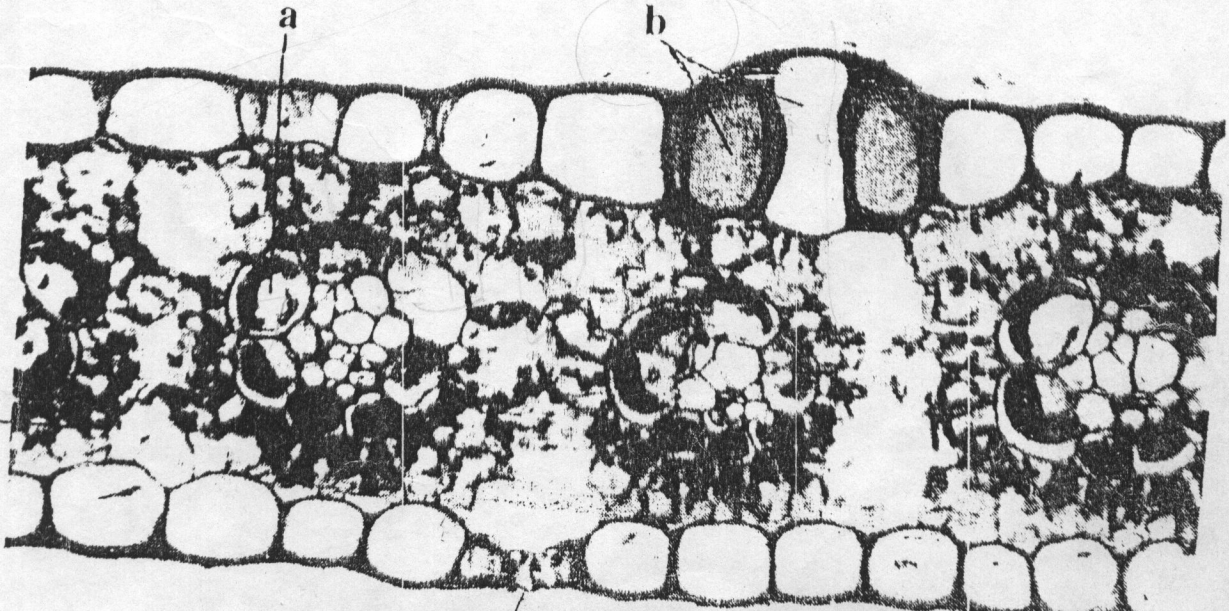


Fig. 7



THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER (1998/99)
DEFERRED/SUPPLEMENTARY EXAMINATIONS, JULY 2000

BS 212
PLANT AND ANIMAL PHYSIOLOGY

THEORY PAPER

TIME: 3 Hours

Instructions: ANSWER FIVE Question, Two from each section and the last question from any section.

Use separate answer books for each section.

SECTION A

PLANT PHYSIOLOGY

1. Pressure – driven bulk flow drives long – distance water transport through tracheids and vessels in the stem to the leaves.

   (a) Explain how the pressure difference arises, and substantiate the statement.

   (b) What have been the main criticisms of the cohesion theory? Do the criticisms invalidate the cohesion theory?

2. In germinating cereal seeds how does the embryo regulate its own development?

3. (a) Describe the organization of pigment-protein complexes in the thylakoid membranes in higher plant chloroplasts.

   (c) During photosynthesis how is light energy absorbed by protein- pigment Complexes transferred to the reaction centres of photosystem I and photosystem II.

4. Auxins and Gibberellins belong to two different families of growth hormones.

   (a) What are their chemical structures, giving one example of the main naturally occuring gibberellin and auxin, and where are the sites of their synthesis in the plant?

   (b) What are their distinguishing physiological effects on growth of stem

tissue?

SECTION B

ANIMAL PHYSIOLOGY

5. How is Osmotic homeostasis maintained in marine and freshwater fishes?

6. Explain the role played by hormones in regulating menstrual cycle in a human female.

7. Describe the process of neurulation or tubulation in frog.

8. Write short notes on <u>any</u> <u>four</u> of the following:

   (a) Bohr effect

   (b) Coprophagy

   (c) Aldosterone

   (d) Cleavage patterns

   (e) Fate maps

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2001

BS 221

FORM, FUNCTION AND DIVERSITY OF PLANTS

PRACTICAL PAPER

TIME: *Two Hours*

INSTRUCTIONS:

1. Answer ***All Questions***.
2. With respect to specimens **A1** to **A10**, write answers from **Section A** in spaces that have been allocated below the relevant questions.
3. Answers from **Section B**, relating to specimens **B1** to **B10**, must be written in separate answer books to be provided by the Examiner.
4. Tie-up and hand in the answer books separately.

SECTION A: THE LOWER PLANTS

NAME (Sirname First): **Computer**

No...... .....

Q1. This question relates to **specimens A1 to A10** as provided under **Section A**.

A1. Identify the

a. symmetry of the thallus

.....

b. common habitat of the specimen

.....

c. phase of the life cycle as seen in the specimen

.....

d. generic name of the specimen.

.....

A2. Identify the

a. thallus type of the specimen

.....

b. chloroplast type present in each cell

.....

c. cell morphology as seen in the outer ring and the central cells

.....

d. generic name of the specimen

.....

A3. i. Identify what structures are seen here?

.....

.....

ii. Identify the branching type seen in the specimen.

.....

.....

iii. Name the organism.

.....

.....

iv. Give the common name of the disease caused by the organism.

.....

A4. i. Name the type of association seen here.

.....

.....

ii. What organism is involved in the association?

.....

.....

iii. Give the common name by which the specimen is called.

.....

.....

iv. Indicate the role of the associated organism in nature.

.....

.....

A5. i. Identify the cell type as seen in the vegetative state

.....

.....

ii. Name two cells other than the vegetative cells

(a) .....

(b) .....

iii. Give the generic name of the specimen

.....

A6. i. Draw and label the structures seen

ii. Identify the specimen by its generic name

.....

A7. i. Draw and label the structures seen here.

ii. Name the process seen.

.....

.....

iii. Give the generic name of the specimen.

.....

A8. i. Assign the specimen to its

Division:.....

Class:.....

Order:.....

Family:.....

ii. Identify the specimen by its generic name:

.....

A9. i. Identify

(a) the thallus type of the specimen

.....

.....

(b) shape of the cell

.....

.....

ii. Give the generic name of the specimen

.....

A10. i. Name the

(a) spherical cavities seen here.....

.....

(b) contents of the cavities

.....

.....

SECTION B: THE HIGHER PLANTS

INSTRUCTIONS:

1. Note that answers derived from this **Section**, relating to specimens **B1** to **B10**, must be written in separate answer books to be provided by the Examiner.
2. Write your ***Sirname*** and ***Computer Number*** on every answer book.
3. Tie-up all the answer books for **Section B** in a single bundle.

Q2. This question refers to specimens **B1** and **B2**.

Make a critical microscopic examination of **specimens B1** and **B2** and set out to

(a) draw features of biological interest;

(b) identify the stele type for each specimen;

(c) classify up to the level of division.

Q3. Carefully examine **specimen B3** and

(a) name the nature of the organ displayed;

(b) identify the specimen up to the level of its division.

Q4. Examine **specimen B4** and proceed to

(i) draw and name the organ;

(ii) describe the natural habitat preferred by this organism.

Q5. Draw a sketch diagram of **specimen B5** and set out to

(i) name the nature of the organ displayed;

(ii) identify the specimen only up to the generic level.

Q6. Examine **specimen B6** and

(a) draw the features displayed;

(b) identify the nature of the organ presented;

(c) give the generic name.

Q7. Study **specimen B7** presented and set out to

(a) identify the structure of the organ and features displayed;

(b) name the specimen to its generic and division categories.

Q8. Draw features of botanical interest displayed in **specimen B8** and then postulate the ecological status of the organism.

Q9. Comment on the unusual features seen in **specimen B9** and identify the organism to the category of the division.

Q10. Draw features of interest exhibited in **specimen B10** and also identify the specimen to the division level.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – MAY, 2000

BS 222

FORM, FUNCTION AND DIVERSITY OF ANIMALS

PAPER I (THEORY)

TIME: THREE HOURS

SPECIAL INSTRUCTIONS: ANSWER **FOUR** (4) QUESTIONS ONLY. TWO QUESTIONS FROM SECTION A AND TWO QUESTIONS FROM SECTION B. ANSWERS FOR EACH SECTION SHOULD BE IN A SEPARATE ANSWER BOOK.

SECTION A

Q1. (a) Draw schematic representations of Pirie's and the Dumbell models on the origin of life, and briefly discuss the similarities and differences between the two models.

(b) Draw the suggested phylogenetic tree of the invertebrate group, indicating any major evolutionary departure points from the main line of evolution of the group.

Q2. With the Aid of a diagram of a member of the class, describe the distinguishing features of the following invertebrate classes:

i. Mastigophora
ii. Sporozoa
iii. Trematoda
iv. Pelecypoda
v. Polychaeta
vi. Scyphozoa
vii. Cephalopoda
viii. Insecta
ix. Diplopoda
x. Hexactinellida

Q3. (a) Define the following terms and phrases as used in this course, giving examples where possible:

i. Monoecious

ii. Homeostasis
iii. Polyphyletic origin
iv. Cephalization
v. Holozoic nutrition

(b) Give an example of a parasitic invertebrate species which you would find in or on the following host animals/plants; give the phyllum, class and order for each of those examples. Also describe its effect on the host.

a. Mosquito
b. Tick
c. Snail
d. Pubic region of man
e. Blood of a cow
f. Skin of a cow
g. Nostril of a chicken
h. Root of a potato.

Q4. Briefly describe the various modes of reproduction in the invertebrates, and give examples where each mode of reproduction occurs in the various phylla.

SECTION B.

Q5. Define the following terms and phrases:

i. Metametrical segmentation
ii. Acrania
iii. Sarcopterygii
iv. Ungulates
v. Cetacea
vi. Longomorpha
vii. Cretaceous period
viii. Filter feeding
ix. Catadromous
x. inetatheria

Q6. In the study of the evolution of vertebrates, Osteichthyes are considered to be more specialised and advanced in comparison to Chondrichthyes in which aspects do Osteichthyes demonstrate evolutionary advancement in comparison to Chondrichthyes.

Q7. Describe the circulatory systems found in the sub phylum Gnathostomata.

Q8. Describe the function of the following organs and structures in the phylum chordata.

i. Pharynx
ii. Chromatophores
iii. Skin
iv. Lateral line
v. Cloaca
vi. Glottis

END OF EXAMINATION - GOOD LUCK

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER FINAL EXAMINATIONS
MAY-JUNE, 2000

BS 319: Biostatistics

TIME : THREE HOURS

ANSWER : FIVE QUESTIONS. TWO QUESTIONS FROM EACH SECTION AND ONE QUESTION FROM EITHER SECTION. ANSWERS SHOULD INCLUDE ALL YOUR CALCULATIONS.

SECTION A

1. A Psychologist measured (in seconds) the times required for 10 experimental rats to complete a maze and obtained the following data:

24	37	38	43	33
35	48	29	30	38

Calculate the mean, Variance, and Standard error of the mean of this data.

2. a. What does a normal distribution look like and why is it important?
   b. What two parameters fix or characterize a normal distribution?
   c. When must a t-distribution be used instead of a normal distribution?
   d. What is the relationship of χ^2 to $N(0, 1)$.
   e. Five coins are tossed at once. Let, **r**, represent the number of heads in the toss. Thus, **r**, can have values 0,1,2,3,4 5. Determine the distribution of **P(r)** in the toss of the five coins.

3. Given the following data on egg production from 12 hens randomly allocated to different diets, estimate the mean difference produced by the diets and attach a 95% confidence interval to each mean. Which of the two diets is better?

Diet A :	166	174	150	166	165	178
Diet B :	158	159	142	163	161	157

4. The organic content of the soil (y) as a percentage of the total content of soil was measured at even distances (x) in meters across a hill and the following data obtained:

x :	0	10	20	30	40	50	60	70	80	90
y :	4.98	3.56	2.53	2.76	1.57	1.15	1.20	0.82	0.08	0.12

   a. Plot this data on a suitable diagramm.

b. Determine the equation for a line of best fit to the data.

SECTION B

5. The numbers from an experiment involving three groups each containing five units are given below:

	Unit Within Group				
Group	1	2	3	4	5
1	19	15	17	16	18
2	10	15	18	13	14
3	17	20	23	18	22

Using data above complete the following ANOVA table:

Source	d.f.	ss	ms	f
Difference due to Groups				
Residuals within Groups				
Total Residual				

Group means: 1. _____ 2. _____ 3. _____.
4. _____ 5. _____.

6. In a report of a randomized complete block design, the following results were given. Treatment means A = 50, B = 47, C = 62, D = 52, E = 54. The experimental error was 96 based on 32 degrees of freedom. The total sum of squared deviations from the overall mean was 5824. Reconstruct the analysis of variance table.

Source	d.f.	ss	ms
Treatments			
Blocks			
Exp't Error			
Total			

7. A plant ecologist measured the growth response (in Cm) of one species of grass to four fertilizer treatments in five tundra locations in northern Alaska and obtained the following data:

Fertilizer	Locations					Means
	B	M	R	S	Q	
None	10	6	11	2	5	6.8
N	58	45	55	50	37	49.0
N + P	63	43	68	41	39	50.8
N + P + K	68	47	63	43	40	52.2
Means	49.75	35.25	49.25	34.00	30.35	39.7

If the five locations are considered as blocks instead of replications, conduct an analysis of variance to see if there are differences in the responses of the grass to the treatments.

8. The table below shows the respective heights of 12 fathers and their eldest sons (Cm) :

Fathers:	65	63	67	64	68	62	70	66	68	67	69	71
Sons:	68	66	68	65	69	66	68	65	71	67	68	70

Find the coefficient of correlation of the heights.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - MAY 2000

BS 332

ANIMAL PHYSIOLOGY (THEORY)

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY **FIVE** QUESTIONS. ALL QUESTIONS CARRY EQUAL MAKRS.

---

1. a.) What is a nehpron?
   b.) List and discuss the three processes used by the mammalian kidney to achieve the final composition of urine. [20-marks]

2. Write short notes on the following:
   a.) Maintenance of osmotic homeostasis in fresh water and marine animals
   b.) Fever
   c.) Oxygen debt
   d.) Pancreatic enzymes
   e.) Acclimatization and acclimation
   f.) Mechanisms of regulating food intake in mammals [20-marks]

3. What thermoregulatory mechanisms are available to homeotherms at temperatures below and above the thermoneutral zone? [20-marks]

4. a.) What is hypoxia?
   b.) Describe the process involved in the acclimation of mammals to reduced availability of oxygen. [20-marks]

5. State three (3) important anterior pituitary gonadotropins. Explain their functions in the reproductive cycle of a female mammal

6. Outline the different physical processes associated with the functioning of the eye as a special sense organ. [20-marks]

7. Describe the different types of muscle fibre proteins and discuss their functions. [20-marks]

8. What are somatic senses? Outline the different types of receptors associated with somatic senses and describe their mechanisms of transduction. [20-marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINAITONS

May/June, 2000

BS 352: Parasitology (THEORY)

Time: Three (3) Hours

INSTRUCTIONS: Answer Five (5) Questions, at least two from each section. All questions carry equal marks.

SECTION A

1. Discuss chemotherapy in malaria relating the different drugs used to their target stages in the life-cycle. What type of drugs are used for prophylaxis? Explain your answer.

2. Provide an overview of the diagnosis of intestinal protozoal infections in human subjects. Include in your write up clinical symptoms and pathology characteristic of named parasite species which are of value in diagnosis.

3. Describe the progression of disease in African sleeping sickness. How can trypanosomiasis be controlled.

4. Write short notes on **two** of the following:
   i. congenital toxoplasmosis
   ii. East Coast fever
   iii. Visceral Leishmaiasis

SECTION B

5. Describe the progression of relationships to parasitism among living organisms, and the benefits enjoyed by the interacting organisms at each stage. Categorize parasites based on extent of dependency on the host.

6. Relate migration, maturation, and establishment of schistosome parasites to the pathological effects in the urinary form of the disease.

7. Describe in detail the life cycle of *Ancylostoma duodenale*. Relate this to the pathology it causes in the various organs in its definitive host and the resultant clinical symptoms.

8. Write notes of **two** of the following:
   i. Pathology in *Trichuris trichuria*
   ii. Life cycle of cestodes
   iii. Life cycle of *Fasciola hepatica*

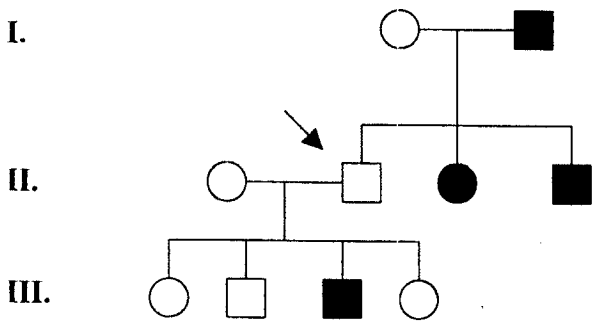
End of Examinaation - Good Luck (No. of pages: 1)

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY, 2000
BS 362 GENETICS
PRACTICAL PAPER

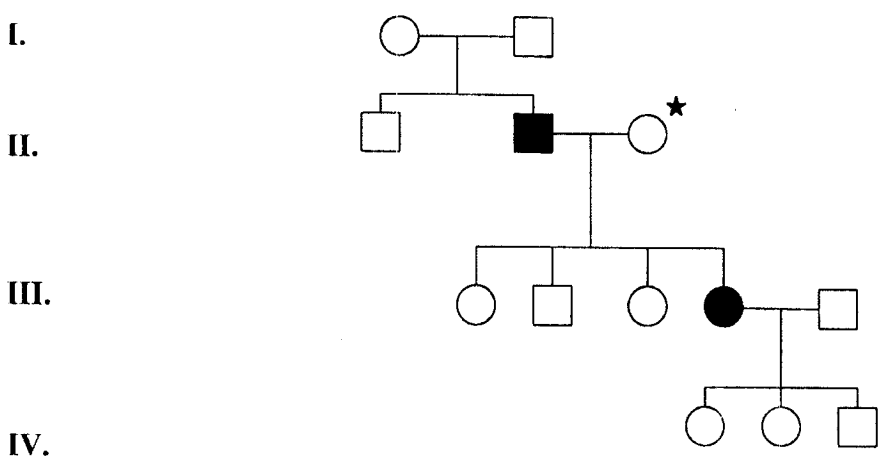
TIME ALLOWED : THREE (3) HOURS

INSTRUCTIONS : ANSWER ALL QUESTIONS .
Answer each question in a separate answer booklet/ set of answer booklets.

1.a) Assuming the father of the propositus is homozygous for the trait in question, explain a mode of inheritance consistent with the pedigree below. In particular, explain the phenotype of the propositus.



b). Using the following pedigree and explaining your reasoning in each case:
i). Deduce the mode of inheritance
ii).Identify the genotype of the individual (★) in question



c). Phenylketonuria (PKU) is a human hereditary disease that prevents the body from processing the amino acid phenylalanine, which is contained in the protein we eat. PKU is manifested in early infancy and, if it remains untreated, generally leads to mental retardation. PKU is caused by simple Mendelian inheritance.

A couple intends to have children but consult you a genetic counsellor because the man has a sister with PKU and the woman has a brother with PKU. There are no other cases in their families. They ask you, the genetic counsellor to determine the probability that their first child will have PKU. What is this probability?

d).A proposita suffering from an unidentified genetic disease seeks your advice as a genetic counsellor prior to starting a family. Construct a pedigree based on the following information given to you:

i).The paternal grandfather of the proposita suffers from the disease .

ii).The father of the proposita is unaffected and the youngest of 6 children the 2 oldest being male.

iii).The proposita has an affected older brother but the youngest sibling is an unaffected girl.

iv).All individuals suffering the disease have been revealed.

What is the mode of inheritance for this disease? Explain your answer.

Q2. i) Genetic distance is a useful tool in determining how closely or differently related two given species are. The information derived can be used in establishing phylogenetic relationships. Given the following data of three populations, at a single locus with four alleles

Allele number	Population 1	Population 2	Population 3
1	0.55	0.67	0.43
2	0.34	0.12	0.54
3	0.15	0.45	0.76
4	0.14	0.32	0.18

a).Calculate the genetic distances between the populations

b).What observations regarding the genetic relatedness between the populations can you make from your calculated values?

ii) Experimental data obtained from a genetic study of a barley species on 6 loci and 3 genotypes is illustrated below:

	Genotype			
	AA	**Aa**	**aa**	**Total**
Locus 1	100	150	50	300
Locus 2	125	75	100	300
Locus 3	65	135	100	300
Locus 4	115	45	150	300
Locus 5	100	105	95	300
Locus 6	120	150	30	300

a).Calculate the heterozygosity for each locus
b).Calculate the gene diversity of each locus (D)
c).If similar values for the two measures are obtained in the above situation what inference can be made?

4.a). Three allelic variants of the red cell acid phosphatase enzyme were present in a sample from a population . The table below gives the genotypes with their frequencies in the sample and the mean enzyme activity of each genotype found in the population.What is the mean enzyme activity in this population?

Genotype	Frequency(%)	Enzyme activity
AA	9.6	112
AB	48.3	154
BB	34.3	188
AC	2.8	184
BC	5.0	212

b).Calculate the mean, variance and standard deviation for the following data on weight ,in grams, of laboratory rats at 90 days of age .
175, 202 , 168, 154, 188 , 195, 209, 191 , 192, 177.

c).What are the differences between quantitative and qualitative traits ?

d).What are the applications of quantitative genetics.

e). What impact do maternal effects have on the offspring and how do these differ from paternal effects?.

---

4. Below are four populations of a plant species.

Population one

RG GG RG GG GG RG RG RG GG RG GG RG
RG RG GG GG RR RR GG RG RG GG RR RG
RR GG RG GG RG RG RG RG GG RR GG RG
RG RR RR RG RG RG GG RR RG RG RG GG
RG RG GG RR RR RG RR RG RG RR RG RG
RG RR GG RG RR RG GG GG RG GG RG RG
RG GG RR RG RG RR RR GG GG RG RR RG
RR RG RG RG GG RG RG GG RG GG RG RG
RG RG RR RG

Population two

GG GG GG GG GG GG GG GG GG GG GG RR
GG RG GG GG GG GG GG GG GG RG GG GG
GG GG GG GG GG GG RG GG RG RR GG RR
GG GG GG RG RR GG GG GG GG GG GG GG
GG GG GG RG RG GG GG GG GG GG GG GG
RG GG GG GG GG RG GG RR GG GG GG GG
GG RR RG RG RR GG GG GG GG GG RG GG
GG GG GG RG GG RR GG GG GG RR GG RG
GG GG GG GG

Population three

GG RR RR RR GG RR RR RR RR GG RR GG
GG GG RR RR RR RR RR GG RR RR RR GG
GG RR GG RR RR RR RR RR RR RR RR GG
RR RR GG RR RR RR RR RR GG RR RR RR
RR RR GG GG RR RR RR RR RR RR RR RR
GG RR RR RR RR RR GG GG RR GG RR RR
RR RR RR RR RR RR RR RR RR GG RR GG
RR RR RR RR RR RR RR RR RR GG RR RR
RR RR RR GG

Population four

RR RR GG RR RR RR GG RR RR GG GG GG
RR RR GG GG RR RR GG RR GG RR RR RG
RR RR GG GG RR RR GG RR GG RR RR RG
GG GG RR GG RR GG GG RR GG GG RR GG
RR RR GG GG GG RR RR GG RR RR GG RR
GG GG GG GG GG RR RR GG RR RR RR GG
RR GG RG GG RR RG GG GG RR RR GG GG
RR GG GG RR RR RR GG RR RR RR RR GG
RR RR RR RR GG GG GG RR RR GG RR GG
RR RR GG GG

The two alleles, Rand G were used to study polymorphism in the four populations. For each population, with clear assumptions, work out ;

a). Allele frequencies

b). Genotype frequencies

c). Goodness of fit to the Hardy-Weinberg equilibrium.

d). Fixation index

e). Level of outcrossing.

END OF EXAMINATION - GOOD LUCK

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER JANUARY 1999/2001EXAMINATIONS

BS 375

PAPER I - THEORY

TIME: THREE (3) HOURS

INSTRUCTIONS: Answer question one (1) and four other questions. Question one (1) carries 30 marks and all other questions carry equal marks.

Q1. Describe, in tabular form and with examples, the key distinguishing features of the following invertebrate orders. Ensure to identify the phylum and class to which each particular order belongs:

i. Protomonadina
ii. Haemosporidia
iii. Opisthopora
iv. Monogenea
v. Stylommatophora
vi. Siphonoptera
vii. Diptera
viii. Acarina
ix. Scolopendromorpha
x. Limacomorpha

Q2. Write brief notes on four of the following topics:

(a) The skeletal system of invertebrates
(b) Evolution of the blood sucking habit in invertebrates
(c) Evolution, Structure and Function of the cuticle
(d) Sources of Energy in invertebrate locomotion.
(e) Evolution, structure and function of the Hydrostatic Skeleton.
(f) Flight in insects

Q3. Give illustrated descriptions of the life histories of Schistosoma haematobium and plasmodium vivax.

Q4. Review the structures of the nervous systems in invertebrates, highlighting the development of sense organs.

Q5. (a) Define respiration.
(b) Compare and construct respiratory mechanisms in aquatic and terrestrial invertebrates.

Q6. Discuss the various types of asexual and sexual reproduction seen in invertebrates. In evolutionary terms, what would be the strengths and weaknesses of each of these reproductive modalities.

Q7. Discuss the relationship between the form and function of invertebrates and their living environments.

END OF EXAMINATION
& GOOD LUCK!

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END OF EXAMINATION
& GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS,

JANUARY 2000

BS 411: INSECT BEHAVIOUR AND ECOLOGY

THEORY : PAPER II

TIME : THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS ONLY

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1. Describe any one method used by insect ecologists to estimate an absolute insect population density. Comment about the accuracy of the chosen method and indicate whether there are ways in which such a method could be improved.

2. Many insect populations show increases and decreases in density that correspond to conditions of the abiotic environment such as (temperature and rainfall). Similarly, various insect species have demonstrated increases and decreases corresponding to the action of natural enemies (like predators and disease). And in laboratory studies, we can demonstrate the importance of intraspecific competition on population numbers when resources are limiting. Given all this, in your opinion what factors are most responsible for maintaining the boundaries of under and over population in the field?

3. Compare and contrast the ecological features of natural and agro-ecosystems. Suggest some ways in which an agro-ecosystem can be manipulated to discourage insect pests.

4. You are told that a young bean crop is being damaged by a pest, believed to be an r-strategist. Describe;
    a) the characters you would use to confirm the diagnosis of the pest.
    b) Possible – identity of such a pest, giving reasons for your answer.
    c) Name any <u>four</u> insects which use **r** and **k** strategies, two in each category.

5. Write short notes on <u>four</u> of the following
    a) Insect dispersion
    b) Population attributes
    c) The damage curve
    d) Slobodkin population growth curves
    e) Trophic relationships among populations.

6. Write an essay on insect herbivory.

7. Using a flow diagram, illustrate the components of an insect life system. Why is the use of an insect life system a meaningful approach in insect ecology?

8. What is a life table? Of what value is it to an insect ecologist? What problems do you expect to encounter in developing a life table of an insect such as the Armoured ground cricket (*Acanthoplus speiseri* Brancsik).

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – MAY, 2000

BS 412

APPLIED ENTOMOLOGY

(THEORY)

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER **FIVE (5)** QUESTIONS ONLY. ALL QUESTIONS CARRY EQUAL MARKS

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1. Write an essay on integrated control for malaria in Africa.

2. The larger Grain borer, *Prostephanus truncatus*, (Horn) has become a serious storage pest in Zambia. What environmental control strategies would you recommend in order to manage this pest in Zambia?

3. One entomologist was quoted as saying "the theory of Integrated Pest Management (IPM) is very sound but difficult to implement." Do you agree or disagree with this statement. In your answer cite case studies where IPM has either failed or succeeded and give reasons for the successes or failures.

4. Termites in Zambia cause substantial economic damage to agricultural crops. Outline a programme of action for controlling termites in Zambia without using chemical insecticides. What are the advantages of such a control programme?

5. Write short notes on Four of the following:

   a) Yield loss

   b) Pest intensity

   c) Major pest

   d) Cultural control

   e) Crop compensation.

6. What are some factors that affect crop protection decisions taken by farmers? Describe how information on pest attack can improve this decision making process?

7. The army worm, *Spodoptera exempta* (Walker) is a serious pest in the SADC region. How can you utilize the knowledge of its life history and ecology to effectively control this pest.

8. Write an essay on the potential of the apiculture and sericulture industries in Zambia.

END OF EXAMINATION – GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS— MAY, 2000

BS 425

IMMUNOLOGY

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FOUR (4) QUESTIONS ONLY.

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1. (a) Elucidate the anatomy and structure of antibodies.
   (b) Describe the biological functions of antibodies.
   (c) Discuss how *Staphylococcus aureus and Schistosoma* mansoni try to evade the immune system.

2. (a) Describe the Zinkernagel *et al* (1974) experiment that showed MHC restriction in cell-mediated responses
   (b) Why is it that the MHC haplotype of an individual can influence whether an antibody response to an antigen is robust or weak?
   (c) Using well-labeled diagrams, show the mechanism of class I restricted recognition in the generation of the killer T cells.

3. (a) Using well-labeled diagrams, show how the T helper cell is at the "centre" of the immune system.
   (b) With the help of well-labeled diagrams, describe how the inflammatory Th1 and classical Th2 T cells can lead to the two different arms of the immune system.

4. (a) Provide experimental evidence for the phenomenon of "patching and capping". What does it try to elucidate, and why is it of immunological significance?
(b) "The B cells in the primary and secondary responses differ not only in the isotype of the antibody displayed as receptor and secreted but also in the binding affinity of the antibody that is produced". Discuss the mechanism relating to the change in affinity.

5. (a) Discuss models of the T cell receptor (TcR). Provide experimental evidence for/against the models.
(b) Describe methods that elucidated the nature of the TcR.
(c) The TcR co-precipitates with non-polymorphic proteins. What are these proteins currently called, and what is their possible role?

6. (a) Discuss immune mechanisms in asthma. Many doctors in Zambia prescribe Frano for the treatment of this condition. What is the general chemical grouping in Frano, and what is the mode of action?
(b) Discuss immuno-suppression with reference to the three effects of HIV nef.
(c) Some individuals who have recovered from *Streptococcus* group A throat infections develop rheumatic fever with subsequent damage to the heart. How does an immune response directed against *Streptococcus* group A lead to autoimmunity in this situation and what type of immune cells participate in this disease?

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THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINAITONS

May/June, 2000

BS 432: Advanced Parasitology II (PRACTICAL)

Time: Three (3) Hours

INSTRUCTIONS: Answer ALL Questions. All questions carry equal marks.

Q.1: You are provided with the following materials:- Parasight F test strips, capillary tubes and rubber bulbs, dispensing tube, devices (tubes and tips), reaction stand, Well-cards, and reagents 1,2,3.

PEOCEDURE:

Place well-card in Reaction Stand.

1. Squeeze 1 drop of Reagent 1 (lysing agent) into Dispense Tube specimen tube. Stand the specimen tube in Reaction Stand.

2. Fill ParaSight F capillary tube, from the end farthest from the line, directly from the collection tube of well mixed venous blood. Fill the tube by capillary action to the line.

3. Keep the tube nearly horizontal and roll between the fingers several times to mix the blood with the anticoagulant coating.

4. Drain the blood from the capillary tube into the Dispense tube specimen tube. If necessary, use a rubber bulb to force the blood from the capillary tube. Insert the empty end of the capillary tube into the small opening of the bulb. Hold the large opening of the bulb closed with index finger, then squeeze the bulb.

5. Place a Dispense Tube tip onto the Dispense specimen tube. DO NOT INVERT TUBE READY TO DISPENSE.

Test Development

6. Squeeze one (1) drop of lysed whole blood from the Dispense Tube into one disposable well in the Reaction Stand.
7. Stand Test Strip in the drop of lysed blood with the white uncoated end down. Wait until all the blood is absorbed into the Test Strip and the is empty before proceeding to step 8.

8. Squeeze 2 drops of reagent (2) into the same well and let it be absorbed by the strip.

9. Squeeze two (2) drops of Reagent 3 (wash agent) into the small well. Wait until all of the Reagent 3 is absorbed into the Test Strip and the well is empty.

TASK

a. Interpret your results accordingly.
b. What is the marker substance in the test?
c. What is the disadvantage of ParaSight F which all immunodiagnostic tests have?
d. When would you choose to use ParaSight F as a diagnostic tool and give two advantages of the test.

Q.2. The slide provided shows some immunopathology which can result from some parasitic infections.

Examine the slide and answer the following questions:

i. Identify the parasite and tissue involved.
ii. Describe the progression of the observed effect.
iii. How is the process a host defence reaction, and how it is triggered?

Q.3. As Director of a National control centre for parasitic diseases, you have received reports of high occurrence of blood in urine associated with unusual clinical disease. Describe a series of experiments you would want carried out to isolate the mature worm for genetic characterisation and the eggs for identification of species. These instructions need to be clear for your technicians to follow with difficulty or mis-interpretation.

End of Examination - Good Luck! (No. of pages 2)

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER EXAMINATIONS

MAY/JUNE, 2000

BS442: Advanced Molecular Biology II (Theory)

TIME: Three (3) Hours

INSTRUCTIONS: Answer Three (3) Questions from section A and Two (2) Questions from Section B. All questions carry equal (20) marks. Inclusion of relevant diagrams, illustrations, labels, drawings and tabulated results will enhance your answer.

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1. In 1953, Watson and Crick Proposed that DNA replicates semiconservatively, i.e. both strands of double helix become templates against which new complimentary strands are made so that the replicated molecule would contain one original strand and one newly synthesised strand. A different hypothesis proposes that DNA replicates conservatively, i.e., the original double helix remains intact so that a replicated molecule would contain two newly synthesised strands. Bacterial DNA can be labeled with a heavy isotope of nitrogen (^{15}N) by growing cells for several generations in a medium that has $^{15}NH4Cl$ as its only nitrogen source. The common "light" form of nitrogen is ^{14}N. Light and heavy molecules can be separated by high-speed centrifugation (50 000 rpm = 10^5 x gravity) in a 6M (molar) CsCl (Cesium Chloride) solution, the density of which is 1.7g/cm^3 (very close to that of DNA). After several hours of spinning, the CsCl forms a density gradient, being heavier at the bottom and lighter at the top. In 1957, Matthew Meselon and Franklin W. Stahl performed a density-gradient experiment to clarify which of the two replication hypothesis was correct.

   (i) How could this be done, and
   (ii) what results are expected after the first, second and third generations of bacterial replication according to each of these hypotheses?

2. Discuss the potential biohazards of genetic engineering and the measures that have been taken to reduce them.

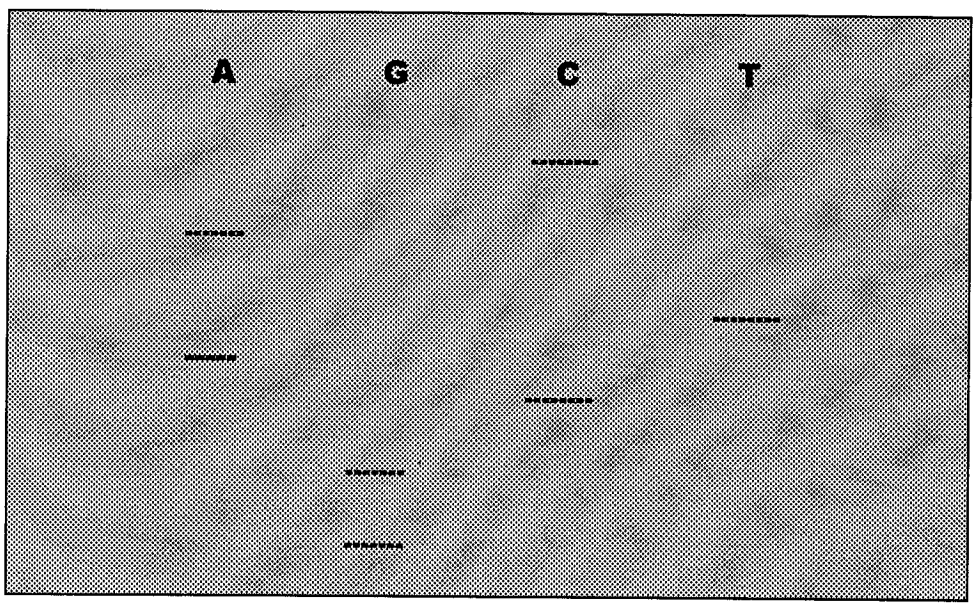
3. Explain the significance of mRNA splicing in relation to:

   (i) the SV40 virus
   (ii) antibody diversity in humans

4. Sickle cell anemia arises from a mutation in the genome for the beta chain of human hemoglobin. The change from GAG to GTG in the mutant eliminates a cleavage site for the restriction enzyme MstII, which recognises the target sequence CCTGAGG.

These findings form the basis of a valuable diagnostic test for the presence of the sickle cell gene. Propose a rapid diagnostic procedure for distinguishing between the normal and the mutant gene. Would a positive result with the test prove that the mutant contains GTG in place of GAG?

5. (a) An autoradiography of a gel containing four lanes of DNA fragments produced by chemical cleavage is shown in the Figure below. The DNA contained a ^{32}P label at its 5' end. What is its sequence?



(b) Suppose that you determine the DNA sequence of 5'-GCCATTGCA-3' by the Sanger dideoxy method, sketch the gel pattern that revealed the sequence of this oligonucleotide.

SECTION B

6. Write an essay on the phenomenon of somoclonal variation in plant tissue culture.

7. Plant breeders make use of interspecific sexual hybrids to transfer genes between species, but sexual incompatibility severely limits this possibility. Explain how the technology of somatic cell hybridisation through protoplast fusion is now used to overcome this problem.

8. Write short notes on any four of the following:

(i) Totipotency
(ii) Haploid plants
(iii) Polymerase Chain Reaction (PCR)
(iv) Biolistic plant transformation
(v) Embryo rescue

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END OF EXAMINATION - GOOD LUCK

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – MAY, 2000

BS 455

WILDLIFE ECOLOGY

PAPER II (PRACTICAL)

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

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1. Samaki – Baruka Farms Ltd is considering establishing a game ranch in the North-West area of Mumbwa District along the Kafue River in the Kafue Basin. Initial investigations show that the range is suitable for Zebra, Sable Antelope, wildebeest and Buffalo. The range is flat, well watered and nearly all the range is within 3.5 km from water. Based on the information from the Ministry of Agriculture, Food and Fisheries (MAFF) in Kabwe, the soils are generally excellent for the game ranch. Also results from your ocular estimates indicate that the production of key forage species averages about 800 kg/ha of dry matter per year. The ranch is 4000 ha in size. Assuming that allowable use is 25% and daily dry matter intake is 2% of the animal body weight, how many:

   (i) 180 kg wildebeest, and
   (ii) 550 kg Buffalo, can you stock as your base herds in the area.

2. Describe the aerial census technique as used in wildlife populations, and give its advantages and limitations.

3. Biologists monitoring the population of Impala *(Aepycerus melampus)* on Nchete island in Lake Kariba, Sinazongwe between 1958 and 1986 gave figures as indicated in the table below. The island is approximately 5 km^2 and is generally covered by a thicket of *combretum* sp. The mean annual rainfall is 900 mm. The island is a protected area and it is regularly patrolled by wildlife scouts. However artisanal fishermen in the lake are allowed to land fish in certain parts of the island. For nearly 12 years the island was exposed to the liberation war between 1968 and 1980, and part of the island was defoliated with herbicides.

   Impalas are polygamous as only one male breeds with a herd of females. The non-breeding males form a batchelor herd. Using the information and data

provided, explain the population trends, and discuss factors which could be most significant to the dynamics of this population on the island.

Table: Impala population at Nchete island, lake Kariba, based on transect ground counts.

Year of census	Juveniles	Males	Females
1958	8	20	47
1968	6	34	76
1972	10	60	100
1975	40	58	210
1980	35	67	138
1985	42	53	123

4. State the main advantages and disadvantages of using mechanical animal capture method, and discuss difficulties associated with the translocation and restocking operations in wildlife management.

5. You are required to use the map provided to answer this question. Study the map carefully.

It is assumed that you have just completed an ecological study of the area, and from this study answer the following questions:

(i) which habitats are important for:

(a) Kudu *(Tragelaphus strepsiceros)*
(b) Zebra *(Equus burchelli)*
(c) Baboon *(Papio ursinus)*
(d) Elephant *(Loxodonta africana)*
(e) Porcupine *(Hystrix africaeaustralis)*

(ii) Describe characteristics which would determine this area to be suitable for a wildlife sanctuary.

END OF EXAMINATION

QUESTION FIVE (5)

DESCRIPTION OF THE AREA:

(i) Vegetation types:

A: Termitaria grassland

B: Munga woodland

C: Chipya woodland

D: Miombo woodland

E: Hyparrhenia grassland

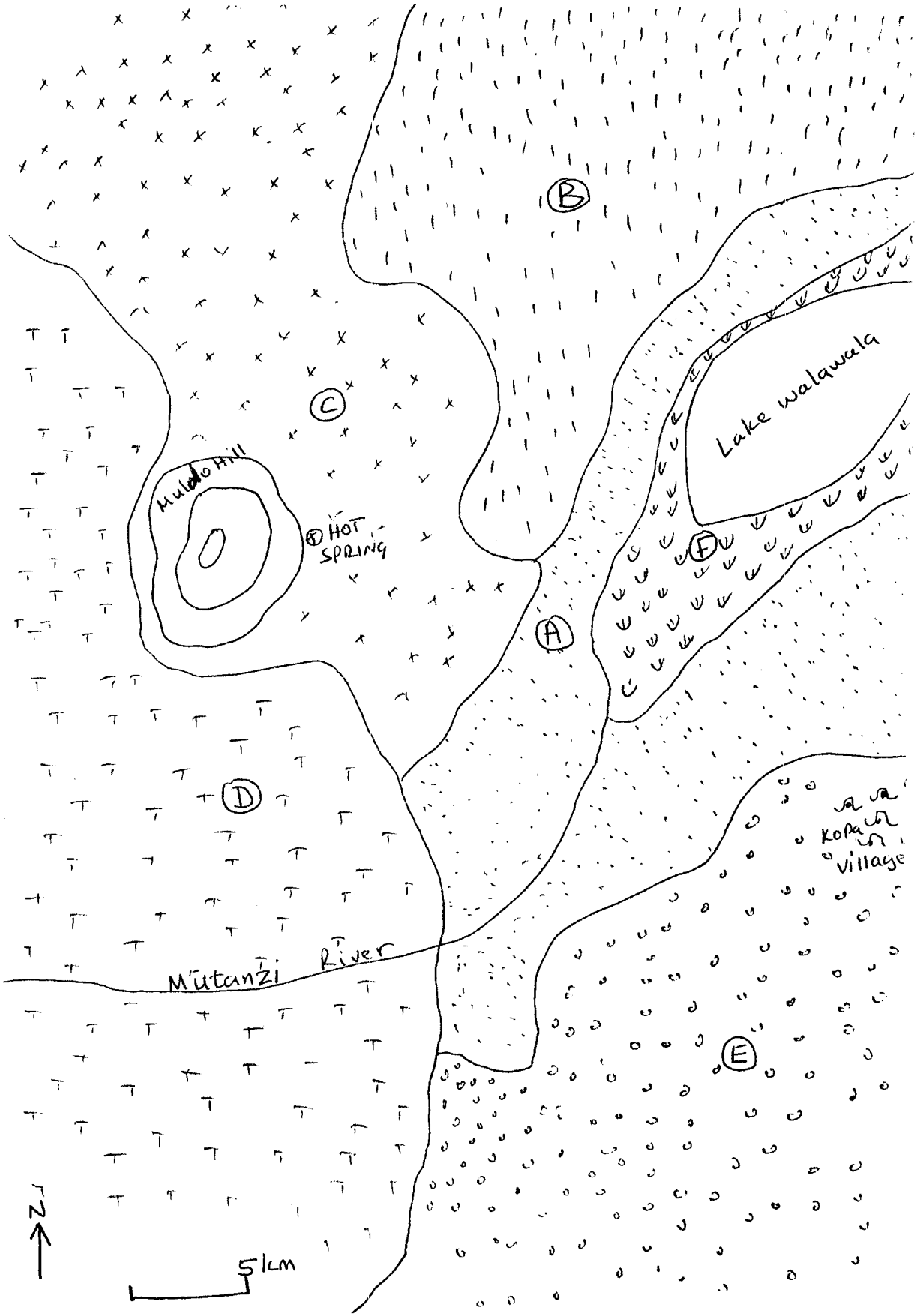
F: Swamp

(ii) The area is located in the South of Central Province of Zambia. Average annual rainfall is approximately 800 mm. The lake is fresh water, and has fish. The river is perennial with riparian vegetation mainly *Diospyros* sp and *Zyzygium* sp. The Hot spring is salty.

There is only one village of about seven household. Its main activity is fishing. Farming is done at a low scale in vegetation type E. Hunting is important.

(iii) The area is being considered for protection because of its importance to conservation. You have been asked to carry out an ecological study of the area. And from your study information answer question <u>five</u>.

MAP


B
C
Mulo Hill
HOT SPRING
Lake walawala
F
A
D
E
Kopa
village
Mutanzi River
N
5km

THE UNIVERSITY OF ZAMBIA

Second Semester Examination

May/June, 2000

BS 492: Fisheries Biology (Theory)

Time: Three (3) Hours

INSTRUCTION: Answer Five questions and use illustration wherever possible. All questions carry equal marks.

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1. Define the following expressions/concepts, and give one illustrating example.
   - Micro-cohort;
   - Unit stock;
   - Recruitment;
   - Feeding habit.

2. Give equations and explain parameters involved in determining the following dimensions of fish populations:
   - the length-at-maturity;
   - the length-fecundity relationship;
   - the gonado-somatic index;
   - the weight-age relationship as described by the usual von Bertalanffy growth model.

3. Briefly describe the main phases of a fish cohort over its life span.

4. What are the principles and relationship underlying the logistic growth of fish populations under density-dependence phenomena?

5. Describe the principle and limitations underlying the use of the CPUE method in estimating fish stock abundance.

6. The following table shows the catch and effort statistics of a (theoretical) fishery.

Fleet	Nominal catch (t)	Nominal fishing effort
X	10000	Not recorded
Y	5000	100000 hours of trawling
Z	15000	500 days of searching
Total	30000	

Estimate the total (i.e. standardized) nominal fishing effort expressed in:
- units of fleet Y;
- units of fleet Z.

7. The following table gives the food items of the pelagic fish community in Lake Tanganyika. Determine and discuss the food web and pyramid for this community (give the meaning of arrows, if used).

Fish species	Food items
Lates mariae	Benthic fish, shrimps, *Stolothrissa tanganicae*, *Limnothrissa miodon*
Lates angustifrons	Benthic fish, shrimps, *S. tanganicae*, *L. miodon*
Lates microlepis	*S. tanganicae*, *L. miodon*, phytoplankton, zooplankton; shrimps, young *Lates stappersii*
Lates stappersii	*S. tanganicae*, *L. miodon*, shrimps, young *Lates stappersii*
Stolothrissa tanganicae	phytoplankton, zooplankton; shrimps
Limnothrissa miodon	*S. tanganicae*, *L. miodon*, shrimps, young *L. miodon*
Young *Lates stappersii*	zooplankton; shrimps

8. Describe the dynamics of a fish cohort in terms of:
   - decay model;
   - mortality and survival rates
   - catch equation.

End of Examination – Good Luck!

(No. of pages: 2)

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS MAY 2000

BS 533 (DISEASES OF LOCAL CROPS)

TIME ALLOWED: THREE HOURS

ANSWER: ANY FIVE QUESTIONS

1. What is 'green ear disease'? Identify the host and causal organism of 'green ear' and describe the symptoms of the disease. What climatic conditions favour development of 'green ear' disease? Suggest its control measures.

2. Enumerate the climatic conditions under which Cercospora leaf spots become a limiting factor in the cultivation of groundnuts in Zambia. Distinguish the two types of leaf spot diseases caused by them on the basis of symptoms and causal organisms. How would you control the two leaf spot diseases?

3. Explain why late blight of potato is called a blight disease? Describe its aetiology, symptoms and methods of control.

4. Compare symptoms and causal organisms of angular leaf spot and anthracnose of *Phaseolus* bean and suggest methods of their control.

5. Compare 'frogeye' leaf spot and red leaf blotch of soybean with particular reference to symptoms, causal organism and control.

6. Discuss the symptoms of tomato wilt and identify the causal organism of the disease. Explain the mechanism of wilting in tomato.

7. Distinguish symptoms and the causal organisms between rusts of groundnuts and soybean. Explain the significance of seed certification in preventing rust incidence in these crops.

8. Write short notes on any TWO of the following:

   i. *Ralstonia solanacearum*
   ii. Powdery mildew of wheat
   iii. *Ascochyta pisi*
   iv. Grey leaf spot of maize

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER M.Sc. EXAMINATIONS MAY 2000

BS 536 PLANT NEMATOLOGY

THEORY PAPER

ALLOWED: **THREE HOURS**

ANSWER: **ANY FIVE QUESTIONS**

1. Distinguish between resistance and susceptibility of a host plant. Describe the steps you would follow to develop resistant varieties of a crop plant against nematode attack.

2. State morphological differences between plant parasitic and non-plant parasitic nematodes. How are plant parasitic nematodes adapted to their mode of existence? Describe the damage caused by plant parasitic nematodes in plants.

3. Compare and contrast a temporal and permanent microscope slide preparation. Explain the various stages involved in the production of a permanent slide preparation.

4. Discuss the different types of parasitism exhibited by nematodes. Using specific examples, explain how nematodes can be taxonomically separated into two large groups on the basis their morphological characteristics.

5. What are the characteristics of an epidemic? Assuming there was an epidemic of a particular nematode disease, what logical sequence of steps would you take to check the problem.

6. Discuss the following topics:

   i. Oxygen requirements by nematodes
   ii. General behaviour of nematodes
   iii. General body characteristics of nematodes

7. What series of studies would one be expected to perform on an apportioned study area where nematode studies are being recommended for the first time. Give reasons to support your answer.

8. Write short notes on the following:

   i. Reproductive system
   ii. Alimentary canal
   iii. Excretory system
   iv. Median bulb

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER UNIVERSITY EXAMINATIONS, MAY 2000

BS 537 (SEED PATHOLOGY)

THEORY PAPER

TIME ALLOWED: THREE HOURS

ANSWER: ~~ALL~~ FIVE QUESTIONS

1. Using appropriate examples, present existing evidence to show that seed-borne diseases are of economic importance in Eastern and Southern Africa? What measures would you take to reduce the impact of seed-borne diseases to achieve higher agricultural production in the region?

2. With suitable examples, discuss seed-borne pathogens in relation to the kinds of damage caused by them in seeds.

3. Describe the conventional methods of routine detection of bacteria in a known group of crops. Discuss what strategies are important in the identification of plant pathogenic bacteria that use rapid and sensitive techniques?

4. Describe methods of general and special application in the control of seed-borne infections in commercial crops.

5. Describe various methods used in the detection of seed-borne viruses

6. What is seed pathology? Describe why seed certification has become an important approach in the control of crop losses on a global basis.

7. Why is Zambia so short on seed pathology literature? What corrective measures would you institute to normalise the situation?

8. Write short notes on the following topics.

   i. The embryo method of seed testing
   ii. Aflatoxins
   iii. Technical constraints in the study of seed-borne diseases.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS- MAY, 2000

BS 925

TERRESTRIAL VERTEBRATE BIOLOGY

PAPER 1 (THEORY)

TIME: THREE HOURS

INSTRUCTIONS: QUESTION **ONE(1)** IS COMPULSORY. ANSWER QUESTION ONE(1) AND FOUR(4) OTHERS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY

---

1. Assign each species to its appropriate **Order** and **Family**.

A. Order	**Species**
SQUAMATA	*Anhinga rufa*
ANSERIFORMES	*Falco peregrinus*
CHIROPTERA	*Manis temmincki*
PELECANIFORMES	*Breviceps mosambicus*
CHELONIA	*Petrodromus tetradactylus*
APODA	*Mabuya varia*
PHOLIDOTA	*Pelusiosus subniger*
INSECTIVORA	*Anas undulata*
FALCONIFORMES	*Rousettus aegyptiacus*
	Scolecomorphus kirki

B. Family	**Species**
PIPIDAE	*Nucras taeniolata*
LACERTIDAE	*Bitis arietans*
VIPERIDAE	*Xenopus laevis*

ANATIDAE	*Geochelone pardalis*
GEKKONIDAE	*Pyxicephalus tuberculosus*
RANIDAE	*Atelerix frontalis*
TESTUDINIDAE	*suncus lixus*
ERINACEIDAE	*Alopochen aegyptiacus*
PTEROPODIDAE	*Eidolon helvum*
SORICIDAE	*Hemidactylus platycephalus*

2. Write short notes on the following terms as used in taxonomy:

   (i) Biochrome
   (ii) Paedogenesis
   (iii) Cryptodira
   (iv) Nomenclature
   (v) Tympanic membrane

3. Discuss the significance of (I) The principle of priority in taxonomy (II) Taxonomic hierarchy

4. Define a species. Discuss the limitations of this concept as it relates to classification.

5. Describe (a) Field impression (b) Food habits (c) Reproductive habits (d) Habitat (e) Distribution of the following species:

   (i) Nile Crocodile (*Crocodylus niloticus*)
   (ii) Bull Frog (*Pyxicephalus adspersus*)

6. Discuss the main taxonomic features that characterize the following species:

   (i) Leopard Tortoise (*Geochelone pardalis*)
   (ii) Epauletted Fruit Bat (Epomophorus labiatus)

7. Define the functions of the following structures present in some groups of vertebrate species.

(a) Cloaca
(b) Air sacs
(c) Pituitory gland
(d) Nuptial plumage
(e) Jacobsons organ

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS: SECOND SEMESTER

15TH MAY, 2000

C102 INTRODUCTORY CHEMISTRY II

TIME: **THREE (03) HOURS**

INSTRUCTIONS:

THIS EXAMINATION HAS THREE (03) SECTIONS: SECTION A, B AND C

SECTION A: This section contains ***TEN (10)*** questions.
Answer *All* questions in this section. Each question carries ***FOUR (04)*** **marks.**

SECTION B: This section contains ***TWO (02)*** open-end questions.
Answer only ***ONE (01)*** question in this section.
It carries ***FIFTEEN (15)*** marks.

SECTION C: This section contains ***FOUR (04)*** open-end questions.
Answer any ***THREE (03)*** questions in this section.
Each question carries ***FIFTEEN (15)*** marks.

SHOW YOUR WORKING CLEARLY

USEFUL DATA

Gas Constant, R= 8.314 J/mol.K
= 0.0821 L.atm/K.mol

Atomic mass:
H=1.01; 0=16.00; N=14.01

SECTION A: Answer *All* questions.

A1 (a) For a first order reaction with a rate constant $K=10sec^{-1}$. Calculate the time required for the concentration to decrease to $^1/_{10}$ of its original value.

(b) Write the rate expression for the following reaction in terms of the rate of change in concentrations of reactants and products.

$$5\ Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

in terms of $-\frac{d}{dt}[Br^-]$.

A2 In how many grams of water should 18.7g of ammonium nitrate be dissolved to prepare a 0.542 molal solution.

A3. The reactions for the production of ammonia can be written in a number of ways.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g).$$

$$1/3N_2(g) + H_2(g) \rightleftharpoons 2/3NH_3(g)$$

(a) Write the equilibrium constant expression for each equilibrium equation.

(b) What is the relationship between the two equilibrium constants?

A4. (i) Write conjugate acid-base pairs for the following reactions:

(a) $HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$

(b) $H_2PO_4^- + H_2O \rightleftharpoons HPO_4^{2-} + H_3O^+$

(ii) Calculate the pH of 1.0×10^{-3}M HCl solution.

A5. The solubility product of $Zn(OH)_2$ is 1.0×10^{-15} at 25°C. Calculate the pH of a saturated solution of $Zn(OH)_2$ at 25°C.

A6. Consider the following equilibrium systems.

$$2PbS(s) + 3O_2(g) \rightleftharpoons 2PbO(s) + 2SO_2(g)$$

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Predict the direction of the net reaction in each case as a result of increasing pressure on the system at constant temperature.

A7. Calculate formal charges for the atoms (excluding hydrogen) in diazomethane, $H_2\ddot{C} - N \equiv N:$

A8. The following IUPAC names are incorrect. Draw the molecular structures they represent and give their correct IUPAC names.

(i) 1 – Bromo – 2- cyclohexene

(ii) 2 – Isopropyl - 4- methylheptane

A9. On conversion into Grignard reagent followed by treatment with water, which alkylbromides would yield n-pentane? Show at least one reaction.

A10. Name the functional group in ethylamine, $CH_3\,CH_2\,NH_2$. Explain its acidic, basic, neutral or amphoteric character.

SECTION B (ANSWER ONE QUESTION)

B1. (a) With the help of a detailed reaction mechanism show what will happen when a mixture containing methane (CH_4), bromine (Br_2) and carbon tetrachloride (CCl_4) is exposed to ultra-violet light. All the steps involved must be shown.

(c) Water has a pKa = 15.74, tert-Butyl alcohol has a pKa = 18. Can tert-butyl alcohol be prepared by dissolving potassium tert-butoxide in water? Explain.

$K^+\ O^-\!-\!\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}\!-CH_3$ Potassium tert-butoxide.

(d) Draw structures of all isomers of C_3H_8O and 1,2 – dimethylcyclopropane, C_5H_{10}, and, in each case, indicate the type of isomers they represent.

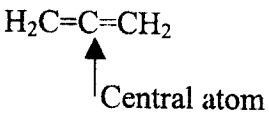
B2. (a) Organometallic coupling using lithium alkylcuprates is a widely used technique for synthesis of many organic compounds. Using this technique show in detail how you would prepare n-butane from ethylbromide (CH_3CH_2Br), and ethyliodide (CH_3CH_2I).

(b) What type of hybridisation and geometry would you expect for each of the following:

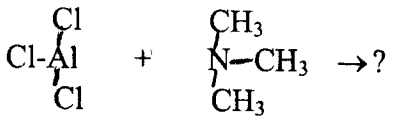
(i) The oxygen atom in methanol, $H_3C\text{-}\ddot{O}\text{-}H$.

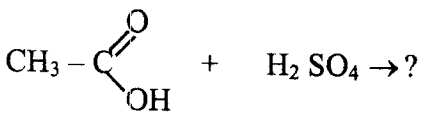
(ii) The nitrogen atom in methylimine, $H_2C{=}\ddot{N}\text{-}H$

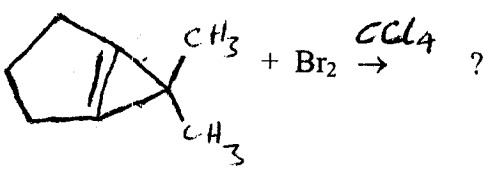
(iii) The central carbon atom in allene (1,2-propadiene),



(c) Predict the products of the following reactions:

(i) 

(ii) 

(iii) 

SECTION C: Answer *ANY THREE* (03) questions.

C1 (a) At 0.0°C the rate constant for the reaction $N_2O_5 \rightarrow NO_2 + NO_3$ is 1.96×10^{-3} s^{-1}. The activation energy of this reaction is 88.0 kJ/mole. Determine the value of the rate constant at 2.0°C.

(b) Define osmotic pressure of a solution. Calculate the freezing point of a 0.01M aqueous solution of a weak acid HA, if the acid is 5.0% ionised. [K_f (H_2O) = 1.86]

C2 (a) Consider the following reaction.

$2NO\ (g) + Cl_2\ (g) \rightleftharpoons 2NOCl\ (g)$.

The equilibrium constant at 35°C is 6.5×10^4. In a certain experiment, 2.0×10^{-2} mole of NO, 8.3×10^{-3} moles of Cl_2 and 6.8 moles of NOCl are mixed in a 2.0 litre flask. In which direction will the system proceed to reach equilibrium?

(c) The value of ΔH° for the reaction PCl_5 (g) $\rightleftharpoons$ PCl_3 (g) + Cl_2 (g) is 92.9 kJ per mole. If the value of Kp for the reaction at 250°C is 1.78, calculate the value of Kp at 400°C. Assume that the reaction enthalpy is constant over this temperature range.

C 3 (a) Calculate the pH of a solution containing 0.20M CH_3COOH and 0.30M CH_3COONa. [Ka of $CH_3COOH = 1.8 \times 10^{-5}$].

(b) What would be the pH of 0.20M solution, if no salt was present in C3 (a) above?

C4. If 50.0cm^3 of 3.00M $Pb(NO_3)_2$ solution are mixed with 25.0cm^3 of 2.00×10^{-3}M sodium iodide solution.

(a) Predict whether the precipitate of lead iodide will form from the resulting solution?

(b) If yes, then calculate the concentrations of Pb^{2+}, I^-, Na^+ and NO_3^{2-} ions at equilibrium.
[Ksp (PbI_2) = 6.5×10^{-9}]

END OF C102 SEMESTER II EXAMINATION, MAY 2000.

The University of Zambia
University Examinations - July 2000

Deferred/Supplementary Examination

C 212 **Introductory Biochemistry**

Instructions

1. Time: **THREE** hours
2. Answer **QUESTION No.1 AND ANY OTHER FOUR QUESTIONS**
3. **If you need to use constants, please find them on the last page.**

---

1. a) **Show** by way of a calculation (and brief explanation, if any) how you would prepare a 1 litre 0.45M phosphate buffer at pH 7.4 given that you have at your disposal H_3PO_4, KH_2PO_4, K_2HPO_4, and K_3PO_4. (RMM: KH_2PO_4 = 136.1g/mol, K_2HPO_4 = 174.2g/mol, and K_3PO_4 = 196.2g/mol)

[15 marks]

b) **What** makes the amino acid histidine act as a buffer at pH 6.0? **Briefly** describe its buffering capacity at pH 7.6

[5 marks]

2. a) A sample of DNA contains 35% adenine. What is the % composition of the other three bases? **Briefly** explain.

[5 marks]

b) i) **Indicate** what would be the complementary anti-parallel strand for the nucleotide sequence shown below. **Draw** in the H-bonds between adjacent bases.

TACCGATGAATCGGTATCGC

[10 marks]

ii) If the double stranded nucleotide sequences you have drawn in b (i) above was cut after the tenth base, **which** sequence would have the higher melting point? **Briefly** explain.

[5 marks]

3. (i) **Rearrange** the Michaelis-Menten equation to give v as a function of V/[S]. **Estimate** the shape of the curve you have obtained above.

[15 marks]

(ii) For an Michaelis-Menten type of enzymatic reaction, **show** that v = Vmax/2 when [S] = Km

[5 marks]

4. (i) **Indicate** the short hand nomenclature for the following:

a) $CH_3(CH_2)_{18}COOH$

b) 

[5 marks]

ii) On hydrolysis a compound X gave the following products glycerol, palmitoleic acid, palmitic acid and inorganic phosphate. The compound X, which was extractable into a hexane/ methanol mixture, was also observed to be optically active. **Draw** the possible structure(s) of compound X.

[15 marks]

5. (i) **Predict** the mobility of the following amino acids during paper chromatography. **Briefly** justify your answer.

lys, ile, ala

[12 marks]

(ii) Consider the following peptide:

met-gly-his-pro-ala-arg-tyr-phe-val-lys-ile-cys

a) **What** is the most probable net charge at pH 7 for this peptide?
b) **How** many amino acids in the peptide have branched chain R-groups, and
c) Polar R-groups?
d) Can the peptide have an intra-chain disulphide bond? **Explain**.

[8 marks]

6. i) a) **What** is Keq for the hydrolysis of ATP to ADP if $\Delta G^{o'}$ is -7.3 kcal/mol (temp. = 25^0C)?

b) In the cell, $\Delta G'$ for the hydrolysis of ATP to ADP is -10 000 cal/mol. **What** is the difference between $\Delta G^{o'}$ and $\Delta G'$?

c) Is this reaction spontaneous at a room temperature?
Is this reaction rapid at room temperature?

[10 marks]

(ii) Given the following equation:

D-glycelaldehyde 3-phosphate + NAD^+ + H_3PO_4 ⟹

1,3-bisphosphoglyceric acid + NADH + H^+

$\Delta G^{o'}$ = +1 500cal/mol.

In vivo (pH = 7, temp. = 37^0C) the following concentrations are observed:
[D-glycelaldehyde 3-phosphate] = 10^{-4}M
[1,3-bisphosphoglyceric acid] = 10^{-5}M
[Inorganic phosphate] = 0.01M

What must the ratio of NAD^+/NADH be in order for the reaction to proceed spontaneously from left to right?

[10 marks]

End of C 212 /2000 Examination .....cheers!!

Useful information:

R = 1.986 cal/mol/deg

pKa values

a) Phosphoric acid system

$H_2PO_4^-/HPO_4^{2-}$ pKa = 7.21

$H_3PO_4/ H_2PO_4^-$ pKa = 2.12

HPO_4^{2-}/PO_4^{3-} pKa = 12.3

b) Selected Amino acids

	PKa1	pKa2	pKa3
Met	2.28	9.21	
Gly	2.34	9.60	
His	1.82	9.17	6.0
Pro	1.99	10.6	
Ala	2.35	9.69	
Arg	2.17	9.04	12.48
Tyr	2.20	9.11	10.07
Phe	1.83	9.13	
Lys	2.18	8.95	10.53
Val	2.32	9.62	
Ile	2.36	9.68	
Cys	1.71	10.78	8.33

University of Zambia
Department of Chemistry

C225 Final Examination

First Semester 2000.

ANSWER ALL QUESTIONS

1. (a) Outline the steps involved in a typical analytical method of quantitative analysis.

   (b) Convert 0.050 M HCl into ppm HCl. Cl = 35.5, H = 1.01.

   (c) Find the molarity and molality of HCl in a reagent labeled 37.0 wt %, density 1.188 g/mL.

2. (a) What is the difference between random and systematic errors?

   (b) What is the meaning of a confidence interval?

   (c) It is found from a reliable assay that ATP (Adenosine Triphosphate) content of a certain type of cell is 111 mmole/100 mL. You have developed a new assay which gave the following values for replicate analyses. 117, 119, 111, 115, 120 mmole/100 mL. The average value is 116 and the standard deviation is 3.578. Can you be 95 % confident that your method produces a result different from the "unknown" value?

   (d) A new calorimetric method was developed for the determination of Fe^{3+} where Fe^{3+} was precipitated with a crystalline organic compound. The accuracy of the method was checked by analyzing iron in an ore sample and comparing the results using the standard precipitation with ammonia and weighing the amount of Fe_2O_3 (iron oxide). The results reported as percentages for each of the analyses were as follows:

	New Method (% Fe)	Standard Folin-Wu Method (% Fe)
1.	20.1	18.89
2.	20.5	19.20
3.	18.65	19.00
4.	19.25	19.70
5.	19.40	19.40

   At the 95 % confidence level is there a statistical difference between the results obtained by the two methods?

3. (a) It is desired to perform 99 % complete separation of 0.01M Ca^{2+} from 0.01 M Ce^{3+} by precipitation with oxalate ($C_2O_4^{2-}$). Given the solubility products below, decide whether this is feasible.

$$CaC_2O_4 \qquad K_{sp} = 1.3 \times 10^{-8}$$
$$Ce_2(C_2O_4)_3 \qquad K_{sp} = 3 \times 10^{-29}$$

(b) Write the solubility product expression for AgCl in terms of x where x is the solubility of AgCl.

4. (a) Write a charge balance equation for a solution of a mixture of H_2SO_4 and $Al_2(SO_4)_3$.

(b) Consider the diprotic acid H_2A with $K_1 = 1.00 \times 10^{-4}$ and $K_2 = 1.00 \times 10^{-8}$. Use the equations from the systematic approach to calculate the pH and concentrations of H_2A, HA^- and A^{2-} in a 0.100 M H_2A.

(c) Calculate α_0, α_1, α_2 and α_3 for phosphoric acid at pH = 7.00. For phosphoric acid, $K_1 = 7.11 \times 10^{-3}$, $K_2 = 6.32 \times 10^{-8}$, $K_3 = 7.1 \times 10^{-13}$.

(c) Calculate pCa after addition of the following volumes of 0.0100 M EDTA in the titration of 50.00 mL of 0.0100 M Ca^{2+}; 10.0 mL, 50.0 mL, and 65.0 mL. $K_{CaY} = 5.0 \times 10^{10}$, $\alpha_4 = 0.35$ **[20]**

5. (a) Write the Nernst equation for the following half reaction:

$$CdS\,(s) + 2H^+ + 2e^- \rightarrow Cd\,(s) + H_2S\,(g)$$

(b) Consider the half reaction:

$$As\,(s) + 3H^+ + 3e^- \leftrightharpoons AsH_3\,(g) \qquad E^0 = -0.238\ V$$

(i) Write the Nernst equation for the half reaction.
(ii) Find E (not E^0) when the pH = 3.00 and P_{AsH3} = 1.00 torr (1 atm = 760 torr).

(c) Consider the titration of 100.0 mL of 0.0100 M Ce^{4+} in 1 M $HClO_4$ by 0.0400 M Cu^+ to give Ce^{3+} and Cu^{2+}, using a pt and saturated Ag | AgCl electrodes to find the end point. (Formal potentials in 1 M $HClO_4$ $Ce^{4+}/Ce^{3+} = +1.70$ and $Cu^{2+}/Cu^+ = 0.521$ V)

(a) Write a balanced titration reaction.
(b) Write two different half reactions for the indicator electrode.
(c) Write two different Nernst equations for the net cell reaction.
(d) Calculate E at the following volumes of Cu^+: 1.00, 24.5, 25.0, 30 and 50.0 mL. Sketch the titration curve.

UNIVERSITY OF ZAMBIA

DEFFERED EXAMINATIONS: SEMESTER II

JULY 2000

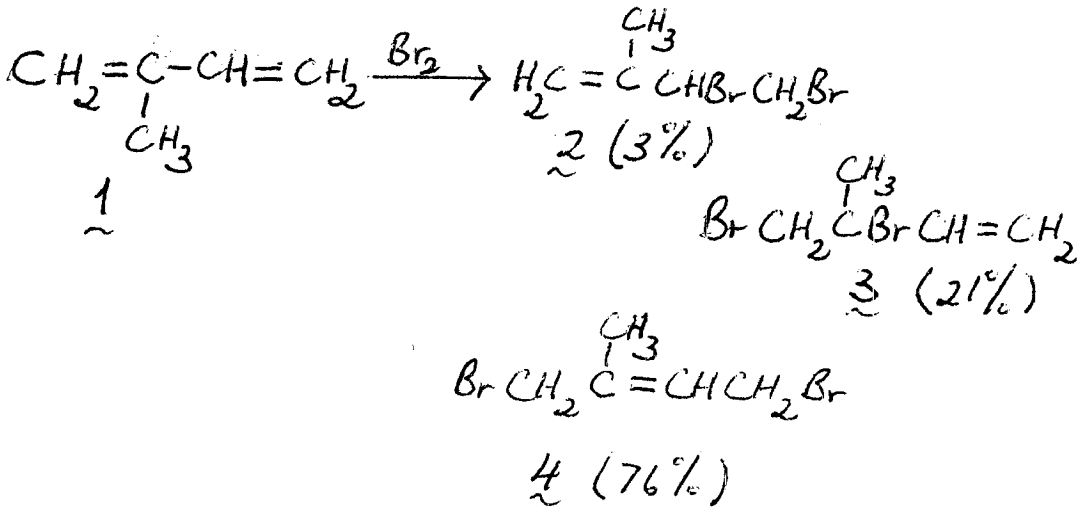
C252-ORGANIC CHEMISTRY 11

TIME: THREE (3) HOURS

INSTRUCTIONS

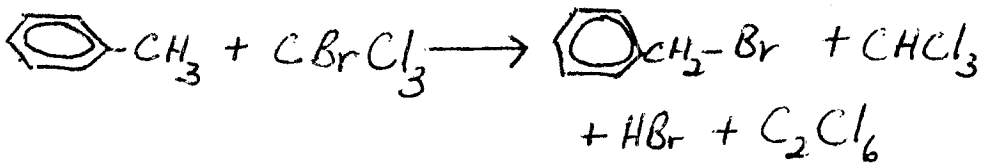
1. ANSWER ALL THE FOUR (4) QUESTIONS
2. ALL QUESTIONS CARRY EQUAL MARKS
3. INDICATE CLEARLY ALL THE DETAILS MEANT TO CLARIFY YOUR ANSWER.

1 (a) The reaction of 2-methyl –1, 3 – butadiene 1 below with Bromine has the indicated product distribution.



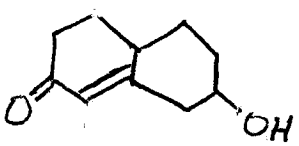
Comment on the product distribution arising from the above reaction.

b. Given the following reaction.

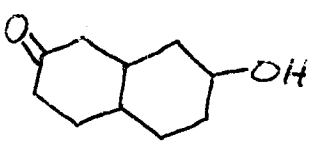


Suggest a mechanism for this chemical transformation.

(C) Which one of the following compounds 4 and 5 readily dehydrates under basic conditions and why?

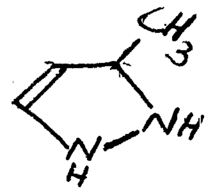


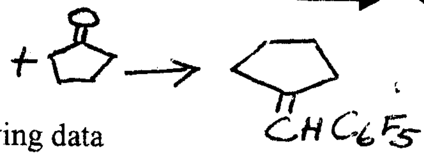
4



5

2 (a) Provide the mechanism for the reactions below

(i) $H_2NNH_2 + CH_3CH{=}CHCHO$ ⟶ 

(ii) $(C_6H_5)_3P{=}CHC_6F_5$ + 

(b) Consider the following data

NH_3 (Pka=34), $PhNH_2$ (Pka=25), RCO NH_2 (Pka=25)

Can you explain the differences in the acidities. Estimate the acidity of P-nitroaniline, NO_2-⌬-NH_2 (Note that for ⌬-OH Pka = 9.94; p-NO_2-⌬-OH Pka=7.14)

(c) Write a reasonable mechanism for the reaction of 1,3-dibromopropane with magnesium in diethyl either to afford cyclopropane

3 (a) Consider the following reaction

$(CH_2{=}CH\text{-})_2$ + HCl. 25°C ⟶ A (80%) + B (2%) + C (0%)

Explain the following concerning the above reaction.

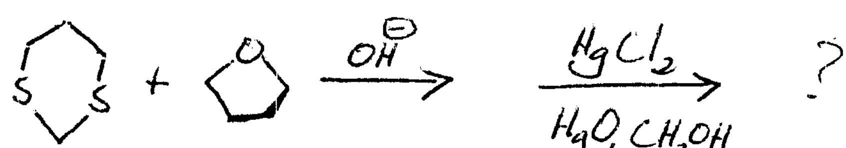
(i) The formation of products A and B

(ii) Why product C is unobtainable.

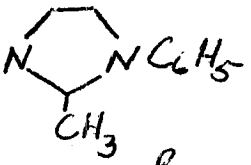
(iii) Draw a potential energy diagram for the formation of products A and B at 25°C and at a higher temperature of say 40°C.

(b) Give the product (s) from the following reaction.

(i) $CH_3CH_2CH_2\overset{+}{N}(CH_3)_3$ $\bar{O}H$ ⟶ ?
CH_3

(ii) 

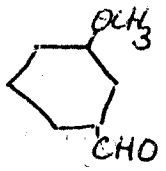
4 (a) Reagent A below has been used with aldehydes to prepare crystalline derivatives such as B for the purpose of their isolation and structural identification

$(CH_2NH\ C_6H_5)_2 + HCOCH_3 \xrightarrow[H^+]{CH_3OH}$ 

A B

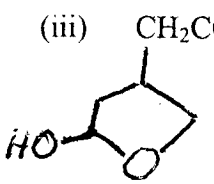
Write a mechanism for the formation of B

(b) Give the product (s) of the following reactions

(i)  + HCHO $\xrightarrow[H_2O/CH_3OH]{30\%\ NaOH}$?

(ii) $(C_2H_5)_3N$ + Br $\underset{CH_3}{\overset{|}{C}}$HCH =$CH_2$ ⟶ A + B

Major Minor

(iii) 

$\xrightarrow{H^+, H_2O}$ D

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER II EXAMINATIONS

MAY 2000

C265- PHYSICAL CHEMISTRY II

Time allocated: 3hours

Instructions:

The question paper consists of three sections.

-Answer **all** questions in section **A**.

-Answer **any two** from both section **B** and **C**

-Use separate booklets for each section.

Useful Data: $K.E = 1/2mv^2$,

Specific heat of fusion of ice = 333.15 J g^{-1}

$K_b(H_2O) = 0.52°C$

Faraday's constant (F) = 96500 C/mol e^-

= 96500 J/V-mol e^-

$E°_{red}\ Al/Al^{3+} = -1.66V$ and $E°_{red}\ Sn^{2+}/Sn^{4+} = 0.15V$

Section A: Answer ALL. Use a separate booklet for this section.

1. (a) Derive the integrated rate law expression for a 2nd order reaction when the two reactants have the same initial concentration.

$$A + B \longrightarrow \text{Products}$$

(b) Define half-life.

(i) Calculate k and $t_{1/2}$ for a 1st order reaction for which $t_{1/3}$ = 25min.

(ii) The disappearance of a reactant in a first order reaction is at a rate of 25%min^{-1}. Calculate the half-life.

(c). The molar conductivity at infinite dilution of KCl, KNO_3 and $AgNO_3$ are 149.9 $\Omega^{-1}cm^2mol^{-1}$, 145.0 $\Omega^{-1}cm^2mol^{-1}$and 133.4x10^{-4}S m^2mol^{-1}, respectively (all at 25°C). What is the molar conductivity of AgCl at infinite dilution at this temperature?

2. A snowball at - 15 °C is thrown at a large tree trunk. If then we disregard all frictional heat loss, at what speed must the snowball travel so as to melt on impact?

3. Give approximate boiling points at sea level for the following:
   (i) 2 molal HBr
   (ii) Suspension of 100 g of powdered glass in 1 litre of water
   (iii) 1.2×10^{24} sucrose molecules/litre of water.

Section B: Answer ANY TWO. Use a separate booklet for this section

4. (a) The Heat of formation of methane from solid carbon and gaseous molecular hydrogen is 74.8.kJ. The heat required to convert 1 mole of hydrogen into atoms is 436 kJ and that required to convert 1 mole of solid carbon dioxide into atoms may be assumed to be 717 kJ. Calculate the heat of formation of methane from gaseous atoms.

   (b) The heats of formation of ethane, ethylene and benzene from gaseous atoms are 2839, 2275 and 5509 kJ respectively. Calculate the resonance energy of benzene with one Kekulé structure.

5. (a) Calculate the heat absorbed and the entropy change when 0.5 mole of a perfect gas is allowed to expand at 300 K from a volume of 1 dm^3 to a volume of 10 dm^3 against a constant pressure of 1 atm.

   (b) An appreciable drop in temperature accompanies ammonium nitrate dissolution in water. Explain why the salt dissolves when it is absorbing so much heat.

6. (a) By means of a table compare the properties of electrostatically and sterically stabilised dispersions.

   (b) What are the effects of low, medium and high concentrations in particle nucleation and particle growth?

Section C: Answer ANY TWO. Use a separate booklet for this section

7. (a) Define the Van't Hoff factor.

(b) For a solute of the type A_2B producing three ions per molecule,

(i) Determine the expression for the total number of moles at equilibrium, taking α to be the degree of dissociation

(ii) Express α in terms of the Van't Hoff factor *i*.

(c) Given that the molar conductivity at infinite dilution for hydrochloric acid, sodium acetate and sodium chloride are 426.2×10^{-4} S m^2mol^{-1}, 91.0×10^{-4} S m^2mol^{-1} and 126.5×10^{-4} $\Omega^{-1}m^2mol^{-1}$, respectively. If a 0.01M solution of acetic acid has an experimental molar conductivity of $16.2\,\Omega^{-1}cm^2mol^{-1}$, what is the degree of dissociation of acetic acid at this dilution?

d. What are the three advantages of applying conductometric titrations?

8. (a) Define and give an example of a chain reaction. Differentiate between an initiation, a propagation and a termination step.

(b) Define the steady state approximation.

(c) A possible mechanism for the reaction $2NO + O_2 \longrightarrow 2NO_2$ is

$$NO + NO \xrightarrow{k_1} N_2O_2$$

$$N_2O_2 \xrightarrow{k_2} 2NO$$

$$N_2O_2 + O_2 \xrightarrow{k_3} 2NO_2$$

(i) By applying the steady state approximation obtain the rate law for the formation of NO_2.

(ii) Explain, under what conditions are kinetics in (i) second order.

(iii) Explain, under what conditions are kinetics in (i) third order.

9. (a) Briefly describe how you can distinguish between a 0^{th}, 1^{st} and 2^{nd} order of reactions.

(b) (i) Define a catalyst. Distinguish and give one example on each type of catalyst system.

(ii) State three functions of catalysts and give examples, were possible.

(iii) Many metallic catalysts, particularly the precious-metal ones, are often deposited as very thin films on a substances such as alumina, Al_2O_3, or silica, SiO_2. Why is this an effective way of utilising the catalyst material?

(c) Consider the cell, at 25°C

$$Al\ /Al^{3+}_{(aq,\ 0.10M)}\ //\ Sn^{2+}_{(aq,\ 0.10M)}\ /\ Sn^{4+}_{(aq,\ 0.10M)}$$

(i) Write the half reactions and the overall cell reaction.

(ii) Find the Emf of the cell.

(iii) Calculate the ΔG for the cell reaction

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – MAY/JUNE, 2000

BIOCHEMISTRY – C312

TIME: 3 HOURS

INSTRUCTIONS:

1. Answer *BOTH* Questions in Section A.
2. Answer any *THREE* Questions in Section B.

SECTION A (40 marks).

Q1. Write short notes on each of the following:

(i) antenna chlorophyll.

(ii) Cyclic photophosphorylation.

[20 Marks]

Q2. (a) Write the structural formulae of the following:

(i) Arachidic acid (20:0)

(ii) Arachidonic acid ($20:4\Delta^{5,8,11,14}$)

(iii) The lipid tripalmitate.

(b) What difference would you find between oleic acid and stearic acids at room temperature?

(c) What is saponification of an ester (lipid)?

(d) Show the saponification of the lipid tripalmitate and name all the products formed.

(e) Give a detailed account of the β-oxidation of palmitic acid in animals. (Show one cyde *ONLY*).

(f) Work out the total A.T.P. yield from the complete oxidation of the molecules of palmitic acid from the saponification of tripalmitate.

[20 Marks]

SECTION B (60 MARKS)

Q3. Exposing a photosynthesizing system to radioactive CO_2 for a brief period yields a compound known as 3-phosphoglycerate. Briefly explain why this so.

[20 Marks]

Q4. (a) Outline the reactions that constitute the urea cycle, giving structures and names of the compounds used and the products made as well as the enzymes.

(b) What α – keto acids (structures and names) are made from the transamination reactions involving the following amino acids:

(i) Alanine
(ii) Aspartate
(iii) Tyrosine

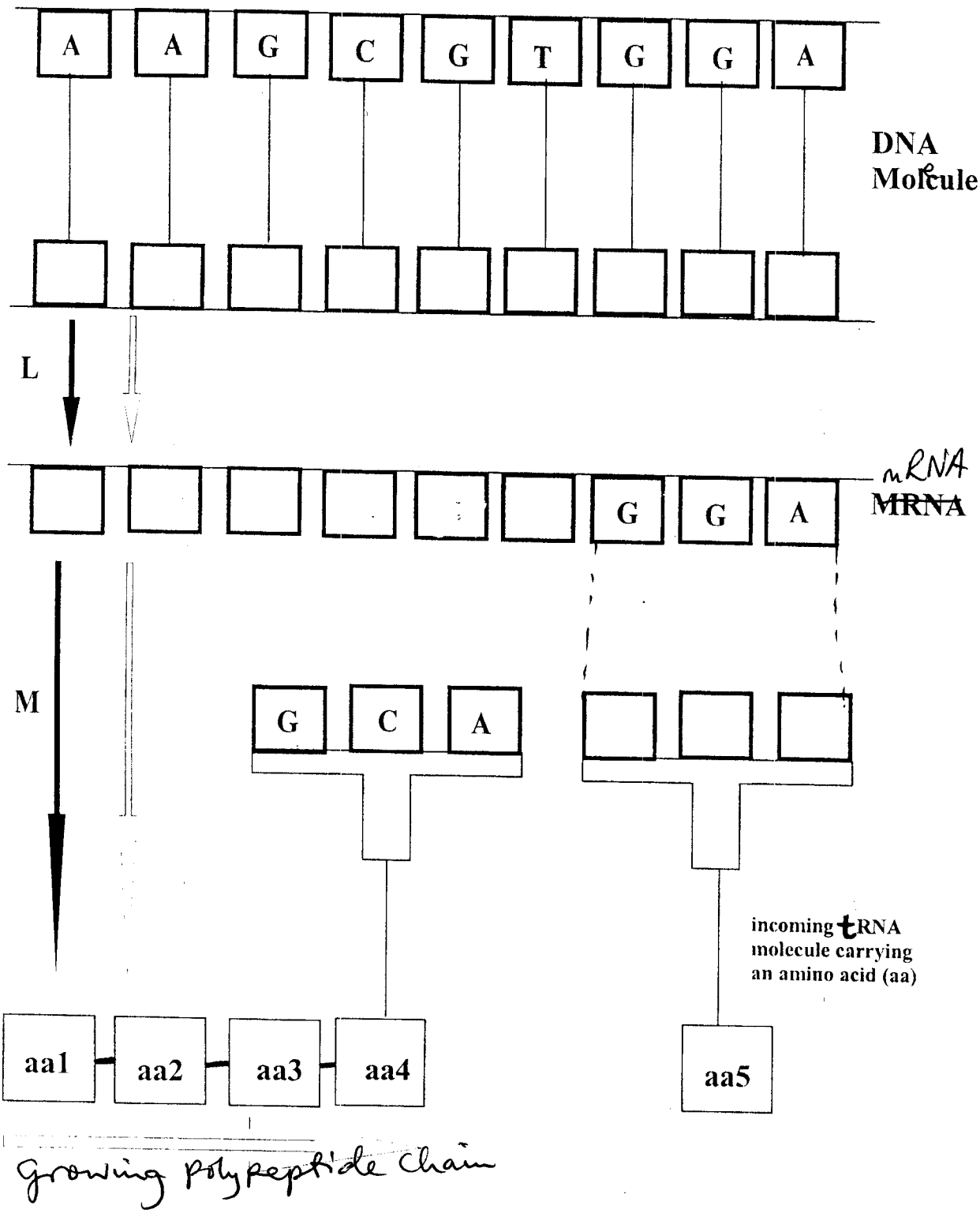
(c) Draw an A:T base pair showing clearly the hydrogen bonds which help to hold together complementary D.N.A. strands.

[20 Marks]

Q5. The diagram in fig. 5.1. shows the information flow in Protein Synthesis.

(a) Write in the boxes in the diagram of fig 5.1 the missing initial letters of the bases on the:

Fig 5.1


A
A
G
C
G
T
G
G
A
DNA Molcule
L
mRNA
MRNA
G
G
A
M
G
C
A
incoming tRNA molecule carrying an amino acid (aa)
aa1
aa2
aa3
aa4
aa5
Growing polypeptide chain

(i) DNA strand

(ii) mRNA molecule.

(iii) incoming tRNA molecule.

(b). what name is given to this triplet of bases on the tRNA molecule?

(c). Name the process shown by the:

(i) Arrow L.

(ii) Arrow M.

(d) In which organelle does the process shown by arrow M take place?

(e) Explain in detail, with the aid of suitable diagrams, the semi-conservative replication of D.N.A.

[20 Marks]

Q6. Write notes (brief) on any *FIVE* of the following:
(include structures, functions, two dietary sources and any deficiency disease):

(i) Biotin.

(ii) Nicotinamide or Nicotinic acid.

(iii) Pyridoxal or pyridoxine (Vitamin B_6).

(iv) Ascorbic acid (Vitamin C).

(v) Retinol (Vitamin A).

(vi) Tocopherol (Vitamin E).

[20 Marks]

END.

University of Zambia
Department of Chemistry

C321 Final Examination

First Semester 2000

ANSWER ALL QUESTIONS

1. (a) What property of electromagnetic radiation allows it to interact with matter? Briefly explain.

   (b) A 1.0000 g sample of steel is dissolved in acid and the solution diluted to 500.0 mL (solution B). A 50.00 mL aliquot of solution B is treated with potassium persulfate in the presence of Ag^+ ions acting as a catalyst, and potassium periodate, whereupon Mn and Cr are oxidized to MnO_4^- and $Cr_2O_7^{2-}$ and diluted to 100.0 mL(solution D). The absorbance of soluti0on D at 440 nm and 545 nm was 0.204 and 0.170 respectively in a 1 cm cell. Calculate the percent Mn and Cr in steel also taking into account the following data from literature:

λ, nm	ε (MnO_4^-)	ε($Cr_2O_7^{2-}$)
440	95	369
545	2350	11

   (c) Sketch the instrumentation for fluorescence. What advantage does detection at 90 degrees to the incident light offer?

2. (a) Briefly explain the operation of an Inductively Coupled Plasma.

   (b) An unknown containing element X was mixed with aliquots of a standard solution of element X for atomic absorption spectroscopy. The standard solution contained 1000.0 μg of X per milliliter.

Volume of Unknown (mL)	Volume of standard (mL)	Total volume (mL)	Absorbance
10.00	0.00	100.0	0.163
10.00	1.00	100.0	0.240
10.00	2.00	100.0	0.319
10.00	3.00	100.0	0.402
10.00	4.00	100.0	0.478

Prepare a calibration graph and calculate the concentration of X in μg/mL.

Mn = 54.94 g/mol
Cr = 52.00 g/mol

(c) In the spectrographic determination of lead in an alloy using magnesium as an internal standard, the following results were obtained.

Solution	Densitometer reading		Concentration of lead (mg/ml)
	Mg	Pb	
1.	7.3	17.5	0.151
2.	8.7	18.5	0.201
3.	7.3	11.0	0.301
4.	10.3	12.0	0.402
5.	11.6	10.4	0.502
A	8.8	15.5	
B	9.2	12.5	
C	10.7	12.2	

Prepare a calibration curve on a log-log paper and calculate the concentrations of solutions A, B and C?

3. (a) Sketch and explain how a Fourier Transform IR spectrometer operates.

(b) What two advantages are obtained in comparison with conventional IR instruments?

(c) The force constant for C≡C bond is 15.6×10^5 dynes/cm. Calculate the vibration frequency of the bond and convert this value to wave numbers cm^{-1}. ($m_H = 1.67 \times 10^{-24}$ g)

4. (a) Write very brief notes on the following:
   (i) Electron Impact Ionization (EI)
   (ii) Chemical Ionization (CI)

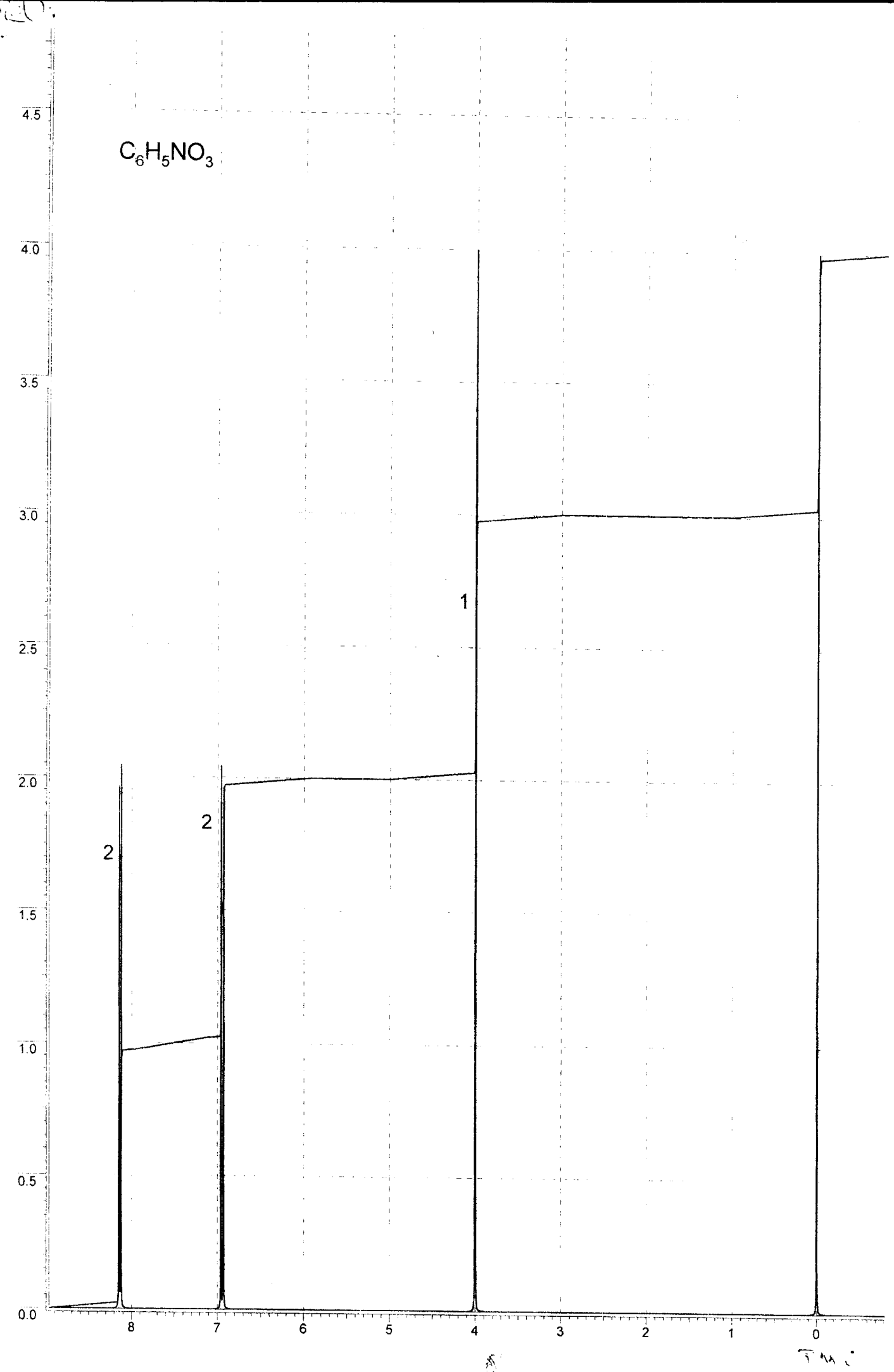
(b) For a drift length of 100 cm in a TOF spectrometer, what is the difference in arrival time between ions of m/z = 44 and m/z = 43 when the accelerating voltage is 2800 V?

5. (a) The spin quantum number I for ^{11}B is 3/2. How many orientations can this magnetic axis assume if it were placed in an external magnetic field.

(b) Write the formula for calculating the chemical shift in NMR and explain the meaning of each term.

(c) Predict and sketch the NMR spectrum for nitrobenzene.

(d) From the NMR spectrum and condensed formula given, what is the structural formula of the compound?


$C_6H_5NO_3$
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
2
2
8
7
6
5
4
3
2
1
0

THE UNIVERSITY OF ZAMBIA

C322 DIFFERED/SUPPLEMENTARY EXAMINATIONS – JULY 2000

TIME: THREE HOURS

INSTRUCTIONS

ANSWER: ANY FOUR QUESTIONS

1. (a) Explain the principle of potentiometry.
   (b) Explain in detail the glass electrode.
   (c) What type of electrodes can you use for:

   i., Neutralization titration.
   ii, Oxidation – reduction titration.
   iii., Precipitation titration.

(d), Given that the standard potential of the calomel electrode is 0.268 V and that of the Hg/Hg_2^{2+} electrode is 0.789 V. Calculate Ksp for the calomel (Hg_2Cl_2).

2 (a) Explain two types of coulometry. Sketch diagrams.
(b) A protein sample is analyzed by a Kjedahl procedure by digesting it with sulphuric acid to convert protein nitrogen to ammonium sulphate. The ammonia produced is determined by adjusting the pH to 8.6 and titrating coulometrically with electrogenerated hypobromite.

$$Br^- + 2OH^- \longrightarrow OBr^- + H_2O + 2e^-$$
$$2NH_3 + 3\ 0Br^- \longrightarrow N_2 + 3\ Br^- + 3H_20$$

If the titration is performed using 19.30 milliamperes current and the end point occurs at 120.0 seconds, how many milligrams protein were present in the sample? One gram of nitrogen is contained in each 6.25 g protein.

(c) For the determination in problem 2(b), you are asked to design a constant current source that will read out directly in micrograms of protein titrated. What current must it supply so that seconds of titration will be equal to micrograms of protein?

3(a) Explain the principle of polarography.
(b) Explain kinetic and adsorption current.
(c), How can you suppress maxima in polarography?
(d) How can you remove oxygen from the polarographic cell?
(e) Calculate the diffusion coefficient of zinc.The concentration of zinc in a polarographic cell is 0.032696g, diffusion current is 20 μA, m = ? and t = ? (100 drops falls after 4.0 min. with a weight of 0.360 g) [Zn = 63.392].

(f) An organic substance is reduced polarographically. At a concentration of 2.0×10^{-4} M, it gives a wave with diffusion current of 3.7μ A, when a capillary with a flow rate of 3.2 mg/s and a drop time of 2.5 s in used. If the diffusion coefficient of the compound in the supporting electrolyte has been determined by other means to be $0.9 \times 10^{-5} cm^2/s$; what is the Z value for the polarographic reduction of the organic compound?

4. (a) Describe the principle underlying all chromatographic processes.
(b) Classify six different types of chromatography, describing the stationary and the mobile phases.
(c) What is a response factor and what is the internal standard method in chromatography?
(d) When 1.06 mmol of 1-pentanol and 1.53 mmol of 1-hexanol were dissolved together and separated by gas chromatography, they gave relative peak areas of 922 and 1570 units, respectively.

(i) Calculate the response factor for 1-hexanol relative to 1-pentanol the internal standard.
(ii) When 0.57 mmol of 1-pentanol was added to an unknown containing 1-hexanol, the relative chromatographic peak areas were 843:816 (pentanol: hexanol). How much 1-hexanol did the unknown contain?

(e) Describe the principle of operation of the following HPLC detectors: Diode array detector, Refractive index detector and UV detector.

5 (a) What is diffusion? Explain its role in chemical separations.

(b) Two peaks with similar retention times generally have similar peak widths; for retained peaks with a width of 2 mL, what must be the difference in retention volumes to increase resolution to 2.

(c) (i) Define the kovats retention index (I).

(ii) The adjusted retention times (t^1_R) in minutes for a series of compounds were determined carefully on a nonpolar column:

Compound	t^1_R(min)
n-pentane	5.8
n-hexane	5.3
n-heptane	13.7
n-octane	29.5
Toluene	16.5
Cyclohexane	12.4

Calculate the kovats retention index for toluene and cyclohexane.

(d) Describe the principle of operation of the following gas chromatographic detectors: Flame lonization detector, Electron capture detector and Thermal conductivity detector.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER II EXAMINATIONS

MAY 2000

C352

ORGANIC CHEMISTRY IV

TIME: THREE (3) HOURS

INSTRUCTIONS:

1. **This paper consists of TWO SECTIONS,** Section A and Section B.
2. **Answer THREE questions from section A.**
3. **Answer TWO questions from section B.**
4. **Answer questions from section A and Section B in separate Answer Books and label the answer books 'Section A' and 'Section B'.**
5. **All questions carry equal marks. Marks for each part of the question are indicated.**

SECTION A

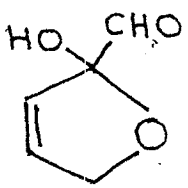
TIME: One Hour forty-five minutes

INSTRUCTIONS:

(i) Answer Any Three Questions from this section.

(ii) Answer questions in this section in a separate Answer Book and label the Answer Book 'Section A'.

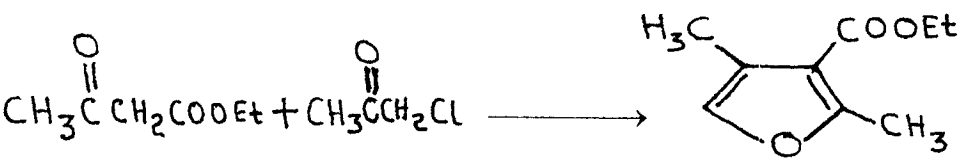
A-1 **(a)** During acidic hydrolysis of glucose a compound **A** is obtained as an intermediate. Acidic hydrolysis of compound **A** yields a compound **B** in good yield. Give the structure and name of compound **B**? Through a reaction mechanism show what product you would expect to obtain if compound **A** were treated with malonic acid in presence of piperidine.



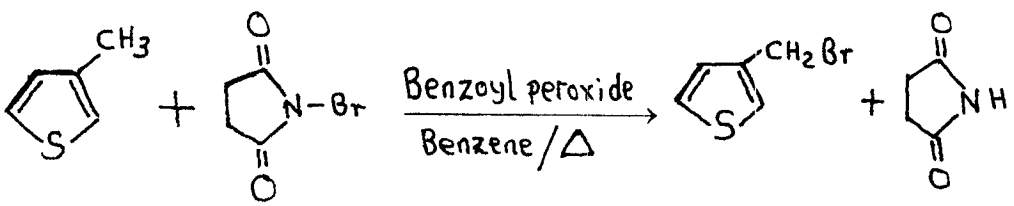
Compound **A**

(08 marks)

(b) Show clearly the mechanism of the following reactions:

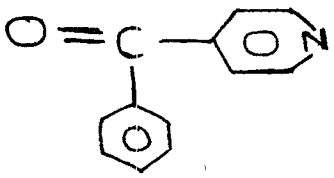
(i) 

(08 marks)

(ii) 

(04 marks)

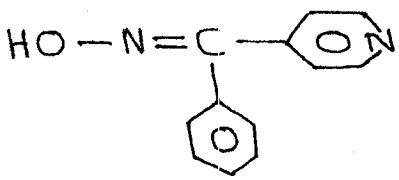
A-2 **(a)** The pyridine ring is inert to Friedel-Crafts acylation reactions. Suggest a method to synthesize phenyl-4-pyridylketone, compound **C**, clearly stating all the steps and give a reaction mechanism to support your proposal.



Compound **C**

(08 marks)

(b) Treatment of compound **C**, structure shown in **A-2 (a)** above, with hydroxylamine yields compound **D**. Show by a reaction mechanism the product of acidic hydrolysis of compound **D**.



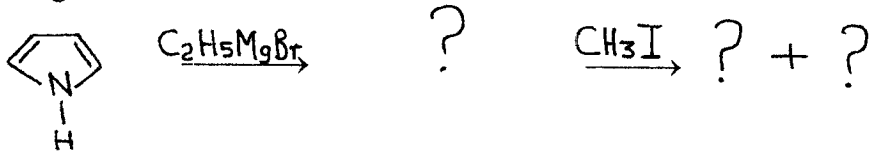
Compound **D**

(08 marks)

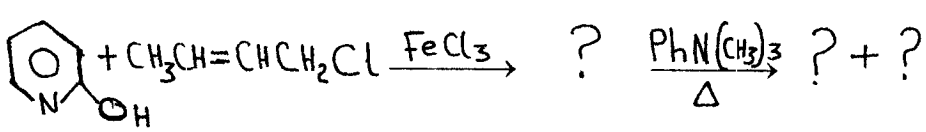
(c) Why is pyrrole more reactive in electrophilic substitution reactions than furan? Explain.

(04 marks)

A-3 **(a)** Predict the major organic products and give the mechanisms of the following reactions

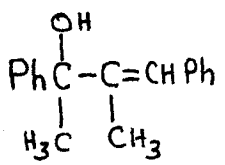
(i) 

(05 marks)

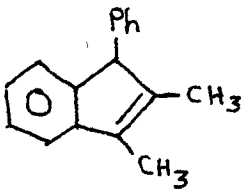
(ii) 

(08 marks)

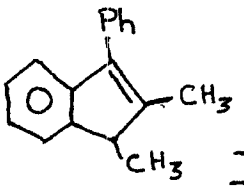
(b) When compound **E** is dissolved in FSO_3H, a strong acid, at -78^0C, a carbocation, **F**, is formed. If the solution is then allowed to warm to -10^0C a different carbocation, **G**, forms. The first cation, **F**, gives compound **H** when quenched with base while the second cation, **G**, undergoes rearrangement and gives **I**. What are the structures of carbocations **F** and **G**. What type of rearrangement mechanism is taking place in the cation **G** molecule?



E



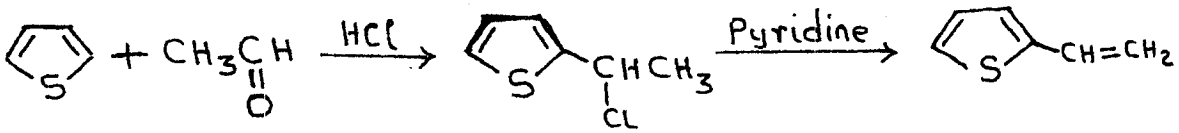
H



I

(07 marks)

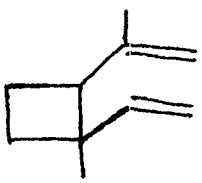
A-4 **(a)** During a laboratory work, a third year organic chemistry student observed the following reaction.



Write a detailed mechanism to show how these transformations took place.

(08 marks)

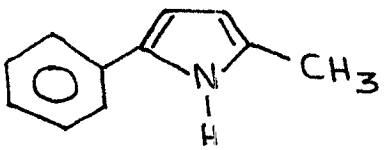
(b) A metal-catalysed dimerisation of isoprene gave compound **J** as an intermediate. Isolation of compound **J** from the reaction mixture that had been allowed to exceed room temperature yielded **NOT** compound **J** but 1,5-dimethyl-1,5-cyclooctadiene. Rationalise this observation.



Compound **J**

(03 marks)

(c) Show how you would synthesize compound **K** via Paal-Knorr reaction using $(NH_4)_2CO_3$ as a source of a heteroatom.



Compound **K**

(09 marks)

SECTION B

TIME: One Hour fifteen minutes

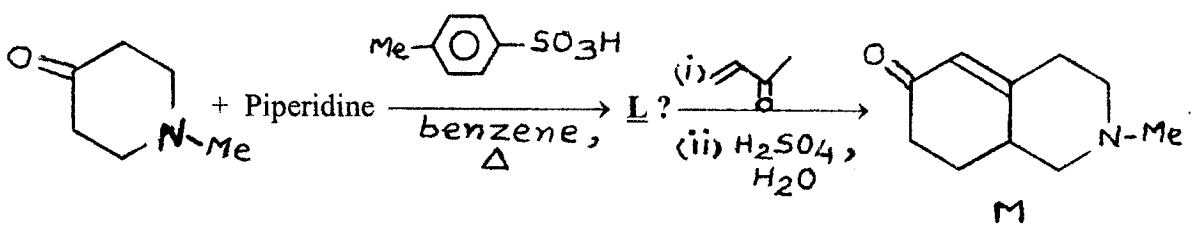
INSTRUCTIONS:

(i) **Answer Any Two Questions from this section.**

(ii) **Answer questions in this section in a separate Answer Book and label the Answer Book 'Section B'.**

(iii) **Unless specifically asked for, the mechanisms of the reactions are NOT required to be shown.**

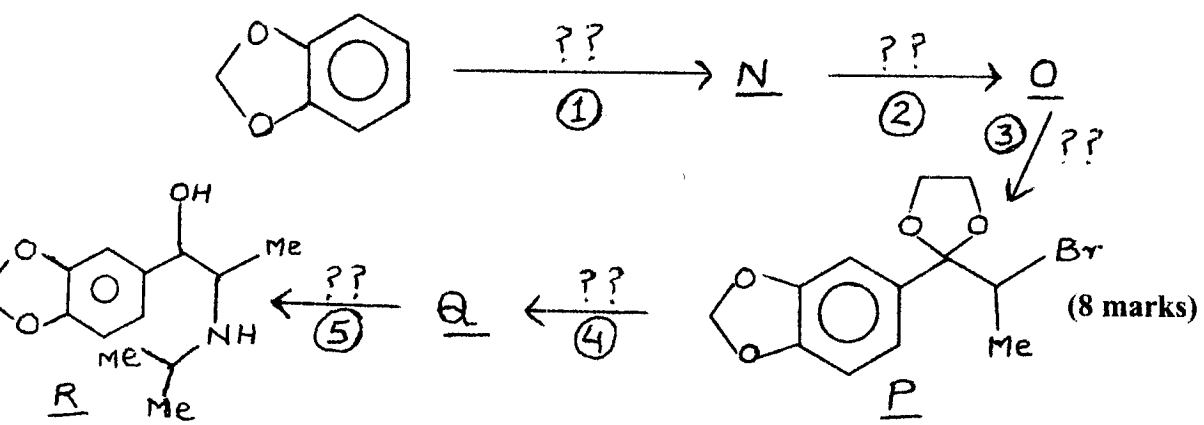
B-1 (a) Give thestructure of the enamine **L** in the following synthesis of compound **M** and provide the mechanisms of the reactions involved in the transformation of enamine **L** into compound **M**.



M

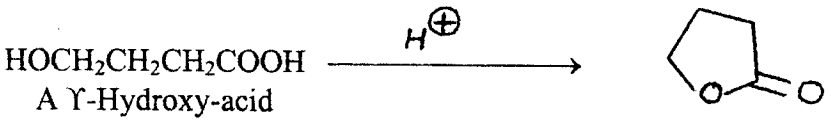
(12 marks

(b) Provide the missing reagents and give the structures of the intermediates **N**, **O** and **Q** in the following transformation.



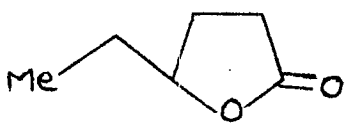
(8 marks)

B-2. (a) ϒ-hydroxy-acids readily lactonise in acidic medium to yield lactones as shown below.



Lactone

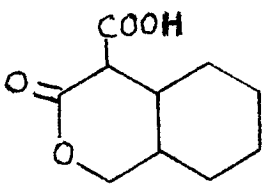
Using this information, propose a malonic ester synthesis of compound **S**.



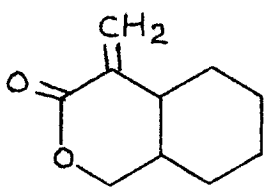
Compound **S**

(7 marks)

(b) Compound **T** was allowed to react with pyrrolidine and methanal (formaldehyde). The product so obtained was treated with sodium ethanoate in ethanoic acid to give a compound **U**, Propose a plausible mechanism to account for the formation of compound **U** in this reaction sequence.



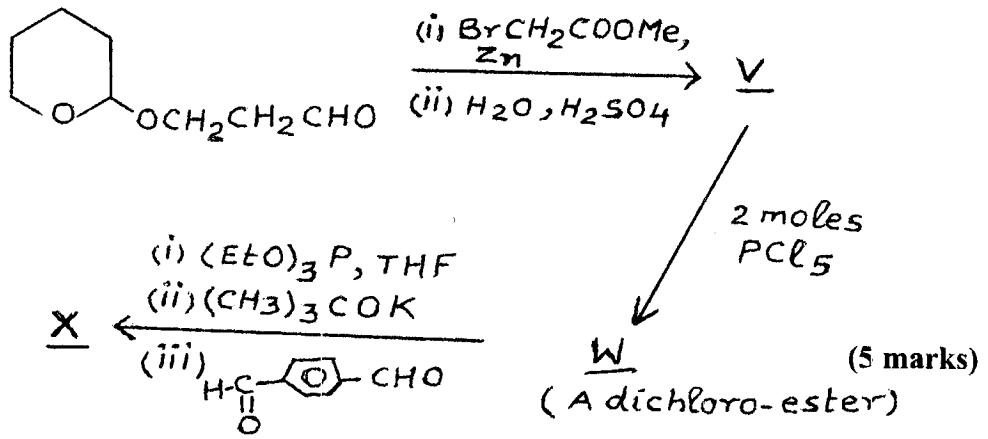
T



U

(8 marks)

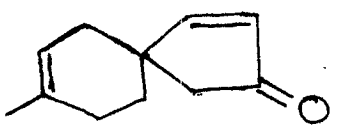
(c) Give the structures of the major organic products, V, W and X of the following reaction sequence.



(5 marks)

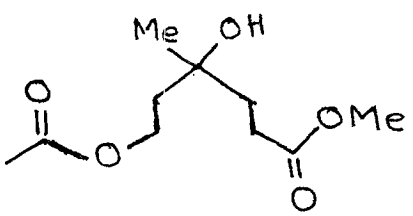
B-3 Propose a stepwise synthesis of **ANY TWO** of the following compounds from readily available materials. State clearly the reagents and special reaction conditions, if any, for each step and show the logic of your proposal.

(a)



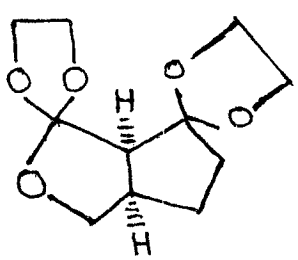
(10 marks)

(b)



(10 marks)

(c)



(10 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

C 362 : PHYSICAL CHEMISTRY
SEMESTER II FINAL EXAMINATION, MAY 1999

Time Allowed: Three (3) Hours
Instructions : Answer Question 1 and Any Four (4) Others

DATA

$h = 6.63 \times 10^{-34}$ J. s; $k_B = 1.38 \times 10^{-23}$ J. K^{-1}, $N_A = 6.02 \times 10^{23}$ mol^{-1}
ln x = 2.303 log x ; 1 cal. = 4.184 J ; 1 atm. = 101,325 $N.m^{-2}$
1 Newton = $J.m^{-1}$

1.(40 %)

a) The following are equations of interest in physical chemistry. Identify each equation and give a brief definition of the symbols that appear:

(i) $\Gamma^1_2 = -[\, d\gamma / d\mu \,]_T$

(ii) $log\, I_o / I = \varepsilon l c$

(iii) $dS \geq dq / T$

(iv) $d[A^*_2] / dt = k_1 I_a$

(v) $\mu_i = [\, \partial G / \partial n_i \,]_{p,T}$

b) For a solute in a solvent, one can derive the expression $d\gamma = -RT\, d ln c_2 \Gamma_2^1$ without drastic assumptions. On the same diagram draw sketch(es) to show the variation of the surface tension as a function of solute concentration. Indicate the sign of Γ_2^1 on each sketch(es)

c) State or give a brief description or explanation of the following
   (i) The principle of microscopic reversibility
   (ii) Fluorescence
   (iv) Phosphorescence
   (iii) Entropy of mixing ideal solutions

d) The initial rate of production of urea from ammonium cyanate increases by a factor of four when the concentration of ammonium cyanate is doubled. If the mechanism is as follows:

1. $NH_4^+ + CNO^- \overset{fast}{\rightleftharpoons} NH_3 + HNCO$

2. $NH_3 + HCNO \overset{Slow}{\rightleftharpoons} (NH_2)_2C{=}O$

   (i) Write the overall equation for the reaction
   (ii) What is the rate law?
   (iii) Does this law account for the experimentally observed increase in the initial rate? Explain.

e) Brown and Borkowski [J. Am. Chem. Soc. 74, 1896 (1952)] found that the values of the rate constants for the hydrolysis of $(CH_2)_6CCH_3Cl$ in eighty per cent ethanol solution at 0 °C and 45 °C are 1.06×10^{-5} and 2.92×10^{-3}, respectively, when the time is expressed in seconds. Calculate the energy of activation for the hydrolysis. What will be the value of the rate constant at 30 °C ?

2. (15 %)

a) Discuss the Langmuir theory of physical adsorption. In your discussion use the following guidelines:
   (i) State the approximations or assumptions made in the theory;
   (ii) Describe the nature of the results (use equations or sketches if they are helpful); and
   (iii) Indicate any major failures of the theory.

b) An amount of nitrogen gas (given as V_a, the volume of gas at standard temperature and pressure, STP) adsorbed on a film of mica at -183 °C was found to vary with pressure as given below:

P (atm)	3.4	6.0	9.4	12.8	17.1	23.5	33.5
V_a (mm)	13.4	19.0	23.9	25.5	28.2	30.8	33.0

Evaluate K_p and the amount of gas needed to form a monolayer at STP.

3. (15 %)

The molar volumes of two common crystal forms of $CaCO_3$, calcite and aragonite, are 36.94 and 34.16 cm^3, respectively. Both have compressibilities of about 1.4×10^{-6} atm^{-1}. The room-temperature standard enthalpy of formation of calcite, ΔH°_{298} is -288,086 calories per mole. For aragonite, ΔH°_{298} is - 288,134 calories per mole. The heat capacities of calcite and aragonite are 25 and 20 $cal.K^{-1}mol^{-1}$., respectively. At a pressure of 3720 atmospheres, calcite and aragonite can coexist at room temperature.

a) What is ΔS° for the change of state: Calcite ➜ Aragonite at 600 K?

b) What is the pressure at which calcite and aragonite are in equilibrium at 600 K?

c) Sketch how μ(calcite) and μ(aragonite) vary with pressure at a constant temperature of 298 K. Which phase is stable at 298 K and 5000 atm? Justify your answer quantitatively.

4. (15 %)

In an experiment similar to laboratory Experiment 5 that you performed, the rate constant k_2 ($dm^3.mol^{-1}.s^{-1}$) of the reaction

$$S_2O_8 \quad + \quad 2I^- \quad \rightarrow \quad 2SO_4^{2-} \quad + \quad I_2$$

was measured at various ionic strengths I ($mol.dm^{-3}$) at 25 °C :

I	0.00245	0.00365	0.00645	0.00845	0.01245
k_2	1.05	1.12	1.18	1.26	1.39

a) Are these results consistent with the Bronsted equation?

b) Calculate the charge on the reactant S_2O_8 (show all work).

c) Calculate the rate constant in the limit of infinite dilution.

d) Calculate the equilibrium constant K^* between the intermediate and the reactants.

e) Calculate the change in the Gibbs free energy of formation of the intermediate.

f) Write the formula for the intermediate.

g) What is the molecularity of each of the species in the reaction.

h) What is the order of the reaction.

5 (15 %)

A mechanism for a certain reaction was proposed to be:

1. $OCl^- + H_2O \leftrightarrows HOCl + OH^-$
2. $HOCl + I^- \rightarrow HOI + Cl^-$
3. $OH^- + HOI \rightarrow H_2O + OI^-$

a) What is the stoichiometric equation for the reaction?

b) Briefly explain the steady state approximation using an example from the above mechanism.

c) Use the steady state approximation to determine the overall rate law for the formation of the chloride ion. From your law, what is the overall order of the reaction?

d) Show that the overall rate law for production of the chloride ion is actually **psuedo-first order** in agreement with the experimentally determined law. State all the assumption you have made.

6. (15 %)

a) Draw a sketch to show how enzyme activity depends on the pH of the medium in which a biochemical reaction occurs. Explain the shape of the graph.

b) Briefly outline the Michaelis and Menten theory of kinetics of enzymatic catalysis.

c) The initial rate J_o(μmol dm^{-3} s^{-1}) of the myosin-catalyzed hydrolysis of adenosine triphosphate (ATP) at constant enzyme concentration varies with concentration (mmol dm^{-3}) as shown:

J_o	0.080	0.114	0.154	0.174	0.189
$[S_o]$	0.01	0.02	0.05	0.1	0.25

(i) What is the substrate in this biochemical reaction?

(ii) Evaluate the Michaelis constant and $J_{o,max}$.

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATIONS - MAY 2000

C412

ADVANCED BIOCHEMISTRY II

TIME: THREE HOURS
ANSWER: **ALL** QUESTIONS IN SECTION A (8-MARKS EACH)
THREE QUESTIONS IN SECTION B (20-MARKS EACH)

SECTION A

1. What is 'Brewer's grist'? Describe the process of its production. [8-marks]

2. Describe with examples, reductive reactions that occur in liver microsomes leading to inactivation of xenobiotics. [8-marks]

3. Briefly discuss the following:
   (a) The use of *Euglena* cultures in the production of radioactive compounds
   (b) Industrial production of penicillin. [8-marks]

4. Describe the three main categories of interferons. [8-marks]

5. How is diversity of antibodies achieved given that we are infected by thousands of elements but have a limited genome? [8-marks]

SECTION B

1. Outline the different physico-chemical factors that might be involved in the distribution of a chemical substance administered into a mammalian body. [20-marks]

2. Protein sequencing has one major disadvantage. Therefore, if you identified a novel protein you will possibly perform partial sequencing of the protein, then identify the gene. How will you sequence DNA? Describe two methods in detail. Why will you not sequence the protein directly? [20-marks]

3. Polymerase Chain Reaction (PCR) is one tool that every molecular biologist and biochemist has to use. Describe in detail how PCR works. Give some applications of PCR. [20-maks]

4. Describe how packaging of DNA is achieved. Assume that 140 bp are wound around a core nucleosome. How much volume will be taken up if 7 kb of DNA is packaged as a cylinder? Assume 110^0A and 55^0A for width and height of the nucleosomes, respectively. If the whole DNA was transcribed and translated into protein, how large is such a protein? Comment on such a protein. [20-marks]

5. Discuss, with examples, the preservation of foods using chemical substances. [20-marks]

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
DEPARTMENT OF CHEMISTRY
C422
MAY EXAMINATIONS 2000
APPLIED ANALYTICAL CHEMISTRY
TIME: 3 HOURS

ANSWER 4 OUT OF THE 6 QUESTIONS IN THIS PAPER

QUESTION 1

(a)Retention times(corrected for air peak) are given for the following compounds. What is the retention index for each of these compounds (time in minutes): ethane, 0.25; propane, 0.54; n-butane, 0.95; pentane, 1.80; n-hexane, 3.50; n-heptane, 6.95; n-octane, 13.7; 2-methylbutane, 1.20; butene-1, 0.80; hexene-1, 2.95; benzene, 3.75; n-butanol, 8.4 and water, 3.50? (6)
(b) Describe how to determine a sweetener and caffeine in a soft drink. (3)
(c) Describe the following terms: hydroxyl value, iodine value, peroxide value and include their uses in food analysis.. (3)
(d) Discuss how to evaluate the effectiveness of the following processes used in food industry: pasteurization and sterilization. (3)

QUESTION 2

(a) Describe how to determine sugars and fats in food samples. (4)
(b) Define the following terms used in chromatography by giving an equation, labelled diagram or description: resolution, retention time, stationary phase, theoretical plate and Kovats index.(4)
(c) Describe how to carry out a non-aqueous titration, highlighting the differences in dealing with basic and acidic compounds. Why is it necessary to use this technique?(3)
(d) Calculate the saponification value of fat. The sample weight was 3.55g, 50ml of 0.5mol/L ethanolic KOH was added and then refluxed, cooled and excess KOH determined using 0.5mol/L HCl. For the phenolphthalein colour change 33.2ml of acid was used. (KOH = 56) (4)

QUESTION 3

(a) Describe how to determine drugs of abuse using HPLC and include the descriptions of useful components of this technique. (4)
(b)Some types of drugs of abuse are better determined in urine than in blood. Discuss the statement giving examples.(3)
(c)The retention times of several compounds measured from sample injection are: air, 45 secs; propane, 1.5min; pentane, 2.35 min; acetone, 2.45 min; xylene, 15.0 min. What are the relative retention times of the compounds using pentane as std. Calculate the

resolution between acetone and pentane if their base widths are 2 and 3 min respectively. (3)

(d) Describe a bio-assay method you would use to determine malathion or carbaryl in foodstuffs (4)

QUESTION 4

(a) You have just made a nitrogen containing compound and would like to know whether it is an amine or a nitro compound. What tests would you carry out to try and identify the compound? (4)

(b) How would you differentiate between thiols and disulfides in organic compounds? (3)

(c) Describe some reactions associated with organic alcohols and acids. (3)

(d)A series of aldehydes (total amount 4mg) were chromatographed. Adjusted retention times, base width and peak heights were:

Component	C_5	C_6	C_7	C_8	C_9
T_R min	8.1	12.2	16.5	22.0	42.0
ΔT_b min	2.5	3.2	4.6	7.5	12.0
Peak height min	15	18	15.5	13.0	11.5

Calculate the amount of each aldehyde in the sample and for each peak calculate the theoretical number of plates. (5)

QUESTION 5

(a) Briefly describe steps you take to determine a herbicide in potatoes with examples of herbicides. (3)

(b) Describe how to make a health soap and discuss how its qualities are established. (4)

(c) Describe or explain the terms: detergency, surfactant, emulsifier, lye and describe their usefulness if any. (4)

(d) To recover levels of tin from foodstuffs, samples are boiled for different times in an open vessel as follows:

30 min boiling 57, 57, 55, 56, 56, 55, 56, 55

75 min boiling 51, 60, 48, 32, 46 58, 56, 51

test whether the boiling time affects the variability of the results and the mean of recovery of tin. At 95% confidence limit the value is 3.79. (4)

QUESTION 6

(a) How would you differentiate a soap from a non-soap detergent and how would you test for the foaming power and total fatty matter of these products. (4)

(b) Describe how to determine electrolytes in blood serum? (2)

(c) Van Slyke method is used in gas analysis. What are the principles of the method. What other method can be used instead of the Van Slyke one? (3)

(d) Describe 3 detectors used in gas chromatography and their principles of operation (3)

(e) Describe how Pb is determined instrumentally in blood. (3)

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF CHEMISTRY

UNIVERSITY SEMESTER II EXAMINATION

MAY 2000

C 482: INORGANIC INDUSTRIAL CHEMISTRY II

TIME: THREE HOURS

INSTRUCTIONS:

1. **ANSWER ANY FIVE QUESTIONS**

2. **FLOW-SHEETS WILL BE PROVIDED**

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1. Describe the manufacturing processes of Compound fertilizers.
2. Discuss the flow-sheet diagram for manufacturing Synthetic ammonia (Flow-sheet attached).
3. Discuss the industrial methods of manufacturing Soda-ash. Flow-sheet is attached.
4. State the industrial methods for manufacturing the following potassium compounds: bromide, iodide, sulphate, nitrate, carbonate, permanganate, and dichromate.
5. Describe the manufacturing of concentrated nitric acid (Flow-sheet is attached).
6. State the industrial methods for manufacturing phosphate fertilizers.
7. Describe the industrial methods for manufacturing Sulphuric acid.
8. Describe in detail the manufacturing of caustic soda and chlorine.

The University of Zambia

Semester II Final Examination May 2000

C492 - Organic Industrial Chemistry

Time : 3 hours
Instructions : Answer any four (4) questions
All questions carry equal marks

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1. (a) Briefly define explosives?

   (b) By means of a diagram show the relative positions of the number-average, weight-average and z-average molar masses on a molar mass distribution plot of a polymer.

   (c) Suggest two advantages of the carbonatation process over the phosphatation process.

   (d) By means of a reaction scheme show how an azo dye may be prepared.

   (e) Mixed-acid nitration is a commonly used technique for effecting nitration. Why is the presence of sulfuric acid in quantity important?

2. (a) Define the following terms as applied to plastics

   (i) Crystallinity (ii) Glass transition temperature

   (b) Explain why bulk polymerisation of monomers involving step polymerization does not have problems associated with bulk polymerization of vinyl monomers.

   (c) Kabwe Industrial Fabrics, in Kabwe, produces polyethylene bags using the technique of film blowing. Draw a fully labeled schematic diagram showing the extruder and film-blowing unit.

3. (a) Outline factors attributed to poor affination in sugar refining.

   (b) Comment briefly on mechanical and chemical methods of clarification in the sugar industry.

   What are the disadvantages of using the mechanical method of clarification?

   (c) What do you understand by the term false grain? Indicate factors that can lead to the formation of false grains.

4. (a) Drug release can be enhanced using a number of techniques. List these techniques with a note to explain how drug release is enhanced.

(b) What do you understand by the term transdermal delivery?

Indicate the essential characteristics of a drug suitable for use in transdermal delivery.

(c) Suggest problems associated with preparation of tablets by direct compression.

5. (a) Write brief notes on the general characteristics of pyrotechnics.

(b) Compare and contrast the burning characteristics of a detonating explosive and a propellant.

(c) Liquid propellants may be either monopropellants or bipropellants. Explain the difference between the two.

End of Examination

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER II EXAMINATIONS

MAY 2000

MEDICINAL CHEMISTRY

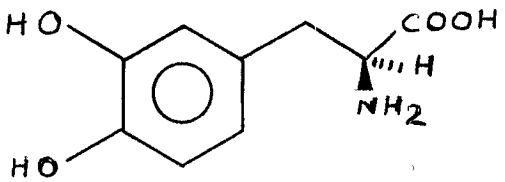
C955

TIME: THREE (3) HOURS

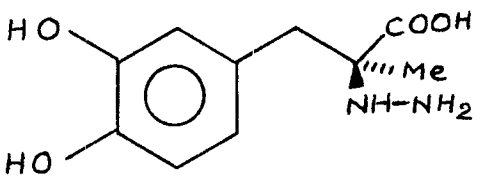
INSTRUCTIONS:

1. **Answer *ANY FOUR* Questions**
2. **Each question carries TWENTY-FIVE (25) Marks .**
3. **Mark allocation for each question is indicated .**

1. **(a)** Large dosage (3-8 g per day) of L-DOPA, a prodrug for Dopamine, β-(3,4-dihydroxyphenyl) ethylamine, are required for the treatment of Parkinson's disease, which often cause nausea and vomiting. A DOPA decarboxylase antagonist, Carbedopa, structure shown below, has been used in conjunction with L-DOPA to substantially reduce the effective dose of L-DOPA.



L-DOPA



Carbedopa

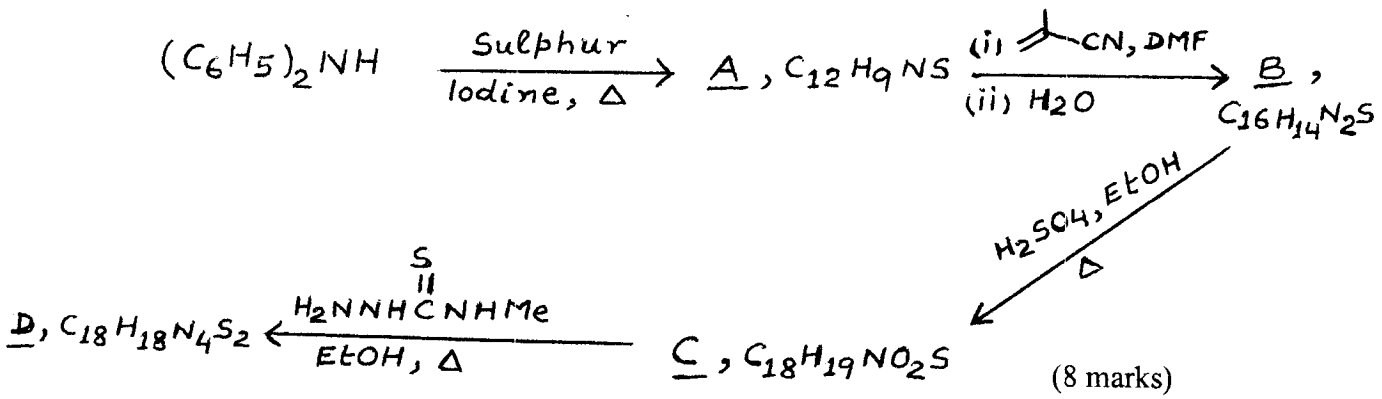
(i) Explain how Carbedopa can substantially reduce L-DOPA dosage required for the treatment of parkinson's disease.

(6 marks)

(ii) Can Carbedopa be used for the treatment of Parkinson's disease? Justify your answer.

(3 marks)

(b) Deduce the structure of an anti-histamine drug D from the following synthesis. Show the structures of the intermediates A – C

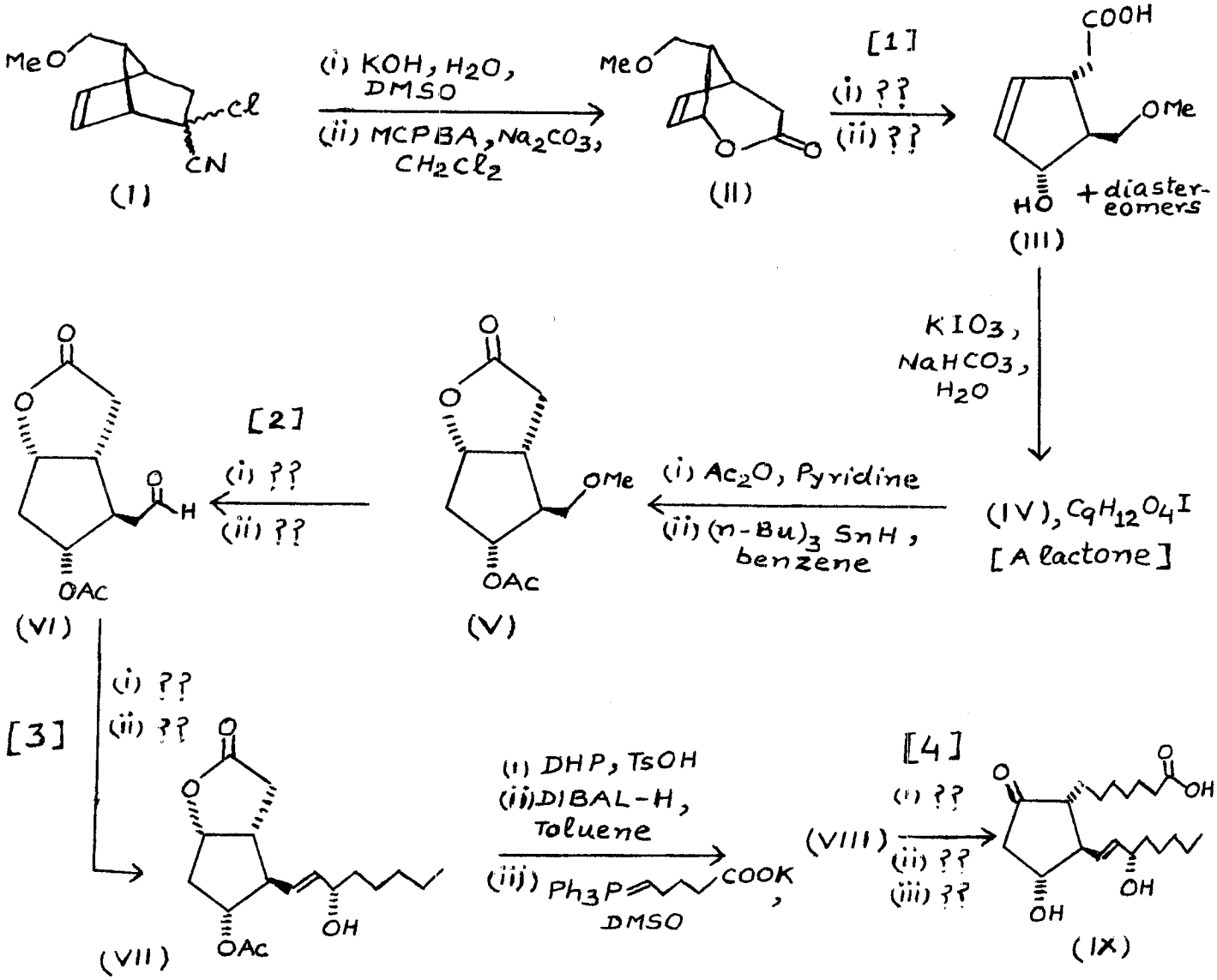


(8 marks)

(c) How would you screen herbal materials traditionally used as medicine for the presence of cyanogenetic glycosides. State the principle of your procedure and the significance of the findings.

(8 marks)

2. A general synthetic route to prostaglandins is outlined below.



(a) Give structures of compounds (IV) and (VIII), including pertinent stereochemistry.

(5 marks)

(b) State the reagents required for the numbered transformations [1] to [4].

(9 marks).

(c) Propose the mechanisms of the reactions involved in the formation of compound (II) from (I)

(7 marks)

(d) Suggest a synthesis of compound (I) from readily available starting materials.

(4 marks)

3. **(a)** Discuss the structure – activity relationships in phenothiazine tranquilizers..

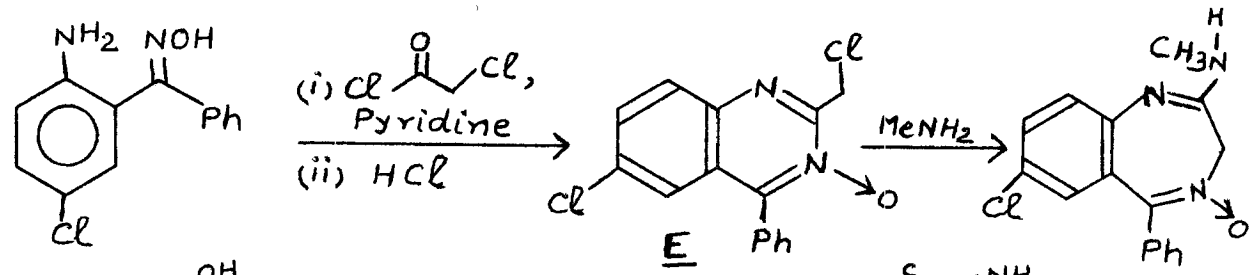
(8 marks)

(b) Outline a general procedure for the isolation of alkaloids from plant materials.

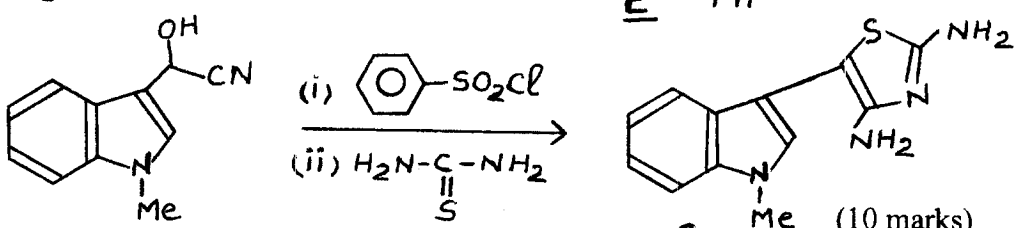
(7 marks)

(c) Propose plausible mechanisms of the reactions involved in the following synthesis of biologically active compounds E and G.

(i)



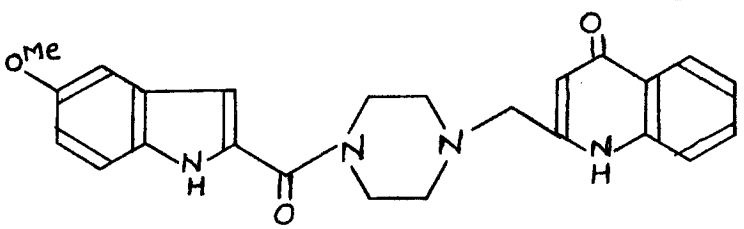
(ii)



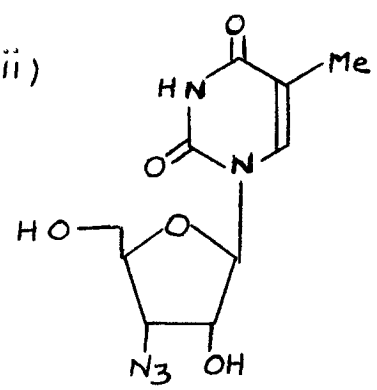
(10 marks)

4. Propose efficient synthetic schemes for ***ANY TWO*** of the following compounds from readily available non-heterocyclic starting materials. State the reagents and special reaction conditions, if any, for each step. Show the logic of your proposal.

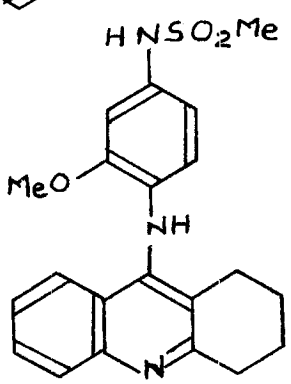
(i)



(ii)

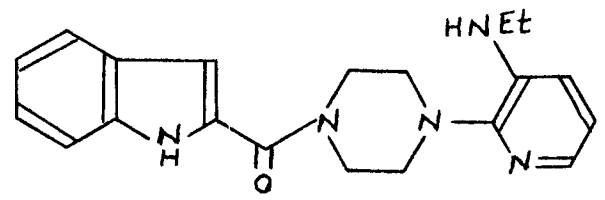


(iii)

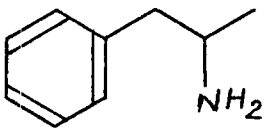


(25 marks)

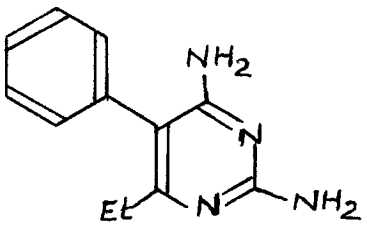
5. **(a) (i)** State the principal pharmacological function (s) of the following compounds and give systematic names for compounds J and K



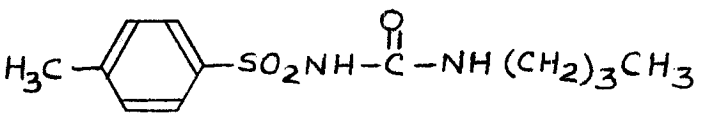
H



I



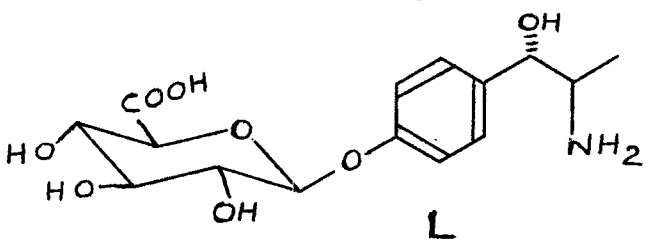
J



K

(8 marks)

(ii) A metabolite L, structure shown below, was detected in the urine of a patient receiving oral dosage of the drug I, structure shown in Q.5 (a) (i) above.



L

Propose a likely metabolic pathway for the drug I to account for the presence of the metabolite L in the urine.

(8 marks)

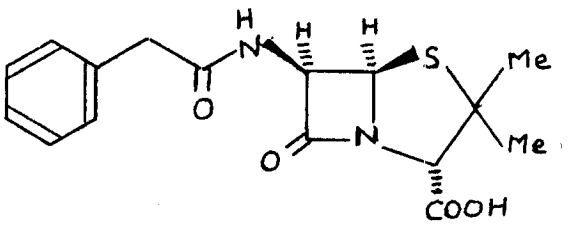
(iii) Compound K, structure shown in a Q.5 (a) (i) above, exhibits short duration of action. Design an analog, excluding isomers, of K that can be expected to possess longer duration of action. Justify your proposal.

(6 marks)

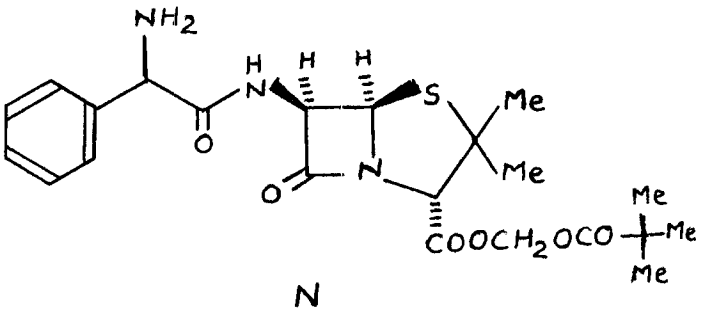
(b). Obesse patients undergoing surgery require more than normal volumes of anaesthetic gases to induce optimum anaesthesia. Explain why?

(3 marks)

6. (a) (i) In contrast to benzyl penicillin, M, which is ineffective when administered orally, oral ingestion of a semi-synthetic penicillin, N, is highly effective in the treatment of a variety of microbial infections.



M



N

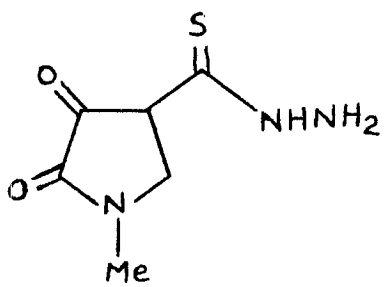
Provide a detailed explanation for the observed differences in the oral efficacy of the two penicillins, M and N.

(9 marks)

(ii) Suggest a synthesis of the semi-synthetic penicillin, N, from the naturally occurring benzyl penicillin, M, structures shown in Q 6 (a) (i) above

(10 marks)

(b) State the mode of anti-viral action of compound Q, structure shown below.



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(6 marks)

END OF C955 SEMESTER II EXAMINATION, MAY 2000

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION EXAMINATIONS – JULY 2000

GEO 111
Introduction to Human Geography I

TIME: Three Hours
ANSWER: Questions One (40%) and any other Three
NOTE: Illustrate your answers wherever possible
Use of a calculator and an approved atlas is allowed

Q1. Table I below shows hypothetical data related to employment in three manufacturing sub-sectors in Zambia.

Table 1: **Hypothetical employment data in three manufacturing sub-sectors**

REGION	TOTAL EMPLOYMENT	FOOD AND BEVERAGE	TEXTILES	PAPER AND PRINTING
Western	502	502	*	*
Central	40 200	11 650	9 682	2 954
Luapula	358	318	40	*
Eastern	1 074	786	288	*
Northern	642	642	*	*
Copperbelt	53 628	11 906	8 488	2 372
N/Western	100	100	*	*
Southern	20 756	14 894	3 886	34
TOTAL	117 260	40 798	22 384	5 360

Note: (i) * Means the industry does not exist in the region
(ii) Formula:

$$\mathbf{LQ} = \frac{\% \text{ of National Employment in Industry in Region}}{\% \text{ of National Employment in all Industries in Region}}$$

a) Using the formula above, calculate the Location Quotient for each industry in each region

b) What is it that Location Quotients? Indicate and describe.

c) Explain the regional factors that might influence the location of these industries.

2. How does the Regional Approach differ from the Quantitative Revolution and the Critical Approaches, found in the development of human geography?

3. Human evolution had two components that are interrelated and interdependent. These are the biological and the cultural. But in 'inventing' culture, biological evolution transcended itself.

   Discuss the significance of the 'invention' of culture as the means for mankind to transcend the biological limits of evolution.

4. a) Define CULTURE HEARTH and CULTURE REALM

   b) Explain what characteristics each of the four major culture hearths of the old world had in common

5. Discuss Torstern Hagerstrand's four stage model for the passage of diffusion in waves.

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

   a) The Primate Radiation
   b) The Nearest-Neighbour Index
   c) The Huxley Model
   d) The four basic processes of culture
   e) Space-adjustment techniques

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - MAY 2000

GEO 112

INTRODUCTION TO HUMAN GEOGRAPHY II

TIME: Three hours
ANSWER: Any four Questions
NOTE: All questions carry equal marks. Illustrations should be used whenever appropriate.

Q1. Write short explanatory notes on the following:

a) Resource
b) Community ownership versus private ownership
c) Types of land tenure in Zambia
d) Economic Growth versus Economic Development
e) Urban population problems

Q2. Elucidate the effects of Industrial Revolution on modernization of society in the developing world.

Q3. Give a critical account of Rostow's Model of Economic Growth.

Q4. 'State of high development of some countries is a cause of the underdevelopment of others'. Discuss.

Q5. Discuss the assertion that the most pressing problem for poor countries is to eliminate the development gap.

Q6. Giving examples of components of culture write an essay on cultural development in pre-colonial Africa.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY DISTANCE EDUCATION EXAMINATIONS-JULY 2000

GEO 112

INTRODUCTION TO HUMAN GEOGRAPHY II

TIME: THREE HOURS
ANSWER: FOUR (4) QUESTIONS.
ALL QUESTIONS CARRY EQUAL MARKS.
ILLUSTRATIONS SHOULD BE USED WHENEVER APPROPRIATE.

Q1. Write short explanatory notes on the following:
- a) Urban population problems
- b) The Components of Culture
- c) Resource conservation
- d) The Tenure Debate
- e) Modernisation

Q2. With reference to 'Space Adjustment', discuss the effects of the Industrial Revolution on the urban centres of England and their hinterlands.

Q3. Discuss the contention that developing countries in Africa will also experience demographic transition.

Q4. What is a resource and how can 'common property' resources be sustainably managed in Africa?

Q5. How can culture contribute to economic development in Africa?

Q6. 'Land reforms in Africa are an unnecessary source of conflict.' Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - MAY 2000

GEO 155

INTRODUCTION TO PHYSICAL GEOGRAPHY

TIME: Three Hours
ANSWER: Any four questions
NOTE: All questions carry equal marks
Use of calculators and approved atlas is allowed.

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1. Discuss the energy balance of the atmosphere.

2. Use the terms saturation, dewpoint and condensation properly in describing what happens when a parcel of moist air is rising.

3. Describe the earth's structure from the centre outward and distiguish the different types of crust.

4. Discuss the essential components of a food web or food chain and how the energy flows through the food web of an ecosytem.

5. Identify four soil forming processes and describe each of them .

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

   (a) Relative humidity and specific humidity
   (b) Initial and sequential landforms
   (c) Soil profile and soil texture
   (d) Ecosystem and ecology
   (e) Granite and Basalt

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION EXAMINATIONS - JULY 2000

GEO 175

INTRODUCTION TO MAPPING TECHNIQUES IN GEOGRAPHY

PAPER I

MAP READING, INTERPRETATION AND ANALYSIS

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

NOTE: THE USE OF CALCULATORS AND AN APPROVED ATLAS IS ALLOWED

Q1. Write short explanatory notes on all of the following:

(a) Grid references

(b) Oblique aerial photographs

(c) The value of maps to geographers

(d) Any four quantitative methods of showing relief on topographical maps

(e) Any four photo. interpretation elements

Q2. With the help of specific examples, outline and discuss the five essential elements of a good map.

Q3. Using a specific example, explain in detail how you would convert a large scale given in figures to a scale in words.

Q4. (a) What do you understand by the term 'drainage pattern'?

(b) Using appropriate sketches, describe any five different drainage patterns.

(c) Briefly comment on the occurrence of each drainage pattern you have described above.

Q5. With the help of an annotated diagram, explain how you would reduce the map of a narrow area such as a river valley, railway or stretch of road using the most appropriate method.

Q6. 'The most widely used Zambian 1:50 000 topographical map series contain symbols for four categories of features'.

Outline and discuss these four categories of features.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION EXAMINATION – JULY 2000

GEO 211
THE GEOGRAPHY OF AFRICA

TIME: Three hours
ANSWER: Any four questions
NOTE: All questions carry equal marks
The Use of any approved atlas is allowed

Q1. Write short explanatory notes on all of the following.

a) Isostacy
b) The effect of altitude on temperature
c) Convection Current theory
d) The effect of coastal alignment on the African climate
e) The relationship between religion and landscape

Q2. In what ways was the Neolithic Revolution of benefit to Africa?

Q3. What are the causes of the socio-economic crisis in Africa and how can it be resolved?

Q4. 'Tourism is the only aid to economic development in East Africa'. Discuss

Q5. Explain the socio-economic advantages and disadvantages of regional integration in Southern Africa.

Q6. a) Describe and explain problems in the Sahel

b) Are the measures put in place to redress the problems mentioned in (a) above successful, and if not what else should be done?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION DEFERRED EXAMINATIONS SEPTEMBER 2000

GEO 212 – THE GEOGRAPHY OF ZAMBIA

TIME: Three Hours

ANSWER: Any Four Questions

NOTE: All questions carry equal marks. Candidates are encouraged to use illustrations wherever appropriate.

Q1. Describe the geology of Zambia and explain its importance to the economy.

Q2. Explain how anthropogenic factors have affected the distribution of vegetation in Zambia.

Q3. Discuss the responses of Small-Scale farmers to the effects of drought in the 1990s.

Q4. Explain why there are regional variations in the distribution of Total Fertility Rates in Zambia.

Q5. Discuss the effects of the economic liberalisation policies on the Manufacturing Sector in Zambia.

Q6. Outline and discuss the factors that affect the distribution of temperature in Zambia.

END OF EXAM

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - MAY 2000

GEO 272

QUANTITATIVE TECHNIQUES IN GEOGRAPHY II

TIME: THREE HOURS
ANSWER: ANY FOUR QUESTIONS
NOTE: All questions carry equal marks.
The use of a Calculator and any approved atlas is allowed.

Q1. Illustrated in Table 1 are metal impurities detected by a hydrologist at different points along three different rivers. Assuming that data for each sample are normally distributed, prove whether there was a significant difference in metal impurities in the three rivers. Assume that tests were conducted on similar stages of the rivers. Use the 0.01 level of significance.

Table 1: **Metal impurities (measured in mg) at dirrernt ponts of three rivers**

River A	River B	River C
10.3	17.0	5.7
5.0	6.9	11.8
12.5	4.6	17.3
15.1	9.0	16.2
11.0	12.6	4.5
9.3	14.2	10.6
6.0	4.9	8.4
8.4	10.4	7.0
16.4	7.2	6.8
4.3	8.0	13.4
3.6	2.8	4.6
7.0	7.4	
	6,6	

Q2. A natural resource student randomly surveyed giraffes in two areas where it was assumed that the ages of the giraffes in the samples were randomly selected and were normaly distributed. This student aimed at analysing her data with a 95% accuracy.

Is it likely that her results showed that giraffes in area A were on average sigificantly older than those in Area B?

Table 2: **Ages (in years) of giraffes samples from two areas.**

Area A: 25; 14; 35; 16; 40; 23.4; 12.8; 18.2; 11.6; 10; 24; 31.3

Area B: 16; 2.5; 6.9; 4.3; 10; 13.4; 8.6; 5.6; 7.0; 12; 9; 16; 3.2; 22; 15.5; 2.8; 18.4

Q3. Two thousand prisoners were sampled in two identical prisons. Assuming that the average age for all the prisoners was 25.5 years and the standard deviation was 9.3. What was the aggregate population of prisoners aged (a) between 20 and 31 years, (b) above 35.5 years, (c) below 15.3 years (d) between 27 and 40 years?

Q4. Table 3 shows tonnes of sand that a grader is able to remove and the number of hours it takes to remove each amount of sand. Assuming that both sets of data presented in Table 3 are normally distributed would a researcher be justified to conclude that the more time a grader takes to remove the sand, significantly the more sand it removes? Use the 0.05 level of significance.

Table 3: **Amounts of sand and time used for removal**

Amount of sand removed (in tonnes)	**Time used**
15.0	6.0
25.5	6.8
16.0	3.5
12.0	6.6
35.0	7.0
31.2	6.4
20.5	6.5
5.0	1.5
30.4	7.5
10.5	3.0
11.0	4.3
23.0	2.3
14.8	5.8
9.4	2.5
36.2	8.2
8.0	5.8

Q5. An educational psychologist claims that the order in which geography test questions are asked affects the student's ability to answer questions correctly. To investigate this assertion, a professor randmoly divides a class of students into two groups as shown in Table 4. The professor prepares one set of geography questions but arranges the questions in two different orders. In test A the questions are arranged in order of increasing difficult (that is from easiest to most difficult while in test B the order is reversed). One group of students is given test A the other test B. The test scores are recorded for each student. The results are as shown in Table 4.

Table 4: **Test scores of two groups of geography students**

Test A: 90; 71; 83; 82; 75; 91; 65; 54; 87; 68; 93; 77; 66

Test B: 67; 66; 78; 50; 68; 80; 60; 50; 56; 45; 25; 62; 20; 70

Do the data sets provided in Table 4 show sufficient evidence to indicate that results illustrated under Test A are significantly better than those illustrated under Test B? Use 0.01 level of significance.

Q6. Ngoza and Liya investigated the effect of the extent of a bystander's commitment to a victim on the basis of the bystander's response to a crime perpetrated on the victim. The investigators simulated a crime in which a shopper's bag was stolen. The extent of the experimental subject's commitment to the victim was determined as follows:

Commitement: The victim would look at he subject and say: "Would you watch this bag for me please? I will be back in a minute". Without waiting for a reply the victim would then walk into a shop and out of the subject's sight.

Non-commitment: The victim would sigh heavily, begin to walk away, turn back to the bag for a second, and then keep going into the shop and out of sight.

After the victim had been out of sight for approximately two minutes, the thief would walk over near the bag, look at it, take a quick glance around, pick up the bag and walk away, at a normal pace, in a direction opposite the victim. In each case it was noted whether the subject intervened when the crime was committed. The resulting data are presented in Table 5.

Table 5: **Commitment versus viewer response**

		COMMITEMENT	
		COMMITTED	NON COMMITTED
RESPONSE	Intervened	52	12
	Did not intervene	26	68

Use the 0.01 level of significance to determine whether people who intervened significantly depended on whether they were committed or non-committed.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - MAY 2000

GEO 912

GEOGRAPHY OF MIGRATION AND REFUGEES

TIME: Three Hours
ANSWER: Four Questions Selecting Two from Each Section
NOTE: All questions carry equal marks

SECTION A

Q1. Elucidate the mechanism of migration within the context of cost-benefit framework and push-pull theory.

Q2. Give an account of the emerging trends in International Migration after World War II.

Q3. Discuss the dynamics of labour migration in South Africa.

SECTION B

Q4. Compare and contrast the situations of urban and rural refugees within the African context.

Q5. Discuss the 'burden sharing approach' in solving the refugee problem in Africa.

Q6. Why is the Sudan a good reference country in attempts to analyse the refugee problem in Africa?

Q7. Examine circumstances that determine the repatriation of refugees and why the exercise of repatriating Angolan refugees has not succeded in Zambia while it succeeded with Mozambican refugees.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – MAY 2000

GEO 922

THE GEOGRAPHY OF REGIONAL PLANNING AND DEVELOPMENT

TIME: THREE HOURS.

ANSWER: FOUR QUESTIONS, TWO FROM SECTION A AND THE OTHER TWO FROM SECTION B.

NOTE: ALL QUESTIONS CARRY EQUAL MARKS.

SECTION A

Q1. What are the differing policy implications of the adoption of Linear stages of growth, Neoclassical structural change and Dependancy theory views of development?

Q2. 'The pattern of third world urbanization reflects the history of economic relationships between the developed and less developed world'. Discuss.

Q3. Critically analyse the structure of Africa's political economy and explain why it is a major component of Africa's problems of under-development.

SECTION B

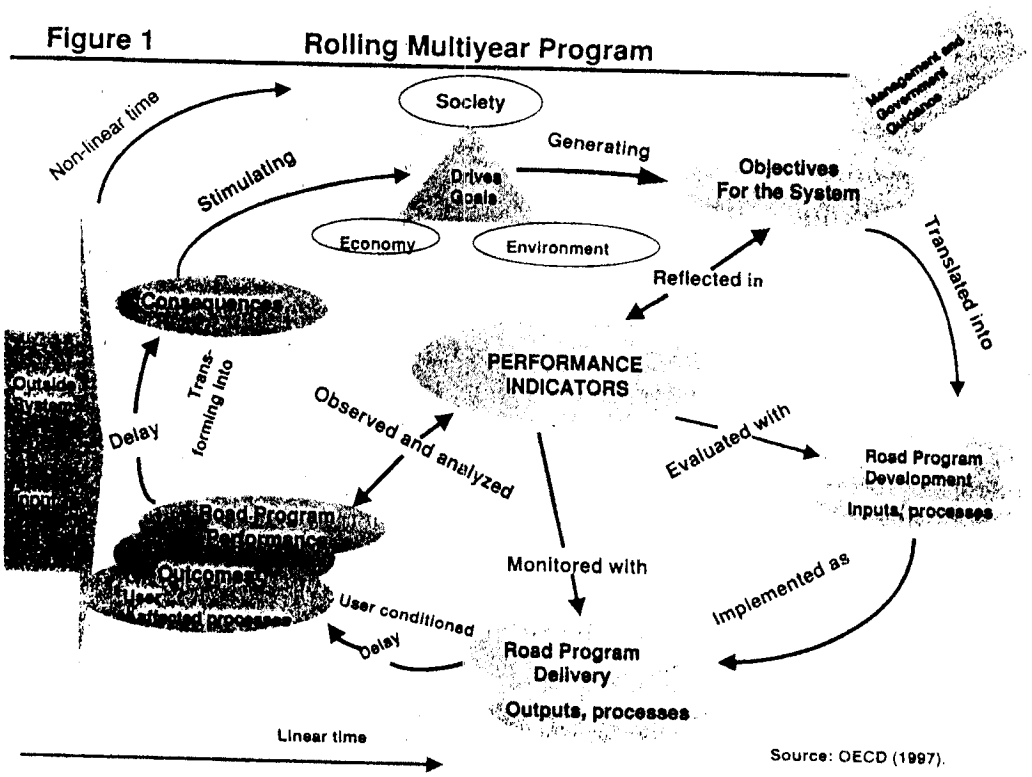
Q4. Compare and contrast the development of Regional Planning in the United States of America and Britain.

Q5. Discuss the importance of modelling in the planning process.

Q6. Discuss the operationalisation of the Rolling Multiyear program in Figure 1.

END OF EXAMINATION

Figure 1 Rolling Multiyear Program



Source: OECD (1997).

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - MAY 2000

GEO 932

URBAN GEOGRAPHY

TIME: THREE HOURS
ANSWER: QUESTION ONE AND ANY OTHER THREE
NOTE: All questions carry equal marks. The use of any approved atlas is allowed.

Q1. Write short explanatory notes on ALL of the folowing:

a) Graph Theory in Urban Geography
b) Rank-Size rule
c) Urban Base Theory
d) Ravenstein's Laws of Migration
e) Oscar Lewis' Culture of Poverty

Q2. 'The economic structure of most third world cities is characterised by a specific combination of formal and informal economic characteristics'. Discuss.

Q3. To what extent are 'Colonial' and 'apartheid' cities merely variants of their counterparts in Capitalist Countries?

Q4. Compare and contrast the genetic growth of the Urban systems in the United States and in Sub-Saharan Africa.

Q5. 'Urban planning is best defined as a form of State intervention in a development process dominated by the private sector'. Discuss.

Q6. Discuss Burgess' 'Concentric Zone Theory' outling the major criticisms and modifications.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS -MAY 2000

GEO 952

GEOGRAPHICAL HYDROLOGY

TIME: THREE HOURS

ANSWER: Question One and any other three

NOTE: All questions carry equal marks. Candidates are encouraged to use illustrations wherever approriate.
Use of calculator is allowed.

Q1. Write short explanatory notes on ALL of the following:

a) Stochastic process
b) Variable source area concept
c) Conditions necessay for precipitation to occur
d) Coefficient of transmissibility
e) Importance of flow nets in studying groundwater movement

Q2. Discuss the functions of the soil-plant-atmosphere-water system (SPAW) and sources of some variations in models used for estimating soil moisture.

Q3. Compare and contrast merits and demerits of using surface water over groundwater for domestic and industrial purposes.

Q4. Discuss the importance of soil moist ure and describe the different techniques for its measurement.

Q5. 'Zambia experiences problems of water supplies in the midst of plenty'. Discuss this assertion paying particular attention to possible solutions.

Q6. Discuss the development of hydrology pointing out the major achievements which led to its present status as an academic discipline.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – MAY 2000

GEO 962

BIOGEOGRAPHY

TIME: THREE HOURS.

ANSWER: ANY FOUR QUESTIONS.

NOTE: YOU ARE ENCOURAGED TO USE MAPS AND DIAGRAMS WHEREVER THEY HELP TO ILLUSTRATE YOUR ANSWER. THE USE OF AN APPROVED ATLAS IS ALLOWED

Q1. Write short explanatory notes on all of the following:

a) Species range
b) Ecological niche
c) Competition
d) Dispersal
e) Migration

Q2. With reference to the theory of Island Biogeography, explain the various factors that affect species diversity on islands.

Q3. Discuss the factors controlling the productivity, abundance and distribution of plants and animals across the surface of the earth.

Q4. Outline and discuss the causes of species extinction in the world today.

Q5. Outline and explain the scales and types of distribution of species population.

Q6. Outline and discuss the major human processes associated with ecosystem modification and then comment on their consequences.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – MAY 2000

GEO 972

SATELLITE REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS

TIME: THREE HOURS.

ANSWER: ANY FOUR QUESTIONS.

NOTE: ALL QUESTIONS CARRY EQUAL MARKS.

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

   a) Temporal resolution
   b) Band Sequential (BSQ) format
   c) Satellite image characteristics
   d) Atmospheric correction
   e) The different ways you can input data into a GIS.

2. Make a comparison between the Landsat Thematic Mapper and SPOT, on the basis of the following properties:

   a) Ground swath width
   b) Spatial resolution
   c) Spectral resolution
   d) Radiometric resolution and
   e) Scanning mechanism.

3. Explain the geometric corrections that may be made if a satellite image scene is going to be used as an overlay to an existing topographic map.

4. At BOTH the Forestry Department and Lusaka City Council (LCC), to what extent can the establishment of GIS units ease operations? Explain your answer with reference to data types, analyses to be undertaken and GIS products.

5. Suppose you had SPOT image bands XS1, XS2 and XS3 covering Lusaka and acquired concurrently. Suppose also that you wanted to map vegetated, built up and bare land using the given satellite image data. Answer the following questions:

   a) How would you enhance the interpretability of the satellite image data given?
   b) Given a false colour composite image created using the enhanced image band data (rgb = 321), how would you classify the image so that the required land cover types are delineated?

6. For any TWO of the following natural resources, discuss the potentials and limitations of using remote sensing and GIS technology in resource assessment and management:

   a) Wildlife
   b) Soil
   c) Water.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - MAY 2000

GEO 975

CARTOGRAPHY

TIME: THREE HOURS
ANSWER: ANY FOUR QUESTIONS
NOTE: ALL QUESTIONS CARRY EQUAL MARKS
CANDIDATES SHOULD USE DIAGRAMS AND EXAMPLES WHEREVER RELEVANT. USE OF AN APPROVED ATLAS IS ALLOWED.

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

   a) Tactile Cartography
   b) Cartograms
   c) Semantic accuracy
   d) Functions of map lettering
   e) Hypsometric colouring

2. What grid system is used for the Zambian topographic map series and explain the basic principles of this position determination.

3. What factors would influence the choice of type for maps?

4. To what extent is colour in cartography worth all the effort and expense involved.

5. Explain the ways in which various point, linear and areal features of any geographic area may be illustrated on a monochrome map.

6. Explain the circumstances under which generalization in map making is undertaken and how it is achieved.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - MAY 2000

GEO 995

ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT I

TIME: Three Hours
ANSWER: Any four questions
NOTE: All questions carry equal marks
The use of calculators and approved atlas is allowed.

Q1. Given the following hypothetical statistics about a plot with Calliandra calothyrsus - a leguminous tree species:

- Population of adult trees in 1999 (N_t)	=	122
- Average number of seeds produced per stand (f)	=	160
- Germination percentage of seeds (g)	=	68
- Survival rate (%) in the field (e)	=	70

a) Show the life table of Calliandra calothyrsus for one life cycle.
b) Calculate the number of trees that will be in the field after a period of one life cycle.
c) Compare the life table you have just used for Calliandra calothyrsus with the simple algebraic equation which describes population change between two points in time:

$$N_{t+1} = N_t + B - D + I - E$$

Q2. Discuss the development of pest resurgency and suggest how this can be prevented.

Q3. What are the socio-economic advantages of biotechnology development and precautions that should be taken to avoid any ecological problems of this development.

Q4. Discuss ecological advantages and disadvantages of the use of agroforestry in land use in the tropical regions.

Q5. Using one example of a marine ecosystem, explain how it functions, its importance, the problems faced with its use and management options for its sustainable use.

Q6. Discuss the factors for the introduction and spread of exotic weeds in Southern and Central Africa.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS
DEFERRED /SUPPLEMENTARY EXAMINATIONS

DISTANCE EDUCATION

SEPTEMBER 2000

M111 - MATHEMATICAL METHODS 1

INSTRUCTIONS : Answer *any* **five** (5) questions.

All questions carry **equal** marks.

Use of **calculators** and **tables** is not allowed.

Write the number of questions attempted on the main answer book.

TIME ALLOWED : **Three** (3) hours.

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1. a). The rational function $f(x) = \dfrac{x+2}{x^3 - 9x}$

i. Find the zeros of f .
ii. Find the domain of f .

b). Rationalize the following in the simplest form :

i $\dfrac{1}{\sqrt{a} - \sqrt{b}}$ ii. $\dfrac{1}{2+\sqrt{3}} + \dfrac{2}{2-\sqrt{3}}$

c) . Solve for x given that :

i. $\sqrt{2x+5} - \sqrt{x-1} = 2$ ii. $2^{2x+1} - 2^x + 1 = 2^{x+1}$

2a). Solve for x and y given that :

i. $\frac{x}{1-i} + \frac{y}{1+3i} = 2$ ii. $\frac{x}{3-2i} + \frac{iy}{2+i} = \frac{2}{1+8i}$

b). A function f is defined on the set of reals by $f(x) = x^2 - 2x$.

i. Explain why $f^{-1}(x)$ does not exist.

ii. Suggest a restricted domain for which $f^{-1}(x)$ does exist.

c). Find the range of values of x which satisfy the inequality :

i. $\frac{3x}{x+1} < 2$ ii. $|x+1| < 2|x-1|$

---

3 a). Find the range of values of k for which the function $f(x) = kx^2 - 2x + (3x - 2)$ is always positive.

b). The function $f(x) = \frac{a}{x} + b$ is such that $f(-1) = \frac{3}{2}$ and $f(2) = 9$.

i State the value of x for which f does not exist.

ii Find the value of a and b .

iii. Evaluate $f^{-1}(3)$.

c). The quadratic function f is given by $f : 5x - 3x^2 - 3, x \in \Re$.

i. Find the values of A ,B and C in the identity
$5x - 3x^2 - 3 = -A(x + B)^2 + C$

ii. Sketch the graph of f.

4 a). i. One root of the of the equation

$6x^2 + 7x + k = 0$ is $-\frac{1}{2}$. Find the other root and the value of k.

ii If $x^2 - bx + q$ and $x^2 + px + s$ have a common factor of $x - k$.

Show that $k = \frac{q - s}{b + p}$.

b). The polynomial $p(x) = 2x^4 + ax^2 + bx - 60$ gives a remainder of -94 when divided by $x - 1$. One factor of the polynomial $x+2$.
Find the values of a and b.

c). Given that $f(x) = px + q$, $g(x) = 8 - x$ and $h(x) = \frac{1}{5x}$.

i. Find conditions on p and q such that $(fog)(x) = (gof)(x)$

ii. Show that each of the functions g and h is its own inverse.

iii. Determine whether $(goh)(x)$ is even , odd or neither.

5a). i. Show that $(\cot\theta + \text{Coesc}\theta)^2 = \frac{1 + \cos\theta}{1 - \cos\theta}$

ii Prove that $\frac{\cos\theta}{1 - \tan\theta} - \frac{\sin\theta}{1 - \cot\theta} = \sin\theta + \cos\theta$.

b). Solve each of the following for $0^\circ \le x \le 360^\circ$:

i. $\cos^2 x + \sin x - 1 = 0$

ii. $\sec^2 x = \tan x + 1$

6a) Evaluate the following :

i. $\lim_{x \to 2} \frac{x^2 - 6x + 8}{x^2 - 4}$

ii $\lim_{x \to +\infty} \frac{6x^3 - 3x^2 + 7}{11x^3 + 5x^2 - 1}$

b). Given that $f(x) = \begin{cases} x^2 & \text{if } x > 0 \\ x & \text{if } x \leq 0 \end{cases}$

i. Determine whether f is continuous at $x = 0$.

ii. Sketch $f(x)$.

7a). Find $\frac{dy}{dx}$ of the following :

i. $y = \ln(2x + 4)^3$ ii. $y = x^4\sqrt{1 + x^5}$ iii. $y = xe^{ax}$

b). i. If $y = Ae^{ax}$, show that $\frac{dy}{dx} = Ay$.

ii. If $x^p y^q = 4$, show that $\frac{dy}{dx} = -\frac{py}{qx}$.

c). Show that there are no points of inflexion in the curve $y = x^4 - 4x^3 + 6x^2 - 4x$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS

DISTANCE EDUCATION

JULY 2000

M 112 - MATHEMATICAL METHODS II

INSTRUCTIONS : Answer *any* **five** (5) questions.

All questions carry **equal** marks.

Use of **calculators and tables** is not allowed.

Write the number of questions attempted on the main answer book.

TIME ALLOWED : **Three** (3) hours.

---

1 a). Prove by mathematical induction that for all positive integers n ,

$$1+2+3+4+5+\ldots\ldots\ldots+n=\frac{n(n+1)}{2}.$$

b). Find the coefficient of the term free of x in the expansion of

$$\left(x+\frac{1}{x^2}\right)^9.$$

c). Find the first four terms in the expansion of $(1+x)^{-1}$.

Use above expansion to approximate $\frac{1}{0.9}$ to three decimal places.

2 a). The vectors $\underline{a}$ and $\underline{b}$ are given by $\underline{a} = 2i + j - k$, $\underline{b} = i - j + 2k$.

i. Find a unit vector perpendicular to the vectors $\underline{a}$ and $\underline{b}$.
ii. Find the angle θ between $\underline{a}$ and $\underline{b}$.

b). The points A, B and C are given by $A(0, -1, 0)$, $B(\frac{1}{2}, 0, \frac{1}{2})$ and $C(1, 1, 1)$ respectively.
Show that the points A, B and C are collinear.

c). The circles A and B are given by:
$A: x^2 + y^2 - 6x - 12y + 40 = 0$, $B: x^2 + y^2 - 4y - 16 = 0$.

i. Find the centre and radius of each of the circles.
ii. Show that the two circles are orthogonal.

---

3 a). Given the matrices

$$A = \begin{pmatrix} 1 & 0 & 3 \\ 3 & 4 & 9 \\ 2 & 5 & 6 \end{pmatrix} \quad \text{and} \quad B = \begin{pmatrix} 1 & k & 2 \\ 3 & 2 & 1 \\ k & 4 & 2 \end{pmatrix}.$$

i. Show that matrix A is singular.
ii. Find the real values of k for, which B is invertible.

b). Let A be a matrix given by $A = \begin{pmatrix} 1 & -1 & 2 \\ 2 & 0 & -1 \\ 1 & 1 & 1 \end{pmatrix}$.

i. Find A^{-1}.
ii. Hence or otherwise , solve the system of equations

$$\begin{aligned} x - y + 2z &= 1 \\ 2x - z &= 2 \\ x + y + z &= 3 \end{aligned}$$

4 α). Given two complex numbers $z_1 = 1 + i$ and $z_2 = -1 + i$.

a). Express in the form $x + iy$: i. $z_1 z_2$ ii. $\frac{z_1}{z_2}$.

b). Express z_2 in the form $r(\cos\theta + i\sin\theta)$. Hence evaluate $(z_2)^{10}$.

β). Find the four **fourth** roots of 1. Illustrate them geometrically in the XOY plane.

---

5 a). Find $\frac{dy}{dx}$ for each of the following :

i. $y = (ax + b)^n$ where a, b and n are constants.

ii. $y = \ln(4x + 7)^{10}$.

iii. $y = 16t^2 + 1$, $t = 2x^3 + 1$

b). Let $y = \frac{x}{\sqrt{1 + x^2}}$. Find i. $\frac{dy}{dx}$ and ii. $\frac{d^2y}{dx^2}$.

Hence find the value of $(1 + x^2)\frac{d^2y}{dx^2} + 3x\frac{dy}{dx}$.

c). Calculate the approximate percentage change in y caused by a 5% change in x when $y = \sqrt{x}$.

Hence find the approximate value of $\sqrt{16.05}$.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

MATHEMATICS M114

INSTRUCTIONS:
(i) Attempt ***five (5)*** questions only.
(ii) Show all ***essential working*** clearly.
(iii) Indicate the ***number*** of each question attempted in the first column on your main answer book.
(iv) No calculators or tables are to be used.

TIME ALLOWED: Three (3) Hours.

---

1. (a) Prove, ***by mathematical induction***, that for all positive integers n,

$$(2\times 2)+(3\times 2^2)+\ldots+((n+1)\times 2^n)=n\times 2^{n+1}.$$

(b) Find the ***term independent of x*** in the expansion of $\left(2x^3-\frac{1}{x}\right)^{20}$.

(c) Write down the ***first four*** terms in the expansion of $(x^2+1)^{\frac{1}{2}}$, and state the ***range of values of x*** for which the expansion is valid.
Hence, by taking an appropriate value of x, ***evaluate*** $\sqrt{26}$, leaving your answer as a fraction.

2. (a) Find ***two equations*** of the ***circle*** having radius $\sqrt{13}$ and tangent to the line $2x-3y+1=0$ at (1,1).

(b) ***Identify*** the conic

$$9x^2-16y^2-18x+64y=199,$$

and state its ***centre***, ***vertex(vertices)***, ***focus(foci)*** and ***eccentricity***.
Hence, find the equation(s) of its ***directrix(directrices)***.

3. (a) The vectors $\underline{u}$ and $\underline{v}$ are given by

$$\underline{u} = 5i - 4j + sk, \qquad \underline{v} = 2i + tj - 3k.$$

(i) Given that the vectors $\underline{u}$ and $\underline{v}$ are *perpendicular*, find a relation between the scalars s and t.

(ii) Given instead that the vectors $\underline{u}$ and $\underline{v}$ are *parallel*, find the values of the scalars s and t.

(b) Find a ***unit vector*** which is ***perpendicular*** to the plane containing the points
A(3,−1,4), B(2,−2,1) and C(5,1,3) at A.

(c) Use ***Cramer's rule*** to solve, for x, y and z, of the system of equations

$$2x + 6y + z = 0$$
$$-x + 2y - z = 10$$
$$4x + 3y + z = 1.$$

4. (a) If $z = 3 - 4i$, express z^2 and $\frac{1}{z}$ in the form $a + ib$ where a and b are real.

If $w^2 = z$, express the values of w in the form $a + ib$.

(b) Express the complex number $z = \frac{8}{\sqrt{2}}(1+i)$ in the form $r(\cos\theta + i\sin\theta)$

and hence show that the three values of $z^{\frac{2}{3}}$ are $2(\sqrt{3}+i)$, $-4i$ and $2(-\sqrt{3}+i)$.

5. (a) Solve the equation

$$2\cosh x + \sinh x = 2.$$

(b) Prove that

$$\arctan x - \arctan y \equiv \arctan\frac{x-y}{1+xy}.$$

(c) Express $\cos 2\theta - \sin 2\theta$ in the form $R\cos(2\theta + \alpha)$, giving values of R and α.
Hence find the ***general solution*** of the equation

$$\cos 2\theta - \sin 2\theta = 1.$$

6. (a) Differentiate with respect to x:

(i) $x^2 \cosh 3x$

(ii) $\tan^{-1}(x^2)$

(iii) $x^y = \sin x$.

(b) Write down the ***equation*** of the ***tangent*** at $(1, \frac{1}{3})$ to the curve whose equation is

$$2x^2 + 3y^2 - 3x + 2y = 0.$$

(c) The power, W watts, consumed by an electrical appliance is given by

$$W = \frac{2R}{(R+9)^2},$$

where R is the resistance of the appliance in ohms. Use differentiation to estimate the ***increase*** in W, when R is increased by 0.1 when R = 3.

7. (a) Evaluate the integrals:

(i) $\int \frac{5x^2}{(1+x^3)^2} dx$

(ii) $\int xe^{2x} dx$.

(b) Find the ***area***, in the first quadrant, bounded by the ***y - axis*** and the curve $x^2 = y(4-y)^2$.

(c) Show that $\frac{d}{dx}(\sin^{-1} x) = \frac{1}{\sqrt{1-x^2}}$.

Hence or otherwise, find the ***particular solution*** of the differentiation equation

$$\frac{dy}{dx} = x\sqrt{1-y^2},$$

given that y = 1 when $x = \frac{\pi}{6}$.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M162 - Introduction to Mathematics, Probability and Statistics II.

INSTRUCTIONS: There are TWO sections in this question paper. Candidates are asked to answer at least two(2) questions from each section. Candidates must answer a total of five(5) questions. Tables will be provided but use of calculators is not allowed.

TIME ALLOWED: Three (3) Hours.

SECTION A

1. a) Evaluate:

i) $\lim_{h \to o} \frac{(2+h)^2 - 4}{h}$

ii) $\lim_{h \to \infty} \frac{\sqrt{4h+3} + 2\sqrt{1+h}}{\sqrt{h}}$

b) Let f be a function given by

$$f(x) = \begin{cases} 2x+1 & x < 0 \\ -x+3 & x \geq 0 \end{cases}$$

i) Evaluate $\lim_{x \to o} f(x)$

ii) Sketch f(x)

c) Differentiate $y = \frac{1}{x}$ from first principles. Hence find the equation of the tangent at the point P(-1,1).

2. a) The gradient of a curve at the point P(x,y) is $3x^2 - 4x + 1$ and that the curve passes through the point (2,3).

i) Find the equation of the curve.

ii) Find the equation of the tangent line at the point A(-1, -3).

b) Find $\frac{dy}{dx}$ of the following:

i) $y = (ax^2 + b)^n$ where a,b and n are constants.

ii) $y = \ln(3x - 1)^4$

iii) $y = xe^{\sin x}$

c) Find $\frac{dy}{dx}$ of the following:

i) $x^2y^3 - 2xy^2 + 3y = 0$
at the point (1,2)

ii) $y = 16t^2 + 1,\ t = 2x^3 + 1$

3. a) The equation of the curve is given by

$y = x^3 - 6x^2$.

i) Find the x and y intercepts.

ii) Find the minimum, maximum and inflexion points.

iii) Sketch the curve of y.

b) Calculate the approximate percentage change in y caused by a 3% change in x when $y = \sqrt{x}$. Hence find the approximate value of $\sqrt{9.03}$.

4. a) Find the following integrals:

i) $\int\left(x^3+4x-\frac{1}{x}\right)dx.$

ii) $\int xe^x dx$

b) A marginal sales function is given by

$MS = x\sqrt{x^2+16}$, where x is the member of items sold.

i) Find the total sales function.

ii) Find the sales of production of three items.

c) Suppose a company's marginal cost, marginal revenue and marginal profit are given in thousands of kwacha in terms of the number x of units produced as

$c'(x) = 1$
$R'(x) = 12 - 2x,\ 0 \leq x \leq 12$
$P'(x) = R'(x) - c'(x).$

If production changes from 3 units to 6 units, find:

i) the change in revenue
ii) the change in profit.

5. a) Given $y = \frac{1}{x^2-4}$.

i) Express y in the form

$$\frac{A}{x+2}+\frac{B}{x-2}$$

where the constants A and B are to be found.

ii) Hence evaluate $\int_3^4 y\,dx$.

b) Evaluate the following integrals:

i) $\int_1^2 \frac{4x+8}{x^2+4x+3}\,dx$ ii) $\int_1^3 \ln x\,dx$.

c) Find the total area of the region bounded by the curves $y = 4 - x^2$ and $y = 3x^2$.

SECTION B

6. a) Park officials want to understand the use of a city park. One evening the officials interviewed 36 people and recorded their ages as shown below:

i) Summarize the resulting data in a grouped frequency distribution with seven intervals starting with class 4.5 - 15.5

ii) Using the frequency distribution table, calculate the modal class and the median class

7	18	35	73	18	28
15	19	41	61	16	24
51	65	12	65	61	26
16	62	14	73	72	48
17	59	16	62	43	68
21	16	17	19	32	72.

b) A fair coin is tossed three times. Let X be the number of heads that can appear on the three tosses.

i) Write down the probability distribution for this experiment.

ii) Using the probability distribution, calculate E(X).

c) Represent the following data in:

i) a histogram (ii) a cummulative frequency curve.

x	10	20	30	40	50
f	4	6	8	4	3

7. a) Define the following terms:

i) A and B are independent events.

ii) A and B are mutually exclusive events

b) If $P(A \cup B) = .7$ $P(A^c) = .9$

find P(B) if

i) A and B are independent events

ii) A and B are mutually exclusive events.

c) A machine is composed of 2 components X and Y, which function (or fail) independently. The machine works only if both components work. It is known that component X is 98% reliable and the machine is 95% reliable. How reliable is component Y?

d) A certain club is to select a chairman, a vice-chairman, a secretary and a treasurer from six members who qualify. How many ways may the office bearers be selected?

8. a) Let A and B be events with $P(A) = 1/3$, $P(B) = 1/4$ and $P(A \cap B) = 1/6$.

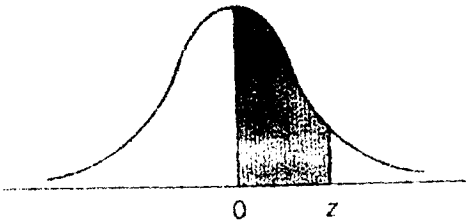
Find: (i) $P(A|B)$ (ii) $P(A \cap B^c)$

b) In its training program, a company has a drop out rate of 0.20. If eight trainees start the program, what is the probability that no one will fail the program?

c) The grades on a certain test are known to be normally distributed with mean 74 and standard deviation 8. What is the probability that a student will make less than 58 on this test?

END OF EXAMINATION.

URVE AREAS



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Source: Abridged from Table I of A. Hald, *Statistical Tables and Formulas* (New York: John Wiley & Sons, Inc.) 1952. Reproduced by permission of A. Hald and the publisher.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JULY 2000

M211 MATHEMATICAL METHODS III

(DISTANCE EDUCATION)

INSTRUCTIONS: Attempt **five (5)** questions only.

TIME ALLOWED: **Three (3)** hours.

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1. Identify the given conic section

$$x^2 + 2xy + y^2 + 6x - 6y = 0,$$

stating the vertex(vertices), focus(foci) and directrix(directrices).

2. (a) Discuss the graph of the curve

$$r = \frac{5}{2 - 3\cos\theta}.$$

Hence sketch the curve.

(b) The orbit of Halley's comet is an ellipse with the sun at one focus. In terms of astronomical units (AU), the major and minor semi axes of this elliptical orbit are 18.09 AU and 4.56 AU, respectively.

(i) What are the maximum and minimum distances from the sun to Halley's comet?

(ii) State the eccentricity for the comet's orbit.

3. (a) Show that the function f defined by

$$f(x) = x^{1/2} - x^{3/2}$$

on [0,1] satisfies the hypothesis of Rolle's theorem on the interval.
Hence find a number c that satisfies the conclusion of the theorem.

(b) State the theorem of the mean without proof.

Hence use it with the function $f(x) = \sqrt[6]{x}$ on the interval [64,65] to approximate the value of $\sqrt[6]{65}$.

4. (a) Evaluate the limits:

(i) $\lim_{x \to 3} \dfrac{x^2 + 2x - 15}{x^2 - 5x + 6}$

(ii) $\lim_{x \to 1^+} x^{\frac{1}{x-1}}$.

(b) Find the equation of the circle of curvature at the point (0,1), of the curve

$$y = 2x^2 + 1$$

5. Evaluate the integrals:

(a) $\int x^3 \ln x dx$

(b) $\int \dfrac{x^2}{\sqrt{4 - x^2}} dx$

(c) $\int \dfrac{1}{2 + \cos\theta} d\theta$.

6. (a) Given $I_n = \int_0^{\pi} \sin^{2n} x dx$, $I_{n-1} = \int_0^{\pi} \sin^{2(n-1)} x dx$, etc, $n \in \mathbb{N}$,

(i) calculate I_0 in terms of π

(ii) show that $I_n = \frac{(2n-1)}{2n} I_{n-1}$, $n \geq 1$

(iii) find I_3 in terms of π.

(b) Find the length of the curve

$$y = \frac{1}{6}x^3 + \frac{1}{2x}, \quad 1 \leq x \leq 2.$$

7. (a) Find the unknown coefficients a_0, a_1, a_3, a_4, and a_4 given that

$$\int x^4 e^{3x} dx = e^{3x}(a_0 x^4 + a_1 x^3 + a_2 x^2 + a_3 x + a_4) + c.$$

(b) Use Maclaurin's theorem to show that if x^5 and high powers of x neglected,

$$\ln\{x + \sqrt{1+x^2}\} = x - \frac{1}{6}x^3.$$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JULY 2000

M212 MATHEMATICAL METHODS IV

(DISTANCE EDUCATION)

INSTRUCTIONS: Answer **five (5)** questions only.

TIME ALLOWED: Three **(3)** hours.

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1. A point P on the parabola $(x-a)^2 = 4ay$ has coordinates

$$x = a + 2at, \quad y = at^2.$$

(a) Find the equation of the tangent and the normal to the parabola at P.

(b) If the tangent and the normal cut the x-axis at the points T and N respectively, prove that

$$\frac{PT^2}{TN} = at.$$

(c) Find the coordinates of the point Q in which the normal at P intersects the parabola again.

2. (a) Find the cosine of the angle between the two planes $x - 2y + 3z = 5$ and $5x + 8y + 6z = 4$.

(b) Find the area of the triangle with vertices P(1,3,-2), Q(2,1,4) and R(-3,1,6).

(c) Find the symmetric equations of a straight line through the point (3,-1,2) that is perpendicular to the plane $x - 2y + 3z = 5$.

3. Given the space curve

$$\bar{R} = e^{t}i + \sqrt{2}tj + e^{-t}k,$$

find, at t =1,

(a) the vector $\bar{T}$, tangent to the curve

(b) the unit vector $\bar{N}$ perpendicular to $\bar{T}$, and

(c) the curvature κ for the curve.

4. (a) Given that $z = \ln(x^2 + y)$, $x = \cos\theta$, $y = \sin\theta$, find $\frac{dz}{d\theta}$ when $\theta = \frac{\pi}{2}$.

(b) Prove that if $z = f(u, v)$ when $u = x + \lambda y$ and $v = x - \lambda y$, then

$$\left(\frac{\partial z}{\partial u}\right)^2 - \left(\frac{\partial z}{\partial v}\right)^2 = \frac{1}{\lambda}\frac{\partial z}{\partial x}\frac{\partial z}{\partial y}.$$

(c) For the formula $R = \frac{E}{C}$, find that maximum error and percentage error when C = 20 with a positive error of 0.1 and E = 120 with a positive error of 0.05.

5. (a) A rectangular metal tank with open top is to hold 256 cubic feet of liquid. Find the dimensions of the tank that requires the least material to build.

(b) (i) Find the total differential of the function $f(x, y) = \frac{x}{y}$.

Hence,

(ii) estimate the number $\frac{3.01}{5.99}$.

6. (a) By making a substitution $y = vx$ or otherwise, solve the differential equation

$$(9x - y)dx + (x - y)dy = 0.$$

(b) Prove that the differential equation is exact and find its general solution:

$$(3x^2y^2 + 2xy^4)dx + (2x^3y + 4x^2y^3 + 1)dy = 0.$$

7. (a) Find the solution to the following initial value problems:

$$\frac{dy}{dx} + 2xy = 4x; \quad y = 3 \text{ when } x = 0.$$

(b) The electric current in a certain circuit is given by

$$\frac{d^2I}{dt^2} + 4\frac{dI}{dt} + 2504I = 110,$$

$I = 0$ and $\frac{dI}{dt} = 0$ when time $t = 0$. Find the current I in terms of t.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M222 LINEAR ALGEBRA II

INSTRUCTIONS: Attempt ANY five (5) questions.

TIME ALLOWED: Three (3) Hours.

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1. Let V and W be vector spaces over a field K. What is the meaning of the following terms:

   (i) a *linear transformation* T from V into W?
   (ii) an *isomorphism* from V into W?

   (a) (i) Let θ be any angle and define the function

   $$T_\theta: \boldsymbol{R}^2 \rightarrow \boldsymbol{R}^2$$

   by

   $$T_\theta(x,y) = (xCos\theta - ySin\theta, xSin\theta + yCos\theta).$$

   Then, show that T_θ is a linear transformation on $\boldsymbol{R}^2$.

   (ii) Let V and W be vector spaces over K and $T: V \rightarrow W$ be a linear transformation. Then, prove that the Null space $N(T)$ of T is a subspace of V and that the Range $R(T)$ of T is a subspace of W.

   (b) (i) Let $T: V \rightarrow W$ be a linear transformation, where V and W are finite-dimensional vector spaces over a field K. Prove that if T is invertible, then $dim(V) = dim(W)$.

   (ii) Let $T: \boldsymbol{R}^2 \rightarrow P_1(\boldsymbol{R})$ be a linear transformation defined by

   $$T(a,b) = a + bx.$$

   Then, show that T is an isomorphism; so that $\boldsymbol{R}^2$ is isomorphic to $P_1(\boldsymbol{R})$.

---

2. Define the following terms:

   (i) the *rank* of a linear transformation $T: V \rightarrow V$;
   (ii) a *non-singular* linear operator.

(a) Determine whether the linear operator T on $V_3(\boldsymbol{R})$ given by

$$T(x,y,z) = (2x + z, -x + 4y + 5z, x + y)$$

is non-singular, and hence, determine <u>*rank(T)*</u>, the rank of T.

(b) The matrix of a linear operator on $V_3(\boldsymbol{R})$ relative to the standard ordered ***R-basis*** for $V_3(\boldsymbol{R})$ is given by

$$\begin{pmatrix} 2 & 1 & -1 \\ 1 & -1 & 1 \\ 1 & 2 & -2 \end{pmatrix}.$$

Find the *rank(T)* and *nullity(T)*, the rank of T and nullity of T, respectively.
Hence, deduce whether or not the homogeneous system of equations

$$\begin{aligned} 2x + y - z &= 0 \\ x - y + z &= 0 \\ x + 2y - 2z &= 0 \end{aligned}$$

has a non-trivial solution.

(c) Let V and W be vector spaces over a field K, and let $T: V \rightarrow W$ be linear and non-singular. Then, prove that $T^{-1}: W \rightarrow V$ is a linear transformation.

---

3. What is meant by each of the following:

(i) an <u>*eigen vector*</u> of a linear operator T?
(ii) a square matrix B is <u>*diagonalizable*</u>?

(a) Let T be the linear operator on $P_2(\boldsymbol{R})$ defined by

$$T(f(x)) = f(x) + (x+1)f'(x)$$

Determine the eigenvalues of T and the corresponding eigenvectors.

(b) Use the Cayley-Hamilton Theorem to compute the inverse of A for

$$A = \begin{pmatrix} 2 & -1 \\ 1 & 1 \end{pmatrix}.$$

4. Let V be a vector space over a field K. What is meant by the following terms?

(i) an *inner product* on V;

(ii) the *orthogonal complement* W of a subset $W^{\perp}$ of V.

(a) Show that

$$\langle u,v \rangle = x_1y_1 + x_2y_2 - x_1y_2 - x_2y_1 + 2x_3y_3$$

defines an inner product on $V_3(\mathbf{R})$, where $u=(x_1,x_2,x_3)$ and $v=(y_1, y_2,y_3)$.

(b) Let W be a subspace of $V_5(\mathbf{R})$ spanned by

$$u = (1,2,3,-1,2) \text{ and } v = (2,4,7,2,-1).$$

Find a basis for the orthogonal complement $W^{\perp}$ of W.

(c) Use the Gram-Schmidt orthogonalization procedure to obtain an *orthonormal basis* for $V_3(\mathbf{R})$, given that the vectors $v_1 = (1,1,0)$, $v_2 = (2,0,1)$ and $v_3 = (2,2,1)$, span $V_3(\mathbf{R})$.

---

5. Define the following terms:

(i) a *bilinear form* on a vector space V over a field K;

(ii) the *matrix representation* of a bilinear form H.

(a) Let $H:\mathbf{R}^2 \times \mathbf{R}^2 \rightarrow \mathbf{R}$ be a function defined by

$$H\left(\begin{pmatrix}a_1\\a_2\end{pmatrix},\begin{pmatrix}b_1\\b_2\end{pmatrix}\right) = 2a_1b_1 + 3a_1b_2 + 4a_2b_1 - a_2b_2$$

for $\begin{pmatrix}a_1\\a_2\end{pmatrix},\begin{pmatrix}b_1\\b_2\end{pmatrix} \in \mathbf{R}^2$.

Show that H as defined is a bilinear form on $\mathbf{R}^2$.

(b) Let H be as in (a) above.

(i) Find the matrices A and B of H in the basis

$\{u_1 = (1,0), \quad u_2 = (1;1)\}$ and

$\{v_1 = (2,1), v_2 = (1-1)\}$, respectively.

(ii) Find the transition matrix P from the basis $\{u_i\}$ to the basis $\{v_i\}$ and verify that $B = P^tAP$, where P^t is the transpose of P.

---

6. What is meant by the term:

a *quadratic form* on a *K-space V*?

Let $\boldsymbol{S}$ be the surface in $\boldsymbol{R^3}$ defined by the equation

$$2t_1^2 + 6t_1t_2 + 5t_2^2 - 2t_2t_3 + 2t_3^2 + 3t_1 - 2t_2 - t_3 + 14 = 0.$$

(i) Find an orthonormal basis γ for $\boldsymbol{R^3}$ such that the equation relating the coordinates of points of $\boldsymbol{S}$ relative to γ is simplified.

(ii) Describe $\boldsymbol{S}$ geometrically.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M232 - Real Analysis II

INSTRUCTIONS: Answer any five (5) questions.

TIME ALLOWED: Three (3) Hours.

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1. a) (i) Let $0 < a_n \leq c_n$ for every $n \geq m$ where $m \in N$.

If $\sum_{n=1}^{\infty} c_n$ converges, then prove that $\sum_{n=1}^{\infty} a_n$ converges.

(ii) Let $0 < d_n \leq a_n$ for every $n \geq m$. If the series

$\sum_{n=1}^{\infty} d_n$ is divergent, then prove that $\sum_{n=1}^{\infty} a_n$ is divergent.

b) Prove that

$$\frac{1}{1.2.3} + \frac{3}{2.3.4} + \frac{5}{3.4.5.} + \ldots$$

is convergent.

2. a) (i) Prove that $\sum_{n=1}^{\infty} \frac{1}{n^p}$ converges if $p > 1$ and diverges if $p \leq 1$.

(ii) Prove that if $p > 1$, the series

$\sum_{n=2}^{\infty} \frac{1}{n(\log n)^p}$ converges and if $p \leq 1$, the series diverges

b) Prove that the series

$$\sum_{n=1}^{\infty}(-1)^n\left[\sqrt{n^2+1}-n\right]$$

is conditionally convergent.

3. a) Examine the convergence of the following series

(i) $\sum_{n=1}^{\infty} n(n+1)x^n$

(ii) $\frac{x}{1.2}+\frac{x^2}{2.3}+\frac{x^3}{3.4}+\ldots.$

b) Prove that the series

$$\sum_{k=1}^{\infty}\frac{1}{k^p}\sin kx$$

converges uniformly if $p > 1$.

4. a) (i) Prove that if $\lim_{x\to a} f(x) = L$ and $\lim_{x\to a} f(x) = M$,

then $L = M$.

(ii) Prove that if $\lim_{x\to a} f(x) = L > 0$, then there exists a $\delta > 0$ such that $f(x) > 0$ for $0 < |x - a| < \delta$.

b) Prove that a function f(x) approaches the limit L as x approaches a if and only if both the right hand limit and left hand limit exist and are equal to L.

5. a) Using the definition of limit prove that

$$\lim_{x \to a} \sqrt{x} = \sqrt{a} \quad \text{for } a > 0$$

b) Prove that

$$\lim_{x \to 0+} \frac{x^2}{3x + |x|} = 0$$

c) Let $f: R \to R$ be defined by

$$f(x) = \begin{cases} 1 + x & \text{if } x > 1 \\ 1 - x & \text{if } x < 1 \\ 0 & \text{if } x = 1. \end{cases}$$

Prove that $\lim_{x \to 1} f(x)$ does not exist.

6. a) Prove that if f is continuous at $x = a$, then $|f|$ is continuous at $x = a$ but the converse is not true.

b) Prove that all polynomials
$p(x) = a_o + a_1 x + a_2 x^2 + \ldots + a_n x^n$

are continuous at each point of R where

$a_o, a_1, a_2, \ldots, a_n$ are constants

c) Examine the continuity of the following function at the origin;

$$f(x) = \begin{cases} \dfrac{xe^{1/x}}{1 + e^{1/x}} & \text{if } x \neq 0 \\ 0 & \text{if } x = 0 \end{cases}$$

7. a) Obtain Taylor formula with Lagrange form of remainder for the function $f(x) = \log(1 + x)$ about $x_0 = 2$ and $n = 3$.

b) Obtain the Maclaurin series expansion of the function sinx for $-\infty < x < \infty$

c) Prove that for $-\infty < x < \infty$,

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots + \frac{x^n}{n!} + \ldots\ldots$$

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M242 - ADVANCED COMPUTER PROGRAMMING

INSTRUCTIONS: Attempt any five(5) Questions
TIME ALLOWED: Three (3) Hours.

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1. a) Define the following terms as applied to Pascal Programming:

   i) Local variable
   ii) Global variable
   iii) Variable parameter
   iv) Value parameter

   b) When can a function identifier appear on the left-hand side of an assignment statement?

   c) Consider the following program

```
Program Quiz (Output);
Var A, B, C:Integer;
Procedure Subprogram(D:Integer; Var E,C:Integer);
Var A : Integer;
Begin
  A:=C+1;
  E:=D+C-1;
  C:=(C*2)
end;
begin
A:=3;
B:=5;
C:=7;
Subprogram:=(B,C,A);
writeln (A,B,C);
end.
```

   What is the output of Program Quiz?

d) Write an appropriate Pascal Subroutine for the following actions:

i) Computation of the sum of the series

$$\sum_{k=1}^{n} k^2 = 1^2 + 2^2 + \ldots + n^2$$

ii) Swap two integer values

2. a) Which of the following assignments are illegal? Indicate the error, if there is any .

```
type   Data = array[1..20,'a'..'z'] of char;
       String = packed array[1..40] of char;
       Whynot = array[1..40] of integer;

var    First, Second : Data;
              Long : String;
              Why : Whynot;
```

i) First[pred(1),'a']:=Second[1,'a'];
ii) Why[Sqr[3]]:=4;
iii) Long[Why[3]]:=Why[Long[3]];
iv) Long:=First[1..20];
v) First[1,First[1,'b']]:=Long[40];

b) What does the following Pascal segment do?

```
  :
  Count:=0;
  For Subscript:= 1 to 10 do begin
  If Sequence [Subscript] = Subscript then
  begin
  Count:=Count + 1
 end;
end;
  :
```

c) Write a procedure that initialises the components of a two dimensional array in the following manner: components above the upper-left to lower-right diagonal should be set to 1, those below the diagonal should get -1 and those on the diagonal should be initialised to zero. Assume the array is [1..MAX, 1..MAX] where MAX is a global constant

3. a) Define the following terms as applied to structured data types in Pascal Programming

i) Record
ii) Variant Record
iii) Field
iv) Tagfield

b) List three ways to access values stored in a record variable.

c) A computer-dating service records data on each of its clients with the following details:-

Name and address
Sex
Age
Interests (In any one of the following:- arts, books, music, theatre, sport, politics)

Define a record-type, enabling the name, address, sex, age and interests for each client to be held as a record variable.

d) In the above records, two clients are said to be compatible if and only if all the following hold:-

- They are of opposite sexes
- Their age difference is less than 10 years
- They have at least one interest in common

Write a function to test the compatibility of two clients.

4. a) Write necessary Pascal declarations for the following definitions;-

i) A set of colours, yellow, green, blue, red, white.
ii) A set of characters

b) Consider the following Pascal Program:-

```
Program Sets(Output);
Type   Cletters = 'A'..'Z';
       Sletters = 'a'..'z';
```

```
Var     SetA : Set of Cletters;
        SetB : Set of Sletters;
        C,Ch : Char;
        i,j : Integer;
Begin
i:=0; j:=0; SetA:=[ ]; SetB:=[ ];
Read(CH);
While CH<>'.' do begin
  For C:='A'to'Z' do
     if CH=C then begin
        i:=i+1;
       SetA:=SetA + [CH]
   end;
For C:='a' to 'z' do
  if CH=C then begin
   j:=j+1;
   SetB:=SetB + [CH]
   end;
 Read(CH);
end;
end.
```

What does the program do?

c) Suppose the input is:-

Computer Science EXAMINATION ends here.

What would be the values of the following, after running the above program?

(i) i (ii) j (iii) SetA (iv) SetB

d) What would be the values of the following (using the same input as in c).

i) NOT (x in SetA) (ii) (A in SetA) or (A in SetB)

5. a) Define a dynamic data structure?

b) Consider the following program:-

```
Program Test (Input, Output)
Type Integerpointer = ^Integer;
Var P,Q,R,S : Integerpointer;
Begin
New(P);
New(Q);
New(R);
New(S);
Read(P^,Q^,R^,S^);
P:=Q;
Q^:=R^;
R^:=S^;
writeln(P^,Q^,R^,S^)
End.
```

What would be the output if the input is:-

10 20 30 40

c) What would be the values of the following boolean expressions,after running the above program, with the same input values?

(i) P<>Q ii) R = S (iii) P^>Q^ (iv) (S^<>R^) OR (S^<Q^)

d) Assume the following definitions and declarations

```
Type integerpointer = ^Node;
     Node           = Record
                        Number:Integer;
                        Link: Integerpointer
                        end;
Var  First, Current :      Integerpointer;
                Value :    Integer;
                Found :    Boolean;
```

Write a Pascal program segment to search a simple linked list for the occurrence of a particular integer value read in. Assume that First, points to the first number in the list.

6. a) (i) What are the standard (or predefined) file parameters?
(ii) Under what circumstances can a file be an argument to a procedure?

b) What is the effect of this code?

```
Counter:=0;
reset(TheSource);
While not eof(TheSource) do begin
 if eoln(TheSource) then Counter:=Counter +1;
 readln(TheSource)
end;
```

c) Using TYPE to define file data types and VAR to declare a file, define and declare files for the following:-

i) A weekly sales record that contains a salesman's name (20 characters), the amount of his sales on each of the five days and his address which is a record containing city (20 characters) and province (30 characters).

ii) A payroll record that contains the following information for an employee:
A social security number (10 characters), name (20 characters) hourly rate(real), hours worked last week (real) and earnings to date (real).

7. a) Give two reasons why a programmer would choose to use subranges?

b) Assuming the declarations:

```
VAR  X, Y, Z: REAL;
        M,N: INTEGER;
PROCEDURE QUIZ(VAR A,B:REAL; X:INTEGER);
```

Which of the following procedure call statements would give syntax errors?

(i) QUIZ(X,Y,Z);
(ii) QUIZ(Z,Y, Maxint);
(iii) QUIZ(X,Y,M + N);
(iv) QUIZ(X,Y,B);
(v) QUIZ(A,B,N);
(vi) QUIZ(X,Y,M,N);

c) Write a Pascal Program that reads integers, stores them in an array, finds their average and produces as output the average and integers from input which are above the average value.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M292 - INTRODUCTION TO PROBABILITY

INSTRUCTIONS: Answer any five (5) questions.
Use of mathematical tables and calculators is allowed.

TIME ALLOWED: Three (3) Hours.

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1. a) Suppose A and B are two events. Prove that if $A \subset B$ then $P(A) \leq P(B)$.

   b) If $P(A \cup B) = 0.4$ and $P(A) = 0.3$, find P(B) if

   (i) A and B are independent events
   (ii) A and B are mutually exclusive events.

   c) In a sample space, events A and B are independent, events B and C are mutually exclusive, and A and C are independent.
   If $P(A \cup B \cup C) = 0.9$, $P(B) = 0.5$ and $P(C) = 0.3$, find P(A).

   d) In a sample space, events A and B are such that $P(A) = P(B)$,
   $P(A \cap B) = P(A^c \cap B^c) = \frac{1}{6}$.
   Find:
   (i) P(A) (ii) P(exactly one of the events A and B occurs).

2. a) State and prove Bayes' theorem.

   b) Bean seeds from supplier A have a 70% germination rate, those from B have 50% germination rate and those from C have 30% germination rate.

   A seed company purchases 30% of the bean seeds from supplier A, 50% from supplier B and the remaining 20% from supplier C. The purchases from the three suppliers are mixed together.

   If a seed germinates, what is the probability that it came from supplier A?

c) Two fair dice are tossed once.
Let d_1 be the value of the up face of the first die
d_2 be the value of the up face of the second die
such that
$A = \{(d_1,d_2): d_1 + d_2 = 4\}$
$B = \{(d_1,d_2): d_2 \geq d_1\}$

Evaluate (i) $P(A|B)$. (ii) $P(B|A)$

d) A commuter's drive to work includes 7 stop lights. Assume that the probability that a light is red when the commuter reaches it is 0.2, and that the lights are far enough apart to operate independently.

i) If X is the number of red lights the commuter stops for, find the probability distribution function of X.
ii) Find $P(X \geq 5)$
iii) Find $P(X \geq 5|X \geq 3)$

3. a) A random variable X has probability density function given by

$$f(x) = \begin{cases} k(x^2 - x^3), & 0 \leq x \leq 1 \\ 0, & \text{otherwise.} \end{cases}$$

i) Find K
ii) Find $P(X \geq 3/4)$
iii) Calculate $P(X \geq 3/4|X > 1/2)$

b) A community fire department is responsible for two types of emergency calls, rescues and fires. Historical data shows that the department has handled an average of two fires and three rescues per day.

ii) What is the probability of more than three rescues in a day?
ii) What is the probability of an entire day passing without an emergency call?

4. a) Let X be a random variable given by

$$f(x) = \begin{cases} \dfrac{1}{b-a}, & a < x < b \\ 0 & \text{elsewhere} \end{cases}$$

i) Find F(x) and sketch it.
ii) Find the moment generating function of X.
iii) Using the moment-generating function found in (ii), calculate the E(X).

b) Let X be an exponential random variable with mean 6.

(i) Find $P(X \geq 4)$
(ii) Find $P(X \geq 4 \mid X \geq 2)$.

c) The moment generating function for a random variable X is

$$M_X(t) = \frac{5}{5-t}.$$

i) Find the mean and variance of X.
ii) Identify the probability distribution of X.

5. a) A production lot of 200 units has 8 defectives. A random sample of 10 units is selected.
Find, to two decimal places, the probability that the sample will contain exactly one defective.

b) The length of life in hours, X, of an electronic component has an exponential probability density function with mean 500 hrs.

i) Find the probability that a component lasts at least 900 hours.

ii) Suppose a component has been in operation for 300 hours. What is the probability it will last for another 600 hrs?

6. a) Suppose X and Y are continuous random variables with a joint probability density function given by

$f(x,y) = Kxy^2$, $0 < x < 1$, $0 < y < 1$.

i) Find the value of the constant K.
ii) Find the marginal densities f(x) and f(y).
iii) Find the conditional density $f(y|x)$.
iv). Find $E[(x|y)]$.

b) Two discrete random variables X and Y have joint probability distribution function given by the following table

		Y		
		1	2	3
X	1	1/2	1/6	1/12
	2	1/6	1/4	1/12
	3	1/12	1/12	0

Compute the probability of each of the following:

i) $X < 1\frac{1}{2}$
ii) X is odd
iii) XY is even.

c) Mathematics aptitude scores X are N(500,400). Find:

i) the probability that the individual's score exceeds 600.

ii) the probability that an individual's score exceeds 600, given that it exceeds 500.

7. The manager of the government motor pool has instituted a ten point weekly maintenance check for all government vehicles. Faults identified by the maintenance check are corrected immediately. The manager feels that one of the benefits of the new program should be a reduction in fuel consumption.

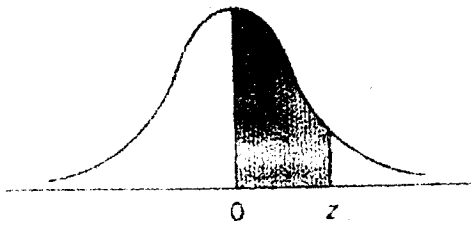
Ten vehicles were selected and the average fuel consumption of each vehicle in litres per one hundred kilometres was recorded for a three week period before introduction of the new maintenance program and a three week period after program introduction. The results are listed below:

Vehicle ID	Before program	After program
GRZ 1208	7.8	7.3
GRZ 768	10.9	11.1
GRZ 2135	6.9	6.4
GRZ 3313	9.3	8.7
GRZ 1111	8.6	8.5
GRZ 582	12.4	10.5
GRZ 803	7.1	6.8
GRZ 207	8.4	7.9

Unfortunately, before the pilot study was completed, one of the ten vehicles went missing and unaccounted and a second vehicle was involved in an accident. Does the ten point weekly maintenance check reduce fuel consumption?

Test the data using $\alpha = 5\%$.

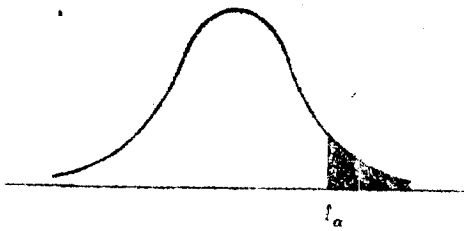
END OF EXAMINATION



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	0793	0832	0871	.0910	.0948	.0987	.1026	1064	.1103	.1141
0.3	1179	1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	1554	.1591	.1628	.1664	.1700	.1736	.1772	1808	.1844	1879
0.5	1915	.1950	.1985	.2019	.2054	.2088	.2123	2157	.2190	2224
0.6	2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	2794	.2823	.2852
0.8	2881	2910	.2939	.2967	.2995	.3023	.3051	3078	.3106	3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Source: Abridged from Table I of A. Hald, *Statistical Tables and Formulas* (New York: John Wiley & Sons, Inc.) 1952. Reproduced by permission of A. Hald and the publisher.

E V
ICAL VALUES OF *t*



DEGREES OF FREEDOM	$t_{.100}$	$t_{.050}$	$t_{.025}$	$t_{.010}$
1	3.078	6.314	12.706	31.821
2	1.886	2.920	4.303	6.965
3	1.638	2.353	3.182	4.541
4	1.533	2.132	2.776	3.747
5	1.476	2.015	2.571	3.365
6	1.440	1.943	2.447	3.143
7	1.415	1.895	2.365	2.998
8	1.397	1.860	2.306	2.896
9	1.383	1.833	2.262	2.821
10	1.372	1.812	2.228	2.764
11	1.363	1.796	2.201	2.718
12	1.356	1.782	2.179	2.681
13	1.350	1.771	2.160	2.650
14	1.345	1.761	2.145	2.624
15	1.341	1.753	2.131	2.602
16	1.337	1.746	2.120	2.583
17	1.333	1.740	2.110	2.567
18	1.330	1.734	2.101	2.552
19	1.328	1.729	2.093	2.539
20	1.325	1.725	2.086	2.528
21	1.323	1.721	2.080	2.518
22	1.321	1.717	2.074	2.508
23	1.319	1.714	2.069	2.500
24	1.318	1.711	2.064	2.492
25	1.316	1.708	2.060	2.485
26	1.315	1.706	2.056	2.479
27	1.314	1.703	2.052	2.473
28	1.313	1.701	2.048	2.467
29	1.311	1.699	2.045	2.462
∞	1.282	1.645	1.960	2.326

Source: From M. Merrington, "Table of Percentage Points of the *t*-Distribution," *Biometrika*. Reproduced by permission of the *Biometrika* Trustees.

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M332 - Real Analysis

INSTRUCTIONS: Answer any five (5) questions.

TIME ALLOWED: Three (3) Hours.

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1. a) Define local maximum and local minimum of a function f:[a,b]→R. Illustrate these concepts by diagrams.

   b) Prove that if f(a) is a local extremum, then $f'(a) = 0$ or else $f'(a)$ does not exist.

   c) Define $f:R \to R$ by $f(x) = e^{-|x|}$.
   Prove that f is continuous at $x = 0$ but not differentiable at $x = 0$.

2. a) (i) State Rolle's Theorem.

   (ii) Examine the validity of the hypothesis and the conclusion of Rolle's theorem for the following function:

   $$f(x) = \sqrt{1-x^2} \quad \text{in } (-1,1).$$

   b) If $\frac{a_0}{n+1} + \frac{a_1}{n} + \ldots + \frac{a_{n-1}}{2} + a_n = 0,$
   then prove that the equation

   $$a_0x^n + a_1 x^{n-1} + \ldots + a_n = 0$$

   has atleast one root between 0 and 1.

   c) If F(x) is a polynomial, then prove that between any two roots of $F(x) = 0$, there exists at least one root of $F'(x) = 0$.

3. a) Using Mean Value theorem prove that

$$1 + x < e^x < 1 + xe^x \text{ for every } x > 0.$$

b) Find the value of c in the generalized Mean Value theorem for the following pair of functions:

$$f(x) = \sin x,\ g(x) = \cos x \text{ in } [-\pi/2, 0].$$

c) Prove that if f' exists and is bounded on some interval I, then f is uniformly continuous on I

4. a) Prove that every continuous function on [a,b] is Riemann integrable.

b) Prove by an example that a function is Riemann integrable on [a,b] but not continuous on [a,b].

c) Prove by an example that a function is bounded on [a,b] but not Riemann integrable on [a,b].

5. a) Prove that if f is Riemann integrable on [a,b], then $|f|$ is Riemann integrable on [a,b] but the converse is not true.

b) If f is Riemann integrable on [a,b], then prove that f^2 is Riemann integrable on [a,b].

c) If f is continuous on [a,b], $f(x) \geq 0$ for $x \in [a,b]$ and $f(c) > 0$ for some point $c \in [a,b]$, then prove that

$$\int_a^b f(x)dx > 0.$$

6. a) (i) State Second Fundamental theorem of calculus

(ii) Using this theorem evaluate

$$\int_{-1}^{1} \frac{1}{1+x^2} dx$$

b) State and prove the second Mean Value theorem of Integral calculus.

c) Using this theorem prove that

$$\frac{11}{24} \leq \int_{0}^{1/2} \sqrt{1-x^2}\, dx \leq \frac{11}{24}\sqrt{4/3}$$

7. (a) Prove that if $\int_{a}^{\infty} f(x)dx$ converges absolutely, then

$$\int_{a}^{\infty} f(x)dx \quad \text{converges.}$$

b) Test for absolute convergence the following integrals:

(i) $$\int_{o}^{\infty} \frac{\cos x}{1+x^2}\, dx$$

(ii) $$\int_{o}^{\infty} e^{-x} \sin x dx$$

c) Prove that $$\int_{o}^{\infty} \frac{dx}{x^2+\sqrt{x}}$$ is convergent

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M362 - LINEAR MODELS AND DESIGN OF EXPERIMENTS

INSTRUCTIONS: i) Answer any four questions
ii) Show all essential working
iii) Calculators are allowed.
iv) Statistical Tables will be provided

TIME ALLOWED: Three (3) Hours.

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1. a) Define the following

i) a random vector
ii) expectation of a vector
iii) a quadratic form

b) The director of admissions of a small college administered an entrance test to 20 students to determine whether a student's grade point average (GPA) at the end of the year (Y) can be predicted from the entrance test score(X). The results of the study follow. Assume that the linear model $Y = X\beta + \varepsilon$ is appropriate.

X		Y	
5.5	4.9	3.1	2.0
4.8	5.4	2.3	2.9
4.7	5.0	3.0	2.3
3.9	6.3	1.9	3.2
4.5	4.6	2.5	1.8
6.2	4.3	3.7	1.4
6.0	5.0	3.4	2.0
5.2	5.9	2.6	3.8
4.7	4.1	2.8	2.2
4.3	4.7	1.6	1.5

i) Write down β, Y, X.

ii) Find $\hat{\beta}$ and state the estimated regression function. Interpret the model.

iii) Find the mean square error (MSE)

$$\left[\begin{array}{l} \sum X_i = 100.0, \sum Y_i = 50.0, \sum X_i^2 = 509.12, \\ \sum Y_i^2 = 134.84, \sum X_i Y_i = 257.66 \end{array}\right]$$

c) Prove that

i) if $X_1, X_2,...,X_n$ are random variables and $c_1, c_2,...,c_n$ are constants
then $E(c'X) = c'\mu$ and
$var(c'X) = c'\Sigma c$
where
$\mu = E(X)$, $\Sigma = cov(X)$,
$c'X = c_1X_1 + c_2X_2 +...+c_nX_n$.

ii) $Cov(AU,BZ) = A\ Cov(U,Z)B'$
where A and B are matrices of constants, U and Z are random vectors.

2. a) Define the following

i) row rank of a matrix
ii) variance-covariance matrix
iii) an orthogonal matrix

b) Set up the X matrix and β vector for the regression models (assume $i = 1,2,...5$)
i) $Y_i = \beta_o + \beta_1X_{i1} + \beta_2X_{i1}X_{i2} + \varepsilon_i$
ii) $\log Yi = \beta_o + \beta_1X_{i1} + \beta_2X_{i1}X_{i2} + \varepsilon_i$

c) The multiple regression relationship of blood pressure (Y) to age (X_1), smoking history (X_2) and body size (X_3) was studied. Three regression models were considered, yielding the following results.

Model 1: $Y = 59.092 + 1.605X_1$
Model 2: $Y = 48.05 + 1.709X_1 + 10.294X_2$
Model 3: $Y = 45.103 + 1.213X_1 + 9.946X_2 + 8.592X_3$

i) Copy and complete the following ANOVA tables

Model 1

Source	SS	df	MS	F*
Regression	3861.63			
Error				
Total	6425.968	31		

Model 2

Source	SS	df	MS	F*
Regression	4689.684			
Error				
Total				

Model 3

Source	SS	df	MS	F*
Regression				
Error	1536.143			
Total				

ii) Using the ANOVA tables, compute and interpret the R^2 values for models 1, 2 and 3.

iii) Carry out the overall F tests for significant regression under models 1,2 and 3. What are your conclusions? Use $\alpha = 0.05$.

iv) Test whether it is necessary to add the variable smoking history (X_2) to the model with age (X_1). Use $\alpha = 0.05$.

v) Test whether it is necessary to add the variable body size(X_3) to the model with age (X_1) and smoking history (X_2). Use $\alpha = 0.05$.

3 (a) i) State Gauss-Markov theorem

ii) Define multicolinearity

(b) Given the model $Y = X\beta + \varepsilon$ with $\varepsilon \sim N(O,\sigma^2 I_n)$. Prove that

i) $\hat{\beta} \sim N_p(\beta, \sigma^2 (X'X)^{-1})$

(b) Prove the following

i) The hat matrix H and I_n-H are orthogonal projections

ii) $S^2 = \dfrac{(Y - X\hat{\beta})'(Y - X\hat{\beta})}{n-p}$ is an unbiased

estimator for σ^2 in the model $Y = X\beta + \varepsilon$ with X full column rank, $E(\varepsilon) = 0$ and $\text{cov}(\varepsilon) = \sigma^2 I_n$.

iii) If an (nxn) matrix A is an orthogonal projection, then $\text{tr}(A) = \text{rank } A$

c) An operations analyst conducted an experiment to study the effects of three factors on the mean time to assemble an electronic chess board. Factor A was the gender of the assembler (i = 1:male, i = 2: female), factor B was the sequence of assembling the components (j = 1,2,3) and factor C was the amount of experience of the assembler (k = 1: under 18 months; k = 2:18 months or more). Randomization was used to assign 15 assemblers of each gender with a given amount of experience to each of the three assembly sequences, with each sequence assigned to five assemblers. A three-way analysis of variance was done.

i) Copy and complete the ANOVA table

Source	SS	df	MS	F*
Factor A (Gender)	540361			
Factor B (Sequence)	49320			
Factor C(Experience)	382402			
AB Interaction	543			
AC Interaction	91			
BC Interaction	911			
ABC Interaction				
Error	41186			
Total	1014833	59		

i) Test for three-factor interactions; use $\alpha = 0.05$.

ii) Test for AB, AC and BC interactions. For each test use $\alpha = 0.05$.

iii) Test for A,B and C main effects. For each test use $\alpha = 0.05$.

iv) State the set of conclusions that can be arrived at from tests in parts (i), (ii) and (iii).

5. (a) Define the following

i) normal probability plot
ii) covariance analysis
iii) a contrast of means

b) i) Derive the least squares estimator for β in the model $Y = X\beta + \varepsilon$ where $\sim N(O,\sigma^2 I_n)$

ii) Derive the weighted least squares estimator for β in the model $Y = X\beta + \varepsilon$ where $\varepsilon \sim N(0, \sigma^2 W)$. Show that it is unbiased and find its covariance.

c) A rehabilitation centre researcher was interested in examining the relationship between physical fitness prior to surgery of persons undergoing corrective knee surgery and time required in physical therapy until successful rehabilitation. The number of days required for successful completion of physical therapy (Y), the prior physical fitness status (below average, average, above average) and age(X) for each patient follow.

Fitness status

1:Below average		2:Average		3:Above average	
X	Y	X	Y	X	Y
29	18.3	30	20.8	26	22.7
42	30.0	35	25.2	32	28.7
38	26.5	39	29.2	21	18.9
40	28.1	28	20.0	20	18.0
43	29.7	31	21.5	23	21.7
40	27.8	31	22.1	22	20.0
30	19.8	29	19.7		
42	29.3	35	24.7		
		29	20.2		
		33	22.9		

Determine the analysis of covariance table. Are the number of days different for the three groups? Use $\alpha = 0.05$.

$$\left[\begin{array}{c} X_{1.} = 304, X_{2.} = 320, X_{3.} = 144, X_{..} = 768 \\ Y_{1.} = 209.5, Y_{2.} = 226.3, Y_{3.} = 130, Y_{..} = 565.8 \\ \sum_i \sum_j X_{ij} Y_{ij} = 18673.7 \end{array}\right]$$

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M412 - FUNCTIONS OF A COMPLEX VARIABLE

INSTRUCTIONS: Attempt any Five questions.
Showing all necessary working.

TIME ALLOWED: Three (3) Hours.

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1. a) Find the Laurent series expansion of

$$f(z) = \frac{1}{z+1} + \frac{1}{1-2z}$$ about the point $z_o = -2i$ in the domain $|z+2i| > \sqrt{17}$

b) Given the function $f(z) = \dfrac{e^{iz}}{z(\pi^2 - z^2)}$,

i) Find the residues at each of its poles.

ii) Hence or otherwise show that

$$\int_0^\infty \frac{\sin x}{x(\pi^2 - x^2)}\,dx = \frac{1}{\pi}.$$

2. a) State without proof the Rouche's Theorem.

b) By using the Rouche's theorem, prove the fundamental theorem of Algebra.

c) Show that the equation $e^z - \lambda z^5 = 0$ with $|\lambda| > e^R/R^5$ has five roots inside the circle $|z| = R$.

3. (a) State and prove the cauchy integral formula.

b) Evaluate $\int_c \frac{ze^z}{z+3}dz$ where C is the circle $|z| = 4$.

c) Locate and identify the singularities of the function $f(z) = \frac{z^4+3}{1+z^4}$.

4. a) Given $f(z) = \cot \alpha z$, (α real), find the residues at each of its singularities.

b) Prove that if z_0 is a simple pole of f(z), then

$$\text{Res}[f(z), \quad z_0] = \lim_{z \to z_0} \left[(z - z_0)f(z)\right]$$

c) Verify that

$$\int_0^{\pi/2} \frac{dx}{a + \sin^2 x} = \frac{\pi}{2[a(a+1)]^{1/2}}$$

5. a) State and prove Liouville's theorem.

b) Show that the function $f(z) = e^z$ satisfies Liouville's theorem.

c) By evaluating the integral $\int_c \frac{dz}{(z^2+1)^2}$ where c is the contour comprising the semi circular arc $|z| = R$ in the upper half plane and the line segment $-R \le x \le R$, show that $\int_{-\infty}^{\infty} \frac{dx}{(x^2+1)^2} = \frac{\pi}{2}$.

6. (a) State and prove the cauchy inequalities theorem.

b) Given that $f(z) = \frac{1}{2z+1}$, verify the cuachy inequality if z lies on the circle $|z-3| = 2$.

c) State Schwarz Lemma.

END OF EXAMINATION.

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

MATHEMATICS M422

INSTRUCTIONS: Attempt four questions in all and atleast one(1) question from each section.

TIME ALLOWED: Three (3) Hours.

SECTION A MODULE THEORY

(Attempt atleast one question from this section)

In this section all modules are left modules defined over an integral domain R

1. What is meant by each of the following terms as applied to an *R-module M*
   (i) A subset X of M *generates M freely*?
   (ii) An element m of M is *torsion-free* ?

(a) (i) Let R^R denote the *R-module R* and let N be the *R-module* given by

$N = R^R \oplus R^R \oplus \ldots R^R$ (s copies of R^R)

Then show that N is a freely generated *R-module.*
Prove that if an *R-module M* is freely generated by its subset $X = \{m_1, m_2, \ldots m_s\}$, *then* $M \cong N$.

(ii) Let $\{m_1, m_2, \ldots, m_s\}$ be a finite subset of an *R-module M* such that each m_i is torsion-free, and $M = Rm_1 \oplus \ldots \oplus Rm_s$. Then show that $\{m_1, m_2, \ldots, m_s\}$ generates M freely.

(b) Show that the $\boldsymbol{Z}$*-module* $\boldsymbol{Z}^{\boldsymbol{Z}}$ is a free $\boldsymbol{Z}$*-module* while the $\boldsymbol{Z}$*-module* Z_n is not $\boldsymbol{Z}$*-free.*

2. Define each of the following terms as applied to *R-modules*

   (i) A *finitely generated R-module M*
   (ii) A *torsion free R-module N*

(a) Prove that if M is a finitely generated module over a principal ideal domain R, then M has a decomposition

$$M = F \oplus T,$$

where T is a torsion submodule of M and F is a free *R-submodule* of M. Hence confirm that free *R-submodule* of M. Hence confirm that if M is a finitely generated module over a principal ideal domain R each of whose elements is torsion-free, then M is a free *R-module*.

(b) Let an *R-module* M have a decomposition

$$M = Rz_1 \oplus Rz_2 \oplus Rz_r \oplus Rz_{r+1} \ldots \oplus Rz_s,$$

where R is a principal ideal domain, and the order ideals $o(z_i)$ of the generators z_i satisfy the condition

$$R \neq o(z_1) \supseteq o(z_2) \ldots \supseteq o(z_s)$$

such that $o(z_i) \neq o$ for all $i \leq r$ and $o(z_i) = o$ for all $i > r$

then show that $T = \oplus \sum_{i=1}^{r} Rz_i$

Confirm that M/T is a torsion-free module of rank s-r.

3. Define each of the following terms as applied to modules over a principal ideal domain R

(i) *A p-component* of a finitely generated *R-module M*
(ii) invariant factors of an *mxn* matrix *A*

(a) Let M be a cyclic *R-module* generated by the element m whose order ideal $o(m) = (g)$ and $g = hy$ with $(h,y) = 1$. Then show that

$$M = R_w \oplus R_z,$$

where $o(w) = (h)$ and $o(z) = (y)$.
Hence deduce that if $g = p_1^{k1} p_2^{k2} \ldots p_n^{kn}$,
where the p_i are all distinct primes, then

$M = \oplus R\, m_i$, where $o(m_i) = \left(p_i^{ki}\right)$.

(b) (i) Find invertible *3x3* matrices Q and P over Z such that QAP is an invariant - factor matrix for A where

$$A = \begin{bmatrix} -4 & -6 & 7 \\ 2 & 2 & 4 \\ 6 & 6 & 15 \end{bmatrix}$$

(ii) If M is the ***Z-module*** $\boldsymbol{Z_6}$, express M as a direct sum of its primary components.

SECTION B (GALOIS AND FIELD THEORY)

(Attempt atleast one(1) question from this section)

4. Define the terms

(i) a *splitting field for* a polynomial $f(x) \in k[x]$

(ii) a *normal extension* of a field k

(a) (i) Prove that a finite normal extension $L:K$ is a splitting field of some polynomial $g(x) \in k[x]$.

(ii) Let G be the Galois group of the field extension $L:K$. Let H be a subgroup of G and let E be the subfield of L given by $E = i_{nv}\, H$. Then prove that if H is normal in G then $E:K$ is a normal field extension. In this case the group of K-automorphisms of E, denoted by $\overline{G} = G(E:K)$, is isomorphic to G/H.

(b) Construct the splitting field L for $x^4 - 3x^2 + 4$ over the field Q of rationals and hence determine the Galois group corresponding to the field extension $L:K$.

Determine all the subfields E of L such that $E:Q$ is a normal extension.

5. What is meant by each of the following?

(i) The *Galois group* of a polynomial f(x) ∈ k[x]

(ii) a *radical field extension*

(a) Prove that a polynomial $f(x)$ is solvable by radicals if and only if its Galois group is solvable

(b) Let α be a root of $f(x) = x^4+1$ in $\boldsymbol{C}$. Then show that

$$\alpha = \frac{1+i}{\sqrt{2}}, \text{ , where } i = \sqrt{-1}.$$

Determine the Galois group of $f(x) = x^4+1$ over Q and hence confirm that $Q(\alpha):Q$ is a radical extension.

6. What is meant by the term "*the polynomial equation f(x) = 0 is solvable by radicals*"?

(a) Show that if $f(x)$ is an irreducible rational polynomial of degree p such that $f(x)$ has precisely two non-real roots in $\boldsymbol{C}$, then its Galois group is S_p, the symmetric group of degree p. Hence conclude that $f(x) = 0$ is not solvable by radicals

(b) Show that $f(x) = x^5 - 9x + 3$ is not solvable by radicals over the rationals.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M462 - Bayesian Inference and Discrete Analysis

INSTRUCTIONS: Answer any four (4) questions.
Full credit will only be given when all the necessary work is shown.

TIME ALLOWED: Three (3) Hours.

1]. a) Define the following terms

(i) Survival function
(ii) Hazard function
(iii) Censoring.

b) (i) Let $\frac{f(t)}{1-f(t)} = g(t)e^{\eta}$, show that

$$f(t) = g(t)\, e^{\eta - G(t)e^{\eta}}$$

(ii) Derive the expression for the log-likelihood using the expression of f(t) given in (i) above if there are n uncensored and m censored observations.

(iii) Write the expression for the log-likelihood function if the distribution of T is

$$f(t) = \lambda e^{-\lambda t}, \quad t > 0, \lambda > 0.$$

c) Let T have a poisson distribution with parameter λ.

(i) Find the survival function
(ii) Find the hazard function.
(iii) Show that the hazard function is monotone increasing.

2]. a) Explain the following terms

(i) Minimax principle
(ii) Bayes principle
(iii) Conjugate family.

b) (i) State the Bayes action for testing

$$H_o : \theta \in \Omega_o \quad \text{vs } H_a : \Omega - \Omega_o$$

where θ is the parameter and Ω is the parameter space.

(ii) Let $X_1, X_2, \ldots, X_n$ be a random sample from normal pdf with mean and variance 1. Let have a prior normal distribution with mean 10 and variance 1. What is the Bayes action for testing

$$H_o : |\mu - 2| \leq 2 \quad \text{vs} \quad H_a : |\mu - 2| > 2$$

at 0.02 level of significance and 99% power?

where $n = 15$ and $\sum_{i=1}^{n} X_i = 43$.

c) Given a random sample of 10 from a Bernoulli population, suppose that there are 8 successes

Compute the posterior probability of the interval $\frac{1}{2} < P < 1$, if the prior is in the conjugate family with $\alpha = \beta = 1$. Do not simplify the answer.

3] a) Define the following

(i) Proportional hazards model
(ii) Cox's proportional-hazards model
(iii) Left censoring.

b) (i) Derive the expression for the hazard function based on the meaning of the hazard function.

(ii) Derive the expression of the hazard function from the equation

$$S(t) = e^{-H(t)}.$$

c) Let $f(t) = \frac{1}{\sqrt{2\pi\sigma^2 t^2}} e^{-\frac{1}{2}\left(\frac{\ln t - \mu}{\sigma}\right)^2}$, $t > 0$

this is the log-normal density.

(i) Derive the survival function
(ii) Derive the hazard function
(iii) Sketch the survival function for $\mu = 0$ and $\sigma = 1$

4] a) Let $X_1, X_2, ..., X_n$ be a random sample from poisson with parameter μ. If μ has the gamma distribution i.e

$$g(\mu) = \frac{\lambda^\alpha \mu^{\alpha-1} e^{-\lambda\mu}}{\Gamma(\alpha)}, \lambda > 0, \mu > 0, \alpha > 0$$

(i) Derive the marginal distribution of the sufficient statistics
(ii) Derive the posterior distribution of μ
(iii) Find the Bayes estimator for μ
(iv) Show that the Bayes estimator for μ approaches the classical estimator for μ as $n \to \infty$.

b) Let $Y_1, Y_2, ..., Y_N$ be independent variables where $Y_i \sim B(n_i, \theta_i)$

(i) Write the loglikelihood function
(ii) Using the logit as a link function with linear predictor

$$\eta_i = \sum_{j=1}^{k} X_{ij}\beta_j$$

Write the log likelihood in (i) as a function of the β_j's.
(iii) Derive the normal equations for the log likelihood in (ii).

c) Let $X_1, X_2, ..., X_n$ be a random sample from normal pdf with mean μ and variance 1. Let μ have a prior normal distribution as its prior with mean -5 and variance 1. Find the shortest 98% bayesian interval for μ if

$n = 15$, and $\sum_{i=1}^{n} X_i = 20$.

5] a) Define the following terms,

(i) Risk

(ii) Relative risk

(iii) Odds ratio.

b) Show that the following are true for a discrete life distribution

(i) $R(t_j) = S(t_j) - S(t_{j+1})$

(ii) $h(t_j) = 1 - \frac{S(t_{j+1})}{S(t_j)}$

(iii) $S(t) = \prod_{j:t_j<t} (1 - h(t_j))$

c) (i) State the formulae for computing the Mantel-Haenzel estimate of relative risk (odds ratio) for case-control and cross-sectional comparative studies for k 2x2 tables.

(ii) Compute the Mantel-Haenszel odds ratio for the following tables from a study for comparing men with low systolic blood pressure (SBP) (SBP < 165) and those with high SBP in relation to developing coronary Heart Disease (CHD) in which there were 423 individuals

SBP	CHD	no CHD	Total
High	15	53	68
Low			335
Total	40	383	423

The men were divided into 3 age groups as age was suspected to be a confounding variable

SP	CHD	no CHD	Totals
High	5	17	22
Low	9	109	118
Total	14	126	140

SBP	CHD	no CHD	Total
High	2	11	13
Low	7	94	101
Total	9	105	114

Third age group

SBP	CHD	no CHD	Total
High	8	25	33
Low	9	127	136
Total	17	152	423

(iv) Is age a real confounding variable.

END OF EXAMINATION.

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER DEFERRED/SUPPLEMENTARY EXAMINATIONS, JULY 2000

M912 -Mathematical Methods IV.

INSTRUCTIONS: Attempt Any five (5) questions showing necessary working. All questions carry equal marks.

TIME ALLOWED: Three (3) Hours.

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1. (a) Solve the equation $2\frac{dx}{dt} + 3x = e^{4t}$, given that $x = 5$ when $t = 0$, using Laplace transforms.

   (b) Show that $\int_0^{\pi/2} \int_x^{\pi/2} \frac{\sin y}{y}\, dydx = 1.$

2. (a) Given that $\vec{V} = \sin(x^2 + y^2 + z^2)\vec{j}$, find its divergence.

   (b) Verify the Divergence theorem for the vector field $\vec{V} = x(y+1)z^3\vec{j}$ over the Pentahedron with faces given by the planes $x = 0$, $x = 2$, $y = 0$, $z = 0$, and $y + z = 1$.

3. (a) Expand $f(x) = x^2$, $0 < x < 2\pi$ in a fourier series with period 2π.

   (b) Hence, show that $\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}$

   (c) Evaluate the integral

   $$I = \int_0^{\infty} \frac{x^c}{c^x}\, dx, \quad \text{where } c \text{ is a constant.}$$

4. (a) Evaluate the laplace transform for the function $f(t) = t^2 \sin kt$, where k is a constant.

(b) Evaluate $L^{-1}\left\{\ln\left(\frac{s+a}{s+b}\right)\right\}$.

(c) Determine if the function

$f(x) = x(10 - x)$ over $0 < x < 10$ with period 10 is even, odd, or neither.

5. (a) Calculate $\int_c \vec{F}.d\vec{r}$ where

$\vec{F} = \vec{f}(x,y) = e^x\vec{i} + e^y\vec{j}$, with c as the curve $y = \sqrt{x}$ from (1,-2) to (2,0).

(b) Use Green's theorem to calculate the area enclosed by the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$.

(c) Given that $L^{-1}\{f(t)\} = \frac{s+2}{s^2-4}$, find f(t).

6. (a) Find the right and left hand derivatives of

$$f(x) = \begin{cases} 100, & x = 0 \\ 0, & \text{elsewhere,} \end{cases}$$ at the po int

$x = 0$.

(b) Given that $\hat{f}(w) = H(w + a) - H(w - a)$, $a > 0$, where H is the unit step function, find its inverse fourier transform.

(c) Derive the fourier integral representation of

$$f(c) = \begin{cases} x, |x| \le L \\ 0, |x| x > L. \end{cases}$$

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M962 - Time Series Analysis

INSTRUCTIONS: Answer any five (5) questions.

TIME ALLOWED: Three (3) Hours.

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1. a) Define a covariance stationary stochastic process.

   b) Let Z_t be a sequence of independent random variables alternately following a Normal distribution N(5,4) and Binomial distribution $B\left(n = 25, p = \frac{1}{5}\right)$. Determine if the process $\{Z_t\}$ is covariance stationary.

   c) Identify with justification appropriate time series model based on the following sample autocorrelations. n = 121.

k	1	2	3	4	5	6	7	8	9	10
ρ_k	.15	-.08	.04	.08	.08	.03	.02	.05	.04	.11

   d) Suppose that $\{Z_t\}$ is a discrete, purely random process with mean μ and variance σ_Z^2. A process $\{X_t\}$ is defined by

$$X_t = X_{t-1} + Z_t$$

   Assuming the process $\{X_t\}$ starts at $X_1 = Z_1$, show that

$$X_t = \sum_{i=1}^{t} Z_i.$$

   Find $E(X_t)$ and $V(X_t)$ and comment on the stationarity of the process $\{X_t\}$.

2 a) Explain what do mean by an invertible moving average process.

   b) Let $\{Z_t\}$ be a discrete purely random process with mean zero and variance σ_Z^2. Show that the following processes $\{X_t\}$ have the same autocorrelation functions.

$$X_t = Z_t + \theta Z_{t-1} \quad - \quad \text{(i)}$$

$$X_t = Z_t + \frac{1}{\theta} Z_{t-1} \quad - \quad \text{(ii)}$$

c) State the range of values of θ for which process (i) of part (b) above is invertible.

d) Find an invertible process which has the following autocorrelation function.

$\rho_o = 1, \rho_1 = 0.4, \rho_k = 0$ for $k \geq 2$.

3 a) Determine the range of values of λ_1 and λ_2 such that the second order autoregressive process defined by $X_t = \lambda_1 X_{t-1} + \lambda_2 X_{t-2} + Z_t$ is stationary and make a sketch of the region of stationarity.

b) Find the autocorrelation function of the process in part (a) given that

$$\lambda_1 = \frac{1}{12}, \lambda_2 = \frac{1}{12}$$

4. a) Show that the process $\{X_t\}$ defined by $X_t = Z_t + C(Z_{t-1} + Z_{t-2} + \ldots)$ where C is a constant and $\{Z_t\}$ is a zero mean white noise process, is non stationary. Identify the process represented by the series of the first differences of $\{X_t\}$ and find the range of values of C for which the process of first differences is invertible.

b) The stationary process $\{X_t\}$ has autocovariance function γ_k given by

$\gamma_k = \lambda^k, k = 0,1,2,....$

Another stationary process $\{Y_t\}$ is defined by $Y_t = X_t - X_{t-1}$. Obtain the autocovariance function of $\{Y_t\}$ in terms of γ_k.

5. The stationary process $\{W_t\}$ is generated from the white noise process $\{a_t\}$ via

$$W_t = \lambda W_{t-1} + a_t - \frac{1}{2}a_{t-1}, \quad |\lambda| < 1$$

a) Show that the first lag autocorrelation of W_t is given by

$$\rho_1 = \frac{(2\lambda - 1)(2 - \lambda)}{5 - 4\lambda}$$

b) Find the autocorrelation of W_t at lags $k \geq 2$. Hence show that beyond ρ_1, the autocorrelations of the given model follow the same pattern as the autocorrelations of an AR(1) process.

6. a) State $\hat{Z_n}(\ell)$, the ℓ step ahead minimum mean square error forecast for the ARIMA process $\{Z_t\}$ as a conditional expectation given that the process $\{Z_t\}$ is known upto time origin n.

b) Given the model

$$(1 - .6B)(Z_t - 19) = a_t$$

where $\{a_t\}$ is a purely random process with mean zero and variance 0.1. Suppose that we have observations $Z_{100} = 18.9$, $Z_{99} = 19$, $Z_{98} = 19$, $Z_{97} = 19.6$

Compute the following

i) Forecast Z_{101}, Z_{102}, Z_{103}.

ii) Find the 95% forecast limits for Z_{101}, Z_{102} and Z_{103}.

iii) Suppose that the observation at $t = 101$ turns out to be $Z_{101} = 18.8$. Update the forecasts for Z_{102} and Z_{103}

You may use the following formulae.

i) $\text{Var}\,(\hat{Z}_n(\ell)) = \sum_{j=0}^{\ell-1} \Psi_j^2$ where $\psi_o = 1$ and ψ_j are the weights associated with the moving average representation of the given model.

ii) the forecast updating equation is

$$\hat{Z}_n(\ell) = \hat{Z}_n(\ell+1) + \psi_{\ell}(Z_{n+1} - \hat{Z}_n(1))$$

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M982 - Numerical Analysis II

INSTRUCTIONS: Attempt any five (5) questions.

TIME ALLOWED: Three (3) Hours.

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1. a) The SOR method is given by

$$x_i^{(k)} = (1-w)x_i^{(k-1)} + \frac{w}{a_{ii}}\left[b_i - \sum_{j=1}^{i-1} a_{ij}x_j^{(k)} - \sum_{j=i+1}^{n} a_{ij}x_j^{(k-1)} \right]$$

Find the first two iterations of the method with w = 1.1 for the linear system using x = 0

$$\begin{aligned} 10x_1 - x_2 &= 9 \\ -x_1 + 10x_2 - 2x_3 &= 7 \\ -2x_2 + 10x_3 &= 6 \end{aligned}$$

b) Given the linear system

$$\begin{aligned} x_1 + x_2 - x_3 &= 2 \\ 2x_1 + 3x_2 + 5x_3 &= -3 \\ 3x_1 + 2x_2 - 3x_3 &= 6 \end{aligned}$$

Find the solution using the LU decomposition.

2. Let $A = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{bmatrix}$

a) Determine the region containing the eigenvalues of A.
b) Find the spectral radius of A.
c) Find the first three iterations obtained by the power method applied to A using $x^{(o)} = (1,-1,2)^t$.

3. Perform two iterations of Newton's method with $x = 0$ for the non-linear system

$$x_1^2 + x_2 - 37 = 0$$
$$x_1 - x_2^2 - 5 = 0$$
$$x_1 + x_2 + x_3 - 3 = 0$$

4. a) Describe the Jacobi iterative method as an iterative technique for solving a system of linear equations.

b) Given the system of linear equations

$$\begin{aligned} 10x_1 + 5x_2 &= 6 \\ 5x_1 + 10x_2 - 4x_3 &= 25 \\ -4x_2 + 8x_3 - x_4 &= -11 \\ - x_3 + 5x_4 &= -11 \end{aligned}$$

Find the first three(3) iterations of the Gauss-Seidel method using $x^{(0)} = (0,0,0,0)^t$

5. Apply the Adams-Bashforth three-step method to obtain the numerical solution to the initial-value problem

$$y' = t^2 + y^2 \ , y^{(0)} = 1$$

performing one step with $h = 0.1$
The method is given by

$$w_0 = , \ w_1 = \alpha_1, \ w_2 = \alpha_2$$

$$w_{i+1} = w_i + \frac{h}{12}\left[23f(t_i, w_i) - 16f(t_{i-1}, w_{i-1}) + 5f(t_{i-2}, w_{i-2})\right]$$

(Use a method of $O(h^4)$ for the necessary start)

6. a) Show that the given initial-value problem has a unique solution

$$y' = \frac{-2}{t^y} + t^2 e^t, \quad 1 \leq t \leq 2, \quad y(1) = \sqrt{2e}$$

b) Use Taylor's method of order four with $h = 0.2$ to approximate the solution to the initial-value problem in a) over the interval $0 \leq t \leq 1$ with initial condition $y(0) = 0.5$.

7. a) Write an algorithm for solving an n x n linear system

$$E_1 : a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n = a_{1,n+1}$$
$$E_2 : a_{21},x_1 + a_{22}x_2 + \ldots + a_{2n}x_n = a_{2,n+1}$$
$$\vdots$$
$$E_n : a_{n1},x_1 + a_{n2}x_2 + \ldots + a_{nn}x_n = a_{n,n+1}$$

Using the Gaussian elimination method.

b) Euler's method is used to obtain the solution for the initial-value problem $y' = xy$, $y(o) = 1$. Estimate the error at $x = 1$, with stepsize $h = 0.01$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT

University Examinations. 1999/2000.
P-192: INTRODUCTORY PHYSICS (Option A)

All questions carry equal marks. The marks are shown in brackets. Answer question 1 and any other four (4) questions. Clearly indicate which questions you have attempted.
Time: Three (3) hours. **Maximum marks = 100.**

Don't forget to write your computer number on the answer book.

Whenever necessary, use

g	$= 9.8 m/s^2$
k	$= 9.0 \times 10^9 Nm^2/C^2$
Speed of light in air	$= 3 \times 10^8$ m/s

Some equations you may find useful :

$PV = nRT$ $P_1V_1^{\gamma} = P_2V_2^{\gamma}$ $P = \rho gh$ $a = -kx/m$ $U = (3/2)nRT$ $\eta = (F/A)/(V/L)$

$e = 1 - (T_C/T_h)$ $e = W/Q_h$ $\Delta S = Q/T$ $S = k.\ln\Omega$ $f = (1/2\pi)\sqrt{(k/m)}$ $f = (1/2\pi)\sqrt{(g/L)}$

$a_{max.} = kx_o/m$ $a_c = \omega^2 x_o$ P.E. $= (1/2)kx^2$ $(1/2)kx^2 + (1/2)mv^2 = (1/2)kx_o^2$ $v = f\lambda$

$\omega = \sqrt{(k/m)}$ $v = \pm\sqrt{[(k/m)(x_o^2 - x^2)]}$ $v = \sqrt{(Y/\rho)}$ $\omega = 2\pi f$ area of a sphere $= 4\pi r^2$

$v = \sqrt{[T/(m/L)]}$ $v = \sqrt{(B/\rho)}$ $v = \sqrt{(\gamma RT/M)}$ $f = 1/\tau$ $\rho = (RA)/L$ $E = (1/2)qV$

area of a right cylinder $= 2\pi rl$ $0\ K = 273°C$ $F = (k\ q_1\ q_2)/r^2$ $\mathbf{F} = q\mathbf{E}$ $V_{AB} = Ed$

$C = (\varepsilon_o A)/d$ $\Delta R = R_o\alpha\Delta T$ $qV = (1/2)mv^2$ $W = qV_{AB}$ $q = CV$ $Q = W + \Delta U$

$I_o = 10^{-12}\ W/m^2$ $I(dB) = 10\log(I/I_o)$ $f_n = nf_1$ $\Delta q = mc\Delta T$ $\Sigma\Delta A.E = q_{encl.}/\varepsilon_o$

$f\ /\ f' = [\ 1 - (v_l/v_w)\ ]\ /\ [\ 1 - (\ v_s\ /\ v_w\ )\ ]$ $f' = (\ f.v_w\ )/\ (v_w \pm v_s\ )$ $v_{rms} = \sqrt{(3kT/m)}$

volume of a sphere $= (4/3)\pi r^3$ $f_b = f_2 - f_1$ velocity of sound $= 331.45 + 0.61t$ $\mathbf{F} = q\mathbf{E}$

$f_n = (2n-1)f_1$ $W_{app.} = mg - B.F. = 1/\tau$ $\omega = 2\pi f$ area of a sphere $= 4\pi r^2$ $V_{AB} = Ed$

area of a right cylinder = $2\pi rl$ $W = (1/2)LI_f^2$ $v = v_o\sin(2\pi ft)$ $I = i_o/\sqrt{2}$ $F = qvB_\perp$

$C = (\varepsilon_o A)/d$ $\Delta R = R_o\alpha\Delta T$ $qV = (1/2)mv^2$ $W = qV_{AB}$ $\rho = (RA)/L$ $v = f\lambda$

$\Delta q = mc\Delta T$ $q = CV$ $E = (1/2)qV$ $\Sigma\Delta A.E = q_{encl.}/\varepsilon_o$ $I(t) = I_f(1 - e^{-t(L/R)})$

$P = IV = I^2R$ $F = BIL\sin\theta$ $qvB = mv^2/r$ $B = \mu_o nI$ $B = (\mu_o I)/(2\pi r)$ $B = (\mu_o I)/(2a)$

$F = (\mu_o I_1 I_2 L)/(2\pi b)$ torque = (area)NIBsinθ $V(t) = V_o e^{-t/RC}$ $\sin(2\varphi) = 2\sin\varphi\cos\varphi$

$\varphi = BA\cos\theta$ e.m.f. $= N(\Delta\varphi/\Delta t)$ $X_L = 2\pi fL$ $Z^2 = R^2 + (X_L - X_C)^2$ $X_C = 1/(2\pi fC)$

$V = v_o/\sqrt{2}$ $V = IZ$ $\tan\varphi = (X_L - X_C)/R$ $f_o = (1/2\pi)\sqrt{(1/LC)}$ e.m.f. $= B_\perp vd$

$e.m.f._{sec} = M(\Delta I_p/\Delta t)$ $P = IV\cos\varphi$ e.m.f. $= L(\Delta I/\Delta t)$ $\mu = (\text{area})I$ $B = B_o\sin(2\pi ft)$

$i(t) = i_o e^{-t/RC}$ $q(t) = q_f(1 - e^{-t/\tau})$ $F = qvB_\perp$ $I_1/I_2 = E_2/E_1 = N_2/N_1$ $\Delta q = n.H_f$

$(\text{kinetic energy})_{max.} = (hf - hf_o)$ $E = E_o\sin(2\pi ft)$ $(1/f) = (1/p) + (1/q)$ $I_{avg.} = (1/2)c\varepsilon_o E_o^2$

$B_o = E_o/c$ $E = hf = hc/\lambda$ optical path difference $= 2nL$

Question 1: Sample answers: L (a), M (b) .... [Marks 10 x 2 = 20]
Do not guess the answer; a wrong answer will be awarded negative marks.

A) The amplitude of a sound wave determines its

(a) pitch (b) loudness
(c) overtones (d) resonance

B) The magnitude of a point charge chosen so that the electric field 50 cm away has the magnitude of 2.0 N/C is

(a) 5.6×10^{-11}C. (b) 11.1×10^{-11} C
(c) 1.1×10^{-10} C (d) 5.6×10^{-10} C

C) Which of the combinations of units is **not** equivalent to the farad?

(a) C/V (b) C^2/J
(c) CV^2 (d) J/V^2

D) Thermal energy is to be generated in a 0.10 Ω resistor at the rate of 10 W by connecting it to a battery whose emf is 1.5 V. The potential difference that exists across the resistor is

(a) 1.0 V (b) 1.5 V
(c) 3.0V (d) 6.0 V

E) An ion moves in a circular orbit of radius R in a magnetic field. If the particle's speed is doubled, the orbit radius will become

(a) R (b) R/2
(c) 2R (d) 4R

F) The current in a circuit falls to zero from 16 A in 0.010 sec. The average emf induced in the circuit during the drop is 64 V. The inductance of the circuit is

(a) 0.032 H (b) 0.040 H
(c) 0.25 H (d) 4.00 H

G) The power factor of a circuit in which $X_L = X_C$

(a) is zero
(b) is one
(c) depends on the ratio X_L/X_C
(d) depends on the value of R

H) All real images

(a) can appear on a screen
(b) cannot appear on a screen
(c) are erect
(d) are inverted

I) A certain myopic eye cannot see objects clearly when they are more than 25 cm away. The power of a corrective lens that will enable this eye to see distant objects clearly is

(a) – 0.25 diopters (b) + 0.25 diopters
(c) – 4.0 diopters (d) + 4.0 diopters

J) A beam of 436×10^{-9} m light is incident perpendicular to a glass plate that is 2.0 cm thick and has refractive index of 1.66. How long does it take a point on the beam to pass through the plate?

(a) 0.111×10^{-9} s (b) 1.11×10^{-9} s
(c) 1.80×10^{-9} s (d) 180×10^{-9} s

Q2 (a) About how many times more intense will the normal ear perceive a sound of 10^{-6} W/m^2 than one of 10^{-9} W/m^2 ? [4]

(b) A hawk is flying directly away from a bird watcher and directly towards a distant cliff at a speed of 15 m/s. The hawk produces a shrill cry whose frequency is 800 Hz.

(i) What is the frequency in the sound that the birdwatcher hears directly from the bird?
(ii) What is the frequency that the birdwatcher hears in the echo that is reflected from the cliff? [4 +4]

(c) A particle of mass m and charge – e is projected with horizontal speed v into an electric field of intensity **E** directed downward. Find

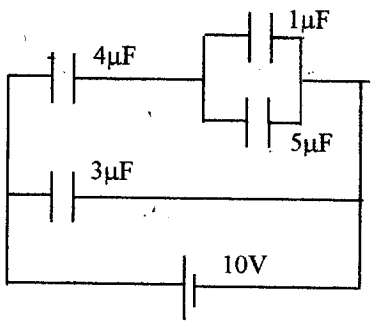
(i) the horizontal and vertical components of its acceleration, $\mathbf{a}_x$ and $\mathbf{a}_y$.
(ii) its horizontal and vertical displacements, **x** and **y** after time t.
(iii) the equation of its trajectory. [8]

Q3 (a) Write short notes on

(i) an equi-potential surface
(ii) the potential difference between two points in space. [4]

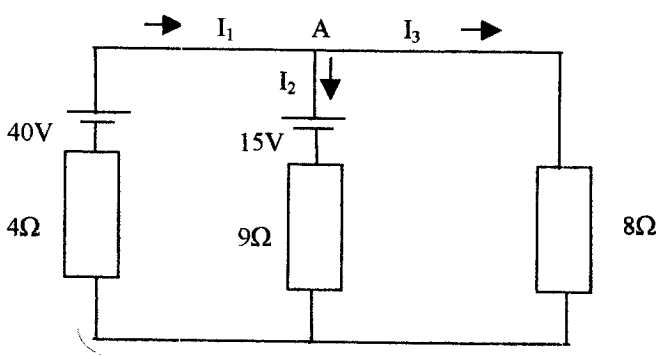
(b) Find the electric potential energy of three point charges placed as follows on the x-axis; +3 μC at x = 0, +4 μC at x = 30 cm and +7 μC at x = 60 cm. Take the electric potential energy to be zero when the charges are far separated. [10]

(c) Find the equivalent capacitance of the combination shown (figure) below and also find the charge on the 4 μF capacitor. [6]



Q4 (a) (i) State Kirchhoff's laws for electric circuits.
(ii) What is an ampere? [2 + 2]

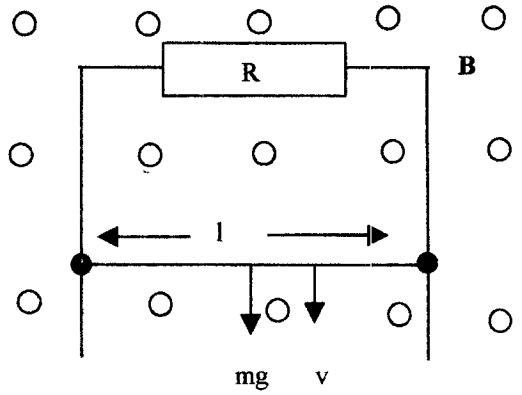
(b) (i) Find the currents I_1, I_2 and I_3 in the figure below.
(ii) Find the potential across the 4Ω resistor. [8]



(c) An electron with an energy of 0.8 eV enters a region of uniform magnetic field 0.30 mT which is perpendicular to the electron's velocity. Find

(i) the radius of the path of the electron
(ii) the energy of the electron in joules after it has traveled 0.10m in the magnetic field. [8]

Q5 (a) A conductor of length l and mass m can slide along a pair of vertical metal guides connected by a resistance R (figure). Friction and resistance of the conductor and the guides are negligible. There is a uniform horizontal magnetic field of strength B normal to the plane of the page and directed outward. Find an expression for the terminal velocity under the influence of gravity in terms of **B**, l, m, g, and R. [8]



(b) An ideal transformer has 550 turns on the primary and 30 turns on the secondary.

(i) What is the maximum output potential difference if the maximum input voltage is 3.3 kV?

(ii) If the transformer is assumed to have an efficiency of 100 %, what maximum primary current is required if a maximum current of 11 A is drawn from the secondary? [6]

(c) A 5μF capacitor is charged to a potential of 20 kV. After being disconnected from the power source, it is connected across a 7 MΩ resistor to discharge.

(i) What is the initial discharge current?

(ii) How long will it take for the capacitor voltage to discharge to 37 % of the 20 kV? [6]

Q6 (a) (i) Define the impedance of a series LRC circuit in terms of the effective voltage and current.

(ii) Define the phase angle between voltage and current. [4]

(b) A circuit has a resistance of 10Ω in series with an inductance of 0.5H. Find the value of the capacitor which, when connected in series in the circuit, will drive maximum current through it. Calculate the potential difference across the resistance, inductance, and the capacitor when the circuit is connected to 220volts, 50Hz a.c. mains. [8]

(c) The impedance of a series LRC circuit at resonance is 8 Ω when the frequency is 60 Hz; the impedance is 10 Ω at 80 Hz. Calculate the values of L and C. [8]

Q7 (a) Define critical angle and find the sine of the critical angle for an air-water interface (n = 1.33 for water). [1 + 3]

(b) A luminous object is placed a distance 40 cm from a screen. A converging lens of focal length 5 cm is used to form an image of the object on the screen. Find the two possible positions of the lens which give a real image on the screen. [10]

(c) A diverging lens is used to form an image that is one third the size of the object. Find the position of the object in terms of the focal length of the lens. [6]

Q8 (a) Define the magnifying power of a lens and show that it is given by

$$M = 1 + \frac{25cm}{f}, \qquad (f \text{ in cm.})$$ [4]

(b) Find the focal length of the reading glasses required by a person whose near point is 90 cm. How far would this person have to hold a book to be able to read it while wearing glasses with a power of 2.0 diopters? [8]

(c) An opera glass is constructed of an objective lens of 8 cm focal length and a diverging eyepiece lens with a focal length of – 6 cm.

(i) How far apart must these lenses be to form a final image of a distant object at infinity?

(ii) What is the angular magnification under these conditions? [8]

END OF EXAMINATION.

The University of Zambia
Physics Department

University Examinations — 1999/2000
P-198 : Introductory Physics II (Option B)

All questions carry equal marks. The marks are shown in brackets.
Question 1 is compulsory. Attempt Four more questions. Clearly indicate which questions you have attempted.
Time : Three Hours. **Maximum Marks = 100.**
Write your computer number clearly on the answer book.

Wherever necessary, use :

g	$= 9.8\ m/s^2$	k	$= 9.0 \times 10^9\ Nm^2/C^2$
speed of sound at 20°C	= 343m/s	charge of electrons	$= 1.6 \times 10^{-19}\ C$
ε_o	$= 8.85 \times 10^{-12}\ C^2/Nm^2$	ρ_{water}	$= 1000 kg/m^3$
1 calorie	= 4.184 J	specific heat of water	= 4184 J/kg.°C
$P_{atm.}$	$= 1.013 \times 10^5$ Pa	m_e mass of electron	$= 9.1 \times 10^{-31}$ kg
μ_o vacuum permeability	$= 4\pi \times 10^{-7}\ N/A^2$	m_p mass of proton	$= 1.67 \times 10^{-27}$ kg
ε_o permittivity constant	$= 8.85 \times 10^{-12}\ C^2/Nm^2$	c speed of light	$= 3 \times 10^8$ m/s
H_f heat of vaporisation of water	= 2200J/g	h Planck's constant	$= 6.62 \times 10^{-34}$ J.s
1eV electron volt	$= 1.6 \times 10^{-19}$J		

Some equations you may find useful :

$A_1v_1 = A_2 v_2$ $PV = nRT$ $P_1V_1^{\gamma} = P_2V_2^{\gamma}$ $P = \rho gh$ $F_D = 6\pi\eta rv$ $N_R = \rho vd/\eta$

$Q = (\pi R^4/8\eta L)(P_1 - P_2)$ $P_1 + (1/2)\rho v_1^2 + \rho gh_1 = P_2 + (1/2)\rho v_2^2 + \rho gh_2$ $a = -kx/m$

$e = 1 - (T_C/T_h)$ $e = W/Q_h$ $\Delta S = Q/T$ $S = k.\ln\Omega$ $U = (3/2)nRT$ $\eta = (F/A)/(V/L)$

$a_{max.} = kx_o/m$ $a_c = \omega^2 x_o$ $P.E. = (1/2)kx^2$ $(1/2)kx^2 + (1/2)mv^2 = (1/2)kx_o^2$ $v = f\lambda$

$\omega = \sqrt{(k/m)}$ $v = \pm\sqrt{[(k/m)(x_o^2 - x^2)]}$ $v = \sqrt{(Y/\rho)}$ $f = (1/2\pi)\sqrt{(k/m)}$ $f = (1/2\pi)\sqrt{(g/L)}$

$v = \sqrt{[T/(m/L)]}$ $v = \sqrt{(B/\rho)}$ $v = \sqrt{(\gamma RT/M)}$ $f = 1/\tau$ $\omega = 2\pi f$ area of a sphere $= 4\pi r^2$

area of a right cylinder $= 2\pi rl$ $0\ K = 273°C$ $F = (k\ q_1\ q_2\ )/r^2$ $\mathbf{F} = q\mathbf{E}$ $V_{AB} = Ed$

$C = (\varepsilon_o\ A)/d$ $\Delta R = R_o\alpha\Delta T$ $qV = (1/2)mv^2$ $W = qV_{AB}$ $\rho = (RA)/L$ $E = (1/2)qV$

$I_o = 10^{-12}\ W/m^2$ $I(dB) = 10\log(I/I_o)$ $f_n = nf_1$ $\Delta q = mc\Delta T$ $q = CV$ $Q = W + \Delta U$

$f / f' = [\ 1 - (v_l/v_w)\ ] / [\ 1 - (\ v_s / v_w\ )\ ]$ $f' = (\ f.v_w\ )/\ (v_w \pm v_s\ )$ $v_{rms} = \sqrt{(3kT/m)}$

volume of a sphere $= (4/3)\pi r^3$ $6\pi\eta a v_T = (4\pi/3)\ a^3(\rho - \sigma\ )\ g$ $f_b = f_2 - f_1$

velocity of sound $= 331.45 + 0.61t$. $\Sigma\Delta A.E = q_{encl.}/\varepsilon_o$ $f_n = (2n-1)f_1$ $W_{app.} = mg - B.F.$

$f = 1/\tau$ $\omega = 2\pi f$ area of a sphere $= 4\pi r^2$ $\mathbf{F} = q\mathbf{E}$ $V_{AB} = Ed$ $F = (k\ q_1\ q_2\ )/r^2$

area of a right cylinder $= 2\pi rl$ $W = (1/2)LI_f^2$ $v = v_o\sin(2\pi ft)$ $I = i_o/\sqrt{2}$ $\mathbf{F} = qvB_{\perp}$

$C = (\varepsilon_o\ A)/d$ $\Delta R = R_o\alpha\Delta T$ $qV = (1/2)mv^2$ $W = qV_{AB}$ $\rho = (RA)/L$ $v = f\lambda$

$\Delta q = mc\Delta T$ $q = CV$ $E = (1/2)qV$ $\Sigma\Delta A.E = q_{encl.}/\varepsilon_o$ $I(t) = I_f\ (1 - e^{-t(L/R)})$

$P = IV = I^2R$ $F = BIL\sin\theta$ $qvB = mv^2/r$ $B = \mu_o nI$ $B = (\mu_o I)/(2\pi r)$ $B = (\mu_o I)/(2a)$

$F = (\mu_o I_1 I_2 L)/(2\pi b)$ torque $=$ (area)NIBsinθ $V(t) = V_o\ e^{-t/RC}$ $\sin(2\varphi) = 2\sin\varphi\cos\varphi$

$\varphi = BA\cos\theta$ $e.m.f. = N(\Delta\varphi/\Delta t)$ $X_L = 2\pi fL$ $Z^2 = R^2 + (\ X_L - X_C\ )^2$ $X_C = 1/(2\pi fC)$

$V = v_o/\sqrt{2}$ $V = IZ$ $\tan\varphi = (\ X_L - X_C\ )/R$ $f_o = (1/2\pi)\sqrt{(1/LC)}$ $e.m.f. = B_{\perp}vd$

$e.m.f._{sec} = M(\Delta I_p/\Delta t)$ $P = IV\ Cos\varphi$ $e.m.f. = L(\Delta I/\Delta t)$ $\mu = (area)l$ $B = B_o\sin(2\pi ft)$

$i(t) = i_o e^{-t/RC}$ $q(t) = q_f\ (1 - e^{-t/\tau})$ $F = qvB_{\perp}$ $I_1/I_2 = E_2/E_1 = N_2/N_1$ $\Delta q = m.H_f$

$(\text{kinetic energy})_{max.} = (hf - hf_o)$ $E = E_o\sin(2\pi ft)$ $(1/f) = (1/p) + (1/q)$ $I_{avg.} = (1/2)c\varepsilon_o E_o^2$

$B_o = E_o/c$ $E = hf = hc/\lambda$ optical path difference $= 2nL$

Question 1 : Sample answers : F(a), G(b) etc. Do NOT guess the answer. A wrong answer will be awarded negative marks. [10 × 2 = 20 marks]

(A) A hollow metal sphere of radius 5cm is charged such that the potential on its surface is 10volts. The potential at the centre of the sphere is

(a) 0 volts (b) same as at point 5cm from the surface
(c) 10 volts (d) same as at point 25cm from the surface.

(B) Four resistances R_1, R_2, R_3, and R_4 are connected in parallel. The resultant resistance is

(a) equal to the sum of the four resistances
(b) greater than the sum of the four resistances
(c) intermediate between the smallest and the largest resistance
(d) less than any of the four resistances.

(C) The magnetic field of a short bar magnet most closely resembles the magnetic field of

(a) a horse-shoe magnet
(b) a current-carrying loop
(c) a straight current-carrying wire
(d) a stream of electrons moving parallel to one another.

(D) A copper ring is held horizontally and a bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet is

(a) equal to that due to gravity
(b) less than that due to gravity
(c) more than that due to gravity
(d) depends on the diameter of the ring and the length of the magnet.

(E) When voltage and current are in phase in an ac circuit, the

(a) reactance is zero (b) resistance is zero
(b) impedance is zero (d) phase angle is 90°.

(F) In a vacuum the speed of an electromagnetic wave

(a) depends on its electric and magnetic fields
(b) is a universal constant
(c) depends on its wavelength
(d) depends on its frequency.

(G) Light goes from medium A to medium B at an angle of incidence of 45°. The angle of refraction is 35°. The speed of light in B

(a) is greater than that in A
(b) is the same as that in A
(c) is less than that in A
(d) may be any of the above, depending on the specific medium.

(H) A concave mirror produces an upright image when the object distance is

(a) equal to f
(b) less than f
(c) greater than 2f
(d) between f and 2f.

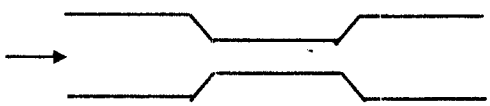
(I) Thin films of oil and soapy water owe their brilliant colours to a combination of reflection and

(a) polarisation
(b) diffraction
(c) refraction
(d) interference

(J) An increase in the brightness of the light directed at a metal surface causes an increase in the photoelectrons'

(a) energy
(b) wavelength
(c) speed
(d) number.

Q2.(a) An oil of density 900kg/m^3 flows through a horizontal pipe having a throat diameter of 5cm. Its entrance diameter is 9cm. The pressure difference between the throat and the entrance is 20cm Hg. Calculate the velocities in the two sections of the pipe. How much oil flows through a cross section of the pipe in one second ? [9]



2(b) The photoelectric threshold for tungsten is 2300×10^{-8}cm. Find the energy (in eV) of the electrons emitted from the surface due to bombardment by ultra-violet light of wavelength $\lambda = 180 \times 10^{-8}$cm. [7]

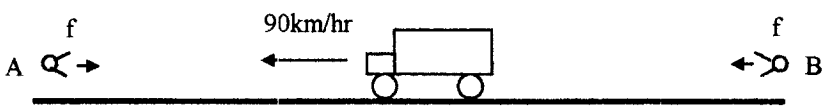
2(c) Write short notes on (i) photoelectric effect, and (ii) work function. [2+2]

Q3.(a) A beam of particles, each of mass m_o and speed v, is directed along the x-axis. The beam strikes an area 2mm^2, with 1×10^{15} particles striking per second. The particles stick to the area when they hit. Find the pressure on the area due to the beam. Evaluate for a beam of protons of velocity 7×10^7 m/s. [9]

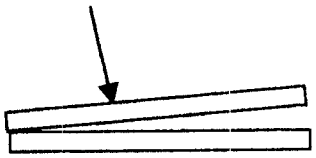
3(b) What spectacles would be required by a long-sighted person whose near point is at 90cm in order that he may be able to read print placed at a distance of 40cm ? Calculate the focal length and the power of the lens ? [7]

3(c) Write short notes on (i) near point, and (ii) far point of the human eye. What are the respective values for a normal eye ? [4]

Q4.(a) Two stationary sources A and B are emitting sound waves of frequency f. An observer in a car is travelling towards A (and away from B) at a speed of 90km/hour. She measures a beat frequency of 25Hz in the interference of the waves from the two sources. Calculate the value of the frequency f. Temperature of air = 25°C. [8]

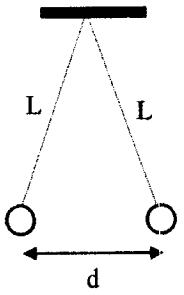


4(b) Two flat glass plates form a very thin air wedge between them. When the combination is viewed with light of wavelength 500nm, a dark fringe exists at the line of contact. What is the thickness of the air wedge at (i) the first bright fringe, and (ii) the third bright fringe ? [8]

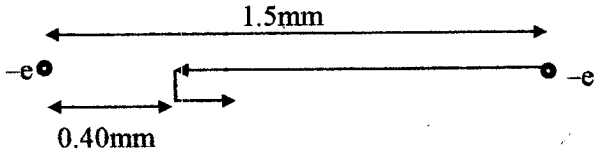


4(c) Explain why (i) Newton's rings interference fringes are circular, and (ii) the centre of the system is normally dark. [4]

Q5.(a) Two tiny conducting balls hang from a support as shown. Each ball has a mass of 1.0g and carries a charge +q. The threads are massless and have a length of 50cm each. At equilibrium the separation d between the two balls is found to be 25cm. Find the value of q. [11]



5(b) A certain electron is at rest. Another electron is projected towards the first electron from a distance of 1.5mm. If the distance of closest approach between the two electrons is 0.40mm, what was the initial speed of the projected electron ? [Hint: you may use conservation of energy]. [9]

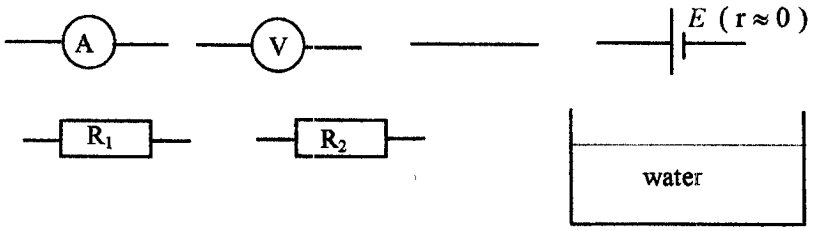


Q6.(a) A converging lens 30cm from a candle produces an inverted image on a screen 30cm on the other side of the lens. A diverging lens is then placed midway between the candle and the converging lens. The image no longer appears on the screen. When the candle is moved back 10cm from its original position (that is, moved 10cm further away from the converging lens), its image reappears on the screen. Find the focal lengths of the two lenses. (Hint : remember the rules for combination of lenses ?) [8]

6(b) The intensity of the e.m. wave from a distant 1.5MHz radio station is 5.0×10^{-10} W/m^2. Calculate the maximum values of the electric and magnetic fields, and hence write the equations for the electric and magnetic field waves in this region. [8]

6(c) Give the names of four different types of e.m. waves. Arrange them in order of increasing frequency. [4]

Q7.(a) Using the symbols given, draw a circuit diagram to show how you could connect the components to heat the water as rapidly as possible. If the emf E = 50volts, and the current through the battery is 5amperes, calculate the total resistance of the circuit and the time in seconds required for all the water to boil away. Given, mass of water = 1000g, room temperature = 20°C. [9]



7(b) A circuit has a resistance of 10Ω in series with an inductance of 0.5H. Find the value of the capacitor which, when connected in series in the circuit, will drive maximum current through it. Calculate the potential difference across the resistance, inductance, and the capacitor when the circuit is connected to 220volts, 50Hz a.c. mains. [8]

7(c) Sketch a typical a.c. voltage or a.c. current curve, showing the peak, average, and r.m.s. values. Relate the r.m.s. value to the peak value in a quantitative way. [3]

Q8.(a) A long straight wire carries a 5.0A current along the positive x-axis; a second wire carries a 6.0A current along the positive y-axis. Find the magnitude and direction of their combined magnetic field at the point x = 6cm, and y = 9cm. [Hint : draw figures to better visualize the situation]. [9]

8(b) A transformer rated at a maximum power of 10kW is used to couple a 5000V transmission line to a 240V circuit.

(i) what is the ratio of turns in the windings of the transformer ?
(ii) what is the maximum current in the 240V circuit ? [7]

8(c) A certain electron does not suffer any deflection while passing through a certain region. Can you say that there is no magnetic field present in the region ? Give a short explanation.

If the electron suffers a deflection, are you sure it is due to a magnetic field only ? Again, give a short explanation ? [4]

— End of Examination —

THE UNIVERSITY OF ZAMBIA

Physics Department

UNIVERSITY EXAMINATIONS –1999/2000

P212

Atomic Physics

TIME: THREE(3) HOURS

ATTEMPT ANY FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

MARKS ARE INDICATED AGAINST EACH QUESTION.

Data

Speed of light in vacuum: $c = 3\times10^{8}\,ms^{-1}$ Electron rest mass, $m_0 = 9.11\times10^{-31}\,kg$

Positron rest mass: $m_0 = 9.11\times10^{-31}\,kg$ Electron charge, $-e = 1.602x10^{-19}\,C$

Rydberg constant $R = 1.0974\times10^{7}\,m^{-1}$ Planck's constant, $h = 6.626x10^{-34}\,J\cdot s$

Boltzmann's constant $k = 1.38x10^{-23}\,JK^{-1}$ Mass of neutron: $m_n = 1.00897u$

Mass of proton: $m_p = 1.00758u$

Avogadro's number: $N_A = 6.023\times10^{23}\,mole^{-1}$

Permittivity of free space, $\varepsilon_0 = 8.854\times10^{-12}\,C^2N^{-1}m^{-2}$

Atomic mass unit: $1u = 1.66\times10^{-27}\,kg \equiv 931MeV$

$1eV = 1.602\times10^{-19}\,J$

Acceleration due to gravity: $g = 9.8ms^{-2}$

$$E = h\nu,\ E = mc^2,\ mvr = n\frac{h}{2\pi},\qquad \lambda = \frac{h}{p} = \frac{h}{mv},\ N = N_0e^{-t\lambda},\qquad \Delta\lambda = \lambda' - \lambda = \frac{h}{m_0c}(1-\cos\theta),$$

$$\tfrac{1}{2}m_0v_{max}^2 = h\nu - \phi = eV_S$$

n	$\int_0^\infty x^n e^{-ax^2}dx$ $\int_0^\infty x^n e^{-ax^2}dx$
0	$\frac{1}{2}\sqrt{\frac{\pi}{a}}$
1	$\frac{1}{2a}$
2	$\frac{1}{4}\sqrt{\frac{\pi}{a^3}}$

3	$\frac{1}{2a^2}$
4	$\frac{3}{8}\sqrt{\frac{\pi}{a^5}}$
5	$\frac{1}{a^3}$

$$\int_0^\infty \frac{x^3}{e^x - 1} dx = \frac{\pi^4}{15}$$

$$e^x - 1 \approx x, x << 1$$

$$e^x - 1 \approx e^x, x >> 1$$

Q.1

(a) Examine and briefly discuss the following postulates in the light of modern knowledge of atomic physics pointing out the extent to which they are true or false

(i) Matter cannot be divided indefinitely into smaller and smaller parts. At a certain stage it will be found to consist of very small sub-microscopic entities called atoms which cannot be divided any further. [2]

(ii) All the atoms of a particular chemical element have identical properties such as mass. [2]

(b) An atom in a certain mechanical mode can absorb energy freely at an absolute temperature T. The probability that an atom will absorb an energy $E_k = \frac{1}{2}mv_k^2$ is

$$p = Ae^{-E_k/kT} = Ae^{-mv_k^2/2kT}$$

where m is the mass of the atom and v_k is the velocity of the atom. Since $0 < p < 1$, A is a constant that can be found from

$$\int_{-\infty}^{\infty} p dv_k = 1$$

(i) Evaluate the constant A [4]

(ii) Find the average velocity of the atoms. [4]

(iii) Find the average value of E_k [4]

(iv) Find the effective or root-mean square speed of the atoms. [4]

Q.2

Given Planck's function for the spectral flux density distribution,

$$\Psi(\lambda, T) = \frac{a}{\lambda^5 (e^{b/\lambda T} - 1)}$$

(a) Determine the condition for which the given distribution reduces to

(i) Raleigh's spectral flux density distribution function, and [2]

(ii) What is the corresponding expression? [3]

(iii) Wien's spectral flux density distribution function, and [2]

(iv) What is the corresponding expression? [3]

(b) Show that integrating Planck's function over all wavelengths evaluates to $W = \sigma T^4$, and hence [6]

(c) Determine the value of σ, given $a = 3.7405 \times 10^{-16} Wm^2$ and $b = 1.4388 \times 10^{-2} mK$ [4]

Q.3

(a) Explain what is meant by wave-particle nature of light. [3]

(b) The photoelectric work function of a certain metal is $2eV$. If light of wavelength 3600 $\mathring{A}$ .falls on the metal surface, find

(i) the velocity of the most energetic of the ejected electrons, [3]

(ii) the threshold frequency, ν_0, and [3]

Q. 3 (continued)

(iii) the stopping potential, V_s [3]

(c) An x-ray photon of wavelength 0.15 $\mathring{A}$ undergoes Compton collision and is scattered through an angle of 60°. Calculate :

(i) The energies of the scattered photon and the ejected electron. [3+3]

(ii) The momentum of the scattered photon. [2]

Q.4

(a) State Pauli's exclusion principle [2]

(b) List the quantum numbers that an atomic electron can have by symbol and range of values. [6]

(c) Adapt the Bohr theory to the He ion, which has two protons and two neutrons in the nucleus and an orbital electron.

(i) What is the ratio of the radius of the nth orbits in He and H? [4]

(ii) Derive the expression for the energy levels, assuming an atom with atomic number Z. [4]

(iii) What is the ratio of E_n for He and H? [4]

Q.5

(a) What is Heisenberg uncertainty principle? [2]

(b) Explain how the Heisenberg principle affects the uncertainty of the atomic radius given the uncertainty in the determination of the velocity of the orbital atomic electron [2]

(c) Derive Heisenberg's relation for the uncertainty in the measurement of time Δt and energy ΔE. [4]

(d) The electron in the hydrogen atom is confined within a region of space of diameter of about $10^{-10} m$.

(i) Approximately what is the minimum value of the uncertainty in the velocity? [4]

(ii) What is the corresponding minimum value of the uncertainty in its kinetic energy, and [4]

(iii) What is the uncertainty in its period of orbit around the nucleus? [4]

Q.6

(a) What is the difference between natural and artificial radioactivity? [4]

(b) State the three important types of radiation emitted in radioactive decay and write down the equation depicting the decay process in each case. [6]

(c) Define half-life as applied to nuclear ~~day~~ decay, and hence [2]

(d) Show that the half-life can be expressed as

$$t_{1/2} = \frac{ln2}{\lambda}$$

where λ is the decay constant. [4]

(e) A certain radioactive element has a half-life of 10^9 years. At time $t = 0$ it emits 10^6 α-particles per second. How many α-particles will it emit

Q. 6 (continued)

per second after a passage of time of

(i) 2×10^{9} years [2]

(ii) 10^{10} years [2]

Q.7

(a) What is

(i) mass defect [2]

(ii) nuclear fusion [2]
as applied to nuclei

(iii) Explain why in the lighter nuclei there are about as many neutrons as protons whereas for the heavier nuclei there are more neutrons than protons [4]

(b) The polonium isotope $_{84}Po^{210}$ is unstable and emits a $5.30MeV$ α-particle ($_{2}He^{4}$). The atomic mass of $_{84}Po^{210}$ is $209.9829u$ and that of $_{2}He^{4}$ is $4.0026u$. The product of the decay is lead, Pb.

(i) Find the velocity of the α-particle [4]

(ii) Write down the equation of the reaction. [2]

(iii) Find the atomic mass of Pb. [6]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT

UNIVERSITY EXAMINATION - DEC. 2000

PROPERTIES OF MATTER AND THERMAL PHYSICS

P231

TIME: THREE (3) HOURS

ANSWER ANY FIVE QUESTIONS

QUESTION 1.

1(a) Show that, if a clean narrow-bore glass tube is placed vertically with one end below the surface of a liquid, the height h of this capillary ascent is given by the formula:

$$h = \frac{2T\cos\theta}{r\rho g}$$ (10 Marks)

where T is the surface tension of the liquid,

ρ is the density 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 measured through the liquid.

1(b) In an experiment to measure the surface tension of water (7×10^{-2} N m^{-1}), a tube of average radius 0.1 mm is placed vertically in the water so that a length of 12 cm is out of the water. Give an explanation as to what will happen. (5 Marks)

1(c) A capillary tube of internal diameter 0.001 m and external diameter 0.005 m hangs vertically from the arm of a balance, the lower end of the tube being in a liquid of surface tension 39.24 N/m. Assuming that the liquid wets the tube, what is the change in the apparent weight of the tube due to the surface tension? (g = 9.81 m/second^2). (5 Marks)

QUESTION 2.

2(a) Define coefficient of viscosity and derive its dimensions in terms of length, mass and time. (3 Marks)

2(b) A flat plate of an area 0.001 m^2 is separated from a large plate by a layer of glycerine 0.001 m thick. If the coefficient of viscosity of glycerine is 2 kgm^{-1} s^{-1} what force is required to keep the plate moving with a uniform velocity of 0.01 m per second? (5 Marks)

2(c) Show that the relationship between pressure and velocity at different parts of a fluid in motion is given by the formula:

$$P + h\rho g + \frac{1}{2}\rho v^2 = k$$

Where P is the pressure in the fluid

k is a constant

v is the velocity of the fluid

g is the acceleration due to force of gravity. (8 Marks)

2(d) Water flows along a horizontal pipe of non-uniform cross-section. The pressure at a point is 0.01 m of mercury, and the velocity is 0.35 m/s. Find the pressure at a point where the velocity is 0.65 m/s.

(4 Marks)

QUESTION 3

3(a) Explain the terms: stress, strain, Young's modulus, and bulk modulus.

(5 Marks)

3(b) The breaking stress of aluminium is 7.3575×10^{10} N/m^2 and that of copper 2.1582×10^{11} N/m^2. Find the maximum lengths of the two wires that could be hung vertically without breaking. Density of aluminium = 2700 kg/m^3 and of copper = 8900 kg/m^3. (5 Marks)

3(c) Show that a small and uniform strain v is equivalent to three linear strains $v/3$ in any three perpendicular directions. (5 Marks)

3(d) Assuming Hooke's law holds, establish an expression for the work done in stretching a wire through 0.01 m. (5 Marks)

QUESTION 4

4(a) Show that the deflection δ at the free end of a uniform loaded cantilever of length L clamped horizontally at one end is given by:

$$\delta = \left(\frac{W + \frac{3}{8} W_1}{3Y I_g} \right) L^3$$

where W is the load

W_1 is the weight of the cantilever.

L is the length of the cantilever

Y is the Young's modulus of the material of the cantilever,

I_g is the geometrical moment of inertia of the material of the cantilever. (10 Marks)

4(b) A uniform rod 1.20 m long is clamped horizontally at one end. A weight of 0.1 kg is attached to the free end; calculate the depression of a point 0.9 m distant from the clamped end. The diameter of the rod is 0.02 m. Young's modulus for the material of the rod is 9.93753×10^{12} N/m^2 and g = 9.81 m/sec^2. (10 Marks)

QUESTION 5

5(a) Explain what is understood by the terms:

(i) longitudinal stress.

(ii) tangential stress and

(iii) shear strain (5 Marks)

5(b) Derive an expression for the bending moment of a rectangular plate. (5 Marks)

5(c) Show that the bending moment of a rectangular beam under deforming forces is given by YI_g/R, where R is the radius of curvature, I_g is the geometrical moment of inertia of the material of the beam and Y is the Young's modulus of material of the beam. (10 Marks)

QUESTION 6

6(a) Show that, using the postulates of kinetic theory of gases, pressure is given by:

$$P = \frac{N m \overline{c^2}}{3V}$$

where N is the number of molecules

m is the mass of each molecule

$\overline{c^2}$ is the mean square velocity of the molecule. (10 Marks)

6(b) A high altitude research balloon contains helium gas. At its maximum altitude of 20 km, the outside temperature is -50°C and the pressure has dropped to 40 mm of H_g. The volume of the balloon at this location is 800 m^3.

(i) Assuming the helium has the same temperature and pressure as the surrounding atmosphere, find the number of moles of helium in the balloon. (5 Marks)

(ii) Find the mass of the helium and the volume of the balloon when it was launched from the ground at standard pressure and temperature. (5 Marks)

QUESTION 7

7(a) Show that the pressure at any moment during an adiabatic expansion of an ideal gas is given by:

$$PV^{\gamma} = k$$

where γ and k are constants. (5 Marks)

7(b) Show that the elasticity of volume for a gas under isothermal conditions is equal to its pressure. (5 Marks)

7(c) Derive an expression for the heat equivalent of the mechanical work done in an isothermal expansion of a gas. (5 Marks)

7(d) Calculate the amount of work required to compress isothermally 2 g of oxygen, initially at STP, to one half its original volume. (Assume that oxygen behaves as an ideal gas). (5 Marks)

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
UNIVERSITY EXAMINATIONS 1999/2000

P252
CLASSICAL MECHANICS II

DURATION: Three (3) hours

INSTRUCTIONS: Answer only four (4) questions in total . Attempt at least one (1) question from each section.
All questions carry equal marks.

MAXIMUM MARKS: 100

Use, where necessary:

$g = 9.8 \text{ m/s}^2$

$$\ddot{x} = \frac{d^2x}{dt^2} = D^2x, \qquad \dot{x} = \frac{dx}{dt} = Dx$$

$$\frac{d}{dt}\frac{\partial L}{\partial \dot{q}_k} = \frac{\partial L}{\partial q_k} + Q_k^{'}$$

$$H = \sum_k p_k \dot{q}_k - L$$

SECTION I

Q1. (a). (i) Explain why simple harmonic motion is called sinusoidal motion. Give the equation for a sinusoidal motion and explain the quantities in it. **(5)**

(ii) Point out what causes the restoring force in the case of a simple pendulum and explain why the motion is only approximately simple harmonic. **(5)**

(b). The end of one of the prongs of a tuning fork that executes simple harmonic motion of frequency 1000 Hz has an amplitude of 0.40 mm. Find

(i) the maximum acceleration and maximum speed of the end of the prong and **(5)**

(ii) the acceleration and the speed of the end of the prong when it has a displacement 0.20 mm. **(5)**

(iii) Express the end's position as a function of time if it is at equilibrium when $t = 0$. **(5)**

Q2. (a). Using the D-operator method, find the general solutions of the equations

$$(i) \qquad m\ddot{x} + c\dot{x} - kx = 0$$

$$(ii) \qquad m\ddot{x} - c\dot{x} + kx = 0$$

Discuss the physical interpretations of these equations and their solutions, assuming that they are equations of motion of a particle. (***Hint***: Using the D-operator method, the general solution of a second-order homogeneous differential equation is given by

$$x(t) = Ae^{D_1 t} + Be^{D_2 t}$$

where D_1 and D_2 are the roots of the resulting auxillary equation.) **(15)**

(b). It is desired to design a bathroom scale with a platform deflection of 2.54 cm under a 90 kg man.

(i) If the motion is to be critically damped, find the required spring constant k and the damping constant c. **(3)**

(ii) Show that the motion will then be over-damped for a lighter person. **(4)**

(iii) If a 90 kg man steps on the scale, what is the maximum upward force exerted by the scale platform against his feet while the platform is coming to rest? **(3)**

SECTION II

Q3. (a). Describe what is meant by

(i) generalised coordinates, **(4)**

(ii) generalised velocities, and **(4)**

(iii) ignorable coordinates. **(4)**

(b). A uniform solid cylindrical drum of mass M and radius a is free to rotate about its axis, which is horizontal. A cable of negligible mass and length l is wound on the drum, and carries on its free end a mass m.

(i) Write down the Lagrangian function in terms of an appropriate generalised coordinate, assuming no slipping or stretching of the cable. **(8)**

(ii) If the cable is initially fully wound up, and the system is released from rest, find the angular velocity of the drum when it is fully unwound. **(5)**

Q4. (a). What is the essential difference between the Lagrangian and Hamiltonian formulations of mechanics? **(6)**

(b). The Lagrangian of a system of one degree of freedom can be written as

$$L = \frac{1}{2}m(\dot{q}^2 \sin^2 \omega t + \dot{q}q \sin 2\omega t + q^2\omega^2)$$

(i) What is the corresponding Hamiltonian? **(6)**

(ii) Is it conserved? **(2)**

(c). Introduce a new coordinate defined by

$$Q = q \sin \omega t$$

(i) Find the Lagrangian in terms of the new coordinate and the corresponding Hamiltonian. **(9)**

(ii) Is H conserved? **(2)**

SECTION III

Q5. (a). Suppose that the speed of light were only 20 m/s, and all the relativistic results applied when this speed was used for c. Discuss how our lives would be changed. **(5)**

(b). (i) First show that the equations describing a rotation of coordinates (x,y) through an angle θ are

$$x' = x\cos\theta + y\sin\theta$$
$$y' = -x\sin\theta + y\cos\theta$$

(10)

(ii) Then show that the Lorentz transformations corresponds to a rotation of coordinates (x,ict) through an angle

$$\theta = \tan^{-1}(i\beta)$$

where $\beta = v/c$. **(10)**

Q6. (a). A cube has an edge length of 4.0 cm when at rest. It is set in motion with a high speed at $0.82c$ parallel to one of its edges.

(i) What shape would it appear to have to a stationary observer? **(4)**

(ii) What will its observed volume be as it hurtles through the laboratory? **(7)**

(b). Two spaceships, each measuring 100 m its own rest frame, pass by each other travelling in opposite direction. Instruments on spaceship A determine that the front end of spaceship B requires 5×10^{-6} s to traverse the full of A.

(i) What is the relative velocity of the two spaceships? **(8)**

(ii) A clock in the front end of B reads exactly one o'clock as it passes by the front end of A. What will the clock read as it passes by the rear end of A? **(6)**

@@@@@@@@ END OF THE EXAMINATION @@@@@@@@@@

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS

UNIVERSITY EXAMINATIONS - 1999/ 2000

P272- GEOMETRICAL AND PHYSICAL OPTICS

TIME: **THREE HOURS**

ANSWER: **FIVE QUESTIONS.**
ALL QUESTIONS CARRY EQUAL MARKS

MAX. MARKS: **100**

Q1. (a) Discuss Fermats' principle and deduce the relation

$$\frac{\mu_2}{V} - \frac{\mu_1}{U} = \frac{(\mu_2 - \mu_1)}{R}$$

for refraction at a spherical surface. (10 Marks)

(b) A converging lens, with radii of curvature 20cm and 30cm respectively and made of glass with refractive index 1.52, has water of refractive index 1.33 on its concave side and air of refractive index 1 on its convex side. If an object is placed 120cm from the convex side, find the position of the image with respect to the lens.
(5 Marks)

(c) Find the radius of curvature of a convex surface if the distances of the object and virtual image from it are 5cm and 15cm respectively and the angles of incidence and refraction of ray of light passing from air of refractive index 1 into a convex surface of refractive index 1.52 are 60° and 45° respectively. (5 Marks)

Q2. (a) Derive an expression for the equivalent focal length of two thin lenses separated by a distance d. (10 Marks)

(b) Two thin lenses of focal length 20cm and 60cm respectively are placed in contact. Find the

(i) ~~Find the~~ focal length of the combination
(ii) ~~Find the~~ focal length of a third lens placed in contact with those two that would result in an overall focal length of equal to -40cm (5 Marks)

(c) ~~Find the~~ equivalent focal length of an optical system consisting of a thin converging lens of focal length 12cm placed 6cm in front of another thin converging lens of focal length 24cm.
(5 Marks)

Q3. (a) Define the cardinal points of a lens system with the help of suitable diagrams. (10 Marks)

(b) Two thin converging lenses of focal lengths 50cm and 20cm are placed coaxially in air and are separated by a distance of 30cm. Determine the positions of the cardinal points. Show them in a diagram. (5 Marks)

(c) For a combination of two lenses, show that $f = \sqrt{x_1 x_2}$ where x_1 and x_2 are the respective distances of the object and image from the first and second focal points. (5 Marks)

Q4. (a) Derive an expression for the focal length of a thick convex lens in air of radii of curvature R_1 and R_2 respectively and thickness t. (15 Marks)

(b) A double convex lens of refractive index 1.5 has radii of curvature 10cm and thickness 5cm. Find its focal length. (5 Marks)

Q5. (a) Derive an expression for the axial chromatic aberration of a thin lens and the diameter of the circle of least confusion for an object kept on the axis. (7 Marks)

(b) Deduce the conditions for achromatism in case of two thin lenses of focal lengths f_1 and f_2 when they are placed in contact. (7 Marks)

(c) Derive an expression for achromatic condition in two thin lenses of separation x. (6 Marks)

Q6. (a) Discuss the conditions for minimum and maximum interference pattern in respect of modified Young's experiment. (10 Marks)

(b) Young's experiment is performed with light of the green mercury line. When the fringes are measured with a micrometer eyepiece 80cm behind the double slit, it is found that 20 of them occupy a distance of 10.92 mm from the centre of the slits. Find the wavelength of the light. (5 Marks)

(c) In Young's double slit experiment the separation of the slits d is 0.03cm and the distance from slits to the screen D is 1 metre. A very thin sheet of transparent material of thickness t = 0.05mm and index of refraction $\mu = 1.5$ is placed over the upper slit. Find the shift in the fringes. (5 Marks)

Q7. (a) A Fresnel bi-prism with apex angles of 130 is used to form interference fringes. The refractive index is 1.52. Find the fringe separation for red light of wavelength 656nm when the distance between the slit and the prism is 20cm and that between the prism and the screen 80cm. (7 Marks)

(b) A soap film 5 x 10^{-5}cm thick with refractive index 1.33 is viewed at an angle of 35 degrees to the normal. Find the wavelengths of light in the visible spectrum which will be absent from the reflected light. (7 Marks)

(c) In a Newton's rings experiment the diameter of the 15^{th} ring was found to be 0.59cm and that of the 5^{th} ring was 0.336cm. If the radius of the plano-convex lens is 100cm, calculate wavelength of light used. (6 Marks)

Q8. (a) The fringes for light of wavelength 500nm with Fresnel bi-prism are obtained 0.2mm apart at distance 1.75m from the prism. The prism is made of glass of refractive index 1.5 and is 0.25m from the slit. Calculate the angle at the vertex of the prism. (7 Marks)

(b) Newton's rings are formed by reflected light of wavelength 589.5nm with a liquid between the plane and the curved surfaces. If the diameter of the 5^{th} bright ring is 3mm and the radius of curvature of the curved surface is 100cm, calculate the refractive index of the liquid. (7 Marks)

(c) If fringe width with wavelength 589nm is 0.431mm and shift of white central fringe on introducing a mica sheet in one of the beams is 1.89mm, calculate the thickness of mica sheet (μ = 1.59). On introducing a 7μm thick mica sheet the central white fringe shifts to a position normally occupied by the 7^{th} bright fringe from the centre. Find the wavelength of light. (6 Marks)

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS-1999/2000
P302: Computational Physics-I

Time: Three Hours. **Max. Marks:** 100

Answer: (i) Question One is Compulsory.
(ii) Any Three questions from 2,3,4,5 and 6.

All questions carry equal marks.
(Marks for each question are shown in the square brackets).

Instruction: *Whenever necessary, use the information given in the Appendix.*

Q.1: **(A)** Identify the errors if any in the following **[5]**

(i)
```
Z = (-A) ^ B
```

(ii)
```
REM this is an example.
INPUT A,B,C
CALL  SUB(P,Q,R,S)
PRINT S
END
```

(iii)
```
SUM=0.0
FOR J%=1 T0 10
INPUT R
SUM=SUM+R
IF X<0 THEN
R=R+1
NEXT J%
ENDIF
PRINT SUM
END
```

(iv)
```
DIM A(10), B$(4,6)
FOR I%=1 TO 4
  FOR J%=1 TO 6
        X(I%,J%)=A(J%)+B$(I%,J%)
  NEXT J%
NEXT I%
```

(v)
```
DATA 2.5 , 1.5E+06 , MARK$
```

(B) Translate the following expressions into BASIC statements. **[2]**

(i) $(1-x)^{-n}$ for $n>2$ and $x \neq 1$

(ii) $$1+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{z}}}$$

(C) Explain the differences between **[3]**

(i) STOP and END,
(ii) Subroutine and Function Subroutine,
(iii) INPUT and READ.

(D) Write a program to sum the series **[5]**

$$\sum_{i=0}^{10} \frac{(-i)^i \, 5^i}{i!}$$

(E) Write a program to read the following data from the default device and to write it on a file with the name "**EX1.DAT**" . **[5]**

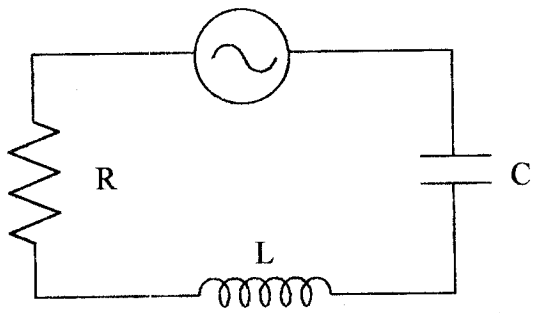
```
1234 , "phiri"   , 40
1567 , "jones"   , 55
1679 , "chanda"  , 25
1856 , "banda"   , 72
1058 , "solo"    , 35
```

(F) An electric power distribution company charges its domestic consumers as follows: **[5]**

Consumer Units	**Rate of Charge**
0- 200	K100 per unit
201-400	K150 per unit plus K5000 as excess charge.
401- 600	K200 per unit plus K7000 as excess charge.
600 – above	K300 per unit plus K10000 as excess charge.

Write a program that reads the customer number and power consumed from the default device and prints the amount to be paid by the customer on the default device.

Q.2: A resonant electric circuit is shown



Natural frequency of the circuit is given by

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \quad \text{and}$$

half width or selectivity is given by $\Delta f = \frac{1}{4\pi R}$

The voltage across the resistor is given by

$$V_R(f) = V_0 \left[1 + \frac{(f^2 - f_0^{\,2})}{f^2 \Delta f^{\,2}}\right]^{-1/2}$$

Assume $L = 5.0\ \mu H$ and $V_0 = 9.0$ Volts.

Write a program to compute and print the output on an output file **"RLC.OUT"** ,

(i) C for $f_0 = 5.0$ MHz, **[2]**

(ii) R_1 for half width $\Delta f = f_0 / 5$, R_2 for half width $\Delta f = f_0 / 20$ and R_3 for half width $\Delta f = f_0 / 80$, **[5]**

(iii) $V_R(f)$ for the three resistances calculated in (ii) for frequencies from 10 MHz to 80 MHz with increments of 0.5 MHz. **[12]**

(iv) Print f and $V_R(f)$ for each of the resistances in a tabulated form on the output file. **[6]**

Q.3: One parameter least square fit to a straight line $y = mx$ is given by

$$m = \frac{S_{xy}}{S_{xx}} \quad \text{and the uncertainty} \quad \Delta m = \frac{1}{\sqrt{S_{xx}}}$$

where $S_{xy} = \dfrac{\sum_{j=1}^{N} x_j y_j}{\sum_{j=1}^{N} \Delta y_j^{\,2}}$ and $S_{xx} = \dfrac{\sum_{j=1}^{N} x_j^{\,2}}{\sum_{j=1}^{N} \Delta y_j^{\,2}}$

Here Δy_j is a measurement error on y_j , and $j = 1.....N$, where N is the total number of data points.
Assume that the data is available on an input file with the name **"LEAST.DAT"** for 10 points with each row corresponding to x , y and Δy respectively.

Write a program to
(i) read the data from the input file, and **[5]**
(ii) to calculate m and Δm . **[20]**

Q.4: An object with mass m is dropped from a height S_0 . The height S(t) of the object after t seconds is given by the non-linear equation ,

$$S(t) = S_0 + \frac{mg}{k} t \; - \frac{m^2 g}{k^2} [\, 1 - \exp(-kt/m) \,]$$

where $g = 9.8 \text{ m s}^{-2}$,
$k = 0.05 \text{ kg s}^{-1}$ = co-efficient of air resistance .

Consider a mass $m = 0.1$ kg , and $S_0 = 50$ m .

Write a (i) pseudo code and then **[10]**
(ii) a program **[15]**
to find, within 0.01 s precision, the time it takes for the mass m to hit the ground.

Q.5: A particle of mass m moving through a fluid is subjected to a viscous resistance R , which is a function of velocity v. The time t required for the mass to slow down from velocity $v(t_0)$ at time t_0 to velocity v(t) at time t is given by the relationship

$$t = m \int_{v(t_0)}^{v(t)} \frac{1}{R(u)} \, du$$

For a particular fluid, it is given that $R(v) = -v^{3/2}$, where R is in Newtons and v is in ms^{-1}.

For a solid mass $m = 10$ kg , $v(t_0 = 0) = 10$ ms^{-1} , write

(i) a pseudo code and then **[10]**
(ii) program **[15]**

to estimate the time required to a precision of 0.01 s for the solid to slow down to $v(t) = 5$ m s^{-1} .

Q.6: The downward acceleration a of a falling spherical object of radius r is given by

$$a = g - \frac{1}{2} C \varrho \frac{\pi r^2}{m} v^2$$

where m = mass of the falling object , $g = 9.8$ ms^{-2} ,
C = 0.46 = drag coefficient due resistance of air ,
ρ = density of air = 1.2 kg m^{-3} ,
v = velocity of the object and $a = \frac{dv}{dt}$ = acceleration.

Assume that $v = 0$ at $t = 0$.

Write a program to

(i) input the data r and m from the default device, **[1]**
(ii) calculate acceleration a and velocity v from time t =0 to 1 s in steps of 0.1 s, **[18]**
(iii) write the output on an output file " **FALLBODY.OUT**" in a tabulated form showing values t , a(t) and v(t) . **[6]**

Hint: Use the Euler's method to solve the differential equation.

@@@@END OF EXAMINATION @@@

APPENDIX

1. Non-Linear Equations:

Newton-Raphson Method:

$$x_n = x_{n-1} - \frac{f(x_{n-1})}{f'(x_{n-1})} \qquad \text{where} \quad f'(x) = \frac{df}{dx}$$

2. Integration:

(a) Trapezoidal Rule:

$$\int_a^b f(x)dx = 0.5h\left[f(a) + f(b) + 2\sum_{j=1}^{m-1} f(x_j) \right]$$

with $x_j = a + j\,h \quad , \; j = 1,2,3.....m-1$

and $f(x_0) = f(a)$, $f(x_m) = f(b)$.

(b) Simpson Rule:

$$\int_a^b f(x)dx = \frac{h}{3}[f(a) + f(b) + 4(f_1 + f_3 + f_5 + ... + f_{2n-1}) + 2(f_2 + f_4 + f_6 + ... + f_{2n-2})]$$

with $f(x_0) = f(a)$, $f(x_{2n}) = f(b)$ *and* $f_i = f(x_i)$.

(c) Monte Carlo Method:

$$\int_a^b f(x)dx = \frac{(b-a)}{N} \sum_{i=1}^{N} f(x_i)$$, where N corresponds to total number of random numbers considered.

3. Solution of First Order Differential Equation with initial Conditions:

The equation is of the form $\frac{dy}{dx} = f(x, y)$ with the given initial boundary condition $y(x_0) = \alpha$.

(i) Euler's Method:

$$y_{i+1} = y_i + h f(x_i, y_i) \qquad \text{where} \quad h = x_{i+1} - x_i$$

(ii) Fourth Order RK-Method:

$$y_{i+1} = y_i + (k_1 + 2k_2 + 2k_3 + k_4)/6$$

where

$k_1 = h f(x_i, y_i)$
$k_2 = h f(x_i + 0.5\,h, y_i + 0.5\,k_1)$
$k_3 = h f(x_i + 0.5\,h, y_i + 0.5\,k_2)$
$k_4 = h f(x_i + h, y_i + k_3)$ *and* $h = x_{i+1} - x_i$

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS 1999/2000
STATISTICAL AND THERMAL PHYSICS
P332

TIME: THREE HOURS
ANSWER: ANY FOUR QUESTIONS
TOTAL MARKS: 100

---

1. **(a)** **(i)** Explain the difference between macroscopic parameters and external parameters. Give four examples of the former and two of the latter. [4]

(ii) Show that the generalised force conjugate to the volume V is the mean pressure $\bar{p}$. [4]

(b) From first principles, show that the number of states of a classical ideal monatomic gas consisting of N identical atoms in a volume V in the energy range from E to $E + \delta E$ is

$$\Omega = BV^N E^{3N/2} \qquad [13]$$

(i) Hence obtain the equation of state for such a gas. [2]

(ii) Establish that the internal energy of the gas is a function of the absolute temperature only. [2]

2. **(a)** Briefly sketch the theory of specific heat in crystalline solids and use the equipartition result

$$\overline{bp_i^2} = \overline{cq_j^2} = \frac{kT}{2}$$

to obtain the classical result for the specific heat of a solid consisting of N atoms. [10]

(b) A particle is in equilibrium with a heat reservoir at absolute temperature T. Show that the probability that it is in the state of energy ϵ_r is

$$P_r = \frac{e^{-\beta\epsilon_r}}{\sum_r e^{-\beta\epsilon_r}} \qquad [5]$$

(c) **(i)** An assemblage of N particles is in equilibrium with a heat reservoir at absolute temperature T. If only the states $\epsilon_1 = 0$ and $\epsilon_2 = \varepsilon$ are accessible to the particles, show that the heat capacity at constant volume of the particles is

$$C_V = \frac{Nkx^2e^{-2x}}{(1+e^{-x})^2} \qquad [10]$$

where $x = \beta\epsilon$.

3. **(a)** Given that the partition function of any system is

$$Z = \sum_r e^{-\beta E_r}$$

prove the following:

(i) The mean energy of the system is

$$\overline{E} = -\frac{\partial \ln Z}{\partial \beta} \qquad [3]$$

(ii) The mean pressure of the system is

$$\overline{p} = \frac{1}{\beta}\frac{\partial \ln Z}{\partial V} \qquad [5]$$

(iii) The entropy of the system is

$$S = k(\ln Z + \beta \overline{E}) \qquad [5]$$

(iv) The Helmholtz free energy of the system is

$$F = -kT \ln Z \qquad [3]$$

(b) The partition function of a real gas of N molecules in a volume V in equilibrium at temperature T is given by

$$Z = A\left(\frac{V - Nb}{N}\right)^N \left(\frac{2\pi mkT}{h^2}\right)^{3N/2} \exp\left(\frac{N^2 a}{VkT}\right)$$

where A is a constant and a and b are small positive constants.

(i) Obtain the equation of state of this gas. [3]

(ii) Obtain the mean energy, the entropy and the Helmholtz free energy of this gas. [4]

(iii) In what limit does this gas behave like an ideal gas? [2]

4. (a) In a monatomic crystalline solid, each atom can occupy either a regular lattice site or an interstitial site. The energy of an atom at an interstitial site exceeds the energy of an atom at a lattice site by an amount ϵ. Assume that the number of interstitial sites equals the number of lattice sites, and also equals the number of atoms N.

(i) Show that the number of ways in which exactly n atoms can occupy interstitial sites is

$$\Omega = \left[\frac{N!}{n!(N-n)!}\right]^2 \qquad [5]$$

(ii) Hence obtain the entropy of the crystal when exactly n of the atoms occupy interstitial sites. [2]

(iii) Obtain the probability that exactly n atoms occupy interstitial sites. [5]

(b) A molecule is capable of translation, rotation and vibration. Hence, its energy is due to all these modes of motion. In addition, there is a contribution due to the motion of the electrons. In a first approximation, the interaction between these modes of motion is neglected, and the total energy of the molecule is

$$\epsilon_{tot} = \epsilon_t + \epsilon_r + \epsilon_v + \epsilon_e$$

where the subscripts tot, t, r, v and e refer to total, translational, rotational, vibrational and electronic respectively.

(i) Show that the partition function of the molecule is a product of factors corresponding to the different modes of motion. [5]

(ii) Hence, show that the entropy and the heat capacity of the molecule are the sums of terms corresponding to the four modes of motion. [5]

4. 5. (a) Briefly describe the differences among the Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. [4]

(b) Consider a system of three identical particles, each of which can be in any one of the three states with energies ε, 2ε, and 3ε. For each kind of statistics, find

(i) enumerate and find the number of states [7]

(ii) obtain the average energy [3]

(iii) obtain the probability that none of the particles is in the highest state [3]

(iv) find the total energy at $T = 0$. [2]

(b) A gas consists of identical indistinguishable particles. The mean number of particles $\overline{n}_s$ in the state s of energy ϵ_s is

$$\overline{n}_s = \frac{\sum_{n_1,n_2,\ldots} n_s e^{-\beta(n_1\epsilon_1+n_2\epsilon_2+\ldots+n_s\epsilon_s+\ldots)}}{\sum_{n_1,n_2,\ldots} e^{-\beta(n_1\epsilon_1+n_2\epsilon_2+\ldots+n_s\epsilon_s+\ldots)}}$$

Show that the mean number of photons in a state of energy ϵ_s at absolute temperature T is

$$\overline{n}_s = \frac{1}{e^{\beta\epsilon_s}+1} \qquad [6]$$

You may need the formula

$$a + ar - ar^2 + \ldots + ar^N = \frac{a(1-r^N)}{1-r}$$

for the sum of a geometric progression.

6. (a) Prove that a system in contact with a pressure reservoir of pressure p_0 and heat reservoir at absolute temperature T_0, and whose external parameters are kept fixed, achieves equilibrium when its Gibbs free energy $G_0 = \overline{E} - T_0 S + p_0 V$ is minimum. [5]

(b) (i) Using the fact that along the phase-equilibrium line separating two phases 1 and 2 the molar Gibbs free energies g_1 and g_2 are such that $dg_1 = dg_2$, derive the Clausius-Clapeyron equation

$$\frac{dp}{dT} = \frac{\Delta s}{\Delta v} \qquad [5]$$

(ii) Hence prove that the vapour pressure of an ideal gas in equilibrium with a solid or a liquid at absolute temperature T is

$$p = p_0 e^{-l/RT} \qquad [5]$$

(**c**) The vapour pressure p (in millimetres of mercury) of solid ammonia is given by $\ln p = 23.03 - 3754/T$ and that of liquid ammonia by $\ln p = 19.49 - 3063/T$.

(**i**) What is the temperature of the triple point (i.e., where solid, liquid and gaseous ammonia can all coexist in arbitrary quantities in equilibrium)? [2]

(**ii**) What are the latent heats of sublimation and of vaporisation at the triple point? [3]

Note that $R = 8.314$ J/mole.K

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

THE UNIVERSITY OF ZAMBIA

PHYSICS DEPARTMENT
UNIVERSITY DEFERRED EXAMINATIONS
JULY 2000

INTRODUCTORY DIGITAL ELECTRONICS
P 342

TIME: **3 HOURS**

INSTRUCTIONS:

ANSWER **FOUR (4)** QUESTIONS ONLY. THE QUESTIONS ARE OF EQUAL MARKS; THE MARKS ARE SHOWN IN SQUARE BRACKETS.

Q1 (a) (i) Convert 3908 to hexadecimal [3]

(ii) Convert hexadecimal 3C1 to binary [4]

(iii) Convert decimal 128 to BCD [2]

(b) Show that $(A+B+C).(A+B+\bar{C}).(\bar{A}+B+\bar{C}) = \overline{A}.\overline{B}.C$ [6]

and that $A+\bar{A}.B+\bar{A}.\bar{B}.C = A+B+C$ [5]

(c) (i) Draw a dynamic timing diagram for a two input Ex-OR gate [5]

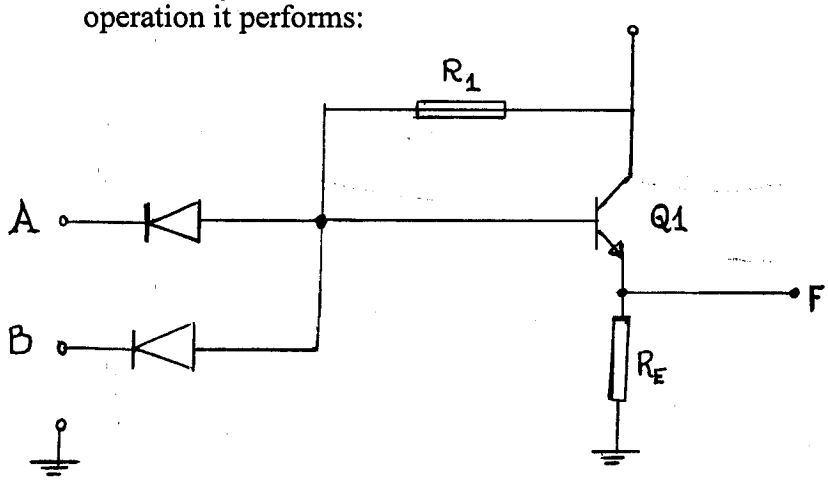
Q2 (a) Explain the meaning of the following terms as understood in digital circuits:

(i) Fan in and fan out; [3]

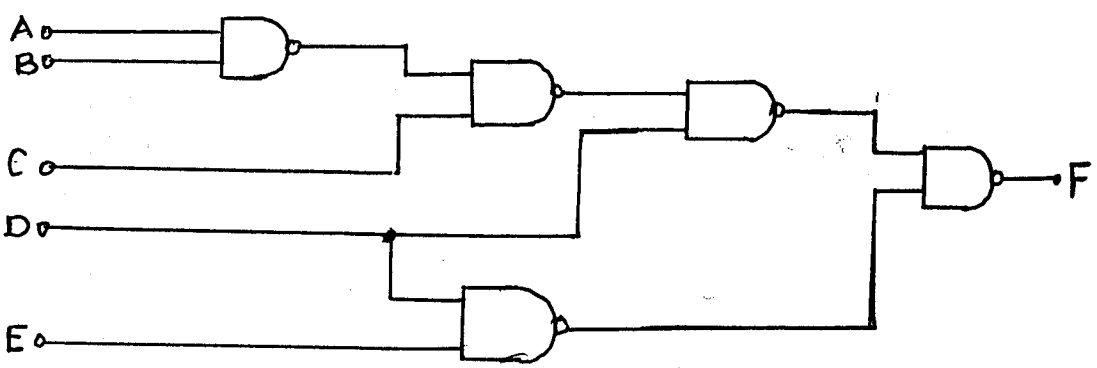
(ii) Propagation delay; [2]

(iii) Noise immunity. [2]

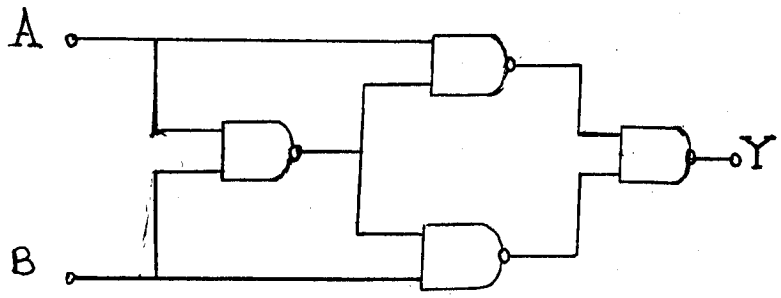
(b) (i) Explain the operation of the following circuit and write the functional operation it performs: [6]



(ii) Write the expression for F in terms of A, B, C, D and E and simplify it [6]



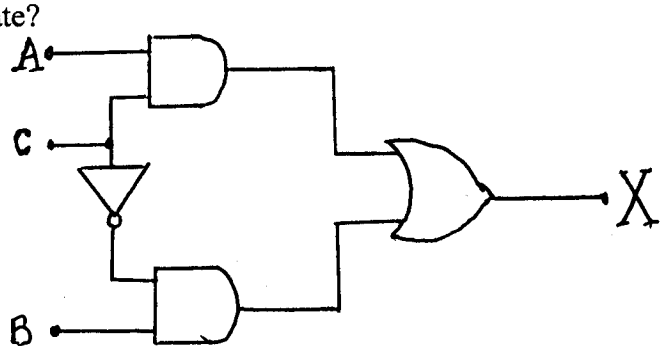
(c) Using De Morgan's dualization laws or otherwise, verify that the circuit shown below performs an Exclusive -OR function. [6]



Q3 (a) Using the following truth table, draw a simplified circuit based on logic gates that compute the function F. [8]

A	B	C	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

(b) Find the truth table for the following circuit. What logic function does it calculate? [6]



(c) (i) State two limitations of diode logic circuits [2]

(ii) State the **rules** of binary addition **and** draw a well labelled diagram of a half adder and explain how it works [6]

(iii) State the reason why the half adder is sometimes referred to as an Exclusive-OR circuit . [3]

Q4 (a) (i) What is the chief limitation of sequential memories? [2]

(ii) Distinguish between a sequential memory and a random access memory. [2]

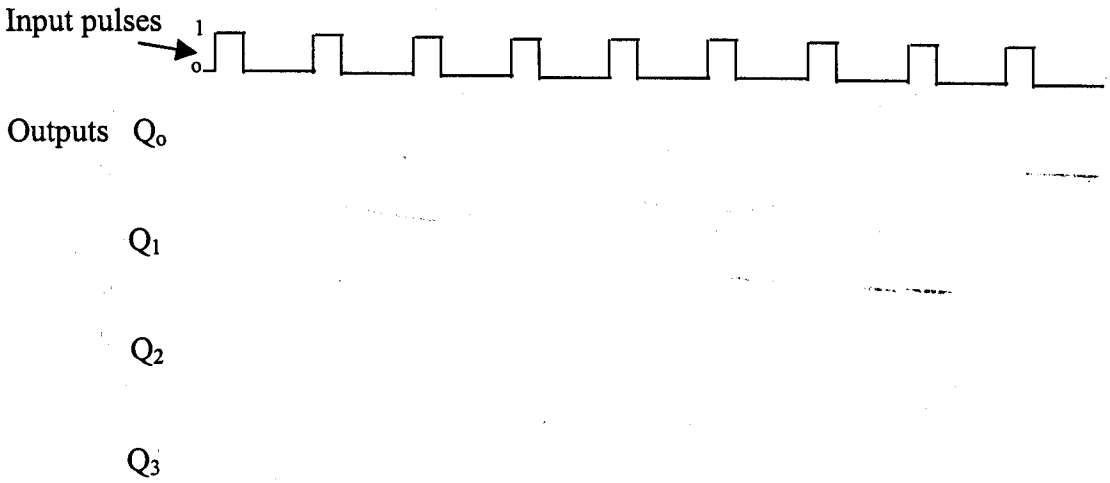
(iii) Differentiate between the following: a "bit", a "byte" and a "word" [3]

(iv) A ROM is organized as 4096x8 bits. What is its capacity in K-bytes? [2]

(v) A ROM has a capacity of 1 K -byte. What is the actual number of bits it has stored? [2]

(b) (i) What are the two main functions of registers in the computer? [2]

(ii) Complete the following diagram of 16 pulses applied to a ripple counter implemented with four flip flops. The flip flops are negative edge triggered [8]



(iii) what is the **modulus** of the above counter? [2]

(iv) what is meant by negative - edge triggering? [2]

Q5 (a) (i) In the seven - segment display, what are the segments activated when the following digits have to be displayed: 2, 3, 6, 7, 9? [4]

(ii) If we let the BCD inputs to the decoder to be represented by the general form $A_3A_2A_1A_0$, a Boolean expression can be found for each segment in the display. Write a Boolean expression for the following segments: A, C, and E. (Hint:track digits which are used in each segment) [10]

(iii) Draw a decoding logic circuit for segment A based on the Boolean expression derived in Q5 (a) (ii) above. [07]

(b) What are light emitting diodes and what advantages do they offer in display systems as compared to the incandescent and neon lamps? [04]

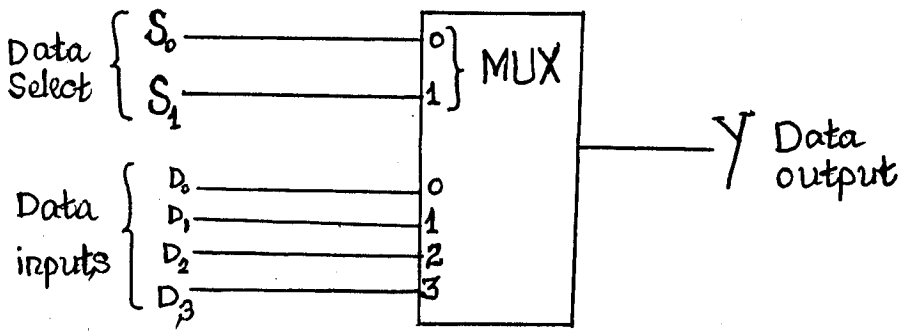
Q6 (a) (i) Motorola manufactures a 16 bit microprocessor with 24 address pins. How many memory locations can it directly access? [2]

(ii) Explain why the address bus is uni-directional whereas the data bus is bi-directional. [3]

(iii) What do you call a group of instructions and data in memory used to direct the operation of a microprocessor? [2]

(b) (i) Distinguish between a multiplexer and a demultiplexer ? [4]

(ii) Study the multiplexer block diagram shown below and answer the questions which follow:



1. What is the function of the data selector? [2]

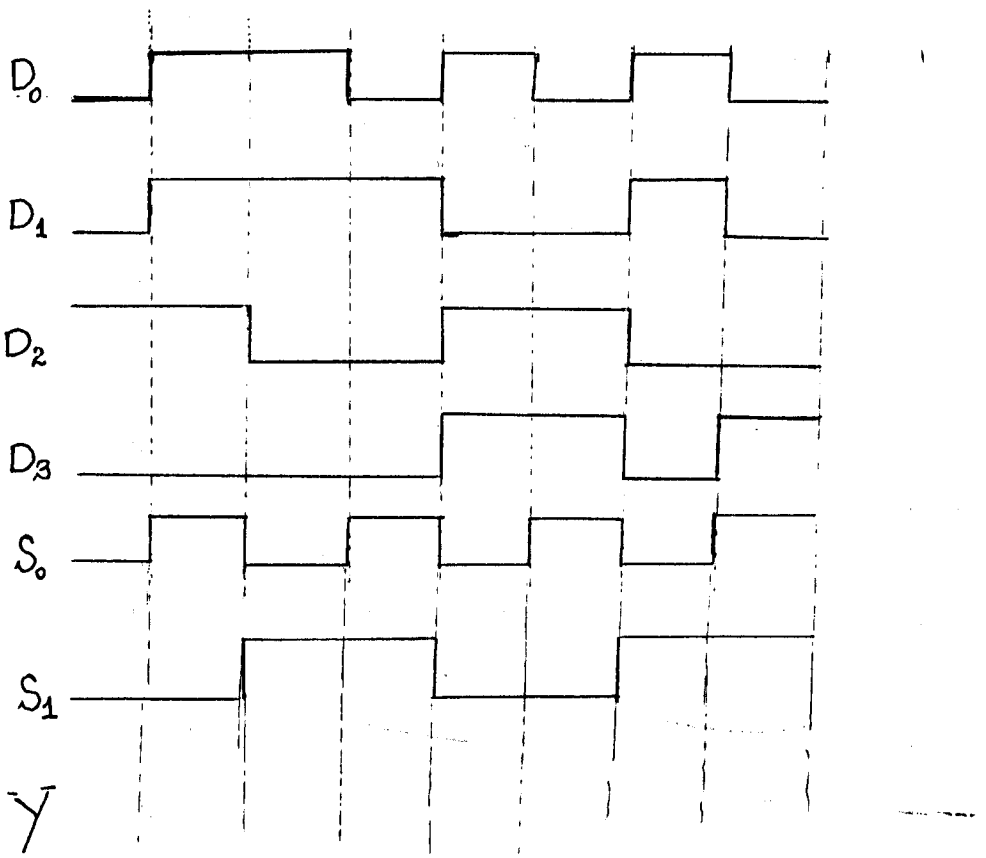
2. Given the truth table as

Data Select		Data output
S_0	S_1	input selected
0	0	D_0
1	0	D_1
0	1	D_2
1	1	D_3

Q6 (b) (ii) contd .

Write the total expression for the data output in terms of the symbol written on the diagram. [4]

(iii) If the following data -input and data -select waveforms are applied to the multiplexer. Determine the output waveform in each time interval. [8]



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER - 2000
P361 - ELECTROMAGNETISM

TIME: 3 HOURS MAX MARKS: 100

ATTEMPT ANY FOUR QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

You may use the following information:

$$\varepsilon_0 = 8.85 \times 10^{-12} \text{ farad/meter}$$
$$\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$$

$$\int \sec\theta \, d\theta = \ln(\sec\theta + \tan\theta)$$

The vector identities

$$\vec{\nabla} \times (\vec{\nabla} \times \vec{A}) = -\vec{\nabla}^2 A + \vec{\nabla}(\vec{\nabla} \cdot \vec{A})$$
$$\vec{\nabla} \cdot (f\vec{A}) = f\vec{\nabla} \cdot \vec{A} + \vec{A} \cdot \vec{\nabla} f$$
$$\vec{\nabla} \times (f\vec{A}) = \vec{\nabla} f \times \vec{A} + f(\vec{\nabla} \times \vec{A})$$
$$\vec{\nabla}\left(V \cdot \vec{\nabla} V\right) = \left(\vec{\nabla} V\right)^2 + V\vec{\nabla}^2 V$$

The vector $\vec{r}$ is directed from $P'(x', y', z')$ to $P(x, y, z)$. If P' is fixed and P is allowed to move, then the gradient under this condition is given by

$$\vec{\nabla}\left(\frac{1}{r}\right) = -\frac{\hat{r}}{r^2}$$

If P is fixed and P' is allowed to move, then the gradient is

$$\vec{\nabla}'\left(\frac{1}{r}\right) = \frac{\hat{r}}{r^2}$$

In spherical coordinates (r,θ,ϕ)

$$\vec{\nabla} f = \frac{\partial f}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial f}{\partial \theta}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial f}{\partial \phi}\hat{\phi}$$

$$\vec{\nabla}^2 \equiv \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2}{\partial \phi^2}$$

$$\vec{\nabla}.\vec{A} \equiv \frac{2}{r}A_r + \frac{\partial A_r}{\partial r} + \frac{A_\theta}{r}\cot\theta + \frac{1}{r}\frac{\partial A_\theta}{\partial \theta} + \frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial \phi}$$

$$\vec{\nabla}\times\vec{A} = \frac{\hat{r}}{r\sin\theta}\left[\frac{\partial}{\partial\theta}(\sin\theta A_\phi) - \frac{\partial A_\theta}{\partial\phi}\right] + \frac{\hat{\theta}}{r}\left[\frac{1}{\sin\theta}\frac{\partial A_r}{\partial\phi} - \frac{\partial}{\partial r}(rA_\phi)\right] + \frac{\hat{\phi}}{r}\left[\frac{\partial}{\partial r}(rA_\phi) - \frac{\partial A_r}{\partial\theta}\right]$$

In cylindrical coordinates (ρ,ϕ,z)

$$\vec{\nabla} f = \hat{\rho}\frac{\partial f}{\partial \rho} + \hat{\phi}\frac{1}{\rho}\frac{\partial f}{\partial \phi} + \hat{z}\frac{\partial f}{\partial z}$$

$$\vec{\nabla}\vec{A} = \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho A_\rho) + \frac{1}{\rho}\frac{\partial A_\phi}{\partial\phi} + \frac{\partial A_z}{\partial z}$$

$$\vec{\nabla}\times\vec{A} = \hat{\rho}\left(\frac{1}{\rho}\frac{\partial A_z}{\partial\phi} - \frac{\partial A_\phi}{\partial z}\right) + \hat{\phi}\left(\frac{\partial A_\rho}{\partial z} - \frac{\partial A_z}{\partial\rho}\right) + \hat{z}\left[\frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho A_\phi) - \frac{1}{\rho}\frac{\partial A_\rho}{\partial\phi}\right]$$

$$\nabla^2 f = \frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\rho\frac{\partial f}{\partial\rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 f}{\partial\phi^2} + \frac{\partial^2 f}{\partial z^2}$$

For any arbitrary vector $\vec{A}$ and a surface S bounding a volume τ

$$\int_\tau \left(\vec{\nabla}\times\vec{A}\right)d\tau = -\int_s \vec{A}\times d\vec{a}$$

Poisson's Equation

$$\vec{\nabla}^2 V = -\frac{\rho}{\varepsilon_0}$$

For a long solenoid of length L, the magnetic induction $B = \frac{\mu_0 NI}{L}$ inside

$= 0$ outside

The vector potential

$$\vec{A} = \frac{\mu_0 I}{4\pi}\oint \frac{d\vec{l}}{r}$$

The magnetic induction

$$\vec{B} = \frac{\mu_0 I}{4\pi}\oint \frac{d\vec{l} \times \hat{r}}{r^2}$$

$$\vec{B} = \vec{\nabla} \times \vec{A}$$

Vector potential due to a magnetic dipole

$$\vec{A} = \frac{\mu_0}{4\pi}\frac{\vec{m} \times \hat{r}}{r^2}$$

The magnetic induction at a point on the axis of a circular current carrying loop is

$$B = \frac{\mu_0 I a^2}{2\left(a^2 + z^2\right)^{3/2}}$$

The Maxwell's Equations are

$$\vec{\nabla} \cdot \vec{D} = \rho_f$$

$$\vec{\nabla} \cdot \vec{B} = 0$$

$$\vec{\nabla} \times \vec{E} + \frac{\partial \vec{B}}{\partial t} = 0$$

$$\vec{\nabla} \times \vec{H} = \vec{J}_f + \frac{\partial \vec{D}}{\partial t}$$

Q.1 A spherical charge distribution is given by

$$\rho = \rho_0\left(1-\frac{r^2}{a^2}\right), \qquad (r<a)$$

$$\rho = 0 \qquad\qquad (r>a)$$

(a) Calculate the total charge. (6 marks)

(b) Use Poisson's equation to find $\vec{E}$ at a point outside the charge distribution in terms of a constant of integration. (7 marks)

(c) Use Poisson's equation to find $\vec{E}$ at a point inside the charge distribution. (8 marks)

(d) By matching the results in (b) and (c) at the surface of the sphere, calculate the value of the constant in (b). Hence express your answer in (b) free from the constant of integration. (4 marks)

Q.2 A dielectric sphere of radius R contains a uniform density of free charge ρ_f. Assume the dielectric material is class A with relative permittivity ε_r. Calculate

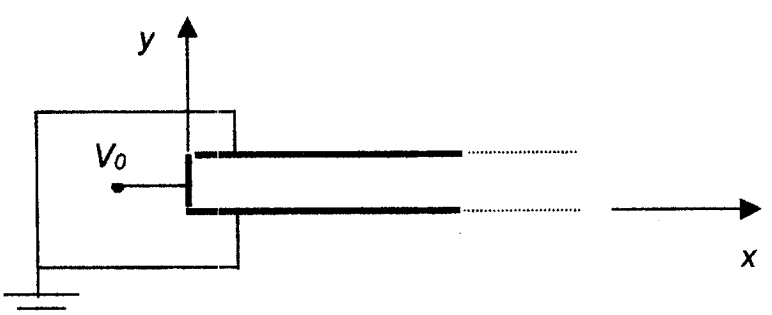
(a) $\vec{D}$ and $\vec{E}$ at a point (i) inside, and (ii) outside the sphere, (6 marks)

(b) polarization $\vec{P}$, (3 marks)

(c) the bound surface and volume charge densities. Hence show that the net induced charge on the sphere is zero, (6 marks)

(d) the potential at a point inside the sphere. (10 marks)

Q.3. As shown in the figure, two semi-infinite grounded parallel electrodes extend to infinity in the $+x$ and $\pm z$ direction. At $x = 0$ they terminate at a potential V_0. Write down the boundary conditions for the problem and use the method of separation of variables to solve the Laplace equation. Hence obtain the general solution satisfying the boundary conditions. (25 marks)



Q.4. (a) Define magnetization and express it in terms of the average dipole moment per atom. (2 marks)

(b) Obtain an expression for the vector potential at an exterior point due to a magnetized material. Hence show that a magnetized material is equivalent to a surface and a volume current density. (10 marks)

(c) A thin disk of iron of radius a and thickness t is magnetized uniformly in the direction parallel to its axis. Calculate $\vec{H}$ and $\vec{B}$ on the axis, both inside and outside the iron. (13 marks)

Q.5. (a) State Faraday's law of electromagnetic induction and obtain its differential form. (4 marks)

(b) Define mutual inductance. (2 marks)

(c) For any two coils a and b, prove that the mutual inductance is reciprocal, i.e. $M_{ab}=M_{ba}$ (8 marks)

(d) A thin conducting disk of thickness h, diameter D and conductivity σ is placed in a uniform alternating magnetic field $B = B_0 \sin \omega t$ parallel to the axis of the disk. Find the induced current density as a function of the distance from the axis. (11 marks)

Q.6 (a) Show that the Maxwell's equations of electromagnetic fields in vacuum lead to wave equations. Calculate the speed of these waves. What implication did this discovery have on the nature of light? (8 marks)

(b) Assuming plane waves, show that electromagnetic waves are transverse in nature. (5 marks)

(c) Show that the $\vec{E}$ and $\vec{H}$ vectors are mutually perpendicular in an electromagnetic wave. (6 marks)

(d) Show that the vector $\vec{E} \times \vec{H}$ represents the rate of energy flow per unit normal area. (6 marks)

..... **END OF THE EXAMINATION** .....

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT

UNIVERSITY EXAMINATIONS-2000
P-401
(Computational Physics-II)

Time: Three Hours **Max.Marks: 100**

Answer:(i) Question **1** is ***compulsory***.
(ii) Any **Three** questions from **2,3,4,5** and **6**.

All questions carry equal marks.
(Marks are shown in the square brackets).

INSTRUCTION: Whenever necessary, use the information given in the Appendix.

Q.1. (A)State the errors if any in the following: **[5]**
(Assume I , J , K , L , M , N to have default representation of integers)

(i)
```
      A=10.5
      DO 10 I=1 , 5, 0.1
      A=A+1
   10 CONTINUE
```

(ii)
```
      FUNCTION FY(X,Y,Z)
      X=2.5
      Y=3.5
      Z=Y+X
      F(X,Y,Z) = X*X +Y*Z
      RETURN
      END
```

(iii)
```
      CHARACTER NAME*22, A*10,B*8,C*12
      A=NAME(1:10)
      B=NAME(11:20)
      C=NAME(13:22)
      D=A\\B
```

(iv)
```
      SUBROUTINE (X,Y,Z,T)
      X=2.5E+07
      Y= -3.5
      Z=X+Y
      T=X+Y*Z
      RETURN
      END
```

(v)
```
OPEN(-5,FILE='FILE1.DAT', STATUS='NEW')
```

(B) Explain the difference between [5]

(i) Real and Floating point representation of numbers.
(ii) An arbitrary number and a random number.
(iii) Integer Arithmetic and Real Number Arithmetic on a Computer.
(iv) Linear and Non-Linear Least Squares Fit.
(v) A file and a Record.

(C) The following data is available for variables (x_i, y_i) with the name **'EXPT.DAT'** [5]

2.1 05.7
8.5 20.5
9.8 25.6
11.3 32.5

Write a program to calculate x_i^2, y_i^2, $x_i y_i$ and to write on an output file 'EXPT.OUT' in a tabulated form of the following :

$x_i, y_i, x_i^2, y_i^2, x_i y_i$

(D) The input file 'STUDENT.DAT' contains the following data [5]

column 1-12 = Name of the student.
column 14 = Gender of the student as character M or F .
column 16-17 = marks obtained in the course P401
column 19-20 = marks obtained in the course P421
column 21-22 = marks obtained in the course P441

If the marks obtained in any one of the courses is less than 40, the remark will be 'Fail', otherwise the remark is 'Pass'.
Write a program to read the data from the input file and process the result to create an output file 'STUDENT.OUT' with the following columns.

Name of the Student, Gender, Marks:P401, Marks:P421, Marks:P441, Remark

(E) A matrix A is of dimension 5 x 5 [5]
Write a program to search for the largest diagonal element and then exchange this row with the first row. Note that it is also likely that the first row itself contains the largest diagonal element and therefore your program should address this situation.

Q.2. Under the influence of air resistance, the velocity of a falling body of mass m is given by the equation

$$\frac{dv}{dt} = g - k\,v^2$$

where g= acceleration due to gravity and k= co-efficient of air resistance.

Writing $\frac{dv}{dt} = \frac{v_{i+1} - v_i}{\Delta t}$, the above differential equation reduces to a difference equation

$$\frac{v_{i+1} - v_i}{\Delta t} = g - k\, v_i^2 \qquad \text{for } i = 1,2,.....N.$$

Consider a man jumping from a stationary balloon, that is the initial condition are at t = 0 , v(0)=0.

Write a single program to calculate

(i) the downward velocity as a function of time at intervals of Δt=0.1 s with k=0,004 m^{-1} **[5]**

(ii) the terminal velocity (the maximum velocity that can be attained). **[5]**

(iii) the downward velocity as a function of time at intervals of Δt=0.2 s under the following conditions: **[10]**

When the man reaches his terminal velocity, he opens his parachute with the result that k=0.3m^{-1} for the remainder of the fall.

(iv) and write the output ***time vs velocity*** on a file 'FALL.OUT' . **[5]**

Q.3. The following data corresponds to the speed of an automobile vs stopping distance.

Speed of automobile in ms^{-1}	8	20	35	45	55
Stopping distance in m	2.5	10	15	30	40

Such a data can be approximated to a polynomial of degree n given by

$$P(x) = \sum_{k=1}^{n} f(x_k) L_{n,k}(x)$$

where $L_{n,k}(x) = \dfrac{(x-x_1)(x-x_2).....(x-x_n)}{(x_k-x_1)(x_k-x_2).....(x_k-x_n)}$ *with* $n \neq k$.

The approximation P(x) is known as Lagrange Interpolating Polynomial.

Write a program

(i) to write the data from a default device to an input file 'SPEED.DAT', **[5]**

(ii) to read this data from this input file , **[5]**

(iii) to calculate the stopping distance at the speed of 50 ms^{-1} and to write the output on the input file 'SPEED.DAT' without deleting the existing data. **[15]**

Q.4. (A) (i) Explain the difference between convolution and correlation. **[2]**

(ii) Explain the difference between cross-correlation and auto-correlation. **[2]**

(iii)Explain the technique of Fast Fourier Transform (FFT) and show through an example how it is faster than the normal transformation. **[6]**

(B) The data p(i) , i=1,2,.....256 , is contaminated with noise. Each data point is at time step Δt =0.01 s with starting value being at time t=0.
Assume that you are given a subroutine FFT(n,s,p,w) for fast fourier transform.

Here p = p(i) the initial data,
w = w(i), fourier transform of p(i) if s = 1
or inverse fourier transform of p(i), if s = -1
n = number of data points,

Write a psuedo code to calculate the auto-correlation of p(i) using FFT. **[15]**

Q.5. (A) Define **[5]**

(i) Chaos,
(ii) Fixed point,
(iii) Periodic point,
(iv) Deterministic Chaos and,
(v) Fractal

(B) A simple pendulum in the presence of damping and driving force can be described by the equation of motion

$$\frac{d^2x}{dt^2} = -c\frac{dx}{dt} - (1 + F\cos wt)\sin(x)$$

where $w = 2\pi f$, f = frequency of the driving force, F= amplitude of the driving force and c = damping factor.
Answer the following:
(i) What is the phase plot in this case? **[1]**
(ii) Which is the parameter in the differential equation that will lead to chaotic behavior of the pendulum? **[6]**
Define the Poincare section in this case.
Which are the parameters that define the Poincare section?
Explain it importance.
(iii) If F=0, will the pendulum attain chaotic behavior? Explain. **[2]**

(C) Define $v(t) = \frac{dx}{dt}$ and
show that the solution of the equation of motion reduces to solving two first order equations, namely **[1]**

$$\frac{dx}{dt} = v(t) \quad \text{and}$$

$$\frac{dv}{dt} = -cv(t) - (1 + F\cos wt)\sin(x)$$

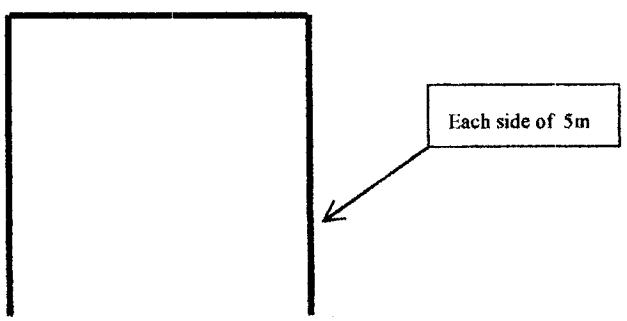
Assuming at t=0, $v(0) = v_0$ and x(0)=0, and that c, F, w are known, write a pseudo code to find the solutions v(t) and x(t) with $\Delta t = 0.1$ s. **[10]**

Hint: Use the RK-method given in the appendix.

Q.6. Consider the diffusion of an aromatic molecule in air, having velocity $1000ms^{-1}$ in air, and the mean free path λ=0.5 m. As soon as the molecule travels a distance of 0.5 m (i.e. the mean free path), the molecule collides with another molecule and after the collision its direction of motion is random. Assume that the molecule moves only in the (x,y) plane and in any of the following directions after each collision

East or **West** or **North** or **South**.

Assume that the molecule starts at time t=0 from the centre with coordinates (0,0) of a square hall of side 5m in length with an opening at one side as shown below and when the molecule reaches the wall it reverses it direction and moves by λ .



(i) What is the distance of each wall from the centre in units of λ? **[2]**

(ii)Assume that the movement of the molecule is random. Write a pseudo code to find the average number of collisions a molecule will undergo to reach the opening. Consider 500 trials for finding this average. **[8]**

(iii)Convert the psuedo code into a program. **[15]**

Assume that function RAN0(idum) is given which returns one random number for a seed idum and a new seed idum for the next random number.

@@@END OF EXAMINATION@@@

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATION
MAY 2000
P442
DIGITAL ELECTRONICS 2

TIME 3 HOURS MAXIMUM MARKS 100

ANSWER 4 QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS

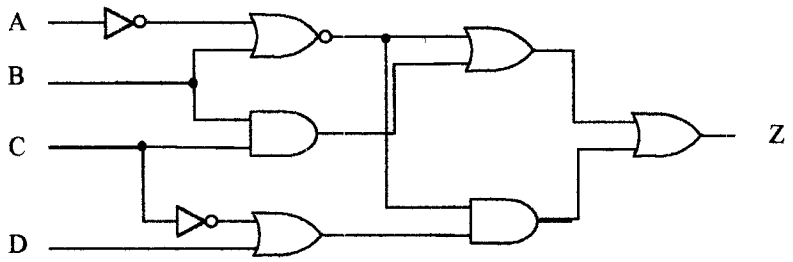
The Instruction set for the Z80 is given at the back.

Q1. a) Apply De Morgan's theorem and boolean algebra rules to simplify the following equations.

i) $Z = \overline{(C + D)\bar{A}\bar{C}\bar{D}(\bar{A}C + \bar{D})}$ [4]

ii) $X = \overline{\overline{(\bar{A} + B)}(B + C)} + \bar{B}C$ [4]

b) Use a K-Map to simplify the circuit below. [7]



c) Minimize the following expressions using K-Maps

i) $Z = \bar{B}\bar{C}D + B\bar{C}D + C\bar{D} + C\bar{D}(B+\bar{A}\bar{B}) + \bar{A}B$ [5]

ii) $Y = ABC + \bar{A}\bar{B}C + B\bar{C} + A$ [5]

Q2. a) Use the two's complement method to perform the following arithmetic calculations in binary.

i) 42 – 18

ii) 56 – 124 [4] X 2

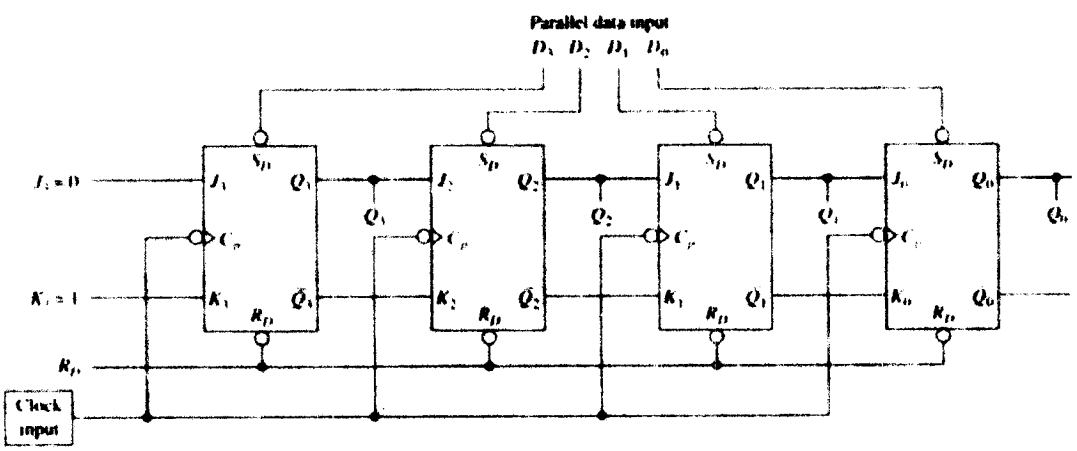
b) Draw a 4 bit two's complement adder/subtractor circuit. Briefly explain how it operates. [7]

c) For the register shown below what must be done to:

i) Load the binary word 0101 from the parallel data input. [6]

ii) Serially output the word 0101 through Q_0. [4]

(Truth table of the flip-flop is given below).



	Inputs				Outputs	
	$\overline{S}_D$	$\overline{R}_D$	Ck	D	Q	$\overline{Q}$
Asynchronous Set	L	H	X	X	H	L
Asynchronous Reset	H	L	X	X	L	H
Not used	L	L	X	X	H	H
Synchronous Set	H	H	↑	H	H	L
Synchronous Reset	H	H	↑	L	L	H

↑ = Positive edge of clock; H = HIGH, L =LOW; h = HIGH, l = LOW just prior to positive clock transition.

Q3. a) Briefly explain the function and operation of the following in a microprocessor system. [2] X 6

i) accumulator
ii) status register
iii) data bus
iv) maskable interrupt line
v) ROM
vi) PIO

b) Briefly outline the steps through which an instruction is executed stating all relevant hardware used in the execution. [6]

c) Using a diagram 4X4 memory array explain how a memory cell is addressed and how a bit is read. [7]

Q4. a) What will be the binary word in register A at the end of the following program? [7]

```
ORG   1800H
      XOR   A
LOOP  RLA
      JRC   SKIP
      ADD   A, 1
      JR    LOOP
SKIP  RST   38H
```

b) What does the following program do? [7]

```
ORG   1800H
      LD    HL, 1B00H
      LD    DE, 1A00H
LOOP  LD    A, (HL)
      LD    (DE), A
      CP    FFH
      JRZ   EXIT
      INC   HL
      INC   DE
      JR    LOOP
EXIT  RST   38H
```

c) Given that a Z80 microprocessor has a clock speed of 2MHz how long will the following program take to execute. [11]

```
        ORG 1800H
        LD    A, FFH
        LD    B, FFH
        LD    C, FFH
LOOP    DEC   A
        DJNZ  LOOP
        DEC   B
        DJNZ  LOOP
        DEC   C
        DJNZ  LOOP
        RST   38H
```

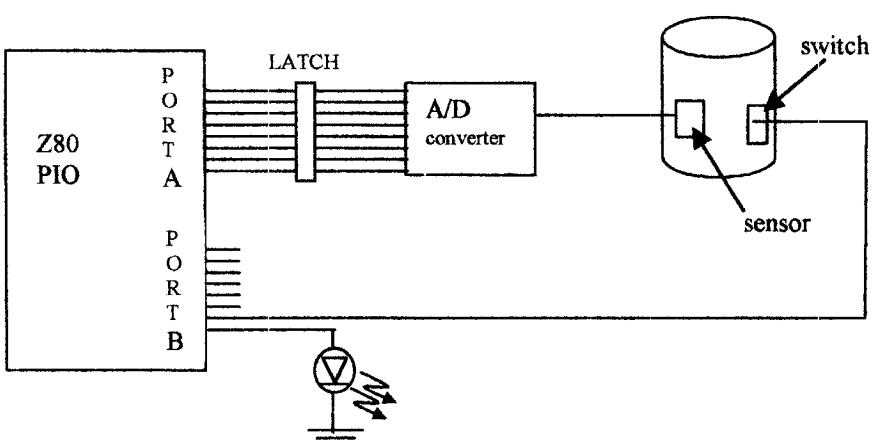
Q5. a) Write a program that performs 8 bit integer multiplication by adding the first number to itself the number of times of second number. i.e. 8x4 = 8+8+8+8 = 32. The two numbers should be in memory locations 1B00H and 1B01H and the answer should be stored in the next two memory locations. Use a flow diagram to plan the program. [10]

b) Convert the program into machine code. [5]

c) Write a program in assembly language to perform 32 bit addition. [10]

Q6. A microprocessor system to monitor the temperature of a boiler as shown in the figure below. The data is fed into the A side of the PIO as an 8 bit binary number representing the temperature in degree Celsius (e.g. 00001000 is 8°C). The CPU continuously scans the temperature and if the temperature is higher than 100 °C it sends a 1 signal via the 0 bit (b_o) of port B of the PIO to a red LED to warn the operator. If the temperature reaches 110 °C then another 1 signal via the 1 bit (b_1) should be sent to shut down the boiler.

a) Write a pseudo code program to plan the program to perform the task. [10]
b) Write an assembly language program to perform the task . [10]
c) Convert the program into machine code. [5]



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS 1999/2000
QUANTUM MECHANICS II
P455

TIME: THREE HOURS
ANSWER: ANY FOUR QUESTIONS
MAXIMUM MARKS: 100

---

1. **(a)** One of the dynamical variables A of a certain system satisfies the eigenvalue equation

$$A\phi_n = a_n\phi_n.$$

(i) Prove that if we use the orthonormal eigenfuctions of A as the basis, the expectation value of another dynamical variable B in the state Ψ can be written as

$$\langle B\rangle = [\Psi]^\dagger[B][\Psi], \qquad [5]$$

where

$$[\Psi] = \begin{pmatrix} c_1 \\ c_2 \\ \vdots \\ c_N \end{pmatrix}$$

and

$$[B] = \begin{pmatrix} B_{11} & B_{12} & .. & B_{N1} \\ B_{21} & B_{22} & .. & B_{N2} \\ \vdots & \vdots & \vdots & \vdots \\ B_{N1} & B_{N2} & .. & B_{NN} \end{pmatrix}.$$

(ii) Show that

$$c_i = \int \phi_i^* \Psi d\tau$$

and give the formula for B_{ij}. [2]

(iii) Hence show that the matrix representation of the differential operator A is a diagonal matrix. [2]

(b) In a certain orthonormal basis, a physical system has the Hamiltonian

$$[H] = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}.$$

(i) What are the possible results when the energy of the system is measured? [5]

(ii) Obtain the eigenvectors of the Hamiltonian. [5]

(iii) Show that the eigenvectors are orthonormal. [3]

(iv) Show that the eigenvectors satisfy

$$\sum_i |u_i\rangle \langle u_i| = \mathbf{1}. \qquad [3]$$

2.The Hamiltonian of a one-dimensional harmonic oscillator of mass m is

$$H = \frac{p^2}{2m} + \frac{1}{2}kx^2.$$

Given that the ladder operators

$$a_\pm = \left(\frac{m\omega}{2\hbar}\right)^{1/2} x \mp i\frac{p}{(2m\hbar\omega)^{1/2}}$$

satisfy the commutation relations

$$[H, a_\pm] = \pm\hbar\omega a_\pm, \quad \text{where } \omega = \sqrt{k/m},$$

(i) show that a_+ is a raising operator and a_- is a lowering operator; [5]

(ii) obtain a differential equation for the ground state of the oscillator and show that the function

$$\psi = \exp(-\alpha^2 x^2/2), \quad \text{where } \alpha = (m\omega/\hbar)^{1/2}$$

is a solution of this equation; [5]

(iii) obtain an unnormalised function for the first excited state; [2]

(iv) obtain the normalisation constant for each function obtained as a result of the action of $a_\pm$. [3]

(iv) Given that $a_+a_- = H/\hbar\omega - 1/2$ and $a_-a_+ = H/\hbar\omega + 1/2$, obtain the matrix representation of a_+, a_-, x, and p_x. [10]

3. **(a)** **(i)** Obtain the expression for the first-order energy correction in non-degenerate time-independent perturbation theory. [5]

(ii) A one-dimensional harmonic oscillator is placed in a medium in which it experiences a perturbation λp_x, where p_x is the momentum and λ is a constant. Calculate the first order correction to the energy of the first excited state. [7]

Note that the first excited state is

$$\psi_1(x) = 2\alpha\left(\frac{\alpha}{2\sqrt{\pi}}\right)^{1/2} xe^{-\alpha^2x^2/2},$$

where

$$\alpha = \left(\frac{m\omega}{\hbar}\right)^{1/2}.$$

Remember that

$$\int_{-\infty}^{\infty} e^{-\xi x^2} dx = \sqrt{\frac{\pi}{\xi}}$$

and that non-vanishing integrals of the form $\int_{-\infty}^{\infty} x^n e^{-\xi x^2} dx$ can be obtained by differentiating this basic integral with respect to ξ.

(b) If a system is initially in the state $\psi_a^{(0)}$ of the Hamiltonian H_0 and if the perturbation $\lambda H'(t)$ acts from t_0 to t on the system, transitions will occur to other states $\psi_b^{(0)}$ of H_0 with transition probability amplitudes given to first order by

$$c_{ba}^{(1)} = (i\hbar)^{-1}\int_{t_0}^{t} H'_{ba}(t')\exp(i\omega_{ba}t')dt'$$

where

$$H'_{ba}(t) = \left\langle \psi_b^{(0)} \left| H'(t) \right| \psi_a^{(0)} \right\rangle \text{ and } \omega_{ba} = \frac{E_b^{(0)} - E_a^{(0)}}{\hbar}.$$

A one-dimensional harmonic oscillator of mass m and force constant k is in a uniform electric field whose time dependence is

$$\varepsilon(t) = \frac{A}{\tau\sqrt{\pi}} \exp[-\left(\frac{t}{\tau}\right)^2],$$

so that it is subject to the perturbation

$$H' = -ex\varepsilon(t),$$

where the quantities A and τ are constants and e is the electronic charge. If the oscillator is in the ground state at $t = 0$ when the perturbation is switched on,

(i) what are the excited states to which the oscillator can make transitions? [6]

(ii) What is the probability of excitation to these states as $t \to \infty$? [7]

You may need the following information: $\int_{-\infty}^{\infty} e^{iay-by^2} dy = \sqrt{\frac{\pi}{a}} e^{-a^2/4a}$

Note that for the harmonic oscillator, the matrix elements of x are

$$x_{nm} = \begin{cases} 0, & m \neq n \pm 1 \\ \frac{1}{\alpha}(\frac{n+1}{2})^{1/2}, & m = n+1 \\ \frac{1}{\alpha}(\frac{n}{2})^{1/2}, & m = n-1 \end{cases}$$

4. (a) (i) What is the main advantage of the variational method over perturbation theory for calculating approximate energies and eigenfunctions of quantum systems? [2]

(ii) The use of the variational method for estimating ground state energies and eigenfunctions is based on the result

$$\langle E \rangle \geq E_0$$

where E_0 is the ground state energy and $\langle E \rangle$ is the expectation value of the Hamiltonian for a selected trial function. Prove this result. [5]

(iii) Use the trial function

$$\phi_\alpha(r) = \begin{cases} C(1 - \frac{r}{\alpha}) & \text{for } r \leq \alpha \\ 0 & \text{for } r > \alpha \end{cases}$$

where C is a normalisation constant and α is the variational parameter, to estimate the ground state energy of the hydrogen atom. Compare your result with the exact ground-state energy

$$E_1 = -\frac{\mu e^4}{64\pi^2\epsilon_0^2\hbar^2} \qquad [18]$$

Note that for this problem, the Hamiltonian is effectively

$$H = -\frac{\hbar^2}{2\mu}\left(\frac{d^2}{dr^2} + \frac{2}{r}\frac{d}{dr}\right) - \frac{e^2}{4\pi\epsilon_0 r}$$

since the trial function is not a function of the angular variables.

5.(a) The operators for the x and y components of the spin for a spin-1/2 system are

$$S_x = \frac{\hbar}{2}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad \text{and} \quad S_y = \frac{\hbar}{2}\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}.$$

An electron is in the spin state

$$\chi = \frac{1}{\sqrt{5}} \begin{pmatrix} 2i \\ 1 \end{pmatrix}.$$

Calculate the expectation values of these two components in this state. [3]

(b) **(i)** Explain the difference between bosons and fermions and give an example of each kind of particle. [2]

(ii) N fermions are non-interacting. Show how to obtain an anti-symmetric wave function to describe their state. [5]

(iii) Hence show that no two fermions can be in the same quantum state. [1]

(c) N identical non-interacting spin-1/2 fermions are confined in a cubic box of dimension L at absolute temperature $T = 0$. Given that the energy levels of a particle of mass m in a cube of side L are

$$E_n = \frac{\hbar^2 \pi^2}{2mL^2} n^2,$$

where

$$n^2 = n_x^2 + n_y^2 + n_z^2,$$

and that the wave function for such a state is

$$\psi_{n_x,n_y,n_z,m_s}(q) = \psi_{n_x,n_y,n_z}(x,y,x)\chi_{\frac{1}{2},m_s},$$

(i) show that the total number of individual particle states for energies up to E is

$$N_s = \frac{1}{3\pi^2} \left(\frac{2m}{\hbar^2} \right)^{3/2} V E^{3/2},$$

where $V = L^3$; [7]

(ii) prove that the highest value of energy occupied by the N particles at absolute temperature $T = 0$, i.e., the Fermi energy, is

$$E_F = \frac{\hbar^2}{2m} (3\pi^2 \rho)^{2/3}, \qquad [4]$$

where $\rho = N/V$;

(iii) show that the total energy of the Fermi gas is

$$E_{\text{tot}} = \frac{3}{5} N E_F. \quad [3]$$

6. **(a)** The harmonic oscillator Hamiltonian is

$$H = \frac{p^2}{2m} + \frac{1}{2} k x^2$$

(i) Write down the time-dependent Schroedinger equation in momentum space. [1]

(ii) Hence, obtain the time-independent Schroedinger equation in momentum space. [4]

(**b**) The momentum-space eigenfunction $\Phi(p_x)$ of a system is related to its coordinate-space eigenfunction $\Psi(x)$ by

$$\Phi(p_x) = (2\pi\hbar)^{-1/2} \int e^{-ip_x x/\hbar} \Psi(x) dx$$

(**i**) What is the interpretation of $|\Phi(p_x)|^2 \, dp_x$? [2]

(**ii**) Obtain $\Psi(x)$ in terms of $\Phi(p_x)$. [4]

(**iii**) Prove that if $\Psi(x)$ is normalised, then so is $\Phi(p_x)$. [4]

(**iii**) Obtain the momentum-space eigenfunction corresponding to the ground state of the harmonic oscillator

$$\Psi_0(x) = \left(\frac{\alpha}{2\sqrt{\pi}}\right)^{1/2} e^{-\alpha^2 x^2/2}, \qquad [8]$$

where $\alpha = \left(\frac{m\omega}{\hbar}\right)^{1/2}$.

(**iv**) Comment on the result in (**iii**) in view of the form of the harmonic oscillator Hamiltonian. [2]

Note that

$$\int_{-\infty}^{\infty} e^{ip_x(x-x')/\hbar} dp_x = 2\pi\hbar\delta(x-x')$$

and

$$\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi}$$

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

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS - 1999/2000
PHYSICS OF RENEWABLE ENERGY RESOURCES AND ENVIRONMENT
P485

TIME: 3 HOURS MAX MARKS: 100

ATTEMPT ANY **FOUR** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

Wherever not specified, the notations used in this paper have their usual meanings.

You may use the following information:

Boltzmann constant $k = 1.38 \times 10^{-23}$ JK^{-1}
Gas constant $R = 8314$ J/kmol.K
1 electron volt $= 1.6 \times 10^{-19}$ J
Stefan's constant $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4
Sun's radius $R_s = 6.96 \times 10^8$m
Mean Earth-Sun distance $r_0 = 1.496 \times 10^{11}$m
Solar constant $I_{sc} = 1367$ Wm^{-2}
Earth's radius $R_e = 6.37 \times 10^6$m
Planck's constant $h = 6.6 \times 10^{-34}$ J.s
Speed of light $c = 3 \times 10^8$ m/s

The Sun-Earth astronomical relations are

$$E_0 = \left(\frac{r_0}{r}\right)^2 = 1 + 0.033\cos\left(\frac{360 d_n}{365}\right)$$

$$\delta = 23.45\sin\left[\frac{360}{365}(d_n + 284)\right]$$

$$\cos\theta_z = \sin\delta\sin\phi + \cos\delta\cos\phi\cos\omega$$

$$\cos\psi = \frac{\sin\alpha\sin\phi - \sin\delta}{\cos\alpha\cos\phi}$$

$$\begin{aligned}\cos\theta = {} & (\sin\varphi\cos\beta - \cos\varphi\sin\beta\cos\gamma)\sin\delta \\ & + (\cos\varphi\cos\beta + \sin\varphi\sin\beta\cos\gamma)\cos\delta\cos\omega \\ & + \cos\delta\sin\beta\sin\gamma\sin\omega\end{aligned}$$

$$\omega = 15^{\circ}(12 - t)$$

$$\omega_s = \cos^{-1}(-\tan\phi \tan\delta)$$

Solar time = clock time + $4(L_l - L_s)$ min + EOT

The emissive power of a black body $B_\lambda(T)$ (in W/m^2 per unit wavelength range) is given by

$$B_\lambda(T) = \frac{2\pi h c^2}{\lambda^5\left(e^{\frac{hc}{\lambda kT}} - 1\right)}$$

Characteristic wavelength for a blackbody spectrum is

$$\lambda_{max} T = 2898 \ \mu\text{m-K}$$

Direct solar flux on an inclined surface is

$$F^{dir} = I_{sc}\, e^{-\frac{\tau}{\cos\theta_z}} \cos\theta$$

Fresnel's equations are

$$r_{||} = \left[\frac{n_r^2\cos\theta_i - n_i\sqrt{n_r^2 - n_i^2\sin^2\theta_i}}{n_r^2\cos\theta_i + n_i\sqrt{n_r^2 - n_i^2\sin^2\theta_i}}\right]^2$$

$$r_{\perp} = \left[\frac{n_i\cos\theta_i - \sqrt{n_r^2 - n_i^2\sin^2\theta_i}}{n_i\cos\theta_i + \sqrt{n_r^2 - n_i^2\sin^2\theta_i}}\right]^2$$

Reflectance at normal incidence is given by

$$r = \left(\frac{n_r - n_i}{n_r + n_i}\right)^2$$

Reflectance at normal incidence for light of wavelength λ at an anti-reflecting coating which is designed for wavelength λ_0 is given by

$$r_\lambda = \frac{2p(1+\cos\beta_\lambda)}{1+2p\cos\beta_\lambda + p^2}$$

$$where \quad p = \left(\frac{n_f - 1}{n_f + 1}\right)^2 ; \quad \beta_\lambda = \frac{\pi\lambda_0}{\lambda}$$

The overall transmittance T of a single glazing is given by

$$T = \frac{\alpha(1-r)^2}{1-\alpha^2 r^2}$$

and the overall reflectance by

$$R = r\left[1 + \frac{\alpha^2(1-r)^2}{1-\alpha^2 r^2}\right]$$

Overall optical efficiency of a glazing-absorber system is

$$\eta_{opt} = \frac{A_p T_g}{1-(1-A_p)T_g}$$

Carrier concentration in an intrinsic semiconductor is

$$n_i = p_i = AT^{3/2} e^{-\frac{\varepsilon_g}{2kT}}$$

The reverse saturation current density is

$$J_0 = DT^3 e^{-\frac{\varepsilon_g}{kT}}$$

and the forward current density

$$J = J_0\left(e^{\frac{eV}{kT}} - 1\right)$$

Yearly variation of the equation of time

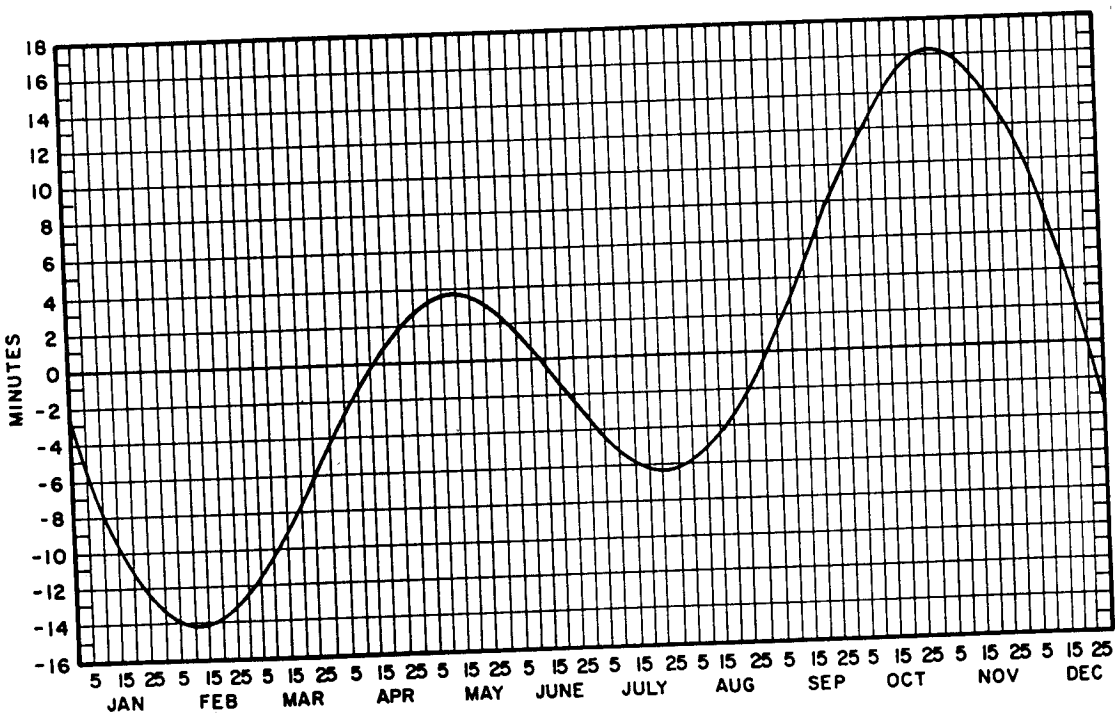


Table for the function $f(x) = f(\lambda T)$

$x(\mu m\text{-}K)$	$f(x)$	$x(\mu m\text{-}K)$	$f(x)$	$x(\mu m\text{-}K)$	$f(x)$
1100	0.001	4600	0.580	8100	0.860
1200	0.002	4700	0.594	8200	0.864
1300	0.004	4800	0.608	8300	0.868
1400	0.008	4900	0.621	8400	0.871
1500	0.013	5000	0.634	8500	0.875
1600	0.020	5100	0.646	8600	0.878
1700	0.029	5200	0.658	8700	0.881
1800	0.040	5300	0.669	8800	0.884
1900	0.052	5400	0.680	8900	0.887
2000	0.067	5500	0.691	9000	0.890
2100	0.083	5600	0.701	9100	0.893
2200	0.101	5700	0.711	9200	0.895
2300	0.120	5800	0.720	9300	0.898
2400	0.140	5900	0.730	9400	0.901
2500	0.161	6000	0.738	9500	0.903
2600	0.183	6100	0.746	9600	0.905
2700	0.205	6200	0.754	9700	0.908
2800	0.228	6300	0.762	9800	0.910
2900	0.251	6400	0.770	9900	0.912
3000	0.273	6500	0.776	10000	0.914
3100	0.296	6600	0.783	11000	0.932
3200	0.318	6700	0.790	12000	0.945
3300	0.340	6800	0.796	13000	0.955
3400	0.362	6900	0.802	14000	0.963
3500	0.383	7000	0.808	15000	0.969
3600	0.404	7100	0.814	16000	0.974
3700	0.424	7200	0.819	17000	0.978
3800	0.443	7300	0.824	18000	0.981
3900	0.462	7400	0.830	19000	0.983
4000	0.483	7500	0.834	20000	0.986
4100	0.499	7600	0.840	30000	0.995
4200	0.516	7700	0.844	40000	0.998
4300	0.533	7800	0.848	50000	0.999
4400	0.549	7900	0.852		
4500	0.564	8000	0.856		

Q.1

The Sun can be regarded as a blackbody at a temperature of 5777 K. The measured value of the solar constant is 1367 W/m^2.

(a) Estimate the value of the solar constant if

(i) the Sun were to cool down to 5000 K (4 marks)

(ii) the Earth-Sun distance was halved. (4 marks)

(b) The band gap of silicon is 1.12 eV. What maximum fraction of the solar flux can be used to generate electron-hole pairs in silicon. (8 marks)

(c) Assuming that the Earth behaves like a blackbody and that its albedo is 0.3,

(i) calculate the Earth's effective temperature. (4 marks)

(ii) find the characteristic wavelength of the earth's emission spectrum. (2 marks)

(iii) explain the reason for the difference between the effective temperature of the Earth and its average surface temperature of 288 K. (3 marks)

Q.2

(a) Show that the radiative transfer flux between two parallel closely-spaced planes at temperatures T_1 and T_2 and with emissive powers ε_1 and ε_2, respectively, is given by

$$J = \frac{\sigma(T_2^4 - T_1^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right)}$$

Assume that the air between the two surfaces is totally transparent to thermal radiation (15 marks)

(b) What will be the radiative flux transfer when

(i) one of the two surfaces is a perfect reflector of thermal radiation, (3 marks)

(ii) both the surfaces are perfect absorbers? (3 marks)

(c) Write down the equation in (a) above in the linearized form

$$J = h_d^{(r)}(T_2 - T_1)$$

and obtain the expression for $h_d^{(r)}$.

Q.3.

A single glazing solar panel has the following specifications:

thermal efficiency of the panel = 0.7
plate absorptance = 0.9
extinction coefficient k for the glazing = 0.1 cm^{-1}
thickness of the glazing = 0.5 cm
refractive index for the glazing = 1.5
surface reflectance r for the glazing = 0.04

If a direct solar beam is incident at an angle of 30° on the panel, calculate for this beam

(i) the bulk transmittivity of the glazing, (6 marks)

(ii) the overall transmittance of the glazing, (6 marks)

(iii) the overall reflectance of the glazing (6 marks)

(iv) the optical efficiency of the glazing-absorber system, (4 marks)

(v) the overall efficiency of the heating panel. (3 marks)

Q.4.

In a single glazing solar collector, the coefficients for heat transfer between the absorber and the glazing are approximately $U_d^{(c)} = 4$ W/m^2-°C and $U_d^{(r)} = 6$ W/m^2-°C, whereas the coefficients for heat transfer from the glazing to the surroundings are approximately $U_\infty^{(c)} = 8$ W/m^2-°C and $U_\infty^{(r)} = 7$ W/m^2-°C. The temperature of the air is 5°C and the panel is in a steady state.

(a) Draw a resistor network representing the system and find the overall $\overline{U}_c$. (6 marks)

(b) Write down the stagnancy condition for the collector. (1 marks)

(c) Obtain the relationship between the absorbed flux and the stagnancy temperature of the plate of the collector. (3 marks)

(d) Obtain the relationship between the absorbed flux and the stagnancy temperature of the glazing. (3 marks)

(e) Repeat the analysis in (c) above when a selective coating deposited on the plates reduces $U_d^{(r)}$ from 6 W/m^2-°C to 1 W/m^2-°C. (7 marks)

(f) Plot the stagnancy temperature vs the absorbed flux for the relationships obtained in (c), (d) and (e) above. State your conclusion. (5 marks)

Q.5

Calculate the direct solar flux on a horizontal surface in Lusaka at 12.00 hrs standard time (clock time) on 29 May if the average optical thickness of the atmosphere $\tau = 0.3$ and the solar constant is 1367 W/m^2. The latitude of Lusaka is 15.3°S, the longitude is 28.5°E and the standard longitude is 30°E. (25 marks)

Q.6

A photovoltaic panel has a total of 72 silicon cells each of area 120 cm^2. These cells are arranged in two parallel rows each having 36 cells in series. The current density in a silicon cell is given

$$J = \overline{K} F - J_0\left(e^{\frac{eV}{kT}} - 1\right)$$

where the average responsivity is $\overline{K}$ = 25 mA/cm^2/Sun and the saturation current density is J_0=5x10^{10} mA/cm^2. Assuming that the temperature of the cell is 300 K and the incident flux is 0.8 Sun,

(a) Obtain the equation relating the panel current and the panel voltage. (5 marks)

(b) Calculate the open circuit voltage V_{oc} and the short circuit current I_{sc} for the panel. (5 marks)

(c) Plot the current voltage graph for the panel. (6 marks)

(d) A battery of E.M.F. 13 volts and internal resistance 0.05 ohm is connected to the panel as a load. Draw on the graph the load line for the battery. Determine graphically the operating point for the charging of the battery and the power delivered to the battery. (5 marks)

(e) A resistor of 0.5 ohm is connected as a load in place of the battery. Draw the load line for the resistor. Find the operating point and the power delivered to the load. (4 marks)

---------- END OF THE EXAMINATION ----------

The University of Zambia
Physics Department
University Examinations — 2000
Physics for Partial Entry

All questions carry equal marks. Attempt any five questions. Clearly indicate which questions you have attempted.
Time : Three Hours. **Maximum marks = 100**

Do not forget to write your name and computer number on the answer book.

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Wherever necessary, use :

$g = 9.8\ m/s^2$.

$k = 9 \times 10^9\ N.m^2/C^2$

vel. of sound at room temp. = 343 m/s

$v_t = 331.45 + 0.610(t^o\ C)$

charge of electron, $e = 1.6 \times 10^{-19}\ C$

mass of electron, $m_e = 9.1 \times 10^{-31}\ kg$

mass of proton, $m_p = 1.67 \times 10^{-27}\ kg$

specific heat of water = 4184 J/kg.^oC

speed of light in vacuum = 3.00×10^8 m/s

one electronvolt, $1eV = 1.6 \times 10^{-19} J$

Planck's constant, $h = 6.63 \times 10^{-34}$ J.s

refractive index of air = 1

refractive index of water = 1.33

$\mu_o = 4\pi \times 10^{-7}\ N^2/A$

$\varepsilon_o = 8.85 \times 10^{-12}\ C^2/N.m^2$

Atmospheric pressure = 1.01×10^5 Pa.

Some equations you may find useful :

$v_f = v_o + at$ $v_f^2 = v_o^2 + 2ax$ $x = v_o t + (1/2)at^2$ $f = \mu F_N$ $W = mg$

$Ft = m(v_f - v_o)$ kin.energy $= (1/2)mv^2$ grav. pot.energy $= mgh$ work $= F.s.\cos\theta$

$\Delta PE + \Delta KE + \Delta TE = 0$ power = work/time $v_{avg.} = (1/2)(v_o + v_f)$ $x = v_{avg.}\, t$

$v_T = \omega r$ $\omega_f = \omega_o + \alpha t$ $\omega_f^2 = \omega_o^2 + 2\alpha\theta$ $\theta = \omega_o t + (1/2)\alpha t^2$ $\mathbf{Ft} = \Delta\mathbf{p}$

$\mathbf{p} = mv$ $a_T = \alpha r$ $L = I\omega$ $\tau = I\alpha = Fr$ Kin. energy $= (1/2)mv^2 + (1/2)I\omega^2$

1 rev $= 360^o = 2\pi$ radians $F_c = (mv^2)/r$ $I = \Sigma\ mr^2$ $F = (Gm_1m_2)/r^2$

$Y = (F/A)/(\Delta L/L_o)$ $B = -\Delta P/(\Delta V/V_o)$ $W_{app.} = mg - B.F.$ $P = \rho gh$

$W_{app.} = W[1 - (\rho_f/\rho)]$ $F = -kx$ $[(1/2)mv^2]_{avg.} = (3/2)kT$ $\Delta Q = cm\Delta T = nC\Delta T$

$\Delta L = \alpha L\Delta T$ $\Delta V = \gamma V\Delta T$ $\Delta W = P\Delta V$ $P_1V_1^{\gamma} = P_2V_2^{\gamma}$ $(\Delta Q/\Delta t) = (kA\Delta T)/\Delta L$

$\Delta Q = \Delta U + \Delta W$ $a_{max.} = kx_o/m$ $a_c = \omega^2 x_o$ P.E. $= (1/2)kx^2$

$(1/2)kx^2 + (1/2)mv^2 = (1/2)kx_o^2$ $a = -kx/m$ $\omega = \sqrt{(k/m)}$ $v = \pm\sqrt{[(k/m)(x_o^2 - x^2)]}$

$v = \sqrt{(Y/\rho)}$ $f = (1/2\pi)\sqrt{(k/m)}$ $f = (1/2\pi)\sqrt{(g/L)}$ $v = \sqrt{[T/(m/L)]}$ $v = \sqrt{(B/\rho)}$

$PV = nRT$ $v = \sqrt{(\gamma RT/M)}$ $f = 1/\tau$ $\omega = 2\pi f$ $I_1\omega_1 = I_2\omega_2$ ΔT.E. $= f.s$

area of a sphere $= 4\pi r^2$ area of a right cylinder $= 2\pi rl$ $0K = 273^oC$

$F = (k\,q_1\,q_2)/r^2$ $\mathbf{F} = q\mathbf{E}$ $V_{AB} = Ed$ $C = (\varepsilon_o A)/d$ $\Delta R = R_o\alpha\Delta T$ $qV = (1/2)mv^2$

$W = qV_{AB}$ $\rho = (RA)/L$ $v = f\lambda$ $I_o = 10^{-12}$ W/m^2 $I(dB) = 10\log(I/I_o)$

$f_n = nf_1$ $\Delta q = mc\Delta T$ $q = CV$ $E = (1/2)qV$ $F = BIL\sin\theta$ $qvB = mv^2/r$

$f'/f = [1 - (v_l/v_w)]/[1 - (v_s/v_w)]$ $P = IV = I^2R$ torque $=$ (area)NIBsinθ

$B = \mu_o nI$ $B = (\mu_o I)/(2\pi r)$ $B = (\mu_o I)/(2a)$ $F = (\mu_o I_1 I_2 L)/(2\pi b)$ $v = v_o\sin(2\pi ft)$

$\varphi = BA\cos\theta$ e.m.f. $= N(\Delta\varphi/\Delta t)$ $W = (1/2)LI_f^2$ $I = i_o/\sqrt{2}$ $V = v_o/\sqrt{2}$

$V = IZ$ $X_C = 1/(2\pi fC)$ $X_L = 2\pi fL$ $Z^2 = R^2 + (X_L - X_C)^2$

$\tan\varphi = (X_L - X_C)/R$ $f_o = (1/2\pi)\sqrt{(1/LC)}$ $1/p + 1/i = 1/f$ $n_1\sin\theta_1 = n_2\sin\theta_2$

$1/f = 1/f_1 + 1/f_2$ $M_o = i_o(1/f_C - 1/f_o)$ $n\lambda = d\sin\theta_n$ $M = 1 + \gamma/f$ $P = IV\cos\varphi$

e.m.f. $= B_\perp vd$ e.m.f.$_{sec} = M(\Delta I_p/\Delta t)$ e.m.f. $= L(\Delta I/\Delta t)$ $\mathbf{F} = qvB_\perp$ $\mu =$ (area)I

$\mu =$ (area)I $I(t) = I_f(1 - e^{-t(L/R)})$ $i(t) = i_o e^{-t/RC}$ $q(t) = q_f(1 - e^{-t/t})$ $V(t) = V_o e^{-t/RC}$

$\varphi = hc/\lambda_o$ $(\text{kin. en.})_{max.} = (hc/\lambda - hc/\lambda_o) = V_o e$ $\sin(2\varphi) = 2\sin\varphi\cos\varphi$ energy $= hf$

volume of a sphere $= (4/3)\pi r^3$ $E = E_o\sin(2\pi ft)$ $I_{avg.} = (1/2)c\varepsilon_o E_o^2$ $B_o = E_o/c$