UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

SECOND SEMESTER EXAMINATIONS

2010-2011 ACADEMIC YEAR

1. BS 432 –Advanced Parasitology II
2. BS 455 –Wildlife Ecology (Practical Paper)
3. BS 482 –Food Microbiology
4. BS 492 –Fisheries Biology (Theory Paper)
5. BS 915 –Biology of seed Plants (Theory Paper)
6. BS 925 –Biology of Terrestrial Vertebrates (practical Paper)
7. BS 925 – Biology of Terrestrial vertebrates (Theory Paper)
8. C102 - Introductory Chemistry II
9. C212 - Introductory Biochemistry
10. C312 –Biochemistry I
11. C322 –Analytical Chemistry III
12. C342 –Inorganic Chemistry III
13. C412 – Advanced Biochemistry II
14. C482 -Inorganic Industrial Chemistry
15. CS 3062 –Advanced Databases and Information Systems
16. CS3252 –Electronics for computing IV
17. CS 4252 –Electronics for computing IV
18. CST 3022 –Exam
19. CST 3062 –Advanced Databases and Information Systems

20. CST 4012 –Advanced Operating Systems and Distributed Systems

21. CST 4122 –Compilers

22. CST 4132 –Computer Graphics

23. EM 312 –Engineering Mathematics IV

24. GEO 111 –Introduction to Human Geography I

25. GEO 175 –Introduction to Mapping Techniques in Geography

26. GEO 211 –Geography in Africa

27. GEO 272 –Quantitative Techniques in Geography II

28. GEO 912 –Geography of Migration and Refugees

29. GEO 922 –Geography of Regional Planning and Development

30. GEO 932 –Urban Geography

31. GEO 952 –Geographical Hydrology

32. GEO 962 –Biogeography

33. GEO 971 –Aerial Photography and Aerial Photo Interpretation Paper II

34. GG332 –Remote Sensing and Geographic Information Systems

35. M112 –Mathematical Methods II –A

36. M114 –Mathematical Methods 11 –B

37. M162 –Introduction to Mathematics, Probability and Statistics II

38. M212 –Mathematical Methods IV

39. M222 –Linear Algebra II
40. M232 –Real Analysis II
41. M292 –Introduction to probability
42. M325 –Group and Ring Theory
43. M412 –Functions of Complex Variables II
44. M462 –Bayesian Inference and Discrete Analysis
45. M912 –Mathematical Methods VI
46. P192 –Introductory Physics II
47. P272 –Geometrical and Physical Optics
48. P412 –Nuclear Physics
49. P422 –Solid State Physics II
50. P442 –Digital Electronics
51. P455 -Quantum Mechanics II
52. P485 –The Physics of renewable energy & environment

THE UNIVERSTITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BS 432: ADVANCED PARASITOLOGY II
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. USE ILLUSTRATIONS WHERE NECESSARY

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1. (a) Discuss nutrient transport in *Plasmodium* and explain how this parasite modulates the host cell membrane.
   (b) Based on the principle stated on (a) above, describe the mode of action of chloroquine as anti-malarial drug.

2. With the aid of a labled diagram, describe the ultrastructure of parasite plasma membrane and explain any three roles proteins played by membrane proteins in the parasite.

3. Discuss how differences in Folate metabolism in man and Protozoa could be exploited to develop anti-protozoal drugs.

4. Describe the tegumentary structure and functions of Cestodes.

5. Discuss carbohydrates and energy metabolism in African Trypanosomes.

6. Discuss the mechanism of action of Neuro-muscular Blocking Agents against helminthes. Give an example of a specific drug in your answer.

7. Discuss tricarboxylic Acid cycle in free-living and larval stages of helminthes.

8. (a) Draw a diagram of *Trichomonas vaginalis* and label its parts. Describe the organelle in which pyruvate oxidation takes place.

   (b) Name the enzymes that are involved in pyruvate oxidation in the parasite mentioned in (a) above

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BS 455: WILDLIFE ECOLOGY
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. USE ILLUSTRATIONS WHERE NECESSARY.

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1. Study the specimens provided and answer the questions.

Specimen A:
Describe the habitat in which this plant is co-dominant

Specimen B:

B1 Give the scientific Name of the specimen

B2 Give the scientific Name of the specimen

Specimen C:
C1 Describe the habitat of this species

C2 Describe the feeding habits of this specimen

Specimen D:
Describe characteristics that distinguish the two specimens
D1
D2

TURN OVER

Specimen E:
E1 Describe the distribution of the species in the Ethiopian Region

Specimen F:
F1 Briefly discuss the conservation status of this specimen.
F2 Describe the most suitable census method of this specimen

Specimen G:
Describe the habitat in which this plant is co-dominant

Specimen I:
Describe food habits of this specimen

Specimen J:
Describe sex dimorphism of this specimen

Specimen K:

K1 Describe the habitat in which this plant dominant

2. Zambezi - Samaki Farms Ltd is considering establishing a Game Ranch in the Choma District along the Munyeki stream. Initial investigations show that the range is suitable for Impala, Zebra, Wildebeest, Kudu and Buffalo. The range is relatively flat, well watered and nearly all the range is within 3.5km from water. Based on the information from the Ministry of Agriculture and Cooperatives in Choma, the soils are generally excellent for game ranching. Also results from your preliminary estimates indicate that the production of key forage species averages about 200kg/ha of dry matter per year. The proposed Sanctuary is 10,000 ha in size. Assuming that allowable use is 25% and daily dry matter intake is 2% of the animal body weight,

(a) Determine the number of 230 kg Sable Antelopes you would stock as your base herd in the area
(b) Discuss the limitations of this method in estimation the stocking rate of wildlife species.

3. You are required to use the map (**Figure 1)** provided to answer this question. Study the map carefully, and then answer the question:
Describe in detail the following habitats as indicated by the vegetation types and give examples of mammal species found in each of the habitats.
(a) Miombo woodland
(b) Munga –Combretum thicket
(c) Mopane woodland
(d) Riverine

NEXT PAGE

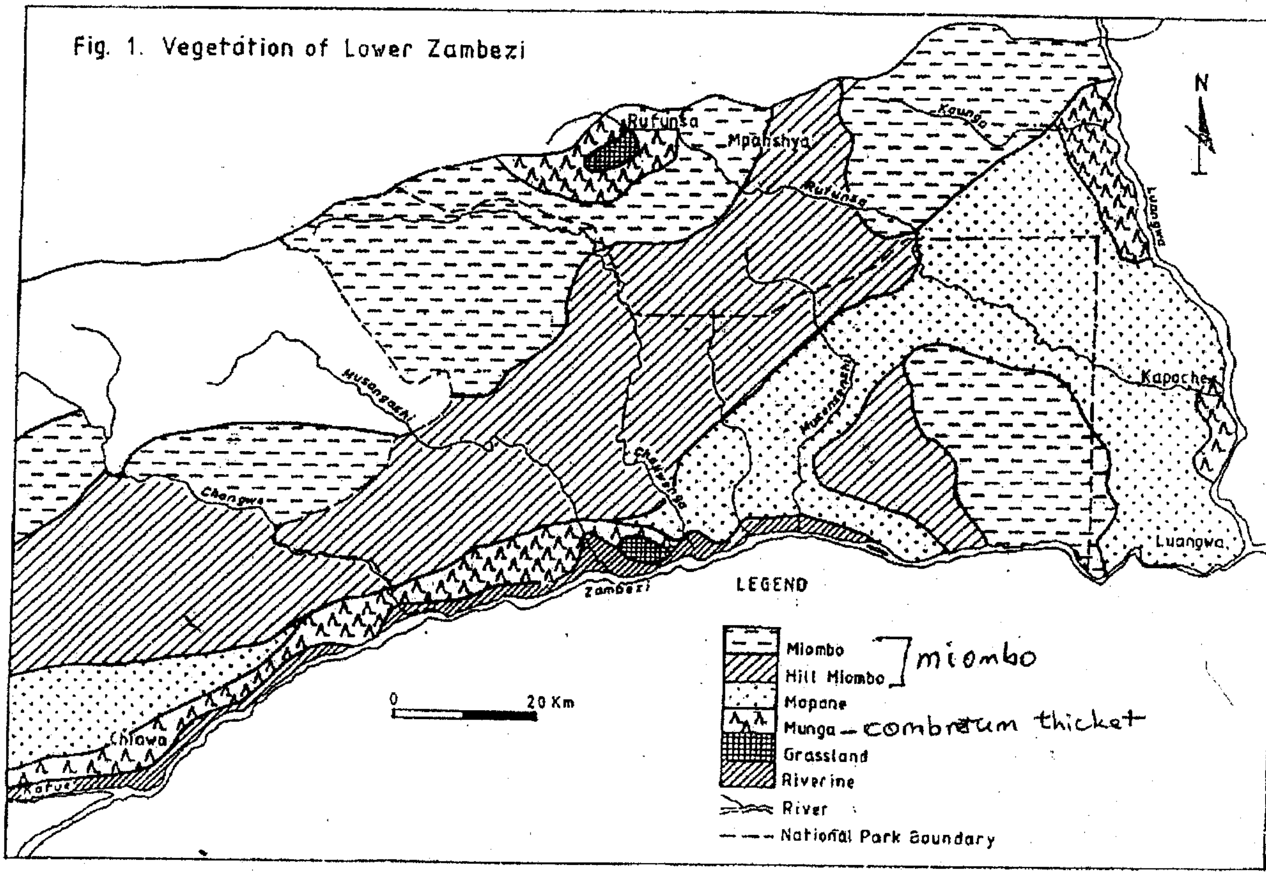

Figure 1: Lower Zambezi National Park

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BS 482: FOOD MICROBIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, **TWO** EACH FROM BOTH SECTION A AND B AND **ONE** FROM EITHER SECTION. USE A SEPARATE ANSWER BOOKLET FOR EACH SECTION.

SECTION A

1. Discuss two parameters that affect the growth of microorganisms in food products listing five factors for each parameter.

2. Explain each of the following:
   (a) Why poultry meat is an ideal medium for microbial growth.
   (b) The significance of microorganisms in milk.
   (c) Two factors that cause spoilage of canned foods.
   (d) The principle of food fermentation.

3. Discuss organisms of concern in food microbiology with reference to:
   (a) Intoxication, infection and enterotoxins.
   (b) Population at risk.
   (c) Incubation period.

4. (a) List the groupings of the enterovirulent *Escherichia coli*.
   (b) Describe the possible sources of *Salmonella* food poisoning.
   (c) List three pathogens of importance that are a threat to humans processing tropical fish and explain the spoilage of marine fish despite storage on ice after harvesting from the sea.

SECTION B

5. Distinguish between pathogens and spoilage organisms and list four types of microorganisms responsible for most food contamination.

6. Describe dehydration food preservation techniques and their benefits.

TURN OVER

7. Describe high-temperature food preservation techniques and their benefits.

8. Bacteriocins are regarded as antibiotics. However, they clearly differ from antibiotics in a number of ways.
   (a) Define the term bacteriocin and explain how these differ from antibiotics as well as their classification.
   (b) Explain how bacteriocins are used in food preservation industry and the factors that limit their efficacy.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR: SECOND SEMESTER
FINAL EXAMINATIONS

BS 492: FISHERIES BIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

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1. Discuss the following in relation to fish growth and development:

   (a) Asymptotic length.
   (b) Growth coefficient.
   (c) Condition factor.
   (d) Recruitment.
   (e) Fecundity.

2. Discuss the following terms and concepts as applied in management and conservation of fish stocks:

   (a) Growth overfishing.
   (b) Maximum Sustainable Yield.
   (c) Output controls.
   (d) Total Allowable Catch.
   (e) Preservation zones.

3. When determining fish stock sizes using the tagging method, explain how the estimates are affected if:

   (a) a constant of 10 percent of tagged fish are unreported by fishers.
   (b) fishers gradually lose interest in returning tagged fish owing to poor incentives given by the research team for reporting tagged fish.

4. Summarise applications of the swept area method in estimating fish stock sizes and highlight both its advantages and limitations.

TURN OVER

5. Discuss the rationale and limitations of the mean length method of Beverton and Holt (1956) in estimating total fish mortality (Z).

6. Explain in detail how fish length frequency data can be processed and used in constructing growth length and age curves.

7. Assess the advantages and disadvantages of a fishery management objective that aims at exploiting fish stocks at the Economic Break Even Point.

8. Discuss the different components of a fisheries management plan highlighting the significance of each one.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 -2011 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BS 915: BIOLOGY OF SEED PLANTS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. USE ILLUSTRATIONS WHEREVER NECESSARY

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1. Compare and contrast cycads and flowering plants in terms of:
   (a) Microsporogenesis.
   (b) The mature male gametophytes.

2. Describe pseudo-cereals with reference to species composition, food value and their potential in improving food security in Zambia.

3. Describe the sporophyte morphology of conifers and the reproductive strategy adopted by them. Explain the biological and economic importance of conifers.

4. Compare Green Revolution for its merits and demerits in relation to the use of traditional varieties of crop plants.

5. Describe the causes of dormancy in seeds and explain how to overcome them.

6. Describe the primary and secondary stem structure in flowering plants with particular reference to the vascular tissue organization.

7. Compare and contrast *Ephedra* and *Gnetum* with reference to distribution, sporophyte morphology and the economic importance.

8. Summarize any Two of the following.

   (a). Crop improvement.
   (b). Grafting.
   (c). Zambezian Phytoregion.
   (d). Apomictic Seed

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 - 2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BS 925: BIOLOGY OF TERRESTRIAL VERTEBRATES
PRACTICAL PAPER

TIME: THREE HOURS

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

EXAMINATION ANSWER BOOK

Candidate's Computer Number...

Full – Time or Part - Time Student...

Qualification for which registered ....

Course No...No of Paper..

Date of Examination...

Examination Venue..

COMPUTER No ------------------------------------

QUESTIONS 1 – 10

Examine specimens **1-10** provided. Identify the taxa and answer the questions associated with each specimen in the spaces provided.

SPECIMEN 1

(a) Order--

(b) Species---

(c) Draw and label both the dorsal and ventral shields of specimen 1.

SPECIMEN 2

(a) Species --

(b) Conservation status in Zambia--

TURN OVER

COMPUTER No---------------------------------

(c) Habitat---

(d) Feeding habits--

SPECIMEN 3

(a) Order --

(b) Species--

(c) Breeding biology--

PROCEED TO THE NEXT PAGE

SPECIMEN 4

(a) Order---

(b) Family---

(c) Species--

(d) Defensive and feeding habits---

SPECIMEN 5

(a) Class --

(b) Draw, label and describe the different types of feathers found on specimen 5 and their functions

TURN OVER

COMPUTER No---------------------------

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Computer No----------------------------

SPECIMENS 6 & 7

Construct a key for identifying specimens 6 and 7.

TURN OVER

COMPUTER No---------------------------

SPECIMENS 8 & 9

(a) Draw and label the dorsal head shields of specimens 8 and 9.

(b) Compare and contrast the feeding habits of specimens 8 and 9.

PROCEED TO THE NEXT PAGE

COMPUTER No------------------------

SPECIMEN 10

(a) Sub-order--

(b) Family---

(c) Species--

(d) Conservation status in Zambia--

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 – 2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BS 925: BIOLOGY OF TERRESTRIAL VERTEBRATES
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. USE ILLUSTRATIONS WHERE NECESSARY.

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1. Describe the morphological, anatomical and physiological adaptations which enabled crossopterygian fishes to successfully invade terrestrial habitats.

2. Discuss why crocodilians are considered to be closely related to birds than to other reptiles.

3. Compare and contrast *Bufo regularis* and *Xenopus laevis* in terms of:
   (a) Habitat.
   (b) Nervous system.
   (c) Breeding.
   (d) Feeding.
   (e) Osmoregulation.

4. Discuss the arboreal adaptive features of *Chamaeleo dilepis*.

5. Describe the different types of feathers found in Class Aves and their functions.

6. Summarise the following:
   (a) Amplexus.
   (b) Neoteny.
   (c) Uropygeal gland.
   (d) Jacobson's organ.

7. Discuss why snakes are believed to have evolved from burrowing lizards.

8. Compare and contrast the reproductive advantages of metatherians and eutherians.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

C102: INTRODUCTORY CHEMISTRY II

TIME: THREE HOURS

INSTRUCTIONS TO CANDIDATES

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

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

3. Section **A** has ten (**10**) short answer questions [Total marks = **40**]

4. Section **B** has five (**5**) long answer questions [Total marks = **60**]
   Questions carry equal marks

5. **ANSWER ALL QUESTIONS IN SECTION A; AND ANSWER <u>B1</u> AND ANY OTHER THREE QUESTIONS IN SECTION B.**

6. **ANSWER ALL QUESTIONS IN SECTION A IN THE MAIN BOOKLET**

7. **ANSWER SECTION B QUESTIONS EACH IN A SEPARATE BOOKLET**

YOU ARE REMINDED OF THE NEED TO ORGANIZE AND PRESENT YOUR WORK CLEARLY AND LOGICALY

USEFUL DATA

The Periodic Table of Elements

The Periodic Table of Elements is attached at the end of the Examination paper

Gas constant R

8.3145 J mol^{-1} K^{-1}
0.083145 L bar mol^{-1} K^{-1}
0.08206 L atm mol^{-1} K^{-1}
62.364 L torr mol^{-1} K^{-1}
62.364 L mmHg mol^{-1} K^{-1}

Pressure

1 atm = 1.01325×10^5 Pa
= 1.01325×10^5 N m^{-2}
= 760 torr
= 760 mmHg
= 1.01325 bar

1 bar = 1.00000×10^5 Pa

SECTION A **ANSWER ALL QUESTIONS**

Question A1.

Calculate K_c at 298 K for the reaction:

$$A\,(aq) + B\,(aq) \rightleftharpoons C(aq) \qquad \Delta G_r^0 = -\,439.6\ \text{kJ mol}^{-1}$$

Question A2.

The solubility of bismuth sulfide (Bi_2S_3) is $1.8\text{x}10^{-5}$g/100 mL of water at 18 °C. Calculate the K_{sp} for Bi_2S_3 at 18 °C.

Question A3.

The composition of an equilibrium mixture produced at 2.0 atmospheres and 997 K is shown below.

	$CH_4(g)$	$+\ H_2O(g)$	$\rightleftharpoons$	$CO(g)$	$+\ 3H_2(g)$
Amount in equilibrium mixture (in mol)	0.80	0.80		1.20	3.60

(a) Write the expression for the equilibrium constant, K_p,

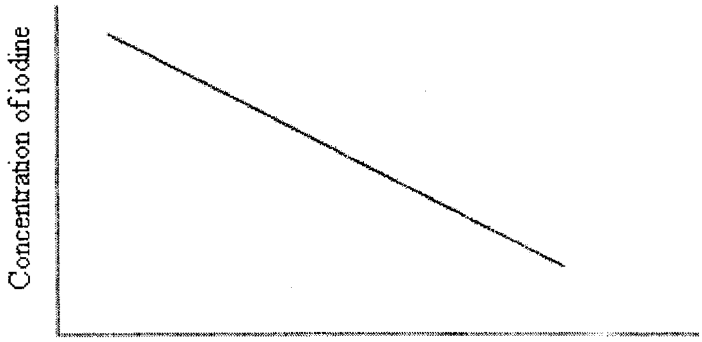
(b) Calculate the value of K_p

Question A4.

A student investigated the reaction between iodine and propanone in acidic conditions.

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

(a) The shape of the graph obtained from the results of the experiment is shown below.



Use the graph to deduce the order of reaction with respect to iodine, explaining your reasoning.

(b) In a further experiment a student collected following data:

Experiment	Volume of H_2SO_4	Volume of propanone	water	Volume of iodine	rate
	20.0	8.0	0.0	4.0	8×10^{-5}
	20.0	4.0	4.0	4.0	4×10^{-5}

$[H_2SO_4] = 2.0$ M

[propanone] = 2.0 M

(i) Deduce the order with respect to propanone.

(ii) If the order with respect to acid is one, write the rate equation.

Question A5.

Name all the intermolecular forces present in each of the following substances?

(a) H_2O (b) H_2S (c) SO_3 (d) CH_3NH_2

Question A6.

(a) Which aqueous solution is likely to have the higher freezing point, 0.5 m NaI or 0.5 m Na_2CO_3? Explain.

(b) Calculate the freezing point of 0.5 m aqueous solution of Na_2SO_4?

$K_f(H_2O) = 1.86$ K kg mol^{-1}.

Question A7.

The van't Hoff equation is given by

$$\ln K_{sp} = -\frac{\Delta H_{sol}}{R}\frac{1}{T} + \frac{\Delta S_{sol}}{R}$$

$$y = bx + a$$

For an exothermic reaction shown below at diffent temperatures, the van't Hoff plot has a **positive slope, b.**

$$Ca(OH)_2(s) + H_2O(l) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$$

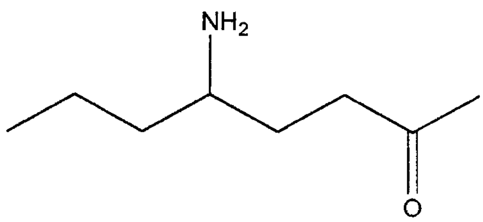
(a) Make a sketch of the van't Hoff plot of the above reaction.

(b) What is the effect of increasing temperature on solubility product, K_{sp}, of $Ca(OH)_2$ in water.

Question A8.

Provide the IUPAC names for following compounds:

(a)



(b)

Question A9.

Give the line (bond-line) formulae corresponding to the following IUPAC names.

(a) 4-Hydroxyheptanal

(b) 1,3-Dimethylbenzene

Question A10

The following names are incorrect. Draw the line (bond-line) structures and provide their correct IUPAC names.

(a) 1-Hydroxy-4, 4-dimethylcyclohexane

(b) 2-Isopropyl-4-methylpentane

Question A5.

Name all the intermolecular forces present in each of the following substances?

(a) H_2O (b) H_2S (c) SO_3 (d) CH_3NH_2

Question A6.

(a) Which aqueous solution is likely to have the higher freezing point, 0.5 m NaI or 0.5 m Na_2CO_3? Explain.

(b) Calculate the freezing point of 0.5 m aqueous solution of Na_2SO_4?

$K_f(H_2O) = 1.86$ K kg mol^{-1}.

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$$Ca(OH)_2(s) + H_2O(l) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$$

(a) Make a sketch of the van't Hoff plot of the above reaction.

(b) What is the effect of increasing temperature on solubility product, K_{sp}, of $Ca(OH)_2$ in water.

SECTION B — **ANSWER B1, AND ANY THREE QUESTIONS EACH IN A SEPARATE BOOKLET**

Question B1

In the C102 Experiment 2 "The quantitative study of reaction rate II: The Effect of Temperature", the following reaction is involved in the experiment:

$$2H^+(aq) + S_2O_3^{2-}(aq) \rightarrow S(s) + SO_2(aq) + H_2O(g)$$

A student collected the following data:

Temperature (K)	Reaction time (s)
295	53.46
305	26.10

(a) Write the Arrhenius equation. **[2 marks]**

(b) Calculate the activation energy of the reaction, given that the rate constant, k, is proportional to $\frac{1}{[\text{reation time}]}$. **[9 marks]**

(c) Give two major sources of error in the experiment. **[4 marks]**

Question B2

For an acid HA the value of the dissociation constant, K_a, is 1.45x 10^{-4} at 298 K.

(a) Write an expression for K_a for HA. **[2 marks]**

(b) Calculate the pH of a 0.250 mol dm^{-3} solution of HA at 298 K. **[5 marks]**

(c) A mixture of the acid HA and the sodium salt of this acid, NaA, can be used to prepare a buffer solution.

(i) State and explain the effect on the pH of this buffer solution when a small amount of hydrochloric acid is added. **[3 marks]**

(ii) The concentration of HA in a buffer solution is 0.250 mol dm^{-3}. Calculate the concentration of A^- in this buffer solution when the pH is 3.59. **[5 marks]**

Question B3.

(a) What is normal boiling point of a substance? **[2 marks]**

(b) Below are the vapour pressures of some common chemicals measured at 20 °C. Arrange these substances in order of increasing intermolecular forces. **[3 marks]**

Substance	**P(torr)**
Benzene ,C_6H_6	80.0
Acetone,C_3H_6O	184.8
Water, H_2O	17.5

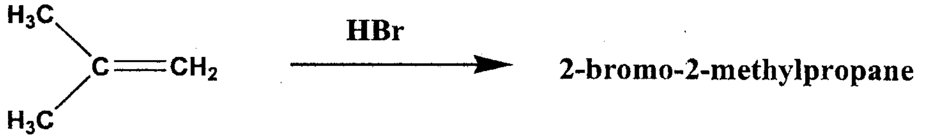
(c) The vapour pressure of acetone is 184.8 torr at 20 °C .The enthalpy of vapour of acetone is 30.3 kJ mol^{-1}. Using the Clausius-Clapeyron equation calculate the normal boiling point of acetone. **[10 marks]**

Question B4.

(a) Write the line (bond-line) formulae for all six possible isomers (acylic and cyclic) with molecular formula C_4H_8. **[3 marks]**

(b) Two isomeric compounds, **A** and **B**, have molecular formula C_4H_8 as the compounds you have drawn in part (a) above. Compound **A** decolorizes a solution of bromine in carbon tetrachloride but compound **B** does not react with bromine. On this basis choose one possible structure for **A** and one for **B**. **[2 marks]**

(c) When 2-methylpropene is reacted with hydrogen bromide, 2-bromo-2-methylpropane is obtained as the major product and a minor product, 1-bromo-2- methylpropane.



(i) Give the bond-line formula for the product shown above. **[1mark]**

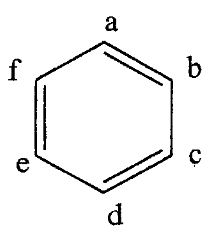
(ii) Given that this reaction proceeds via a carbocation intermediate, show all steps and mechanisms for this reaction. **[6 marks]**

(iii) Using the reaction mechanism, explain why 1-bromo-2-methylpropane is minor product. **[3 marks]**

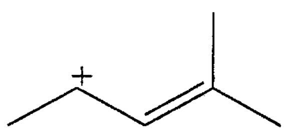
Question B5

(a) Draw the resonance structures for each of the following species. Clearly show the movement of electrons. **[4 marks]**

(i)



(ii)



(b) Give the structures and names for all the five monochlorinated products arising from the reaction of 1-methylcyclohexane and chlorine in light. **[5 marks]**

(c) Complete the following reaction equations by providing reagent and conditions **A** and reactant or substrate **B**: **[2 marks each]**

(i) $H_3CH_2CHC{=}CHCH_2CH_3 \xrightarrow[\text{reagent and conditions}]{\text{A?}}$ Hexane

(ii) **B?** **Reactant or substrate required** $\xrightarrow{Cl_2}$ 2, 3-Dichlorobutane

(iii) C_6H_{12} + excess $O_2 \longrightarrow$ **Products and balance the equation**

=====================END OF EXAMINATION=====================

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass

Name of the element X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Inidum	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

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

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATION

C 212: **INTRODUCTORY BIOCHEMISTRY**

TIME: **THREE HOURS**

1. All questions carry **EQUAL** marks
2. Answer **QUESTION 1** and any other **FOUR (4)** questions
3. Your answers must **NEAT AND TIDY**
4. There are **FOUR (4)** printed pages in this examination paper

---

Question 1 (COMPULSORY)

a) A buffer solution has a pH = 4.00. It was made using the conjugate pair benzoic acid and sodium benzoate. The benzoic acid concentration is 0.20 M. If the K_a of benzoic acid is 6.5×10^{-5}, **what** is the concentration of the sodium benzoate in the solution?

[5 marks]

b) **What** is the pH of a 1 L solution containing 0.240 mol $HC_2H_3O_2$ and 0.180 mol $NaC_2H_3O_2$? $K_a(HC_2H_3O_2) = 1.8 \times 10^{-5}$.

[3 marks]

c) **Calculate** the pH of an aqueous solution prepared by combining 60 mL of 0.1 M KOH and 180 mL 0.1 M acetic acid (pKa = 4.76). **What** would be the pH if a further 20 ml of the KOH solution is added to this solution?

[12 marks]

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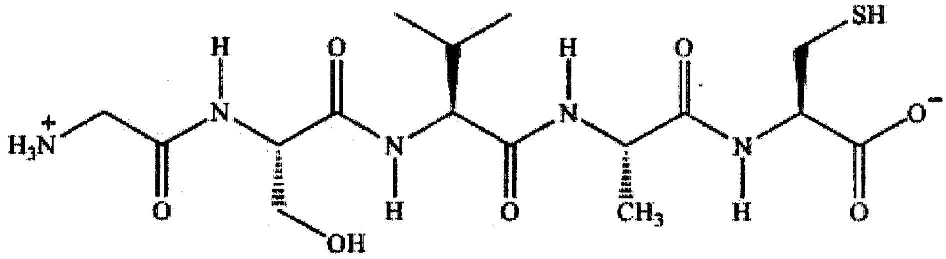
Question 2

a) **Write** down the names and three letter abbreviations of all the amino acids in the peptapeptide below starting from the N-terminal:



[15 marks]

b) **Which** of the amino acids in questions 2 a) above is an α-helix breaker? **Why**?

[5 marks]

Question 3

a) **Draw** structures of:
  i) UMP
  ii) dGDP

[5 marks]

b) **Complete** the pairing in the following piece of DNA indicating clearly the polarity of the molecule:

GATAACCTC

[5 marks]

c) If an *E. coli* cell is a flat ended cylinder of diameter 1.00 μm and length 2.00 μm:
  i) **What** is the volume of such a cell in cm^3?
  ii) If such a cell contains one chromosome of molecular weight 2.5×10^9, **what** is the intracellular molarity in mol/L of DNA, and
  iii) its concentration in $\mu g/cm^3$
  iv) **Calculate** the approximate length of the bacterial chromosome in mm.

[10 marks]

NOTE:

Avogadro's number = 6.022×10^{23} particles/mole, the average molecular weight of nucleotide in DNA is 310, the diameter of DNA is 2.00 nm and each nucleotide occupies 0.34 nm along the DNA molecule. 1 kb = 1000 base pairs. 1 μm = 10^{-6} m, 1 nm = 10^{-9} m.

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Question 4

a) If a mixture consisting of a triglyceride and phosphatidic acid were analyzed by thin layer chromatography on a silica gel in a chloroform-methanol-water developing solvent, you would observe complete separation, with R_f of the triacylglyeride being approximately 1 and that of phosphatidic acid approximately 0.4. Using general structures of these lipids, briefly **explain** why their R_f values differ so widely.

[10 marks]

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

[10 marks]

Question 5

a) Given the following information:

D-glyceraldehyde 3-phosphate + NAD^+ + H_3PO_4 =➔ 1,3 – Bisphosphoglyceric acid + NADH + H^+

$\Delta G^{0'} = +1500$ cal/mol

In vivo (pH 7.0, temp. 37 ^{0}C) the flowing concentrations are observed:
[D-glyceraldehyde 3-phosphate] = 10^{-4} M
[1,3-bisphosphoglyceric acid]= 10^{-5} M
[inorganic phosphate] = 0.01 M

What must the ratio of NAD^+/NADH be in order for the reaction to proceed spontaneously from left to right? **Show** your calculation.
R = 1.987 cal/K.mol

[10 marks]

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b) The H^+ concentration in gastric juice is 0.1M. The protons arise from blood, which has a pH of 7.4. **Calculate** the free energy change required for transport of enough protons to produce 1 liter of gastric juice at 37 ^{0}C.
HINT: You are asked to calculate the free energy change (ΔGt) for transport of a compound from a compartment where its concentration is C_1 across a membrane into another compartment where its concentration is C_2.
The "reaction" is:
$solute_{origin}$ -----> $solute_{destination}$.

$\Delta G^{0'}$ for this transport process = 0 because the "reactants" and "products" are chemically identical.

R = 8.315 J/K.mol

[10 marks]

Question 6

i) Match the enzyme on the left with the appropriate reaction on the right in the table below:

Enzyme	Reaction
Oxidoreductases	Isomerizations
Transferases	Hydrolysis reactions
Hydrolyases	Group elimination to form double bonds
Lyases	bond formation coupled with ATP Hydrolysis
Isomerases	Oxidation-reduction reactions
Ligases	Transfer of functional groups

[12 marks]

ii) Methanol is oxidized by alcohol dehydrogenase (ADH, found in the liver and other tissues) to the highly toxic compound formaldehyde. Drinking methanol is fatal because of the production of formaldehyde; methanol itself is harmless and is excreted by the kidneys.
ADH will also oxidize other alcohols, such as ethanol.

Based on this information **propose** a way to treat an individual who has ingested methanol. **What** additional information would you need before such a treatment could be tried?

[8 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATION

C 312: BIOCHEMISTRY II

1. Time: **THREE (3)** hours
2. Answer **ANY FOUR (4)** questions
3. Make sure you have **THREE (3)** printed pages in this examination
4. You are reminded of the need to present your work **NEATLY**

Question 1

a) **Write** down the complete structure of myristic acid (C14:0). **What** steps are involved in the biosynthesis of this fatty acid? **Show** by use of structures of all key compounds.
b) **Write** down four (4) differences between fatty acid oxidation and fatty acid synthesis.
c) **Give** two (2) reasons why biosynthesis of fatty acids does not follow the same path as the breakdown (oxidation) reactions.

Question 2

a) **Calculate** the $\Delta G'_0$ for the transfer of an electron in cyclic photophosphorylation from the primary acceptor of photosystem I (E'_0 = - 0.50 V) to cytochrome b_6 (E'_0 = -0.05 V). Faraday constant = 2.304×10^4 cal/volt/eq. Is the amount of energy generated in this process sufficient to result in synthesis of ATP from ADP and Pi. **Explain** (*Hint*: ATP hydrolysis yields 7.3 kcal/mol energy).

b) Reduction of three moles of CO_2 to form one mole of triose phosphate requires nine moles of ATP and six moles of NADPH. **What** is the source of NADPH in the reduction of CO_2? Is additional NADPH required for CO_2 fixation in C4 plants? Briefly **explain**.

PLEASE TURNOVER THE PAGE

Question 3

a) **Outline** the reaction(s) leading to the incorporation of nitrogen as ammonium ion into biological systems (leguminous plants).
b) **Write** down the glutamate dehydrogenase reaction and **explain** why this is considered logical control point in cells.

Question 4

a) Outline the reactions leading to the biosynthesis of deoxythymine 5'-monophosphate from uridine 5'monophosphate.
b) **Compare** and **contrast** the reaction leading to formation of carbamoyl phosphate in the urea cycle and that in the biosynthesis of pyrimidines.

Question 5

"Even when you are on a low-fat diet you can still put on weight if you do not watch your keep a lid on the starch and protein containing foods"

Explain in detail the biochemical basis of the truthfulness of this statement using glucose and the amino acid alanine as examples (show with use of key structures in the reactions).

Question 6

Using a **NEAT** and **WELL-LABELLED** diagram **describe** the replication of DNA. **Highlight** the roles of all enzymes and proteins involved in this process. **Explain** clearly how replication is carried on both strands.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATION

C322 ANALYTICAL CHEMISTRY III

TIME: **Three (3) Hours**

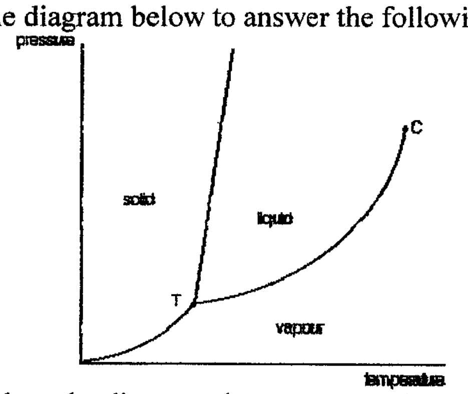
INSTRUCTIONS: Answer **any four** questions in this examination paper. Questions carry equal marks.

Question 1

(a) (i) How can you remove oxygen from the polarographic cell and why?

(ii) Explain how convective and electrostatic attractions are minimized in polarography.

(b) (I) Use the diagram below to answer the following questions:



(i). What does the diagram above represent?
(ii). What do points T and C represent?
(iii). What happens along the curve TC?

(II). Compare the efficiency of two separations with retention factors of 0.90 and 0.25 respectively, with clear reference to the mobile and stationary phases of the systems involved.

(c) Voltammetry was used to determine the zinc content of a breakfast cereal. A 2.314g sample was digested in boiling concentrated nitric acid. After the sample dissolved, it was diluted to 100ml. A 5.00ml portion of this solution was analyzed by differential pulse polarography, giving a current of 2.31μA. when 50.0μL of 100ppm zinc standard was added to this solution, the current was 2.99μA. What is the concentration of zinc in the cereal?

(d) A 0.3619g sample of tetrachloropicolinic acid, $C_6HNO_2Cl_4$, is dissolved in distilled water, transferred to a 1000 ml volumetric flask, and diluted to volume. An exhaustive controlled-potential electrolysis of a 10.00ml portion of this solution at a spongy silver cathode requires 5.374C of charge. What is the value of n for this reduction reaction?

Question 2

(a) Ion selective electrode and reference electrode pair was placed in exactly 100ml of the sample; a reading of 21.6mV was obtained. After the addition of exactly 10ml of a standard solution with a concentration of 100µg/ml, the electrode pair reading gave a reading of 43.7mV. The response slope of the indicator electrode was previously determined to be 57.8mV. What is the sample concentration?

(b) An unknown amount of copper (II) ions in a food sample produces a faradic current of 12.3µA on a normal pulse voltammogram. After 0.100ml of 1.0×10^{-3}M Cu^{2+} is added to the original volume of 5.00ml, the new current is 28.2µA. Calculate the original amount of copper in the food sample.

(c) The purity of a sample of $Na_2S_2O_3$ was determined by a coulometric redox titration using I^- ions as a mediator, and I_3^- ions as the 'titrant'. A sample weighing 0.1342g is transferred to a 100ml volumetric flask and diluted to volume with distilled water. A 10.00ml portion is transferred to an electrochemical cell along with 25ml of 1M KI, 75ml of pH 7.0 phosphate buffer, and several drops of a starch indicator solution. Electrolysis at a constant current of 36.45mA required 221.8s to reach the starch indicator end point. Determine the purity of the sample.

(d) (I) Ethanol and methanol were separated on a capillary GC column. Retention times recorded were 370 and 385seconds respectively and peak base widths of 16.0 s and 17.0 s while an unretained air peak occurred at 10.0 s. Calculate the resolution, R_s for the two compounds.

(II). The height equivalent to a theoretical plate (HETP) is defined according to the equation: HETP = $A + B/u + Cu$; where u is the average velocity of the mobile phase. A, B, and C are factors which contribute to band broadening.

(i). What is the name of the equation used to ensure optimal operational conditions in GLC?

(ii). Explain the role of any one of the constants A, B and C in the equation?

Question 3

(a) A 0.40g sample of toothpaste Colgate was suspended in 50ml of fluoride ionic strength buffering medium (TISAB), and boiled to extract the fluoride. The mixture was cooled, transferred quantitatively to a 100ml volumetric flask and diluted to volume with deionised water. A 25.0ml aliquot was transferred to a beaker; a fluoride ISE and reference electrode inserted and a potential of -155.3mV was obtained after equilibration. A 0.100ml spike of 0.5mg/ml fluoride stock solution was added after which the potential was -176.2mV. Calculate the percentage of F^- ions by weight in the original toothpaste sample.

(b) In coulometric titration of Fe^{2+} with Ce^{4+} which were generated at the cathode. The resistance was R = 150Ω, potential was 0.705V and the end point was reached after 352 seconds. Calculate the amount of iron in μg.

(c) (i) Define the term retention factor, and state which type of chromatography it is used in.

(ii). Calculate the retention factor, R_f, for a chromatography experiment during which the analyte travels 2.1cm, while the solvent front travel 2.8cm. What are the units of R_f?

(d) Calculate the relative decrease of concentratrion of zinc in %, after electrolysis on the drop mercury electrode which lasted 17 minutes. Suggest that current during electrolysis is constant. Given that: $m = 2.6x10^{-3}$g/s, t = 2.3s, $D = 0.95x10^{-5}cm^2/s$, $C = 2.5x10^{-4}$M volume is 15ml ($3.75x10^{-2}$mmol/l in 15ml or $3.75x10^{-5}$mol/L.

Question 4

(a) (i). A certain chromatographic separation resulted in a retention factor equal to 1. Explain why.

(ii). Give two characteristics which differentiate partition and ion-exchange chromatography equilibration processes.

(iii). A column has a retention time of 52.3 mm, and width at peak base = 9.0 mm. Calculate the number of theoretical plates for the column.

(b) Sodium benzoate, a salt of benzoic acid (a weak acid), is widely used as a food preservative. You wish to determine the ionization constant of benzoic acid and you choose to use conductometric method for your determination. You find that the equivalent conductance of a 0.002414M benzoic acid solution is found to be 32.22 at 25°C. Calculate the degree of dissociation of benzoic acid at this concentration, and calculate the ionization constant. Given that the Limiting Equivalent conductance of some ions in water at 25°C are:

Cations	λo+	Anions	λo-
H^+	349.8	OH^-	198.6
Na^+	50.1	Cl^-	76.4
Ca^{2+}	59.5	Acetate	40.9
Mg^{2+}	53.1	Benzoate	32.4

(c) Ions that react with Ag^+ can be determined electrogravimetrically by deposition on a silver anode:

$$Ag(s) + X^- \longrightarrow AgX(s) + e$$

(i) What will be the final mass of a silver anode used to electrolyze 75.00ml of 0.02380M KSCN if the initial mass of the anode is 12.4638g?

(ii) At what anode potential versus SCE cathode will 0.10M Br^- be deposited as AgBr(s)?

(d) What potential would a cell have which contain hydrogen electrode and calomel electrode. Potential of calomel electrode is 0.244V, t = 25°C and pressure of H_2 is P_{H2} = 101.325kPa

Question 5

(a) Briefly explain the roles of the working, counter and reference electrodes in potentiostatic electrolytic cell.

(b) Explain how you would determine the molar conductivity at infinite dilution for a strong and weak electrolyte in a food sample.

(c) The concentration of Ca^{2+} in a sample of sea water is determined using a Ca ion-selective electrode and a one-point standard addition. A 10.00-mL sample is transferred to a 100-mL volumetric flask and diluted to volume. A 50.00-mL aliquot of sample is placed in a beaker with the Ca ion-selective electrode and a reference electrode, and the potential is measured as –0.05290 V. A 1.00-mL aliquot of a 5.00 x 10^{-2} M standard solution of Ca^{2+} is added, and a potential of –0.04417 V is measured. What is the concentration of Ca^{2+} in the sample of sea water?

(d) (i). Name any three (03) key components of a gas chromatograph, then give details of what occurs in the sample injection port.

(ii). The efficiency of a chromatographic (GLC) column is expressed as (N) the number of theoretical plates. Calculate the retention time of a column with width at peak base = 20.0 s, and number of theoretical plates equal to 500 plates.

END OF EXAMINATION

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number **X** Atomic mass Name of the element X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
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89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einstienium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

C 342: INORGANIC CHEMISTRY III

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS

Question 1.

(a) Discuss lanthanide contraction giving causes and its consequences.
(b) Explain the following:
(i) Which is more basic: Nd_2O_3 or Dy_2O_3
(ii) Which is thermally more stable: $Sm(NO_3)_3$ or $Tm(NO_3)_3$
(iii) La^{3+}, Lu^{3+}, Yb^{2+}, Ce^{4+} are diamagnetic while Sm^{3+} has low paramagnetism
(c) Discuss the variation in melting point and boiling point, density, magnetic properties and reducing power, reactivity and colour of actinides.

Question 2.

(a) Describe the separation of lanthanides by ion exchange method.
(b) Helium-6 is a radioactive isotope with $t^{1/2}$ = 0.81 s. Calculate the binding energy if mass defect is 0.03141 g/mol. Also calculate binding energy of Helium-4 whose mass defect is 0.03038 g/mol. Is a Helium-6 nucleus more stable or less stable than a Helium-4 nucleus?
(c) Give a detailed description of artificial or induced radioactivity.

Question 3.

(a) What is the importance of binding energy curve?
(b) Chelate effect is essentially entropy effect? Explain
(c) Write the rate law for the formation of $[MnX(OH_2)_5]^+$ from aqua ion and X^-. How would you undertake to determine whether the reaction is dissociative or associative?

Question 4.

(a) Write out the inner and outer sphere pathways for the reduction of azidopentamine cobalt III ion with V^{2+} aq. What experimental data might be used to distinguish between the two pathways?
(b) The reaction of $CrCl_3$ with liquid ammonia ordinarily gives principally $[Cr(NH_3)_5Cl]Cl_2$, but when a trace of KNH_2 is present, the main product is $[Cr(NH_3)_6]Cl_3$. Explain.
(c) In ligand replacement reactions at tetrahedral sites there involves large negative values of Δs (entropy). Comment.

Question 5.

(a) Sketch a η^2 interaction of 1, 3 butadiene with a metal atom M and (b) do the same for an η^4 interaction.
(b) The CO stretching wave numbers in $[Cr(CO)_4(PPh_3)_2]$ are lower than in the corresponding hexacarbonyl compounds. Why?
(c) Do (1) $IrBr_2(CH_3)(CO)(PPh_3)$ and (2) $Cr(C_5H_5)(C_6H_6)$ obey 18 electron rule?

Question 6.

(a) Describe the physical and chemical properties of liquid hydrofluoric and sulphuric acids, ammonia and sulphur dioxide.
(b) Write down the reactions between:
(i) Liquid H_2SO_4 and oxides of nitrogen and SO_3.
(ii) Liquid SO_2 and H_2S at room temperature and at -70° C.
(c) Write down the reactions between AgCl and KNO_3 in liquid ammonia and explain why the result is considerable different if KCl and $AgNO_3$ react in water

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2011 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATIONS

C412: ADVANCED BIOCHEMISTRY II

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer any **FOUR (4)** questions
2. Time: **THREE** (3) hours
3. All questions carry **EQUAL MARKS**

Question 1

a) **What** principles underlie any food preservation method?
b) **What** method may be used in the preservation of fresh milk? meat? beer?
c) **What** is the scientific basis for using each the methods in b) above?

[25 marks]

Question 2

a) Briefly **describe** any four elements of innate immunity.
b) **What** three (3) features distinguish immunoglobulin (Ig) from a T-cell receptor(TCR)?
c) **Explain** in detail the generation of TCR diversity highlighting key differences with generation of Ig diversity.

[25 marks]

Question 3

Discuss in detail real and perceived dangers associated with genetically engineered products.

[25 marks]

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Question 4

Discuss in detail how DNA is packed in the nucleus of eukaryotic cell. **Explain** how this DNA still remains available for replication and gene expression at the same time. **Cite** experimental evidence in your discussion.

[25 marks]

Question 5

i) **Explain** what is meant by:

a) Plasmid
b) Restriction endonuclease
c) PCR
d) Deoxyribonuclease

[10 marks]

ii) Suppose that a circular plasmid contains 1000 bp. It is cut by three different restriction endonucleases, both singly and in pairs, with the results as shown below.

ENZYME(S)	FRAGMENT LENGTH(S)
A	1000
B	100, 300, 600
C	200, 800
A + B	50, 100, 300, 550
A + C	200, 375, 425
B + C	75, 100, 125, 225, 475

Reconstruct the plasmid, indicating where each enzyme cuts and the distances between all cuts.

[15 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2011 ACADEMIC YEAR, SECOND SEMESTER
FINAL EXAMINATION

C482: INORGANIC INDUSTRIAL CHEMISTRY

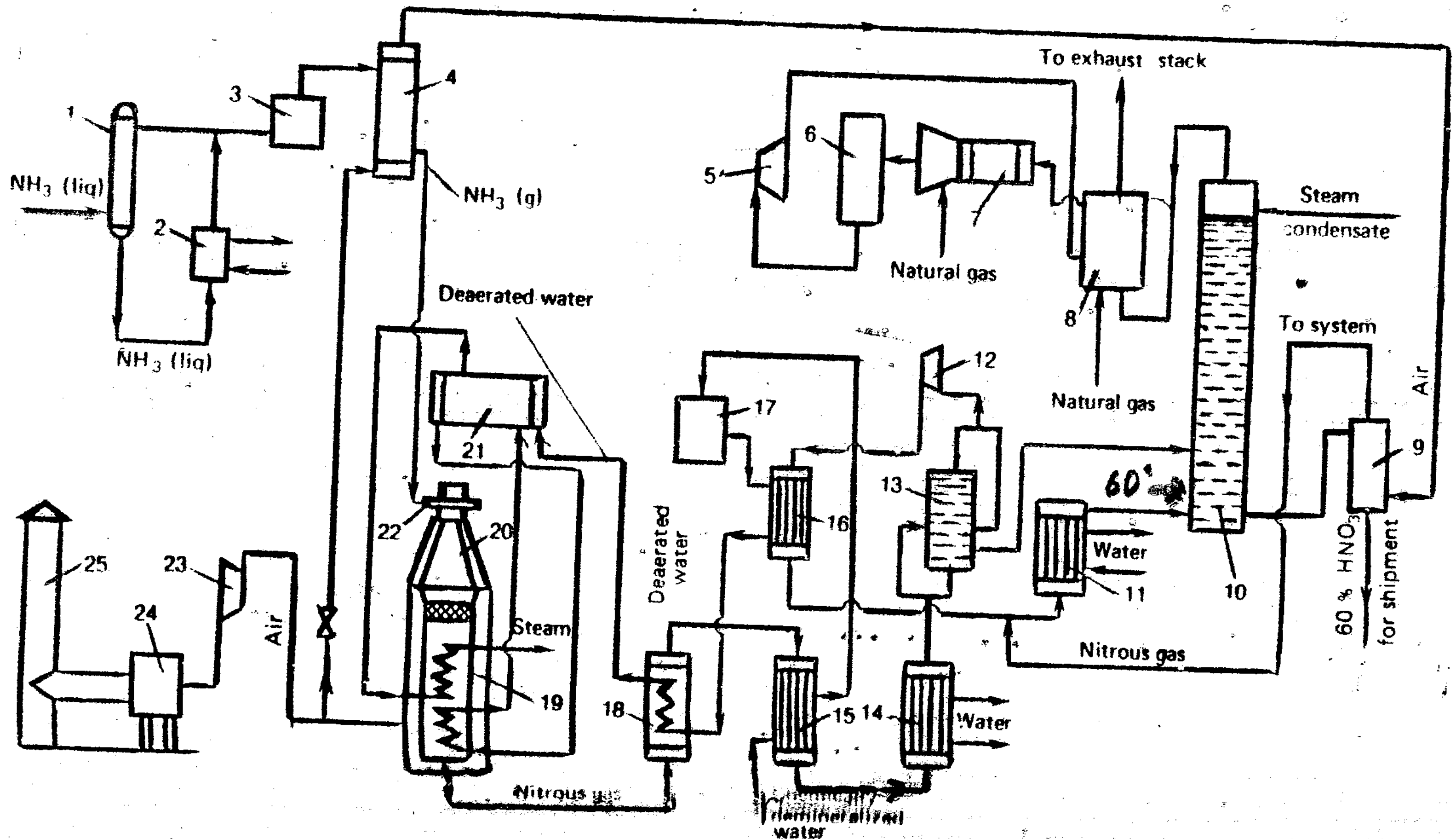
TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS

Question 1.
Describe the properties, manufacture and use of:
(a) Compound fertilizers (give examples of synergism and antagonism of the mixed fertilizers).
(b) Ammonium sulphate.
(c) Single and double superphosphate.

Question 2.
(a) Describe the production processes of calcined soda: write down reactions of the processes, indicate the yield of the products at calcinations and carbonization stages.
(b) In the production of Nitric acid, Ammonia is mostly used. Outline the physicochemical foundation manufacturing dilute Nitric acid.
(c) Outline the production process of dilute nitric acid (write down the temperatures, pressures and concentrations of the main components in the liquid and gaseous phases on the given flow sheet).

Question 3.
(a) Briefly explain how ortho-phosphoric acid is produced by wet-method and how they determine the concentrations of H_3PO_4 and remains of H_2SO_4 in the resulting product.
(b) Describe the production process of concentrated sulphuric acid.
(c) Write down the reactions production of the following Potassium salts: sulphate, carbonate, bromate ,iodate, and permanganate.



NH3 (liq)
NH3 (liq)
NH3 (g)
Deaerated water
To exhaust stack
Natural gas
Natural gas
Steam
condensate
To system
Air
60 % HNO3
for shipment
Water
Nitrous gas
Deaerated water
Steam
Air
Nitrous gas
Water
water
60°
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

Question 4.

In the production of Sulphuric acid Iron pyrite and Sulphur are usually used.
(a) What are the advantages and disadvantages associated with the use of these raw materials?
(b) Describe the SO_2 oxidation to SO_3 process (indicate kindling and other temperatures if Vanadium catalyst is used).
(c) State the properties of 98.3% sulphuric acid and why this acid is used for absorption of SO_3 containing gas?

Question 5.
Write down the reactions and outline the major steps involved in the production of:
(a) Ammonium nitrate.
(b) Urea.
(c) Hydrochloric acid.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Studies

CS3062 Final Exam

Advanced Databases and Information Systems

Time 3 Hours

05/05/11

This exam has seven questions. Answer any five questions. Each question question carries 20 points. Label your questions clearly.

1. Consider the following simplified relational schema for InstantBuy:

OrderDetail(orderNo, itemType)	10,000 records stored in London
Client(clientNo, cCity)	1,000 records stored in Glasgow
ClientOrder(clientNo, orderNo)	100,000 records stored in London

For simplicity, assume that each tuple in each relation is 10 characters long, there are 100 clients who have ordered item 'TV3190', there are 10 clients in Edinburgh and computation time is negligible compared to communication time. The communication system has a data transmission rate of 10,000 characters per second and a 1-second access delay to send a message from one site to another.

   a. Briefly discuss the advantages and disadvantages of a DDBMS. **[2 points]**
   b. Compare and contrast the different ownership models for replication in relation to replication servers. Give examples to illustrate your answer. **[2 points]**
   c. Briefly discuss the advantages and disadvantages of fragmentation. **[2 points]**
   d. Write an SQL query that will list the clients in Edinburgh who have ordered items of type 'TV319'. **[4 points]**
   e. Give five possible strategies for retrieving data for this query. **[5 points]**
   f. Calculate the amount of time it would take to run the query under each of the strategies stating any assumptions you make to support your calculations. **[5 points]**

2. Perilous Printing is a large printing company that does work for book publishers throughout Europe. The company currently has over 50 offices, most of which operate autonomously, apart from salaries, which are paid by the head office in each country. To improve the sharing and communication of data, the company has decided to implement a Distributed DBMS. Perilous Printing jobs consist of printing books or part of books. A printing job requires the use of materials, such as paper and ink, which are assigned to a job via purchase orders. Each printing job may have several purchase orders assigned to it. Likewise, each purchase order may contain several purchase order items.

Office	(<u>officeNo</u>, oAddress, oTelNo, oFaxNo, mgrNIN, countryNo)
Staff	(<u>NIN</u>, fName, lName, sAddress, sTelNo, sex, DOB, position, taxCode, salary, officeNo)
Publisher	(pubNo, pName, pCity, pTelNo, pFaxNo, creditCode, officeNo)
Bookjob	(<u>jobNo</u>, pubNo, jobDate, jobDescription, jobType, supervisorNIN)
PurchaseOrder	(<u>jobNo</u>, <u>poNo</u>, poDate)
POItem	(<u>jobNo</u>, <u>poNo</u>, <u>itemNo</u>, quantity)
Item	(itemNo, itemDescription, amountInStock, price)
Country	(<u>countryNo</u>, countryName)

Office contains details of each office and the office number (officeNo) is the key. Each office has a Manager represented by the manager's national insurance number (mgrNIN).

Staff contains details of staff and the national insurance number (NIN) is the key. The office that the member of staff works from is given by officeNo.

Publisher contains details of publisher and the publisher number (pubNo) is the key. Publishers are registered with the nearest office in their country, given by officeNo.

Bookjob contains details of publishing jobs and the job number (jobNo) is the key. The publisher is given by the publisher number (pubNo) and the supervisor for the job by supervisorNIN.

PurchaseOrder contains details of the purchase orders for each job and the combination of job number and a purchase order number (jobNo, poNo) form the key.

Item contains details of all materials that can be used in printing jobs and the item number (itemNo) is the key.

POItem contains details of the items on the purchase order and (jobNo, poNo, itemNo) forms the key.

Country contains the names of each country that Perilous Printing operates in and the country number (countryNo) is the key.

As well as accessing printing jobs based on the publisher, jobs can also be accessed on the job type (jobType), which can be: 1 – Normal; 2 – Rush.

The offices of Perilous Printing are grouped into countries as follows:

Country 1:	UK	Country 2:	France	Country 3:	Germany
Country 4:	Italy	Country 5:	Spain		

a. A DDBMS may be classified as homogeneous or heterogeneous. Compare and contrast these two types of distributed systems. **[2 points]**

b. Discuss the extended capabilities or services that a DDBMS must provide over a centralized DBMS. **[2 points]**

c. Draw an Entity–Relationship Diagram for the above case study. Indicating clearly the multiplicities. **[6 points]**

d. Using this diagram from (c) above, produce a distributed database design for the system that satisfies the correctness rules for fragmentation and include:

   I. a suitable fragmentation schema for the system; **[4 points]**

   II. in the case of horizontal fragmentation, give a minimal set of predicates; **[4 points]**

   III. The reconstruction of global relations from fragments. **[2 points]**

3. You have a database that has information about a family. Each person stored in the database has a name and may have a father mother and children. Note that in using this data we should be able to interlink the data. For example given a particular person we should be able to retrieve the record of their father if existing.

   a. What is a dtd? **[2 points]**

   b. State and contrast the two different types of dtds. Give examples of their usage. **[4 points]**

c. What are the two data types that are supported in XML? Explain their significance. **[2 points]**
d. Write down the XML dtd that defines the data in the database and some sample XML data that conforms to this dtd. **[5 points]**
e. What is XSLT? **[2 points]**
f. Write the XSLT that displays all the records in the XML document in a table and the other that displays the data of a particular person in a table. **[5 points]**

4. You are a database administrator and you have been assigned the responsibility of designing a simple student record system. The database is to store student names, date of birth and computer numbers. Students take different courses. Those taking science courses do labs. Those taking education related courses have practice sessions. The last category of students is that of social science students and these students should have a reading group. A reading group defines the time and place to meet on a weekly basis.
    a. What is an object oriented database? **[2 points]**
    b. What are the advantages of an object oriented database as compared to a relational database? **[4 points]**
    c. Draw an object model to illustrate the class design. **[2 points]**
    d. Using this model write the java code that would be used to implement the design and create the database using db4o. **[6 points]**
    e. Write the code for inserting a student record into this database, updating the student's record and also for deleting the record. **[6 points]**

5. You have been tasked to implement a simple database for a University. Below is the simple schema of this database

    Student (compNum (PK), fName, lName,contactNum),
    Course (courseID (PK), Description,instructorID)

    a. Write the SQL to create a database Schema called University **[2 points]**
    b. Write the SQL to create the following tables in the University Schema **[4 points]**
    c. The relationship between Course and Student is a many to many relationship. What sorts of problem can this cause? Resolve the problem stating any assumptions made. **[4 points]**
    d. Describe the alternative strategies that can be applied if there is a child record referencing a parent record that we wish to delete. **[2 points]**
    e. Write an SQL trigger that gets activated when updating a student record and inspects the condition (d) above. **[6 points]**
    f. Write a query that returns the number of students enrolled for each course. **[2 points]**

6. There are a lot database related technologies which are arising and are related to networking.
    a. Give two examples of advanced applications that are network based. **[2 points]**
    b. What are the advantages and disadvantages of using Web based applications? **[2 points]**

c. Discuss, in brief, distributed processing and parallel database management systems. **[2 points]**
d. With illustration explain the main architectures for parallel database systems. **[2 points]**
e. How do XML and its related technologies try to support the dynamic aspect of Web pages? **[2 points]**
f. You have just been hired as a database specialist at Fiction Company. Your first task is to automate the capture of sales orders. Given the sales order form below normalize this data to third normal form (3NF) **[10 points]**

Sales Order

Fiction Company
202 N. Main
Mahattan, KS 66502

CustomerNumber:	*1001*	**Sales Order Number:**	405
Customer Name:	*ABC Company*	**Sales Order Date:**	2/1/2000
Customer Address:	*100 Points*	**Clerk Number:**	*210*
	Manhattan, KS 66502	**Clerk Name:**	*Martin Lawrence*

Item Ordered	Description	Quantity	Unit Price	Total
800	*widgit small*	*40*	*60.00*	*2,400.00*
801	*tingimajigger*	*20*	*20.00*	*400.00*
805	*thingibob*	*10*	*100.00*	*1,000.00*
	Order Total			*3,800.00*

7.

a. Explain in details the weaknesses of Relational Database Systems **[5 points]**
b. Compare and contrast synchronous and asynchronous replication **[5 points]**
c. Define and give an example of UNF, 1NF, 2NF, 3NF. **[5 points]**
d. Discuss the general characteristics of advanced database applications. **[5 points]**

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

CS3252: ELECTRONICS FOR COMPUTING IV

SEMESTER 2 EXAM **18th MAY 2011**

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

QUESTION 1
(i) List three (3) VLAN Implementations methods [4 Marks]
(ii) Describe each method in details [12 Marks]
(iii) Give advantages and disadvantages for each [4 Marks]

QUESTION 2
(i) List four (4) layer 1 network design goals and describe each in details [12 Marks]
(ii) List four (4) critical network design components that should be addressed [8 Marks]

QUESTION 3
(i) List four (4) steps in LAN design and implementation [10 Marks]
(ii) Explain the details involved in each step [10 Marks]

QUESTION 4
(i) Design a network encompassing 50 workstations, 1 mail server, 1 web server, 4 switches, and 1 router. The network should have the following characteristics:
1. It should be a three layered hierarchical network in topology
2. It should have at least two departments and VLANs
Describe your design in details (including vertical and horizontal cabling) [40 Marks]

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

CS4252: ELECTRONICS FOR COMPUTING IV

SEMESTER 2 EXAM **4^{th} MAY 2010**

TIME: <u>THREE HOURS</u>

ANSWER: <u>ANY FIVE QUESTIONS</u>

QUESTION 1
(i) List three (3) VLAN Implementations methods [3 Marks]
(ii) Describe each method in details [6 Marks]
(iii) Give advantages and disadvantages for each [3 Marks]

QUESTION 2
(i) List four (4) layer 1 network design goals and describe each in details [8 Marks]
(ii) List four (4) critical network design components that should be addressed [4 Marks]

QUESTION 3
(i) List four (4) steps in LAN design and implementation [4 Marks]
(ii) Explain the details involved in each step [8 Marks]

QUESTION 4
(i) Design a network encompassing 100 workstations, 1 mail server, 1 web server, 6 switches, and 2 routers. The network should have the following characteristics:
1. It should be a three layered hierarchical network in topology
2. It should have at least three departments and VLANs
Describe your design in details (including vertical and horizontal cabling) [12 Marks]

QUESTION 5
(i) Explain the Spanning Tree Protocol (STP) [2 Marks]
(ii) Describe its operation in details [5 Marks]
(iii) List the five STP states [5 Marks]

QUESTION 6
(i) List four (4) unique issues about wireless media [4 Marks]
(ii) Describe the configuration of the BSS infrastructure [4 Marks]
(iii)List four (4) MAC functionality [4 Marks]

QUESTION 7
(i) Describe the CSMA/CA protocol in terms of DIFS, PIFS, SIFS and Contention Window [12 Marks]

END OF EXAM

CST 3022 Exam
Friday 6th May 2011

Answer any **five** questions. All questions carry equal marks.
Write clearly and explain steps precisely.
Lecturer: Dr. John Regan

1.

a) Consider a midtest loop, here written in Java, that looks for blank lines in its input:

```
for(;;) {
   line = read_line();
   if (all_blanks(line)) break;
   consume_line(line);
   }
```

Show how you might accomplish the same task using a `while` or a `do-while` loop, if midtest loops were not available. How do these alternatives compare to the midtest version? *Midtest means testing in the middle of a loop.*

b) Consider the following expression in Java: `(a/b > 0 && b/a > 0)`
What will be the result of evaluating this expression when `a` is zero? What will be the result when `b` is zero? Would it make sense to try to design a language in which this expression is guaranteed to evaluate to false when either `a` or `b` (but not both) is zero? Explain your answer in each case clearly.

c) Describe what is meant by an ***r-value*** and an ***l-value***. Give an example of each in a language of your choice.

d) In certain circumstances the following expression may lead to bugs in a developers program. Explain why the expression could be potentially dangerous.

```
a - f(b) - c * d
```

2.

a) Explain the difference between **imperative** and **declarative** languages.

b) Explain the role of the **scanner** and the **parser** in compilation.

c) There is no obvious one-step algorithm to convert a set of regular expressions into an equivalent deterministic finite automaton (DFA). Therefore a typical scanner uses three steps. **Describe and explain** each of these steps.

d) Construct a minimised DFA equivalent to the regular expression

```
digit* ( . digit | digit . ) digit*
```

In answering this question you should break it into the three parts in part c. Marks will be awarded for each of the three parts.

3.

a) Explain the term **binding lifetime** of an object[1].
b) Explain the terms **static allocation, stack based allocation** and **heap based allocation** giving examples of each.
c) Explain the term **garbage collection** and how it relates to programming languages. Give an example of a language that uses garbage collection and one that doesn't.
d) What is meant by the **scope** of an object? Explain the difference between **static scoping** and **dynamic scoping.**
e) Consider the following pseudocode:

```
x : integer;                                  --global

procedure set_x(n : integer)
      {
            x := n;
      }
procedure print_x()
      {
            write_integer(x);
      }
procedure first()
      {
            set_x(1);
            print_x();
      }
procedure second()
      {
            x : integer;
            set_x(2);
            print_x();
      }
set_x(0);
first();
print_x();
second();
print_x();
```

What does the program print if the language is **statically scoped**? What does it print with **dynamic scoping**? Explain briefly the reason for the value printed in each case.

1Recall that an object in this sense refers to anything that might have a name: variables, constants, types and so on and is not related to the concept of an object in an object orientated language.

4.

a) Give three examples of **built-in** types in a language of your choice. Clearly name the language and the built-in types.
b) Explain each of the following terms giving examples where appropriate:
   1. Type Equivalence
   2. Type Conversion
   3. Type Compatibility
   4. Type Inference
   5. Universal Reference Types
c) Explain each of the following terms giving an example of a language that uses each:
   1. Row-Major Layout
   2. Column-Major Layout
   3. Row-Pointer Layout

5.

a) Explain the difference between **callee-save** registers and **caller-save** registers.
b) Explain the term **in-line** expansion. Give an example of why and where it would be used.
c) Explain what is meant by ***call-by-value***, ***call-by-reference*** and ***call-by-sharing***. Consider the following pseudocode:

```
a : integer;                            --global
c : integer;                            --global
procedure A(a : integer, c : integer)
{
     c = a/3;
     print a;
     print c;
     a = 19;
}

a = 12;
c = 3*a;
A(a, c);
print a;
print c;
```

What is the output of the above program in each of the following cases:
   1. Call-by-value
   2. Call-by-reference
   3. Call-by-sharing

6.

a) Scheme is a functional language and has both ***first class procedures*** and ***higher order procedures*** – briefly explain both terms.

b) In Scheme ***parameter passing is by value*** – explain briefly what this means with relation to Scheme.

c) Consider the following Scheme code.

```
(define x 6)
(define y 7)

(define (double x) (+ x x))

(define (func1)
     (let ((a 10)
           (b 20))
             (double a)
             (double b)
             (double x)))

(define (func2)
     (let ((a 20)
           (b 40))
             (let ((c 1)
                   (d 2))
                (double a)
                (double c)
                (double d))))
```

   a) What is returned by calling `func1`?
   b) What is returned by calling `func2`?
   c) Using contour scope blocks draw out the bindings for the local variables in `func1` and `func2`.

d) Given the following Scheme code – say what is returned by the call to the procedure `result` at the end and why:

```
(define a 6)
(define (func) a)

(define (result)
     (let ((a 9))
         (func)))
(result)
```

7.

a) Write a scheme procedure which takes the minimum of two numbers.
b) What is meant by the ***car*** of a pair and the ***cdr*** of a pair in scheme?
c) Show in Scheme how to create a variable `foo` which is a pointer to a pair of numbers.
d) Write a procedure in Scheme that calculates the length of a list (ignore the fact that Scheme has a built in procedure called length). Your procedure should take a list as an argument e.g. (my-length my-list) where my-length is the function and my-list is the list passed in as an argument.
e) Give an example of four predicates built into Scheme – explain what each one does.

8.

a) Explain what is meant by the terms ***actual*** parameters and ***formal*** parameters.
b) Explain what the function of the ***stack pointer*** and ***frame pointer*** is.
c) Explain the role of **Dope Vectors** in arrays. Describe what is meant by a **conformant array**.
d) Assume that a subroutine takes as its only argument the size of an array e.g.

```
void foo(int size) {
   double M[size][size];
   ...
   return;
}
```

Using the above subroutine as a template sketch out the stack frame for the above subroutine.

University of Zambia

School of Natural Sciences

Department of Computer Studies

CST3062 Final Exam

Advanced Databases and Information Systems

Time 3 Hours

This exam has two sections. Section A has two compulsory questions and you are expected to answer all the Questions. Section B has Five Questions and you are expected to answer any Three of the Five Questions.

SECTION A

Answer all questions in this Section. Question 1 carries 25 points. Question 2 carries 30 points.

1. Given the form below answer the following questions **[25 points]**

Wellmeadows Hospital
Patient Medication Form

Patient Number: P10034

Full Name: Robert MacDonald   Ward Number: Ward 11

Bed Number: 84   Ward Name: Orthopaedic

Drug Number	Name	Description	Dosage	Method of Admin	Units per Day	Start Date	Finish Date
10223	Morphine	Pain Killer	10mg/ml	Oral	50	24/03/01	24/04/02
10334	Tetracyclene	Antibiotic	0.5mg/ml	IV	10	24/03/01	17/04/01
10223	Morphine	Pain Killer	10mg/ml	Oral	10	25/04/02	02/05/03

(a) Define normalization. **[2 points]**

(b) Identify the functional dependencies represented by the data shown in the form. **[2 points]**

(c) Describe and illustrate the process of normalizing the data shown in the form to first (1NF), second (2NF), third (3NF). **[6 points]**

(d) Identify the primary, alternate, and foreign keys in your 3NF relations. **[3 points]**

(e) An agency called Instant Cover supplies part-time/temporary staff to hotels within Scotland. The table shown below lists the time spent by agency staff working at various hotels. The National Insurance Number (NIN) is unique for every member of staff.

NIN	contractNo	hours	eName	hNo	hLoc
1135	C1024	16	Smith J	H25	East Kilbride
1057	C1024	24	Hocine D	H25	East Kilbride
1068	C1025	28	White T	H4	Glasgow
1135	C1025	15	Smith J	H4	Glasgow

I. The table is susceptible to update anomalies. Provide examples of insertion, deletion, and update anomalies. **[3 points]**

II. Describe and illustrate the process of normalizing the table shown to 3NF. State any assumptions you make about the data shown in this table. **[9 points]**

2. A company called Perfect Pets runs a number of clinics. A clinic has many staff and a member of staff manages at most one clinic (not all staff manage clinics). When a pet owner contacts a clinic, the owner's pet is registered with the clinic. An owner can own one or more pets, but a pet can only register with one clinic. When the pet comes along to the clinic, it undergoes an examination by a member of the consulting staff. The examination may result in the pet being prescribed with one or more treatments.

   a) Identify the main entity types of Perfect Pets Company. **[5 points]**
   b) Identify the main relationship types between the entity types described in (a) and represent each relationship as an ER diagram. **[5 points]**
   c) Determine the multiplicity constraints for each relationship described in (b). Represent the multiplicity for each relationship in the ER diagrams created in (b). **[5 points]**
   d) Identify attributes and associate them with entity or relationship types. Represent each attribute in the ER diagrams created in (c). **[5 points]**
   e) Determine candidate and primary key attributes for each (strong) entity type. **[5 points]**
   f) Using your answers (a) to (e) attempt to represent the data requirements of Perfect Pets as a single ER diagram. State any assumptions necessary to support your design. **[5 points]**

SECTION B

Answer any three Questions in this Section. Each question carries 15 points

3. An Adult Education Department runs various courses during the daytime and evenings, and at different times of the year. For example, 'Spanish level 1' is offered on Monday mornings, Monday evenings or Wednesday evenings, and runs over 25 weeks from October to March. On the other hand, 'Introduction to Digging Up Your Ancestors' only runs for 8 weeks, but is offered on Tuesday or Wednesday evenings from October to December, January to March, and April to June, with an optional field week in August.
   There is always a maximum number of places for each course offering, which is dependent on the individual tutor. For example, 'Spanish level 1' on Monday evenings may be limited to 20 places, but on Wednesday evenings the limit may be 25. Each course offering is only taken by one tutor, however, a tutor may take different courses, for example, 'French level 1' and 'Spanish level 2'. To guarantee enrolment, prospective students must pay the fee before the start of the first class. There is a special reduction for those unemployed. All applicants are kept on a register for subsequent mailshots.
   a) Develop an Entity–Relationship model to illustrate the logical database design. **[5 points]**
   b) Produce a set of tables from your Entity–Relationship model, clearly identifying the primary keys. **[5 points]**
   c) Show that your data model supports the following transactions: **[5 points]**
      I. Add a new course to the database, prior to it being offered on any particular day or from any particular date.

II. Enrol a new student on the 'German level 2' course that runs on Monday evenings commencing October 10 1994.

4.

a) Describe two approaches to checking that a logical data model supports the transactions required by the user. **[3 points]**
b) Describe what a superclass and a subclass represent and the relationship between a superclass and its subclass. **[3 points]**
c) Describe and contrast the process of specialization with the process of generalization. **[3 points]**
d) What two main constraints apply to a specialization/generalization relationship? **[3 points]**
e) Describe the inputs and outputs of physical database design. **[3 points]**

5.

a) Having identified a column as a potential candidate index, under what circumstances would you decide against indexing it? **[3 points]**
b) Discuss the purpose of analyzing the transactions that have to be supported and describe the type of information you would collect and analyze. **[3 points]**
c) Describe the alternative strategies that can be applied if there is a child record referencing a parent record that we wish to delete. **[3 points]**
d) Suppose you are given a relation R = (A, B, C, D, E) with the following functional dependencies: {CE → D,D → B,C → A}. **[6 points]**
    I. Find all candidate keys.
    II. Identify the best normal form that R satisfies (1NF, 2NF, 3NF).

6. Database technology continues to evolve and has many interesting emerging trends.
    a) Give a definition of a data warehouse. Discuss the benefits of implementing a data warehouse. **[3 points]**
    b) Discuss what online analytical processing (OLAP) is and how OLAP differs from data warehousing. **[3 points]**
    c) What is XML and discuss the approaches for managing XML-based data. **[3 points]**
    d) Discuss why the weaknesses of the relational data model and relational DBMSs may make them unsuitable for advanced database applications. **[3 points]**
    e) Explain what is meant by a DDBMS, and discuss the motivation in providing such a system. **[3 points]**
7. Database design is defined as a structured approach that uses procedures, techniques, tools, and documentation aids, to support and facilitate the process of design
    a) Describe the main phases involved in database design **[3 points]**

b) How would you identify entity and relationship types from a user's requirements specification? **[2 points]**

c) A database developer normally uses several fact-finding techniques during a single database project. The five most commonly used techniques are examining documentation, interviewing, observing the business in operation, conducting research, and using questionnaires. Describe each fact-finding technique and identify the advantages and disadvantages of each. **[10 points]**

The University of Zambia
School of Natural Sciences

Semester 2 Final Examinations – May 2011

CST4012 : Advanced Operating Systems and Distributed Systems

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

Question One

There are various functions performed by different operating systems.

a) Explain what you understand by the term distributed operating system. What are the consequences of the given definition on concurrency, time and failure management? (8 Marks)

b) Distinguish between a network operating system and a distributed operating system (10 Marks)

c) Describe the services offered by a network operating system (4 Marks)

d)Give THREE reasons why it has taken a long time to implement a distributed operating system? (3 Marks)

(Total 25 Marks)

Question Two

A distributed system and applications that support internal concurrency require that several activities be performed at the same time.

a) Make a contrast between multiprocessing and multithreading (4 Marks)

b) Give three reasons why multi-threaded process model should be preferred to the multi single-single threaded process in the realization of concurrency. (6 Marks)

c) Describe the complete life cycle of a thread. (5 marks)

d) A client makes remote method invocations (RMIs) to a server. A client makes RMIs to a server. The client takes 5ms to compute the arguments for each request, and the server takes 10 ms to process each request. The local operating system time for each send or receive operation is 0.5 ms, and the network time to transmit each request or reply message is 3 ms. Marshalling or unmarshalling takes 0.5 ms per message.

Estimate the time taken by the client to generate and return from 2 requests if is

i) single-threaded

ii) it has two threads which can make requests concurrently on a single processor

(10 Marks)

(Total 25 Marks)

Question Three

Modern operating systems are designed to handle multiple processors

a) Describe, giving a suitable application, each of the following architectures.

i) Single Instruction Stream Multiple Data stream

ii) Multiple Instruction Stream Single Data stream

iii) Multiple Instruction Stream Multiple Data stream (12 Marks)

b) Critically discuss the relative advantages of the two-tier and three-tier architectures. Give an appropriate example of each architecture. (8 Marks)

c) Discuss five issues that designers of distributed systems have to face (5 Marks)

(Total 25 Marks)

Question Four

a) Many distributed algorithms require the use of a coordinating process. To what extent can such algorithms actually be considered distributed? Discuss (5 Marks)

b) Transactions T and U are run with timestamp ordering concurrency control as illustrated:

T	U
x = Read(i)	
	Write(i,55);
	Write(j,66);
Write(j,44);	
	Commit
Commit	

Required:

i) Describe the information written to the log file on behalf of T and U, allowing for the fact that T has a later timestamp than U and must wait to commit after U.

ii) Why is it essential that the commit entries in the log file be ordered by timestamps?

iii)Describe the effect of recovery if the server crashes between the two Commits

iv) What would be the effect of recovery if the server crashes after both of them?

v) What are the advantages and disadvantages of using timestamp ordering?

(12 Marks)

c) Distinguish between

i) centralized and distributed deadlocks

ii) optimistic and pessimistic concurrency control techniques

(8 Marks)

(Total 25 Marks)

Question Five

a) Provide an overview of the security concerns in a distributed system. (10 Marks)

b) Suppose you were asked to develop a distributed application for setting up and conducting examinations, give at least three statements that would be part of the security policy for such an application. (6 Marks)

c) Critically evaluate the need for data recovery. Discuss three mechanisms that can be used to achieve data recovery. (9 Marks)

(Total 25 Marks)

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF COMPUTER STUDIES

CST4122 - COMPILERS

UNIVERSITY EXAMINATION

Friday, May 06, 2011; 09:00Hrs

INSTRUCTIONS : There's FIVE(5) questions in this examination and you are required to answer ANY FOUR of them. Good luck!

DURATION : 3 Hours

1.
   a. Describe the phases of the compilation process from the point of view of the analysis and synthesis of a program. Outline the functions of each phase stating the form of its input and output. [you can use a labelled diagram]
   b. Discuss the role that the symbol table plays in the compilation process.
   c. Outline the algorithm used by the compiler to create a symbol table.

2.
   a. Write a regular expression which generates all binary representation of odd numbers. [Note: all odd numbers end in a 1 bit and a zero should not be at the beginning of the binary string e.g. 00101 is simply 101]
   b. Construct an NFA for your grammar above.
   c. Convert NFA into a DFA.
   d. Using a schematic diagram, show how scanner generators process REs into a scanner.

3. For each of the following grammars
   a. State whether it is LL parsable or not, stating reasons if not?
   b. If it is not, convert it into an LL parsable grammar.

      i. $A \rightarrow A\ \alpha$
         $A \rightarrow \beta$
         $A \rightarrow \gamma$

      ii. A -> B C D E F
          A -> B C D G

      iii. A -> B D
           B -> A C | E

   c. Construct a parse table for the LL version of grammar (i)

4. Consider the grammar given the below

```
E -> E + T | E
T -> T * F | F
F -> id | num
```

where id and num are terminals representing identifiers and numbers respectively

a. Draw the syntax tree for a + b - c
b. Discuss the precedence and associativity of the operators *, +.
c. By using brackets, show how the following expressions are evaluated
   i. a + b * c + d * e
   ii. a + b + c + d + e
d. Suppose you intend to include the unary negative operator(-) to allow sentences of the form -a, -23 etc, how would you change this grammar to accommodate this, given that this operator has the highest precedence of the operators available?

5.

a. Describe the difference between top-bottom (LL) and bottom-up (LR) parsing
b. There are the two modes of implementing an LL parser i.e. using a recursive descent parser and using a stack. Describe these two methods.
c. Given the following grammar

```
E -> id ET
ET -> + E | - E | ε
```

   i. Show how the stack implementation will parse the following expression a + b - c. [you need a parse table]

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

THE UNIVERSITY OF ZAMBIA

Department of Computer Studies

EXAMINATION

CST4132 – Computer Graphics

INSTRUCTIONS: Answer Four(4) out of Five(5) questions in this exam. Question 1 is COMPULSORY.
DURATION: 3 HOURS

1.

a. Describe 5 input devices commonly used in Computer Graphic applications.
b. Explain the difference between Vector display and the Raster display system and cases in which each technology is preferred.
c. Computer Graphics applications are resource intensive (CPU, memory etc). Discuss how the architecture of such applications ensures that they function concurrently with other applications. [Use a labelled diagram]
d. Explain how the Graphics application program, application model and the Graphics system interact and the functions they perform in a Computer Graphics system.

2.

a. Using a labeled diagram, illustrate the operations and functions of the Cathode Ray Tube (CRT) technology.
b. Describe the two mechanisms used to realize colour in the CRT.
c. Differentiate between the operations of Plasma and LCD technologies.

3.

a. Consider the following Raster system with resolution 1024 by 1024 with 24 bits per pixel with a frame refresh of 60Hz.
b. How much memory is required for frame buffer of this system?
c. Suppose you are given that the system has a horizontal retrace of 0.005 seconds and a vertical retrace of 0.25seconds. How much time is wasted in retrace in 1 minute?

4.

a. Outline the steps of the Bressenham for rasterizing a line.
b. You are using the algorithm above to scan convert the line $y = 5x + 2$ from (0, 0) to (5, 7). Show the set of points that will be selected.
c. Show that decision parameter P_k in b above is exactly the one generated when using the Midpoint algorithm. Take note of the gradient of the line.

5.

a. When drawing primitives, a number of attributes are taken into account. Describe three attributes of a line.
b. Describe how each of the attributes above is realized.
c. Consider the following Java code in a JFrame class.

```
public void paint(Graphics g){
        g.setColor(Color.BLUE);
        g.drawOval(12, 13, 80, 80);
}
```

   i. Briefly explain what the piece of code does. What is the centre and radius of the circle drawn in this method?

d. Write a piece of code in the JFrame class that draws a filled circle of colour red and radius 20 centred at (0,0)

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

The University of Zambia

School of Natural Sciences

Department of Mathematics & Statistics

Second Semester Examinations - May 2011

EM312 - Engineering Mathematics IV

Time allowed : Three (3) hours — Full marks : 100

Instructions:
- This paper consists of **two** sections, **Section A** and **Section B**. Attempt **any three** questions from **Section A** and **any two** from **Section B**. All questions carry equal marks.
- **Full credit** will only be given when **necessary work** is shown.
- Indicate your **computer number** on all answer booklets.

This paper consists of 4 pages of questions.

Section A

1. a) A surface in $\mathbb{R}^3$ is described in spherical coordinates by $\rho \sin^2 \phi = \cos\phi$. Sketch the surface and give its equation in both rectangular and cylindrical coordinates.

   b) Let R be the region enclosed between the sphere $x^2 + y^2 + z^2 = 9$ and the cone $z = \sqrt{x^2 + y^2}$.

      (i) Sketch the region R and describe it using spherical coordinates.

      (ii) Calculate the volume of the region R.

   c) Evaluate the integral

$$\int_0^{\frac{1}{\sqrt{2}}} \int_{x^2}^{\frac{1}{2}} x \sec^2 y^2 \, dydx \; .$$

   d) Let $9x^2 - 36x + 4y^2 + 8y - 18z^2 + 108z - 158 = 0$ be the equation of a surface. Identify the surface and write down the centre.

2. a) Suppose that over a certain region of space the electrical potential V is given by $V(x, y, z) = 5x^2 - 3xy + xyz$.

   (i) Find the rate of change of the potential at $P(3, 4, 5)$ in the direction of the vector $V = \mathbf{i} + \mathbf{j} - \mathbf{k}$.

   (ii) In which direction does V change most rapidly?

   (iii) What is the maximum rate of change?

b) Calculate the surface area of the part of the paraboloid $z = x^2 + y^2$, lying in the first octant, between $z = 1$ and $z = 2$.

c) R is the region in the first quadrant bounded by the graphs of $xy = 3$, $xy = 5$, $y = x$ and $y = 2x$.

   (i) The region R is transformed into the region R' under the mapping $u(x, y) = xy$ and $v(x, y) = \frac{y}{x}$. Sketch the region R'.

   (ii) Find $\frac{\partial(u,v)}{\partial(x,y)}$.

   (iii) Transform the integral $\int\int_R \left(\frac{y}{x}\right)^2 \sin\left(\frac{y}{x}\right)^2 \, dA$ into a double integral with respect to the variables u and v.

   (iv) Evaluate the double integral in (iii).

3. a) Given

$$\mathbf{F}(x, y, z) = y^2\,\mathbf{i} + (2xy + e^{3z})\,\mathbf{j} + 3ye^{3z}\,\mathbf{k} \ ,$$

   (i) find a function f such that $\nabla f = \mathbf{F}$.

   (ii) Evaluate the line integral $\int_C \mathbf{F} \cdot dr$ where C is the straight line from $(1, 1, 0)$ to $(2, 3, 1)$.

b) Use Stoke's theorem to evaluate $\oint_C \mathbf{F} \cdot dr$, where $\mathbf{F}(x, y, z) = -y^2\,\mathbf{i} + x\,\mathbf{j} + z^2\,\mathbf{k}$ and C is the curve of intersection of the plane $y + z = 2$ and the cylinder $x^2 + y^2 = 1$.

c) Let C be the curve $\mathbf{r}(t) = \left(\frac{1}{t}, t, t^2\right)$, $t > 0$ and let S be the surface $x^2 - y^2 - 4z + 4 = 0$

   (i) Find a cartesian equation of the tangent plane to S at the point $(1, 1, 1)$.

   (ii) Obtain a vector equation for the tangent line to C at the point $(1, 1, 1)$.

   (iii) Show that curve C intersects the surface S at the point $(1, 1, 1)$ at right angle.

4. a) Given the parametric equations

$$x = \cos t, \quad y = \sin t, \quad z = t, \quad 0 \leq t \leq 2\pi \ ,$$

   (i) sketch the graph of the parametric equations.

(ii) A particle moves along the curve in (i) subject to the force $F = y \sin z$. How much work is done in moving the particle?

b) Verify the divergence theorem for the case where $\mathbf{F}(x, y, z) = (x, y, z)$ and B is the solid sphere of radius R centred at the origin.

c) Evaluate the line integral

$$\oint_C (3y - e^{\cos x})\, dx + (7x + \sqrt{y^4 + 1})\, dy \ ,$$

where C is the unit circle $x^2 + y^2 = 1$.

Section B

5. a) 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 $P(A)$.

b) In rolling two fair dice, what is the probability of obtaining

(i) a sum less than five,

(ii) an even product,

(iii) a sum less than five given that the product is even?

c) John travels to work by either route A or B. The probability that he chooses route A is $\frac{1}{4}$. The probability that he is late for work if he goes via route A is $\frac{2}{3}$ and the corresponding probability if he goes via route B is $\frac{1}{3}$.

(i) What is the probability that he is late for work?

(ii) Given that he is late for work, what is the probability that he went via route B?

d) Let X be the life in hours of a light bulb with density function

$$f(x) = 0.001e^{-0.001x}, \qquad (x \geq 0) \ .$$

(i) Find the mean of X.

(ii) Find the c.d.f $F(x)$ of X and use it to find $P(1 < X < 3)$ and $P(X \leq 10)$.

6. a) Given that a random variable X has a c.d.f

$$F(x) = \begin{cases} 1 - e^{-3x} & \text{if} \quad x > 0\,, \\ 0 & \text{if} \quad x \leq 0\,, \end{cases}$$

(i) find the probability density function of X.

(ii) find x such that $F(x) = 0.9$

(iii) evaluate $E(X)$ and $\text{Var}(X)$.

b) Six fair coins are tossed simultaneously. Find the probability mass function of the random variable $X \equiv$ Number of heads, and compute the probabilities of obtaining

(i) no head.

(ii) at least 1 head.

(iii) less than 6 heads.

c) Calculate the mean and variance of the random variable X in (b).

7. a) Events A and B are such that $P(A) = 0.3$, $P(B) = 0.5$. Find $P(A \cap B)$ and $P(A \cup B)$

(i) if A and B are independent.

(ii) if A and B are mutually exclusive.

b) A random variable X has probability function $f(x)$ with $f(1) = 0.1$, $f(2) = 0.2$, $f(3) = y$, $f(4) = 0.2$, $f(5) = 0.1$. Find

(i) the value of y.

(ii) $P(X \leq 4)$

c) A random variable X has p.d.f. $f(x)$ where

$$f(x) = \begin{cases} k(1-x), & 0 \leq x \leq 1 , \\ 0, & \text{otherwise} . \end{cases}$$

Find

(i) the value of the constant k.

(ii) $P(X \geq \frac{3}{4} | X \geq \frac{1}{2})$.

d) Mathematics aptitude scores X are normally distributed with mean 500 and standard deviation 20, i.e. $X \sim N(500, 400)$. Find :-

(i) the probability that an individual's score exceeds 535,

(ii) the probability that an individual's score exceed 535, given that it exceeds 500, i.e. $P(X > 535 | X > 500)$.

END!

(ii) A particle moves along the curve in (i) subject to the force $F = y \sin z$. How much work is done in moving the particle?

b) Verify the divergence theorem for the case where $\mathbf{F}(x, y, z) = (x, y, z)$ and B is the solid sphere of radius R centred at the origin.

c) Evaluate the line integral

$$\oint_C (3y - e^{\cos x})\, dx + (7x + \sqrt{y^4 + 1})\, dy \ ,$$

where C is the unit circle $x^2 + y^2 = 1$.

Section B

5. a) 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 $P(A)$.

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$$f(x) = 0.001e^{-0.001x}, \qquad (x \geq 0) \ .$$

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(ii) Find the c.d.f $F(x)$ of X and use it to find $P(1 < X < 3)$ and $P(X \leq 10)$.

6. a) Given that a random variable X has a c.d.f

$$F(x) = \begin{cases} 1 - e^{-3x} & \text{if} \quad x > 0\,, \\ 0 & \text{if} \quad x \leq 0\,, \end{cases}$$

(i) find the probability density function of X.

UNVERSITY OF ZAMBIA

INSTITUTE OF DISTANCE EDUCATION

2010 ACADEMIC YEAR DISTANCE EDUCATION FINAL EXAMINATIONS

GEO 111: INTRODUCTION TO HUMAN GEOGRAPHY I

TIME: THREE HOURS

INSTRUCTIONS: Answer Question 1 and three others. Use of an approved calculator is allowed. You are encouraged to use examples and illustrations wherever possible.

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1. Study Table 1 which shows population sizes and gross domestic product (GDP) for selected countries in southern Africa in 2001 and then answer the questions that follow:

Table1: Population size and gross domestic product for southern African countries

S/N	Country	Population size (thousands)	Gross domestic product (GDP) (thousand dollars)
1.	South Africa	43,586	466,370
2.	Mozambique	19,371	23,245
3.	Zambia	9,770	78,160
4.	Malawi	10,548	63,288
5.	Botswana	1,586	13,957
6.	Angola	10,366	19,695
7.	Namibia	1,798	12,766
8.	Zimbabwe	11,365	21,593

Source: Based on information from CIA (2001). The World Factbook

(a) Construct a Lorenz curve to depict disparities in the distribution of GDP as an economic proxy in the southern African sub-region. [20 Marks]

(b) Explain the pattern that emerges. [10 Marks]

(c) Explain how the inequalities depicted by the graph can be addressed. [10 Marks]

2. Apply Alfred Weber's factors of industrial location to the location of industries in Zambia. [20 Marks]

3. With regard to migration, outline the causes and effects of the following:
   (a) Brain drain
   (b) Refugees
   (c) Human trafficking
   (d) Rural flight [20 Marks]
4. Compare and contrast the biblical and evolutionary perspectives of the origin of life on Earth. [20 Marks]
5. 'Today's modern cultural hearths include world cities like London, Paris and Tokyo and places such as the United States'. Discuss. [20 Marks]
6. Explain the meaning and importance of the following basic concepts in the Central Place Theory (GPT):
   (a) Threshold population
   (b) Central goods and services
   (c) Range of a good
   (d) Complementary region [20 Marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

CANDIDATE'S COMPUTER NUMBER: ....

2010 ACADEMIC YEAR SECOND SEMESTER DEFERRED EXAMINATIONS

GEO 175: INTRODUCTION TO MAPPING TECHNIQUES IN GEOGRAPHY

PAPER 1: PRACTICAL
AIR PHOTOGRAPHS, MAP READING AND MAP INTERPRETATION

TIME: Three Hours

INSTRUCTIONS: Answer **all** the questions. The use of a Philip's University Atlas and a certified calculator is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

MATERIALS PROVIDED:

Topographic Map Sheet 1131 C4
A4 Metric Graph Paper
A4 Tracing Paper

FOR USE BY EXAMINER

Question	Mark
Q1	
Q2	
Q3	
Q4	
Total	

IMPORTANT

Please read the instructions carefully before attempting any question in this Examination. Failure to follow instructions will lead to automatic loss of marks.

SECTION A: GENERAL QUESTIONS

Answer all questions in this section in the spaces provided on this question paper

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

(a) Stereoscopic pairs [5 marks]

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(b) Oblique aerial photographs [5 marks]

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(c) Sheet Reference number [5 marks]

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(d) Quantitative methods of showing relief on maps [5 marks]

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(e) Calculation of gradient on a map [5 marks]

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2 (a) Express 1:500,000 as a scale in words [5 marks]

(b) Express 2cm to a kilometre as a scale in figures [5 marks]

(c) Using a scale of 1:40,000, draw a line scale in metric units given that the maximum space available is 17 centimetres. [5 marks]

(d) What do you understand by the term 'vertical exaggeration' and briefly explain why the vertical scale on a profile is always exaggerated. [5 marks]

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(e) With the help of a diagram, describe a dendritic drainage pattern and briefly explain the characteristics of the area in which it develops. [5 marks]

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SECTION B: MAP BASED QUESTIONS

3. Use Topographic Map sheet 1131 C4 to answer this question

(a) When was Map Sheet 1131 C4 published and by whom? [2 marks]

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(b) In which district is Chief Luchembe's Headquarter in Grid Square 1093 located? [2 marks]

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(c) If you were driving northwards to Isoka along the main tarred road from Serenje, what other map sheet would you require? [2 marks]

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(d) What pieces of evidence are there on map sheet 1131 C4 to explain the absence of cultivation in Grid Square 2594. [2 marks]

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(e) What is the approximate distance in kilometres along the main tarred road from the road junction in Grid Square 2784 to another road junction at Grid Square 2988? [2 marks]

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(f) What is the Grid Bearing of the trigonometrical station in Grid Square 3490 from Grid Reference point 300940? [2 marks]

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(g) Map Sheet 1131 C4 uses a vertical interval of 20 metres, what does it mean? [2 marks]

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(h) What is the scale of Map Sheet 1131 C4 and what does it mean? [2 marks]

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(i) In which direction does the Chabuluma River generally flow? [2 marks]

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(j) What is the latitude and longitude of the south eastern corner of Map Sheet 1131 C4? [2 marks]

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(k) According to map evidence only, what human induced drainage feature is associated with Westhill in Mpika Township area? [2 marks]

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(l) Assuming that you drew a straight line profile from the triangulation station in Grid Square 2974 to the source of the Munjesa stream in grid Square 3372. Would the triangulation station and the source of the Munjesa Stream be intervisible? [1 marks]

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(j) What is the approximate size of the township area of Mpika in square kilometres and state the method that you have used to calculate the area. [2 marks]

(k) Calculate the average gradient along a straight line between grid reference point 300770 and the triangulation station in Grid Square 3490. [2 marks]

(l) Using map evidence only, explain how one could read a four figure grid reference on map sheet 1131 C4. [3 marks]

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5. On the sheet of either graph or plain paper provided, draw a map on a scale of 1:100,000 extending from eastings 20 to 30 and northings 90 to 00. On your map show the following features: [20 marks]

(a) The Tan-Zam Railway

(b) The Lwitikila/Mukungwa river

(c) The road from Mpika to Kasama

(d) The power line

(e) Chitulika School in Grid Square 2991

(f) Shade the area below 1320 metres.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
INSTITUTE OF DISTANCE EDUCATION

2010 ACADEMIC YEAR DISTANCE EDUCATION FINAL EXAMINATIONS

GEO 211: GEOGRAPHY OF AFRICA

TIME: Three Hours

INSTRUCTIONS: Answer any FOUR questions. Candidates are advised to make use of Illustrations and examples wherever appropriate. Use of a Philips University Atlas is allowed.

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1. With the aid of a diagram, illustrate the general extent of the rift valley system and explain the theories regarding its origin.

2. Discuss the main factors, both natural and human, which lead to soil erosion in Tropical Africa and show in what ways it is being combated.

3. "Although still a controversial topic, it appears likely that it was in Africa that man began to develop as a separate being, distinct from the animal primates…" (Pritchard, 1979:44). Discuss this statement with regard to early man in Africa.

4. With the aid of appropriate examples explain the challenges that African people face in forging national unity due to linguistic and religious diversity on the continent.

5. Discuss the significance of Africa's natural resource endowment in promoting socio-economic development in the continent during the present times.

6. Outline and evaluate the major differences in economic strategies that were followed by Kenya and Tanzania after the attainment of political independence.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS
GEO 272: QUANTITATIVE TECHNIQUES IN GEOGRAPHY II

TIME: **Three hours**

INSTRUCTIONS: **Answer any FOUR questions**
All questions carry equal marks
Use of certified calculator is allowed

Q1. Write short explanatory notes on all of the following:

a) Characteristics of statistics
b) Limitations of statistics
c) Descriptive and inferential statistics
d) Parameter and statistic
e) Measures of central tendency

Q2. Does temperature affect human performance? To answer this question, use the data presented in Table 1, which shows the winning times (minutes) for UNZA male marathon runners and the temperature (^oF) on the day the race was run.

Table 1: Winning times and temperature

Winning Times (minutes)	Temperature (^oF)
132.2	75
131.7	80
129.683	50
128.217	54
129.483	52
128.983	59
134.883	79
131.567	72
131.1	65
131.017	64
128.333	67
128.017	56

Source: Keller (2001)

Assuming the samples are random and normally distributed, what conclusion would you draw at 0.05 level of significance?

Q3. Under the Agricultural Support Programme (ASP) in the Ministry of Agriculture, the government has been encouraging farmers to diversify their crop production and more so to focus on the growing of cash crops instead of maize. A geographer measured the yields of beans produced by small scale farmers for two consecutive years as illustrated in Table 2.

Table 2: Yields of Beans (in kg) by small scale farmers in 2008/2009 and 2009/2010

2008/2009	2009/2010
16.5	16.5
7.2	25.7
16.4	7.8
8.6	22.3
10.0	17.8
11.8	9.9
9.8	28.4
16.3	16.3
12.6	29.8
4.8	14.5
11.6	32.7
13.9	18.8
20.6	6.4
17.8	21.7
6.6	

Source: Hypothetical

Assuming that the data for both years were normally distributed, would one be justified to conclude that there was a significant improvement in the yields of beans in the year 2010 as compared to the year 2009? Use the 95% accuracy level.

Q4. Who is more likely to ask for directions when lost, men or women? The conventional wisdom overwhelmingly favours women. However, conventional wisdom may be wrong. The 2010 Geo 272 class conducted a Lusaka-wide survey that asked 503 men and 502 women what they do when they are lost while driving a car. The responses are shown in Table 3.

Table 3: Actions of men and women when lost

Responses	Gender	
	Men	Women
Consult a map	129	99
Ask someone for directions	164	305
Continue driving until location or direction determined	181	51
Other	29	47

Source: Keller (2001)

At 0.01 level of significance, can we infer that men and women differ in their actions when lost?

Q5. A Social geographer aimed at determining whether significantly older sex workers frequented social places in Solwezi than in Livingstone. The results are shown in Table 4.

Table 4: Age of sex workers who frequent social places in Livingstone and Solwezi

Livingstone	Solwezi
15.03	19.00
14.08	29.50
18.50	28.30
12.30	38.24
20.25	33.50
19.00	33.00
25.40	35.80
33.00	25.60
13.70	16.00
28.50	36.24
16.00	30.32
21.50	34.80
18.30	40.30
15.40	27.50
26.40	34.80
	41.30
	42.4
	35.1
	37.8

Source: Hypothetical

Use the 0.01 level of significance to test this hypothesis.

Q6. From a study of agricultural land use in an area west of Mpangwe Hill in Katete, it appeared that land given over to rough pasture varied according to altitude. The results are given in Table 5.

Table 5: Relationship between altitude and pastureland.

Height (m)	147	125	160	118	149	128	150	145	115	140	152	155
Rough pasture (%)	56	42	72	36	63	47	55	49	38	42	68	60

Source: Hypothetical

(a) Plot the data provided in Table 5
(b) Conduct a regression analysis so as to come up with a regression equation related to data provided in Table 5.
(c) Draw a line of best fit in your scatter diagram.
(d) Define your regression equation

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATION

GEO 912: GEOGRAPHY OF MIGRATION AND REFUGEES

TIME: **THREE HOURS**
INSTRUCTIONS: **Answer any question FOUR questions.**
All questions carry equal marks

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1. Discuss the challenges of Article 1 and 33 of the 1951 the United Nation Refugee Convention in dealing with refugees of the contemporary period.

2. Elucidate Mabogunje's (1970) systems schema of migration in relation to Zambia.

3. Examine how decolonisation of Zimbabwe and Angola contributed to the escalation of refugees in the region and how Zambia managed to help out.

4. Ascertain how collective behaviour has been crucial in determining migratory forces, class, type of, selectivity and destinations of migrants in the world.

5. 'There have been disparities international assistance to refugees in many parts of the world'. Discuss this statement with reference to any two regions of your choice.

6. Explain how the tripartite approach when resettling and repatriating refugees in the world.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 922: GEOGRAPHY OF REGIONAL PLANNING AND DEVELOPMENT

TIME: Three Hours

INSTRUCTIONS: **Answer any FOUR questions. All questions carry equal marks.**

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1. With reference to Zambia, discuss the validity of the statement that 'production output is an indicator of economic development of a nation'.

2. Examine the statement that 'globalisation should be considered in regional development planning in any developing country'.

3. 'Cumulative regional economic growth potential may be quantified by examining a region's employment base and its propensity to engage in production for export'. Discuss.

4. Using Zambia as an example, discuss the notion that regional development planning cannot be delinked from politics.

5. Explain the merits and demerits of the conservative approach to economic development.

6. Outline and discuss the strengths and weaknesses of decentralisation as a mode of regional planning.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS
GEO 932: URBAN GEOGRAPHY

TIME: **Three hours**

INSTRUCTIONS: **Answer any FOUR questions**
All questions carry equal marks

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

    a) Industrial and post-modern cities
    b) Harris and Todaro's (1970) model of rural-urban growth
    c) Defining urban as an entity
    d) National and global hierarchies
    e) Urban planning and party politics

2. With examples, discuss five ways in which global cities influence their hinterlands as 'command and control centres'. What are the major limitations of the global approach in ranking cities?

3. Discuss Clark and Onaka's (1983) classification of reasons for household moves and relocation. How relevant are these reasons in explaining household movements in Zambia?

4. 'Urban informality', a common feature of most cities in the developing world may be there to stay. With examples, discuss the problems associated with the urban informal sector and show how these can be overcome.

5. With examples, discuss the major urban planning problems in developing countries and suggest solutions.

6. Discuss the different paradigms and theories used in the development of urban geography.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 952: GEOGRAPHICAL HYDROLOGY

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FOUR (4) QUESTIONS.

ALL QUESTIONS CARRY EQUAL MARKS.

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1. Write short explanatory notes on **ALL** of the following:

(a) Runoff

(b) Factors that influence infiltration.

(c) Soil moisture measurement

(d) Hydrological drought

(e) Concept of River Basin Development

2. Discuss the concepts of Integrated Water Resources Management (IWRM) and Water Efficiency (WE) and their application to the Zambian context.

3. Describe the three balances encountered in hydrology and explain their roles in the transfer of mass and energy around the globe.

4. 'The Penman equation is one of the models which has been extensively used worldwide to estimate potential evaporation and evapotranspiration'. Discuss.

5. In what way and to what extent is hydrology a multidisciplinary science?

6. (a) With the aid of a diagram, describe the underground water profile.
(b) Explain the importance of groundwater in the hydrological cycle.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 962: BIOGEOGRAPHY

TIME: Three hours

INSTRUCTIONS: Answer any four questions. Candidates are encouraged to make use of illustrations wherever appropriate.

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1. Write short explanatory notes on all of the following:
   (a) Principal marine biomes
   (b) Habitats and niches
   (c) Ecological effects of fire on tropical savannas
   (d) Vicariance biogeography
   (e) Importance of process in biogeography

2. 'When we think in terms of flow of energy and recycling of nutrients, it is impossible to divorce the living organisms from their physical environment'. Discuss.

3. "In natural situations it is often almost impossible to tell which of many possible limiting factors is mainly responsible for the distribution of a particular species" (Cox and Moore, 1985:40). Discuss.

4. Examine the contemporary interactions of humans and biota in the world.

5. 'Biogeographers readily accepted the theory of continental drift, whereas geologists initially treated it with skepticism'. Briefly, explain why geologists initially took such a stance.

6. With reference to the statement 'generally, pressures reduce the number of organisms but rarely eliminate the last surviving individuals', explain how endangered species finally become extinct.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 971: AERIAL PHOTOGRAPHY AND AERIAL PHOTO INTERPRETATION – PAPER II

TIME: Three hours

INSTRUCTIONS: Answer All questions

All question carry equal marks

Use of an approved calculator is allowed.

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1. What steps are carried out in flight planning?

2. 'The "effective area" is important in aerial photo-interpretation'. Explain how the area is established and what may cause its variation.

3. Outline and discuss the steps that you would undertake in soil mapping using aerial photographs and other data types.

4. (a) A project area at an elevation of 500m above sea level is 50km long in the north-south and 35km wide in the east-west direction. The air-base is 2.3km, the side-lap is 25%, the focal length of the camera to be used is 150mm, the negative format is 230mm x 230mm and the flying height is 4,200m above sea level. Calculate the following:

   (i) The scale of the photographs. [5 marks]
   (ii) The ground dimensions of an individual photograph. [5 marks]
   (iii) The number of photographs required to cover the project area. [10 marks]

   (b) A set of vertical aerial photographs at a scale of 1:25 000, were acquired for a forest plantation at sea level. A superwide angle lens of 83mm was used. What would be the relief displacement of a 20m *Eucalyptus* tree if it is 150mm away from the photo centre? [5 Marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – MAY 2011

GG332: REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

TIME: 3 HOURS

ANSWER: FIVE (5) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS (WILL BE MARKED OUT OF 20 MARKS). NEATLY DRAWN SKETCHES/ DIAGRAMS RECOMMENDED FOR A FULL MARK.

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1. With neatly labeled sketches or diagrams, **EXPLAIN** difference between the following:
   (i) Vector Model and Raster Model...(8 marks)
   (ii) Geographic Coordinate System (GCS) and Projected System.......(8 marks)
   (iii) Atmospheric Blind and Atmospheric Window..........................(8 marks)
   (iv) Passive and Active Sensors..(8 marks)
   (v) Real-time and Post-processing differential corrections applicable to GPS..(8 marks)

2. You have just been hired to work for Science and Technology Council of Zambia. The Council would like to introduce Remote Sensing in Zambia and your task is to convince the Chief Executive Officer (CEO) of the Council to buy in this new emerging technology. The CEO has requested you to outline the following:

   (a) The value of Remote Sensing to Zambia....................................(10 marks)
   (b) The value of GIS to Zambia..(6 marks)
   (c) The value of GPS.. (6 marks)
   (d) The data sources i.e. various forms of data that you could enter into a GIS project..(4 marks)
   (f) What are the possible misconceptions?.......................................(4 Marks)

3. (a) What is a model in GIS, and define their characteristics..................(5 marks)
   (b) List the advantages for having a Polar Orbiting Earth Resources satellite (6 marks)
   (c) What does a Digital Image Data File consists of..........................(4 marks)
   (d) Outline the anatomy of a GIS... (6 marks)
   (f) What is the value of GIS?..(6 marks)

4. (a) Briefly describe the procedure one will use to be able to obtain a stereovision i.e. able to see the objects in three dimensions....................................(5 marks)

(b) In satellite image interpretation, a number of imagery recognition elements are used. Explain these elements……………………………………………(20 marks)

5. (a) Outline the advantages of manual map digitizing………………………(8 marks)
   (b) What steps should you take when digitizing – List them…………………(7 marks)
   (c) Give a formula for the spectral fingerprint of a target…………………….(2 marks)
   (d) Using GPS Data in ArcGIS, what software did you use in order to bring your data in ArcGIS………………………………………… (2 marks)
   (d) Differentiate between Database and Database Management Systems (4 marks)

6. (a) What does following abbreviations stand for?
   (i) RDMS……………………………………………………………(1 mark)
   (ii) UV………………………………………………………………(1 mark)
   (iii) EMR……………………………………………………………(1 mark)
   (iv) NDVI……………………………………………………………(1 mark)
   (v) DEM……………………………………………………………(1 mark)

   (b) Differentiate between the following:
   (i) Radiometric Resolution and Spectral Resolution………………(4 marks)
   (ii) Band Sequential (BSQ) and Band Interleaved (BIL) …………..(4 marks)
   (iii) Path and Samples…… ……………………………………………(4 marks)
   (iv) False Colour Composite and True Colour Composite…………..(4 marks)
   (v) Coordinates and Attributes ……………………………………...(4 marks)

7. (a) Define the following terms:
   (i) Shape files………………………………………………………(2 marks)
   (ii) Datum ……………………………………………………… (2 marks)
   (iii) ArcMap ……………………………………………… ……… (2 marks)
   (iv) Coverage…………………………………………………… (2 marks)
   (v) Geoid……………………………………………………… (2 marks)

   (b) Give the Spatial Resolution of the Following:
   (i) Landsat TM Multi-spectral system……………………………… (1 mark)
   (ii) Quickbird Multi-spectral……………………………………… (1 mark)
   (iii) SPOT Panchromatic …………………………………………… (1 mark)

   (c) Give the components of a Geographic Coordinate System…………… (3 marks)
   (d) Give the Wavelength of Blue, Green and Red Light. What is the name given to these Bands in Remote Sensing? ………………………………………(4 marks)

END -- GOOD LUCK

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Mathematics and Statistics

2010 Academic Year

Semester II

M112 Mathematical Methods II – A

FINAL EXAMINATION

Time Allowed: Three (3) Hours **May, 2011.**

Instructions:

1. You must write your **Computer Number**, and your **TG Number** on each answer booklet you have used.

2. There are Seven (7) questions in this paper, Attempt **Any Five (5)** questions. All questions carry equal marks

3. Calculators are **Not** allowed.

4. Should you have any problem or if you need more answer booklet, put up your hand an invigilator will come to attend to you.

(1) (a) Let $A=\begin{pmatrix}3 & 0\\ -1 & 5\end{pmatrix}$, $B=\begin{pmatrix}4 & -2 & 1\\ 0 & 2 & 3\end{pmatrix}$, $C=\begin{pmatrix}1 & 2\\ 3 & 4\\ 5 & 6\end{pmatrix}$, $D=\begin{pmatrix}0 & -3\\ -2 & 1\end{pmatrix}$.

Find

(i) A + 2D

(ii) $B-C^T$

(iii) AB

(b) The function $f(x)=ax^3-bx+c$ passes through the origin, $f(-1)=\frac{4}{3}$ and it has an extreme point at $x=1$.

(i) Find the values of a, b and c.

(ii) Sketch the graph of $f(x)$

(iii) Find the area bounded by the graph of $f(x)$ and the $x-$ axis between the lines $x=-1$ and $x=1$

(c) A is the point $(-1, 2)$, B is the point $(2, 3)$ and C is the point $(3, 5)$. P is a point which divides BC in the ratio 3 : 4 and Q lies on AB such that $AQ=\frac{2}{5}AB$.

(i) Find the coordinates of P

(ii) Find the coordinates of Q.

2. (a) (i) Solve the equation $\log_3 x-\frac{4}{\log_3 x}+3=0$

(ii) Find the center and the radius of the circle given by the equation $4x^2+4y^2-6x+10y-1=0$.

(b) The number of units N, of electricity used by a household after t months is given by $N=30(1+e^{kt})$ where k is a constant.

(i) Find the value of k if 270 units were used by the household at the end of one month.

(ii) Find in simplified form ,the exact value of the number of units used by the household at the end of three months.

(c) Let $f(x)=\frac{2x-3}{x-2}$ be a rational function.

(i) Find all the vertical and horizontal asymptotes of $f(x)$

(ii) Sketch the graph of $f(x)$

3. (a) (i) Differentiate $y=a^{x^2}-\cos\left(\frac{1}{x}\right)$

(ii) Find $f'(3)$ given that $f(x)=\ln(x^3-3x)$

(b) (i) Find the inverse of the matrix $A = \begin{pmatrix} 3 & -1 & 2 \\ 1 & 1 & 1 \\ 2 & 2 & -1 \end{pmatrix}$

(ii) Use your inverse to solve the system of linear equations

$$3x - y + 2z = 4$$
$$x + y + z = 2$$
$$2x + 2y - z = 3$$

(c) Evaluate the following integrals

(i) $\int \frac{1}{\sqrt{x}} dx$

(ii) $\int \frac{x+3}{x^2 - 4} dx$

(iii) $\int x e^{3x} dx$

4. (a) (i) The first three terms in the expansion of $\left(1 + \frac{x}{p}\right)^n$ in ascending powers of x are $1 + x + \frac{9}{20}x^2$. Find the values of n and p.

(ii) Find the modulus and the argument of the complex number $z = \frac{\left[\sqrt{3}\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)\right]^4}{\left(\cos\frac{\pi}{4} - i\sin\frac{\pi}{4}\right)^2}$.

(b) (i) Prove the identity $\sinh 2x = 2\sinh x \cosh x$

(ii) Solve the equation $3\sinh x - \cosh x = 1$

(c) (i) Find the derivative of $f(x) = \tan^{-1} x$

(ii) The derivative of a function $f(x)$ is $f'(x) = x^2 - \frac{2}{x}$. If $f(1) = \frac{7}{3}$, find the function $f(x)$.

5. (a) (i) Factorize the determinant $\begin{vmatrix} x & x & x \\ x & y & y \\ x & y & z \end{vmatrix}$

(ii) Use Cramer's rule to solve the system of linear equations

$$x + 2y + 3z = 6$$
$$2x + y + z = 5$$
$$3x + y - 2z = 1$$

(b) (i) Express $\frac{x+5}{(1+3x)(2-x)}$ into partial fractions

(ii) Find the first three terms in the expansion in ascendind powers of x of $\frac{x+5}{(1+3x)(2-x)}$ and state the range of values for which your expansion is valid.

(c) (i) Find the equation of the tangent and the equation of the normal to the graph of the function $f(x)=x+\frac{1}{x}$ at the point $P(1, 2)$.

(ii) Find $\frac{dy}{dx}$ given that $x^2y-y^2-x=2$

6. (a) (i) Sketch the graph of the function $f(x)=x(x-2)$ for values of x in the interval $-2 \le x \le 4$

(ii) Find the area bounded by the curve $f(x)=x(x-2)$ and the x- axis between $x=-1$ and $x=2$

(b) Let $f(x)=(x^2-9)^2$

(i) Find the relative maxima and minima points of $f(x)$

(ii) Determine intervals where the function is increasing.

(c) (i) Evaluate $(1+i)^{10}-(1-i)^{10}$

(ii) Find the square roots of $z=\frac{1}{2}(-1+i\sqrt{3})$

7. (a) A circle C_1 has its center at $(-2, 5)$ and is tangent to the line $x+3y-9=0$

(i) Find the equation of the circle C_1

(ii) Another circle C_2 concentric with the circle C_1 passes through the point $(2, 2)$. Find the equation of the circle C_2

(b) Given that $2\log_y x+2\log_x y=5$

(i) show that $\log_y x$ is either 2 or $\frac{1}{2}$

(ii) Hence find all values of x and y which also satisfy simultaneously the equation $xy=27$

(c) Evaluate the following integrals

(i) $\int_0^{2\sqrt{3}} \frac{3x}{\sqrt{x^2+4}}dx$

(ii) $\int_{\frac{\pi}{6}}^{\frac{\pi}{2}} \sin^2 x dx$

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
APRIL - 2010

MATHEMATICS M114 – MATHEMATICAL METHODS II B

INSTRUCTIONS: Attempt any five (5) questions. You are required to show all your working for full credit. Calculators are not allowed.

TIME ALLOWED: ~~Answer All Questions~~. Three Hours

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1. (a) (i) State the period and amplitude of the function $f(x) = \cos 2x$.

   (ii) Sketch the curves of $f(x) = \cos 2x$, $g(x) = 7\cos x$ and $h(x) = 7\cos x + 3$ on the same plot.

   (iii) Mark the points of intersection of curves $f(x)$ *and* $h(x)$ on your graph without specifying them.

   (iv) Find all solutions of the equation $\cos 2x = 7\cos x + 3$ for $0 \le x \le 360°$.

   (b) Consider a parallelogram $ABCD$ in which $\overrightarrow{AB} = \vec{a}$ and $\overrightarrow{AD} = \vec{b}$

   (i) Find $\overrightarrow{AC}$ and $\overrightarrow{BD}$ in terms of $\vec{a}$ and $\vec{b}$.

   (ii) Assuming scalar product of vectors distributes addition, show that $(\vec{a} + \vec{b}).(\vec{b} - \vec{a}) = |\vec{b}|^2 - |\vec{a}|^2$

   (iii) If $|\vec{b}| = |\vec{a}|$ in (ii), what would you conclude for parallelogram $ABCD$?

   (c) Find the solution of the differential equation $(1 + \cos x)\, dy + \sin x\, dx = 0$, given that $y = 0$ at $x = \frac{\pi}{2}$

2. (a) Find $\frac{dy}{dx}$ given that:

   (i) $y = x \sin x^2$

(ii) $y = x\sin^2 x$

(iii) $y = \frac{\sqrt{x^2+1}}{x}$

(b) Consider the function $f(x) = \frac{x}{1+x^2}$:

(i) Show that f is an odd function

(ii) Find the intervals on which the graph of f is increasing and/ or decreasing.

(iii) Find the intervals on which the graph of f is concave up and/ or down.

(iv) Compute $\lim_{x\to\infty} \frac{x}{x^2+1}$

(v) Find horizontal asymptotes to the curve if there is any

(vi) Sketch the graph of $f(x)$.

(vii) Find the area bounded by the curve $f(x)$, the x –axis and the ordinates $x = -1$ and $x = 1$

(c) A capacitor is discharging with a growth factor of 0.5 per second. Let I_O represent the charge at $t = 0$ (initial charge) and $I(t)$ denote the charge after t seconds.

(i) Write down the charge after 1 second, 2 seconds and t seconds.

(ii) Find the time when the charge will be $\frac{1}{8}$ of the initial change.

3. (a) (i) Sketch the graph of $y = e^{-x}, x \geq 0$

(ii) Sketch the graph of $y = -e^{-x}, x \geq 0$ and state the horizontal asymptote to the curve y

(iii) Draw the graph of $y = 1 - e^{-x}, x \geq 0$ indicating the point where the graph cuts the y –axis

(iv) Find the area bounded by the curve $y = 1 - e^{-x}$, the x –axis and the ordinate $x = 1$

(b) Evaluate the following integrals:

(i) $\int \frac{\sec^2 x}{1+\tan x} dx$

(ii) $\int \frac{\sec^2 x}{1+\tan^2 x} dx$

(iii) $\int \cos^3 t \, dt$

(c) (i) expand $\sqrt{1+x}$ as far as the term in x^3

(ii) Can you approximate $\sqrt{50}$ by writing $\sqrt{50} = \sqrt{1+49}$ and using expansion of part (i). Explain.

4. (a) (i) Find r and α such that $\cos\theta - \sin\theta = r\cos(\theta + \alpha)$

(ii) Find the maximum value of $f(\theta)$ where $f(\theta) = \cos\theta - \sin\theta$ and find θ at which $f(\theta)$ is maximum

(b) (i) Given the points $A(2,0,0)$, $B(0,1,1)$ and $C(1,2,1)$, find the area of the triangle ABC

(ii) Show that the vectors $\vec{U} = 2i - j + k$ and $\vec{V} = -i + j + 3k$ are perpendicular to each other

(iii) Find the work done by the force $F = 3i + j + k$ in moving an object from $A(2,0,0)$ to $B(2,1,1)$.

(c) The height in meters, of a rocket t minutes after blast-off is given by $h(t) = \frac{1}{4}t(24t - t^3)$.

(i) Find the velocity of the rocket at time t.

(ii) Find the maximum velocity.

5. (a) Given $\left(2x - \frac{1}{x^2}\right)^5$

(i) State the r^{th} term in the binomial expansion of the above expression

(ii) Find the coefficient of the term in $\frac{1}{x}$ in the binomial expansion of the above expression.

(b) Evaluate the following integrals:

(i) $\int_0^{\pi/2} x \sin 2x \, dx$

(ii) $\int \frac{x+2}{x^2+1} dx$

(iii) $\int \frac{x+2}{x^2-1} dx$

(c) (i) Sketch the graphs of $f(x) = \log_{\frac{1}{2}} x$ and $g(x) = \left(\frac{1}{2}\right)^x$ on the same plot

(ii) Find values of x which satisfy the inequality $\log_{\frac{1}{2}} x > \log_{\frac{1}{2}} 2$

(iii) Write the following as a single term: $2 \ln x + \ln 5 - \ln 3 \log_2 x$

6. (a) given matrix $A = \begin{pmatrix} -2 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & \frac{1}{2} \end{pmatrix}$, find the following:

(i) $det\, A$

(ii) A^{-1}

(iii) A^2 and A^3

(iv) Prove the following by mathematical induction:

$$A^n = \begin{pmatrix} (-2)^n & 0 & 0 \\ 0 & (5)^n & 0 \\ 0 & 0 & \left(\frac{1}{2}\right)^n \end{pmatrix}$$ where n is a positive integer.

(b) (i) The volume of a spherical balloon is $V = \frac{4}{3}\pi r^3$, where r is the radius. If $r = 5$ and $\frac{dr}{dt} = 2$ at time $t = 1$, find $\frac{dv}{dt}$ at that instant. State if the balloon is expanding or contracting

(ii) The curve $x^2 + xy + y^2 = 3$ has two tangents at $x = 1$. Find the equations of these two tangents.

(c) Given the function $f(x) = arc\sin x$

(i) State the domain and range of f

(ii) Find values of $arc\sin 1$, $arc\sin -\frac{\sqrt{3}}{2}$ and $arc\sin\left(\frac{1}{2}\right)$

(iii) Find $\frac{d}{dx}(arc\sin x)$

(iv) Using your formula of part (iii), find $\frac{d}{dx}(arc\sin x^2)$

END OF EXAMINATION

$dV/dt = dr/dt \times dV/dr$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS AND STATISTICS

2010 ACADEMIC YEAR
SECOND SEMESTER EXAMINATIONS

M162: INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS II

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS:
1. Answer any **Five** (5) Questions
2. Show All Essential Working
3. Calculators are NOT allowed
4. Express All Answers in Simplest Form

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1. (a) (i) Evaluate $\lim\limits_{x\to -2} \dfrac{x^3+8}{x^2-4}$

(ii) Find the derivative of $f(x) = \dfrac{x-2}{x}$ from first principles.

(b) Find the gradient of the curve $y = 2x^3 - x + 5$ at the point A(1, 6). Hence or otherwise, find the
(i) equation of the normal to the curve at point A.
(ii) point at which the normal in (i) meets the line $y = x - 1$.

(c) Evaluate $\displaystyle\int_{-2}^{-1} \frac{x}{\sqrt{x+2}}\, dx$

2. (a) Find $\dfrac{dy}{dx}$ if $y = \dfrac{2x+3}{4x-1}$

(b) Find all the critical points of the function $f(x) = x^3 - 3x^2 - 6$, stating whether they are minimum, maximum or inflection points. Hence or otherwise sketch the graph of $f(x)$.

(c) Find
(i) $\displaystyle\int \frac{2x-3}{(x^2-3x+1)^2}\, dx$
(ii) $\displaystyle\int \sin^3 x \; dx$

3. (a) Given the function $f(x) = \begin{cases} x+1 & , \quad x < -1 \\ (x+1)^2, & x \geq -1 \end{cases}$

(i) Determine if $f(x)$ is continuous at $x = -1$.

(ii) Sketch the graph of $f(x)$.

(b) The probability function for a discrete random variable X is given by

x	-2	-1	0	1	2	3
$P(X = x)$	0.05	0.2	k	0.25	0.1	0.1

Find

(i) the value of k.

(ii) the cumulative distribution function of X.

(iii) $P(-1 \leq X < 2)$

(iv) $E(X)$

(c) Evaluate $\int \frac{dx}{x^2 + 4}$

4. (a) The following data represent marks of 20 students in a statistics quiz.

11	26	16	22	13	19	13	24	20	16
18	21	17	20	19	14	10	16	18	15

(i) Construct a grouped frequency distribution table taking equal class intervals 10 – 12, 13 – 15, …

(ii) Construct a frequency histogram using the classes in (i).

(iii) Construct a frequency polygon as a separate graph using the classes in (i).

(b) A continuous random variable X has the following probability density function $f(x) = \begin{cases} k(1-x^2), & -1 \leq x \leq 1 \\ 0 \quad , & \textit{otherwise} \end{cases}$

(i) Show that $k = \frac{3}{4}$.

(ii) Find $P(-1 \leq X \leq 0)$

(iii) Find $E(X)$

(c) Find $\frac{dy}{dx}$ if $y = \tan^{-1}\left(\frac{1}{\sqrt{1-x^2}}\right)$

5. (a) Given the set of numbers

4 6 5 2 1 9 5 8

Find the

(i) range

(ii) mode

(iii) median

(iv) mean using an assumed mean of $\bar{x}_a = 5$

(v) variance

(b) A bag contains 10 counters of which 4 are blue, 3 are green and 3 are yellow. Counters are removed at random, one at a time without replacement. Find the probability that the

(i) first one drawn is green.

(ii) second one drawn is blue, given that the first one drawn is yellow.

(iii) first two counters are of the same colour.

(iv) first counter drawn is green, given that the second one is blue.

(c) Evaluate $\int x\, e^{2x}\, dx$

6. (a) From a group of 10 people with different ages, 4 are to be chosen to serve on a committee.

(i) In how many ways can the committee be chosen?

(ii) Among the 10 people there is one married couple. Find the probability that both husband and wife are chosen.

(iii) Find the probability that the 3 youngest people will be chosen.

(b) Consider the word SIMMS. Find the

(i) number of ways of arranging all the letters of this word in a line.

(ii) probability that 3 letters chosen from this word are all consonants.

(iii) probability that 4 letters chosen from the word contain a vowel.

(c) Evaluate $\int \frac{x+2}{x^2-1}\, dx$

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2011 ACADEMIC YEAR

SECOND SEMISTER FINAL EXAMINATIONS

M212: MATHEMATICAL METHODS IV

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer any **Five** (5) questions. All questions carry equal marks. You must show detailed working for full credit.

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1. a) Find the general series solution of the given differential equation.

$$(3x + 2x^2)\frac{dy}{dx} = 6y(1 + x)$$

b) Find the length of one arc of the Cycloid

$$R = a(t - sint)i + a(1 - cost)j, \ 0 \le t \le 2\pi$$

c) State if a function has a limit, if not state why?.

$$\lim_{\substack{x \to 0 \\ y \to 0}} \frac{\sin(2x^2+2y^2)}{x^2+y^2}$$

2. a) Let $f(t) = t^2$, $\gamma(t) = ti + t^2j + 2tk,$ $\beta(t) = (1 + t^2)i + (2 - t)j + 3k,$

$d(\gamma \cdot \beta)/_{dt}$ in two different ways and confirm your solution

b) Given the curve whose vector is

$R = (3cost)i + (3sint)j + t^2k$. Compute the curvature.

c) The legs of a right Triangle were measured and found to be 120 ft and 160 ft with an error of at most 1ft. Find an approximation for the maximum error when the area and the hypotenuse are computed from these measurements.

3. a) Show that the distance from the point P to the plane through the three points A , B and C is given by the formula

$D = \frac{AP \cdot AB \times AC}{|AB \times AC|}$. Hence find the distance given that $P(2,2,9)$, $A(2,1,3), B$ (3,3,5) and $C(1,3,6)$.

b) Find the point of intersection of the line $\frac{x-7}{3} = \frac{y-3}{1} = \frac{z+1}{-2}$ with the plane $2x + y + 7Z - 3 = 0$

c) Prove that the given differential equation is exact and solve

$$(3x^2y^2 + 2xy^4)dx + (2x^3y + 4x^2y^3 + 1)dy = 0$$

4. a) Use Chain rule for partial derivative to calculate $\frac{\partial \omega}{\partial t}$

$$\omega = e^{x^2+y^2} \quad , \ x = sint \, , \qquad y = cost.$$

b) Find three positive numbers whose product is as large as possible, and such that the first plus twice the second plus three times the third is 54

c) Find a function $g(x)$ such that the function

$$f(x.y) = \begin{cases} \frac{x^2-4y^2}{x-2y} & if \ x \neq 2y \\ g(x) & if \ x = 2y \end{cases}$$ is continuous at every point in R^2.

5. a) Solve the given differential equation

$$x^2dy + (y^2 - xy)dx = 0$$

b) Solve the initial value problem

$$y'' - y' - 2y = 10sinx\,, \ y\left(\tfrac{1}{2}x\right) = -3\,, \ \ y'\left(\tfrac{1}{2}x\right) = -1$$

c) State the Bernoulli's equation and solve the differential equation

$$y' - \frac{2}{x}y = y^4x$$

6. a) Solve the given differential equation using Variation of parameters

$$y'' + 2y' + y = e^x$$

b) Find the Volume of the parallelepipiped if one vertex is at the origin and three of the edges are the vectors

$$A = i - j - k, \quad B = i + 3j + k \ and \ 2i + 3j + 5k$$

c) Find the Critical point of the given function and determines it's maxima, and minima or saddle point $\qquad f(x, y) = x^2 + 6xy + 2y^2 + 16x + 6y.$

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2011 ACADEMIC YEAR

SECOND SEMISTER FINAL EXAMINATIONS

M222: LINEAR ALGEBRA II

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer any **Five (5)** questions and **show** all necessary working

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1. (a) Define / state the following terms.

   (i) Inner product of a vector space V.

   (ii) Diagonalizable matrix A.

   (b) (i) Prove this inequality $|\langle v, w\rangle| \leq \|v\| \cdot \|w\|$ with the standard inner product where $v, w \in V_n(\mathbb{R})$.

   (ii)Using the inner product $< w, z >= w_1\overline{z_1} + 2w_2\overline{z_2} + 3w_3\overline{z_3}$ on $V_4(\mathbb{R})$.Verify the inequality in b(i) where $w = (i\,, -i\,, 1 + 2i)$ and $z = (1, -i, 1 + i)$.

   (c) Compute the spectral decomposition of the matrix $A = \begin{pmatrix} 0 & 0 & -2 \\ 0 & -2 & 0 \\ -2 & 0 & 3 \end{pmatrix}$ with eigenvalues $\lambda = -2, 4, -1$.

2. (a) Define/ state the following terms.

   (i) Orthogonal basis

   (ii) Eigenspace of a Matrix A.

   (b)Find the orthonormal basis of the subspace U of $V_4(\mathbb{R})$ such that

$$U = \left\{ \begin{pmatrix} x \\ y \\ z \\ w \end{pmatrix} | x - y - z + w = 0 \;\; and \;\; x + z = 0 \right\}.$$

(c)If $\{u_1, u_2, \ldots, u_n\}$ is an orthonormal basis, prove that every vector in $v \in V$ can be expressed as $v = \sum_{i=1}^{n} \langle v, u_i \rangle\, u_i$.

3. (a) Define the terms.

(i) Direct sum of two subspaces of a vector space V.

(ii)Orthogonal complement of a subspace U of a vector space V.

(b) Prove that

(i) *if* W is a subspace of V, then $W^{\perp}$ is also a subspace of V.

(ii) If $V = U + W$, then $V = U \oplus W$ if and only if $U \cap W = \{0\}$.

(c) Obtain the QR-decomposition of the matrix $A = \begin{bmatrix} 1 & 3 \\ 1 & -1 \end{bmatrix}$.

4. (a) Define the following terms

(i) a linear transformation T .

(ii) an eigenvector of a linear transformation T.

(b)Prove that if V and W are finite dimensional vector spaces over K and T a linear transformation from V into W, then

$$dim_K \ker T + \dim_K Im\, T = dim_K V \ (nullity\ T + rank\ T = dim_K V).$$

(c) Find an orthogonal matrix P for which the matrix PAP^t or P^tAP is diagonal where

$$A = \begin{pmatrix} 0 & 2 & 2 \\ 2 & 0 & 2 \\ 2 & 2 & 0 \end{pmatrix}.$$

5. (a) Define/state the following .

(i) Orthogonal matrix A.

(ii) Principal axis theorem.

(b)If A is an orthogonal matrix. Prove that,

(i) the determinant ,$\det(A) = \pm 1$

(ii)$\|Ax\| = \|x\|$ for all $x \in V_n(\mathbb{R})$.

(c)(i)Prove that, if λ is an eigenvalue of a matrix A with eigenvector x. If k is a positive integer, then λ^k is an eigenvalue of A^k with corresponding eigenvector x.

(ii)Show that any two similar matrices have the same characteristic polynomials.

6. (a)Define the following terms.

(i) Symmetric bilinear form.

(ii) Quadratic form on V.

(b)Suppose q is a quadratic form and f be the underlying symmetric bilinear form. If $u, v \in V$, Show that

$$f(u,v) = {}^1/_2\left(q(u+v) - q(u) - q(v)\right).$$

(c)(i)Determine the definiteness of the following quadratic forms.

(a) $q(x,y) = 5x^2 - 4xy + 5y^2$ (b) $q(x,y) = 2x^2 + 2xy$

(ii)Draw the graph of the conic section $27x^2 - 18xy + 3y^2 = 3$.

END OF EXAM

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics

2010/11 ACADEMIC YEAR
SECOND SEMESTER FINAL EXAMINATIONS

M232 – REAL ANALYSIS II

27th May, 2011

INSTRUCTIONS: 1. Answer any **Five (5)** Questions Only.
2. All questions carry equal marks.
3. Indicate the question number for each question answered on the cover of the main answer book.

TIME ALLOWED: **Three (3)** hours.

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1. (a) (i) Give the definition of a sequence.

(ii) When does a sequences $\{x_n\}_{n=1}^{\infty}$ of real numbers diverge to $+\infty$?

(iii) Give the definition of a convergent sequence of real numbers.

(b) Prove each of the following:

(i) The sequence $\{x_n\}_{n=1}^{\infty}$ defined by $x_n = \frac{n^2-1}{2n+3}, (n \in \mathbf{N})$ has the property that $x_n \to +\infty$ as $n \to +\infty$.

(ii) If $|x| < 1$ then $\lim_{n\to\infty} x^n = 0$.

(c) Let $\{x_n\}_{n=1}^{\infty}$ be a non-decreasing sequence of real numbers. Prove that either

(i) $\{x_n\}_{n=1}^{\infty}$ is bounded above and convergent, or

(ii) $\{x_n\}_{n=1}^{\infty}$ is not bounded above and $x_n \to \infty$ as $n \to \infty$.

2. (a) Let $\{x_n\}_{n=1}^{\infty}$, $\{y_n\}_{n=1}^{\infty}$ and $\{z_n\}_{n=1}^{\infty}$ be three sequences of real numbers such that $x_n \le z_n \le y_n$ for all $n > N_0$, for some positive integer N_0. Prove that if $\lim_{n\to\infty} x_n = l$ and $\lim_{n\to\infty} y_n = l$, then $\lim_{n\to\infty} z_n = l$.

(b) For $\alpha \in \mathbf{R}$, let $\{n^{\alpha}\}_{n=1}^{\infty}$ be a sequence of real numbers. Prove that

$$\lim_{n\to\infty} n^{\alpha} = \begin{cases} \infty \text{ if } \alpha > 0 \\ 1 \text{ if } \alpha = 0 \\ 0 \text{ if } \alpha < 0 \end{cases}$$

(c) Prove that a sequence $\{x_n\}_{n=1}^{\infty}$ converges to l if and only if every subsequence of $\{x_n\}_{n=1}^{\infty}$ converges to l.

3. (a) Give the definition of each of the following:

(i) A Cauchy sequence.

(ii) A limit superior.

(iii) A limit inferior.

(b) Prove that every Cauchy sequence in $\mathbf{R}$ is convergent in $\mathbf{R}$.

(c) Let $\{x_n\}_{n=1}^{\infty}$ be a bounded sequence in $\mathbf{R}$ and l is a real number. Prove that $\lim_{n\to\infty} x_n = l$ if and only if $\lim_{n\to\infty} \sup\{x_n\} = l = \lim_{n\to\infty} \inf\{x_n\}$.

4. (a) Give the definition of a convergent infinite series of real numbers.

(b) Let $\{a_n\}_{n=1}^{\infty}$ be a sequence of positive real numbers and p be any positive integer. Prove that the two infinite series $\sum_{n=1}^{\infty} a_n$ and $\sum_{n=p}^{\infty} a_n$ converge together.

(c) Let $\sum_{n=1}^{\infty} c_n$ be an infinite series of positive terms that converges to a real number.

(i) If $\{\gamma_n\}_{n=1}^{\infty}$ is a bounded sequence of positive real numbers, prove that $\sum_{n=1}^{\infty} \gamma_n c_n$ converges.

(ii) Let $\sum_{n=1}^{\infty} a_n$ be an infinite series of positive terms such that there exists a positive integer M and for all $n \geq M$, $a_n \leq c_n$. Prove that $\sum_{n=1}^{\infty} a_n$ converges.

5. (a) Let $\{b_n\}_{n=1}^{\infty}$ be a sequence of positive real numbers and p a positive integer. Prove that the two infinite series $\sum_{n=1}^{\infty} b_n$ and $\sum_{n=p}^{\infty} b_n$ diverge together.

(b) Let $\sum_{n=1}^{\infty} d_n$ be an infinite series of positive terms that diverges to $+\infty$.

(i) If $\{\delta_n\}_{n=1}^{\infty}$ is a bounded sequence of positive real numbers, prove that terms $\sum_{n=1}^{\infty} \delta_n d_n$ diverges.

(ii) Let $\sum_{n=1}^{\infty} a_n$ be an infinite series of positive terms such that there exists a positive integer M such that if $n \geq M$ then $d_n \leq a_n$. Prove that $\sum_{n=1}^{\infty} a_n$ diverges.

(c) Show that the harmonic series $\sum_{n=1}^{\infty} \frac{1}{n}$ diverges. Deduce that if p is a real number less than 1 then the harmonic series $\sum_{n=1}^{\infty} \frac{1}{n^p}$ diverges.

6. (a) Let $\sum_{n=1}^{\infty} c_n$ be an infinite series of positive terms that converges to a real number. Suppose that the terms of a given infinite series $\sum_{n=1}^{\infty} a_n$, also of positive terms, satisfies that there exists a positive integer M such that if $n \geq M$ the condition $\frac{a_{n+1}}{a_n} \leq \frac{c_{n+1}}{c_n}$ holds. Prove that $\sum_{n=1}^{\infty} a_n$ converges to a real number.

(b) Let $\sum_{n=1}^{\infty} d_n$ be an infinite series of positive terms that diverges to $+\infty$. Suppose that the terms of a given infinite series $\sum_{n=1}^{\infty} a_n$, also of positive terms, satisfies that there exists a positive integer M such that if $n \geq M$ the condition $\frac{a_{n+1}}{a_n} \geq \frac{d_{n+1}}{d_n}$ holds. Prove that $\sum_{n=1}^{\infty} a_n$ diverges to $+\infty$.

(c) Let $\sum_{n=1}^{\infty} a_n$ be an infinite series of positive terms and let a be a real number such that $0 < a < 1$.

(i) Suppose that there exists a positive integer M such that if $n \geq M$ then $\frac{a_{n+1}}{a_n} \leq a < 1$. Prove that $\sum_{n=1}^{\infty} a_n$ converges.

(ii) Suppose that there exists a positive integer M such that if $n \geq M$ then $\frac{a_{n+1}}{a_n} \geq 1$. Prove that $\sum_{n=1}^{\infty} a_n$ diverges.

7. (a) Let $\sum_{n=1}^{\infty} a_n$ be an infinite series of real numbers that converges to a real number.

(i) Prove that $\lim_{n\to\infty} a_n = 0$

(ii) If $r_n = \sum_{k=n+1}^{\infty} a_k$, prove that $\lim_{n\to\infty} r_n = 0$.

(b) Define each of the following:

(i) An absolutely convergent infinite series of real number terms.

(ii) A conditionally convergent infinite series of real number terms.

(c) Prove that every absolutely convergent infinite series of real number terms is unconditionally convergent.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

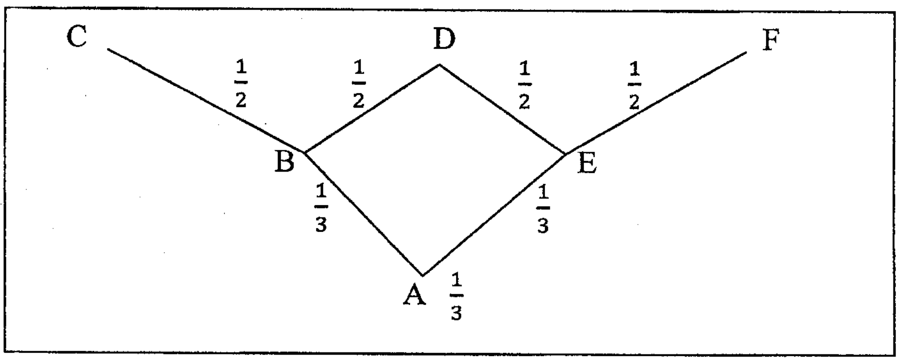
M292: INTRODUCTION TO PROBABILITY

INSTRUCTIONS:

1. Answer any FIVE (5) questions.
2. Calculators are allowed.
3. You may use statistical tables provided if necessary.
4. Show all your work to earn full marks.

TIME: THREE (3) Hours

Q [1] In the picture below a woman is at point A which is her home. If she makes a 1 step trip she will be at B or E. If she makes a 2 step trip from her home she will be at C or D or F.



The probability of her decision to move from one point to another are indicated along the paths. The probability that she does not move from her home is $\frac{1}{3}$.

(a) She intends to either make a 2 step trip to go and sell some products or sell them at her home.

(i) Copy and complete the probability table below.

Selling Point	A	C	D	F
Probability of being there				

(ii) Her possible earning at each selling point (in 100,000 of Kwacha) are shown below. Find her expected sales if she had to sell at these points.

Selling Point	A	C	D	F
Possible Earnings	K1	K2	K3	K1.8

(b) Calculate the standard deviation of her earnings from the sales.

(c) Given that she decides <u>not to sell at home</u> but make a 2 step trip, carry out the following.

(i) Copy and complete the <u>conditional probability</u> table below.

Selling Point	C	D	F
Probability of being there	$Pr(C/A^C)$	$Pr(D/A^C)$	$Pr(F/A^C)$

(ii) Find her expected sales if she does not sell at home.
(iii) Would her decision not to sell at home be profitable?

Q[2] (a) Suppose that in a soccer game ZANACO beat Kabwe Warriors 3 to 2.

(i) Determine the number of ways in which the goals could have been ordered (i.e. scoring order).
(ii) Find the probability that the goals were scored in the order KZZZK, where Z stands for a ZANACO goal and K stands for a Kabwe Warriors goal.
(iii) Find the probability that the score was 2-2 at some stage.

(b) Suppose that A and B are events in the sample space S:
(i) If $B \subset A$ show that $Pr(A \cap B^C) = Pr(A) - Pr(B)$
(ii) If A and B are disjoint, under what conditions are A^C and B^C disjoint?

(c) A campus student club distributed material about membership to new students attending an orientation meeting. Of those receiving this material 40% were men and 60% were women. Subsequently, it was found that 7% of the men and 9% of the women who received this material joined the club.

(i) Find the probability that a randomly chosen new student who receives the membership material will join the club.
(ii) Find the probability that a randomly chosen new student who joins the club after receiving the membership material is a woman.

Q[3] (a) Suppose that two random variables X and Y have joint probability density function given by,

$$f(x, y) = \begin{cases} \frac{1}{6} e^{-\left(\frac{x}{2}+\frac{y}{3}\right)} & \text{for } 0 < x < \infty \text{ and } 0 < y < \infty \\ 0, & \text{otherwise} \end{cases}$$

(i) Determine the marginal distribution of X.
(ii) Determine the marginal distribution of Y.
(iii) Are X and Y independent random variable?
(iv) Find Pr(1< X, 2< Y)

(b) Suppose that the Road Transport and Safety Agency (RTSA) determines that on average, 4 breakdowns occur along the Great East Road per day. Assume that the number of breakdowns X, follows a Poisson distribution.

(i) Write down the probability density function of X.
(ii) Find the probability that on any given day there will be fewer than two breakdowns on the Great East Road.
(iii) Find the probability that on any given day there will be more than five breakdowns on the Great East Road.

(c) Suppose that a team of five athletes from a group of four women athletes and five men athletes is to be chosen to represent the nation at some international event. Determine the following:

(i) The number of ways officials can select the five athletes.
(ii) The number of ways officials can select the five athletes if two are to be women and the rest men.
(iii) Find the probability that a particular woman athlete, who is so excited, will be selected if the team consists of two women and three men.

Q[4] Suppose that a random variable X has the following probability density function.

$$f(x) = \begin{cases} x, & for\ 0 < x < 1 \\ 2 - x, & for\ 1 < x < 2 \\ 0, & otherwise \end{cases}$$

(a) (i). Draw the graph of the probability density function f(x).
(ii) Show that f(x) is indeed a probability density function.

(b) Find $\Pr(1.5 < X / 1 < X)$

(c) (i) Find the expected value of X.
(ii) Find the Variance of X.

Q[5] (a) Mention one major property of the normal distribution.

(b) (i) State, do not derive, the moment generating function, $M_X(t)$ of the normal random variable X with mean μ and variance σ^2.

(ii) Show that: $\frac{d^2M_X(t)}{dt^2}\Big|_{t=0} - \left(\frac{dM_X(t)}{dt}\Big|_{t=0}\right)^2 = \sigma^2$

(c) Suppose that the weight of Nshima a randomly selected hungry man takes with beef follows a normal distribution with mean 800 g and standard deviation 190 g.

(i) Determine the proportion of men who will take beyond 600 g of Nshima in a given meal with beef.

(ii) What proportion of men will take Nshima within 300 g of the mean?

(iii) 70% of the men will eat less than what weight of Nshima?

Q[6] (a) A discrete random variable X has a moment generating function $M_X(t)$ given by $M_X(t) = (0.8 + 0.2e^t)^{10}$. Determine the following:

(i) The value of E[X(X-1)]

(ii) The value of its Coefficient of Variation given by $CV = \frac{\text{Mean of X}}{\sqrt{\text{Variance of X}}} \times 100$

A researcher suspects that the number of between-meal snacks eaten by students in a day during final examination might depend on the number of tests a student had to take on that day. The table below show joint probabilities, estimated from a survey. For question (b) and (c) refer to the table below.

	Number of Tests (X)			
Number of Snacks (Y)	0	1	2	3
0	0.07	0.09	0.06	0.01
1	0.07	0.06	0.07	0.01
2	0.06	0.07	0.14	0.03
3	0.02	0.04	0.16	0.04

(b) (i) Find the marginal distribution of X

(ii) Find $Pr(1 < X \le 3, 0 \le Y \le 2)$

(c) (i) Find $Pr(Y|X=2)$, the probability distribution of Y given X = 2. Keep the probability values in proper fraction form i.e., $\frac{a}{b}$.

(ii) Find $E(Y|X=2)$, the expected value of Y given X = 2.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2011 ACADEMIC YEAR

SECOND SEMISTER FINAL EXAMINATIONS

M325-**GROUP AND RING THEORY**

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer **Five** (5) questions, 4 from **section A** and one from **section B** .**Show** all necessary working

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SECTION A : GROUP THEORY

1. (a) Define/state the following

(i) A group

(ii) Center of a group.

(b)Prove the following.

(i) the intersection of two subgroups, is also a subgroup

(ii)The center Z(G) of a group G is a normal subgroup of G.

(c)(i)Determine whether the set $\langle \mathbb{Q}^+, * \rangle$ is a group or not where for any elements

$a, b \in \langle \mathbb{Q}^+, * \rangle$ the binary operation $(*)$ is defined by $a * b = {ab}/{5}$.

(ii)Determine the center of the symmetric group S_3.

2. (a) Define/state the following

(i) Lagrange's theorem.

(ii) Group homomorphism.

(b) State and prove the first isomorphism theorem.

(c)(i)Find the gcd(840,231) and express it as a linear combination $840s + 231t$ where s and t are integers.

(ii) State the division algorithm theorem for integers.

3. (a) Define/state the following

   (i) A normal subgroup

   (ii) Sylow's third theorem.

   (b) Prove the following

   (i) A subgroup N is normal in a group G if and only if $gNg^{-1} = N$.

   (ii) If every element in a group G is its own inverse, then the group is Abelian.

   (c) Show if G is a group of prime order, then G is simple.

4. (a) Define/state the following

   (i) Factor group.

   (ii) An external direct product of groups $H_1, H_2, \dots, H_n$.

   (b) Let G be a group and Z(G) be the centre of G. Prove that if $G/Z(G)$ is cyclic, then G is an abelian

   (c)(i) Let H be a subgroup of a group G of index 2. Show that H is a normal subgroup G.

   (ii) Given $G = S_3$. If $H = \langle(12)\rangle$ and $K = \langle(13)\rangle$ are subgroups of S_3. Find HK and determine with reason whether or not HK is a subgroup of G.

5. (a) Define/state the following

   (i) A Cycle on S_n.

   (ii) Cayley theorem

   (b) Prove the following.

   (i) Let G be a group. For each $g \in G$, define a mapping $\alpha_g: G \to G$ by $\alpha_g(x) = gxg^{-1}$ for all $x \in G$. Show that for $g, h \in G$, $\alpha_g * \alpha_h(x) = \alpha_{gh}(x)$.

   (ii) Evaluate the number of permutations in S_5 with same cycle structure as $\sigma = (142)(35)$.

   (c) Let σ and τ be two disjoint cycles on S_n, show that $\sigma\tau = \tau\sigma$.

SECTION B: RING THEORY

6. (a) State/define the following.

   (i)Integral domain

   (ii) Sub-ring of a ring R .

   (ii) Ideal of a ring R.

   (b)Prove the following

   (i) the intersection of two sub-rings is a sub-ring.

   (ii)If φ is a ring homomorphism from R into $\tilde{R}$ with kernel $\varphi(I)$, then $\varphi(I)$ is an ideal of R.

   (c)(i)Show that $R = \{a + b\sqrt{2} | a, b \in \mathbb{Z}\}$ is a field.

   (ii) Prove that the residue class of $\mathbb{Z}$ modulo 5 ($\mathbb{Z}_5$) is an integral domain.

7. (a) define/state the following.

   (i) Eisenstein Criterion for irreducibility.

   (ii) Unique factorization domain.

   (b) Show that If R is an integral domain, then R[x] is also an integral domain.

   (c)(i)Determine the irreducibility in $\mathbb{Q}[x]$ of polynomials $f(x) = 2x^4 + 3x^3 + 3x^2 + 9x + 6$ and $g(x) = x^4 + 15x^3 + 7$.

   (ii)Find the roots of the equation $x^2 + 1 = 0$ in $\mathbb{Z}_5$.Hence show that the set $\{a + bx | a, b \in \mathbb{Z}_5\}$ where $x^2 + 1 = 0$ in $\mathbb{Z}_5$, is not an integral domain.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Mathematics & Statistics

SECOND SEMESTER FINAL EXAMINATIONS

May, 2011

M412—FUNCTIONS OF A COMPLEX VARIABLE II

Time allowed : THREE(3) HOURS

Instructions : There are seven(7) questions. Answer **ANY FIVE (5)** questions. All questions carry equal marks. Show all your working to earn full marks.

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1. (a) State the Maximum Modulus Principle.

   (b) Use elementary methods to verify that $f(z) = 1 + \sin z$ satisfies the Maximum Modulus Principle in the unit disk $|z + \frac{\pi}{2}| \leq 1$.

   (c) In each case below write the principal part of the function at its isolated singularity. Then determine if that singularity is a pole, an essential singularity, or a removable singularity.

   (i) $f(z) = \frac{1}{z}e^z$.

   (ii) $f(z) = \frac{\sin z}{z}$.

2. (a) State and prove Jordan's Inequality.

   (b) Find the Laurent series expansion of

$$f(z) = \frac{1}{z(z^2 - 3z + 2)}$$

   in the annular domain $0 < |z| < 1$.

   (c) (i) State the Mean Value theorem.

   (ii) Hence, considering the function $f(z) = \sin z$ on the unit circle, show that

$$\int_0^{2\pi} \cos(\cos\theta)\sinh(\sin\theta)d\theta = 0.$$

3. (a) State, without proof, Jordan's Lemma.

(b) By evaluating

$$\int_{\Gamma_R} \frac{(z+1)e^{iz}}{z^2 - \pi z + 1 + \frac{\pi^2}{4}} dz,$$

where Γ_R is a semi-circular arc of radius R centred on the origin in the upper half plane, and letting $R \to \infty$, find

$$I = \int_{-\infty}^{\infty} \frac{(x+1)\cos x}{x^2 - \pi x + 1 + \frac{\pi^2}{4}} dx.$$

(c) Use Contour integration to show that

$$\int_0^{\infty} \frac{x^2}{(x^2+1)(x^2+4)} dx = \frac{\pi}{6}.$$

4. (a) State and prove the Cauchy Inequality theorem.

(b) Verify the Cauchy Inequality theorem for the function $f(z) = \frac{2}{3z-1}$ if z lies on the circle $|z+1| = 1$.

(c) Show that the function

$$f_1(z) = \frac{1}{z^2+1}, \quad (z \neq \pm i)$$

is the analytic continuation of the function

$$f(z) = \sum_{n=0}^{\infty} (-1)^n z^{2n}$$

into the domain consisting of all the points in the complex plane except $z = \pm i$.

5. (a) Locate and identify the nature of the zeros of the function $f(z) = z \cot n\pi z$.

(b) State and prove the Residue Theorem.

(c) Use the Residue Theorem to show that

$$\int_0^\infty \frac{\sin x}{x(\pi^2 - x^2)} dx = \frac{1}{\pi}.$$

6. (a) (i) State Rouche's theorem.

(ii) Using Rouche's theorem, show that the roots of the equation $z^4 + 6z + 1 = 0$ lie within the circle $|z| < 2$ but one root lies inside the circle $|z| < \frac{3}{2}$.

(b) Evaluate

$$\int_C \frac{f'(z)}{f(z)} dz$$

if C is the circle $|z| = 3\pi$ for

$$f(z) = \frac{\sqrt{2}\sin z - 1}{(z-1)^2(z+5)}.$$

(c) (i) Find the Laurent series expansion of

$$f(z) = \frac{e^{-z}}{(z-2)^4}$$

in the domain $0 < |z - 2| < R$, for arbitrarily large R.

(ii) Hence find the residue of $f(z)$ at its singularity.

7. (a) By using the expansion of $\frac{1}{1+z}$, find the Maclaurin series expansion of

$$\text{Arctanz} = \int_0^z \frac{dt}{1+t^2}.$$

(b) Show that the equation $e^z - \lambda z^5 = 0$ with $|\lambda| > \frac{e^R}{R^5}$ has five roots inside the circle $|z| = R$.

(c) Evaluate the integral

$$I = \int_0^{2\pi} \frac{1}{(3 + 2\cos\theta)^2} d\theta.$$

END.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS & STATISTICS

2010/2011 ACADEMIC YEAR
SECOND SEMESTER FINAL EXAMINATIONS

M462 Bayesian Inference and Discrete Analysis

Time Allowed: Three (3) Hours

Instructions:

1. You must write your **Computer Number** on each answer booklet used
2. There are Five (5) questions in this paper, Attempt **Any Four (4)** questions.
3. Show all the necessary working to get full credit
4. All questions carry equal marks

---

1. (a) Define the following:
   (i) Risk function
   (ii) Minmax decision function
   (iii) Bayes decision function

   (b) (i) Let T be a discrete lifetime random variable which takes the values t_j , $j = 1, 2, 3, ...$, show that

$$s(t) = \prod_{j:t_j<t} \left(1 - h(t_j)\right)$$

   (ii) Prove that if there is a function $d(x)$ that minimizes the posterior risk, then $d(x)$ is a Bayes decision function.

   (iii) Given the following loss function

State of Nature

Decision	H_0 true	H_0 false
Accept H_0	0	b
Reject H_0	a	0

Show that the Bayes action is to reject H_0 if and only if $\text{Prob}\{\theta \in \Omega_1 | \underline{X}\} > \frac{a}{a+b}$ for testing $H_0 : \theta \in \Omega_0$ vs $H_a : \theta \in \Omega_1$, $\Omega_0 \cap \Omega_1 = \phi$, and $\Omega_0 \cup \Omega_1 = \Omega$ the parameter space.

(c) A case – control study was conducted to investigate the relationship between physical activity and myocardial infarction (MI), (heart problem). A case is one with MI and a control is one without MI. The data is given below with Exposed = physical activity index ≤ 25000k cal/day.

Physical Activity	Cases	Controls	
≤ 25000 kcal/day	176	157	
> 25000 kcal/day	190	266	
			789

Cigarette smoking was suspected to be a confounder. To control for this , the data was separated into four categories; Never smoked, Exsmoker more than 10 years, Exsmoker less than 10 years and current smoker.

Never Smoked

Physical Activity	Cases	Controls	
≤ 25000	46	52	
> 25000	41	84	
			223

Ex smoker more than 10 years

Physical Activity	Cases	Controls	
≤ 25000	30	39	
> 25000	41	80	
			190

Ex smoker less than 10 years

Physical Activity	Cases	Controls	
≤ 25000	21	26	
> 25000	22	34	
			103

Current Smoker

Physical Activity	Cases	Controls	
≤ 25000	79	40	
> 25000	170	68	
			273

(i) Compute the crude odds ratio and interpret it
(ii) Compute the crude odds ratio for each of the four levels of smoking and interpret each
(iii) Compute the adjusted odds ratio and interpret it.

2. (a) Define the following:
(i) Mean risk
(ii) Domination of a decision function by another
(iii) Admissible decision function

(b) (i) Prove that if Ω is an interval and d^* is a Bayes estimator with respect to the prior *pdf* $g(\theta)$ such that $g(\theta) > 0$ for all $\theta \in \Omega$ and $R(\theta, d)$ is a continuous function of θ for all decision function d, then d^* is admissible.

(ii) Let T be a continuous lifetime random variable and hazard function $h(t) = g(t)e^{\eta}$, show that

$$f(t) = g(t)e^{\eta - G(t)e^{\eta}}$$

(iii) Derive the hazard function from its definition.

(c) Let T be a continuous lifetime random variable with the extreme value distribution, i.e

$$f(t) = \frac{1}{\beta}e^{\frac{1}{\beta}(t-\mu) - e^{\frac{1}{\beta}(t-\mu)}} , \quad \begin{matrix} -\infty < t < \infty , \beta > 0 \\ -\infty < \mu < \infty \end{matrix}$$

Find the following

(i) Cumulative distribution function

(ii) Survival function

(iii) Hazard function.

3. (a) Define the following:

(i) Survival function

(ii) Hazard function

(iii) Incidence

(b) (i) Derive the log – likelihood function for the Binomial data with complementary log – log function as the link function as a function of regression coefficients.

(ii) Let $x_1 , x_2 , \ldots , x_n$ be a random sample from a Bernoulli with parameter P. If P has a prior distribution given by

$$g(P) = \frac{P^{\alpha-1}(1-P)^{\beta-1}}{B(\alpha , \beta)}, \quad P \in (0 , 1)$$

Derive the Bayes estimator for P.

(c) The lifetimes T, following a heart surgery is exponentially distributed, but the hazard function λ varies across individuals. In particular, suppose the distribution of T given λ has the *pdf* $f(t/\lambda) = \lambda e^{-\lambda t}$, $t > 0 , \lambda > 0$, and λ itself has the following *pdf*

$$g(\lambda) = \frac{\lambda e^{-\frac{\lambda}{k}}}{k^2} , \lambda > 0 , k > 0$$

(i) Find the unconditional *pdf* of T

(ii) Find the unconditional survival function

(iii) Find the unconditional hazard function

(iv) Sketch the graphs of $s(t)$ and $h(t)$ on the same graph.

4. (a) Define the following:

(i) Prior odds ratio

(ii) Posterior odds ratio

(iii) Bayes factor

(b) (i) Let T be a continuous lifetime random variable. Given that the survival function can be given by

$$s(t) = e^{-\int_0^t h(u)du} \qquad (*)$$

Derive the expression of the hazard function from (*) and use it to show that the *pdf* of T can be given as

$$f(t) = h(t)e^{-\int_0^t h(u)du}$$

(ii) Let T be a discrete lifetime random variable with probability function

$$P(T = t) = p(1-p)^t \ , \ t = 0, 1, 2, ...$$

Find the survival and hazard functions of T

(c) A manufacturer produces items in lots of 21. One item is selected at random and is tested to determine whether or not it is defective. If the selected item is defective, either the remaining 20 items can be sold at \$1 per item with a double – year money back guarantee on each item or the whole lot can be discarded at a cost of \$1. Consider the following decisions:

d_1: sell if the item selected is good, discard if defective

d_2: sell in either case.

If k denotes the number of defectives in a lot of 21, and x be 1 or 0 if the tested item is good or defective respectively. Thus $P(X = 0) = \frac{k}{21}$.

(i) Show that the loss functions are

$$L(k, d_1(x)) = \begin{cases} -20 + 2k \text{ if } x = 1 \\ 1 \qquad\qquad \text{if } x = 0 \end{cases}$$

and

$$L(k, d_2(x)) = \begin{cases} -20 + 2k \ \text{ if } x = 1 \\ -20 + 2(k-1) \text{ if } x = 0 \end{cases}$$

(ii) Calculate the risk functions of d_1 and d_2.

(iii) Which of these decisions is minimax? Justify your answer.

(iv) Let us assume that the prior distribution of k is Binomial with probability p. i.e $k \sim B(21, p)$. Evaluate the Bayes risk as a function of p.

5. (a) Explain the following:

(i) Generalized linear model

(ii) Proportional hazard model

(iii) Cox's proportional hazard model.

(b) Let T be a lifetime random variable with log – normal distribution. i.e

$$f(t) = \frac{1}{\sqrt{2\pi\sigma^2 t^2}} e^{-\frac{1}{2}\left(\frac{\ln t - \mu}{\sigma}\right)^2}, t > 0$$

(i) Derive the *cdf* of T

(ii) Find the survival function of T

(iii) Find the hazard function of T

(c) A matched case – control study was conducted to investigate the relationship between postmenopausal estrogen and endometrial cancer. A case was a woman with endometrial cancer and matched to a control, a woman with other gynecologic problem but no cancer. The match control for each case was chosen on the basis of age and other characteristics to eliminate confounding. Exposure was defined as at least 6 months of postmenopausal estrogen use. There were 39 pairs in which both the case and the control used estrogen, 150 pairs in which both the case and the control didn't use estrogen, 113 pairs in which the case used estrogen while the control didn't use estrogen, and 15 pairs in which the case didn't use estrogen while the control did use estrogen.

(i) Display the given data in an appropriate two – by – two table.

(ii) Test the hypothesis of no relationship between endometrial cancer and estrogen use at 0.05 level of significance.

(iii) Compute an estimate of the relative risk and interpret it.

------------------------------------ **END OF EXAM** ------------------------------

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Mathematics and Statistics

2010 Academic Year

Semester II

M912 Mathematical Methods VI

FINAL EXAMINATION

Time Allowed: Three (3) Hours **19th May, 2011.**

Instructions:

1. You must write your **Computer Number**, on each answer booklet you have used.
2. There are Six (6) questions in this paper, Attempt **Any Four (4)** questions. All questions carry equal marks
3. Should you have any problem or if you need more answer booklet(s), put up your hand, an invigilator will come to attend to you.

1. (a) Evaluate the following line integrals:

(i) $\int_{\gamma} y \sin z ds$, where γ is the circular helix given by the equations $x = \cos t$, $y = \sin t$, $z = t$, $0 \le t \le 2\pi$.

(ii) $\int_{\gamma} 2x ds$, where γ is an arc of the parabola $y = x^2$ from $(0,0)$ to $(1,1)$.

(b) A periodic function is defined in one period by the equation $f(x) = 4 - x^2$, $-2 \le x \le 2$.

(i) Determine whether the function is even, odd or neither

(ii) Find the Fourier series expansion of the function $f(x)$.

(iii) Use your series expansion of the function $f(x) = 4 - x^2$, $-2 \le x \le 2$ in (ii) to find the sum

$$1 - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \frac{1}{5^2} - \ldots\ldots$$

(c) (i) Find the general solution of the Euler equation $x^2 y'' - 2xy' - 4y = 0$

(ii) Use the method of variation of parameters to solve the initial value problem

$$x^2 y'' - 2xy' - 4y = 5x^2 , \quad y(1) = y'(1) = 0$$

2. (a) Find the Laplace transform of each function below:

(i) $$f(x) = \begin{cases} -1 , & \text{if } 0 < x < 1 \\ 1 , & \text{if } x \ge 1 \end{cases}$$

(ii) $$f(x) = \frac{e^{-3x} \sin 2x}{x}$$

(b) Consider the differential equation $x^2 \frac{d^2 y}{dx^2} - x \frac{dy}{dx} + y = \ln x$

(i) By the substitution $t = \ln x$, use the chain rule of differentiation and show that the equation reduces to

$$\frac{d^2 y}{dt^2} - 2\frac{dy}{dt} + y = t .$$

(ii) Use the method of Laplace transform and take $y(0)$ and $y'(0)$ to be constants, to find the general solution of the equation $\frac{d^2 y}{dt^2} - 2\frac{dy}{dt} + y = t$ in (ii).

(iii) Hence find the general solution of the equation $x^2 \frac{d^2 y}{dx^2} - x \frac{dy}{dx} + y = \ln x$ in (i).

(c) Use the method of Frobenius to find two independent solutions to the differential equation $xy'' + 2y' + xy = 0$. Write at least two terms for each solution.

3. (a) Let $f(x) = y(x) + \int_0^x k(x-t)y(t)dt$ be an integral equation where $y(x)$ is the unknown function

(i) Show that $L[y(x)] = \dfrac{L[f(x)]}{1+L(k(x))}$ where $L[y(x)]$ is the Laplace transform of $y(x)$

(ii) Hence solve the integral equation $3\sin 2x = y(x) + \int_0^x (x-t)y(t)dt$.

(b) (i) Show that the integral $\int_C (6xy^2 - y^3)dx + (6x^2y - 3xy^2)dy$ is independent of the path from the point $(1, 2)$ to the point $(3, 4)$.

(ii) Evaluate the line integral $\int_C (6xy^2 - y^3)dx + (6x^2y - 3xy^2)dy$ where C is any path joining the points $(1, 2)$ and $(3, 4)$.

(c) Solve the system of linear differential equations

$$\begin{cases} \dfrac{dx}{dt} = -4x - y \\ \dfrac{dy}{dt} = x - 2y \end{cases}$$

4. (a) (i) Use the convolution theorem to find the particular integral of the differential equation $y'' + a^2y = f(t)$, $y(0) = y'(0) = 0$

(ii) Find the Wronskian of the functions: $y_1(x) = e^{2x}\sin x$ and $y_2(x) = -e^{2x}\cos x$

(b) (i) Find $L^{-1}\left[\dfrac{2s+3}{s^2 - 4s + 20}\right]$

(ii) Use Green's theorem to evaluate the line integral $\int_\gamma (x^2 + 2y^3)dy$, where γ is the circle $(x-2)^2 + y^2 = 4$.

(c) A surface S is given parametrically by the equation $\mathbf{r}(u, v) = u\cos v\mathbf{i} + u\sin v\mathbf{j} + u^2\mathbf{k}$, $0 \le u \le 4, 0 \le v \le 2\pi$.

(i) Calculate $\dfrac{\partial \mathbf{r}}{\partial u} \times \dfrac{\partial \mathbf{r}}{\partial v}$

(ii) Hence calculate the surface area of the surface S.

5. (a) Use the method of power series to find the general solution of the differential equation $y'' + xy = 0$. Write at least four terms in each bracket.

(b) (i) Use the Divergence theorem to evaluate the integral $\iint_S xz^2 dydz + (x^2 y - z^3)dzdx + (2xy + y^2 z)dxdy$, where S is the entire surface of the hemisphere region bounded by $z = \sqrt{a^2 - x^2 - y^2}$ and $z = 0$.

(ii) Evaluate using Stokes theorem the integral $\oint_{\partial S} \mathbf{F}(x, y, z).\mathbf{T}dS$ where $\mathbf{F}(x, y, z) = 3y\mathbf{i} - xz\mathbf{j} + yz^2\mathbf{k}$, **T** is the unit tangent to the curve and S is the surface of the paraboloid $2z = x^2 + y^2$ bounded by the plane $z = 2$

(c) Let $C[0,1]$ be the space of continuous functions on the interval $[0,1]$. Define an inner product on $C[0,1]$ by

$(x_m, x_n) = \int_0^1 x_m(t)\, x_n(t)dt$ for $x_m, x_n \in C[0,1]$.

(i) Show that the polynomials $x_0(t) = 1$, $x_1(t) = 2t - 1$ and $x_2(t) = 6t^2 - 6t + 1$ are orthogonal.

(ii) Find $\| x_1(t) \|$

6. (a) Let S be the surface of the paraboloid $z = 2 - (x^2 + y^2)$ above the xy – plane.

(i) Evaluate the surface area of the surface S

(ii) Calculate the mass of S if the density is $\rho(x, y, z) = x^2 + y^2$.

(b) Let $f(x) = x, 0 < x < 2$

(i) Find the half range cosine series expansion of $f(x)$

(ii) Find the half range sine series expansion of $f(x)$

(c) Solve the system of linear differential equations

$$\begin{cases} \dfrac{dx}{dt} = 5x + 4y \\ \dfrac{dy}{dt} = x + 2y \end{cases}$$

The University of Zambia

School of Natural Sciences

Department of Mathematics & Statistics

Second Semester Examinations - April/May 2010

M912 - Mathematical Methods VI

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

Instructions:
- Attempt **any five (5)** questions. All questions carry equal marks.
- **Full credit** will only be given when **necessary work** is shown.
- Indicate your **computer number** on all answer booklets.
- **Calculators** are **not** allowed.

This paper consists of 3 pages of questions.

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1. a) Given

$$\mathbf{F}(x, y, z) = y^2\,\mathbf{i} + (2xy + e^{3z})\,\mathbf{j} + 3ye^{3z}\,\mathbf{k}\ ,$$

(i) find a function f such that $\nabla f = \mathbf{F}$.

(ii) Evaluate the line integral $\int_C \mathbf{F} \cdot dr$ where C is the straight line from $(1, 1, 0)$ to $(2, 3, 1)$.

b) Evaluate $\oint_C \mathbf{F} \cdot dr$, where $\mathbf{F}(x, y, z) = -y^2\,\mathbf{i} + x\,\mathbf{j} + z^2\,\mathbf{k}$ and C is the curve of intersection of the plane $y + z = 2$ and the cylinder $x^2 + y^2 = 1$.

c) The surface S consists of that part of $x^2 + y^2 = 4$ which lies in the first octant, between $z = 0$ and $z = 3$. Find the mass of the surface S if the density is given by $\rho(x, y, z) = x^2yz$.

2. a) Given the parametric equations

$$x = \cos t, \quad y = \sin t, \quad z = t, \quad 0 \le t \le 2\pi\ ,$$

(i) sketch the graph of the parametric equations.

(ii) A particle moves along the curve in (i) subject to the force $F = y \sin z$. How much work is done in moving the particle?

b) Verify the divergence theorem for the case where $\mathbf{F}(x, y, z) = (x, y, z)$ and B is the solid sphere of radius R centred at the origin.

c) Evaluate the line integral

$$\oint_C (3y - e^{\cos x})\, dx + (7x + \sqrt{y^4 + 1})\, dy \ ,$$

where C is the unit circle $x^2 + y^2 = 1$.

3. a) Find the Laplace transforms of the following functions:

(i) $f(t) = \sin^2 t$ (ii) $f(t) = \int_0^t (e^t - \cos 2t) dt$.

b) Find $f(t)$ given that

$$\mathcal{L}\{f(t)\} = \ln\left(\frac{s^2 + 1}{s\,(s + 1)}\right) .$$

c) (i) Sketch the graph of the function $f(t)$ given by

$$f(t) = e^t.U(t) + (e - e^t).U(t - 1) - (e + e \cos t).U(t - \pi)$$

$$+ e \cos t.U(t - 2\pi) + U(t - 2\pi) \ ,$$

where e is the number $e = 2.718\ldots$

(ii) Find $\mathcal{L}\{f(t)\}$.

4. a) (i) Find the Fourier series expansion of the periodic function

$$f(x) = \begin{cases} -1, & -\pi < x < 0 \\ 1, & 0 < x < \pi \end{cases}$$

with period 2π.

(ii) Hence deduce that

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots\ldots$$

b) Find the Fourier Sine integral of

$$f(x) = \begin{cases} x^2, & 0 < x < 1 \ , \\ 0, & x > 1 \ . \end{cases}$$

c) Find the Fourier Cosine transform of the function

$$f(x) = \begin{cases} 1, & 0 < x < \frac{\pi}{2} \ , \\ 0, & x > \frac{\pi}{2} \ . \end{cases}$$

5. a) Given that m and n are integers, prove that

$$\int_{-\pi}^{\pi} \cos mx \sin nx = \begin{cases} 0 & \text{when } m \neq n \\ \pi & \text{when } m = n \end{cases}$$

b) Use Laplace transforms and the result

$$\mathcal{L}^{-1}\left(\frac{1}{s(s^2+1)^2}\right) = \int_0^t \frac{1}{2}(\sin\tau - \tau\cos\tau)\, d\tau$$

to solve the differential equation

$$\frac{d^3y}{dt^3} - \frac{d^2y}{dt^2} + \frac{dy}{dt} - y = \cos t + \sin t - 1 ,$$

$$y(0) = y''(0) = 0 , \qquad y'(0) = 1 .$$

c) i) Let the Laplace transform of the function $f(t)$ be denoted by $F(s)$, that is, $\mathcal{L}(f(t)) = F(s)$. Given that

$$\mathcal{L}\left\{\int_0^t f(\tau)\, d\tau = \frac{1}{s} L(f(t))\right\} ,$$

find $f(t)$ if $\mathcal{L}(f(t))$ is given as

$$\frac{1}{s^4 - 2s^3} .$$

ii) Find the inverse transform of

$$\mathcal{L}(y(t)) = \frac{s+1}{s^2+s-6} .$$

6. a) Given the differential equation

$$9x(1-x)y'' - 12y' + 4y = 0 ,$$

(i) show that $x = 0$ is a regular singular point of the differential equation.

(ii) Hence find series solutions of the given differential equation.

b) Find a general solution of the following linear system

$$\begin{aligned} y_1' &= -3y_1 + y_2 + 3\cos t \\ y_2' &= y_1 - 3y_2 - 2\cos t - 3\sin t \end{aligned}$$

END!

The University of Zambia
Physics Department
University Examinations 2011
P-192: Introductory Physics- II
(Option A)

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script left column on the cover page the questions you have answered.

Time : Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together.

==

Wherever necessary use :

$g = 9.8 \text{m/s}^2$

1 metric ton = 1000 kg

$P_A = 1.01 \times 10^5 \text{ N/m}^2$

1 cal. = 4.18 J

$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$

$c = 3 \times 10^8 \text{ m/s}$

$h = 6.63 \times 10^{-34} \text{ J-s}$

1 pascal =1 N/m^2

$1\text{eV} = 1.6 \times 10^{-19} \text{ J}$

$e = 1.6 \times 10^{-19} \text{ C}$

$m_e = 9.11 \times 10^{-31} \text{ kg}$

$k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$

$\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$

$\rho_{water} = 1000 \text{ kg/m}^3$

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

Question 1 : For each correct answer, 2 marks. For each wrong answer, 0.67 will be deducted. No answer, zero mark. The minimum total mark for Question 1 is zero.]

(A) For a gas approximating the ideal gas, the velocity of sound is.

a) Proportional to the absolute temperature.
b) Proportional to the square of the absolute temperature.
c) Proportional to the square root of the absolute temperature.
d) Independent of the absolute temperature.

(B) For capacitors connected in series:

a) The difference of the potential is the same for all.
b) The charge on each capacitor is the same.
c) The resultant capacitance is greater than the sum of the individual capacitances.
d) The resultant capacitance is equal to the sum of the individual capacitances.

(C) A Carnot engine that operates between the absolute temperatures T_1 and T_2:

a) Has an efficiency of T_1/T_2.
b) Is 100% efficient.
c) Has an efficiency of a non-reversible engine.
d) Has the maximum efficiency possible for the given temperatures.

(D) In simple harmonic motion it is found that the total energy of the system:

a) Depends on the amplitude squared.
b) Is inversely proportional to the amplitude.
c) Is independent of the mass.
d) Is independent of the amplitude.

(E) Ohm's law states that;

a) The current through a resistor is directly proportional to the applied voltage.
b) The voltage across a resistor is directly proportional to the current passing through.
c) Resistance is the constant of proportionality between the voltage and current.
d) All of the above.

(F) In natural convection a heated portion of fluid moves because:

a) of molecular vibrations about the equilibrium
b) its density is less than that of the surrounding fluid.
c) of molecular collisions within it.
d) its molecular motions become aligned.

(G) The force per unit charge is known as:

a) Electric potential.
b) Electric current.
c) Electric field intensity.
d) Test charge.

(H) The equivalent resistance of resistors in parallel is always:

a) Greater than the sum of the separate resistances.
b) Less than the sum of the reciprocals of the separate resistances.
c) Less than the resistance of any of the separate resistances.
d) In between the values of the lowest and the highest resistor.

(I) The temperature coefficient of a resistance of a material of a wire is 0.00125 $^{\circ}C^{-1}$. Its resistance at 300 K is 1Ω. At what temperature will the resistance of the wire be 2Ω.

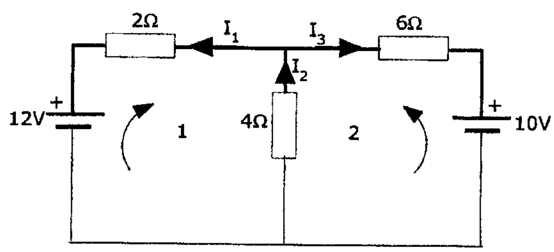
a) 1154 K
b) 1100 K
c) 1400 K
d) 1127 K

(J) In an adiabatic process there is no:

a) Work done.
b) Internal energy change.
c) Temperature change.
d) Heat exchanged.

ATTEMPT ANY FOUR QUESTIONS FROM BELOW:

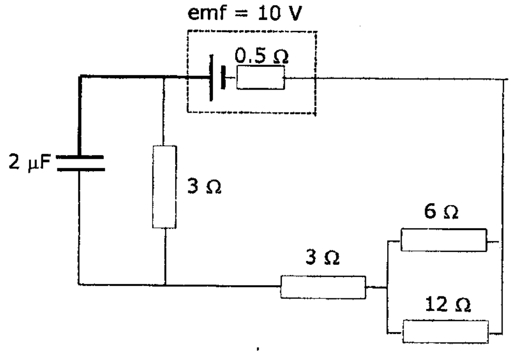
Q.2 (a) Find the currents I_1, I_2 and I_3 in the circuit shown below. Follow the loop directions indicated on the diagram. **[13]**



(b) A mass *m* attached to spring vibrates freely with a period of 2.0 seconds. When the mass is increased by 2.0 kg the period of vibration increases to 3.0 seconds. Find the value of the mass *m*. **[7]**

Q.3 (a) For the circuit below find:

i) the current drawn from the battery;
ii) the terminal potential difference of the battery;
iii) the power dissipated by the 6 Ω resistor; and
iv) the charge stored in the capacitor. **[11]**



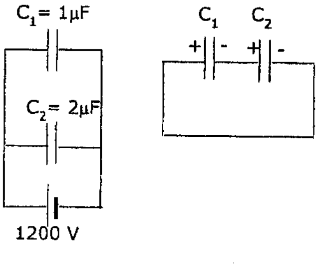
(b) A cube of ice is taken from the freezer at -8.5 °C and placed in a 95 g aluminium calorimeter filled with 310 g of water at room temperature of 20 °C. The final temperature of the water is observed to be 17 °C. What is the mass of the ice cube? [Given c_{ice} = 2100 J/kg.C, c_{Al} = 900 J/kg. °C, H_f = 3.35 x 10^5 J/kg] **[10]**

Q.4 (a) A police car with its 300 Hz siren is moving toward a warehouse at 30 m/s, intending to crash through the door.

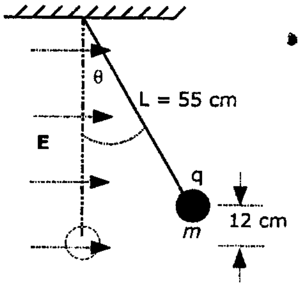
i) What frequency does the driver of the police car hear reflected from the warehouse?
ii) Suppose the police car is moving away at 20 m/s, what frequency does the driver hear reflected from the warehouse? **[10]**

(b) A 1 μF capacitor and a 2 μF capacitor are connected in parallel across a 1200 V source.

i) Find the charge on each capacitor.
ii) The charged capacitors are disconnected from the source and each from other and then reconnected with terminals of unlike sign together. Find the final charge on each capacitor, see diagrams below. **[10]**



Q.5 (a) A point charge (m = 1.0 g) at the end of an insulating string of length 55 cm is observed to be in equilibrium in a uniform horizontal electric field of 12,000 N/C when the pendulum's position is as shown below, with the charge 12 cm above the lowest (vertical) position. If the field points to the right, determine the magnitude of the charge. **[11]**



(b) A car engine has an efficiency of 25% and produces an average of 30,000 J of mechanical work per second during operation.

i) How much heat input is required in kW, and
ii) How much heat is discharged as waste heat from this engine, per second? **[6]**

(c) A police siren emits a sinusoidal wave with a frequency f = 300 Hz. The speed of sound is 340 m/s.

i) Find the wavelength of the waves if the siren is stationary, and
ii) if the siren is moving at 30 m/s, find the wavelengths in front and behind the source. **[3]**

Q.6 (a) The temperature of the glass surface of a 60 W light-bulb is 65 °C when the room temperature is 18 °C. Estimate the temperature of a 150 W light-bulb with a glass bulb the same size, if only 90% of the energy is given out as radiation. **[10]**

b) A storage tank contains 21.6 kg of nitrogen (N_2 , molecular mass = 28 kg/mol) at an absolute pressure of 3.65 atm. What will be the pressure if nitrogen is replaced by an equal mass of carbon dioxide (CO_2, molecular mass = 44 kg/mol)? **[6]**

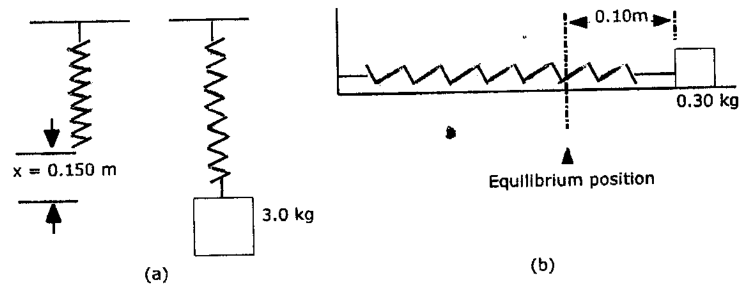
c) Workers around jet aircraft typically wear protective devices over their ears. Assume that the sound level of a jet plane engine, at a distance of 30 m, is 140 dB, and that the average human ear has an effective radius of 2.0 cm. What would be the power intercepted by an unprotected ear at a distance of 30 m from the jet plane engine? **[4]**

Q.7 (a) A spring stretches 0.150 m when a 3 kg mass is gently hung on it as shown in figure (a) below. The spring is then setup horizontally with 0.30 kg mass resting on frictionless table as in figure (b) below. The mass is pulled so that the spring is stretched 0.100 m from equilibrium point, and released from rest. Determine:

i) the spring constant of the spring;
ii) the amplitude of the horizontal oscillation of the 0.30 kg mass;
iii) the magnitude of the maximum velocity;

iv) the magnitude of the velocity when the mass is 0.05 m from equilibrium; and

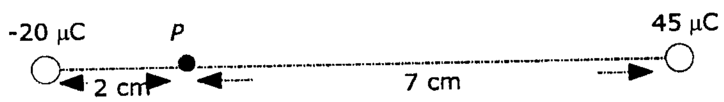
v) the maximum acceleration of the mass. **[8]**



(b) Two point charges are separated by a distance of 9 cm. One has a charge of -20 μC and the other 45 μC.

i) Determine the direction and magnitude of the electric field at a point *P* between the two charges that 2.0 cm from the negative charge, see the diagram below.

ii) If an electron is placed at point *P* and then released what will be its initial acceleration (direction and magnitude)? **[10]**



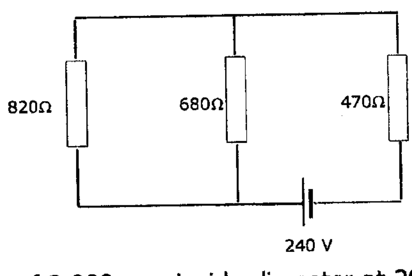
(c) Name any two factors that affect the resistance of an ohmic conductor. **[2]**

Q.8 (a) A wire stretched between two poles 2 m apart is seen to vibrate in the wind with 3 nodes in the middle. The sound produced by the vibrating wire has a frequency by the vibrating wire has a frequency of 90 Hz. If the wire has a mass of 500 g. What tension must the wire have? **[8]**

(b) Determine:

i) the equivalent resistance of the circuit shown below, and

ii) the voltage across each resistor. **[7]**



(c) A steel ring of 3.000 mm inside diameter at 20 °C is to be heated and slipped over a brass shaft measuring 3.0002 mm in diameter at 20 °C. To what temperature should the ring be heated? (α_{steel} = 1.2 x 10^{-5}/°C and α_{brass} = 2.0 x 10^{-5}/°C)? **[5]**

END OF EXAMINATION

Some useful equations

Thermal properties of matter:

$Q/t = e\sigma AT^4$ $Q/\Delta t = (kA\Delta T)/\Delta L$ $\Delta Q = mc\Delta T = nC\Delta T$ $\Delta L = \alpha L\Delta T$

$\Delta V = \gamma V\Delta T$ $\Delta W = P\Delta V$ $\Delta W = nRT.ln(V_f/V_i)$ $C_v = C_p - R$

$PV = nRT$ $P_1V_1^{\gamma} = P_2V_2^{\gamma}$

Thermodynamics:

$Q = \Delta U + W$ Carnot engine, $e = 1 - T_2/T_1 = \dfrac{\text{work done}}{\text{input heat at high temperature}}$

$S = k\ln\Omega$ $\Delta S = Q/T$ Efficiency $= W/Q_h$ $COP_{fridge} = Q_c/W_{in}$

$COP_{heat\ pump} = Q_h/W_{in}$ $COP_{max\text{-}fridge} = T_c/(T_h - T_c)$ $COP_{max\ h.\ pump} : T_h/(T_h - T_c)$

Waves and vibrations:

$F = -kx$ $\omega = 2\pi f$ $f = (1/2\pi)\sqrt{(g/L}$ $a_c = \omega^2 x_0$

$P.E. = (1/2)kx^2$ $1/2)kx^2 + (1/2)mv^2 = (1/2)kx_0^2$ $\omega = \sqrt{(k/m}$

$f = (1/2\pi)\sqrt{(k/m)}$ $v = f\lambda$ $f_n = v/\lambda_n = n(v/2L)$ $L = n(\lambda_n/2)$

Sound waves:

$v = \sqrt{(Y/\rho)}$ $v = \sqrt{(B/\rho)}$ $I_o = 10^{-12}\ W/m^2$ $I(dB) = 10\log(I/I_o)$

$I(r) = P/4\pi r^2$ $f' = f\left(\dfrac{v + v_l}{v - v_s}\right)$ (moving source and moving listener)

Electric forces and fields, electric potential:

$\mathbf{F} = q\mathbf{E}$ $\mathbf{E} = kQ/r^2$ $\mathbf{F} = (k\, q_1\, q_2)/r^2$ $V_{AB} = Ed$

$V = kq/r$ $\Delta PE = qEd$ $C = (\varepsilon_o A)/d$ $W = qV_{AB}$

$Energy = \dfrac{\frac{1}{2}q^2}{C} = \frac{1}{2}qV = \frac{1}{2}CV^2$ $C_{par} = C_1 + C_2 + .. + C_n$ $C_{ser} = 1/C_1 + 1/C_2 + ...$

$C = Q/V$

Direct current circuits:

$V = IR$ $R = \rho\dfrac{L}{A}$ $\Delta R = R_o\alpha\Delta T$ $P = IV = I^2R = V^{@}/R$

$V_{terminal} = \varepsilon - Ir$ $R_{eq} = R_1 + R_2 + ...$series $1/R_{eq} = 1/R_1 + 1/R_2 + ...$parallel

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS

UNIVERSITY EXAMINATIONS -2011

P272 - GEOMETRICAL AND PHYSICAL OPTICS

TIME:	THREE HOURS
ANSWER:	FIVE QUESTIONS ALL ANSWERS CARRY EQUAL MARKS
MAX. MARKS:	100

1. (a) Using Fermat's principle, establish the laws of reflection.

[8 Marks]

(b) A convex surface of radius 30 cm separates two media of refractive indices 4/3 and 1.5. An object is placed at a distance of 20 cm from the surface in the first medium. Calculate the position of the image.

[5 Marks]

(c) An object is situated on the optical axis of a convex spherical surface. A ray of light starting from the object subtends an angle of 5^{o} with the optical axis and intersects the spherical surface at a height of 2.5 cm. If the radius of curvature of the surface is 5 cm and the refractive index of the material is 1.5, find the angle which the refracted ray makes with the optical axis.

[7 Marks]

2. (a) Derive an expression for lateral magnification.

[10 Marks]

(b) A converging lens of refractive index 1.52 has a focal length of 40 cm in air. Find its focal length when it is immersed in water which has a refractive index of 1.33.

[6 Marks]

(c) Two thin convex lenses having focal lengths of 0.05 m and 0.02 m are coaxial and separated by a distance of 0.03 m. Find the equivalent focal length.

[4 Marks]

3. (a) Derive an expression for the equivalent focal length of two thin lenses separated by a distance d.

[10 marks]

(b) The incident face of a glass block is bounded by a concave surface of radius 0.03 cm. A small object 2×10^{-2} m high is situated in air at a distance 0.1 m from the vertex. Find the first and second focal lengths, given that refractive index of glass is 1.5.

[5 Marks]

(c) The dispersion powers of crown and flint glasses are 0.03 and 0.05 respectively. If the difference in the refractive indices of blue and red colours is 0.014 for crown glass and 0.023 for flint glass, calculate the angles of the two prisms for a deviation of 10^{o} (without dispersion). **[5 Marks]**

4. (a) Drive a relation connecting μ_1, the refractive index of the first medium, μ_2 the refractive index of the second medium, u the object distance, v the image distance, and R the radius of curvature of the refracting surface, when refraction takes place at a concave spherical surface and a virtual image is formed.

[10 Marks]

(b) Show that the minimum distance between an object and its real image in a convex lens is four times the focal length of the lens.

[6 Marks]

(c) Calculate the focal length of a lens of dispersive power 0.031 which should be placed in contact with a convex lens of focal length of 0.88 m and dispersive power of 0.022 to make the combination achromatic.

[4 Marks]

5. (a) Derive an expression for longitudinal chromatic aberration.

[5 Marks]

(b) An achromatic doublet of a convex lens of focal length 0.30 m is to be formed out of flint and crown glass whose dispersive powers are 0.03 and 0.02 respectively. Calculate the focal length of the two lenses.

[6 Marks]

(c) The dispersive power of crown and flint glass are 0.015 and 0.030 respectively. The refractive index for the mean ray are 1.52 and 1.65. If one of the surfaces of the flint glass is plane, calculate the radii of curvature of the other two surfaces of the two lenses which form an achromatic combination of focal length 30 cm.

[9 Marks]

6. (a) The inclined faces of a bi-prism of refractive index 1.50 make angle of 2° with the base. A slit illuminated by monochromatic light is placed at a distance 10 cm from the bi-prism. If the distance between the two dark fringes observed at a distance of one metre from the bi-prism is 0.18 mm, find the wavelength of light used.

[7 marks]

(b) In a typical bi-prism experiment, the fringe width is 10^{-3} m for a wavelength of 5893 Å. If $y = 20x$, where y is the distance between the bi-prism and the screen and x the distance between the slit and the bi-prism, calculate the refracting angle of the bi-prism, given $\mu = 1.5$.

[7 Marks]

(c) Interference fringes are produced by Fresnel's bi-prism in the focal plane of a reading microscope which is 1.0 m from the slit. A lens interposed between the bi-prism and the microscope gives two images of the slit in two positions. If the images of the slits are 4.05 mm in one position and the wavelength of the sodium light is 5893 Å, find the distance between consecutive interference bands.

[6 Marks]

7. (a) Fringes of equal thickness are formed when two glass plates are kept over each other with a small gap in between. If a parallel beam of light of wavelength 6000 Å is used and fringe separation is 3 mm, what is the angle between the plates in seconds?

[6 Marks]

(b) A wedge-shaped air film having an angle of 40 seconds is illuminated by monochromatic light and fringes are observed vertically through a microscope. The distance measured between consecutive bright fringes is 0.12×10^{-2} m. Calculate the wavelength of light used.

[6 Marks]

(c) When a thin sheet of thickness 7.2×10^{-6} m is introduced in the path of one of the interfering beams, the central fringe shifts to a position occupied by the sixth bright fringe. If $\lambda = 6\times10^{-7}$ m, find the refractive index of the sheet.

[8 Marks]

==End of P-272 Examination==

The University of Zambia
School of Natural Sciences
Physics Department
University Examinations 2011
Second Semester
P-412: Nuclear Physics

Attempt any four questions. All questions carry equal marks. The marks are shown in brackets. Clearly indicate on the answer script cover page which questions you have attempted.

Time: Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book.

==

Wherever necessary use:

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2	$m_{hydrogen\ atom}$ = 1.007825 a.m.u.
m_n = 1.008665 a.m.u. = 939.551 MeV	m_{alpha} = 4.002603 a.m.u.
1 a.m.u. = 931.5 MeV = 1.6604×10^{-27} kg	$m_p = 1.67 \times 10^{-27}$ kg = 938.28 MeV
$c = 3 \times 10^8$ m/s	$m_e = 9.11 \times 10^{-31}$ kg = 0.511 MeV
$h = 6.63 \times 10^{-34}$ J-s	$e = 1.6 \times 10^{-19}$ C
$\hbar = 6.58 \times 10^{-22}$ MeV-s = 1.05×10^{-34} J-s	1eV = 1.6×10^{-19} J
1 fermi = 10^{-15} m	1 barn = 10^{-28} m^2
Avogadro's constant = 6 x 10^{23} per mole	Velocity of light = 3 x 10^8 m.sec^{-1}.
$\dfrac{e^2}{4\pi\varepsilon_0}$ = 1.44 MeV-fermi	$\hbar c$ = 197.33 MeV-fermi $m = \dfrac{m_0c^2}{c^2} \equiv \dfrac{MeV}{c^2}$

$(1s_{1/2})^2$, $(1p_{3/2})^4$, $(1p_{1/2})^2$, $(1d_{5/2})^6$, $(2s_{1/2})^2$, $(1d_{3/2})^4$, $(1f_{7/2})^8$, $(2p_{3/2})^4$, $(1f_{5/2})^6$, $(2p_{1/2})^2$, $(1g_{9/2})^{10}$, [50]. $E = \dfrac{\hbar^2}{2\Im}\left[J(J+1) - BJ^2(J+1)^2\right]$. $\Delta E_C = \dfrac{3}{5}\dfrac{e^2}{R}\left[Z^2 - (Z+1)^2\right]$

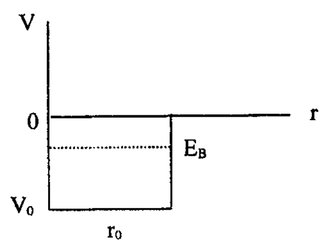
Q1(a) (i) Name the four basic interactions known in nature and give a number characterizing the strength of each interaction. [10]

(ii) Discuss the range of each of these interactions and explain how each one is believed to arise. [4]

(iii) List a few important processes for which each one of these interactions is essential. [4]

(b) The electrostatic energy of a charge q uniformly distributed throughout a sphere of radius R is $U = \frac{3}{5}\frac{e^2}{R}\frac{1}{4\pi\varepsilon_0}$, [$W_{Coul.} = \frac{3}{5}\frac{q^2}{R}$].
Using this in the case of positron beta decay, derive an expression for the decrease in Coulomb energy. [7]

Q2 A neutron is bound in the lowest possible state $(l = 0)$ to a heavy nucleus. The binding energy is E_B = 20 MeV (E_B = - 20 MeV). The potential acting on the neutron is V_0 = 40 MeV; the radius r_0 of the well is not known:



i) solve the radial wave equation for $l = 0$ inside and outside the well, and sketch the wave function u

ii) apply boundary conditions at $r = r_0$ to obtain an equation between the pertinent wave numbers and r_0

iii) find the numerical values of the wave numbers and solve the equation mentioned under (ii) for r_0.

(For the reduced mass use $m = 1$ *a.m.u.*). [8+8+9]

Region I: $E = -E_B$ $V = -V_0$. We have $\frac{d^2u}{dr^2} + k_1^2 u = 0$ where $k_1 = \frac{\sqrt{2\mu(V_0 - E_B)}}{\hbar}$

Q3(a) The semi-empirical formula for binding energy is given by

$B(N,Z) = aA - bA^{2/3} - s\frac{(N-Z)^2}{A} - d\frac{Z^2}{A^{1/3}} - \frac{\delta}{\sqrt{A}}$, where a = 15.835MeV, b = 18.33 MeV, s = 23.20 MeV, d = 0.714 MeV, δ = 11.2 MeV for odd-odd nuclei and δ = -11.2 MeV for even-even nuclei and = 0 for even-odd or odd-even nuclei.

Explain each of the terms in this formula. [15]

(b) Assume that the expression for the average binding energy of a nucleus having Z protons, N neutrons and A nucleons may be written as: [10]

$$-B.E. = f(A) + \frac{0.083}{A}\left(\frac{A}{2} - Z\right)^2 + 0.000627\frac{Z^2}{A^{1/3}} \pm 0.036A^{-3/4} \text{ a.m.u.}$$ (+ for Z odd, and – for Z even). Where $f(A) = Z.M_H + (A\text{-}Z)M_n$

Determine the number of stable nuclides of mass $A = 36$.

Take $A^{1/3} = 3.3$, $A^{1/4} = 2.45$ and confine your attention to the range $13 \le Z \le 20$.

Q4(a) Describe briefly the independent particle approximation and the collective approximation.

What properties and types of nuclei are described by them? [10]

(b) Show that an alpha particle with total energy E_o incident on a potential barrier of energy V ($V > E_o$) and of thickness b has a quantum probability of penetrating. [8]

Sketch the energy diagram showing the incident and transmitted waves of the particle. [2]

(c) An alpha particle is trapped inside a nucleus whose radius is $r_0 = 1.4 \times 10^{-15}$ m. What is the probability that the alpha particle will escape from the nucleus if its energy is 2.0 MeV. The potential barrier at the surface of the nucleus is 4.0 MeV. [5]

$$\text{Probability } P = \exp\left[\frac{-2\sqrt{2m}}{\hbar}\sqrt{V - E} \times t\right]$$

Q5(a) Give short explanations of the terms *allowed, super allowed, first forbidden,* and *second forbidden* in beta transitions in terms of the nuclear matrix element $|M_{if}|$, log fT values and the nuclear shell model. [12]

(b) Distinguish between the Fermi and the Gamow-Teller selection rules in beta decay of nuclei. [7]

(c) On the basis of these selection rules, deduce:

(i) the degree of forbiddenness, and
(ii) the type (Fermi, G-T, or mixed) of the following beta transitions:

$0^+ \rightarrow 1^+$ $\quad \tfrac{5}{2}^+ \rightarrow \tfrac{7}{2}^+$ $\quad \tfrac{1}{2}^+ \rightarrow \tfrac{1}{2}^+$ $\quad 0^+ \rightarrow 0^+$ [6]

Q6(a) Explain the origin of electric and magnetic multipole transitions in gamma decay of a nucleus. [6]

(b) Explain *nuclear isomerism*. Under what conditions can this effect manifest itself? Given an example of nuclear isomerism. [5]

(c) $^{108}_{47}Ag$ has a spin and parity 1^+. It is beta-unstable with a mean life-time of 3.4 minutes. It has an excited state at 109keV excitation energy, spin and parity 6^+, which is an isomeric state with a mean life of 180 years.

Explain how an excited state of a nucleus can be more stable than the ground state. [5]

(d) What multipole types of gamma ray transitions are likely to be predominant if the J^π of the initial and final nuclei are given as below: [9]

(i) $1^- \rightarrow 0^+$ (ii) $\frac{3}{2}^+ \rightarrow \frac{5}{2}^+$ (iii) $\frac{3}{2}^- \rightarrow \frac{1}{2}^-$

(iv) $\frac{3}{2}^- \rightarrow \frac{1}{2}^+$ (v) $(3/2)^+$ to $(½)^+$ (vi) $\frac{3}{2}^+ \rightarrow \frac{5}{2}^-$

==End of P-412 Exam==

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF PHYSICS

UNIVERSITY SECOND SEMESTER EXAMINATIONS

P 422: SOLID STATE PHYSICS II

DATE: MAY 24, 2011

DURATION: THREE HOURS

TOTAL MARKS: 100

ANSWER ANY FOUR QUESTIONS

ALL WORKING SHOULD BE SHOWN CLEARLY TO EARN FULL CREDIT.

A SHEET OF FORMULAE IS ATTACHED AT THE BACK OF THE QUESTION PAPER.

QUESTION ONE

(a) Explain why metallic bodies are always opaque. [4]

(b) The electron and hole mobilities in a Si sample are 0.135 and 0.048 m^2/Vs respectively.

(i) Determine the conductivity of intrinsic Si at 300 K if the intrinsic carrier concentration is 1.5×10^{16} atoms/m^3. [3]

(ii) The sample is then doped with 10^{23} phosphorus atoms/m^3. Determine the equilibrium hole concentration, the conductivity and the Fermi level relative to the intrinsic level [6]

(iii) Hence find the resistance of an Si rod 1 cm long, 1 mm wide and 1 mm thick at temperature 300K. μ_n =1350 cm^2/Vs and μ_h =480 cm^2/Vs [2]

(c) Show that the conductivity of a semiconductor is minimum when it is lightly doped with P type impurity such that

(i)

$$P = n_i \sqrt{\frac{\mu_n}{\mu_p}}$$ [6]

(ii) Show that the minimum conductivity is $2n_i\sqrt{\mu_n \mu_p}e$. [2]

(iii) Hence determine the value of the minimum conductivity of Si. [2]

QUESTION TWO

(a) What is the difference between a conductor cooled to 0 K and a superconductor? Explain in terms of the Meissner effect and the disappearance of resistivity. [5]

(b) Apply Hund's rules to calculate the quantum numbers S, L and J for the spin, orbital and total angular momenta respectively and hence the effective number of Bohr magnetons for the following configurations

(i) Eu^{+} $4f^8 5s^2 p^6$ (ii) Er^{3+} $4f^{11} 5s^2 p^6$ (iii) Gd^{3+} $4f^7 5s^2 p^6$

[13]

(c) The London penetration depths for a superconductor at 3 K and at 7 K are 39.6 nm and 173 nm respectively. Show that the superconducting transition temperature is 7.19 K.

[7]

QUESTION THREE

(a) What are the differences between an antiferromagnet and a ferrimagnet? Supplement your brief answer with pertinent diagrams

[6]

(b) Nickel has an atomic number of 28. Compute the effective number of Bohr magnetons for nickel ion Ni^{2+}

(i) if the orbital angular momentum is not quenched [5]

(ii) if it is quenched. [3]

(b) (i) Show that the exchange integral (coefficient) J_e is given by

$$J_e = \frac{3k_B T_C}{2ZS(S+1)}$$

for a ferromagnet with Curie temperature T_C. Each atom has Z identical nearest neighbours and each has spin S. **[6]**

(ii) Hence calculate the exchange integral for nickel which has a face centred cubic structure (with lattice constant 3.52 Angstroms) and a Curie temperature of 631 K. **[3]**

(iii) Calculate the internal field also. **[2]**

QUESTION FOUR

(a) What is the Bloch theorem? **[4]**

(b) Using the Kronig-Penney model, where

$p\frac{\sin \alpha a}{\alpha a} + \cos \alpha a = \cos ka$ and $\alpha^2 = \left(\frac{2mE}{\hbar^2}\right)^{\frac{1}{2}}$ show that for $P << 1$, the energy of the lowest energy band is

$$E = \frac{\hbar^2 P}{ma^2}$$ **[5]**

(c) Show that for the tightly bound electron approximation, the energy $E(k)$ for a simple cubic of lattice constant a is

(i)

$$E(k) = E_\varphi - \gamma_0 - 2\gamma\left(\cos k_x a + \cos k_y a + \cos k_z a\right)$$ **[6]**

(ii) Show that for small values of k the energy varies with k^2 and hence find the expression for the effective mass of the electron. **[5]**

(iii) Determine the maximum energy range for this dispersion. **[5]**

QUESTION FIVE

(a) (i) What is the relationship between the ***s-shell*** and a ***d-shell*** in terms of magnetism and electrical conductivity? **[2]**

(ii) Explain the difference between type I and type II superconductors using the Meissner effect. Prove that the Meissner effect and the disappearance of resistivity are mutually consistent. **[5]**

(b) The transition from the normal to the superconducting state results in a discontinuity in specific heat capacity given by

$$c_n - c_s = \frac{T_c}{4\pi}\left[\left(\frac{dH_c}{dT}\right)^2 + H_c\left(\frac{d^2H_c}{dT^2}\right)\right]_{T=T_c}$$

If

$T_c = 1.18K,\ H_c(0) = 99$ Gauss and γ(specific heat constant at normal state)=$1.35\text{x}10^4$ ergs/mol.K, calculate the fractional change in specific heat capacity for Aluminum at T_c

[12]

(c) Determine the magnitude of the total angular momentum quantum number J for the following using the Hund rules:

(i) Ce^{3+} with outer shell configuration, $4f^15s^2P^6$; **[3]**

(ii) Pr^{3+} with outer shell configuration, $4f^25s^2P^6$. **[3]**

QUESTION SIX

(a) (i) What is the cause of the macroscopic magnetic properties of materials? [3]

(ii) What is spontaneous magnetization? [2]

(b) (i) What is the Hall Effect? State some applications of Hall Effect. [3]

(ii) In a particular semiconductor there are 10^{23} donors/cm^3 with an ionization energy of 1 meV and an effective mass of $0.01m_0$, where m_0 is the rest mass of an electron.

Estimate the concentration of conduction electrons at 4 K. [6]

Hence what is the Hall coefficient? (Assume no acceptor atoms present and that $E_g >> kT$) [2]

(c) The wave function of the hydrogen atom in its ground state (1s) at S.T.P is

$$\Psi(r) = \frac{1}{\sqrt{\pi a_0^{\ 3}}}\exp\left(-\frac{r}{a_0}\right)$$

where $a_0 = 0.529 \times 10^{-8}$ cm is the atomic radius. Show that for this state,

$\langle r^2 \rangle = 3a_0^{\ 2}$. [6]

Hence calculate the diamagnetic susceptibility of atomic hydrogen. [3]

FORMULAE AND CONSTANTS YOU MAY NEED

Electron rest mass $m_e = 9.109 \times 10^{-31}$ kg Electron charge $e = 1.602 \times 10^{-19}$ C

Planck's constant $h = 6.626 \times 10^{-34}$ Js^{-1} Bolzmann constant k_B=1.381 × 10^{-23} JK^{-1}

Avogadro's number $N_A = 6.022 \times 10^{23}$/g mole Bohr magneton $\mu_B = 9.274\times10^{-24}$ Am^2

Permeability of free space $\mu_0 = 4\pi\times10^{-7}$Hm^{-1}

$M = Ng\mu_B JB_J(y)$ where $y = \left(\frac{g\mu_B JB}{k_B T}\right)$ $B_J(y) \approx \frac{y(J+1)}{3J}$ for $y << 1$

Curie temperature for a ferromagnet,

$$T_C = \frac{\lambda N g^2 \mu_B{}^2 J(J+1)}{3k}$$

Exchange energy $U_i = -gS_{zi}\mu_B\lambda\mu_0 M$ OR $U_i = -\frac{2ZJ_e S_{zi} M}{g\mu_B N}$

$\mu = IA$

$N_C = 2\left[\frac{2\pi m_n{}^* kT}{h^2}\right]^{\frac{3}{2}}$, $N_V = 2\left[\frac{2\pi m_h{}^* kT}{h^2}\right]^{\frac{3}{2}}$ Effective number of electrons and holes at the conduction and valence band edge respectively.

$n = [N_C N_V]^{\frac{1}{2}} \exp\left(\frac{E_d - E_C}{2kT}\right)$ OR $n = n_i \exp\left(\frac{E_f - E_i}{kT}\right)$

Diamagnetic susceptibility

$$\chi_{dia} = -\frac{N\mu_0 Ze^2}{6m}\langle r^2\rangle$$

$$\int_0^\infty x^4 e^{-x} dx = 24$$

Superconductivity

$$H_c = H_{co}\left[1 - \left(\frac{T}{T_c}\right)^2\right]$$

$$\frac{\lambda_d(T)}{\lambda_d(0)} = \left[1 - \left(\frac{T}{T_c}\right)^4\right]$$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

P442: DIGITAL ELECTRONICS II

Time: Three Hours **Maximum Marks = 100**

Attempt any four questions.
All questions carry equal marks.
The marks are shown in brackets.

8085 / 8080A Instruction summary by Functional Groups

DATA TRANSFER (COPY)

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
40	MOV B,B	58	MOV E,B	70	MOV M,B	1A	LDAX D
41	MOV B,C	59	MOV E,C	71	MOV M,C	2A	LHLD
42	MOV B,D	5A	MOV E,D	72	MOV M,D	3A	LDA
43	MOV B,E	5B	MOV E,E	73	MOV M,E	02	STAX B
44	MOV B,H	5C	MOV E,H	74	MOV M,H	12	STAX D
45	MOV B,L	5D	MOV E,L	75	MOV M,L	22	SHLD
46	MOV B,M	5E	MOV E,M	77	MOV M,A	32	STA
47	MOV B,A	5F	MOV E,A	78	MOV A,B	01	LXI B
48	MOV C,B	60	MOV H,B	79	MOV A,C	11	LXI D
49	MOV C,C	61	MOV H,C	7A	MOV A,D	21	LXI H
4A	MOV C,D	62	MOV H,D	7B	MOV A,E	31	LXI SP
4B	MOV C,E	63	MOV H,E	7C	MOV A,H	F9	SPHL
4C	MOV C,H	64	MOV H,H	7D	MOV A,L	E3	XTHL
4D	MOV C,L	65	MOV H,L	7E	MOV A,M	EB	XCHG
4E	MOV C,M	66	MOV H,M	7F	MOV A,A	D3	OUT
4F	MOV C,A	67	MOV H,A	06	MVI B	DB	IN
50	MOV D,B	68	MOV L,B	0E	MVI C	C5	PUSH B
51	MOV D,C	69	MOV L,C	16	MVI D	D5	PUSH D
52	MOV D,D	6A	MOV L,D	1E	MVI E	E5	PUSH H
53	MOV D,E	6B	MOV L,E	26	MVI H	F5	PUSH PSW
54	MOV D,H	6C	MOV L,H	2E	MVI L	C1	POP B
55	MOV D,L	6D	MOV L,L	36	MVI M	D1	POP D
56	MOV D,M	6E	MOV L,M	3E	MVI A	E1	POP H
57	MOV D,A	6F	MOV L,A	0A	LDAX B	F1	POP PSW

ARITHMETIC

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
80	ADD B	CE	ACI	D6	SUI	23	INX H
81	ADD C	90	SUB B	DE	SBI	33	INX SP
82	ADD D	91	SUB C	09	DAD B	05	DCR B
83	ADD E	92	SUB D	19	DAD D	0D	DCRC
84	ADD H	93	SUB E	29	DAD H	15	DCR D
85	ADD L	94	SUB H	39	DAD SP	1D	DCR E
86	ADD M	95	SUB L	27	DAA	25	DCR H
87	ADD A	96	SUB M	04	INR B	2D	DCR L
88	ADC B	97	SUB A	0C	INR C	35	DCR M
89	ADC C	98	SBB B	14	INR D	3D	DCR A
8A	ADC D	99	SBB C	1C	INR E	0B	DCX B
8B	ADC E	9A	SBB D	24	INR H	1B	DCX D
8C	ADC H	9B	SBB E	2C	INR L	2B	DCX H
8D	ADC L	9C	SBB H	34	INR M	3B	DCX SP
8E	ADC M	9D	SBB L	3C	INR A		
8F	ADC A	9E	SBB M	03	INX B		
C6	ADI	9F	SBB A	13	INX D		

LOGICAL

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
37	STC	A9	XRA C	B3	ORA E	BD	CMP L
A0	ANA B	AA	XRA D	B4	ORA H	BE	CMP M
A1	ANA C	AB	XRA E	B5	ORA L	BF	CMP A
A2	ANA D	AC	XRA H	B6	ORA M	FE	CPI
A3	ANA E	AD	XRA L	B7	ORA A	07	RLC
A4	ANA H	AE	XRA M	F6	ORI	0F	RRC
A5	ANA L	AF	XRA A	B8	CMP B	17	RAL
A6	ANA M	EE	XRI	B9	CMP C	1F	RAR
A7	ANA A	B0	ORA B	BA	CMP D	2F	CMA
E6	ANI	B1	ORA C	BB	CMP E	3F	CMC
A8	XRA B	B2	ORA D	BC	CMP H		

BRANCHING

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
C3	JMP	D7	RST 2	EC	CPE
C2	JNZ	DF	RST 3	F4	CP
CA	JZ	E7	RST 4	FC	CM
D2	JNC	EF	RST 5	C9	RET
DA	JC	F7	RST 6	C0	RNZ
E2	JPO	FF	RST 7	C8	RZ
EA	JPE	CD	CALL	D0	RNC
F2	JP	C4	CNZ	D8	RC
FA	JM	CC	CZ	E0	RPO
E9	PCHL	D4	CNC	E8	RPE
C7	RST 0	DC	CC	F0	RP
CF	RST 1	E4	CPO	F8	RM

CONTROL

Hex	Mnemonic
00	NOP
76	HLT
F3	DI
FB	EI
20	RIM
30	SIM

Q1. (a) Draw the diagram of a typical microprocessor. The diagram should include all the necessary components of a microprocessor. Show all the interconnections between components. Describe the functions of all the components. [11]

(b) (i) Write a program for multiplication of non-negative integers using the instruction subset shown below. [7]

Instruction	Mnemonic	Immediate	Direct	Relative	Inherent
Load Accumulator	LDA	86	96		
Clear Accumulator	CLRA				4F
Decrement	DCA				4A
Accumulator	INCA				4C
Increment Accumulator	STA		97		
Store Accumulator	ADD	8B	9B		
Add	BRA			20	
BRANCH always	BCS			25	
BRANCH if carry set	BEQ			27	
BRANCH if carry zero	BMI			2B	
BRANCH if minus	HLT				3E
HLT					

(ii) Include the flow diagram of your program. Translate your program into machine code. [7]

Q2. (a) (i) Explain the step-by-step procedure by which a computer executes a program. [10]

(ii) Explain the necessity for condition codes (flags) in a microprocessor. [5]

(b) (i) From which location will the next instruction be fetched if the BRA instruction is located at 30_{16} and the relative address is 4_{16}? [5]

30	BRA
31	4
32	–
33	–
34	–
35	–
36	-

(ii) What is the relative address if we want to jump to location A7 and the BRA instruction is located at B2? [5]

A7
A8
A9
AB
AC
AD
AE
AF
B0
B1
B2
B3
B4

Q3. (a) (i) Define a microprocessor and a microcomputer respectively. [3]

(ii) Explain the purpose of a data register and an accumulator in a microprocessor. [2]

(iii) Convert the binary coded decimal of the decimal number 9789 to gray code. [5]

(b) (i) Draw a Karnaugh map in the seven variables A, B, C, D, E, F and G. [8]

(ii) Draw the subcubes for a three variable Karnaugh map in X, Y and Z for m1+m3+m5+m0. [7]

Q4. (a) Design a **circuit** and write a **program** to read eight ON/OFF switches connected to the input port with address 01H and turn on the devices connected to an output port with address 01H. The appliances are

Air conditioner-ON [8+4]
Television-OFF
Space heater-OFF
Radio-ON
Light 1-ON
Light 2-ON
Light 3-OFF
Light 4-ON

(b) Modify the program to keep the space heater ON continuously without affecting the functions of other appliances even if someone turns off the switch. [6]

(c) Explain the output of the following program. Show the contents of the registers and memory locations after the execution of each instruction. [7]

```
        MVI B,5H
        LXI H, 2600H
        LXI D, 9000H
LOOP    MOV A,M
        STAX D
        DCX D
        DCX M
        DCR B
        JNZ LOOP
        HLT
```

Q5. (a) (i) Write the instruction and machine code to rotate the contents of the accumulator left through carry, assuming the accumulator has A7H and the carry flag is reset. Show the contents of the accumulator before and after the instruction. [4]

(ii) Which instruction is used to restore the original contents of the accumulator? Illustrate using figures. [4]

(b) Read the following program and answer the following questions given below.

Line no.	Mnemonics
1	LXI SP, 0400H
2	LXI B, 2055H
3	LXI H, 22FFH
4	LXI D, 2090H
5	PUSH H
6	PUSH B
7	MOV A,L
↓	↓
20	POP H

(i) Illustrate the contents of various registers and stack memory locations after the execution of each instruction. Use separate figures for PUSH and POP instructions. [8]

(ii) What is the memory location of the stack where the first data byte will be stored? [2]

(iii) After the execution of line 6, what is the address in the stack pointer register and what is stored in the stack memory location 03FDH? [2]

(iv) Specify the contents of register pair HL after the execution of line 20. [3]

(c) Write short notes on [6]

(i) opcode and operand (ii) stack pointer

Q6. A system is desigmed to monitor the voltage of a circuit. A set of voltage readings are stored in memory locations starting at XX60H. The end of data string is indicated by 00H. The readings are expected to be positive. Using the instruction set of 8085 microprocessor, draw a flowchart and write a program to [25]

(i) check each reading to determine whether it is positive or negative

(ii) reject all negative readings

(iii) add all positive readings

(iv) store '**FFH**'in memory location XX80H when the sum exceeds 8-bits to indicate '**ERROR**'; otherwise store the sum.

END OF P442 EXAMINATION

UNIVERSITY OF ZAMBIA

DEPARTMENT OF PHYSICS

2011 SECOND SEMESTER UNIVERSITY EXAMINATIONS

P455
QUANTUM MECHANICS II

DURATION: Three hours.

INSTRUCTIONS: Answer four questions from the six given. *Each question carries 25 marks with marks indicated in parenthesis.*

MAXIMUM MARKS: 100

DATE: Friday 6$^{\text{th}}$ May 2011.

Formulae that may be needed:

1. Equations which give corrections to the unperturbed energy and energy eigenstates to various orders:

$$\begin{aligned}(H_0 - W^{(0)})v^{(0)} &= 0,\\ (H_0 - W^{(0)})v^{(1)} + (H' - W^{(1)})v^{(0)} &= 0,\\ (H_0 - W^{(0)})v^{(2)} + (H' - W^{(1)})v^{(1)} - W^{(2)}v^{(0)} &= 0.\end{aligned}$$

2.

$$\begin{aligned}a &= \left(\frac{m\omega_c}{2\hbar}\right)^{\frac{1}{2}} x + i\left(\frac{1}{2m\hbar\omega_c}\right)^{\frac{1}{2}} p\\ a^\dagger &= \left(\frac{m\omega_c}{2\hbar}\right)^{\frac{1}{2}} x - i\left(\frac{1}{2m\hbar\omega_c}\right)^{\frac{1}{2}} p\end{aligned}$$

3.

$$a_f^{(1)} = \frac{1}{i\hbar}\int_0^t e^{i\omega_{fi}t'} H'_{fi}(t')\, dt'$$

4. Hermite polynomials are generated by

$$H_n(\alpha x) = H_n(\xi) = e^{\xi^2/2}\left(\xi - \frac{d}{d\xi}\right)^n e^{-\xi^2/2}.$$

5.

$$\int_{\infty}^{\infty} x^2 e^{-\alpha x^2}\, dx = \frac{\sqrt{\pi}}{2\alpha^3}$$

6.

$$u_n = \frac{a^{(\dagger)^n}}{\sqrt{n!}}\, u_0$$

7.

$$\begin{aligned}J_+ &= J_x + iJ_y, \quad J_- = J_x - iJ_y\\ J_\pm|j,m\rangle &= \hbar[j(j+1) - m(m\pm1)]^{\frac{1}{2}}|j, m\pm1\rangle,\end{aligned}$$

8.

$$a^\dagger u_n = \sqrt{n+1}\, u_{n+1}, \qquad a u_n = \sqrt{n}\, u_{n-1}$$

9. Hermite polynomials

$$H_n(\alpha x) = H_n(\xi) = e^{\xi^2/2}\left(\xi - \frac{d}{d\xi}\right)^n e^{-\xi^2/2}, \quad \xi = \alpha x, \quad \alpha = \left(\frac{m\omega_{10}}{\hbar}\right)^{\frac{1}{2}}$$

10.

$$\int_0^\infty x^{2m} e^{ax^2}\, dx = \frac{1.3.5\ldots(2m-1)}{2^{m+1}a^m}\left(\frac{\pi}{a}\right)^{\frac{1}{2}}$$

11.

$$\cos 2\theta = 1 - 2\sin^2\theta$$

12.

$$H_0 = -\frac{\hbar^2}{2m}\nabla^2 - \frac{z'e^2}{r}, \qquad H_0 U_{100}(x, z') = \frac{|z'|^2 e^2}{2a} U_{100}(x, z').$$

13. The Hamiltonian for a two electron atom is

$$H = -\frac{\hbar^2}{2m}\nabla_1^2 - \frac{z'e^2}{r_1} - \frac{\hbar^2}{2m}\nabla_2^2 - \frac{z'e^2}{r_2} + \frac{e^2}{r_{12}}$$

14. For $\psi(12) = U_{100}(x_1, z')U_{100}(x_2, z')$ we have

$$\int\int \psi^* \frac{e^2}{r_{12}} \psi\, dr_1 dr_2 = \frac{5e^2 z'}{8a}, \qquad \int\int \psi^* \frac{1}{r_1}\psi\, dr_1 dr_2 = \int\int \psi^* \frac{1}{r_2}\psi\, dr_1 dr_2 = \frac{z'}{a}$$

15.

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + V(x)\psi(x) = E\psi(x)$$

QUESTION 1

(a) For the harmonic oscillator problem prove the results:

$$a^\dagger u_{n-1} = \sqrt{n}\, u_n, \qquad a u_n = \sqrt{n}\, u_{n-1}.$$

(8 marks)

(b) Find the expectation value of p^2. (8 marks)

(c) Prove that

$$J_x|jm\} = \frac{\hbar}{2}[j(j+1) - m(m+1)]^{\frac{1}{2}}|j, m+1\} + \frac{\hbar}{2}[j(j+1) - m(m-1)]^{\frac{1}{2}}|j, m-1\}.$$

Use this result to express J_x for $j = 1$ as a matrix in the angular momentum representation.

(9 marks)

QUESTION 2

The Hamiltonian for the unharmonic oscillator is

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega_c^2 x^2 + \lambda x^4, \qquad \omega_c = \sqrt{k/m}.$$

Calculate the first order correction $W^{(1)}$ to the energy of the m^{th} excited state of the anharmonic oscillator and hence write down the total energy W of the m^{th} excited state. (25 marks)

QUESTION 3

Consider a particle in a two-dimensional, infinite square potential well extending from 0 to L in the x and y directions. The particle is subject to the perturbation $H' = Cxy$, where C is constant. The eigenenergies and eigenfunctions of the unperturbed system are:

$$E_{n_1,n_2} = \frac{\hbar^2\pi^2}{2mL^2}(n_1^2 + n_2^2), \ \psi_{n_1,n_2}(x,y) = \frac{2}{L}\sin\left(\frac{\pi n_1 x}{L}\right)\sin\left(\frac{\pi n_2 y}{L}\right), \ n_1, n_2 = 0, 1, 2\ldots$$

a) Write down the energy and the corresponding eigenfunction/s of the first excited state of the unperturbed system. State whether or not the states is degenerate giving reasons for your answer. (4 marks)

b) Derive the first of the following equations:

$$\begin{aligned} h_{11} - W^{(1)} a_1^{(0)} + h_{12} a_2^{(0)} &= 0, \\ h_{21} a_1^{(0)} + h_{22} - W^{(1)} a_2^{(0)} &= 0, \end{aligned}$$

where

$$\begin{aligned} h_{11} &= \langle \psi_{12} | H' | \psi_{12} \rangle = h_{22} = \langle \psi_{21} | H' | \psi_{21} \rangle = \frac{L^2 C}{4}, \\ h_{12} &= \langle \psi_{12} | H' | \psi_{21} \rangle = h_{21} = \langle \psi_{21} | H' | \psi_{12} \rangle = \frac{256 L^2 C}{81 \pi^4}. \end{aligned}$$

(9 marks)

(c) Use the values of the first order corrections to the energy given by

$$W_+^{(1)} = \frac{L^2 C}{4} + \frac{256}{8\pi^4} L^2 C, \quad \text{and} \quad W_-^{(1)} = \frac{L^2 C}{4} - \frac{256}{81\pi^4} L^2 C$$

to find the wavefunction or wavefunctions of the first excited state to zeroth order. (9 marks)

d) Explain the physical meaning of your results from part (c). (3 marks)

QUESTION 4

Consider a one-dimensional harmonic oscillator with angular frequency ω_0 and electric charge q. At time $t = 0$ the oscillator is in the ground state. An electric field is applied for time τ, so the perturbation is

$$W(t) = \begin{cases} -qex & 0 \leq t \leq \tau \\ 0 & \text{otherwise,} \end{cases}$$

where ϵ is a field strength and x is a position operator.

a) Using first-order perturbation theory, calculate the probability of transition to the state $n = 1$. (17 marks)

(b) Using first-order perturbation theory, show that a transition to $n = 2$ is impossible. (8 marks)

QUESTION 5

Consider a two electron atom or ion whose nucleus has charge ze. Use the variational method to obtain an estimate $W^{(1)}$ of the ground state of such a two-electron system. (25 marks)

QUESTION 6

a) Obtain the exact nonlinear equivalent of the Schrödinger equation used to obtain the WKB approximation. (7 marks)

(b) Using the WKB approximation reduce the nonlinear equation obtained in part (a) to series of equations of various orders of approximation. Solve the appropriate equation to obtain a formula for the zeroeth order term $S_0(x)$ and for the first order term $S_1(x)$, Hence write down the WKB formula for approximating a wave function ψ for the case $E > V(x)$. State in words only the kind of region for which the WKB approximation is a good approximation. (18 marks)

END

The University of Zambia

Department of Physics

First Semester University Examinations - 2010

The Physics of Renewable Energy & Environment – P485

Duration: Three (3) Hours

Date: April 2010

Instructions

- This paper contains six (6) questions and has a total of 100 marks.
- Attempt any four (4) questions of your choice. Each question carries 25 marks.
- Show all your work clearly. Omission of essential work will result in loss of marks.
- Marks allocated for each question are indicated in square brackets [ ].

Table 1: Values of $f(x) = 1/\sigma\left(\int_0^x \left(a/\left(x^5\left(e^{(b/x)}-1\right)\right)\right)dx\right)$ for different x.

x (µm-K)	$f(x)$	x (µm-K)	$f(x)$	x (µm-K)	$f(x)$
1100	0.0001	4600	0.580	8100	0.860
1200	0.0002	4700	0.594	6200	0.864
1300	0.0004	4800	0.608	8300	0.868
1400	0.0008	4900	0.521	8400	0.871
1500	0.0013	5000	0.634	8500	0.875
1600	0.0020	5100	0.646	8600	0.878
1700	0.0029	5200	0.658	8700	0.881
1800	0.0040	5300	0.669	8800	0.884
1900	0.0052	5400	0.680	8900	0.887
2000	0.0067	5500	0.691	9000	0.890
2100	0.0083	5600	0.701	9100	0.893
2200	0.101	5700	0.711	0200	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	0.934
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		

Table 2: The Equation of Time in Minutes

Day of Month	1	4	7	10	13	16	19	22	25	28
January	-4	-5	-6	-8	-9	-10	-11	-12	-12	-13
February	-14	-14	-14	-14	-14	-14	-14	-14	-13	-3
March	-13	-12	-11	-10	-10	-9	-8	-7	-6	-5
April	-4	-3	-2	-1	-1	0	+1	+1	+2	+2
May	+3	+3	+3	+4	+4	+4	+4	+4	+3	+3
June	+2	+2	+2	+1	0	0	-1	-2	-2	-3
July	-3	-4	-5	-5	-6	-6	-6	-6	-6	-6
August	-6	-6	-6	-5	-5	-4	-4	-3	-2	-1
September	0	+1	+2	+3	+4	+5	+6	+7	+8	+9
October	+10	+11	+12	+13	+14	+14	+15	+15	+16	+16
November	+16	+16	+16	+16	+16	+15	+15	+14	+13	+12
December	+11	+10	+9	+7	+6	+4	+3	+2	0	-2

Table 3: Some Physical Constants

Radius of the Sun, $R_{\odot} = 6.96 \times 10^{8}$ m	Mass of the Sun, $M_{\odot} = 1.99 \times 10^{30}$ Kg
Radius of the Earth, $R_{\oplus} = 6.38 \times 10^{6}$ m	Mass of the Earth, $M_{\oplus} \simeq 5.97 \times 10^{24}$ Kg
1 Astronomical Unit, 1 AU $\simeq$ 149.6×10^{9} m	Earth's Solar constant, $S \simeq 1352$ W.m^{-2}
Eccentricity of Earth, $\varepsilon = 0.0167$	Boltzmann constant, $k \simeq 1.38 \times 10^{-23}$ J.K^{-1}
Universal gas constant, $R = 8317$ J/Kg mole-K	Stefan-Boltzmann constant, $\sigma \simeq 5.67 \times 10^{-8}$ W.m^{-2}K^{-4}
Mean molecular mass of air, $\bar{M} = 29.0$ amu	One atomic mass unit, 1 amu $= 1.66 \times 10^{-27}$ Kg,
Speed of light (vacuum), $c = 2.9979 \times 10^{8}$ m.s^{-1}	Planck's constant, $h \simeq 6.63 \times 10^{-34}$ J-s
Specific heat of water, $c_w = 4.186$ KJ.Kg^{-1}.K^{-1}	Electron charge, $e \simeq 1.60 \times 10^{-19}$ Coulombs

Table 4: Formulae That May Be Useful

$\delta = 23.45\sin\left[\frac{360}{365}(d_n + 284)\right]$	$r = \frac{a(1-\varepsilon^2)}{1+\varepsilon\cos\theta}$
$n_f = \sqrt{n_g}$	$dq = du + Pdv$
$J = \varepsilon\sigma T^4$	$R = Nk$
Solar time = Standard time + 4(Long$_{st}$ − Long$_{loc}$) + EOT	$\cos D' = \sin 23.5^\circ \sin\left(\frac{360^\circ}{365.25}n\right)$
$F_\lambda^{(dir)} = \mu S_\lambda \exp\left(-\frac{\tau_\lambda}{\mu}\right)$ where $\mu = \cos\theta$	$\nabla\cdot(\boldsymbol{\kappa}\nabla T) + q_g = \rho c\frac{\partial T}{\partial t}$
$\dot{Q} = \frac{(T_1 - T_{(n+1)})}{\sum_1^n \frac{L}{kA}}$	$T_{f,e} = T_B - [T_B - T_{f,i}]\exp\left(\frac{U_L L}{\dot{m}c}\right)$
$s_f = \frac{m\lambda_0}{4n_f}$	$\text{cr} = \frac{A}{A'}$
$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$	$m = \frac{(f/p)}{(1-f/p)}$
$r_\parallel = \left[\frac{n_r^2\cos\theta_i - n_i\sqrt{n_r^2 - n_i^2\sin^2\theta_i}}{n_r^2\cos\theta_i + n_i\sqrt{n_r^2 - n_i^2\sin^2\theta_i}}\right]^2$	$r_\perp = \left[\frac{n_i\cos\theta_i - \sqrt{n_r^2 - n_i^2\sin^2\theta_i}}{n_i\cos\theta_i + \sqrt{n_r^2 - n_i^2\sin^2\theta_i}}\right]^2$
$R = r\left[1 + \frac{\alpha^2(1-r)^2}{1-\alpha^2 r^2}\right]$	$T = \frac{\alpha(1-r)^2}{1-\alpha^2 r^2}$
$J_0 = DT^3\exp\left(-\frac{\varepsilon_g}{kT}\right)$	$J = J_0\left[\exp\left(\frac{qV}{kT} - 1\right)\right]$
$(\dot{Q}_{12}) = \frac{A_1\sigma(T_1^4 - T_2^4)}{\left(\frac{1-\varepsilon_1}{\varepsilon_1}\right) + \left(\frac{1-\varepsilon_2}{\varepsilon_2}\right)\frac{A_1}{A_2} + \left(\frac{A_1 + A_2 - 2A_1F_{1-2}}{A_2 - A_1F_{1-2}}\right)}$	$\alpha = \exp\left(-\frac{n\kappa s}{\sqrt{n^2 - \sin^2\theta_i}}\right)$
$\cos Z = \sin D'\cos L' + \sin D'\sin L'\cos H$	$\tan A = \frac{\cos D'\sin H}{(\sin D'\cos L'\cos H - \cos D'\sin L')}$

1. (a) The spectrum of extraterrestrial solar radiation can be considered as a black-body at 5760 K and leads to the earth's solar constant of about $1352\ \text{W.m}^{-2}$.

(i) Define the term solar constant, **[2]**

(ii) Calculate the energy fraction of extraterrestrial solar radiation for wavelengths between $0.3\mu\text{m}$ and $0.5\mu\text{m}$. **[4]**

(b) Given that earth's albedo is 0.33 and assuming the planet to be at a uniform temperature with a thermal emissivity equal to unity,

(i) Show that its steady-state (effective) temperature would be

$$T_{\text{eff}} = \left[\frac{0.67}{4\sigma}S\right]^{1/4},$$

where S is earth's solar constant and σ is the Stefan-Boltzmann constant. **[6]**

(ii) Hence, or otherwise, estimate the effective temperature of the earth and the characteristic wavelength of its emission spectrum. **[3]**

(c) Consider an atmosphere in which temperature, density and pressure vary only with altitude z, where $z = 0$ at sea level. Show that the density profile of a dry atmosphere with a temperature profile $T = T_0 - \alpha z$ is given by

$$\rho = \frac{\rho_0}{(1-\beta z)}\exp\left[\frac{1}{\beta H}\ln[1-\beta z]\right],$$

where $\beta = \alpha/T_0$ and $H = \dfrac{RT_0}{Mg}$. Here, α is the temperature lapse rate, T_0 is the temperature at sea level, ρ_0 is the density of air at sea level, R is the universal gas constant and M is the molecular mass of air. **[10]**

2. (a) Find the local coordinates of the sun in terms of the zenith angle and azimuth angle at 12:00hrs noon on 25th April for an observer at Lusaka (Longitude 28°16'**E**, Latitude 15°17'**S**). **[5]**

(b) For an observer in Lusaka on 25th April, find

(i) the time of sunset and sunrise, **[5]**

(ii) the number of daylight hours, **[5]**

(iii) the noontime zenith angle, **[5]**

(iv) the sunset and sunrise azimuth angles. **[5]**

3. (a) Prove that the overall reflectance of a single glazing is given by

$$R = r\left[1 + \frac{\alpha^2(1-r)^2}{1-\alpha^2 r^2}\right],$$

where r and α are the reflection coefficient and bulk transmissivity, respectively. **[8]**

(b) A glazing 1.5 cm thick has an index of refraction of $n = 1.5$ and a bulk extinction coefficient of $\kappa = 0.2$ cm^{-1}. Find the overall transmittance of the glazing for direct solar radiation at an incident angle of $60°$. **[7]**

(c) The insulation boards for air-conditioning purposes are made of three layers; a middle layer made of packed grass 10 cm thick and thermal conductivity $\kappa = 0.02$ W/m°C while the sides are made of plywood each of 2 cm thickness and thermal conductivity $\kappa = 0.12$ W/m°C. The three layers are glued to each other. Neglecting the thermal resistance of glue, determine the heat flow per unit area if one of the exterior surfaces is at $35°$C and the other is at $20°$C **[10]**

4. (a) A spherical mirror has a radius of $R = 60.0$ cm and a rim angle of 40°.

   (i) If aberrations increase the image radius of the solar disc to 6 times the minimum value, find the concentration ratio of the mirror, **[6]**

   (ii) Find the average flux and the power falling on a small absorber at the focal point if the direct solar flux is 900 W/m^2. **[7]**

(b) A p-n junction photovoltaic is made of a semiconductor whose bandgap is $\varepsilon_g = 1.2$ eV. It has a junction parameter $D = 0.2$ amp/cm^2-K^3 and an average responsivity of $\bar{K} = 0.25$ amp/W.

   (i) Find the reverse saturation current of the photovoltaic when the operating temperature is 300 K, **[5]**

   (ii) Find the open circuit voltage at 300 K when the intercepted flux is 1 sun. **[7]**

5. (a) A glazing of refractive index 1.6 is coated with a film to make it antireflective at normal incidence.

   (i) What should the film refractive index be? **[2]**