UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2010-2011 SECOND SEMESTER EXAMINATIONS

POST GRADUATE

1. BIO 2032 - Microbiology Final paper
2. BIO 2032 - Microbiology Deferred paper
3. BIO 3092 - Animal physiology Theory paper
4. BIO 3092 - Animal physiology Practical paper
5. BIO 3102 - Bacteriology
6. BIO 3112 - Biochemistry and physiology of parasites theory paper
7. BIO 3122 - Biology of seed plants
8. BIO 3282 - Plant pathology
9. BIO 3182 - Genetics
10. BIO 5101 - Biosystematics of tropical plant taxonomy
11. BIO 5502 - Invertebrate systematic
12. BIO 5512 - Insect functional morphology
13. BIO 5492 - Forest/Woodland insect pest management theory paper I
14. BIO 5512 - Insect functional morphology theory paper II
15. BIO 5522 - Freshwater entomology theory paper II
16. BIO 5532 - Taxonomic methods
17. BIO 9555 - Fish biology
18. PHY 5011 - Mathematical methods for physics
19. PHY 5022 - Mathematical methods for physics
20. PHY 5922 - Computational physics and modeling II

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 2032: BASIC MICROBIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: THE PAPER IS DIVIDED INTO TWO SECTIONS. ANSWER **FIVE** QUESTIONS, **THREE** FROM SECTION A AND **TWO** FROM SECTION B. USE SEPARATE ANSWER BOOKLETS FOR EACH SECTION.

SECTION A

1. (a) Describe the characteristics of photosynthetic bacteria.
   (b) Identify various groups of photosynthetic bacteria.
   (c) Describe the distinguishing features of any TWO of the groups you identified in (b).

2. Describe the general structure of a prokaryotic cell and the range of variability of the cell form shown by bacteria.

3. Describe the structure and composition of the bacterial cell wall and explain the underlying differences based upon which bacteria are separated into two groups.

4. Describe the features of bacterial genomes.

5. (a) Describe the characteristics of the Archaea.
   (b) State the distinguishing features of the groups the various members of the Archaea.
   (c) Explain the significance of Methanogens.

SECTION B

6. Describe nucleic acid replication in:
   (a) Retroviruses,
   (b) Negative strand RNA viruses and
   (c) Hepadnaviridae.

TURN OVER

7. Discuss the characteristics of negative-strand RNA viruses of animals using two named examples.

8. Explain the various morphological and genome variations of plant viruses a named example of each group.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR SECOND SEMESTER
DEFERRED FINAL EXAMINATIONS

BIO 2032: BASIC MICROBIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: THE PAPER IS DIVIDED INTO TWO SECTIONS. ANSWER **FIVE** QUESTIONS, **TWO** FROM EACH SECTION AND THE FIFTH FROM EITHER SECTION. USE SEPARATE ANSWER BOOKLETS FOR EACH SECTION.

SECTION A

1. (a) Identify all groups of phototrophic bacteria and describe the basis on which their grouping is based.
   (b) Describe the characteristics of cyanobacteria and their contribution to the evolution of life on earth.

2. Describe the characteristics of prokaryotic cell walls and their distinguishing features.

3. Describe the effects of temperature on the growth of bacteria.

4. Summarise any TWO of the following.
   (a) Bacterial differentiation.
   (b) Diauxic growth.
   (c) Bacterial genome.
   (d) Plasmids.

SECTION B

5. Describe using one named example of a family representative in each case:
   (a) The structural and genomic variations in plant DNA viruses and
   (b) Negative stranded RNA plant viruses.

6. Discuss the characteristics of positive-stranded RNA viruses of animals using two named examples.

TURN OVER

7. Describe three different enzymes encoded by bacteriophages and three different enzymes encoded by animal viruses and their functions. In each case state a representative family member that produces the named enzyme.

8. Discuss eight different ways by which plant viruses are transmitted.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 – 2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 3092: ANIMAL PHYSIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

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1. Discuss the roles of hypothalamic neural centres and hormones released from the gastrointestinal tract and adipose tissue in regulating food intake in animals.

2. Discuss the compensatory measures that occur:
   (a) in response to a fall in core body temperature as a result of cold exposure
   (b) in response to a rise in core body temperature as a result of heat exposure.

3. (a) Describe how steroid hormone synthesis in the gonads of mammals is controlled.
   (b) Discuss the interactions between the gonadotropins and steroid hormones in the mammalian female's reproductive cycle.

4. Summarise each of the following:
   (a) Non-shivering thermogenesis.
   (b) cAMP as second messenger.
   (c) Counter-current heat exchange in an animal's body.
   (d) Roles of hormones in insect development.

5. (a) Describe the osmoregulatory mechanisms employed by animals living in freshwater and seawater environments.
   (b) Outline the homeostatic roles of the kidney.

6. (a) Explain why plasma calcium must be closely regulated.
   (b) Discuss the contributions of parathyroid hormone, calcitonin, and vitamin D to calcium metabolism.

7. (a) Describe the principal means by which acclimatisation to low oxygen levels occurs in animals.
   (b) Discuss the various physiological changes and adjustments that take place in air breathing vertebrates during diving.

TURN OVER

8. (a) Describe the events at a neuromuscular junction.
   (b) Describe the excitation-contraction coupling and relaxation in skeletal muscle fibre.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 – 2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 3092: ANIMAL PHYSIOLOGY
PRACTICAL PAPER

TIME: ONE AND HALF HOURS

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

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1. A research student used the Winkler method to determine oxygen consumption in goldfish at room temperature and the following data was obtained:

   Table 1. Oxygen Consumption in Goldfish

Mass of goldfish (g)	Amount of Oxygen in jar without fish (mg O_2/ litre) (control)	Amount of Oxygen in jar with fish (mg O_2/ litre) after 25 minutes
0.50	10.01	8.95
2.00	10.01	7.89
1.35	10.01	8.02
2.80	10.01	7.55
1.00	10.01	8.40
3.00	10.01	7.40

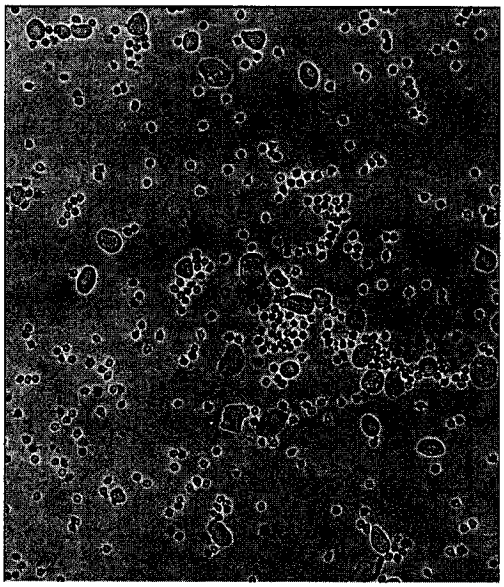
   (a) Using the information given in table 1, calculate:
      (i) The total oxygen consumption for each fish, giving your answer in ml O_2/litre /hour.
      (ii) The metabolic rate for each fish, giving your answer in ml O_2/g/hour.
   (b) Tabulate your results obtained in (a) above and plot them (each set) against the body weight.
   (c) Explain the differences in the graphs obtained in (b) above.
   (d) Discuss the significance of the relationship between metabolism and body weight in animals.
   (e) Distinguish between standard metabolism and active metabolism.

2. Vaginal smears from 3 different rats were prepared and mounted on a microscope slide. The observations were as shown in **figure 1**.
   (a) Describe the procedure used to prepare the rat vaginal smears.
   (b) State the stages of the oestrus cycle for the smears of rats A, B and C.
   (c) State the main event or occurrence in the ovary and vaginal wall of each of the rats at these stages of the oestrus cycle.
   (d) For each rat, predict the number of hours from the next ovulation.

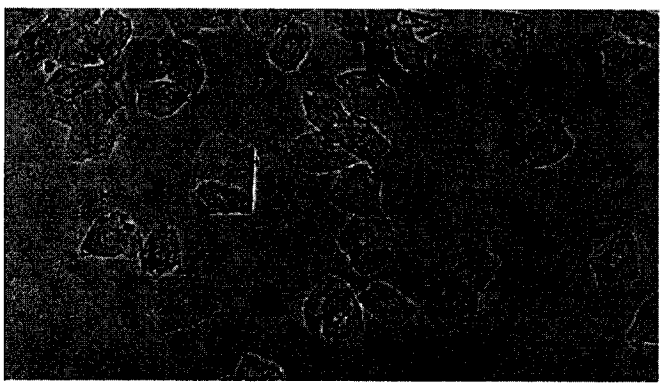
TURN OVER

(e) Discuss the significance of the vaginal smear – preparation technique for clinical and animal husbandry purposes.

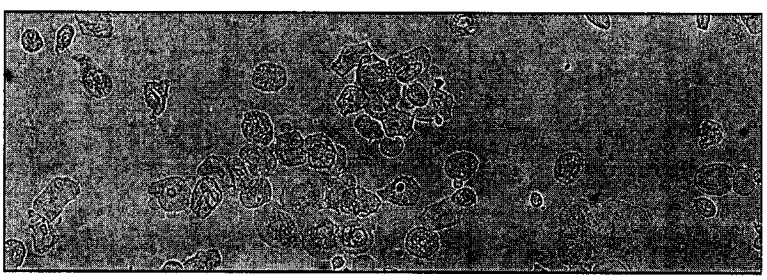
Figure 1. Vaginal smears for 3 different rats as shown under the microscope (original mag.: X100).



Rat A



Rat B



Rat C

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 3102: BACTERIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

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1. Discuss Myxobacteria with reference to their characteristics, taxonomic position and unusual life cycle.

2. Describe the role of bacteria in the dairy industry and give examples of bacteria and their products.

3. Discus the features of phototrophic bacteria and the role of cyanobacteria in transforming the early Earth in the evolution of diversity of life.

4. (a) Compare and contrast Proteobacteria and Alpha-proteobacteria
   (b) Give examples of Alpha-proteobacteria involved in nitrogen fixation.

5. Describe the structure and life cycle of *Caulobacter*.

6. (a) Explain the significance of transformation in bacteria.
   (b) Name bacteria in which this process is more common.
   (c) Give names of bacteria where this process has been experimentally demonstrated.

7. Discuss food spoilage attributed to bacteria and the methods used to prevent it.

8. Summarize any TWO of the following:

   (a) Bacterioids
   (b) *Methanococcus*
   (c) *Mycobacterium*
   (d) Biofilms

END OF EXAMINATION

THE UNIVERSTITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 3112: BIOCHEMISTRY AND PHYSIOLOGY OF PARASITES
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. TWO QUESTIONS FROM EACH SECTION AND ONE QUESTION FROM EITHER SECTION. USE ILLUSTRATIONS WHERE NECESSARY.

SECTION A

1. Describe parasite circadian rhythms and transmission with respect to synchronous cell division and release of infective parasite stages from hosts.

2. Describe cell invasion in malaria parasites and discuss the factors that affect it.

3. Summarize all of the following:
   (a) The role of bile salt in parasite establishment.
   (b) Reproductive synchrony.
   (c) The protonephiridial system of platyhelminthes.

4. (a) Describe the pattern of parasite migration and site selection.
   (b) Describe animal hookworm and roundworm larval migratory patterns in the human host and their effects.

SECTION B

5. Summarize the following:
   (a) Paratenic host
   (b) Mutualism
   (c) Parasitism
   (d) Hemozoin
   (e) Sporozoans

6. Discuss the mechanism of energy metabolism of the malaria parasite. Outline the pathways of glucose degradation by this parasite.

TURN OVER

7. (a) Draw and describe the organelle in which glycolysis takes place in the following parasites:

   (i) African Tyrpanosomes
   (ii) Trichomonads
   (b) Compare and contrast between Monogenea and Digenea.

8. (a) Draw and describe the polymorphic forms of *Trypanosoma brucei* and list their end products of glucose metabolism.

   (b) Given an un-limited source of glucose to a parasite cell, mention the limiting factor in the glycolytic reactions

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 3122: BIOLOGY OF SEED PLANTS
THEORY PAPER

TIME: THREE HOURS

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

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1. Summarize the following:
   (a) Acid growth hypothesis in seed plants.
   (b) Determinate and indeterminate growth.
   (c) *Tunica-corpus* organization of the meristem.
   (d) Interfascicular cambium.

2. Compare and contrast the different types of tissues found in seed plants.

3. Discuss the common features of spermatophytes and the significance of these features to their unique success among the chlorobionta.

4. Discuss the various meristem classification systems, highlighting the basis for each of them.

5. Briefly discuss secondary growth in eudicotyledons, explaining the transverse distribution and functional and economic significance of the resulting secondary tissues.

6. Compare and contrast the morphological and anatomical structures of vascular tissue systems of monocotyledonous and eudicotyledonous leaves, and the spatial relationship of the structures to the mesophyll.

7. Briefly discuss the genetic control of gametophytic and sporophytic self incompatibility in spermatophyte breeding systems.

8. Describe plant cell wall architecture and explain the differences in wall components between commelinoid and non-commelinoid type monocotyledons.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 3282: PLANT PATHOLOGY
THEORY PAPER

TIME: THREE HOURS

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

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1. Describe the nature, symptoms and methods of disease transmission of mycoplasmas including description of a familiar example of a mycoplasma disease.

2. Describe plant pathogens and the disease cycles they represent. Identify pathogens and their characteristics that enable them to cause disease epidemics.

3. (a) Describe the characteristics of plant nematodes.
   (b) Describe a local nematode disease in relation to:
   (i) Disease symptoms.
   (ii) The causal organism, and the
   (iii) Effect of nematodes on plant growth and yield.

4. Compare and contrast plant resistance and plant susceptibility and describe types of resistance shown by plants.

5. Describe plant toxins and their role in pathogenicity.

6. Describe the taxonomy of cereal rusts giving examples with particular reference to wheat stem rust and the process of rust development in its host.

7. Compare and contrast damping-off and downy mildew diseases in relation to:
   (a) Pathogen types
   (b) Disease symptoms
   (c) Effect of climate on disease.

8. Summarize any TWO of the following:
   (a) Blight
   (b) Anthracnose
   (c) Smuts
   (d) Vascular wilt disease syndrome.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO3182: GENETICS
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS

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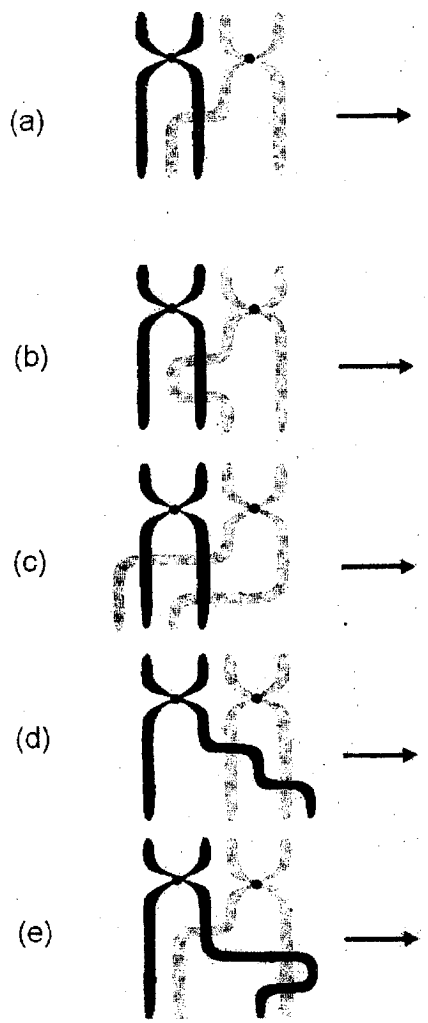
1. Examine the meiotic Chromosomes given below and draw the meiotic products that arising from the various cross-over patterns:



2. A three-point test cross was made in corn involved recessive genes of purple leaves (p), virus resistant seedlings (v) and brown seeds (b). The dominant genes were green (+), sensitive (+) and plain (+) respectively to obtain F1 generation.

The test cross was then carried out to obtain F2 progeny and 10,000 offspring were counted with the results shown here.

Class	Progeny Phenotypes	No of off-spring	P-b	P-v	v-b
1	+ + +	3210			
2	P v b	3222			
3	+ v +	1024			
4	P + b	1044			
5	P v +	690			
6	+ + b	678			
7	+ v b	72			
8	P + +	60			

Based on the information in the above table, answer the following questions:

(a) Calculate the X^2 value to see whether the test of linkage fit a 1: 1: 1: 1: 1: 1: 1: 1 ratio or not.
(b) Estimate the recombination frequencies
(c) Determine the gene order and draw a map showing the distances between the Loci.
(d) Calculate the value of the mean Chiasma frequency
(e) Determine the distance between the genes in **centimorgan**.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009-2010 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 5101-BIOSYSTEMATICS OF TROPICAL PLANT TAXA
PRACTICAL PAPER

TIME: TWO HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS

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1. Write in detail the procedure and precautions taken in collecting and presenting dry plant herbarium specimens for the Department of Biological Sciences.

2. You have been provided leaves of TEN grasses representing the Zambian flora. Describe how you would proceed to analyse them for the data on micro-characters using the structural features of the epidermal cells.

3. Describe the method of Cluster Analysis for similarity and dissimilarity among plants occurring in two different woodland types of Zambia. Explain and illustrate the procedure.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009-2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 5502: INVERTEBRATE SYSTEMATICS
THEORY PAPER II

TIME: THREE HOURS

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

SECTION A: Classification of the Protozoa

1. Discuss the basis of the traditional classification of the protozoa highlighting features of the major groups recognized under the system. In your answer also explain the relationship between protozoa and the invertebrates.

2. Summarise the following:
   (a) Apicomplexa.
   (b) Choanoflagellates.
   (c) Kinetoplastida.
   (d) Rhizopoda.
   (e) Mastigophora.

3. The rooting of the "Tree of life" and the relationships of the major lineages at this level are still controversial. Name the three major branches of living organisms that may have stemmed from this root according to our current understanding and describe the characteristics of the branch that is believed to have given rise to the Metazoa and the invertebrates

4. Distinguish between Protists and Protozoa and explain the phylogenetic relationship(s) between them and the invertebrates.

SECTION B: Invertebrate Classification

5. Discuss the determinants of the most primitive metazoan and explain which of the extant metazoan taxa exhibits these characteristics.

6. Discuss the classification of acoelomate invertebrates giving specific examples and explain the relationship of these taxa to the Porifera and Cnidaria.

7. Discuss the classification of Pseudocoelomate invertebrates giving specific examples.

TURN OVER

8. Distinguish between: (a) protostome and Deuterostome invertebrates, and (b) Diploblast and triploblast invertebrates giving specific examples.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009-2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 5512: INSECT FUNCTIONAL MORPHOLOGY.
THEORY PAPER I

TIME: THREE HOURS

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

SECTION A: Insect Embryology

1. With the aid of well labelled diagrams, distinguish between holoblastic and meroblastic egg cleavage in insects, giving specific examples of insect groups that exhibit each type of egg cleavage.

2. Explain how the dorsal closure is achieved in a developing embryo in insect eggs and the fate of the extra-embryonic membranes following the closure.

3. Discuss segmentation, appendage formation and the fate of the germ bands during the developments of embryos in insects.

4. Discuss the development of the organ systems and the control of this development in insect embryos .

SECTION B: Evolutionary History of the Insect Body

5. Discuss the five theoretical evolutionary stages that the insect body is envisaged to have passed through according to R.E. Snodgrass (1935).

6. Discuss the paranotal (flying squirrel) and the exite theories on the origin of insect wings, giving evidence in support and against each theory. In your view which of the two theories is more formidable.

7. Discuss the adaptive radiation that has occurred in the insect mouthparts from the primitive mandibulate type.

8. Compare and contrast the structural adaptations of the respiratory systems exhibited by aquatic and endoparasitic insects.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009-2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 5492: FOREST/WOODLAND INSECT PEST MAMANGEMENT
THEORY PAPER I

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. TWO QUESTIONS FROM EACH SECTION AND THE FITH QUESTION FROM EITHER SECTION. GIVE EXAMPLES WHERE NECESSARY.

SECTION A

1. Discuss three important theories which seek to explain forest insect outbreaks.

2. Explain how forest insect populations are regulated in nature.

3. Summarise **each** of the following:
   (a) Wood insects pests
   (b) Forest-insect interactions
   (c) Plantation tree insect pests in Zambia

4. Compare the life cycles of two named insect pests of the Miombo woodland and their management in Zambia.

SECTION B

5. Discuss the conditions under which prey populations are more likely to be regulated by predators.

6. "Pine bark beetles, *Dendroctonus frontalis* L. and *D. brevicomis* L. can only attack weakened pines when their populations are sparse, but large populations can overwhelm the resistance of relatively vigorous trees." Berryman(1986). Discuss the validity of this statement.

7. Summarise any **four** of the following:
   (a) Natural enemy hierarchies
   (b) Insect parasitoids
   (c) Ground sampling
   (d) Monitoring and forecasting forest insect outbreaks
   (e) Spatial distribution

8. Describe the means by which forest trees defend themselves against insect attacks.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009-2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 5512: INSECT FUNCTIONAL MORPHOLOGY
THEORY PAPER II

TIME: THREE HOURS

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

SECTION A: Insect Locomotion

1. Discuss the mechanism of walking in insects in terms of forces acting on the insect body and the patterns of leg movements exhibited at low, normal and fast speeds.

2. Discuss giving examples the standard mechanisms involved in jumping in insects, without using legs.

3. Explain the concept of support by alternative triangles of legs in relation to patterns of leg movements in insects and indicate which insects are exceptions to this mode of locomotion.

4. Explain how insect legs act both as struts and levers during insect walking and show how balance is achieved in insects like the preying mantis in which at low speeds the sequence of leg movements is: L3L2R2R3L3L2R2R3.....L3L2R2R3

SECTION B: Insect Flight

5. Distinguish the activities of direct and indirect flight muscles in insects indicating which insects bear them and their efficiency.

6. Explain factors that initiate takeoff in insects and how forces of rolling, pitching and yawing acting on an insect in a steady flight are overcome in two-winged flies.

7. Discuss the roles of campaniform sensilla and Chordotonal organs during insect flight and indicate on which part of the insect body these proprioceptors are located in relation to insect wings.

8. With the aid of well labelled diagrams explain how halteres in true or two-winged flies (Order Diptera) control yawing in insect flight.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009-2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 5522: FRESHWATER ENTOMOLOGY
THEORY PAPER II

TIME: THREE HOURS

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

SECTION A: Biology and Bionomics of Freshwater Insects

1. Compare and contrast the obligatory freshwater insect orders Ephemeroptera, Odonata and Plecoptera on the following:
   (a) Morphological adaptations
   (b) Biology
   (c) Habitat preferences

2. Discuss the biology and aquatic life adaptations of named Hemiptera families that are totally aquatic, leaving the freshwater habitat only when they migrate.

3. Discuss the life history and metamorphosis in the following aquatic Coleoptera families:
   (a) Gyrinidae.
   (b) Dytiscidae.
   (c) Curculionidae.

4. Compare and contrast aquatic Hemiptera and Trichoptera in terms of:
   (a) Diversity and contemporary distribution
   (b) Behaviour and feeding habits
   (c) Life history strategies and metamorphosis

SECTION B: Economic Importance and Ecosystem Roles of Freshwater Insects

5. Discuss the roles of the following freshwater insects in freshwater ecosystem functioning in terms of nutrient recycling and aquatic food webs:
   (a) Aquatic wasps
   (b) Odonata

6. Discuss freshwater insect groups important in the biological control of aquatic weeds giving specific examples involving the Kafue weed, *Eichhornia crassipes* (water hyacinth) here in Zambia.

TURN OVER

7. Discuss the use of named freshwater insect groups in freshwater ecosystem biomonitoring and whether the latter is feasible in Zambia.

8. Explain the medical importance of the following freshwater insect taxa:
   (a) Black flies (Order Simuliidae)
   (b) Anopheline mosquitoes
   (c) *Aedes aegypti* L.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009-2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 5532: TAXONOMIC METHODS
THEORY PAPER I

TIME: THREE HOURS

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

SECTION A: Principles of Taxonomy

1. Compare and contrast the principles of organismal classification and phylogenetic reconstruction used by the two major contemporary schools of taxonomy.

2. Discuss the taxonomic treatment of allopatric, sympatric and parapatric speciation in developing classifications.

3. Explain the roles of a taxonomist in the following phases of taxonomy:
   (a) α-Taxonomy.
   (b) β-Taxonomy.
   (c) γ-Taxonomy.

4. Discuss how the following ruling principles of nomenclature are applied when naming a new species:
   (a) Typification.
   (b) Synonymy.
   (c) Homonymy.
   (d) Priority.
   (e) First Reviser.

SECTION B: Basic Taxonomic Procedures

5. Explain the sources of taxonomic characters used in modern organismal classification.

6. Discuss the procedures used when describing a new insect species that has just been discovered.

7. Discuss roles of taxonomy in documenting biodiversity and in planning for the conservation of biological natural resources.

TURN OVER

8. Explain why a dichotomous taxonomic key is considered as a classification tool to someone using it for the first time to identify insect taxa not familiar to them but that have already been named.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010-2011 ACADEMIC YEAR: SECOND SEMESTER
FINAL EXAMINATIONS

BIO 9555: FISH BIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. ANSWER QUESTIONS **1, 2 AND 3** AND ANY **TWO** OTHER QUESTIONS. USE ILLUSTRATIONS AND EXAMPLES WHERE NECESSARY

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1. Discuss the reproductive strategies in fish that ensure successful fertilisation and survival of the young.

2. Compare and contrast the two living classes of the Super Class Pisces.

3. (a) Discuss selection pressures associated with schooling fish species.
   (b) Summarise the advantages gained by schooling and its costs.
   (c) Give reasons for the minor morphological variations among individuals of schooling fish species.

4. Discuss the values associated with fish conservation.

5. Compare and contrast the Families Cyprinidae and Cichlidae.

6. Describe major characteristics of the Family Anguillidae and give reasons for the limited geographical range of species of this family in the Zambezi River.

7. Discuss the methods used to determine fish growth rate.

8. Describe the respiratory methods and organs observed in the family Clariidae.

END OF THE EXAMINATION

UNIVERSITY OF ZAMBIA

DEPARTMENT OF PHYSICS

M.Sc.

2009 FIRST SEMESTER UNIVERSITY EXAMINATIONS

PHY5011
MATHEMATICAL METHODS FOR PHYSICS

DURATION:	Three hours.
INSTRUCTIONS:	Answer any four questions from the six given. *Each question carries 25 marks with the division of marks within each question indicated by the numbers in parenthesis next to the question.*
MAXIMUM MARKS:	100
DATE:	Monday 26th October 2009.

Included items:

1. Tables of Laplace transforms:

Formulae that may be needed:

1.
$$[x^v J_v(x)]' = x^v J_{v-1}(x).$$

2. Bessel's equation:
$$x^2y'' + xy' + (x^2 - \nu^2)y = 0$$

3. General solution of Bessel's equation:
$$W = c_1 J_0(s) + c_2 Y_0(s)$$

4. Bessel functions of the first kind:
$$J_0(s) = \sum_{m=0}^{\infty} \frac{(-1)^m S^{2m}}{2^{2m}(m!)^2}$$

5. Bessel functions of the second kind:
$$Y_0(s) = \frac{2}{\pi}\left[J_0(s)\left(\ln\frac{s}{2} + \gamma\right) + \sum_{m=1}^{\infty} \frac{(-1)^{m-1} h_m s^{2m}}{2^{2m}(m!)}\right]$$

6. Laplace transform:

$$\mathcal{L}(f) = F(s) = \int_0^\infty e^{-st} f(t)\, dt$$

7. Laplace transform of a derivative of any order

$$\mathcal{L}(f^{(n)}) = s^n \mathcal{L}(f) - s^{n-1} f(0) - s^{n-2} f^{(1)}(0) - \ldots - f^{(n-1)}(0).$$

8. First shifting theorem for Laplace transforms

$$\mathcal{L}[e^{at} f(t)] = F(s-a).$$

9. Second shifting theorem for Laplace transform (inverse form)

$$\mathcal{L}^{-1}[e^{-as} F(s)] = f(t-a)u(t-a),$$

where $u(t-a)$ is the Heavyside function.

10. First and second derivative of a Fourier transform:

$$F[f'(x)] = i\omega F[f(x)] \quad \text{and} \quad F[f''(x)] = -\omega^2 F[f(x)]$$

11. Shifting formula for Fourier transforms

$$F[f(x-a)] = e^{-i\omega a} F[f(x)]$$

QUESTION 1

Derive the one-dimensional wave equation from first principles. Clearly state any assumptions made and include illustrative diagrams. (25 marks)

QUESTION 2

(a) Find the solutions of

$$u_{xy} = u$$

by separating variables. (10 marks)

(b) Using the transformations $v = x + y$ and $z = 3x + y$, solve the following equation

$$u_{xx} - 4u_{xy} + 3u_{yy} = 0.$$

(15 marks)

QUESTION 3

Obtain the solution satisfying the boundary conditions for the heat equation

$$\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$$

by separating variables for the case of a bar which is insulated both laterally and at its ends. First write the boundary conditions appropriate to this problem. The initial condition is

$$u(x,0) = f(x).$$

You are given that the appropriate constant to use is separating variables in $-\rho^2$.

(25 marks)

QUESTION 4

For a circular membrane fixed at its boundary the two-dimensional wave equation can be separated into two ordinary differential equations, one for the radial distance r and one for the time t. These are:

$$W''(r) + \frac{1}{r}W'(r) + k^2 W(r) = 0 \quad (1)$$

$$\ddot{G}(t) + \lambda^2 G(t) = 0 \quad (2)$$

(a) By the appropriate choice of a new variable, transform eq. (1) into Bessel's equation.

(6 marks)

(b) From the general solution of Bessel's equation determine the solution W that satisfies the boundary condition in terms of the zeroes of the Bessel function of the first kind.

(14 marks)

(c) Solve eq. (2) for $G(t)$ with $\lambda = \lambda_m = ck_m$ and hence write the complete solution that satisfies the boundary conditions. (5 marks)

QUESTION 5

(a) Solve the following differential equation by Laplace transforms:

$$\frac{\partial u}{\partial x} + 2x\frac{\partial u}{\partial t} = 2x, \qquad u(x,0) = 1, \qquad u(0,t) = 1.$$

(14 marks)

(b) Use Fourier transforms to obtain the d'Alembert solution of the wave equation subject to the conditions

$$u(x,0) = f(x), \qquad u_t(x,0) = 0, \qquad u \to 0,\ u_x \to 0 \quad \text{as } |x| \to 0.$$

(11 marks)

QUESTION 6

(a) Describe the rotations $M_z(\alpha)$, $M'_y(\beta)$ and $M''_z(\gamma)$ in words and illustrate with diagrams. Name the angles. (7 marks)

(b) Write down the matrices $M_z(\alpha)$, $M'_y(\beta)$ and $M''_z(\gamma)$ explicitly and from these obtain an explicit form for the matrix $M(\alpha, \beta, \gamma)$ for arbitrary rotations.

(7 marks)

(c) Give an explicit example of an active and passive transformation and clearly indicate the meaning of your results. Illustrate both examples with diagrams.

(4 marks)

(d) Define the Levi-Civita symbol ϵ_{ijk} and prove that it is a tensor under proper rotations, and a pseudo-scalar under improper rotations. You may use the result

$$\sum_{lmn} A_{il}A_{jm}A_{kn}\epsilon_{ijk} = \epsilon_{ijk} \det A$$

without proving it. (7 marks)

END

UNIVERSITY OF ZAMBIA

DEPARTMENT OF PHYSICS

M.Sc.

2010 SECOND SEMESTER UNIVERSITY EXAMINATIONS

PHY5022

MATHEMATICAL METHODS FOR PHYSICS

DURATION:	Three hours.
INSTRUCTIONS:	Answer any four questions from the six given. *Each question carries 25 marks with the division of marks within each question indicated by the numbers in parenthesis next to the question.*
MAXIMUM MARKS:	100
DATE:	Monday 19th April 2010.

Formulae that may be needed:

1.

$$[lm,n] = \frac{1}{2}\left(\frac{\partial g_{ln}}{\partial x^m} + \frac{\partial g_{mn}}{\partial x^l} - \frac{\partial g_{lm}}{\partial x^n}\right)$$

$$\left\{ \begin{array}{c} s \\ lm \end{array} \right\} = g^{sn}[lm,n]$$

2. Definition of a covariant derivative

$$A^{p_1\cdots p_m}_{r_1\cdots r_n;q} = \frac{\partial A^{p_1\cdots p_m}_{r_1\cdots r_n}}{\partial x^q} - \left\{ \begin{array}{c} s \\ r_1 q \end{array} \right\} A^{p_1\cdots p_m}_{sr_2\cdots r_n} - \left\{ \begin{array}{c} s \\ r_2 q \end{array} \right\} A^{p_1\cdots p_m}_{r_1 s r_3\cdots r_n} - \cdots\cdots - \left\{ \begin{array}{c} s \\ r_n q \end{array} \right\} A^{p_1\cdots p_m}_{r_1\cdots r_{n-1} s}$$
$$+ \left\{ \begin{array}{c} p_1 \\ qs \end{array} \right\} A^{sp_2\cdots p_m}_{r_1\cdots r_n} + \left\{ \begin{array}{c} p_2 \\ qs \end{array} \right\} A^{p_1 s p_3\cdots p_m}_{r_1\cdots r_n} + \cdots\cdots + \left\{ \begin{array}{c} p_m \\ qs \end{array} \right\} A^{p_1\cdots p_{m-1} s}_{r_1\cdots r_1 s}$$

3.

$$\frac{\partial^2 x^r}{\partial \overline{x}^j \partial \overline{x}^k} = \overline{\left\{ \begin{array}{c} n \\ jk \end{array} \right\}} \frac{\partial x^r}{\partial \overline{x}^n} - \frac{\partial x^i}{\partial \overline{x}^j}\frac{\partial x^l}{\partial \overline{x}^k}\left\{ \begin{array}{c} r \\ il \end{array} \right\}$$

4.

$$\sum_{i=1}^{i=s} n_i^2 = h,$$

5.

$$\sum_{k=1}^{k=s} p_k\, \chi^{(i)}(c_k)^* \chi^{(j)}(c_k) = h\delta_{ij}$$

6.

$$\chi(c_k) = \sum_{k=1}^{k=s} c_i \chi^{(i)}(c_k)$$

7.

$$c_j = \frac{1}{h}\sum_{k=1}^{k=s} p_k\, \chi^{(i)}(c_k)^* \chi^{(j)}(c_k)$$

8.

$$\sqrt[n]{z} = \sqrt[n]{r}\left(\cos\frac{\theta+2k\pi}{n} + i\,\sin\frac{\theta+2k\pi}{n}\right), \qquad k = 0, 1, 2, 3, \ldots, (n-1)$$

QUESTION 1

(a) Use the formula for a differential to show how the differential dx^i transforms noting that $\overline{x}^i = \overline{x}^i(x^1, x^2, \ldots)$. State what kind of entity is dx^i and give the general form of transformation law for this kind of entity. (4 marks)

(b) Beginning with the derivative of a scalar ϕ

$$\frac{\partial \phi}{\partial x^j}$$

derive and name the transformation law for this kind of entity. (4 marks)

(c) Name the three types of second-rank tensor and write down their transformation law. (3 marks)

(d) Test whether or not the derivative of a vector produces another tensor. Give an explanation for your answer. (5 marks)

(e) Form the outer product of the tensor A^{ij} and B_k give the rank of the new tensor. Form the inner product and show that it is a tensor of rank 2 less than the outer product. (9 marks)

QUESTION 2

If A_p and A^p are tensors show that:

(a)

$$A_{p;q} = \frac{\partial A_p}{\partial x^q} - \left\{ \begin{array}{c} s \\ pq \end{array} \right\} A_s, \quad \text{and}$$

(13 marks)

(b)

$$A^p_{;q} = \frac{\partial A^p}{\partial x^q} + \left\{ \begin{array}{c} p \\ qs \end{array} \right\} A^s$$

are tensors. (12 marks)

QUESTION 3

Consider the circular drum problem for which the equation and boundary condition are

$$\nabla^2 u + k^2 u = 0 \text{ at } r = R.$$

(a) Write down the equation satisfied by the Green's function for this equation, noting that the drum is struck at the point $\vec{x'}$ a distance r' from the center. (3 marks)

(b) The solution of the equation of part (a) for $\vec{x}' \neq \vec{x}$ is

$$G\begin{cases} \sum_m A_m J_m(kr)\cos m\theta & (r < r') \\ \sum_m B_m[J_m(kr)Y_m(kR) - J_m(kR)Y_m(kr)]\cos m\theta & (r > r') \end{cases}$$

Finding A_m and B_m gives the Green's function G for the problem. These are found by solving two equations relating A_m and B_m. Determine, but DO NOT solve, these equations. (22 marks)

QUESTION 4

(a) Solve the integral equation

$$f(x) = e^x + \lambda \int_0^1 e^{x-y} f(y)\, dy.$$

From this solution write the eigenvalue of the homogeneous part of the equation. (14 marks)

(b) Solve the integral equation

$$f(x) = x + \lambda \int_0^1 y(x+y) f(y)\, dy$$

by Neumann's method, keeping terms of λ^2. (11 marks)

QUESTION 5

(a) Prove that the cosets Sg_1 and Sg_2 are either identical or have no elements in common. (6 marks)

(b) Prove that elements of different orders cannot be in the same class. (4 marks)

(c) Prove that two elements which belong to the same class have the same character in any representation. (5 marks)

(d) Define the elements of the symmetry group S_8 of a square. The elements have the following multiplication table:

E	C_{4z}^+	C_{2z}	C_{4z}^-	σ_x	σ_y	σ_1	σ_2
C_{4z}^+	C_{2z}	C_{4z}^-	E	σ_1	σ_2	σ_y	σ_x
C_{2z}	C_{4z}^-	E	C_{4z}^+	σ_y	σ_x	σ_2	σ_1
C_{4z}^-	E	C_{4z}^+	C_{2z}	σ_2	σ_1	σ_x	σ_y
σ_x	σ_2	σ_y	σ_1	E	C_{2z}	C_{4z}^-	C_{4z}^+
σ_y	σ_1	σ_x	σ_2	C_{2z}	E	C_{4z}^+	C_{4z}^-
σ_1	σ_x	σ_2	σ_y	C_{4z}^+	C_{4z}^-	E	C_{2z}
σ_2	σ_y	σ_1	σ_x	C_{4z}^-	C_{4z}^+	C_{2z}	E

Use this table to determine the regular representation of S_8. (10 marks)

QUESTION 6

Consider S_8, the symmetry group of a square. Its 8 elements are divided into 5 classes, with C_1 being the class containing the identity. Class C_2 has 1 element, C_3 has 2 elements, C_4 has 2 elements and C_5 has 2 elements.Complete the following character table for S_8:

	$\chi^{(1)}$	$\chi^{(2)}$	$\chi^{(3)}$	$\chi^{(4)}$	$\chi^{(5)}$
C_1					
C_2				1	-2
C_3				-1	0
C_4				-1	0
C_5				1	0

(25 marks)

END

The University of Zambia

Department of Physics

University Examination-2010

PHY 5922

Computational Physics and Modelling II

Instructions **Max. Marks 100**

- **Time allowed:** Three (3) Hours.
- **All questions carry equal marks.**
- Marks for each question are shown in the square brackets [ ].
- **Answer any four (4) questions.**

Q.1 **(a)** Given the initial-value problem,

$$y' + 2xy = 0, \qquad y(1) = \frac{1}{e}$$

i) Show that it has a unique solution in some specific rectangle around $[1, e]$,

ii) determine the particular solution satisfying the given initial condition.

[10 Marks]

(b) A projectile of mass $0.11\,kg$ shot vertically upward with initial velocity $v(0) = 8\,m/s$ is slowed due to the force of gravity, $F_g = -mg$, and due to air resistance, $F_r = -kv^2$, where $g = 9.8\,m/s^2$ and $k = 0.002\,kg/m$. The differential equation for the velocity v is given by

$$mv' = -mg - kv^2$$

i) Using the Taylor series, find the velocity after 0.2 and 0.4. Take $h = 0.1$.

ii) To the nearest tenth of a second, determine when the projectile reaches its maximum height and begins falling.

[15 Marks]

Q.2 **(a)**Show that Euler's method for approximating solutions of ODE initial value problems

$$y_{i+1} = y_i + hf(x_i, y_i) \qquad y(x_0) = y_0$$

is simply a first order Taylor expansion

[5 Marks]

(b) According to Torricelli's law, the depth y of the water in a tank with a hole in the bottom changes according to the differential equation

$$\frac{dy}{dx} = -k\sqrt{y}A(y)$$

where $A(y)$ is the cross-sectional area of the tank at depth y. The parameter k is defined as $k = a\sqrt{2g}$, where g is the gravitational constant ($9.8\ m/s^2$) and a is the area of the hole.
Use the the classic Runge-Kutta method

$$y_{i+1} = y_i + \frac{1}{6}k_1 + \frac{1}{3}k_2 + \frac{1}{3}k_3 + \frac{1}{6}k_4$$

where

$$k_1 = hf(x_i, y_i)$$
$$k_2 = hf(x_i + 0.5h, y_i + 0.5k_1)$$
$$k_3 = hf(x_i + 0.5h, y_i + 0.5k_2)$$
$$k_4 = hf(x_i + h, y_i + k_3)$$

to find the water depth in a tank with cross-sectional area $A(y) = \pi y$; i.e., formed by rotating the curve $y = x^2$ arount the $y-$axis. Let the initial water depth be 0.6 m and the area of the be 0.001 m^2.
When is the tank empty?

[20 Marks]

Q.3 **(a)** Show that Poisson's equation

$$\frac{\partial^2 u(x,y)}{\partial x^2} + \frac{\partial^2 u(x,y)}{\partial y^2} = f(x,y)$$

can be approximated by the difference equation

$$\frac{u(x_{i+1},y_j) - 2u(x_i,y_j) + u(x_{i-1},y_j)}{h^2} + \frac{u(x_i,y_{j+1}) - 2u(x_i,y_j) + u(x_i,y_{j-1})}{k^2} = f(x_i,y_j)$$

where h is the step size in the x direction and k is the step size in the y direction.

[7 Marks]

(b) A rectangular plate has dimensions 4 cm and 3 cm. It has heat being generated uniformly at each point at the rate $q = 1.5$ cal/cm^3 sec. Let x represent the distance along the edge of the plate of length 4 cm and y the distance along the edge of the plate of length 3 cm. Suppose the temperature u along the edges is kept at the following values:

$$\begin{aligned} u(x,0) &= x(4-x), \quad u(x,3) = 0, \quad 0 \le x \le 4 \\ u(0,y) &= y(3-y), \quad u(4,y) = 0, \quad 0 \le y \le 3 \end{aligned}$$

where the origin lies at a corner of the plate with coordinates $(0,0)$ and the edges lie along the positive $x-$ and $y-$ axes. The steady-state temperature $u = u(x,y)$ satisfies Poisson's equation:

$$\frac{\partial^2 u(x,y)}{\partial x^2} + \frac{\partial^2 u(x,y)}{\partial y^2} = -\frac{q}{K}, \quad 0 < x < 4, \quad 0 < y < 3$$

where K the thermal conductivity, is 1.04 cal/cm deg sec.

i) Derive the linear system from which you can obtain the temperature $u(,xy)$ if $h = 1$ and $k = 1$.

ii) Express the linear system in matrix form.

[18 Marks]

Q.4 **(a)** The motion of a vibrating string of unit length with both ends held fixed and an initial displacement described by the PDE

$$\frac{\partial^2 u}{\partial t^2} = \frac{\partial^2 u}{\partial x^2}, \qquad \text{for} \qquad 0 < x < t, \qquad 0 < t$$

Show that the above PDE is hyperbolic.

[10 Marks]

(b) Use the finite-difference method to solve the problem

$$y'' = y + x(x-4), \qquad 0 \leq x \leq 4$$

with $y(0) = y(4)$ and $n = 4$ subintervals. Taking $h = 1$, find an approximate solution at the points $x_1 = 1$, $x_2 = 2$, and $x_3 = 3$.

[15 Marks]

Q.5 Consider the motion of a pendulum with angular displacement $y(t)$ given by

$$y'' + \frac{c}{mL}y' + \frac{g}{L}\sin(y) = 0; \qquad y(0) = a, \qquad y'(0) = b$$

i) Choosing $g/L = 1$ and $c/(mL) = 0.3$, $a = \pi/2$, and $b = 0$, convert the above second order ODE-IVP to a system of first-order ODE by means of the change of variables.

ii) Using the information in (i) and taking $h = 0.15$, find the displacement after $0.3s$.

[25 Marks]

Q.6 **(a)** Consider an initial-value problem

$$y' = f(x, y) \qquad y(x_0) = y_0,$$

derive the Adams-Bashforth method of fourth-order

$$y_{i+1} = y_i + \frac{h}{24}(55f_i - 59f_{i-1} + 37f_{i-2} - 9f_{i-3})$$

where $i = 1, 2, \cdots N-1$

[13 Marks]

(b) Derive the Adam-Moulton method

$$y_{i+1} = y_i + \frac{h}{24}(9f_{i+1} + 19f_i - 5f_{i-1} + f_{i-2})$$

from the four-order Adams-Bashforth method.

[12 Marks]

$\star\star\star\star\star\star\star$ **End of Examination** $\star\star\star\star\star\star\star$