THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGNEERING
2005 FIRST SEMESTER EXAMINATIONS

COURSE/ CODE		COURSE /TITLE
CE	219	Statics and introduction to strength of materials
CST	3031	Introduction to Software Engineering
CST	3061	Computer networks and communication
CST	4141	Multimedia and human Computer Interaction
EA	311	Farm power and machinery
EE	441	Electronic Engineering (Deferred)
EM	311	Engineering mathematics III
EM	411	Engineering Mathematics

THE UNIVERSITY OF ZAMBIA.

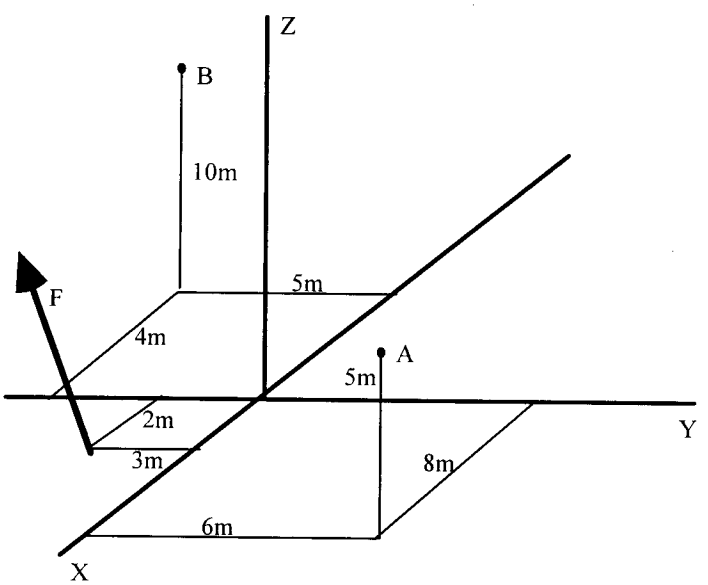
UNIVERSITY FIRST SEMESTER EXAMINATION – JUNE 2005.

CE 219 : STATICS AND INTRODUCTION TO STRENGTH OF MATERIALS.

TIME: Three Hours. **ANSWER:** Any THREE from Section A, and Any TWO from Section B.

Section – A.

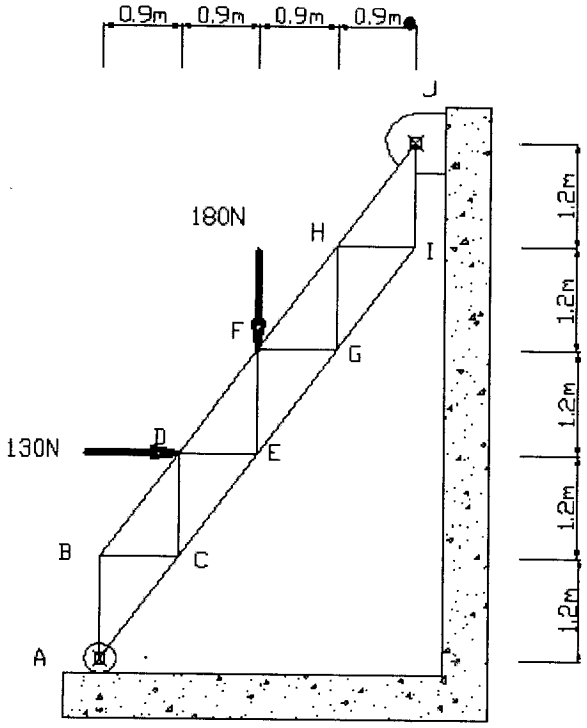
1. Determine the moment of the force $\mathbf{F} = 2\mathbf{i} - 4\mathbf{j} + 10\mathbf{k}$ kN acting as shown in figure about the AB axis. Show using a small circle curving around the axis AB the sense of the moment M_{AB}. (1 kN = 10^3N)



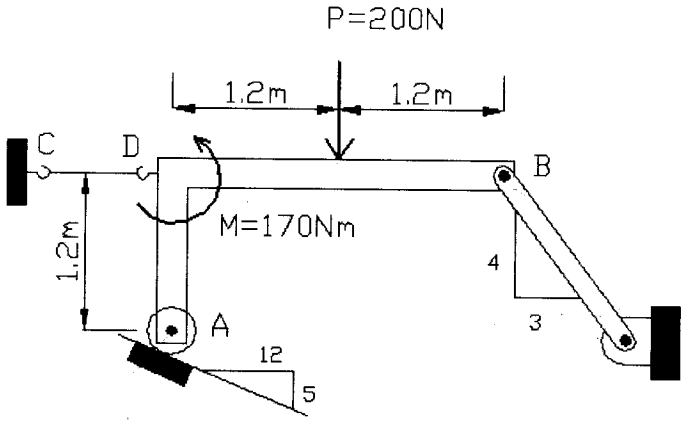
2. The truss shown is supported by a roller and a pin at J. A 130N horizontal force is applied at joint D and a 180 N vertical force is applied at joint F.

(a) Using the method of joints, determine the force in
  (i) AB
  (ii) BC

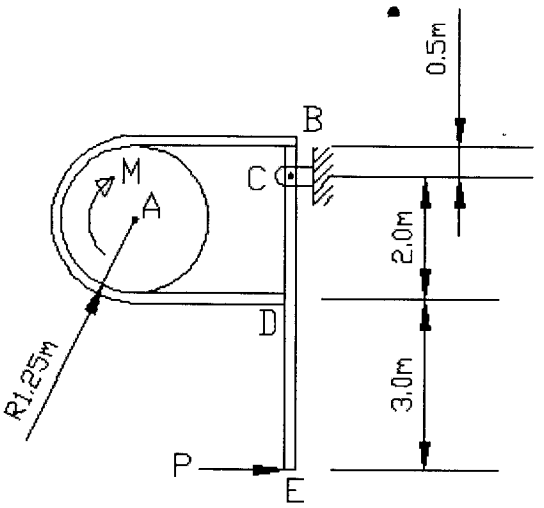
(b) Using the method of sections, determine the force in member EG.



3. Find the tension in the cable CD required to keep the bar ADB in equilibrium. (Hint: Start by taking the moments about the point E where the reaction at A, i.e. R_A, intersects the portion DB of the bar ADB).

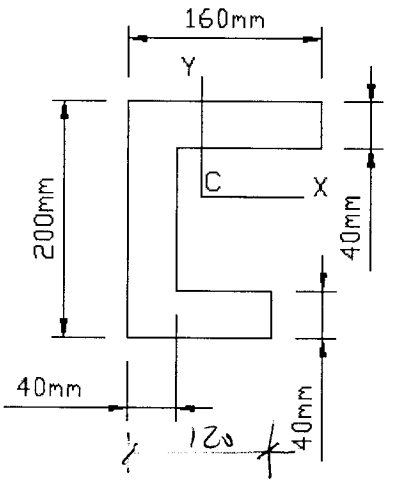


4. The brake belt is used to control the rotation of a drum by application of a force P on the lever BE. The lever is hinged at C, and the coefficient of static friction between the drum and the belt is 0.30. Determine the minimum force P necessary to prevent rotation of the drum when M = 20Nm.



Section – B.

5. Determine the moment of Inertia Ix and the product of Inertia Ixy of the composite area about the centroidal axes passing through C.



6. A 400 mm long circular bar has 50 mm diameter for the middle half of its length, and a reduced diameter for the two end portions .

(a) Determine the diameter of the end portions if the bar is subjected to a tensile load of 100 kN, and the maximum stress is limited to 150 N/mm^2 while the total allowable extension is not to exceed 0.3 mm.
(b) Determine the total strain energy stored in the bar.

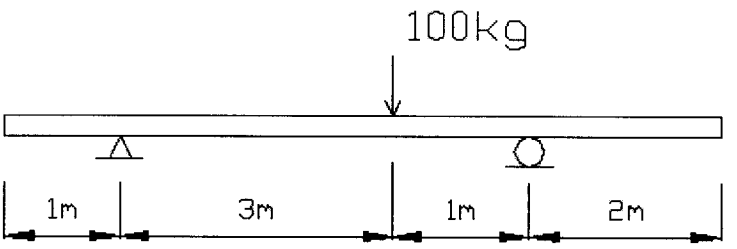
(Given, E = 200 kN/mm^2).

7. A mass of 100kg is exerting a concentrated load at a point A on a steel beam. The weight of the beam is 150N/m.

(a) Find the reactions at the supports.

(b) Draw the shear force diagram, showing the values of all critical values. Show that $\frac{dv}{dx} = -w_x$

(c) Draw the bending moment diagram, showing all the extreme values. Show that $\frac{dM}{dx} = v$



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATION – JUNE/JULY 2005

CST3031

INTRODUCTION TO SOFTWARE ENGINEERING

INSTRUCTIONS:

1. **Time: THREE (3) HOURS.**
2. **There are Three (3) Sections in this examination paper, Section A, Section B, and Section C.**
3. **Answer All questions in Section A and Section B and any Two (2) questions in Section C.**
4. **Marks for Each Part of the Question are Indicated.**

Section A – Attempt All questions in this Section. Fill in Blank Spaces

1. _____ defines how many objects participate in a relationship. [1 mark]

2. The other name for black-box testing is _____. [1 mark]

3. _____ is the process of making sure that we have built the product right. [1 mark]

4. Equivalent partitioning is a way of deriving _____. [1 mark]

5. _____ is a mental process of selecting some characteristics and properties and excluding others that are not relevant. [1 mark]

6. _____ is a measure of how independent or inter-dependent modules are. [1 mark]

7. The central transform is the function (or functions) on a DFD which lie between _____ _____. [1 mark]

8. _____ is a product result that is delivered to the customer. [1 mark]

9. _____ maintains information about the entities used in a system design. [1 mark]

10. _____ provides the capability to create superclasses that encapsulate structure (attributes) and behaviour (operations) common to several classes. [1 mark]

Section B - Answer All questions in this Section

1. (a) Briefly, discuss at least four reasons why software designers / engineers use models? [4 marks]

(b) What is the distinction between a model and UML? [6 marks]

(c) A customer has a name, and an address. Customers can be assigned a credit rating and are either corporate customers or personal customers.

Corporate customers have a contact name, credit rating and credit limit, while personal customers hold credit cards. The corporate customers may be reminded of their bills. The billing(s) are done monthly. The corporate customers are employees.

All customers are allowed or entitled to order some products. Each order has date order received, a flag for prepaid, order number, and order price. The transacted orders may be dispatched and none transacted may be closed. The order is made up of order line. The order line has quantity, price and flag indicating satisfaction.

All products are classified under the order line.

Draw an UML class diagram for the above system. All the key words you need to include are underlined – do *not* invent any details additional to those given above. [15 marks]

2. (a) In software development, what is a critical path? [3 marks]

(b) Can the activities that do not lie on the critical path cause any delay on the overall completion of the project? Discuss. [4 marks]

(c) What is project scheduling? [3 marks]

(d) Figure 1. sets out a number of activities, durations and dependencies. Draw an activity chart showing the project schedule which starts on 23/06/2005 and ends on 10/09/2005. In addition, determine the minimum time required to finish the project. [15 marks]

Task	Duration (days)	Dependencies
T1	10	
T2	10	
T3	18	T1
T4	15	T3
T5	15	
T6	20	T1, T2
T7	10	T3
T8	15	T4, T7
T9	5	T5, T6
T10	20	T5
T11	20	T8

Figure 1. Task Duration and Dependencies

Section C - Answer Any Two (2) questions in this Section

1. (a) What is quality assurance ? [4 marks]

(b) How do we measure the software quality in terms of customer's and developer's point of views ? [2 marks]

(c) What is software metrics? [2 marks]

(d) Discuss the ISO 9000/9003 and illustrate by diagram its general quality management structure. [12 marks]

2. (a) Discuss the differences between defect testing and debugging. [4 marks]

(b) If the members of the software development team ask you the following question: "when do we stop testing"? As a team leader what do you advise the team? [4 marks]

(c) Identify and discuss at least four testing priorities? [4 marks]

(d) During system development, the advantages and disadvantages of both white and black box testing are compared. Regardless of the results (from comparison), it has been argued that "both tests are essential, and they complement each other". Justify this statement. [8 marks]

3. (a) What is software requirements validation? [2 marks]

(b) What is the distinction between software process and requirements engineering? [6 marks]

(c) Discuss the evolution development process model. State how or where this approach is more effective than the waterfall approach. [12 marks]

4. (a) What does a structure chart show or represent? [3 marks]

(b) List and discuss at least four advantages of using the structure chart. [5 marks]

(c) The third year students are required to secure industrial attachment(s) with various companies, organisations, etc in preparation of their project in the next academic year 2006. Using the information given below, construct the structure chart for looking/applying for an Industrial Attachment. [12 marks]

"You start with the preliminaries. This consists of writing out your CV and submitting it to the placement office, rewriting it until it's acceptable to them and, if you need a local placement, producing a letter stating your reasons.

Then you move on to making applications. You keep checking the industrial placement notice board and when you see a suitable placement you submit an application and wait patiently for an interview.

If you are asked for interview you polish your shoes, make your way there and try to convince them you're the best person for the job".

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATION – JUNE 2005

CST3061

COMPUTER NETWORKS AND COMMUNICATION

INSTRUCTIONS

1. Time: **3 hours**
2. This examination has Six (6) questions
3. Answer any **FOUR** (4) questions
4. Each question carries equal question

Question 1

Distinguish between

a) Two tier and three tier computer network architectures (5 Marks)
b) ISDN and modem (5 Marks)
c) Broadband and baseband transmission (5 Marks)
d) Circuit switching and packet switching (5 Marks)
e) intranet and extranet (5 Marks)

(Total 25 Marks)

Question 2.

a) Discuss three primary reasons for networking computers (6 Marks)
b) Distinguish between a Metropolitan Area Networks (MAN) and a Local Area Network (LAN) (3 Marks)
c) Describe how a number of Local Area Networks (LANs) can be connected to form a Wide Area Network (WAN) (10 Marks)
d) Give three disadvantages for networking computers (6 Marks)

(Total 25 Marks)

Question 3.

Different types of computer network topologies do exist.

a) Explain what you understand by the term network topology (2 Marks)
b) Explain each of the following topologies
   i) Mesh
   ii) Star-Ring
   iii) Star-Bus (6 Marks)
c) Netsoft has 10 computers scattered over two floors of a single building. All the 10 computers need to be connected to a single print server to be installed on the first floor.
   i) Design a network topology to support this infrastructure (7 Marks)
   ii) Suggest a least five factors that must be taken into account when designing a network (5 Marks)
   iii)Critically evaluate the designed network topology above taking into account the outlined factors above (5 Marks)

(Total 25 Marks)

Question 4

The ISO OSI model is of such importance in networking to both purchasers and vendors

a) Why are standards and the OSI reference model of such importance in networking (10 Marks)

b) Using a layered block diagram, describe each of the ISO OSI layer reference model stating their functionality. (15 Marks)

(Total 25 Marks)

Question 5

Current network technologies and the internet rely heavily on TCP/IP and fully understanding IP addressing is imperative.

a) Distinguish between
   i) TCP and UDP protocols (6 Marks)
   ii) IP and MAC addressing schemes (4 Marks)
b) The IP address of a network is given as 202.100.99.230
   i) Discuss the two sections of an IP address using the above IP address to explain your answer (4 Marks)
   ii) Suggest the subnet mask of the above network (2 Marks)
   iv) Given the subnet mask as 225.225.225.112, find the network ID of this subnetwork(4 Marks)
   v) Suggest a subnet mask to accomodate ten subnetworks. (5 Marks)

(Total 25 Marks)

Question 6

a) Explain with examples applications that can be used in a network to provide the following services

i) File transfer (3 Marks)
ii) E-mail(3 Marks)
iii) Remote login(3 Marks)
iv) Network management(3 Marks)
v) Name management (3 Marks)

b) State the purpose and functionality of middleware within distributed systems (10 Marks)

(Total 25 Marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATION – JUNE/JULY 2005

CST4141

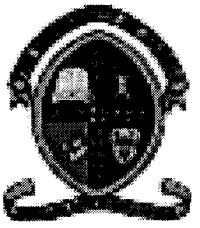
MULTIMEDIA AND HUMAN-COMPUTER INTERACTION

INSTRUCTIONS:

1. **Time: THREE (3) HOURS**
2. **There are Four (4) Sections in this Examination Paper. Section A, Section B, Section C and Section D**
3. **Answer All Questions in Section A, Section B and Section C**
4. **Answer One (1) Question in Section D**
5. **Marks for Each Part of the Question are Indicated**

USEFUL INFORMATION:

Images (.gif)



UnzaLogo.gif

UnzaFrontView.gif

Section A. Answer ALL Questions in this Section **[20 marks]**

TRUE/FALSE Questions

1. TIFF, PICT, and PCX graphics can usually be viewed on modern Macintosh and Windows systems. [1 mark]
2. Modern Web browsers are consistent in their compliance with HTML standards. [1 mark]
3. JavaScript is uniformly supported in modern Web browsers. [1 mark]
4. When placing a graphic button in a Web page, it's usually a good idea to use the attribute BORDER="0". [1 mark]
5. To keep users' attention, navigation cues should frequently move to different parts of the screen. [1 mark]
6. The expense of multimedia means that its use at home will also be limited. [1 mark]
7. The lower the megapixel rating of a digital camera, the higher the resolution. [1 mark]
8. Browsers can use only fonts installed in the user's system. [1 mark]
9. Most multimedia authoring tools can only develop multimedia for the platform on which the tool runs. [1 mark]
10. Modern Macintoshes and Windows PCs use the same basic fonts, making this one less thing for multimedia designers to worry about. [1 mark]

MULTIPLE CHOICE Questions

11. The graphic for a Macintosh icon should be what size in pixels? [1 mark]

    a. 32×16
    b. 32×32
    d. 64×32
    e. 64×64

12. A run-time version of a project allows you to: [1 mark]

    a. Play the project on the Internet
    b. Play the project within the authoring system
    c. Play the project without the authoring system
    d. Play the project in Apple QuickTime

13. Which of the following multimedia-friendly features did the first Macintosh include? [1 mark]

    a. Built-in audio and a speaker
    b. 8-bit (256 color) display
    c. 640×480 pixel display
    d. All of the above

14. Which of the following allows you to get digital video into a computer? [1 mark]

a. Video display adapter
b. A digital still camera
c. Video capture card
d. All of the above

15. During the initial proposal phase, what should you do with the project ideas? [1 mark]

a. Brainstorm the ideas with your entire development team.
b. Organize them using idea management software.
c. Test the ideas with people who are representative of the target audience.
d. Write them down on paper.
e. All of the above

Fill in Blank Spaces

16. Authoring packages usually allow you to create a _____ version of your movie or presentation that can be played on a wide variety of systems that do not have the full authoring system installed. [1 mark]

17. A _____ map provides a table of contents and charts the logical flow of your project. [1 mark]

18. _____ help control the presentation of multimedia elements. [1 mark]

19. A multimedia presentation that puts the user in a simulated three dimensional world is called _____. [1 mark]

20. The _____ format is best suited for photo-realistic graphics on the Web. [1 mark]

Section B. Answer ALL Questions in this Section **[20 marks]**

Matching Questions

1. Match the hierarchy order (i.e. First, Second, Third, and Last) of execution for Handlers contained in these Scripts. [2 marks]

   a. movie
   b. sprite
   c. cast
   d. frame

2. Match the type of authoring tool with the descriptions. Some choices may be used more than once. [2 marks]

   a. Time-based tool b. Icon-based tool c. Card-based tool

   i. Best when a message must be played from beginning to end.
   ii. Elements are organized as objects in a structural framework.
   iii. Best when most content consists of elements that can be viewed individually.
   iv. Elements are to be triggered at specific locations in a sequence of events.
   v. Activities are displayed using flow diagrams.

3. Match the hierarchy order of execution for Handlers contained in these Scripts. [2 marks]

   a. Composite
   b. Nonlinear
   c. Linear
   d. Hierarchical

   i. Users navigate freely through the project.
   ii. Users navigate freely, but are occasionally restricted to a specific path
   iii. Users navigate through branches of a tree structure.
   iv. Users navigate sequentially along a specific path.

Short Answer Questions

4. Name in sequence the Event Handlers that exist in Lingo (the Director scripting language) for use in Movie Scripts. [2 marks]

5. What are the three types of scripts as shown in the Director property inspector of a script type cast member? [2 marks]

6. Define the term Lingo in relation to Macromedia Director. [2 marks]

7. What is a "Request For Proposal"? [2 marks]

8. What does the IMG tag attribute ALIGN provide? [2 marks]

9. Can you play MIDI files directly in DirectorMX? [2 marks]

10. What is a storyboard? [2 marks]

Section C. Answer ALL Questions from this Section **[40 marks]**

1. a) What is SMIL? [3 marks]

b) Identify and discuss the advantages and disadvantages of SMIL. [5 marks]

c) Using a detailed SMIL code, illustrate how you can insert or position a media. The University of Zambia logo (UnzaLogo.gif) needs to be inserted in the region called University icon. Create a window with a 600x300 pixels dimension and set the background to white. Then insert the University of Zambia icon (533x250 pixels) at 30 pixels from the left border and at 25 pixels from the top border. Add duration of time of 8 seconds to a media element and specify a delay time of 3 seconds when to begin displaying the media. Show the result after the code has been run. [12 marks]

2. a) Discuss by stating some examples of the basics of HTML in connection with the web. [5 marks]

b) Assuming that you are creating a website using Dreamweaver, and based on the information given below, your task is only to draw or show how the finished page will look like. [15 marks]

- one type of heading (i.e. Flight Route Map)
- three different font types
- an image (Map of the World, showing a plane flying from NewYork to Los Angeles)
- a background colour (i.e blue or color of your choice) or image

- a table (3 rows, 3 columns)
    - Departing from
    - Tokyo 12:00pm
    - Flight number QZ2020
    - Arriving at
    - Singapore 05:55pm
    - Flight number QZ2020
    - Departing from
    - Singapore 11:55pm
    - Flight number BA447
    - Arriving at
    - Rome 07:10am+1
    - Flight number BA447
- a horizontal rule
- a link to your Home page
- a link to Search any airline information
- a link to Flight Schedules
- a horizontal rule

Section D. Answer One (1) Question from this Section **[20 marks]**

1. a) Identify and list the stages a multimedia project go through. [4 marks]

b) What is Project Management? [6 marks]

c) Under multimedia, discuss the benefits and drawbacks of using the iterative design techniques. [10 marks]

2. **a)** What is the scripting language? [4 marks]

b) What is the distinction between a web and page? [3 marks]

c) Web pages can be static or dynamic. Discuss their differences. [3 marks]

d) Draw the web page that would be displayed when this HTML code was interpreted by a browser. [10 marks]

```
<html>
    <head><title>HTML Course for Beginners</title></head>
    <body>
    <center>
        <h1>Teach Yourself HTML: "Interpreting HTML" </h1>
    </center>
    <br/>
    <hr/>
    <br/>
    <h2> These are a few HTML tags I can recognize and interpret </h2>
      <h3> Tags used to </h3>
      <blockquote>
        <ul>
          <li> start and end of a HTML document</li>
          <li> define the head and body sections of a HTML document </li>
          <li> create line and paragraph breaks</li>
          <li> create lists, either ordered or unordered</li>
          <li> create a horizontal line</li>
          <li> create a link </li>
          <li> include an image </li>
        </ul>
      </blockquote>
  <p>
    <center>
        These tags are essential to the creation of simple HTML code
    </center>
    <a href="http://www.unza.compdept.edu/Subjects/Informal/CST4141"> An Online
    ICT Educational Program on Web Design</a> <br/>
    Here is a link to <a href= "htmlprimer.html"> a locally-stored Online HTMLprimer
    </a><br/>
  <center>
      <a href= mailto:unza.compstudies@unza.edu>
                  <img src= "UnzaFrontView.gif"></a>
  </center>
  </body>
</html>
```

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
2005 ACADEMIC YEAR FIRST SEMESTER
DEFERED EXAMINATIONS
EA 311: FARM POWER AND MACHINERY

INSTRUCTIONS:

TIME ALLOWED: **THREE** HOURS

ATTEMPT: **FIVE** QUESTIONS ONLY; **TWO FROM SECTION A** AND **THREE FROM SECTION B.**

ANSWER **SECTION A** AND **SECTION B IN SEPARATE ANSWER BOOKLETS.**

ALL QUESTIONS CARRY **EQUAL MARKS**, (20 MARKS EACH).

SECTION A: ANSWER TWO (2) QUESTIONS FROM THIS SECTION

Question 1

a) List **three** basics steps involved in carbohydrate metabolism.

[6 marks]

b) Continuous physical power output of an adult healthy human varies with time according to the following equation:

$$P = (68 + 932e^{-0.908t^{0.16}})$$

where: P = power output [W]
t = time [Sec]

i) Calculate the time period over which the sustainable power output of 100W is possible.

[6 marks]

ii) If a field activity requires a continuous physical power input that can be sustained for 30 minutes only, calculate rest period required if the activity has to be performed for an extended period of time while maintaining the same level of power input?

[8 marks]

Question 2

a) State **five** characteristics of an ideal draft animal.

[4 Marks]

b) List **three** steps involved in training animals for draught work.

[6 Marks]

c) A farmer has a pair of oxen, each weighing about 500 kg that he uses for ploughing his field. The soil is predominantly clay loam. The plough cuts a furrow slice 20 cm wide by 25cm deep. The specific soil resistance of clay loam soil is about 20 kN/m^2. The oxen work for 5 hours per day at an average speed of 3.6 km/h. The oxen are fed on guinea grass. Given the following additional information:

Guinea grass gross energy content: = 14.0 MJ/kg

Guinea grass DE : GE Ratio (DE/GE): = 0.5

Maintenance Energy: = 8.3 + (0.091W) MJ/day

Appetite Limit: = 0.025W kg of dry matter

where W is the weight of the draft animal

Energy conversion efficiency of draft animals: = 20%

i) Show that the oxen will need supplementary feed to meet their total daily energy requirement.

[5 Marks]

ii) Briefly discuss the factors that have to be considered when selecting the supplementary feed for animals.

[5 Marks]

Question 3

a) A farmer has a tractor and a plough that he primarily uses to till his 1,500 hectare farm. The plough is 2.5 m wide and is operated at an average speed of 7.5 km/h at a field efficiency of 80%.

i) Calculate the effective field capacity

[3 marks]

ii) Calculate the time required to plough the whole farm

[3 marks]

b) Given the following additional information:

	Tractor	**Plough**
Purchase price, P	K 120,000,000	K 10,000,000
Trade-in value, S	10% P	0
Shelter/Insurance/Tax	1.5% P	0.5% P
Depreciation life	12 years	10 years
R&M (Cumulative over machinery life)	100% of P	150% of P
Fuel Consumption	20 l/h	-
Price of Fuel	K 5,000/l	-
Cost of lubricants	15% of Fuel Cost	-

Labour cost is K 5,000 per hour and the bank interest rate on agricultural loans is 20%.

c) Calculate the total cost for ploughing, per hour and per hectare.

[10 marks

d) Briefly explain how the farmer can lower the cost of ploughing.

[4 marks]

SECTION B: ANSWER THREE (3) QUESTIONS FROM THIS SECTION

QUESTION 4

a) What is primary Tillage.

[2 marks]

b) What is the objective of tillage.

[2 marks]

c) Distinguish between conventional and conservation tillage.

[4 marks]

d) State the conditions that would favour the use of a disc plough over the mouldboard in primary tillage.

[4 marks]

e) Describe the correct sequence of the process, and state the equipment that would be required to remedy a drainage problem created by the formation of a hard pan following the use of heavy equipment in carrying out field operations. The field predominantly has clay soils and need to be prepared for planting carrot seeds.

[8 marks]

QUESTION 5

a) What is the objective of crop planting.

[2 marks]

b) State **two** advantages and **one** disadvantages of row crop planting as opposed to broadcasting.

[3 marks]

c) Name **six** parts of a seed drill and briefly explain the function of each part.

[6 marks]

d) List the processes that have to be carried by a planter to accurately plant a seed.

[3 marks]

e) Describe the process of calibrating a broadcaster.

[5 marks]

QUESTION 6

a) With the aid of a sketch trace the flow of power from the engine to the wheels of a tractor.

[7 marks]

b) List **three** functions of the transmission system.

[3 marks]

c) State **three** control systems on the tractor hydraulic system and briefly describe how each one of them functions.

[6 marks]

d) List **four** components of the tractor hydraulic system.

[4 marks]

QUESTION 7

a) Make a sketch of the diesel fuel system and label **four** parts.

[8 marks]

b) How is the fuel atomised in the diesel fuel system.

[2 marks]

c) A six cylinder two stroke I.C (internal combustion) diesel engine has been designed to be used for running a power generator to power a small farming community. With the aid of sketches, describe the events that occur in this engine.

[10 marks]

QUESTION 8

a) Chemical control is one of the components of Pest Management. Briefly describe **the other two** components and give **one** example of each component

[4 marks]

b) List **three** advantages and **three** disadvantages of chemical control

[6 marks]

c) What is the principle difference between a duster and a sprayer?

[1 mark]

d) List **four parts** of a sprayer and briefly explain the function of each part.

[6 marks]

e) Why is it important to calibrate your sprayer.

[3 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

DEFERRED UNIVERSITY EXAMINATIONS FOR FIRST SEMESTER
TUESDAY (AM) – 19TH JULY 2005

ELECTRONIC ENGINEERING I (EE441)

TIME ALLOWED: THREE (03) HOURS *TOTAL MARKS: 100*

ANSWER: THIS PAPER HAS EIGHT QUESTIONS. YOU MUST ANSWER ANY FIVE (05) QUESTIONS. EACH QUESTION CARRIES 20 MARKS AND THEIR BREAKDOWN ARE INDICTED IN ITALICS. USEFUL CONSTANTS & VARIABLES ARE GIVEN AT THE END THE QUESTION PAPER.

Q1.

A. A bipolar junction transistor (BJT) is fabricated in the p^+-n-p configuration:

(i) Detail electron and hole current components in the emitter, base and collector regions when the BJT is in active mode. *(5 marks)*

(ii) Express terminal currents I_E, I_C and I_B as a function of electron and hole currents inside the BJT. *(3 marks)*

(iii) Define emitter efficiency and express it as a function of currents in the transistor. Hoe does emitter doping affect your expression? *(3 marks)*

B. A silicon p^+-n-p transistor has impurity concentrations $5\times10^{18}cm^{-3}$, $10^{16}cm^{-3}$ and $10^{15}cm^{-3}$ in the emitter, base and collector regions respectively. The transistor is operated at room temperature with the emitter-base junction forward biased to 0.5V and base-collector junction reverse biased to 5V. Calculate:

(i) The equilibrium minority carrier concentrations in the emitter, base and collector. *(3 marks)*

(ii) The minority carrier concentration at the edge of emitter-base junction. *(4 marks)*

(iii) The minority carrier concentration at the edge of the collector-base junction. *(2 marks)*

Q2.

A. The concept of crystal formation is central in the development semiconductor electronics.

(i) Discuss forces that hold atoms in their respect positions to form the crystal structure? *(3 marks)*

(ii) Discuss any two important bonds in electronic engineering materials naming an example for each case. *(3 marks)*

(iii) Briefly discuss the origins and nature of any two types of charge carrier scattering in a semiconductor crystal.*(4 marks)*

B. When doping silicon, both acceptor and donor impurities may be added until the desired semiconductor composition is obtained. Calculate the majority and minority carrier concentrations at room temperature in silicon doped with the following impurities: (Assume all impurities are ionised and clearly state the type of semiconductor obtained. N_d and N_a are donor and acceptor impurity atom concentrations respectively).

(i) $N_d = 10^{25}\,cm^{-3}$, $N_a = 10\,cm^{-3}$ *(2½ marks)*

(ii) $N_d = 10^{20}\,cm^{-3}$, $N_a = 10^{20}\,cm^{-3}$ *(2½ marks)*

(iii) $N_d = 10\,cm^{-3}$, $N_a = 10^{14}\,cm^{-3}$ *(2½ marks)*

(iv) $N_d = 0$, $N_a = 0$ *(2½ marks)*

Q3.

A.

(i) Comment on any three commonly used semiconductors in respect of their production methods and application in device fabrication. *(6 marks)*

(ii) Conversion of an intrinsic gallium arsenide semiconductor to n-type and p-type specimens. *(4 marks)*

B. Electrons are injected into one end of a bar of p-type silicon at room temperature. The initial concentration of excess carriers is $10^{18}\,cm^{-3}$. Determine the distance along the bar at which the minority carrier concentration drops to quarter of its initial value. *(10 marks)*

Q4.

A. **Fabrication of modern silicon bipolar junction transistors (BJT's) employs the planar process in which the device is formed only on one side of the silicon wafer as shown in figure 01 below.**

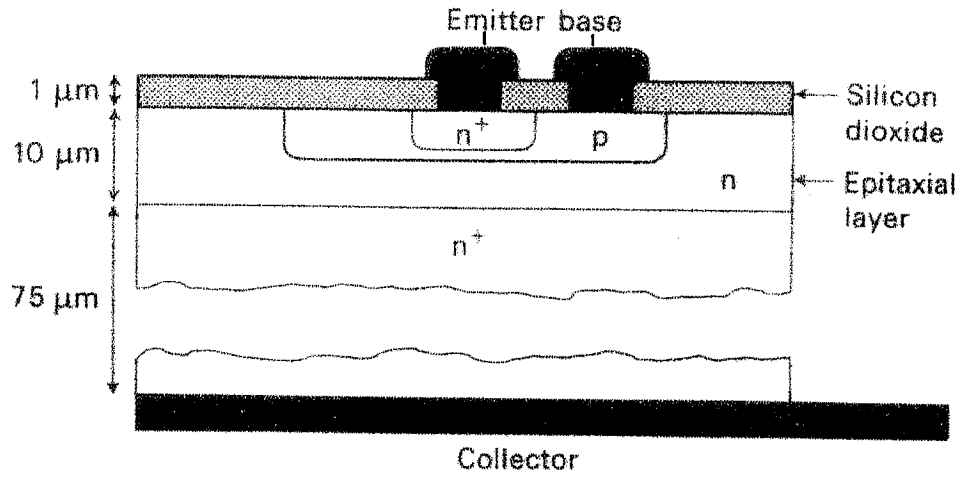


Figure 01. Sectional view of a planar process n^+-p-n silicon bipolar junction transistor

(i) **Briefly describe the processes involved in fabricating the above BJT.** *(3 marks)*

(ii) **Name any two commonly used metals for interconnections in silicon BJTs and briefly discuss their merits or demerits.** *(3 marks)*

(iii) **In the above BJT what metal would you use for the emitter, base and collector contacts? Discuss the type of contact formed in each case.** *(3 marks)*

(iv) **Give any two reasons why silicon dioxide is preferably used in silicon devices processing?** *(2 marks)*

B. **An ideal n^+-p-n transistor has a current gain of 95 and is operated on a base current of 20 μA. The recombination time of charge carriers in the base is 0.1μs.**

(i) **Find the emitter current.** *(3 marks)*

(ii) **Determine the time taken by minority carriers to cross the base region.** *(3 marks)*

(iii) **Determine excess minority charge in the base.** *(3 marks)*

Q5.

A. Briefly discuss the following:

(i) The concept and consequence of effective mass of charge carriers in a semiconductor. *(3 marks)*

(ii) Drift current in a pure semiconductor specimen to which an external a low electric field is applied. Derive the drift velocity equation of the total current as a function of applied field. *(3 marks)*

(iii) Write brief notes on an intrinsic semiconductor, extrinsic semiconductor, degenerate semiconductor and semi-insulating semiconductor. *(4 marks)*

B. Find the conductivity and resistivity of a pure silicon semiconductor at absolute zero and room temperature respectively. *(10 marks)*

Q6.

A.

(i) Name any two main sources of noise in electronic devices and discuss their origins. *(4 marks)*

(ii) Write brief notes on Recombination, Partition, Intermodulation and Flicker noise in electronic devices. *(4 marks)*

(iii) Define noise factor? Sketch a general graph showing variation of noise factor with frequency in an electronic amplifier (clearly explain how noise factor varies with amplifier operating frequency). In which region must an amplifier be operated and why? *(4 marks)*

B. An amplifier with effective resistance 100kΩ is operated at on a current of 10mA over a bandwidth of 10 MHz. When operating at room temperature, determine the mean square:

(i) Shot noise current. *(4 marks)*

(ii) Thermal noise current. *(4 marks)*

Q7.

A. Silicon is the most widely used raw material for manufacture of present day electronic devices as eptomised by so many 'Silicon Valleys and Parks' worldwide.

(i) Discuss quantum numbers that completely describe the electronic structure of a silicon atom. *(2 marks)*

(ii) Determine the electronic configuration of a silicon atom and use your finding to explain the formation of energy bands in a silicon crystal composed of X number of atoms. (Assume X is a very large number and temperature is absolute). *(6 marks)*

(iii) Using the concept developed in (iii), describe a metallic conductor, semiconductor and insulator. *(1½ marks)*

B. In a pure silicon crystal specimen:

(i) Discuss conditions that determine whether electrons obey Fermi-Dirac or Maxwell-Boltzmann statistics. *(5 marks)*

(ii) Determine chances of a Fermi-Dirac electron and Maxwell-Boltzmann electron appearing in the conduction band at room temperature. *(3 ½ marks)*

(iii) Compare the nature of conduction in metals with that which takes place in semiconductors. *(2 marks)*

Q8.

A.

(i) Briefly describe any two semiconductor doping methods and profile their dopant distribution as a function of material depth. *(4 marks)*

(ii) Describe processes of de excitation in a direct and an indirect energy band gap semiconductors. *(5 marks)*

(iii) For both intrinsic and extrinsic semiconductors, explain the significance of the equation given below, where symbols have their usual semiconductor meanings. *(4 marks)*

$$np = ni^2 = N_C N_V \exp(-\frac{E_g}{2kT})$$

B. Given that for pure silicon $N_C = N_V = 10^{25}$ energy levels per cubic meter, find the density of charge carriers at room temperature and absolute temperature. *(7 marks)*

END OF EXAMINATION

LIST OF USEFUL CONSTANTS AND VARIABLES

1. **Boltzmann constant** $= 1.38 \times 10^{-23}\ JK^{-1}$
2. **Electronic charge** $= 1.602 \times 10^{-19}\ C$
3. **Speed of light** $= 3.0 \times 10^{8}\ m/s$
4. **Silicon atom atomic number** $= 14$
5. **Electron mobility in silicon** $= 1450\ cm^2V^{-1}s^{-1}$
6. **Assume room temperature if not specified.**
7. **Hole mobility in silicon** $= 450\ cm^2V^{-1}s^{-1}$
8. **1 electron volt** $= 1.602 \times 10^{-19}\ J$
9. **Room temperature** $= 27^{\circ}C$
10. **Silicon intrinsic carrier concentration** $= 1.5 \times 10^{16}\ m^{-3}$ **at room temperature**
11. **Lifetime of electrons in silicon** $= 10\ \mu s$
12. **Silicon energy gap** $= 1.12eV$ **at room temperature & 1.16eV at 0K**
13. **Absolute Temperature** $= -273^{\circ}C$
14. **Planck's constant** $= 6.63 \times 10^{-34}\ Js$

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATION- JUNE 2005

EM 311 ENGINEERING MATHEMATICS III

Answer any Five (5) questions.
Instructions: Time allowed Three (3) hours.
All Questions carry the same points.

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1. a) Find the general solution of the equation

$$x^2\frac{d^2y}{dx^2}-2x\frac{dy}{dx}+2y=10x^3Cosx$$

b) Solve the initial value problems:

(i) $y'''-2y''-y'+2y=2x^2-6x+4, y_{(0)}=5, y'_{(0)}=-5. y''_{(0)}=1$

(ii) $y''-\frac{1}{2}y'-\frac{1}{2}y=3Cosx+\sin x+e^x, y_{(0)}=0, y'_{(0)}=-1.5.$

c) Find the solutions to the following equations:

(i) $\left(4x^3y^3+\frac{1}{x}\right)dx+\left(3x^4y^2-\frac{1}{y}\right)dy=0, x_{(e)}=1$

(ii) $2x^2\frac{dy}{dx}-2xy=-5x^4y^3$

2.

a) Show that $y_1=\frac{Cosx}{\sqrt{x}}$ is a solution of the following Legendre equation and find the other solution y_2.

$$\frac{d^2y}{dx^2}+\frac{1}{x}\frac{dy}{dx}+\left(1-\frac{1}{4x^2}\right)y=0$$

b) The vibration of a cantilever beam supporting the Kafue bridge is modelled by the differential equation: $y''-3y'+2y=e^x\sin x$. Find the general solution that could be used to predict time of collapse of the beam using the method of undetermined. coefficients.

c) For the given equation below:

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

Use the method of variation of coefficients (parameters) and the Wrosnkian method to find the general solution.

3. Find the solution of the system of differential equations given below:

a) $$x' = 5x + 4y - 5t^2 + 6t + 25$$
$$y' = x + 2y - t^2 + 2t + 4$$
$$x(0) = 0, y(0) = 0$$

b) By means of a power series of the form

$$y = c_o + c_1(x-1) + c_2(x-1)^2 + c_3(x-1)^3 + c\ (x-1)^4 + \ldots.$$

Solve the following equation:

$y'' + y = 0$ $\quad$ y(1) = 1, y'(1) =0

and check your result by obtaining an exact solution.

c) Solve the Euler-Cauchy Equations given below:

(i) $$x^2y'' + 2xy' - 12y = \sqrt{x}$$

(ii) $$(x+1)^2 y'' + 5(x+1)y' + 3y = 0$$

4. Solve the initial value problem:

(a) $$y'' + y = 2t \qquad y\left(\frac{\pi}{4}\right) = \frac{1}{2}\pi \qquad y'\left(\frac{\pi}{4}\right) = 2 - \sqrt{2}$$

(b) Find the *Laplace inverse transform* $L^{-1}\{F(s)\}$ for the following given functions F(s):

i) $$F(s) = \frac{s + 1 - 2w}{(s^2 + 2s + w^2 + 1)}$$

ii) $$F(s) = \frac{s^2 + a^2}{(s^2 - a^2)^2}$$

iii) $$F(s) = \frac{s - 2}{\left(s^2 - 4s + \frac{17}{4}\right)}$$

(c) Find the *Laplace transform F(s) for the following given functions f(t):*

i) $$e^{-3t}\left(Cos2t - \frac{3}{2}Sin2t\right)$$

ii) $tSin\beta t$

iii) $te^{-2t}Sin\omega t$

5. Find the *Fourier series expansions* for the following function s:

a) $$f(x)=\begin{cases} x & if \quad -\frac{\pi}{2}<x<\frac{\pi}{2} \\ (\pi-x) & if \quad \frac{\pi}{2}<x<\frac{3\pi}{2} \end{cases}$$

b) $$f(x)=\begin{cases} x^2 & if \quad -\frac{\pi}{2}<x<\frac{\pi}{2} \\ \frac{\pi^2}{4} & if \quad \frac{\pi}{2}<x<\frac{3\pi}{2} \end{cases}$$

c) $$f(x)=\begin{cases} -x^2 & if \quad -\pi<x<0 \\ x^2 & if \quad 0<x<\pi \end{cases}$$

6. (a) Solve the following problem using the *convolution theorem*

i) $y''+y=\sin 3t \qquad y(0)=0 \qquad y'(0)=0$

ii) $y''+3y'+2y=e^t \qquad y(0)=0 \qquad y'(0)=0$

(b) Evaluate the:

(i) Fourier Cosine and Sine integrals of

$$f(x)=e^{-kx} \qquad (x>0, k>0)$$

(ii) The two half-range (odd and even) expansions of function given below:

$$f(x)=\begin{cases} 2\frac{k}{L}x & if \quad 0<x<\frac{L}{2} \\ 2\frac{k}{L}(L-x) & if \quad \frac{L}{2}<x<L \end{cases}$$

(iii) Using the Fourier integral representation, show that

$$\int_0^\infty \frac{Cosx\omega+\omega Sinx\omega}{1+\omega^2}d\omega=\begin{cases} 0, & if \quad x<0 \\ \frac{\pi}{2} & if \quad x=0 \\ \pi e^{-x} & if \quad x>0 \end{cases}$$

END OF EM 311 ENGINEERING MATHEMATICS III, 2005.

UNIVERSITY OF ZAMBIA

2005 FIRST SEMESTER EXAMINATIONS

EM411 ENGINEERING MATHEMATICS

TIME ALLOWED	:	THREE (3) HOURS
INSTRUCTIONS	:	ATTEMPT ANY FIVE (5) QUESTIONS

Q1. (a) (i) Calculate the square roots of $\sqrt{3} + 3i$

(ii) By writing $w = \cos z = \frac{1}{2}(e^{iz} + e^{-iz})$ show that

$\cos^{-1} w = \pm i \log (w + \sqrt{w^2 - 1})$

(b) Let f be differentiable at $z = x + iy$. Give the formula for $f'(z)$ and use it to show that $(z^2)' = 2z$

Q2. (a) Under the transformation $w = iz + i$, show that the half plane $x > 0$ maps onto the half plane $v > 1$.

(b) Sketch the set of points in the z – plane which map the rectangular region bounded by the lines $u = 1$, $u = 2$, $v = 1$, $v = 2$ under the transformation $w = z^2$.

Q3. (a) If f is analytic within and on an oriented closed contour C and if z_0 is not on C, show why it follows that

$$\int_C \frac{f'(z)}{z - z_o}\, dz = \int_C \frac{f(z)}{(z - z_o)^2}\, dz$$

(b) Let C denote the boundary of the square $x = \pm 2$, $y = \pm 2$ described in the positive sense. Give the value of

$$\int_C \frac{\tan(z/2)}{(z - x_o)^2}\, dz, \; (|x_o| < 2).$$

Q4. (a) (i) Let $\{\alpha_n\}_{n=1}^{\infty}$ and $\{\beta_n\}_{n=1}^{\infty}$, be sequences of complex numbers such at that for each positive integer n, $\beta_n \neq 0$ and also that $\lim_{n\to\infty} \alpha_n$ exists and equals α. Explain what is meant by $\alpha_n = \alpha + O(\beta_n)$.

(ii) $\lim_{h\to 0} \dfrac{1-\cos h}{h} = 0$ at what rate of convergence?

(b) Find the first three iterations obtained by the Power method applied to the matrix.

$$\begin{bmatrix} 4.75 & 2.25 & -0.25 \\ 2.25 & 4.75 & 1.25 \\ -0.25 & 1.25 & 4.75 \end{bmatrix}$$

use $\bar{x}^{(o)} = (0, 1, 0)^t$

Q5. (a) Various values of a function f(x) are given in the following table:

x	0.0	0.5	1.0	2.0
f(x)	1.00000	1.64872	2.71828	7.38906

(i) approximate f(0.25) using linear interpolation with $x_o = 0$ and $x_1 = 0.5$;

(ii) approximate f(0.75) using quadratic interpolation with $x_o = 0$, $x_1 = 1$ and $x_2 = 2$.

(b) Suppose the following data has been experimentally collected.

x	1.00	1.01	1.02
f(x)	1.27	1.32	1.38

(i) Approximate $f'(1.005)$ and $f'(1.015)$ using a formula of error $O(h^2)$.

(ii) Approximate $f''(1.01)$ using the same formula as in part (a) and the results of part (a).

Q6. Let f be defined by

$$f(x) = \begin{cases} x^3+1, & 0 \le x \le 0.1 \\ 1.001+0.03(x-0.1)+0.3(x-0.1)^2+2(x-0.1)^3, & 0.1 \le x \le 0.2 \\ 1.009+0.15(x-0.2)+0.9(x-0.2)^2+2(x-0.2)^3, & 0.2 \le x \le 0.3 \end{cases}$$

(a) Investigate the continuity of the derivatives of f.

(b) Approximate $\int_0^{0.3} f(x)\,dx$ using the composite trapezoidal rule with n = 6 and estimate the error.

(c) Approximate $\int_0^{0.3} f(x)dx$ using the composite Simpson's rule with n = 6

Q7. (a) Solve the following equation using Euler's method. Carry out five steps using the indicated step size and compare with the exact solution.

$y' = -y^2$, $y(1) = 1.0$, $h = 0.1$

(b) Write an algorithm for Euler's method to obtain an approximation to the initial – value problem.

$\frac{dy}{dt} = f(t, y)$, $a \le t \le b$, $y(a) = \alpha$

at (N + 1) equally spaced numbers in the interval $[a, b]$.

END OF EXAMINATION