

**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF ENGINEERING**  
**ACADEMIC YEAR 2021/2022**

1. AEN 3331: Farm Power and Machinery
2. CEE 3111: Civil Engineering Materials and Practices
3. EEE 3121: Signals And Systems
4. EEE 4362: Electrical Power Systems I
5. EEE 4670: Electronic Engineering II
6. EEE 6661: Cyber Forensics Digital Investigation
7. GGY3051: Engineering Geology

**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF ENGINEERING**  
**DEPARTMENT OF AGRICULTURAL ENGINEERING**  
**UNIVERSITY EXAMINATIONS**  
**JULY 2022**  
**FINAL EXAMINATIONS**  
**AEN 3331: FARM POWER AND MACHINERY**

**TIME ALLOWED: THREE HOURS**

**INSTRUCTIONS:**

1. THIS EXAMINATION PAPER HAS TWO SECTIONS, **SECTION A** AND **SECTION B**.
2. **SECTION A** HAS 10 MULTIPLE CHOICE QUESTIONS. ATTEMPT **ALL** QUESTIONS IN THIS SECTION. EACH QUESTION HAS **TWO MARKS**.
3. **SECTION B** HAS **SEVEN QUESTIONS**. ATTEMPT **FOUR** QUESTIONS ONLY. EACH QUESTION CARRIES **20 MARKS**.
4. MARKS ALLOCATED FOR EACH SUB-QUESTION IN SECTION B ARE INDICATED IN BRACKETS.
5. WHERE NECESSARY, RELEVANT EQUATIONS HAVE BEEN PROVIDED.
6. JUSTIFIABLE ASSUMPTIONS ARE TO BE MADE WHERE INFORMATION APPEARS TO BE MISSING
7. START EACH QUESTION IN SECTION B ON A NEW PAGE.
8. CLEARLY INDICATE THE QUESTION NUMBER IN THE ANSWER BOOKLET AND NUMBER THE ANSWERS CORRECTLY ACCORDING TO THE NUMBERING SYSTEM USED IN THIS QUESTION PAPER.
9. SHOW ALL CALCULATIONS AND UNITS. ROUND OFF FINAL ANSWERS TO TWO DECIMAL PLACES.
10. WRITE NEATLY AND LEGIBLY.
11. WRITTEN MATERIALS, CELL PHONES AND PROGRAMMABLE CALCULATORS ARE **NOT ALLOWED** IN THE EXAMINATION ROOM.

**DO NOT TURN THE PAGE UNTIL YOU ARE TOLD TO DO SO!**

**SECTION A (20 MARKS): THERE ARE TEN (10) MULTIPLE CHOICE QUESTIONS IN THIS SECTION. ATTEMPT ALL QUESTIONS**

**For each of the following questions, choose the BEST answer and write, in capital letters, the letter corresponding to your answer in the answer sheet.**

1. Three of the following are primary objectives for mechanisation. Which one is not?
  - a) Reduce the drudgery of farm work.
  - b) Increase the productivity of farm worker.
  - c) Increase the timeliness and quality of work.
  - d) Reduce the cost of production.
  
2. Which of the following is not a simple machine.
  - a) Wedge
  - b) Lever
  - c) Pulley
  - d) Wheelbarrow
  
3. The general term for muscles that straighten joints when they contract is ...
  - a) biceps
  - b) triceps
  - c) flexor muscles
  - d) extensor muscles
  
4. Anaerobic energy metabolism refers to the generation of ATP:
  - a) without the use of glycogen
  - b) without the use of oxygen
  - c) in the absence of oxygen
  - d) by the conversion of pyruvate to lactate
  
5. Excess glucose after a meal is converted into glycogen in a process called ...
  - a) glycolysis
  - b) glycogenesis
  - c) glycogenolysis
  - d) lipogenesis
  
6. Compression ratio refers to ...
  - a) Cylinder volume / Clearance volume
  - b) Swept Volume / Clearance volume
  - c) Clearance volume / Cylinder volume
  - d) Cylinder volume / Swept volume
  
7. Which component of the engine converts reciprocating motion of the piston into rotational motion?
  - a) Crankshaft
  - b) Camshaft
  - c) Conrod
  - d) Piston
  
8. Valve overlap occurs during which of the following strokes?
  - a) Exhaust and Intake
  - b) Intake and Compression
  - c) Power and Exhaust
  - d) Exhaust and Compression

9. What event is characterised by a closed intake and exhaust valves and the movement of the piston from TDC to BDC in a four stroke cycle engine?
- a) Induction stroke
  - b) Compression stroke
  - c) Power stroke
  - d) Exhaust stroke
10. Which one of the following implements is best suited for conservation tillage?
- a) Disc plough
  - b) Mouldboard plough
  - c) Chisel plough
  - d) Power harrow

**SECTION B (80 MARKS): ATTEMPT ANY FOUR QUESTIONS FROM THIS SECTION.**  
**START EACH QUESTION ON A NEW PAGE.**

**QUESTION 1**

a) Briefly explain the following terms:

- i) Glycogenesis
- ii) Basal Metabolic Energy

[4 marks]

b) A farm worker is tasked to clear virgin land consisting of shrubs and small to medium size trees. The worker can sustain the task without rest for 18.75 minutes only. He is expected to work for 6 hours per day. Continuous physical power output of a normal healthy human being varies with time according to the following equation:

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

where: P = power output [W]

t = time [s]

Assume energy conversion efficiency of human beings to be 25%.

i) Calculate the average power output of the farm worker when clearing the field.

[4 marks]

ii) Determine the power consumption of the farm worker when clearing the field.

[2 marks]

iii) Calculate the rest period needed.

[2 marks]

iv) Briefly explain why the farm worker needs to rest during the land clearing operation.

[3 marks]

v) Calculate the ratio of rest period to working time.

[2 marks]

vi) Determine the total time (in hours) that the worker needs to rest during the 6 hour work day.

[3 marks]

**QUESTION 2**

a) Define the following terms:

- i) Digestible energy
- ii) Appetite Limit.

[3 marks]

b) A pair of oxen, each weighing 400 kg is used to plough a field. The plough cuts furrow slices that are 20cm wide by 12.5cm deep. The specific soil resistance is 5N/cm<sup>2</sup> and the oxen have a working speed of 2.88 km/h. The oxen work for 6 hours per day and they are fed on Sudan grass which has a gross energy of 17 MJ/kg of dry matter and DE/GE ratio of 0.60. Given the following additional information:

- Maintenance Energy =  $8.3 + (0.091W)$  MJ/day, Where W is the mass of the draft animal
  - Appetite Limit =  $0.025W$  kg of dry matter
  - Metabolisable Energy (ME) = 0.8 of Digestible Energy (DE)
  - Energy Conversion Efficiency of Draft Animals = 20%
- i) Calculate the power, P, required to pull the plough. [1 marks]
  - ii) Calculate the amount of energy, E, (in MJ) required to plough the field per day. [2 marks]
  - iii) Calculate the maintenance energy,  $ME_{MR}$ , for a pair of oxen. [2 marks]
  - iv) Calculate the amount of metabolisable energy,  $ME_{WD}$ , needed to plough the field per day. [2 marks]
  - v) Calculate the total daily metabolisable energy,  $ME_{Tot}$ , requirement (for maintenance and work) for a pair of oxen. [2 marks]
  - vi) Calculate the quantity of Sudan grass (in kg) needed to meet the total daily energy requirement for a pair of oxen. [1 marks]
  - vii) Calculate the appetite limit for a pair of oxen. [1 marks]
  - viii) Show that the oxen need supplementary feed. [2 marks]
  - ix) State two important characteristics of feed that must be taken into account in selecting a suitable supplement [2 marks]
  - x) Suggest two measures that the farmer can take to enable the oxen meet the total daily energy requirement **without** having to provide supplementary feed. [2 marks]

### QUESTION 3

- a) One of the functions of engine lubrication oil is to reduce friction in the engine. State three (3) reasons why friction must be reduced in the engine. [3 marks]
- b) Define the following terms:
  - i) Viscosity Index
  - ii) Oiliness [4 marks]
- c) Oil additives are chemical compounds added to base oil in order to improve the lubricant performance. Name any **four** (4) such additives. [4 marks]

d) List **three** (3) types of engine lubrication systems.

[3 marks]

e) State the function of each of the following parts of an engine lubrication system?

- i) Pressure relief valve
- ii) Oil filter
- iii) Galleries

[6 mark]

#### QUESTION 4

a) State the functions of the following parts of an engine?

- i) Engine block
- ii) Cylinder head
- iii) Cylinder head gasket
- iv) Valve train
- v) Flywheel

[10 marks]

b) In four-stroke-cycle engines, why does the camshaft rotate at half the speed of the crankshaft?

[3 marks]

c) A spark ignition engine is idling at 500 revolutions per minute (rpm). If the average flame speed is 10 m/s and the flame front must travel 55 mm from the spark plug to consume 85% of the fuel-air mixture,

i) Determine the spark advance needed if 85% of the fuel is to be consumed before the crankshaft reaches  $10^\circ$  after Top Dead Centre (TDC)?

[4 marks]

ii) What must the spark advance be at high idle speed of 2000 rpm?

[3 marks]

#### QUESTION 5

a) What is the most important factor that determines the extent of land clearing when opening up new land for agricultural development?

[2 marks]

b) State **two** benefits of leveling land after land clearing operation for arable crop production

[4 marks]

c) What are the **four** main purposes of tillage?

[4 marks]

d) State **three** ways how a very fine tilth can be achieved when preparing a seedbed using a rotary cultivator.

[6 marks]

e) Briefly explain **two** situations where a chisel plough would be preferred to a mouldboard plough for primary tillage operation.

[4 marks]



### QUESTION 7

- a) Outline **five** functions performed by a precision planter. **[5 marks]**
- b) State **two** objectives for calibrating a seed drill. **[3 marks]**
- c) Soybeans is to be planted using a precision planter with a vacuum metering disk that meters 54 seeds per revolution of a metering disk. The soya beans is to be planted in rows 40 cm apart at a planter speed of 7.2 km/hr. A plant population of 324,000 per hectare is desired.
- i) Calculate the required seed rate, assuming a seed emergence rate of 90% **[3 marks]**
- ii) Given that a sample of 100 grams of soya beans seed in the above question contained 360 seeds, determine the required seed rate (in kg) per hectare. **[4 marks]**
- iii) Calculate the required seed spacing along the row. **[5 marks]**

**END OF EXAMINATION**

**THE UNIVERSITY OF ZAMBIA**  
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**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING**  
**2021/2022 ACADEMIC YEAR**  
**CEE 3111 – CIVIL ENGINEERING MATERIALS AND PRACTICES**  
**FINAL EXAM**

TUESDAY 12<sup>TH</sup> JULY 2022

DURATION: THREE (3) HOURS

CLOSED BOOK EXAM

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INSTRUCTIONS

1. There are seven (7) questions in this Examination Paper
  2. **Each Question carries 20 Marks**
  3. **ANSWER ANY FIVE (5) QUESTIONS (TOTAL MARKS = 100)**
  4. Remember to clearly number your answers
  5. The answer for each question should begin on a new sheet
  6. Make sure your computer number is indicated on all booklets including the questions attempted
  7. All the relevant information is provided. However, if you fill the information provided is not adequate, make and state your assumptions
  8. Calculations must be clear and logical
  9. Marks will be lost for illegible, untidy and unorganised answers
  10. All necessary graphs, tables, and equations are given in the appendices
-

## QUESTION 1

- a) The three (3) key players in the construction industry are client, consultant, and contractor. Briefly explain the role of the consultant in the construction industry.
- b) In civil engineering, steel is normally classified based on production method and use, briefly, describe the various classifications of steel products as applied in the construction industry?  
 - Structural Steel -  
 - Cold-formed Steel -
- c) Table 1 provides indicator test results for three (3) soil samples obtained from three different borrow pits that a contractor on the Lusaka–Ndola Road Project intend to use as subgrade material in sections that have weak in-situ material.

Table 1: Indicator Test Results for Soil Samples

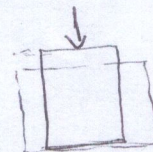
Soil	Percent passing			L.L.	P.L.
	No. 10	No. 40	No. 200		
1	97	82	74	52	44
2	79	62	48	37	25
3	99	85	71	55	44

Classify each of the three soils according to the AASHTO classification system and comment on the suitability of each soil to be used as subgrade material.

[1+4+15 Marks]

## QUESTION 2

- a) What is a bill of quantities (BoQ) and what is its purpose to a contractor?
- b) During the tension test on a steel rod, the following data were measured within the elastic region.
- Applied load = 102 kN
  - Original diameter = 25 mm
  - Diameter at yield point = 24.99325 mm
  - Original gauge length = 100 mm
  - Gauge length at yield point = 100.1 mm



Calculate the Young's modulus and Poisson's ratio of this steel rod.

- c) A compacted asphalt concrete specimen contains 5% asphalt binder (Sp. Gr. 1.023) by weight of total mix, and aggregate with a specific gravity of 2.755. The bulk density of the specimen is 2.441 Mg/m<sup>3</sup>. Ignoring absorption, compute the following parameters.
- i. Percent of air voids (voids in total mix) (VTM),
  - ii. Voids in the mineral aggregate (VMA), and
  - iii. Voids filled with asphalt (VFA).

[2+6+12 Marks]

$$VTM = \frac{V_w}{V}$$

$$207.7926 \text{ MPa}$$

### QUESTION 3

- a) Discuss any three (3) major uses of asphalt.
- b) Table 2 shows sieve analysis results obtained for three aggregates A, B, and C. The three aggregates were blended at a ratio of 15:25:60 by weight, respectively.

Table 2: Sieve Analysis results for three (3) aggregates from three crusher plants

	Percent Passing								
	Size								
	25 mm	19 mm	12.5 mm	9.5 mm	4.75 mm	1.18 mm	0.60 mm	0.30 mm	0.15 mm
Aggregate A	100	100	100	77	70	42	34	28	20
Aggregate B	100	85	62	43	24	13	7	0	0
Aggregate C	100	100	84	51	29	19	8	14	9

for  
VTM  
100/100

- i. Provide the grain size distribution of the blend aggregate
- ii. Given that the specification limits for the intended use of this aggregate are as shown in Table 3, plot the grain distribution of the **blend aggregate** and the **specification limits** on the attached semi-log graph.

Table 3: Gradation Limits specified for aggregate for concrete works

	Percent Passing								
	Size								
	19 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	0.60 mm	0.30 mm	0.075 mm	
Spec. limits	100	80-100	70-90	50-70	35-50	18-29	13-23	8-16	4-10

- iii. Use your graph to state if the blend aggregate meets specification limits.

[3+17 Marks]

### QUESTION 4

- a) Wood is a versatile organic material and a renewable construction material. Wooden structures have certain properties that make them durable and strong. With an adequate fire-retardant treatment, wood can be a reliable construction material with a long service life. Within the context of wood as a construction material answer the following questions:
- Untreated wood can deteriorate when four conditions required for decay and insects occur. States these four conditions. How do preservatives reduce or eliminate wood decay?
  - What are the two types of preservatives that can be used to protect wood from decay? How are these preservatives applied?
- b) A simple lab test for specific gravity,  $G$ , on two samples of lumber indicate that sample A has  $G = 0.4$  and sample B has  $G = 0.5$ . Based on this information alone, which wood sample would you choose as a structural member for your construction project? Briefly explain why.

- c) You are an engineer in charge of mixing concrete in an undeveloped area where no potable water is available for mixing concrete. A source of water is available that has some impurities. What tests would you run to evaluate the suitability of this water for concrete mixing? What criteria would you use?   
 - Test that water is salt free  
 - Test for acidity of water using pH
- d) The wet weight of a specimen of soil is 340 g and the dried weight is 230 g. The volume of the soil before drying is 210 cm<sup>3</sup>. If the specific gravity of the soil particles is 2.75, determine the following:
- porosity, and
  - void ratio

$$n = \frac{V_v}{V}$$

$$V = V_a + V_w + V_s = 210$$

$$V_w = \frac{W_w}{\gamma_w} \Rightarrow 340 - 230$$

$$V_w = \frac{110}{1}$$

$$V_w = 110 \text{ cm}^3$$

$$V_a = 210 - 110 - 88.6 = 16.36 \text{ cm}^3$$

$$n = \frac{16.36 + 110}{210}$$

$$\Rightarrow 10$$

### QUESTION 5

- a) CEE 3111 students from the University of Zambia, during their materials laboratory session, subjected three concrete masonry units to compression until failure. The typical dimensions of the three masonry units that were tested are shown in the Figure 1.

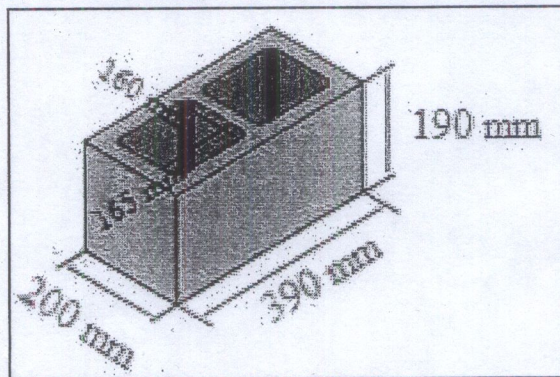


Figure 1: Typical Dimensions of an 8 Inch Block in Zambia

The average compressive load of the three units at failure was 307 kN

- Determine the gross area compressive strength of these masonry units
- Determine the net area compressive strength of these masonry units
- Does the net area compressive strength satisfy the ASTM requirements for load bearing units shown in table below?

Table 4: Minimum Compressive Strength for Load Bearing Masonry Units according to (ASTM,

Type	Minimum Compressive Strength Based on Net Area MPa	
	Average of Three Units	Individual Units
Load bearing	13.1	11.7
Non-load-bearing	4.1	3.5

- b) Table 5 shows Bill No. 4, the bill for Asphalt Pavement and Seals, of a particular project in Zambia. Based on the quantified items, calculate the **Total Amount of Bill No. 4** that must be taken to the summary.

Table 5: Summary of Bill No. 4 for a particular road project in Zambia

BILL NO. 4: ASPHALT PAVEMENT AND SEALS						
ITEM NO.	PAYMENT REFERS	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT(ZMW)
	4000	SEALS				
	4100	PRIME COAT				
4.1	41.01	Prime coat				
		(c) MC-30 cut-back bitumen at 1.0L/tr/m <sup>2</sup>	litre	48,714.00	15.00	
	41.02	Aggregate for Blinding	sqm	Rate only	300.00	
4.2	41.03	Extra over item 41.01 for applying the prime coat in areas accessible only to hand held equipment	litre	Rate only	15.00	
	4200	ASPHALT BASE AND SURFACING				
	42.02	Asphalt surfacing 40mm thick, hot-mix Asphalt Concrete				
		(a) continuously graded, 0/12mm	sqm	38,121.60	165.00	
	42.03	Apply SS60 tack coat at 0.5litrs/sqm	sqm	Rate only	15.00	
	42.06	Trial Section, 30mm thick	sqm	267.00	150.00	
	42.07	100mm Diameter Cores in Asphalt Paving	NO.	11.00	250.00	
		TOTAL CARRIED TO SUMMARY				

[10+10]

### QUESTION 6

In designing an asphalt concrete mixture for a highway pavement to support medium traffic, data in Table 6 was obtained in the lab using the Marshall mix design method.

Table 6: Asphalt Concrete Data from Marshall Mix Design

Asphalt Content	Asphalt Concrete Data				
	Marshall Stability (kN)	Flow (0.25 mm units)	VMA (%)	VFA (%)	VTM (%)
5.00	6.42	7.17	14.25	69.78	4.5
5.50	7.05	9.5	13.75	70.94	4.2
6.00	6.82	11.17	13.52	70.58	3.8
6.50	6.21	13.17	14.36	74.54	3.66
7.00	5.28	15.67	15.3	77.49	3.44

- Plot the Asphalt Content vs Stability, Flow, VMA, VFA, and VTM graphs.
- Assume a design air void content of 4% to determine the Optimum Asphalt Content (OAC) for this mix.
- For the OAC found in 6 (ii), which parameters do not meet the limits specified in Table 7.

Table 7: Acceptance Criteria of various parameters in Marshall Mix Design

Parameter	Acceptance Criteria
Stability in N at OAC	5400 (min)
Flow (0.25 mm) at OAC	8 to 16
VMA (%) at OAC	15.0 (min)
VFA at OAC	65 to 78

[15+3+2]

## QUESTION 7

- a) Define the word "Paint" and state four principal uses of paints.
- b) As a student engineer on industrial training, your departmental head assigns you to supervise the painting of a newly constructed ablation block at your place of work. Explain how you will carry out the painting process, stating the key stages you will cover before handing over the block for usage. *Primer coat, undercoat, finishing coat*
- c) The specific gravity and absorption test (ASTM C128) was performed on fine aggregate and the following data were obtained:
- Mass of SSD sand = 500.0g
  - Mass of pycnometer with water only = 623.0g
  - Mass of pycnometer with sand and water = 938.2g
  - Mass of dry sand = 495.5g
  - Calculate the specific gravity values (dry bulk, SSD, and apparent) and the absorption of the fine aggregate.

[3+7+10]

$\gamma =$



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**SCHOOL OF ENGINEERING**

**DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING**

**UNIVERSITY EXAMINATIONS**

**FINAL EXAM – 2021/2022 ACADEMIC YEAR – JULY 15, 2022**

**EEE 3121**

**EEE 3121: SIGNALS AND SYSTEMS**

<b>TIME</b>	<b>:</b>	<b>THREE HOURS</b>
<b>INSTRUCTIONS</b>	<b>:</b>	<b>There are SEVEN QUESTIONS each having 20 MARKS, ANSWER ANY FIVE QUESTIONS, TOTAL 100 MARKS.</b>
<b>ADDITIONAL INFORMATION:</b>		<b>A table of Laplace Transforms is provided on the last page of this Exam Paper.</b>

**QUESTION 1**

(a) Resolve the continuous-time aperiodic current signal  $i(t)$  shown in Figure Q1(a) into its even and odd components. Carefully label all relevant dimensions. [8 Marks]

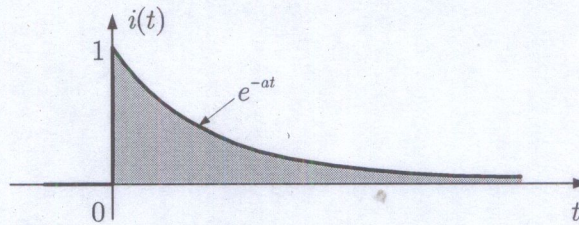


Figure Q1(a)

(b) Consider a periodic voltage signal given in Figure Q1(b).

(i) Find the complex Fourier coefficients  $\beta_n$  and series  $v_n(t)$ . [8 Marks]

(ii) Hence, sketch the frequency spectra. [4 Marks]

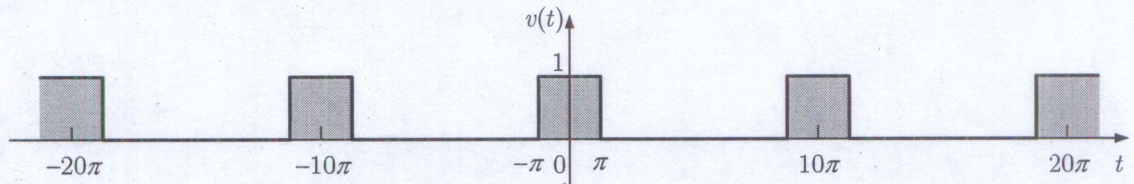


Figure Q1(b)

[Total 20 Marks]

**QUESTION 2**

(a) We call a set of signals  $\{\phi_n(t)\}$  orthogonal over an interval  $[T_1, T_2]$  if any signals  $\phi_m(t)$  and  $\phi_k(t)$  in the set satisfy the condition  $\langle \phi_m, \phi_k^* \rangle \triangleq \int_{T_1}^{T_2} \phi_m(t)\phi_k^*(t)dt = \begin{cases} 0 & \forall m \neq k \\ \alpha & \forall m = k \end{cases}$ , where  $*$  denotes the complex conjugate and  $\alpha \neq 0$ .

(i) Show that the set of complex exponentials  $\{e^{jk\omega_0 t} : k = 0, \pm 1, \pm 2, \dots\}$  is orthogonal on any interval over a period  $T_0$ , where  $T_0 = 2\pi/\omega_0$ . [5 Marks]

(ii) Hence find the norm  $\|\phi_i\| \triangleq \langle \phi_i, \phi_i^* \rangle^{1/2}$  of an element  $\phi_i(t)$  in the orthogonal set  $\{\phi_n(t)\}$  above and normalize the set. [5 Marks]

(b) For the LTIC system depicted in Figure Q2(b), use time domain analysis to determine  $v(t)$  for  $0 \leq t < \infty$ , given that the initial energy is zero. [10 Marks]

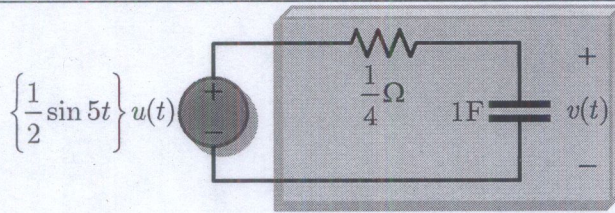


Figure Q2(b)

[Total 20 Marks]

**QUESTION 3**

(a) Find the inverse Fourier transform  $\mathcal{F}^{-1}\{X(\omega)\} = x(t)$  for the aperiodic impulse spectrum depicted in Figure Q3(a). [10 Marks]

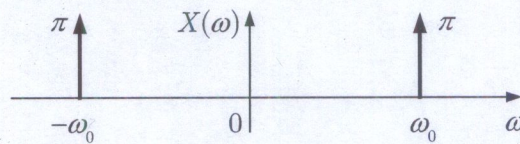


Figure Q3(a)

(b) A certain response transform  $R(s)$ , has a pole-zero plot of the form depicted in Figure Q3(b). In addition, it is known that  $r(t) = 4$  for very large  $t$ . Find  $r(t)$ . [10 Marks]

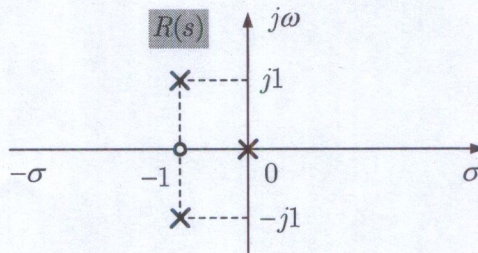


Figure Q3(b)

[Total 20 Marks]

**QUESTION 4**

(a) The Laplace transform of a causal periodic signal can be determined from the knowledge of the Laplace transform of its first cycle (period).

(i) If the Laplace transform of the first period  $x(t)$  of the periodic signal  $g(t)$  is  $X(s)$ , then show that  $G(s)$ , the Laplace transform of  $g(t)$  is of the form

$$G(s) = \frac{X(s)}{1 - e^{-sT_0}}; \quad \forall \text{Re } s > 0 \text{ and } T_0 = \text{period}; \quad [6 \text{ Marks}]$$

(ii) Hence, use the result in (i) to find Laplace transform of a causal periodic pulse train of the form depicted in Figure Q4(a). [4 Marks]

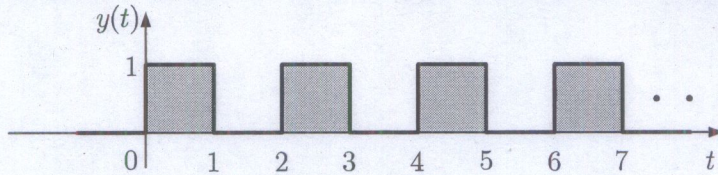


Figure Q4(a)

(b) Shown in Figure Q4(b) is a parallel resonant LTIC system. Assume all initial conditions to be zero and, in both cases,  $\omega_0^2 = 1/LC$ . Find the current  $y(t)$  if the input is:

(i)  $x(t) = V_0 \cos \omega_0 t u(t)$ . [5 Marks]

(ii)  $x(t) = V_0 \sin \omega_0 t u(t)$ . [5 Marks]

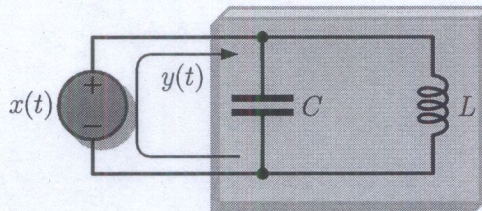


Figure Q4(b)

[Total 20 Marks]

**QUESTION 5**

(a) Use the Laplace transform method to determine the expressions for  $i_1(t)$  and  $i_2(t)$  in the LTIC system shown in Figure Q5(a). Assume zero initial energy. [12 Marks]

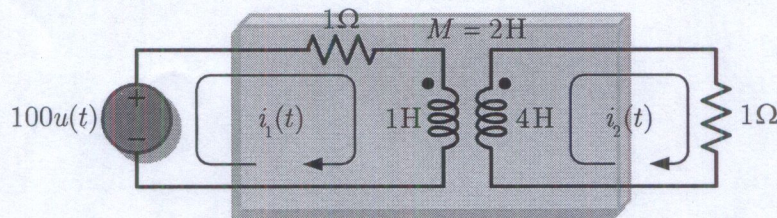


Figure Q5(a)

(b) Consider a periodic real valued signal of the form depicted in Figure Q5(b).

(i) Find the power  $P_x = \lim_{T \rightarrow \infty} \frac{1}{T} \int_a^{a+T} |x(t)|^2 dt$  of the signal  $x(t)$ . [4 Marks]

(ii) Determine the RMS value of  $x(t)$ . [4 Marks]

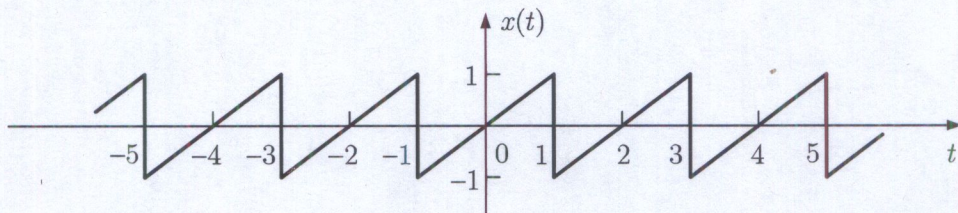


Figure Q5(b)

[Total 20 Marks]

**QUESTION 6**

(a) Consider the signal of the form given in Figure Q6(a).

(i) Use the time-shifting property to show that if  $\mathcal{F}\{x(t)\} = X(\omega)$ , then

$$\mathcal{F}\{x(t+T) + x(t-T)\} = 2X(\omega)\cos T\omega. \quad [4 \text{ Marks}]$$

(ii) Hence, use the result in (i) to find the Fourier transform of the signal in Figure

Q6(a). [6 Marks]

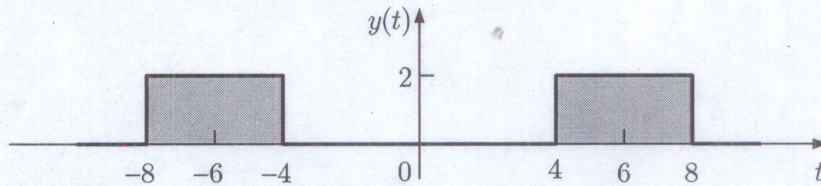


Figure Q6(a)

(b) For the LTIC system shown in Figure Q6(b), use the convolution integral to find  $y(t)$

for  $x(t) = 2e^{-3t}u(t)$ . Assume zero initial conditions.

[10 Marks]

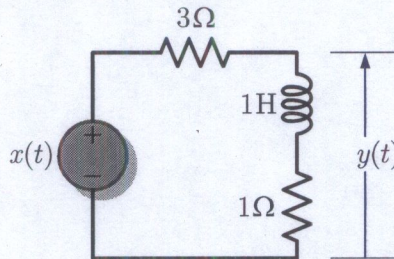


Figure Q6(b)

[Total 20 Marks]

**QUESTION 7**

(a) A two-port LTIC system depicted in Figure Q7(a) is initially inert.

(i) Determine the system function  $H(s) = \frac{Y(s)}{X(s)}$ . [4 Marks]

(ii) Let  $s = j\omega$  which yields  $H(j\omega) = M(\omega)e^{j\phi(\omega)}$ . Carefully sketch the amplitude

$M(\omega)$  and phase  $\phi(\omega)$  response. [8 Marks]

(iii) Comment on the type of filter. [2 Marks]

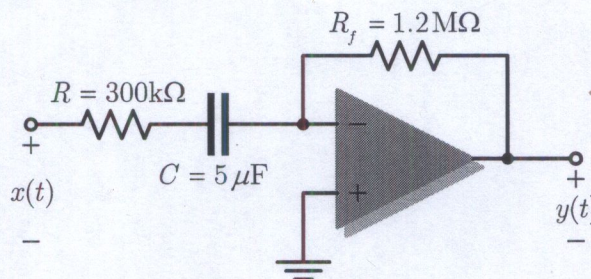


Figure Q7(a)

(b) The current waveform  $i(t)$  in Figure Q7(b) is of the form

$$i(t) = \begin{cases} \alpha e^{-at}, & \forall t \geq 0 \\ 0, & \text{otherwise} \end{cases} . \text{ Show that as } \alpha \rightarrow \infty, i(t) \text{ becomes a unit impulse. [6 Marks]}$$

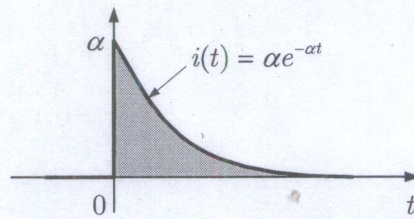


Figure Q7(b)

[Total 20 Marks]

END OF EEE 3121 EXAMINATION

### Table of Laplace Transforms

	$f(t)$	Laplace Transform, $F(s)$
1.	$f(t)$	$F(s) = \int_{0^-}^{\infty} f(t)e^{-st} dt$
2.	$\frac{d}{dt} f(t)$	$sF(s) - f(0^-)$
3.	$\frac{d^n}{dt^n} f(t)$	$s^n F(s) - \sum_{k=1}^n s^{n-k} f^{(n-k)}(0^-)$
4.	$\int_{0^-}^t f(\tau) d\tau$	$\frac{1}{s} F(s)$
5.	$f(t-a)u(t-a)$	$e^{-as} F(s)$
6.	$e^{at} f(t)$	$F(s-a)$
7.	$\delta(t)$	1
8.	$\frac{d^n}{dt^n} \delta(t)$	$s^n$
9.	$u(t)$	$\frac{1}{s}$
10.	$t$	$\frac{1}{s^2}$
11.	$e^{-\alpha t}$	$\frac{1}{s + \alpha}$
12.	$\sin \omega t$	$\frac{\omega}{s^2 + \omega^2}$
13.	$\cos \omega t$	$\frac{s}{s^2 + \omega^2}$
14.	$e^{-\alpha t} \sin \omega t$	$\frac{\omega}{(s + \alpha)^2 + \omega^2}$
15.	$e^{-\alpha t} \cos \omega t$	$\frac{(s + \alpha)}{(s + \alpha)^2 + \omega^2}$
16.	$e^{-\alpha t} \left[ A \cos \omega t + \frac{B - A\alpha}{\omega} \sin \omega t \right]$	$\frac{As + B}{s^2 + 2\alpha s + \zeta}$ ; where $\omega = \sqrt{\zeta - \alpha^2}$
17.	$\frac{t^n}{n!}$	$\frac{1}{s^{n+1}}$
18.	$\frac{t^n e^{-\alpha t}}{n!}$	$\frac{1}{(s + \alpha)^{n+1}}$
19.	$\frac{t}{2\omega} \sin \omega t$	$\frac{s}{(s^2 + \omega^2)^2}$



THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATIONS

Deferred – January 2021

**EEE 4362**

**ELECTRICAL POWER SYSTEMS I**

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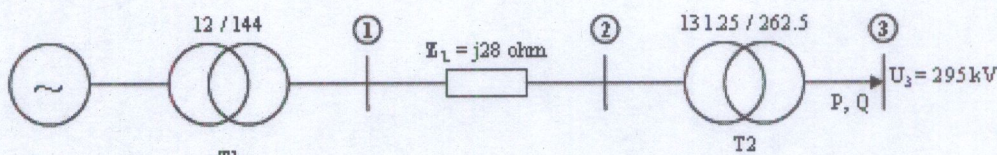
<b>TIME</b>	:	Three (3) hours
<b>INSTRUCTIONS</b>	:	Answer any five (5) questions: Two (2) from section A and three (3) from section B in Separate Answer Booklets
<b>ADDITIONAL INFORMATION</b>	:	$\mu_0 = 4\pi \times 10^{-7}$ H/m and $\epsilon_0 = 8.85 \times 10^{-12}$ F/m

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**SECTION A: ANSWER ANY TWO (2) QUESTIONS IN THIS SECTION**

**Question 1. [20 marks]**

- a) Describe why transmitting electrical power by HVAC are undesirable, while clearly justifying why HVAC is commonly used for transmitting power. **[5Marks]**
- b) Describe four ways in which Transmission lines can be classified. While clearly indicating the main types of conductors used for both transmission and distribution lines. **[5Marks]**



c)

Figure 1: Electrical Power System

**Generator:**  
 $S=147\text{MVA}$   
 $\text{Cos}\phi = 0.8$   
 $U=10.5\text{kV}$   
 $X_d=1.0\text{pu}$

**Transformer 1:**  
 $S=160\text{MVA}$   
 $Z= 8 \%$   
 $r= 0$   
 $U= 144/12\text{kV}$

**Transformer 2:**  
 $S=175 \text{MVA}$   
 $Z= 8 \%$   
 $r= 0$   
 $U= 132.24/262.5\text{kV}$

The power values provided are all three phase and all voltages are line-to-line. Also keep in mind that the per unit values are referred to the component rated values. For system global per units use the following references values:

$S_{ref}= 300\text{MVA}$  (3-Phase)      $U_{3,ref}= 300\text{kV}$  (Line-to-line)

- i. Calculate per unit values of all parameters in the diagram **[8Marks]**
- ii. Draw a per phase equivalent impedance diagram for the system in figure 1. **[2Marks]**

**Question 2. [20 marks]**

- a) Discuss the terms voltage regulation and transmission efficiency as applied to transmission lines. **[4Marks]**
- b) Three conductors of a 3-phase transmission line are placed at the corners of a triangle of sides 2m, 2.5m, and 4.5m respectively. Calculate the inductance per km of the line when the conductors are regularly transposed. The diameter of each conductor is 1.24 cm. **[8Marks]**
- c) A 200 km, 3-phase transmission line has its conductors placed at the corners of an equilateral triangle of 2.5 m side. The radius of each conductor is 1 cm. Calculate:
  - i. The line to neutral capacitance of the line
  - ii. The charging current per phase if the line is maintained at 66 kV, 50 Hz. **[8Marks]**

**Question 3. [20 marks]**

- a) In the context of power system substations:
- (i) State four types of substation categories according to service requirements [4 Marks]
  - (ii) Name any six main equipment that are found in electrical power system substations. [6 Marks]
- b) A 150 km, 3-phase, 110 kV, 50 Hz transmission line transmits a load of 40,000 kW at 0.8 p.f. lagging at the receiving end. Resistance /km/phase is 0.15  $\Omega$ ; reactance/km/phase is 0.6  $\Omega$ ; susceptance/km/phase is  $10^{-5}$  siemens. Determine:
- i. The A, B C, and D constants of the line [8Marks]
  - ii. The regulation of the line [2Marks]

**SECTION B: ANSWER ALL THREE (3) QUESTIONS IN THIS SECTION**

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**Question 4. [20 marks]**

(a) Show that the maximum tension  $T_{max}$  and maximum sag  $d$  of a conductor of length  $l$  supported at equal heights at both ends are given by  $T_{max} = T_H \cosh \frac{\omega l}{2T_H}$  and

$d = \frac{T_H}{\omega} \left( \cosh \left( \frac{\omega l}{2T_H} \right) - 1 \right)$ , respectively, where  $T_H$  is the horizontal tension at mid-span and  $\omega$  is the mechanical loading on the conductor.

[10 marks]

(b) Steel-cored aluminium conductors have an overall diameter of 2.5 cm and are carried by suspension-type insulators 1.2 m long. Determine the height above ground at which the insulators must be supported to the tower when the minimum clearance between the ground and conductor is 6 m for a horizontal wind pressure of 400 N/m<sup>2</sup> on span lengths of 300 m. The allowable tension in the conductor is  $3 \times 10^4$  N and the conductor weighs 12 N/m.

[10 marks]

**Question 5. [20 marks]**

(a) Derive, with a definition of terms, the expressions for calculating the fault currents and post fault voltages in a large power network by application of a systematic method for symmetrical fault and the use of the bus impedance matrix.

[6 marks]

(b) An 11-kV, interconnected generator-reactor system shown in Figure Q5 has equipment information as below.

Generator G1:	10 MVA,	$X'' = 10 \%$ ;
Generator G2:	20 MVA,	$X'' = 15 \%$ ;
Reactor X1:	10 MVA,	$X = 5 \%$ .

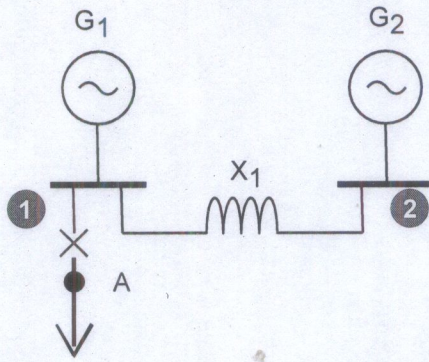


Figure Q5.

A three-phase fault occurs at point A, where the prefault voltage is 11 kV and prefault current can be neglected.

(i) Find the fault current and the contribution to the fault current of generator G2 by a systematic method employing the bus impedance matrix. [10 marks]

(ii) Before the interconnector was installed the Generators G1 and G2 were feeding a common 11-kV busbar. Compare the fault levels at point A before and after the installation of the interconnector. [4 marks]

Question 6. [20 marks]

(a) Describe the use of the plug setting multiplier and time multiplier setting in an IDMT over-current relay. [8 marks]

(b) Figure Q6 is a one-line diagram of a 13.2-kV radial system. All loads have the same power factor and that the CT ratios are 300:5, 400:5, and 600:5, at substations 1, 2, and 3 respectively. The maximum fault currents at buses 1, 2, and 3 are 2400, 2700, and 3000 A, respectively, with the busbars fitted with 5-A IDMT overcurrent relays. Determine the coordinated relay setting for Bus 2, if the protection at bus 1 is required to operate in 0.5 s for a close-up fault, with characteristic time estimated by  $t = \frac{0.14}{PSM^{0.02} - 1}$ .

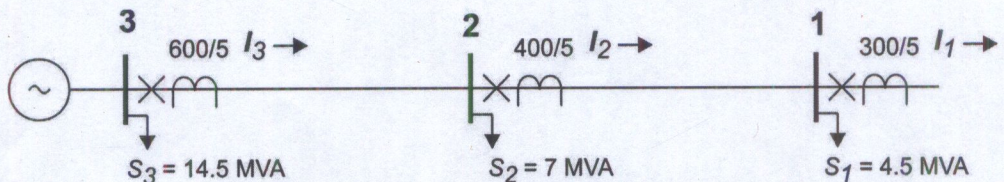


Figure Q6. Radial distribution network

[12 marks]

END OF EEE 4362 EXAMINATION



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UNIVERSITY EXAMINATIONS

END OF YEAR DEFERRED EXAM – JANUARY, 2020

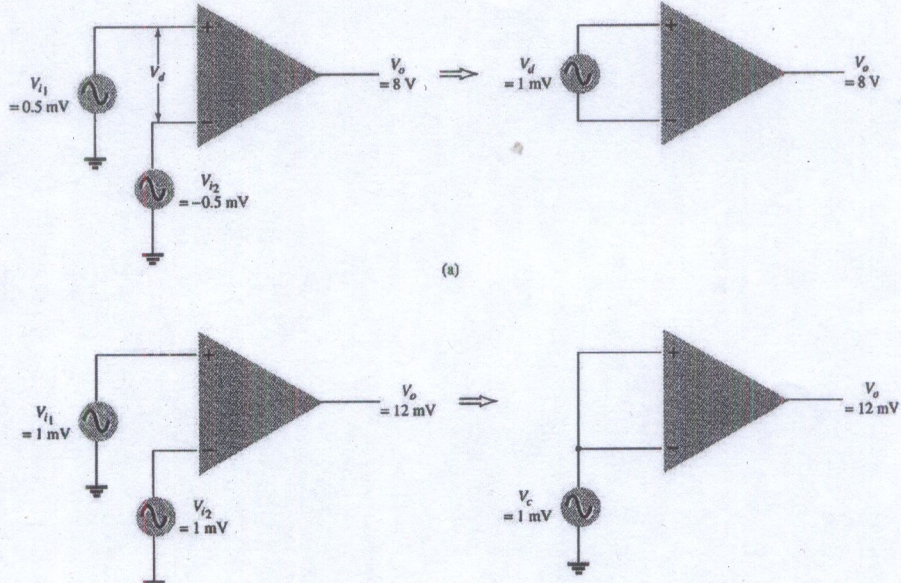
**EEE 4670**

**EEE 4670: ELECTRONIC ENGINEERING II**

<b>TIME</b>	: Three (3) hours
<b>INSTRUCTIONS</b>	: Answer any Five (5) questions
<b>ADDITIONAL INFORMATION</b>	: ➤ Where not specified take the diode and transistor to be of Silicon.

**Question One**

- a) Calculate the CMRR for the circuit measurements shown in **Figure 1** below. [8]



**Figure 1**

- b) A sample of intrinsic germanium at room temperature has a carrier concentration of  $2.4 \times 10^{19} \text{ m}^{-3}$ . It is doped with antimony at a rate of one antimony per million atoms of germanium. If the concentration of the germanium atoms is  $4 \times 10^{28} \text{ m}^{-3}$ . Determine the hole concentration. [6]
- c) Consider an intrinsic semiconductor that has length  $L=0.8\text{cm}$  Cross-section area  $S=15 \times 15 \text{ mm}^2$ . DC voltage across it  $V=10\text{V}$ ,  $n_i=1.5 \times 10^{16} \text{ m}^{-3}$ ,  $\mu_n=0.14 \text{ m}^2/(\text{V}\cdot\text{s})$ ,  $\mu_p=0.05 \text{ m}^2/(\text{V}\cdot\text{s})$ ,  $q=1.6 \times 10^{-19} \text{ C}$ .
- (i) Calculate electron and hole velocity [3]
- (ii) Calculate total current flowing through the semiconductor [3]

### Question Two

- a) Given the packaged amplifier shown in Figure 2,

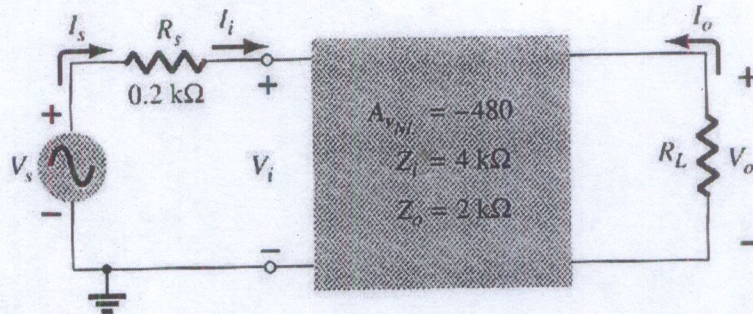


Figure 2

- (i) Determine the gain  $A_{VL}$  with  $R_L=1.2k\Omega$  and compare it to the no-load value. [4]
  - (ii) Repeat part a) with  $R_L=5.6k\Omega$  and compare solutions. [4]
  - (iii) Determine  $A_{VS}$  with  $R_L=1.2k\Omega$  [3]
  - (iv) Find the current gain  $A_i=I_o/I_i=I_o/I_s$  with  $R_L=5.6k\Omega$  [3]
- b) The current flowing in a certain PN-Junction at room temperature is  $0.2\mu A$  when a large reverse bias voltage is applied. Calculate the current flowing when a forward bias of  $0.1V$  is applied. Data:  $I_s=0.2\mu A$   $V_D=0.1V$   $T=300K$   $kT/q=0.026V$  [6]

### Question Three

- a) For a non-ideal amplifier and the following parameters.

$$\text{Input signal power} = 2 \times 10^{-10} \text{ W}$$

$$\text{Input noise power} = 2 \times 10^{-18} \text{ W}$$

$$\text{Power gain} = 1,000,000$$

$$\text{Internal noise } (N_d) = 6 \times 10^{-12} \text{ W}$$

Determine.

- (i) Input S/N ratio (dB) [3]
  - (ii) Output S/N ratio (dB) [3]
  - (iii) Noise factor and Noise figure [5]
- b) For the three cascaded amplifier stages, each with noise figures of  $3dB$  and power gains of  $10dB$ . Determine the total noise figure. [3]
- c) Calculate the output offset voltage of the op-am circuit shown in Figure 3 below with lists of  $V_{IO}=1.2mV$ . [6]

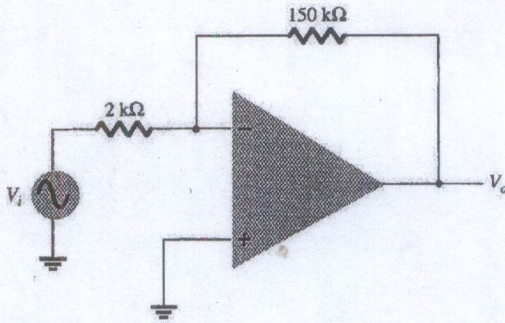


Figure 3

**Question Four**

- a) Calculate the DC bias voltage and currents in the circuit for the Darlington pair shown in Figure 4. [12]

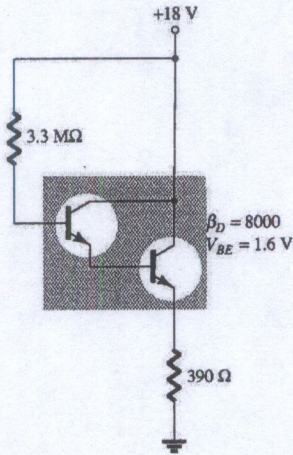
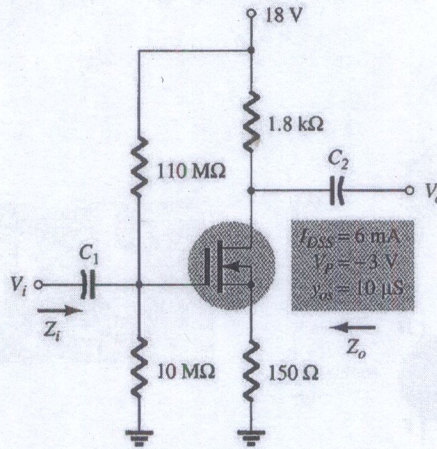


Figure 4

- b) Assume that mobility of hole in the semiconductor is  $0.5 \text{ m}^2 / (\text{V}\cdot\text{s})$ . Determine the average time between collision of this hole. Where effective mass of hole ( $m_p^*$ ) is 0.55 times rest mass in vacuum. [8]

**Question Five**

a) For the network shown in **Figure 5** below;

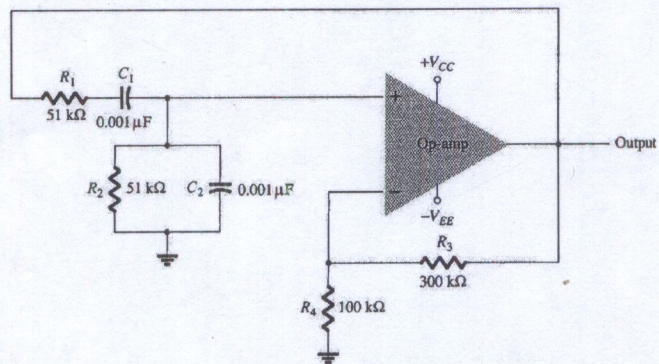


**Figure 5**

- (i) Determine  $g_m$  [3]
- (ii) Find  $r_d$  [2]
- (iii) Sketch the AC equivalent network [4]
- (iv) Find  $Z_i$  [4]
- (v) Calculate  $Z_o$  [4]
- (vi) Find  $A_v$  [3]

**Question Six**

a) Calculate the resonant frequency of the Wien bridge oscillator of the **Figure 6a** shown below [6]



**Figure 6a**

- b) A sample of intrinsic germanium at room temperature has a carrier concentration of  $2.4 \times 10^{19} \text{ m}^{-3}$ . It is doped with antimony at a rate of one antimony per million atoms of germanium. If the concentration of the germanium atoms is  $4 \times 10^{28} \text{ m}^{-3}$ . Determine the hole concentration. [8]
- c) Calculate the regulated output voltage in the circuit shown in **Figure 6b**. [6]

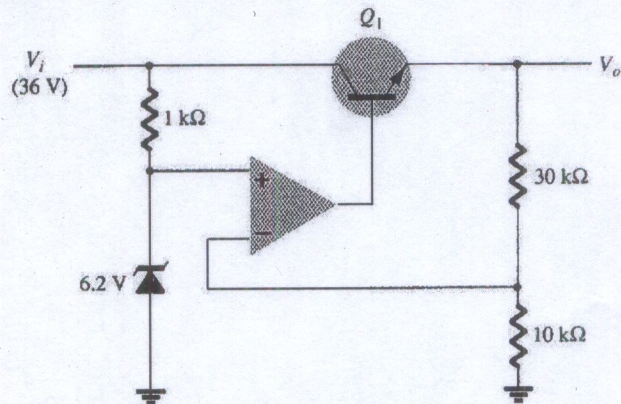


Figure 6b

**Question Seven**

- a) Calculate the DC voltages and currents in the circuit shown in **Figure 7**. [8]

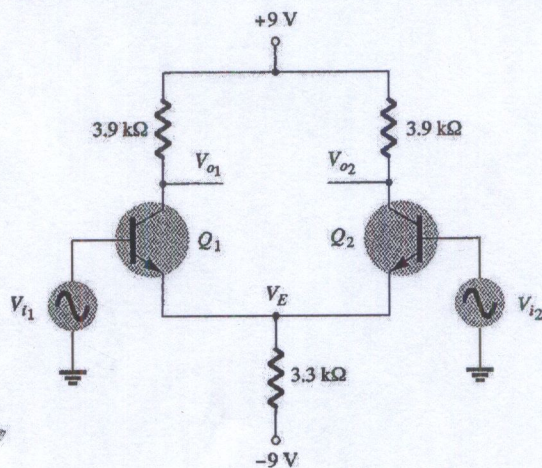


Figure 7

- b) Determine the frequency of radiation emitted by an electron in an excited hydrogen atom when it jumps from  $n=3$  orbit to  $n=2$  orbit. Take  $h=6.625 \times 10^{-34} \text{ J.s}$  [6]
- c) A sample of intrinsic germanium at room temperature has a carrier concentration of  $2.4 \times 10^{19} \text{ m}^{-3}$ . It is doped with antimony at a rate of one antimony per million atoms of germanium. If the concentration of the germanium atoms is  $4 \times 10^{28} \text{ m}^{-3}$ . Determine the hole concentration. [6]



THE UNIVERSITY OF ZAMBIA

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DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATIONS

2022 ACADEMIC YEAR

**EEE 6661**

**CYBER FORENSICS & DIGITAL INVESTIGATION**

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**TIME** : Three (3) hours

**INSTRUCTIONS** : Answer any five questions

**ADDITIONAL INFORMATION** :

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### Question one

- a) Define precisely cyber forensic? [1 Mark]
- b) Give a reason why computers of 1980s and 90s could not attract the name cyber? [1 Mark]
- c) Explain briefly IP spoofing. [3 Marks]
- d) Describe in detail the start-up process or boot process of a computer. [10 Marks]
- e) Before embarking investigations of a device connected on the network briefly describe why it may be necessary to do the following:
- i. to disconnect your machine from the network before performing digital analysis on a drive? [2 Marks]
  - ii. to use a separate blank drive that contains all the extracted evidence and reports obtained from the image and should make this drive be significantly larger than the original drive? [3 Marks]

### Question two

- a) Explain the main difference between the governing law of the land and scientific knowledge in forensic investigations. [2 Marks]
- b) What is the significant focus when preparing a forensic evidence? How should the evidence be? [1 Mark]
- c) Describe scientific truth Vs legal truth citing Galileo's experience. [7 Marks]
- d) Outline five fundamental concepts required by a forensic investigator as he or she carries out his or her forensic investigations. [10 Marks]

### Question three

- a) Roberta Hutchins is being investigated for selling company secrets on a top secret project to a competitor. Her computer was seized and turned over to your team for analysis. You've been asked to find the evidence on her computer to link her to the crime. During the interview process you learn that Roberta is a secretary for Kerry Shank who is the leading manager for Project Boondoggle. She was using a Windows XP system formatted with the NTFS File system. Roberta's colleagues have reported seeing her browsing Porsche websites and pricing them even though her salary at the company is not significantly high. She has been carrying a new cell phone to work in which coworkers have only heard her talk to a person whom she calls Jessie. Unfortunately, the cell phone was not found during the seizure of her computer and remains missing. You also discover that proper procedures were not taken when suspicions were raised. Roberta's boss made the mistake of confronting Roberta about the accusations before considering to call in a forensics team. Due to this mistake Roberta denied everything and would have had plenty of time to delete any

incriminating files before your team was notified. From the information given about this interview process, what will you include in your list of search words when beginning your search of Roberta's hard drive? **[5 Marks]**

- b) As a follow up from Q3.a: can you use dd to write the image file to a new blank drive as a clone that is bootable? Why or why not? **[2 Marks]**
- c) You just extracted data from slack space. Will that data also exist in the file you extracted of unallocated space? Why or why not? **[3 Marks]**
- d) What do you think the difference is between slack space and slack data? Can slack data exist in unallocated space? Why or why not? **[5 Marks]**
- e) Calculate the capacity of a hard disk if the hard disk has 1024 cylinders, 256 heads and 63 sectors. **[5 Marks]**

#### Question four

- a) What is steganography? **[4 Marks]**
- b) What is malware? **[1 Mark]**
- c) Outline and describe five types of malware **[10 Marks]**
- d) Explain how a Master File Table (MFT) is of a very high forensic significant. **[5 Marks]**

#### Question five

- a) Describe the work of a master boot record (MBR) and its location. **[5 Marks]**
- b) Describe windows registry as a source of forensic evidence. **[6 Marks]**
- c) Describe how the file system of any storage device operates. **[6 Marks]**
- d) Calculate the number of clusters in FAT16 file system. **[3 Marks]**

#### Question six

- a) Describe with the help of suitable diagram file system for a UNIX system. **[6 Marks]**
- b) Explain, using a suitable diagram, compartmentalization. What is the advantage of compartmentalization? **[6 Marks]**
- c) Describe how you would make a bit stream copy of a suspected hard drive for containing forensic evidence. State also how the preparatory works can be conducted. **[8 marks]**

**Question seven**

- a) Describe how Data Link layer can be a source of digital evidence. **[7 Marks]**
  
- b) Explain the differences between Ethernet and ATM network technologies. **[5 marks]**
- c) Explain Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocol. At which layer is it applied? **[5 Marks]**
- d) How do computers on network use numbers or ports to distinguish between different types of data? **[3 Marks]**

END of EXAM

-Page 3-

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – JUNE 2022

**GGY 3051 – ENGINEERING GEOLOGY FINAL EXAM**

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS TOTAL MARKS: 100

TIME ALLOWED: 3 HOURS

**NB. The marks allocated are an indication of the amount of detail expected. Show your working clearly.**

**ALL THE BEST!**

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**Section A has 25 Multiple Choice Questions. Attempt all. (25 marks)**

- 1. During which condition would permeability of rocks have to be given more importance?**
  - a) When general water is much above the top reservoir level
  - b) When the general water table is is much below the minimum water level
  - c) When the general water table and top water level of the proposed reservoir are almost the same
  - d) When the general water table is slightly above the top reservoir level
  
- 2. Which of the following need not be given prime importance during geological site investigations?**
  - a) Groundwater conditions
  - b) Wind conditions
  - c) Structural constitution
  - d) Trend and rate of weathering
  
- 3. Silting in reservoirs is usually undesirable. Removal of silt is usually**
  - a) Time consuming
  - b) Energy consuming
  - c) Money consuming
  - d) Time, energy and money consuming
  
- 4. Reservoirs are usually constructed water-tight. The major problem in a reservoir over time which may affect the storage capacity is**
  - a) Leakage
  - b) Silting

- c) Reduction in rainfall
- d) Weathering of side slopes

**5. Which statement is true?**

- a) Bedding is a primary structure in igneous rocks
- b) Foliation is secondary structure in metamorphic rocks
- c) Minerals of the same chemical composition will always have the same colour
- d) None of the above

**6. The methods of site investigations are largely dependent on**

- a) Climatic conditions
- b) Local topography
- c) Nature of the engineering project
- d) All of the above

**7. The general site investigations (exploration) gives information about which of the following features?**

- a) Depth to top of fresh rock
- b) Composition of soil strata
- c) Groundwater level
- d) All of the above

**8. Which of the following processes would produce metamorphic rocks?**

- a) Gradual erosion
- b) Slow cooling
- c) Extensive flooding
- d) Extreme pressure

**9. Which of the following best describes how igneous rocks are formed?**

- a) Rock changed by heat and pressure
- b) Tiny pieces of rock cementing together
- c) Layered rock splitting apart
- d) Melted rock that cools

**10. What is sedimentary rock made from?**

- a) Metal ores that are exposed to moisture
- b) Molten lava that has cooled
- c) Large boulders close together
- d) Pieces of other rock and fossilized organisms

- 11. Based on their processes of formation, how many categories of rocks are there?**
- a) Two
  - b) Three
  - c) Four
  - d) Five
- 12. Wana tests a sample of mineral by rubbing it on a piece of white tile. She observes a yellow mark that is left on the tile. What property of minerals is Wana testing?**
- a) Lustre
  - b) Streak
  - c) Colour
  - d) Strength
- 13. Which of these correctly explains the relationship between rocks and minerals?**
- a) Rocks are materials that are found on the surface of the earth, and minerals are found only underground
  - b) Minerals are the basic building blocks from which nearly all minerals are made
  - c) Minerals are large structures that can be broken down into smaller pieces called rocks
  - d) When rocks are heated to very high temperatures, they are changed into minerals
- 14. Triaxial compression test is used to find ..... of soil**
- a) Compressive strength
  - b) Shear Strength
  - c) Permeability
  - d) Specific gravity
- 15. An indirect method of geotechnical investigation is also termed as**
- a) Borehole method
  - b) Geophysical method
  - c) Geochemical method
  - d) Rock and fluid mechanics
- 16. Physical weathering results in an increase in the size and number of discontinuities in a rock mass**
- a) True
  - b) False
  - c) Both A and B
  - d) None of the above
- 17. When discontinuity spacing is large, the behavior of a rock mass will be strongly influenced by intact rock properties**
- a) True

b) False

**18. In engineering practice, it is best to make a road cut when a hill is downslipping in the opposite direction to the dip of the strata**

- a) True
- b) False
- c) Sometimes
- d) None of the above

**19. Bedding is:**

- a) Geological layering in Sedimentary rocks
- b) Geological layering in Igneous rocks
- c) A primary structure in Metamorphic rocks
- d) All of the above

**20. Compressional stresses in rocks result in**

- a) Shortening strain
- b) Lengthening strain
- c) Shear failure
- d) None of the above

**21. In reverse fault that results from horizontal compressive stresses, the hangingwall side moves**

- a) Sideways
- b) Downwards
- c) Upwards
- d) In same direction as Footwall

**22. Which of the following are all geological structures?**

- a) Joints, beds, folds, sediments
- b) Faults, layering, joints, vugs
- c) Joints, contacts, faults, pores
- d) Folds, beds, joints, layering

**23. What kind of soils do you expect to have heaving effect on structures?**

- a) Shrinking soils
- b) Collapsible soils
- c) Cohesionless soils
- d) Expansive soils

24. When magma from the earth's mantle extrudes to the surface of the earth in form of lava and solidifies, it forms extrusive igneous rocks. Compared to the intrusive igneous rocks that form from within the earth's crust, what will be the texture of extrusive igneous rocks?

- a) Fine
- b) Coarse
- c) Concoidal
- d) Amygdaloidal

25. Which statement is correct?

- a) A structural valley is synclinal in nature and the younger rocks will be in the centre/middle
- b) A structural dome is anticlinal in nature and the younger rocks will be in the centre/middle
- c) A structural dome is synclinal in nature and the older rocks will be in the centre/middle
- d) A structural valley is anticlinal in nature and the younger rocks will be in the centre/middle

Section B has five questions. Each question is allocated 25 marks. Attempt any three Questions. (75 marks)

### QUESTION ONE

- a) In soils and/ or rock engineering, what do the following terms mean? (8 marks)
  - i. Rippability
  - ii. Cohesion
  - iii. Compressibility
  - iv. Shear strength
- b) What is the difference between consolidation and compaction? (2 marks)
- c) A slightly moist clayey sample is subjected to a normal force  $\sigma' = 40\text{KN}$  in a direct shear test like the one shown below. If the strength parameters of the sand are  $c = 3\text{KPa}$  and  $\phi = 32^\circ$ , **calculate** the shear stress at failure if the soil sample is  $16\text{ cm} \times 16\text{ cm}$  in plane and  $5\text{cm}$  in height. (5 marks)
- d) List any 4 forces/stresses that act on a dam (4 mark)
- e) i) List any 4 uses of dams (2 marks)  
ii) List any 4 environmental impacts that dams pose (2 marks)

iii) What two methods can you employ to treat the ground in foundation engineering for dams? (2 marks)

## QUESTION TWO

- a) What is the difference between an intact rock and a rockmass? (2 marks)
- b) As an engineering geologist, what physical properties of rocks would be of value to you before you advise the structural engineer on any construction works? (3 marks)
- c) What factors of discontinuities influence the strength and deformability of rockmasses in construction works? (3 marks)
- d) As an engineering geologist/geotechnical engineer, would you recommend design of structures based on intact rock properties? Give a reason for your answer (2 marks)
- e) Geological structures are usually points/planes of weakness in rocks. Describe (with sketches where possible) the following structures/terms:
  - i) Joints (2 marks)
  - ii) Shearing (2 marks)
  - iii) Bedding (2 marks)
- f) i) What is weathering? List and explain the three commonly known types of weathering (3 marks)  
ii) Why is it important to consider the effect of weathering when designing buildings? (1 mark)
- g) In plate tectonics, there are three main types of boundaries. Briefly describe these with the aid of sketches (5 marks)

## QUESTION THREE

- a) What are site geological site investigations? (2 marks)
- b) Give at least five objectives of conducting site investigations (5 marks)
- c) i) Why is knowledge of fractures in rocks important in engineering practice? (4 marks)  
ii) Why is it important to treat/seal joints under foundations? (2 marks)
- d) Define the following terms:
  - i) Infiltration (2 marks)
  - ii) Percolation (2 marks)
  - iii) Porosity (1 mark)
  - iv) permeability (1 mark)
- e) A cylindrical sample of partly saturated clay with an original length of 205mm and radius of 45mm is subjected to a normal load of 200kN. This leads to an increase in the

sample's diameter by 5%. If the soil's Poisson's ratio is 0.4, what is the final length of the sample? (6 marks)

#### QUESTION FOUR

Groundwater Resources are a huge and vital source of water for several purposes.

- a) (i) Explain in detail how groundwater levels are *affected in different seasons*, providing details of how *different processes* as well as *ground conditions* contribute to a higher and lower groundwater table. (8 marks)
- (ii) What impact would groundwater level fluctuations have on completed structural engineering works? (2 marks)
- b) As an engineering Geologist, you have been tasked with devising a plan to supply clean drinking water to residents of Matero, Chunga and Mandevu in Lusaka.
- (i) Explain what **challenges** you would anticipate/expect if provision of such water is through drilled boreholes in the mentioned areas, as well as the **measures** you would put in place before and after drilling of the boreholes in the mentioned areas (5 marks)
- c) You have won a contract to construct a 120km tarred road between the hilly towns of Lundazi and Katete in Eastern Zamba, where the water table sits quite deep below the earth's surface..  
What logistical, hydrological and geotechnical issues would be of concern to you to ensure that the project is successful?  
(5 marks)
- d) Borings are some of invasive site investigation methods in which a hole is left in the ground following extraction of drillhole samples. In site investigations, what are some parameters of geological and/or geotechnical importance that can be acquired from/through borings? (5 marks)

#### QUESTION FIVE

- a) Outlining each stage clearly, write brief notes on the five main Site Investigation stages. (10 marks)
- b) Mr. Abel Kunda Kapulumuna intends to build a 7 storey Hotel in Lukulu District of Western Province. He contacted Kenny Ntanda and Ryan Chota to conduct some Geophysical Seismic Surveys at the proposed site. It was necessary to carry out a site investigation to determine the properties of the sub-surface geology in order to establish the thickness of the drift. An 8KG sledge hammer, adequate for 45m penetration of seismic waves was used to generate the seismic vibrations. The table below shows the results.
- c) i) List and explain any two *definitive* properties of minerals (2 marks)

ii) List and explain any two *diagnostic* properties of minerals (2 marks)

	Geophone 1	Geophone 2	Geophone 3	Geophone 4
Distance from vibration source (meters)	20	40	60	80
Direct wave arrival time (milli seconds)	25	50	75	100
Refracted wave arrival time (milli seconds)	34	42	50	58

Calculate:

1. The wave velocities  $V_1$  and  $V_2$  (4 marks)
2. The critical distance ( $D$ ) (2 marks)
3. The thickness of the drift (4 marks)
4. The time intercept  $t_0$  (1 mark)

**END OF EXAMINATION**

APPENDIX

$$\rho_i = \frac{p * B (1 - \mu^2) * I_p}{E}$$

Wherein:

$p$   $\equiv$  uniform contact pressure;

$B$   $\equiv$  Width of foundation;

$\mu$   $\equiv$  Poisson's ratio of the soil;

$E$   $\equiv$  Modulus of elasticity of the soil

$I_p$   $\equiv$  Influence factor depending upon dimensions of foundation, i.e. length (L) & width (B).

$$V_p = \sqrt{\frac{K + \frac{4}{3} * G}{\rho}}$$

Where:

$V_p$   $\equiv$  seismic p-wave velocity

$K$   $\equiv$  bulk modulus;

$G$   $\equiv$  shear modulus;

$\rho$   $\equiv$  density of medium transmitting waves.

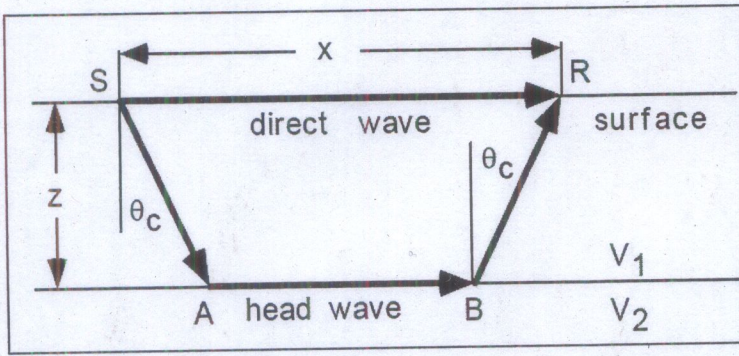
$$\frac{V_p}{V_s} = \sqrt{\frac{2 * (1 - \mu)}{1 - (2 * \mu)}}$$

$$E = k * \rho * V_s^2 \frac{(3 * V_p^2 - 4 * V_s^2)}{(V_p^2 - V_s^2)}$$

$$V_s = \sqrt{\frac{G}{\rho}}$$

$$\text{Poisson's Ratio, } \mu = \frac{V_p^2 - 2 * V_s^2}{2 * (V_p^2 - V_s^2)}$$

$$\text{Shear Modulus, } G = \rho * V_s^2$$



$$t = \frac{SA}{V_1} + \frac{AB}{V_2} + \frac{BR}{V_1}$$

$$X_c = 2z \sqrt{\frac{V_2 + V_1}{V_2 - V_1}}$$

$$Z = \frac{X_c}{2} \sqrt{\frac{V_2 - V_1}{V_2 + V_1}}$$

$$t_0 = \frac{2z * \sqrt{V_2^2 - V_1^2}}{V_1 * V_2}$$

$$Z = \frac{t_0}{2} \frac{V_1 V_2}{\sqrt{V_2^2 - V_1^2}}$$