Problem : P21 **Area: Computational Intelligence** **Student Code:____**

Formulate the mathematical foundations of reinforcement learning as a Markov Decision Process. Illustrate this on mple example problem of your choice.

Problem : P23 **Area: Computational Intelligence** **Student Code:____**

Describe key issues in parallel / high-performance computing implementation of neural networks, giving specific mples.

Problem : P24 **Area: Computational Intelligence** **Student Code:____**

Compare and contrast three important techniques in unsupervised learning, a.k.a. clustering.

Problem : P29 **Area: Integrated Circuits and Logic Design** **Student Code:____**

Answer the questions for parts **a** and **b** below.

a. Simplify the logic expression $G(x,y,z) = \overline{(\bar{x} + yz)(x\bar{y} + z)}$ using algebraic manipulation to obtain a logic expression that uses as few gates as possible (exclude inverters from the total gate count). *Show your work for full credit.* DO NOT USE K-MAPS.

b. Construct the truth table for $G(x,y,z) = \overline{(\bar{x} + yz)(x\bar{y} + z)}$.

Problem : P30 **Area: Integrated Circuits and Logic Design** **Student Code:_____**

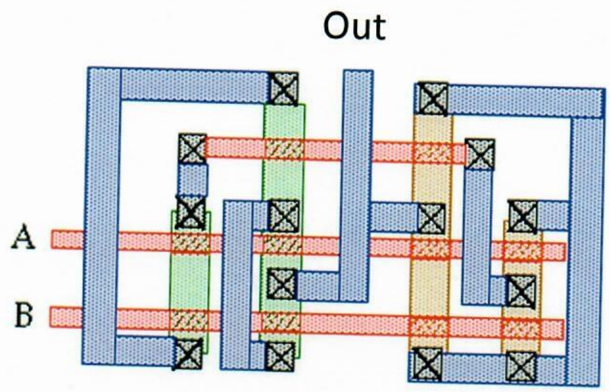
Answer the questions for parts a and b below.

a. What are the required logic operations for a combination of logic gates to be considered a complete logic set for implementing logic functions? Give 3 examples of combinations of logic gates that are complete logic sets.

b. Implement the logic function $F(a, b, c) = (a + \bar{b})\bar{c}$ using 2 combinations of logic gates for complete logic sets from your answer in part a. To be clear, the same function F is to be implemented (drawn) twice using different complete logic sets of gates from part a.

Problem : P31 **Area: Integrated Circuits and Logic Design** **Student Code:____**

For the following CMOS layout, blue represents metal 1, red represents polysilicon, green represent n-diffusion, and brown represents p-diffusion.

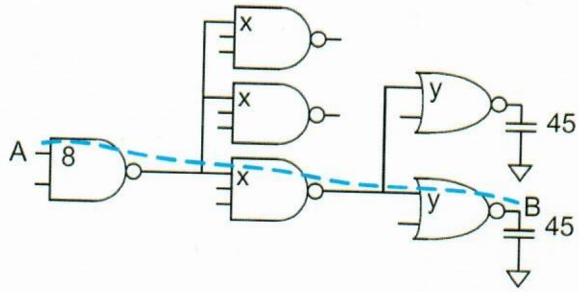


a. Draw a transistor level schematic for the circuit represented in the layout

b. Give the truth-table for the output (Out) in terms of the inputs A and B

Problem : P32 **Area: Integrated Circuits and Logic Design** **Student Code:____**

a. Using the method of Logical Effort, estimate the minimum delay of the path from A to B in units of τ (the delay of a parasitic-free fanout-of-1 inverter).The initial NAND2 gate may present a load of 8λ of transistor width on the input and the output load is equivalent to 45λ of transistor width.



b. Choose transistor sizes to achieve this delay.

Problem : P33 **Area: Networking, Security and Dependability** **Student Code:____**

A Cyclic code word is received as 1011110, which may or may not be erroneous. Assuming generator polynomial) = $x^3 + x + 1$, determine if the received Cyclic code word is valid or invalid. Show any calculations you carried out to reach your conclusion of whether the code word is valid or invalid. An answer with no work will receive no credit.

Problem : P34 **Area: Networking, Security and Dependability** **Student Code:____**

This problem has two parts. For full credit, you must answer both parts correctly.

Part 1: Bob intercepts a ciphertext, C, intended for Alice and encrypted with Alice's public key, e. Bob wants to obtain the original message, $M = C^d \bmod n$. Bob chooses a random value m, less than n, and computes:

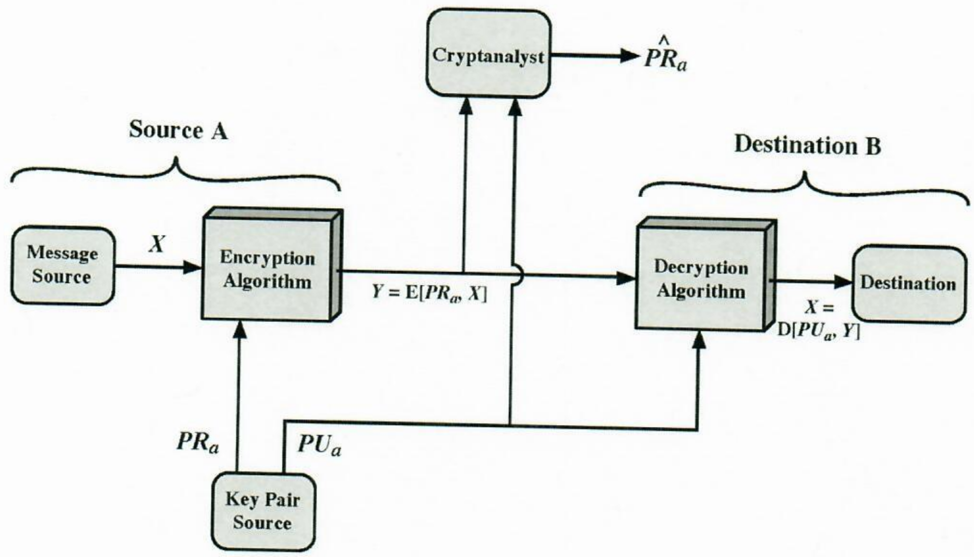
$Z = m^e \bmod n$

$X = ZC \bmod n$

$t = m^{-1} \bmod n$

Next, Bob gets Alice to authenticate (sign) X with her private key (as in the figure below), thereby decrypting X. Alice returns $Y = X^d \bmod n$.

Show (mathematically) how Bob can use the information now available to him to determine M.



Part 2: Briefly describe the roles of the public and private key, respectively, in asymmetric encryption.

Problem : P35 **Area: Networking, Security and Dependability** **Student Code:____**

This problem has two parts. <u>For full credit, you must answer both parts.</u>

Show every step of your work. Answers without full justification will receive no credit.

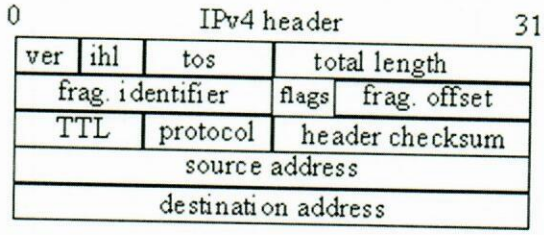
Part 1: An organization has been assigned the prefix 212.1.1.0/24, and wants to form subnets for the three following departments: A, which requires 40 hosts; B, which requires 19 hosts; and C, which requires 65 hosts. Give a possible arrangement of subnet masks to make this possible. Your final answer should include one subnet mask for each of the three departments, assigned such that any potential host address can be unambiguously associated with only a single department. Note that 212D = D4H.

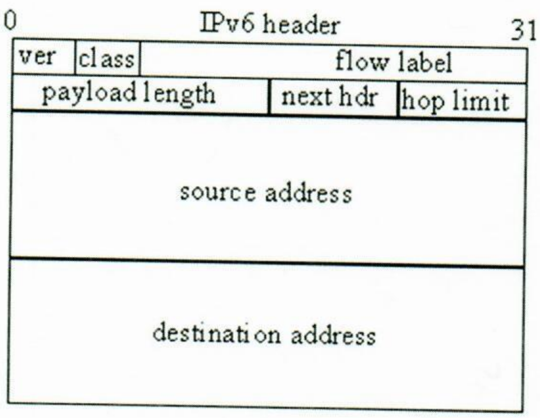
Part 2: What is the difference between the subnet mask for a Class A address with 16 bits for the subnet ID and a Class B address with 8 bits for the subnet ID? Show each subnet mask and compare them to justify your answer.

Problem : P36 **Area: Networking, Security and Dependability** **Student Code:____**

This problem has two parts. <u>For full credit, you must answer both parts.</u>

Part 1: Discuss the differences between IPv4 and IPv6. What are the advantages and advantages of each protocol version? The headers below may be useful in this comparison.

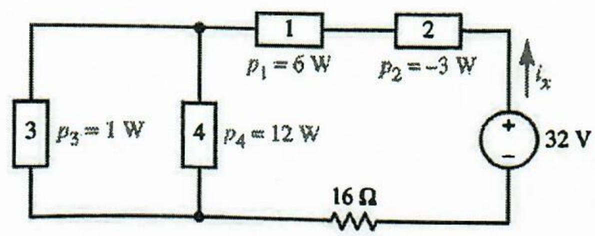




Part 2: Explain the Network Address Translation (NAT) mechanism. How does it work with IPv4 and IPv6 protocol versions, respectively?

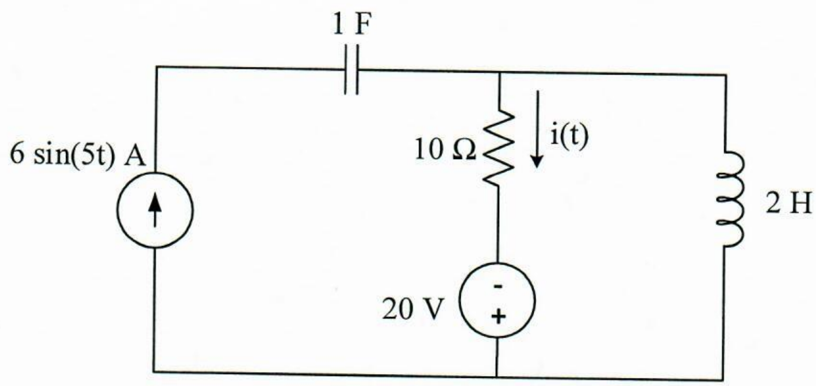
Problem P1 Circuits Code #________

Referring to the right network with power (in watts) and resistor (in ohms) values specified in the elements of the figure, determine the value of i_x



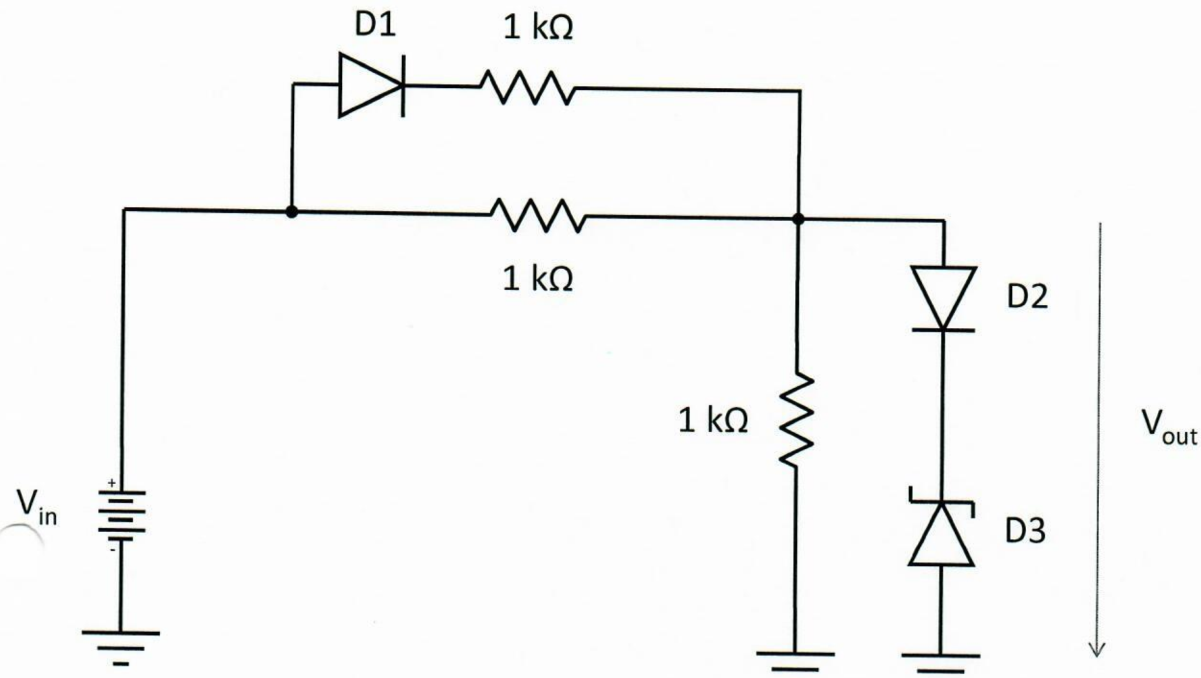
Problem : P2 Area: Circuits/Electronics Student Code:____

_alculate the steady-state current i(t) and the average power dissipated by the 10-Ω resistor in the following circuit.



Problem :__P3___ Area:_____ Circuits/Electronics ________________________ Student Code:____

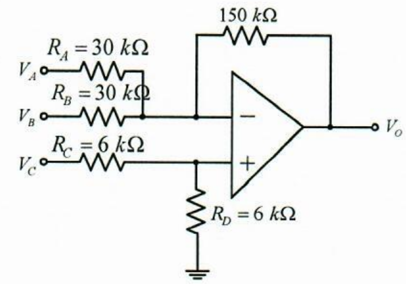
. the circuit below the input voltage changes from -10 V to 10 V. Plot the output DC voltage V_{out} as a function of the input DC voltage V_{in}. Determine the coordinates of all breaking points of the curve. Use piecewise linear approximations for the V-I curves of the diodes. For the diodes D1 and D2 assume the turn-on voltage V_γ=0.7 V, and differential resistance r_f=0 Ohm. For the Zener diode D3 the break-down voltage is 3 V, and the differential resistance r_z=0 Ohm.



Problem: P4 **Area: Circuits/Electronics** **Student Code:____**

Consider the op-amp circuit shown.

a) Assuming an ideal op-amp, find V_O in terms of V_A, V_B, and V_C. (50%)



Answer: V_O=____________________

b) Now assume that the op-amp has input bias currents of $I_{B1} = I_{B2} = 1\mu A$ flowing into the op-amp input terminals. Let $V_A = V_B = V_C = OV$ and find V_O due to the bias currents. (25%)

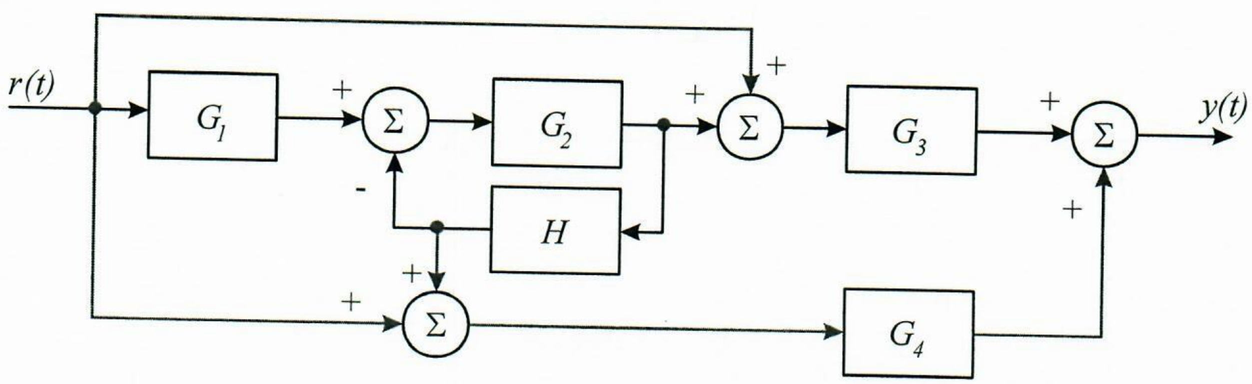
Answer: V_O=____________________

c) Find new values for R_C and R_D to compensate for the input bias currents without changing the relationship you found for V_O in part a). (25%)

Answer: R_C=____________________, R_D=____________________

Problem : 9 **Area: Control Systems** **Student Code:____**

Determine the transfer function of the following control system.



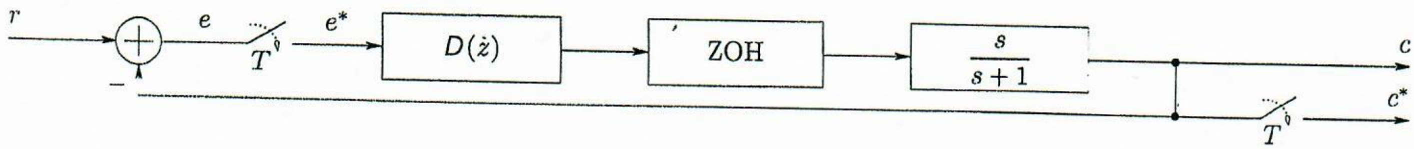
Problem : 10 **Area: Control Systems** **Student Code:____**

Consider the system defined by $G(z) = \dfrac{z+1}{z^2+z+0.16}$, obtain the

(a) Controllable canonical form (33%)
(b) Observable canonical form (33%)
(c) Diagonal canonical form (34%)

Problem : 11 **Area: Control Systems** **Student Code:____**

Consider the following system with a sampling period of 1 second.



Determine the simplest controller $D(z)$, such that the steady-state error for a step reference-input is zero.

Problem : 12 **Area: Control Systems** **Student Code:____**

a. Evaluate the stability of the following system

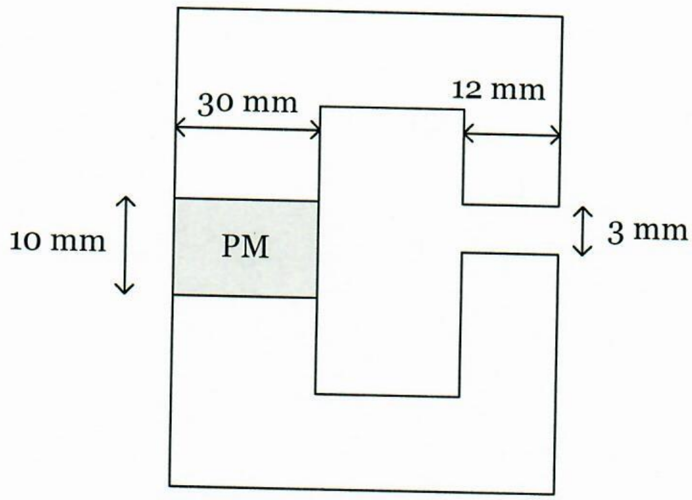
$$\dot{x}_1 = (x_1 - x_2)(x_1^2 + x_2^2 - 1)$$
$$\dot{x}_2 = (x_1 + x_2)(x_1^2 + x_2^2 - 1)$$

b. Evaluate the stability of the following system

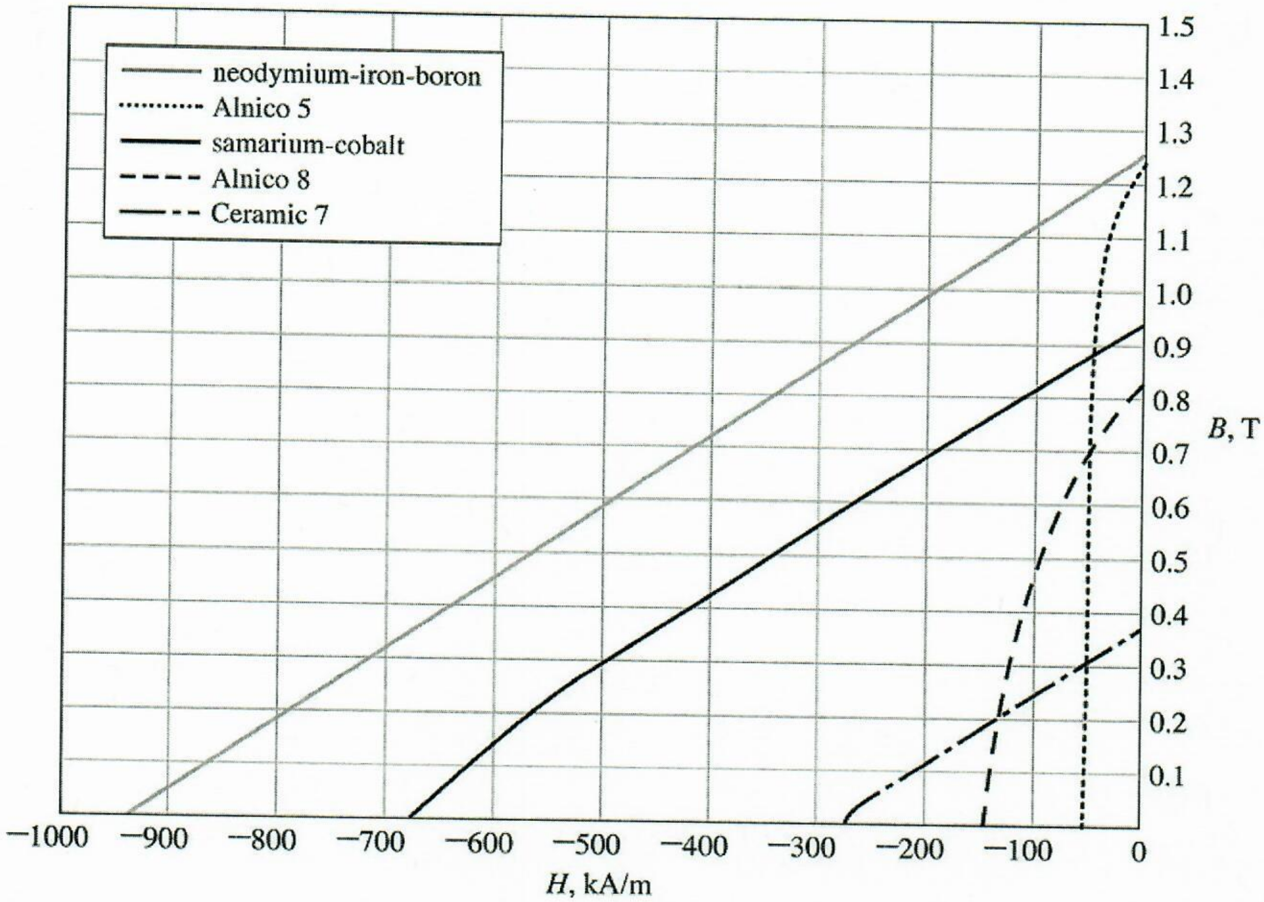
$$\dot{x}_1 = -x_1 + x_2^2$$
$$\dot{x}_2 = -x_2$$

Problem 13 **Power** **Code #__________**

The magnetic structure below includes an Alnico 8 permanent magnet. The recoil permeability of Alnico 8 in this operating region is approximately $2.1\mu_0$. Dimensions are as shown. Depth into the page is 15 mm. The steel is infinitely permeable. Neglect fringing.



a. Determine an equation for the load line that would be used to determine the operating point of the magnet.
b. Determine the operating point of the magnet (H_m, B_m). Please note that curves are available on the next page.
c. Determine the equivalent coercivity, H_c', that might be used to create a linearized model of the magnet.



neodymium-iron-boron
Alnico 5
samarium-cobalt
Alnico 8
Ceramic 7
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
B, T
−1000
−900
−800
−700
−600
−500
−400
−300
−200
−100
0
H, kA/m

Problem 14 **Power** **Code #__________**

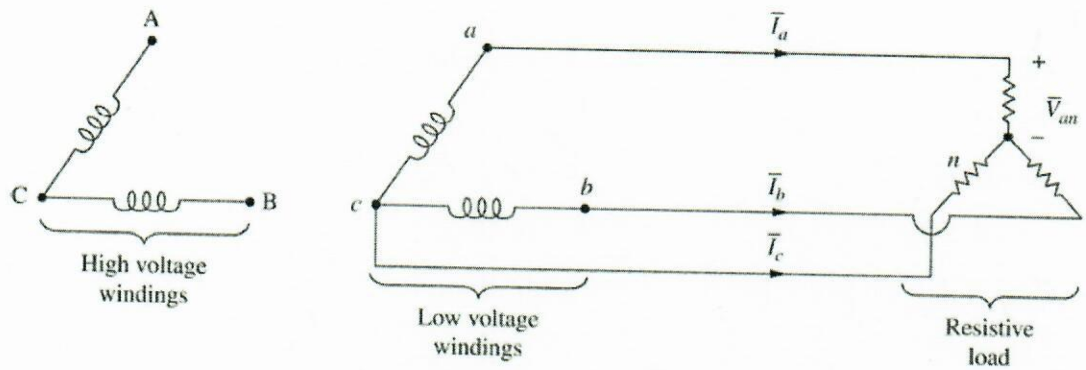
Three single-phase two-winding transformers, each rated 25 MVA, 34.5/13.8 kV, are connected to form a three-phase Δ– Δ bank. Balanced positive-sequence voltages are applied to the high-voltage terminals, and a balanced, resistive Y load connected to the low-voltage terminals absorbs 75 MW at 13.8 kV. If one of the single-phase transformers is removed (resulting in an open- Δ connection as shown in the below diagram) and the balanced load is simultaneously reduced to 43.3 MW (57.7% of the original value), determine

(a) the load voltages V_{an}, V_{bn}, and V_{cn}; (40 points)

(b) load currents I_a, I_b, and I_c; (40 points)

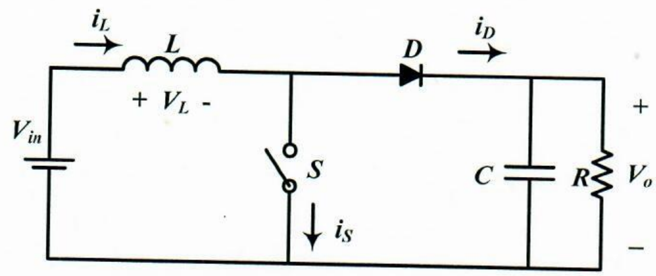
(c) the MVA supplied by each of the remaining two transformers. (20 points)

Note: assume the transformers are ideal transformers, and ignore transmission line impedances. Select V_{an} as reference, i.e., 0 degree angle.



Problem 15 **Power** **Code #__________**

A Boost dc-dc converter has the following parameters: $V_{in} = 400$ V, $d = 0.25$, $V_{out} = 650$ V, $L = 100$ µH, and $f_{sw} = 100$ kHz.



a) Find the peak value of the inductor current. (20 points)

b) Accurately plot the waveform of the inductor current. (20 points)

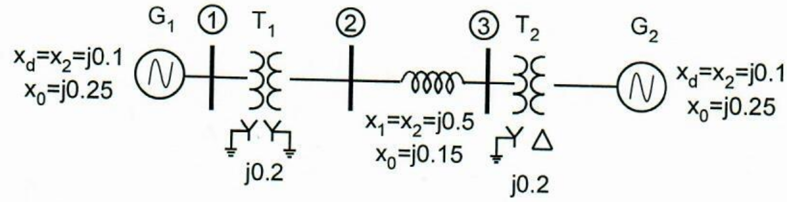
c) Find the average value of the inductor current. (20 points)

d) Find the input power. (20 points)

e) Find the value of the load resistor. (20 points)

Problem 16 **Power** **Code #__________**

In the system shown below, a solid line-ground fault occurs on bus 3.



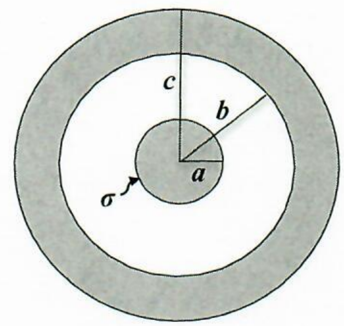
What is the abc fault current in line 2-3? The prefault voltages are 1.0 per unit.

Problem : 17 **Area: Waves & Devices** **Student Code:____**

Concentric spherical metal shell. The figure below shows a cross-section of a concentric spherical metal shell. The radii of the inner solid spherical conductor, the inner wall of the outer spherical conductor, and the outer wall of the outer spherical conductor are a, b, and c, respectively, as marked in the figure. Consider a positive surface charge density σ at the surface of the inner spherical conductor.

A) Find the electric field everywhere as a function of radial distance r (i.e., $r < a$, $a < r < b$, $b < r < c$ and $r > c$).

B) Please plot the electric field strength as a function of radial distance r.



Problem : 19 **Area: Waves & Devices** **Student Code:____**

Three half-wave dipoles are arranged in an array, as shown.

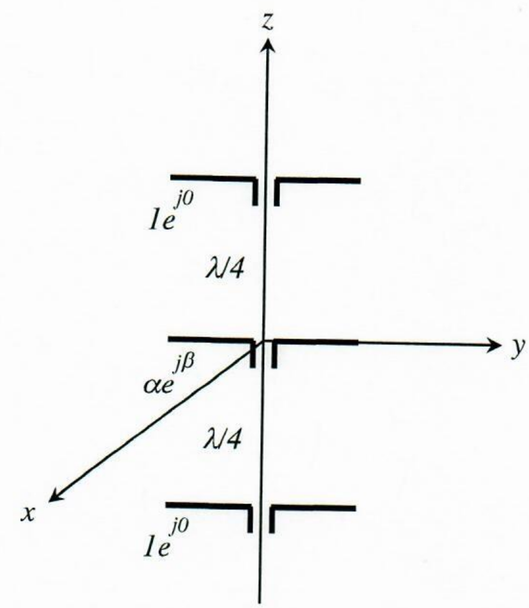
a- What should α and β be so that the array factor has a null at $\theta = 0°$ and $\theta = 180°$ simultaneously?

b- If $\alpha = 7$ and $\beta = \pi$ what is the $|AF|$ equal to in the ($\theta = 90°$, $\phi = 0°$) and ($\theta = 90°$, $\phi = 270°$) directions?

c- If $\alpha = 5$ and $\beta = \pi$ what is the normalized magnitude of the overall array antenna radiation intensity (U_n) in the ($\theta = 90°$, $\phi = 90°$) direction?

d- Would you get the same answer in part (c) for (U_n) in the ($\theta = 0°$, $\phi = 180°$) direction? Explain/show.

Must show work or sufficiently explain your answers.



Problem : 20 **Area: Waves & Devices** **Student Code:____**

I. An abrupt silicon p-n junction has a net acceptor concentration 10^{18} cm^{-3} in the p-side and a net donor concentration 10^{15} cm^{-3} in the n-side, respectively. Answer the following questions assuming all dopants are ionized at room temperature (i.e. 300 K).

a. [35%] Calculate the potential difference at thermal equilibrium (i.e. contact potential or built-in potential) across the depletion region (or space charge region) of the junction.
b. [10%] Calculate the potential difference across the junction when a forward bias (0.2 V) is applied.
c. [10%] Describe the difference, in terms of physical meaning or definition, between the contact potential (in the problem a) and the diode turn-on voltage (e.g. the typical default 0.7 V for silicon p-n diode) (no more than two sentences or ~40 words).

II. Consider a silicon sample doped with donors (10^{14} cm^{-3}) at room temperature. Excess carriers by photon absorption (steady-state concentrations of 2.0 x 10^{13} cm^{-3} electrons and 2.0 x 10^{13} cm^{-3} holes) are generated during a light illumination. Answer the following questions assuming electron mobility = 1,500 $cm^2/V\cdot sec$ and hole mobility = 500 $cm^2/V\cdot sec$, respectively.

a. [25%] Calculate the conductivity of the sample without illumination.
b. [10%] Calculate the conductivity of the sample during illumination.
c. [10%] Discuss a possible application of this sample (no more than one sentences or ~20 words).

Constants*	Equations*
▪ Elementary charge = 1.6 x 10^{-19} [C] ▪ kT = 0.0259 [eV] (at 300 K) ▪ Intrinsic concentration = 9.65 x 10^9 [cm^{-3}] (for silicon at 300 K)	▪ $\sigma = q(n\mu_n + p\mu_p)$ ▪ $n_o p_o = n_i^2$ ▪ $n_o = n_i \exp[(E_F - E_i) / kT]$ or $(E_F - E_i) = kT \ln(n_o/n_i)$ ▪ $p_o = n_i \exp[(E_i - E_F) / kT]$ or $(E_i - E_F) = kT \ln(p_o/n_i)$

* Definitions of parameters are not given for the provided information. It is expected that the examinees interpret the meaning.