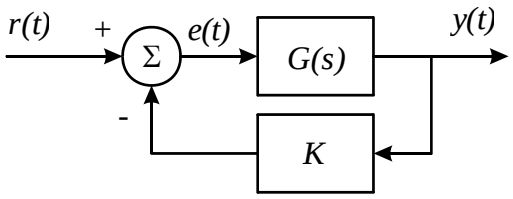
Problem : 9 **Area: Controls** **Student Code____**

The characteristic polynomial of the *closed-loop* transfer function of the following control system is

$$s^3 + 6s^2 + (12 + K)s + (8 - K) = 0$$



(a) Determine *G(s)*.
(b) Find the range of *K* such that the system is stable

Problem : 10 **Area: Controls** **Student Code____**

A continuous-time control system is described by

$$\dot{\boldsymbol{x}}(t) = \begin{bmatrix} -2 & 2 \\ 0 & 0 \end{bmatrix} \boldsymbol{x}(t) + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t),$$

and

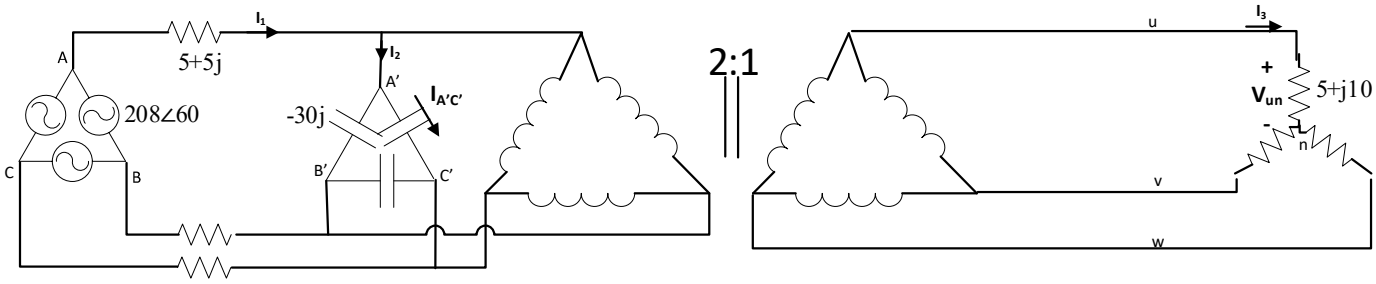
$$y(t) = \begin{bmatrix} 1 & -1 \end{bmatrix} \boldsymbol{x}(t) + \begin{bmatrix} 3 \end{bmatrix} u(t),$$

where u, $\boldsymbol{x}$, and y are the input, the state, and the output variables, respectively. Determine its discrete-time state-space representation, when $T = 1$ second.

Problem: 14 **Area: Power** **Student Code: _____**

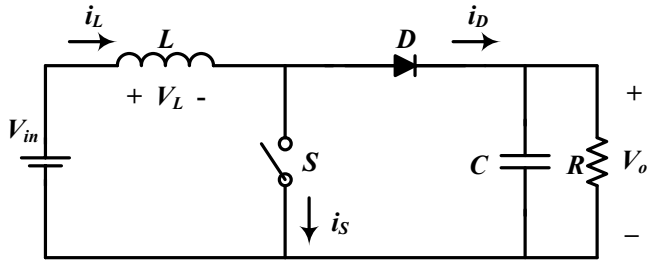
In the following circuit, find the following (both amplitude and angle):

a) I_1, I_2, and I_3 (50 points).
b) $I_{A'C'}$ (Capacitor current) (20 points).
c) Phase voltage of the load (5+10j) equal to V_{un} (15 points).
d) 3-phase complex power of the source (15 points)



Problem: 15 **Area: Power** **Student Code:_____**

A Boost dc-dc converter has the following parameters: V_{in} = 300 V, d = 0.25, V_{out} = 450 V, L = 100 μH, and f_{sw} = 100 kHz.



a) Find the peak value of the inductor current (25 points).

b) Accurately plot the waveform of the inductor current (25 points).

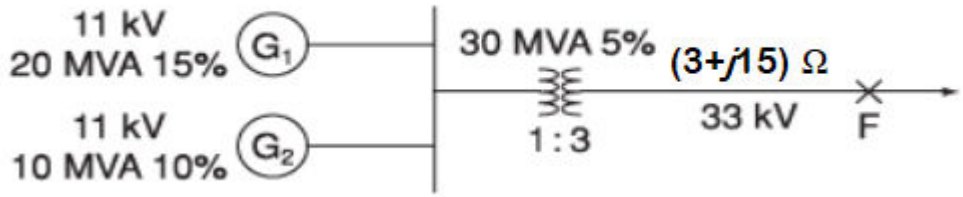
c) Find the average value of the inductor current (25 points).

d) Find the input power (15 points).

e) Find the value of the load resistor (10 points).

Problem: 16 **Area: Power** **Student Code:_____**

In the system shown below, a three-phase short circuit occurs at point F. Assume that prefault currents are zero and that the generators are operating at rated voltage. Choose base MVA as 30 MVA and the base line voltage at the HV-side of the transformer to be 33kV. Determine the fault current in per unit.



A spherical shell with outer radius b surrounds a charge-free cavity of radius a, where $a < b$. If the shell contains a charge density given by $\rho_v = -\rho_0/r^2$ for $a < r < b$, where ρ_0 is a positive constant, determine $\vec{D}$ in all regions defined by (1) $r < a$, (2) $a < r < b$, and (3) $b < r$.

Assume in a free space the medium is vacuum.

(1) A source is placed at the origin and is radiating 150 kW isotopically into the space. Please compute the peak magnitude of the electric field at 100 km. (5 Points)
(2) Then the source is replaced by an antenna that has 3dB Antenna Gain. The antenna's efficiency is only 50%. Assume the total radiated power by the antenna is still 150 kW. Please compute the max peak magnitude of the electric field at 100 km. (5 Points)

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

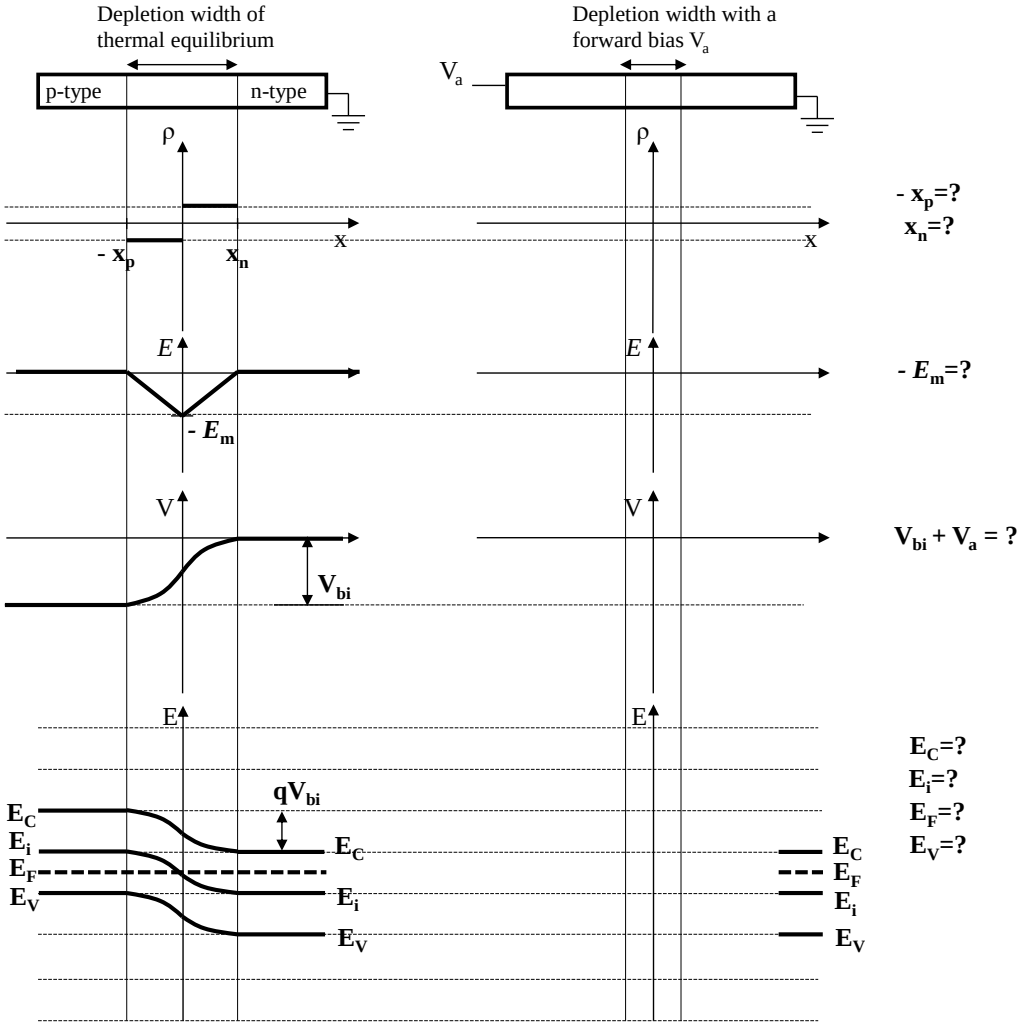
1. [50%] An abrupt silicon p-n junction diode has a net acceptor concentration of $10^{18}cm^{-3}$ in the p-side and a net donor concentration $10^{18}cm^{-3}$ in the n-side, respectively. Calculate the voltage (i.e. contact potential or built-in potential) across the depletion region (or space charge region) at thermal equilibrium in room temperature (300K).

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

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

2. [50%] Sketch the diagrams of a forward-biased symmetric p-n junction and clearly identify the location of each question-marked item (i.e. Show the expected difference from the equilibrium conceptually when a forward bias is applied). Assume the n-side is electrically grounded. The dashed lines serve only as "reference lines" to indicate the value of each item at thermal equilibrium.

(distance x, charge density ρ, electric field *E*, voltage across depletion region V, elementary charge q, electron energy E, bottom level of conduction band E_C, intrinsic level E_i, Fermi level E_F, top level of valence band E_V)



Problem: 21 **Area**: Computational Intelligence **Code #_____**

Answer the questions for parts a and b below.

(a) Suppose that you are given a dataset with 10,000 feature vectors with 20 features and a class label of 0, 1, or 2. Describe the criteria used to select a CI technique for discriminating the feature vectors into the 3 classes.

(b) Suppose that you are given a dataset with 10,000 feature vectors with 20 features and no class labels but you are seeking to partition the dataset into n groups, where n is determined based on maximizing separability of the data. Describe the criteria used to select a CI technique for separating the data into n groups.

Problem: 23 **Area**: Computational Intelligence **Code #_____**

Answer the following questions.

(a) What is the relationship between Artificial Intelligence (AI) and Computational Intelligence (CI)?

(b) Describe the different between the traditional Artificial Intelligence (AI) and the modern CI. Give an example of an application where AI is the more appropriate paradigm. Give an example of an application where CI is the more appropriate paradigm. Justify your application selections for AI and CI.

Problem: 24 **Area**: Computational Intelligence **Code #_____**

Answer the following questions.

a) When applying CI techniques to a given dataset, the dataset is broken up into training, cross-validation, and test sets. Define the terms data normalization and regularization as related to the training, cross-validation, and test partitioning of the dataset.

b) Describe the process of applying a CI technique to a training dataset to determine whether the CI technique has been overtrained. What are indicators that a CI technique has been overtrained?

Problem: P29 **Area: Integrated Circuits and Logic Design** **Code #_____**

Given the Boolean expression, answer the following questions:

$$F(A,B,C) = \underline{(AB + \underline{C})}(\underline{A} + B)(\underline{B + C})$$

a) Find the truth table for F.

b) Simplify the function F using any appropriate method (express F in its simplest form).

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

Define a complete logic set for implementing logic functions. Is the two variable exclusive OR operator an example of a complete logic set? Show your work to demonstrate yes or no.

Problem: P31 **Area: Integrated Circuits and Logic Design** **Code #_____**

Design and implement a state machine (circuit) to detect the input sequence (last digit) 0 1 0 0 (first digit) given from the input binary variable S. The circuit will output a 1 if the input sequence 0100 has been detected and a 0 otherwise. The circuit must reset itself when the sequence 0100 is detected, meaning that the state machine circuit is reset to looking for the first digit of the sequence. Derive the state table and draw the state machine circuit. Use D flip flops for the state variable(s) (memory element(s)).

Problem: P32 **Area: Integrated Circuits and Logic Design** **Code #_____**

Given the function: F(w,x,y,z) = ∑(0,2,3,6,10,11,12)+dc(4,7,8)

Answer the following questions.

a) Write the minimal sum-of-products expression for F.

wx \ yz	00	01	11	10
00				
01				
11				
10				

b) Write the minimal product-of-sums expression for F.

wx \ yz	00	01	11	10
00				
01				
11				
10				

c) Write the canonical SOP expression for F.

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

This problem has three parts. For full credit, you must answer all three parts correctly.

Show your work for each part.

Part 1. A company has been assigned the network block 192.168.16.0/20.

- **a.** Write the corresponding subnet mask in dotted-decimal format.
- **b.** How many usable host addresses are available in this allocation?
- **c.** Compare this allocation with the traditional Class C addressing scheme. How many contiguous Class C networks would be required to cover the same address space?

Part 2. Consider the allocation described in Part 1. The company decides to create four equal-size subnets out of this allocation.

- **a.** What prefix length will be required for each subnet?
- **b.** Write down the network address of the first and the last subnet.

Part 3. Consider that a packet with source IP address 192.168.25.34 and destination IP address 10.0.8.15 arrives at a router.

The router's routing table contains the following entries (prefix → next hop):

• 192.168.16.0/20 → Interface A

• 10.0.0.0/8 → Interface B

• 0.0.0.0/0 → Interface C (default route)

- **a.** Which routing table entry will be selected for forwarding this packet? Explain briefly using the principle of longest prefix match.
- **b.** If the destination were 192.168.19.200, which interface would be chosen?