# ARTIFICIAL INTELLIGENCE
# TOPICS for FINAL REVIEW (23CLC7 – 23CLC8)

1. **UNINFORMED SEARCH and INFORMED SEARCH**
    a. Tree-search algorithm vs. Graph-search algorithm
    b. Uninformed search: BFS, DFS, and UCS
    c. Informed search: Greedy Best First Search (GBFS) and A*
    d. Admissible heuristic and Consistent heuristic
    e. Draw the search tree that shows reached states during the search.
2. **LOCAL SEARCH**
    a. Global search vs. Local search
    b. Hill-Climbing (Hill-climbing and variants, simulated annealing, and local beam search)
    c. Genetic Algorithm
3. **ADVERSARIAL SEARCH**
    a. Minimax
    b. $\alpha - \beta$ pruning
4. **CONSTRAINT SATISFACTION PROBLEMS**
    a. Formulation: Variables, Domains, and Constraints (Unary/Binary)
    b. Algorithms:
        i. Node consistency
        ii. Arc consistency (AC-3)
        iii. Backtracking with Forward Checking
        iv. Heuristics: DH, MRV, and LCV
5. **PROPOSITIONAL LOGIC**
    a. Syntax, Semantic (Entailment)
    b. Algorithms:
        i. CNF conversion
        ii. Resolution (Contradiction) ← KB in CNF
        iii. Forward and Backward Chaining ← KB in Definite Clauses
6. **FIRST-ORDER LOGIC**
    a. Syntax, Semantic: Predicate, Function, Term, Quantifiers (∀, ∃)
    b. Algorithms:
        i. Unification, CNF conversion
        ii. Resolution ← KB in CNF
        iii. Forward and Backward Chaining ← KB in Definite Clauses
7. **MACHINE LEARNING**
    a. Learning Types: Supervised, Unsupervised, and Reinforcement learning
    b. Algorithms:
        i. ID3: Algorithm, Metrics to evaluate attributes (Entropy, Average Entropy, and Information Gain)
        ii. Perceptron Learning Rule (both feedforward and weight update)
        iii. Multi-layer Neural Network (both feedforward and weight update)

## ID3 formulas

The Entropy measure evaluates the uncertainty of a random variable $V$ with values $v_k$.

$$H(V) = \sum_k P(v_k) \log_2 \frac{1}{P(v_k)} = -\sum_k P(v_k) \log_2 P(v_k)$$

- $v_k$ is a class in $V$ (e.g., yes/no in binary classification).
- $P(v_k)$ is the proportion of the number of elements in class $v_k$ to the number of elements in $V$.

**Example 1:** The class attribute $V$ has two classes $v_1$ and $v_2$.

$$H(V) = -P(v_1) \log_2 P(v_1) - P(v_2) \log_2 P(v_2)$$

**Example 2:** The class attribute $V$ has three classes $v_1, v_2$, and $v_3$.

$$H(V) = -P(v_1) \log_2 P(v_1) - P(v_2) \log_2 P(v_2) - P(v_3) \log_2 P(v_3)$$

The Average Entropy measure for an attribute $X$ with values $x_i$

$$AE(X) = \sum_i P(X = x_i) H(X = x_i)$$

- $x_i$ is a value of the attribute X.
- $P(X = x_i)$ is the proportion of the number of elements in value $x_i$ to the number of elements in $X$.

**Example :** The attribute $X$ has three values $x_1, x_2$, and $x_3$.

$$HE(X) = P(X = x_1) H(X = x_1) + (X = x_2) H(X = x_2) + (X = x_3) H(X = x_3)$$

The Information Gain measure for an attribute $X$ with values $x_i$

$$IG(X) = AE(Dataset\ before\ splitting\ by\ X) - AE(X)$$

## Perceptron formulas using bias b

**Forward:**

$$Y(p) = \sigma\left(\sum_{i=1}^{n} w_i \cdot x_i + b\right)$$

where the step activation function is $\sigma(x) = \begin{cases} 1 & if\ x \geq 0 \\ 0 & if\ x < 0 \end{cases}$ and $n$ is the number of perceptron inputs.

**Backward:**

Update the weights $w_i$

$$w_i = w_i - \Delta w_i = w_i - \eta \cdot x_i \cdot (a - t)$$

where $\eta$ is the learning rate $(0 < \eta < 1)$, $a$ is the actual value, and $t$ is the target value.

Update the bias $b$

$$b = b - \eta \cdot \mathbf{1} \cdot (a - t)$$