**CSCI 446 – ARTIFICIAL INTELLIGENCE**

**EXAM 1 STUDY OUTLINE**

**Introduction to Artificial Intelligence**

I. Definitions of Artificial Intelligence

A. Acting Like Humans -- Turing Test

B. Thinking Like Humans -- Cognitive Modeling

C. Thinking Rationally -- Logicist Approach

D. Acting Rationally -- Rational Agents

1. Rationality

II. History of Artificial Intelligence

A. Gestation

B. Early Enthusiasm, Great Expectations

C. Dose of Reality

D. Knowledge Based Systems

E. AI Becomes and Industry

F. Return of Neural Networks

G. Recent Events

III. Rational Agents

A. Percepts

B. Environment

C. Actions

**Uninformed Search**

I. Planning Agents

A. Optimal vs. Complete

B. Planning vs. Replanning

II. Search Problem Formulation

A. State Space

B. Successor Function

C. Start State

D. Goal Test

E. Solution / Plan

A. Problem Types

1. Deterministic, fully observable: Single-State Problem

2. Non-observable: Conformant Problem

3. Nondeterministic and/or partially observable: Contingency Problem

4. Unknown state space: Exploration Problem

III. State Space Graphs and Search Trees

A. Tree Search

1. Completeness

2. Time Complexity

3. Space Complexity

4. Optimality

B. Depth First Search

C. Breadth First Search

D. Iterative Deepening

D. Uniform Cost Search

**Informed Search**

I. Heuristics

A. Admissible Heuristic

B. Consistency or Monotonicity

C. Dominance

D. Creating Heuristics – Relaxed Problems

II. Greedy Search

A. Heuristic h(n)

III. A\* Search

A. Actual Cost to Current Node + Heuristic -- g(n) + h(n)

IV. Graph Search

A. Consistency of Heuristic

**Constraint Satisfaction Problems (CSPs)**

I. CSP Problem Formulation

II. Using Search in CSPs

III. Improving Search

A. Backtracking Search

B. Filtering

1. Forward Checking

2. Constraint Propagation

C. Arc Consistency

C. Ordering

1, Minimum Remaining Values

1. Least Constraining Value

D. Problem Structure

IV. Problem Structure and Decomposition

A. Independent Sub-problems

B. Tree-Structured CSPs

C. Nearly Tree Structured CSPs

1. Cutset Conditioning

V. Local Search

A. Iterative Improvement

B. Hill Climbing

C. Genetic Algorithms

**Logical Agents**

I. Knowledge Based Agents

A. Knowledge Base

B. Inference Engine

C. Separation of Knowledge and Process

II. An Example

A. Wumpus World

III. General Logic

A. Entailment

B. Models

C. Inference

IV. Propositional Logic

A. Syntax

B. Truth Tables

V. Equivalence, Validity, Satisfiability

VI. Inference Rules / Theorem Proving

A. Forward Chaining

B. Backward Chaining

C. Resolution

1. Conjunctive Normal Form (CNF)

2. Conversion to CNF

3. Resolution

**First Order Logic**

I. Overview

II. Syntax and Semantics

A. Basic Elements

B. Atomic Sentences

C. Complex Sentences

D. Models

E. Universal Quantification

F. Existential Quantification

III. Fun with Sentences

A. Equality

**Inference in First Order Logic**

I. Unification

A. Universal Instantiation

B. Existential Instantiation

C. Reduction to Propositional Inference

D. Unification

II. Generalized Modus Ponens

III. Forward and Backward Chaining

A. Forward Chaining

B. Backward Chaining

IV. Resolution

**Games (Adversarial Search)**

I. Overview

A. Deterministic Games

B. Zero-Sum Games

II. Adversarial Search – Minimax (Perfect Play)

III. Resource Limits

A. Evaluation Functions

III. αβ Pruning

**Expectimax Search and Utilities**

I. Uncertain Outcomes

II. Expectimax

III. Optimism vs. Pessimism

IV. Utilities and Preferences

A. Lotteries

B. Rational Preferences

C. MEU Principles

D. Human Utilities

1. Micromorts

2. QALYs

3. Money – not an exact utility

**Markov Decision Processes**

I. Non-deterministic Search

A. MDP Formulation

B. Policies

C. MDP Search Trees

II. Utilities of Sequences

A. Discounting (γ)

III. Solving MDPs

A. Optimal Quantities

1. V\*(s)

2. Q\*(s,a)

3. π\*(s)

B. Bellman Equations

IV. Value Iteration

V. Policy Methods

1. Policy Evaluation

2. Policy Extraction

3. Policy Iteration

**Reinforcement Learning**

I. Offline (MDPs) vs. Online (Reinforcement Learning)

A. Model-Based Learning

1. Learn empirical MDP model

2. Solve the learned MDP

B. Model-Free Learning

C. Passive Reinforcement Learning

1. Policy Evaluation vs. Direct Evaluation

D. Temporal Difference Learning

D. Active Reinforcement Learning

II. Exploration vs. Exploitation

A. ε-Greedy

B. Exploration Functions

C. Regret

III. Approximate Q-Learning

A. Generalizing Across States – Feature Based Representations

IV. Relationship to Least Squares

A. Minimizing Error

B. Overfitting

V. Policy Search