*Total # points = 70.*

1. **[20 points]** Given the set of sentences below in a propositional-logic knowledge base (*KB*). (a) Apply *forward chaining* until no new facts (sentences) are produced. List the content of the *KB* when forward chaining stops. Here, a *query* is not given. (b) Given the hypothesis (or query) *S*, apply *backward chaining* to check whether *KB* entails *S*. What is the result after applying backward chaining? Does KB entails *S*? Why or why not?

**2. [10 points]** Is each of the following a *legal* atomic sentence that satisfies the syntax of first-order logic? In the following, Father( ) is a predicate; Mother( ) is a function; David, John and Mary are constants. *Just answer* True *or* False *to each part. No need to explain.*

(a) David = Father(John),

(b) Mary = Mother(John),

(c) Mother(Father(John))

(d) Father(Mother(John)).

**3. [20 points]** Convert the English sentences below to First-Order Logic sentences by using the predicates given. Use only the given predicates and do not introduce new ones.

Predicates: *Fish*(*x*): *x* is a fish. *Mammal*(x): *x* is a mammal. *Intelligent(x): x* is intelligent.

*Lives*(*x,y*) – person *x* lives in city *y*. *Owns*(*x,y*) – person *x* owns *y*. *Rich*(*x*) – person *x* is rich.

(a) Fish are not mammals.

(b) Some mammals are intelligent.

(c) Everyone who lives in NYC and owns a Condo is rich.

**4.** **[10 points**] What axiom is needed to infer the fact *Female (Laura)* given the facts *Male(Jim)* and *Spouse(Jim, Laura)*? Write your axiom in the form of a first-order-logic implication rule (See Section 8.3.2 of Chapter 8 in the text book for examples.)

*Multiple choices. Choose one and only one answer. No explanations to your answers are required.*

**5. [5 points]** Given a set of input samples in a 2-dimensional feature space, we apply a machine learning algorithm that will learn the structure of the sample points based on their proximity (or distance) to each other in the feature space. No output labels are available for these sample points. This is an example of

(a) Supervised learning

(b) Unsupervised learning

(c) Semi-supervised learning

(d) Reinforcement learning

(e) None of the above.

**6. [5 points]** Given a set of training samples where *x* is the input and *y* is the output, we apply a machine learning algorithm that will learn a hypothesis *h* that allows us to predict *y* given *x*. This is an example of

(a) Supervised learning

(b) Unsupervised learning

(c) Semi-supervised learning

(d) Reinforcement learning

(e) None of the above.