Ref. No.: Ex/CSE/T/325/2017 (Old)

B.E. COMPUTER SCIENCE AND ENGINEERING
3rd Year, 2nd Semester Examination, 2017 (Old)
Mathematical Logic and Functional Programming

Full Marks: 100 Time : 3 Hr

Attempt Any Five Questions. Write answers to the point and state all the assumptions (wherever required). ALL PARTS OF THE QUESTION SHOULD BE ANSWERED TOGETHER

Q 1) (a) Write a Prolog predicate `facti(N, F)` that asserts F is the factorial of N. (10)

(b) What is the taxonomy of programming languages. With each of the programming paradigms, give suitable examples to enunciate. (10)

Q 2) (a) Give a Prolog rule for the shift relation, using the append relation. shift(L1,L2) is true if list L2 is a circular shift of the list L1, e.g., shift([1,2,3,4],[3,4,1,2]) is true. (4)

(b) What is the difference between `[[1] | [2, 3]]` and `[1 | [2, 3]]` (4)

(c) What is *unification* ? Discuss the Herbrand Unification Algorithm with examples. (4+8)

Q 3) (a) Devise and test goals to find (a) all the mammals, (b) all the carnivores that are mammals, (c) all the mammals with stripes, (d) whether there is a reptile that has a mane. $(4 \times 3 = 12)$

```
animal(mammal,tiger,carnivore,stripes).
animal(mammal,hyena,carnivore,ugly).
animal(mammal,lion,carnivore,mane).
animal(mammal,zebra,herbivore,stripes).
animal(bird,eagle,carnivore,large).
animal(bird,sparrow,scavenger,small).
animal(reptile,snake,carnivore,long).
animal(reptile,lizard,scavenger,small).
```

(b) Assuming append has the usual definition, consider the following mystery predicate:

```
p([ ],[ ]).
p([A|B], C) :- p(B, D), append(D, [A], C).
```

Describe what would happen for each of the following queries in terms of the kinds of errors that would result or the solutions(s) that would be found. If more than one solution would be found, characterize them all.

(i) p([a,b,c,d,e],X). (4)
(ii) p(X,[a,b,c,d,e]). (4)

Q 4) (a) Write the negation of each statement as simply as possible stating the propositional logic used: $(4 \times 2 = 8)$

(i) If she works, she will earn money.
(ii) He swims if and only if the water is warm.

(b) Negate each of the following statements: $(4 \times 3 = 12)$

(i) All students live in the dormitories.
(ii) All mathematics majors are males.
(iii) Some students are 25 years old or older

Q 5) (a) For each of the English sentences below, come up with a translation to a first-order-logic or lambda-calculus expression that captures the meaning of the English sentence. $(3 \times 3 = 9)$

(i) Cory is happy.
(ii) Cory goes home.
(iii) All people go home.

(b) Consider following expression of the λ calculus: $(5 + 6 = 11)$

$$((\lambda x.\lambda y.(x)(x)y)\lambda x.x)a$$

(i) Which of the variables are bound? Mark all bound variables with arrows to their corresponding functions. Are there any free variables? If yes, circle them.
(ii) Derive the expression as far as possible using α conversions and β reductions. Take care that each intermediate step is shown and consistent. α conversions must not be omitted if they are required to preserve the meaning of the λ expression.

Q 6) (a) Given

$$A = \lambda m.\lambda n.\lambda f.\lambda x.mf(nfx)$$

and

$$T = \lambda f.\lambda x.f(fx)$$

. Find the normal form of (ATT). Conjecture what would happen if $T = \lambda f.\lambda x.f(f(fx))$. [10]

(b) Write Scala functional programmes for adding (**add**) and multipling (**mul**) two integers. [10]

Q 7) (a) Apply β -reduction to the following λ -expressions as much as possible $(3 \times 4 = 12)$

(i) $((\lambda.x)\lambda x.x)a$

(ii) $(((\lambda x.\lambda y.(xy))(\lambda y.y))w)$

(iii) $((\lambda x.xx)(\lambda y.y))(\lambda y.y)$

(b) Discuss Functional Programming with respect to the following factors: $(4 \times 2 = 8)$

(i) Functional Programming systems as programming languages

(ii) Advantages of Functional Programming systems.