Exercise 1 (Course questions / 06 points)

1) **selection, crossover, mutation**.....1.5
2) **Solution = program (GP), = path to food source (ACO), = food source (BCO), = position (PSO)** 1
3) **if we take α = 0, the ant move will depend only of the visibility, the pheromone will have any impact.** 0.5
4) **the purpose of velocity in the PSO algorithm is position change (particle move)→ exploring landscape**...0.5
5) **pbest = particle best position (inner attraction) ; gbest = global swarm best position (social attraction)** 1
6) **- good solutions are refined (*Employed and onlooker bees* intensify the search around good food sources (promising solutions) using local neighborhood search),**
   - bad ones are replaced (*Scout bees* search randomly for new food sources) 1

Exercise 2 (07 points)

1) 1.5

$$P(A,B) = \frac{\tau_{AB}^{\alpha}\eta_{AB}^{\beta}}{\tau_{AB}^{\alpha}\eta_{AB}^{\beta}+\tau_{AD}^{\alpha}\eta_{AD}^{\beta}} = \frac{\frac{1}{6}}{\frac{1}{6}+\frac{1}{3}+\frac{1}{2}} = \frac{1}{6}$$

$$P(A,C) = \frac{\tau_{AC}^{\alpha}\eta_{AC}^{\beta}}{\tau_{AB}^{\alpha}\eta_{AB}^{\beta}+\tau_{AD}^{\alpha}\eta_{AD}^{\beta}} = \frac{\frac{1}{3}}{\frac{1}{6}+\frac{1}{3}+\frac{1}{2}} = \frac{1}{3}$$

$$P(A,D) = \frac{\tau_{AD}^{\alpha}\eta_{AD}^{\beta}}{\tau_{AB}^{\alpha}\eta_{AB}^{\beta}+\tau_{AD}^{\alpha}\eta_{AD}^{\beta}} = \frac{\frac{1}{2}}{\frac{1}{6}+\frac{1}{3}+\frac{1}{2}} = \frac{1}{2}$$

2) **The cumulated probabilities are** $\frac{1}{6} \approx 0.16$; $\frac{1}{6}+\frac{1}{3} = 0.50$; $\frac{1}{6}+\frac{1}{3}+\frac{1}{2} = 1.$
   Since 0.76 ∈[0.5,1] therefore the next city chosen by this ant is D. 1
3) **Length(ADBC) = 2+4+8+3 = 17**.....0.5

$\tau_{AB} = \rho.\tau_0 = 0.8$

$\tau_{AC} = \rho.\tau_0 + \frac{Q}{\text{Length(ADBC)}} = 1.39$

$\tau_{AD} = \rho.\tau_0 + \frac{2.Q}{\text{Length(ADBC)}} = 1.39$

$\tau_{BC} = \rho.\tau_0 + \frac{Q}{\text{Length(ADBC)}} = 1.39$

$\tau_{BD} = \rho.\tau_0 + \frac{Q}{\text{Length(ADBC)}} = 1.39$

$\tau_{CD} = \rho.\tau_0 = 0.8$.....3

algorithm that updates the matrix τ. 1

```
Void updatepheromone(){
for (ant = 1; ant<= m; ant++)
      delta[i][j]+= Q/length(tour);
for (i=0; i<n; i++)
      for (j=0; j<n; j++)
            τ [i][j] = ρ ∗ τ [i][j] + delta[i][j] ;}
```

Exercise 3 (07 points)

1) **x= AAGCGCT.** 0.5
   search space = { A , T , C , G }^{n} ; |search space | = 4^n. 1
   Initialization algorithm. 1

```
Void initialization(){
for (i=0; i<m; i++)
     for (j=0; j<n; j++)
          P[i][j] = random(A,T,C,G) ;}
```

2) **parent1 = TCTATCC parent2 = AAGCGCT**
   child1 = TCTAGCT **child2 =** AAGCTCC 0.5

crossover algorithm.....1.5

```
Void Crossover(){
for (i=0; i<m-1; i+=2)
    if (random(0,1) <= pc )
        { point = randomint(0,n)
          for (j=point ; j<n; j++)
              swap(P[i][j], P[i+1][j]);}}
```

3) **a mutation of s = TCTATCC is = TCTTACC.** 0.5

Mutation algorithm.....1

```
Void Crossover(){
    for (i=0; i<m-1; i+=2)
        if (random(0,1) <= pm )
            { point = randomint(0,n-1)
              swap(P[i][point], P[i][point+1]);}}
```

4) **evaluation algorithm.** 1

```
    int hamming(int[] s; int[] x){
    count=0;
    for (j=0; j<n; j++)
              if (s[j] != x[j]) count ++;
    return count ;}
    void evaluation (){
    opt= infini;
    for (i=0; i<m; i++)
        if( hamming (s,P[i]) < opt)
            { opt = hamming (s,P[i]) ;
              Sol_opt= P[i];}}
```