1. Consider the UPA relation in an access control system implementing RBAC to be as follows:

$$UPA = \{ (u_1,p_1), (u_5,p_2), (u_1,p_2), (u_1,p_4), (u_4,p_3), (u_1,p_5), (u_2,p_3), (u_2,p_4), (u_2,p_2), (u_2,p_5), (u_3,p_2), (u_3,p_5), (u_3,p_1),$$

$$ (u_4,p_4), (u_5,p_1), (u_1,p_3), (u_5,p_3) \}$$

(a) Construct a bipartite graph from the above relation.

(b) Draw a biclique cover for this graph with 4 bicliques. From this biclique cover, write the UA and PA relations.

(c) Consider a Boolean matrix representation of the UPA relation given above with users as rows and permission as columns. Make a decomposition of this matrix into two matrices $A$ and $B$ where rows and columns of $A$ represent users and roles, respectively, and rows and columns of $B$ represent roles and permissions respectively. The number of columns of $A$ should be 3 and the decomposition is $\delta$-consistent with the original matrix for a $\delta$ value of 6.

$$[5+6+4+15=30]$$

2. Write a periodic expression to represent an infinite set of time intervals that begin at 9:00 am of every Monday, Thursday and Saturday of the months of March, June and October of every year and last for 45 seconds.