1. Using the corresponding letter labels, provide separate classifications of the Chess task environment according to the following class types and for each classification include a brief explanation:

(a) Fully observable/partially observable [2]  
    Fully observable, because a player’s sensors give access to the complete state of the environment (e.g., board state, time remaining for each player, number of moves since the last pawn moved or a piece was captured, player’s turn, etc.).

(b) Single agent/multiagent [2]  
    Multiagent because it involves two players.

(c) Deterministic/stochastic [2]  
    Deterministic, because future states of the environment are completely determined by the current state and the actions taken.

(d) Episodic/sequential [2]  
    Sequential, because the environment in any given state is dependent on the actions in previous states: the current board state is determined by the sequence of all moves made so far in the game.

(e) Static/dynamic/semi-dynamic [2]  
    Semi-dynamic, because while contemplating ones next move the board state remains unchanged, but the performance measure decreases as the amount of remaining time goes down.

(f) Discrete/continuous [2]  
    Discrete, because there are a finite number of percepts, actions, and reachable states.

(g) Known/unknown [2]  
    Known, because the players know the outcome for all actions.

2. Describe two advantages of Iterative Deepening Minimax algorithms over Depth Limited Minimax algorithms. [4]

   I) Solution availability: i.e., you always have the solution of the previous iteration available during the execution of the current iteration (this is particularly useful when under a time constraint).

   II) Information gleaned during the current iteration can be employed to increase pruning in successive iterations (e.g., history table). Because successive iterations require exponentially more CPU time, the overhead of searching at lower depths is typically insignificant while increased pruning at higher depths can be very significant.
The remaining questions are about the following adversarial search tree. State evaluation heuristic values for the max player are provided in the form of numbers following the letter labels of the states (e.g., A19 indicates that the state evaluation heuristic value of state A for the max player is 19). The order in which successors are generated is from left to right. Example: A generates first B, then C, and finally D.

3. Give the execution trace for HTABIDM(A,3,−∞,∞) [HTABIDM = History-Table Iterative-Deepening Depth-Limited Minimax with Alpha-Beta Pruning]. [30]

#define DLM( ) HTABDLM( ), #define Max( ) HTABMaxV( ), #define Min( ) HTABMinV( )

call frontier eval value α,β best action,value
DLM(A,1,−∞,∞) B0C0D0 B MinV(B,0,−∞,∞)=1 1,∞ AB, 1
D0 C MinV(C,0,1,∞)=5 5,∞ AC, 5

DLM(A,2,−∞,∞) D1B0C0 D MinV(D,1,−∞,∞)=6 (SSS) 6,∞ AD, 6 [DK:1]
B0C0 B MinV(B,1,6,∞)=4 6,∞ AD, 6
C MinV(C,1,6,∞)=3 6,∞ AD [6 AD:2]

MinV(B,1,6,∞) E0F0G0 E MaxV(E,0,6,∞)=8 6,8 BE, 8
F0G0 F MaxV(F,0,6,8)=4 (Prune) 6,8 BF, 4 [BF:1]

MinV(C,1,6,∞) H0I0J0 H MaxV(H,0,6,14)=14 6,14 CH, 14
I0J0 I MaxV(I,0,6,14)=3 (Prune) 6,14 CI, 3 [CI:1]

DLM(A,3,−∞,∞) D2B0C0 D MinV(D,2,−∞,∞)=9 9,∞ AD, 9
B0C0 B MinV(B,2,9,∞)=3 9,∞ AD, 9
C0 C MinV(C,2,9,∞)=1 9,∞ AD [9 AD:3]

MinV(D,2,−∞,∞) K1 K MaxV(K,1,−∞,∞)=9 −∞,9 DK, 9 [DK:2]
MaxV(K,1,−∞,∞) Y0Z0 Y MinV(Y,0,−∞,∞)=9 9,∞ KY, 9
Z0 Z MinV(Z,0,9,∞)=3 9,∞ KY, 9 [KY:1]

MinV(B,2,9,∞) F1E0G0 F MaxV(F,1,9,∞)=3 (Prune) 9,∞ BF, 3 [BF:2]
MaxV(F,1,9,∞) P0Q0 P MinV(P,0,9,∞)=2 9,∞ PF, 2
Q0 Q MinV(Q,0,9,∞)=3 9,∞ FQ, 3 [FQ:1]

MinV(C,2,9,∞) I1H0J0 I MaxV(I,1,9,∞)=1 (SSS,Prune) 9,∞ CI, 1 [IV:1,CI:2]

4. Indicate for each depth iteration of HTABIDM(A,3,−∞,∞) which nodes, if any, get pruned. [8]

Depth 1: none
Depth 2: G,J

5. What is the Principal Variant (PV) found by HTABIDM(A,3,−∞,∞)? [3]

A→D,D→K,K→Y

6. Would ABIDM(A,3,−∞,∞) have found the same PV? Explain your answer! [2]

Yes, because backward pruning methods such as αβ – pruning do not effect the outcome of a search, only its efficiency, so move ordering can only increase pruning, but not affect the search outcome.

7. Would IDM(A,3) have found the same PV? Explain your answer! [2]

Yes, because backward pruning methods such as αβ – pruning do not effect the outcome of a search, only its efficiency.