

Exam

● Graded

Student

Boxiang Fu

Total Points

81 / 100 pts

Question 1

(no title)

4 / 4 pts

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

✓ - 0 pts Correct

Question 2

(no title)

4 / 4 pts

✓ - 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Question 3

(no title)

2 / 4 pts

- 0 pts Correct

✓ - 1 pt A

✓ - 1 pt B

- 1 pt C

- 1 pt D

Question 4

(no title)

2 / 4 pts

– 0 pts Correct

– 1 pt A

– 1 pt B

✓ – 1 pt C

✓ – 1 pt D

Question 5

(no title)

4 / 4 pts

✓ – 0 pts Correct

– 1 pt A

– 1 pt B

– 1 pt C

– 1 pt D

Question 6

(no title)

3 / 4 pts

– 0 pts Correct

– 1 pt A

✓ – 1 pt B

– 1 pt C

– 1 pt D

Question 7

(no title)

3 / 4 pts

– 0 pts Correct

✓ – 1 pt A

– 1 pt B

– 1 pt C

– 1 pt D

Question 8

(no title)

2 / 4 pts

- 0 pts Correct

- 1 pt A

✓ - 1 pt B

- 1 pt C

✓ - 1 pt D

Question 9

(no title)

4 / 4 pts

✓ - 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Question 10

(no title)

4 / 4 pts

✓ - 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Question 11

(no title)

3 / 4 pts

- 0 pts Correct

- 1 pt A

- 1 pt B

✓ - 1 pt C

- 1 pt D

Question 12

(no title)

4 / 4 pts

– 0 pts Correct

– 1 pt A

– 1 pt B

– 1 pt C

– 1 pt D

Question 13

(no title)

3 / 4 pts

– 0 pts Correct

– 1 pt A

– 1 pt B

– 1 pt C

– 1 pt D

Question 14

(no title)

3 / 4 pts

– 0 pts Correct

– 1 pt A

– 1 pt B

– 1 pt C

– 1 pt D

Question 15

(no title)

3 / 4 pts

– 0 pts Correct

– 1 pt A

– 1 pt B

– 1 pt C

– 1 pt D

Question 16

(no title)

2 / 4 pts

– 0 pts Correct

– 1 pt A

– 1 pt B

✓ – 1 pt C

✓ – 1 pt D

Question 17

(no title)

3 / 4 pts

– 0 pts Correct

– 1 pt A

– 1 pt B

✓ – 1 pt C

– 1 pt D

Question 18

(no title)

3 / 4 pts

– 0 pts Correct

✓ – 1 pt A

– 1 pt B

– 1 pt C

– 1 pt D

Question 19

(no title)

3 / 4 pts

– 0 pts Correct

– 1 pt A

✓ – 1 pt B

– 1 pt C

– 1 pt D

Question 20

(no title)

4 / 4 pts

- 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Question 21

(no title)

3 / 4 pts

- 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Question 22

(no title)

4 / 4 pts

- 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Question 23

(no title)

4 / 4 pts

- 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Question 24

(no title)

4 / 4 pts

- 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Question 25

(no title)

3 / 4 pts

- 0 pts Correct

- 1 pt A

- 1 pt B

- 1 pt C

- 1 pt D

Boxiang Fu
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CS 15-888 Computational Game Solving: Final Exam

Instructions: The total number of points possible is 100. Each question is worth 4 points. Each question has *one or more* correct answers, and you must select all of them to receive full credit. For each subquestion, getting it right yields 1 point and getting it wrong yields 0 points.

1. Consider a sequential game with perfect information. Which of the following statements are true?

- (A) Backward induction always gives a subgame perfect equilibrium
- (B) There exists a pure Nash equilibrium
- (C) Every Nash equilibrium is subgame perfect
- (D) Every subgame perfect equilibrium is a Nash equilibrium

2. The minmax theorem for 2-player n -action 0-sum normal-form games was proven by

- (A) Emile Borel
- (B) John von Neumann
- (C) John Nash
- (D) Harold Kuhn

3. Consider a two-player zero-sum game in which the utilities of the row player are given by the following table.

	p_1	p_2	$1-p_1-p_2$
p_1	A	B	C
A	0	-2	1
B	2	0	-1
C	-1	1	0

Which of the following strategies is in the set of maxmin strategies for the row player?

- (A) $(0.25, 0.25, 0.5)$ $0.25(-2p_2 + 1 - p_1 - p_2) = 0.25(2p_1 - 1 + p_1 + p_2)$
 $= 0.25(-p_1 + p_2)$
- (B) $(0.25, 0.5, 0.25)$
- (C) $(1/3, 1/3, 1/3)$
- (D) $(0.5, 0.25, 0.25)$

Column p :
 A B C
 B A C

$E_R \approx \frac{1}{3}$

4. Consider the two-player general-sum game

	A	B
A	(3, 2)	(0, 0)
B	(0, 0)	(2, 3)

How many Nash equilibria does this game have?

- A) 1
 - B) 2
 - C) 3
 - D) Infinitely many
5. Consider a two-player zero-sum game in which the utilities of the row player are given by the following table.

	A	B	C	D	E	F	G	H	I	J
A	0	1	-2	0	3	-1	2	-3	1	0
B	-1	0	2	-1	0	1	-2	2	-1	3
C	2	-2	0	1	-1	0	2	-2	0	-1
D	0	1	-1	0	2	-2	1	0	-1	2
E	-3	0	1	-2	0	1	-3	2	0	-2
F	1	-1	0	2	-1	0	0	1	-2	1
G	-2	2	-2	-1	3	0	0	-1	2	0
H	3	-2	2	0	-2	-1	1	0	-1	2
I	-1	1	0	1	0	2	-2	1	0	-2
J	0	-3	1	-2	2	-1	0	-2	2	0

What is the value of this game?

- A) -1
 - B) 0.5
 - C) 1
 - D) 0
6. Which of the following is guaranteed to converge to the set of minimax equilibria in two-player zero-sum games?
- A) Last iterate of fictitious play
 - B) Average iterate of fictitious play
 - C) Average iterate of regret matching⁺
 - D) Average iterate of best-response dynamics
7. Which of the following statements are true for normal-form games?

- A) A Nash equilibrium can be supported on weakly dominated actions
- B) A correlated equilibrium can be supported on strictly dominated actions
- C) A coarse correlated equilibrium can be supported on strictly dominated actions
- D) If a player has a strictly dominant action a , a coarse correlated equilibrium can be supported on an action $a' \neq a$
8. Which of the following solution concepts supports polynomial-time strategy finding in adversarial team games?
- A) Team maxmim equilibrium (TME)
- B) Team maxmim equilibrium with coordination device (TMECor)
- C) Nash equilibrium that minimizes the utility of the adversary
- D) Coarse correlated equilibrium
9. Which of the following algorithms is the most efficient in terms of per-iteration running time?
- A) CFR
- B) Outcome-sampling MCCFR
- C) External-sampling MCCFR
- D) Fictitious play
10. The *price of anarchy* PoA_E of a game with respect to a solution concept E is defined as the ratio between the maximum attainable social welfare in the game and the welfare of the worst-case equilibrium from the set E . (The game is assumed to have nonnegative utilities.) The *price of stability* PoS_E is the ratio between the maximum attainable social welfare and the welfare of the best-case equilibrium from E . Which of the following statement(s) holds?
- A) $\text{PoA}_{NE} \leq \text{PoA}_{CCE}$
- B) $\text{PoA}_{CCE} \leq \text{PoA}_{CE}$
- C) $\text{PoS}_{NE} \leq \text{PoS}_{CCE}$
- D) $\text{PoS}_{CCE} \leq \text{PoS}_{CE}$
11. Which of the following is an advantage of the sequence-form representation over behavioral strategies?
- A) It uses less memory
- B) It is as expressive as mixed strategies in both imperfect- and perfect-recall games
- C) It is as expressive as mixed strategies in perfect-recall games
- D) The utility is linear in that player's strategy when the rest of the players are fixed
12. Which of the following statements are true?

- A) CE allows deviating after observing the recommendation; CCE only before
 B) In a zero-sum game, the marginals of any CCE constitute a Nash equilibrium
 C) In a zero-sum game, the marginals of any CE constitute a Nash equilibrium
 D) CCE allows deviating after observing the recommendation; CE only before
- 13. A pair of strategies (x, y) is symmetric if $x = y$. A correlated distribution μ is symmetric if $\mu_{ij} = \mu_{ji}$. Consider a symmetric two-player game (A, A^\top) . Which of the following statement(s) is true?
- A) There is always a symmetric Nash equilibrium
 B) All Nash equilibria are symmetric
 C) Running simultaneous regret matching⁺ produces a correlated distribution that is in the limit a symmetric coarse correlated equilibrium
 D) Running simultaneous regret matching produces a correlated distribution that is in the limit a symmetric coarse correlated equilibrium
14. Which of the following is true about the regret matching algorithm?
- A) When employed by all players, the correlated distribution of play converges to a coarse correlated equilibrium in general-sum games
 B) When employed by all players, it converges to a Nash equilibrium in general-sum games
 C) It guarantees sublinear external regret against an adversary
 D) When employed by all players, the correlated distribution of play converges to a welfare-maximizing coarse correlated equilibrium in two-player games
15. Which of the following statements are true for the sequence-form polytope?
- A) The number of vertices can be exponential in the dimension
 B) It can be described with a number of constraints that is polynomial in the dimension
 C) Given a point, there is a polynomial-time algorithm that ascertains whether that point belongs in the sequence-form polytope
 D) It is a bounded set
16. Which of the following algorithms can strictly increase exploitability in a zero-sum game from one iteration to the next?
- A) Anytime double oracle
 B) Double oracle
 C) Last iterate of best-response dynamics
 D) Last iterate of regret matching

17. Which of the following statements are true about Deep CFR?
- A) It uses neural networks to approximate the counterfactual regrets at each information set
 - B) It is guaranteed to converge to optimal strategies in imperfect-recall games
 - C) It obviates the need for manual game abstraction
 - D) It relies on MCCFR
18. Which of the following statements are true?
- A) Executing the Blum-Mansour algorithm for minimizing swap regret in extensive-form games requires exponential time
 - B) There are online algorithms with zero external regret but swap regret growing linearly in the time horizon
 - C) Swap regret minimization guarantees convergence to a Nash equilibrium in general-sum games
 - D) Swap regret minimization guarantees time-average convergence to a Nash equilibrium in two-player zero-sum games
19. Which of the following statements are true concerning abstraction in two-player zero-sum games?
- A) Computing an equilibrium in a coarser abstraction will always result in greater exploitability
 - B) If abstraction is performed only with respect to the maximizing player, a max-min strategy in a finer abstraction can only be closer to the value of the game
 - C) Lossless abstraction can result in a game with the same number of nodes
 - D) The value of a game is equal to the value of a lossless abstraction thereof
20. Which of the following statements are true concerning optimistic no-regret algorithms?
- A) Their per-iteration running time is lower than their non-optimistic counterparts
 - B) They rely on a prediction vector
 - C) They converge to Nash equilibria in two-player general-sum games
 - D) They can guarantee $o(\sqrt{T})$ regret against an adversary
21. Which of the following online algorithms are equivalent, in that they produce the same sequence of strategies under the same sequence of utilities?
- A) Mirror descent and FTRL with entropic regularization
 - B) Mirror descent and FTRL with Euclidean regularization
 - C) Best-response dynamics and mirror descent with learning rate $\eta = \infty$
 - D) Fictitious play and FTRL with learning rate $\eta = \infty$

22. Which of the following statements are true regarding computational game theory in Texas hold'em poker?

- A) The state-of-the-art abstractions are imperfect-recall games
- B) Libratus used a different strategy against different human opponents
- C) Reaching superhuman level in 6-player poker required more computation than reaching superhuman level in 2-player poker
- D) Libratus learned weaknesses in the humans' play and changed its strategy to exploit those weaknesses

23. Which of the following statements are true?

- A) Optimal play has been reached in 2-player no-limit Texas hold'em poker
- B) Superhuman play has been reached in Fog-of-War chess
- C) No strategy is known for beating AlphaGo
- D) Bluffing is helpful in Stratego

perfect recall

24. Consider a finite 2-player 0-sum extensive-form game. Which of the following statements are true?

- A) All Nash equilibrium strategies are minmax strategies
- B) By playing a non-equilibrium strategy, a player can in some cases cause the opponent's beliefs to be incorrect
- C) By playing a non-equilibrium strategy, a player can in some cases achieve higher expected utility against an opponent who plays one of the opponent's equilibrium strategies
- D) There is exactly one equilibrium

25. Which of the following statements are true?

- A) Every finite normal-form game has at least one equilibrium
- B) Finite 2-player 0-sum extensive-form games can be solved in polynomial time
- C) In (finite) normal-form 2-player games, finding a Nash equilibrium is PPAD-complete.
- D) In (finite) normal-form 2-player 0-sum games, a player's set of minmax strategies can be disconnected