Indian Institute of Technology Kharagpur
Department of Computer Science and Engineering

CS60025 Algorithmic Game Theory **Autumn 2026**

Quiz 2 **17 September, 3:00 PM – 3:20 PM** **Marks :10 $\times$ 1.5=15**

Name: ______________________________ **Roll No.:** ____________________

Please write your answers in the space provided. Do not mark on the questions.
Abbreviations: *Dominant Strategy Equilibrium (DSE), Pure Strategy Nash Equilibrium (PSNE), Mixed Strategy Nash Equilibrium (MSNE), Correlated Equilibrium (CE), Coarse Correlated Equilibrium (CCE)*

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1. A finite game is a potential game if and only if for every two strategy profiles $\mathbf{s^1}$, $\mathbf{s^2}$ that differ in two players' choices (say, i and j), the following holds.
   - A. $\pi_j(\mathbf{s}^2) - \pi_j(s_i^2, \mathbf{s}_{-i}^1) = \pi_i(\mathbf{s}^2) - \pi_i(s_j^2, \mathbf{s}_{-j}^1)$
   - B. $\pi_i(s_i^2, \mathbf{s}_{-i}^1) - \pi_i(\mathbf{s}^1) = \pi_i(\mathbf{s}^2) - \pi_i(s_j^2, \mathbf{s}_{-j}^1)$
   - **C.** $\pi_i(s_i^2, \mathbf{s}_{-i}^1) - \pi_i(\mathbf{s}^1) + \pi_j(\mathbf{s}^2) - \pi_j(s_i^2, \mathbf{s}_{-i}^1) = \pi_j(s_j^2, \mathbf{s}_{-j}^1) - \pi_j(\mathbf{s}^1) + \pi_i(\mathbf{s}^2) - \pi_i(s_j^2, \mathbf{s}_{-j}^1)$
   - D. $\pi_i(s_i^2, \mathbf{s}_{-i}^1) - \pi_i(\mathbf{s}^1) + \pi_i(\mathbf{s}^2) - \pi_i(s_i^2, \mathbf{s}_{-i}^1) = \pi_j(s_j^2, \mathbf{s}_{-j}^1) - \pi_j(\mathbf{s}^1) + \pi_j(\mathbf{s}^2) - \pi_j(s_j^2, \mathbf{s}_{-j}^1)$
2. Which of the following is true?
   - A. Every CE is an PSNE.
   - **B. Every MSNE is a CCE.**
   - C. Every CE is a DSE
   - D. Every CCE is an MSNE.
3. Pick the incorrect option. Computing PSNE for symmetric congestion games is
   - A. in NP
   - B. PLS-Complete
   - C. in TFNP
   - **D. in P**
4. Which of the following is not true for the problem Π of computing MSNE in a finite bimatrix game (A, B), where players 1, 2 have n, m choices respectively ($A \in \mathbb{R}^{n\times m}$, $B \in \mathbb{R}^{m\times n}$)?
   - A. $\Pi \in$ PPAD-Complete
   - **B. $\Pi \in$ FNP-Complete**
   - C. $\Pi \in$ P when $B = -A^T$
   - D. $\Pi \in$ FNP
5. Best response dynamics on a finite potential game
   - A. always takes exponential time to converge to a PSNE.
   - **B. always converges to a PSNE.**

C. may not reach a PSNE in finite time.

D. reaches a PSNE in time polynomial in the game parameters

6. When every player runs no external regret dynamics, the time averaged product distribution of the distributions output by the players is a

   A. CE

   B. Approximate CCE

   C. Approximate CE

   D. CCE

7. Consider a network congestion game on two parallel edges e_1, e_2 shared by 3 players. The edge costs are $c_1(k) = 3k$ and $c_2(k) = k^2 + 1$, where k is the number of players using edge e. If 2 players choose e_1 and 1 player chooses e_2, what is potential function value $\Phi(s) = \sum_e \sum_{i=1}^{n_e(s)} c_e(i)$?

   A. 15

   B. 11

   C. 13

   D. 9

8. Consider the following 2×2 game:

	C	D
C	$(5,5)$	$(1,6)$
D	$(6,1)$	$(0,0)$

   A mediator samples an outcome from the joint distribution $\sigma(C,C) = \sigma(C,D) = \sigma(D,C) = \frac{1}{3}$ and $\sigma(D,D) = 0$. Which of the following statements regarding their conditional expected payoffs is correct?

   A. $\mathbb{E}_{s\sim\sigma}[u_1(s) \mid s_1 = C] = 3$ **and** $\mathbb{E}_{s\sim\sigma}[u_1(D, s_2) \mid s_1 = C] = 3$

   B. $\mathbb{E}_{s\sim\sigma}[u_1(s) \mid s_1 = C] = 3$ and $\mathbb{E}_{s\sim\sigma}[u_1(D, s_2) \mid s_1 = C] = 3.5$

   C. $\mathbb{E}_{s\sim\sigma}[u_1(s) \mid s_1 = C] = 2.5$ and $\mathbb{E}_{s\sim\sigma}[u_1(D, s_2) \mid s_1 = C] = 1.5$

   D. $\mathbb{E}_{s\sim\sigma}[u_1(s) \mid s_1 = C] = 5$ and $\mathbb{E}_{s\sim\sigma}[u_1(D, s_2) \mid s_1 = C] = 6$

9. Consider the following two-player coordination game with strategy sets $S_1 = S_2 = \{B, S\}$:

	B	S
B	$(2,1)$	$(0,0)$
S	$(0,0)$	$(1,2)$

   Which of the following distributions, over profiles $(B,B), (B,S), (S,B), (S,S)$, is **NOT** a CE?

   A. $\left(\frac{1}{6}, \frac{1}{3}, \frac{1}{3}, \frac{1}{6}\right)$

   B. $\left(\frac{1}{2}, 0, 0, \frac{1}{2}\right)$

   C. $\left(\frac{2}{9}, \frac{4}{9}, \frac{1}{9}, \frac{2}{9}\right)$

D. $\left(\frac{1}{3}, \frac{1}{6}, \frac{1}{6}, \frac{1}{3}\right)$

10. Consider an n-player cost minimisation game where $C_i(\mathbf{s}) \geq 0$ denotes the cost function for player $i \in [n]$ under strategy profile $\mathbf{s}$. At each iteration $t \in [T]$, each player i chooses a mixed strategy $p_i^t \in \Delta(S_i)$, forming the product distribution $\sigma_t = \prod_{j=1}^n p_j^t$. How is player i's time-averaged external regret $R_i(T)$ defined, and what does no-external-regret dynamics guarantee regarding the empirical time-averaged distribution $\sigma = \frac{1}{T}\sum_{t=1}^T \sigma_t$?

    A. $R_i(T) = \frac{1}{T}\left(\max_{s_i^* \in S_i} \sum_{t=1}^T \mathbb{E}_{\mathbf{s}^t \sim \sigma_t}[C_i(\mathbf{s}^t) - C_i(s_i^*, \mathbf{s}_{-i}^t)]\right)$, and σ converges to a PSNE.

    B. $R_i(T) = \frac{1}{T}\left(\min_{s_i^* \in S_i} \sum_{t=1}^T \mathbb{E}_{\mathbf{s}_{-i}^t \sim \sigma_{-i}^t}[C_i(s_i^*, \mathbf{s}_{-i}^t)] - \sum_{t=1}^T \mathbb{E}_{\mathbf{s}^t \sim \sigma_t}[C_i(\mathbf{s}^t)]\right)$, and σ converges to an approximate CCE.

    C. $R_i(T) = \frac{1}{T}\left(\sum_{t=1}^T \mathbb{E}_{\mathbf{s}^t \sim \sigma_t}[C_i(\mathbf{s}^t)] - \min_{s_i^* \in S_i} \sum_{t=1}^T \mathbb{E}_{\mathbf{s}_{-i}^t \sim \sigma_{-i}^t}[C_i(s_i^*, \mathbf{s}_{-i}^t)]\right)$, and σ converges to an exact CE.

    D. $R_i(T) = \frac{1}{T}\left(\sum_{t=1}^T \mathbb{E}_{\mathbf{s}^t \sim \sigma_t}[C_i(\mathbf{s}^t)] - \min_{s_i^* \in S_i} \sum_{t=1}^T \mathbb{E}_{\mathbf{s}_{-i}^t \sim \sigma_{-i}^t}[C_i(s_i^*, \mathbf{s}_{-i}^t)]\right)$**, and σ converges to an approximate CCE.**