BKU, VNU-HCM
FACULTY OF CS AND ENGINEERING

MIDTERM
Subject: **Maths Modelling** (CO2011)
Class: **CC18KHMT** Groups: **CC01, CC02**
Time: **60 minutes** ***(One personal A4-sheet allowed)***
Test date: **June 3, 2020**

(*There are* ***20*** *MCQs, each question is worth* ***0.5*** *points. Indicate your choice on the answer sheet.*)

Question 1. Which of the following statements is true for a pair of primal and dual problems?

(A) If the primal problem is infeasible, it is possible that the dual problem still has an optimal solution.
(B) The dual problem of the dual problem is different from the primal problem.
(C) Variables in one program correspond to constraints in the other.
(D) There is no guarantee that the optimal solution to one problem will exist if the optimal solution to the other problem exists.

Question 2. Which of the following predicate calculus formulas must be true under all interpretations?

I. $(\forall x P(x) \vee \forall x Q(x)) \longrightarrow \forall x(P(x) \vee Q(x))$.

II. $\forall x(P(x) \vee \forall x Q(x)) \longrightarrow (\forall x P(x) \vee \forall x Q(x))$.

III. $(\exists x P(x) \vee \exists x Q(x)) \longrightarrow \exists x(P(x) \vee Q(x))$.

(A) I only. (B) III only. (C) I and III. (D) I and II.

Question 3. Suppose that $P(x, y)$ means "x is a parent of y" and $M(x)$ means "x is male." If $F(v, w)$ equals

$$M(v) \wedge \exists x \exists y(P(x, y) \wedge P(x, v) \wedge (y \neq v) \wedge P(y, w)),$$

then what is the meaning of the expression $F(v, w)$?

(A) v is a brother of w.
(B) v is a nephew of w.
(C) v is a grandfather of w.
(D) v is an uncle of w.

Question 4. In the branch and bound technique, what is the definition of the incumbent?

(A) The upper bound of the objective function.
(B) The best integer solution that we obtain at each step of branching and bounding.
(C) The lower bound of the objective function.
(D) None of the other choices is correct.

For questions 5–7, use the following information.

Payoff matrix. Consider a game for 2 players. The game proceeds in a series of identical rounds, in each round the 2 players make a move and depending on the moves either a tie is declared or one player is declared the loser and has to pay the winner a certain amount. A payoff matrix for the player one is defined as the matrix $A = (a_{ij})$ such that $a_{ij} > 0$ if the player I wins, $a_{ij} < 0$ if the player II wins, and $a_{ij} = 0$ if the round is a tie.

Morra game. In each round each player hides either one or two coins and also guesses how many coins the other player hid (they guess in secret and reveal their guesses simultaneously). If either both players guess incorrectly or both players guess correctly the round is a tie and no money changes hands. But if exactly one player guesses correctly, then that player gets to keep the coins hidden by both players.

Question 5. If $HmGn$ denotes a player hides m coins and guesses n coins for $m, n \in \{1, 2\}$. Which of the following is the payoff matrix of the Morra game for the player I?

(A)

	H1G1	H1G2	H2G1	H2G2
H1G1	0	2	-3	0
H1G2	-2	0	0	3
H2G1	3	0	0	-4
H2G2	0	-3	4	0

(B)

	H1G1	H1G2	H2G1	H2G2
H1G1	1	2	-3	0
H1G2	-2	1	0	3
H2G1	3	0	1	-4
H2G2	0	-3	4	1

(C)

	H1G1	H1G2	H2G1	H2G2
H1G1	1	-2	3	0
H1G2	2	1	0	-3
H2G1	-3	0	1	4
H2G2	0	3	-4	1

(D)

	H1G1	H1G2	H2G1	H2G2
H1G1	0	-2	3	0
H1G2	2	0	0	-3
H2G1	-3	0	0	4
H2G2	0	3	-4	0

Question 6. Each row and column of the payoff matrix A for the player I respectively is a strategy of the player I and the player II. If $y := (y_1, y_2, y_3, y_4)$ is the probability of the 4 strategies that the player II uses, the expected winnings of the player I will be $x^T Ay$, where $x := (x_1, x_2, x_3, x_4)$ is the probability of the 4 strategies that the player I plays. The player II thus wants $\min_y(x^T Ay)$, and the player I can win the game if he can find x maximizing $\min_y(x^T Ay)$. Let

$$z := \min_y (x^T Ay).$$

Which of the following can be a model for finding an optimal strategy for the player I in the Morra game?

(A) max z subject to $\{z - 2x_2 + 3x_3 \le 0; z + 2x_1 - 3x_4 \le 0; z - 3x_1 + 4x_4 \le 0; z + 3x_2 - 4x_3 \le 0; x_1 + x_2 + x_3 + x_4 = 1; x_1, x_2, x_3, x_4 \ge 0\}$

(B) max z subject to $\{z + 2x_2 - 3x_3 \le 0; z - 2x_1 + 3x_4 \le 0; z + 3x_1 - 4x_4 \le 0; z - 3x_2 + 4x_3 \le 0; x_1 + x_2 + x_3 + x_4 = 1; x_1, x_2, x_3, x_4 \ge 0\}$

(C) max z subject to $\{2x_2 - 3x_3 \le 0; -2x_1 + 3x_4 \le 0; 3x_1 - 4x_4 \le 0; 3x_2 - 4x_3 \le 0; x_1, x_2, x_3, x_4 \in \{0, 1\}\}$

(D) max z subject to $\{z + 2x_2 - 3x_3 \le 0; z - 2x_1 + 3x_4 \le 0; z + 3x_1 - 4x_4 \le 0; z - 3x_2 + 4x_3 \le 0; x_1, x_2, x_3, x_4 \ge 0\}$

Question 7. The optimal value of z is

(A) 0 (B) 1 (C) 3 (D) 2 or 4

Question 8. An optimal solution for the player II is approximately $(y_1, y_2, y_3, y_4) = (0, 0.5715, 0.4285, 0)$. Thus an optimal strategy for the player II is:

(A) 57.15% of the time hide 1 and guess 2.
(B) 42.85% of the time hide 1 and guess 1.
(C) 57.15% of the time hide 2 and guess 1.
(D) 42.85% of the time hide 2 and guess 2.

Question 9. Which of these is NOT a valid inference rule, where A, B and C are any propositional formula?

(A) From $\neg B$ and $A \longrightarrow B$ infer $\neg A$.
(B) From A infer $A \wedge B$.
(C) From A and $A \longrightarrow B$ infer B.
(D) From A infer $\neg\neg A$.

Question 10. Four men and four women are nominated for two positions. Exactly one man and one woman are elected. The men are A, B, C, D and the women are E, F, G, H. We know:

- if neither A nor E won, then G won
- if neither B nor G won, then C won
- if neither A nor F won, then B won
- if neither C nor F won, then E won.

Who were the two people elected?

(A) $C; G$. (B) $B; G$. (C) $B; E$. (D) $C; E$.

Question 11. Which of the following statements is true?

(A) It is always possible to obtain an optimal solution to a linear programming problem by using the simplex method while it is not the case where we use the interior-point methods.
(B) We begin the simplex algorithm and the interior-point methods at a vertex of the feasible polyhedron.
(C) In the interior-point methods, the simplex tableaux must be established in order to obtain valid cuts.
(D) If we can obtain an optimal solution to a linear programming problem by using interior-point methods, strong duality holds for the problem.

Question 12. A farmer has recently acquired a 110 hectares piece of land. He has decided to grow Wheat and Barley on that land. Due to the quality of the sun and the region's excellent climate, the entire production of Wheat and Barley can be sold. He wants to know how to plant each variety in the 110 hectares, given the costs, net profits and labor requirements according to the data shown below:

Variety	Cost (Price/Hec)	Net Profit (Price/Hec)	Man-days/Hec
Wheat	100	50	10
Barley	200	120	30

The farmer has a budget of US\$ 10000 and availability of 1200 man-days during the planning horizon. Find the maximum profit that he can attain.

(A) US\$ 1200 (B) US\$ 4500 (C) US\$ 5400 (D) US\$ 6500

Question 13. Consider the linear pogramming problem

$$\max\ 5x_1 + 2x_2 + x_3$$

$$\begin{array}{lrcrcrcl} \text{subject to} & x_1 & + & 3x_2 & - & x_3 & \le & 6 \\ & & & x_2 & + & x_3 & \le & 4 \\ & 3x_1 & + & x_2 & & & \le & 7 \end{array}$$

The dual problem is:

(A) $\min\ 6x_1 + 4x_2 + 7x_3$ subject to $\{x_1 + 3x_3 \ge 5; 3x_1 + x_2 + x_3 \ge 2; x_2 - x_1 \ge 1\}$
(B) $\min\ 6x_1 + 4x_2 + 7x_3$ subject to $\{x_1 + 3x_3 \ge 5; 3x_1 + x_2 + x_3 \ge 2; -x_2 + x_1 \ge 1\}$
(C) $\min\ 6x_1 + 4x_2 + 7x_3$ subject to $\{x_1 + 3x_2 - x_3 \ge 5; x_2 + x_3 \ge 2; 3x_1 + x_2 \ge 1\}$
(D) $\min\ 5x_1 + 2x_2 + x_3$ subject to $\{x_1 + 3x_3 \ge 6; 3x_1 + x_2 + x_3 \ge 4; x_2 - x_1 \ge 7\}$

Question 14. In the first step of a branch and bound approach to solving integer programming problems is to

(A) Graph the problem.
(B) Change the objective function coefficients to whole integer numbers.
(C) Solve the original problem by allowing continuous noninteger solutions.
(D) Compare the lower bound to any upper bound of your choice.

Question 15. By assigning $p = r = 0$, and $q = 1$, the true value of the following propositions

$$(p \longrightarrow q) \wedge (q \longrightarrow r);\ \ p \longrightarrow q \longrightarrow r$$

are, respectively,

(A) $0; 0.$ (B) $1; 1.$ (C) $0; 1.$ (D) $1; 0.$

Question 16. Consider the set of 12 bit string of length 6 as follow:

$$\{(000000), (100000), (110000), (111000), (111100), (111110),$$

$$(111111), (011111), (001111), (000111), (000011), (000001)\}.$$

For each $0 \le i \le 5$, let's denote by b_i the proposition "the i-th bit in the string is 1." Which of the following formula cab be used for modeling the given set?

(A) $\bigvee_{k=0}^{5}\left(\left(\bigwedge_{i=0}^{k} \neg b_i \wedge \bigwedge_{i=k+1}^{5} b_i\right) \wedge \left(\bigwedge_{i=0}^{k} b_i \wedge \bigwedge_{i=k+1}^{5} \neg b_i\right)\right)$.

(B) $\bigwedge_{k=0}^{5}\left(\left(\bigwedge_{i=0}^{k} \neg b_i \wedge \bigwedge_{i=k+1}^{5} b_i\right) \wedge \left(\bigwedge_{i=0}^{k} b_i \wedge \bigwedge_{i=k+1}^{5} \neg b_i\right)\right)$.

(C) $\bigvee_{k=0}^{5}\left(\left(\bigwedge_{i=0}^{k} \neg b_i \wedge \bigwedge_{i=k+1}^{5} b_i\right) \vee \left(\bigwedge_{k=0}^{k} b_i \wedge \bigwedge_{i=k+1}^{5} \neg b_i\right)\right)$.

(D) $\bigwedge_{k=0}^{5}\left(\left(\bigwedge_{i=0}^{k} \neg b_i \wedge \bigwedge_{i=k+1}^{5} b_i\right) \vee \left(\bigwedge_{i=0}^{k} b_i \wedge \bigwedge_{i=k+1}^{5} \neg b_i\right)\right)$.

Question 17. There are three suspects for a murder: Adam, Brown, and Clark. It has been established beyond any reasonable doubt that exactly one of them is the killer. [So, two are innocents, one is guilty.] Your task is to figure out which one. You questioned Adam, Brown, and Clark one-by-one. Adam says "I didn't do it. The victim was old acquaintance of Brown's. But Clark hated him." Brown states "I didn't do it. I didn't know the guy. Besides I was out of town all week." Finally, Clark says "I didn't do it. I saw both Adam and Brown downtown with the victim that day; one of them must have done it." Assuming that the innocent men are telling the truth, but that the guilty man might not be, discover the killer.

(A) Adam is the killer.
(B) Brown is the killer.
(C) Clark is the killer.
(D) The given information is insufficient to discover the killer.

Question 18. An adequate set of connectives for propositional logic is a set such that for every formula of propositional logic there is an equivalent formula with only connectives from that set. Which of the following is an adequate set?

(A) $\{\neg, \wedge\}$.
(B) $\{\neg, \to\}$.
(C) $\{\to, \perp\}$.
(D) $\{\to, \wedge\}$.

Question 19. In this question, assume the following predicate and constant symbols:

$W(x, y)$: x wrote y	h : Hardy	p : Pride and Predjudice.
$L(x, y)$: x is longer than y	a : Austen	
$N(x)$: x is a novel	j : Jude the Obscure	

Given these specifications, which of the predicate logic formulas below represent the sentence, "*Hardy wrote a novel which is longer than any of Austen's*" in predicate logic?

(A) $\forall x(W(h, x) \to L(x, a)))$.
(B) $\forall x \exists y(L(x, y) \to W(h, y) \wedge W(a, x))$.
(C) $\forall x \forall y(W(h, x) \wedge W(a, y) \to L(x, y)))$.
(D) $\exists x(N(x) \wedge W(h, x) \wedge \forall y(N(y) \wedge W(a, y) \to L(x, y)))$.

Question 20. A *precondition* (a condition specifies what should be true upon entering the program (i.e., under what inputs the program is expected to work).) of the following program

$$\begin{array}{l} r := 1; \\ i := 0; \\ \textbf{while } i < n \textbf{ do} \\ \qquad r := r * m; \\ \qquad i := i + 1 \end{array}$$

is

(A) $(m \ge 0) \wedge (n \ge 0)$.
(B) $m \ge 0$.
(C) $n \ge 0$.
(D) $(m > 0) \wedge (n \ge 0)$.

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(B) $\bigvee_{k=0}^{5}\left(\left(\bigwedge_{i=0}^{k}\neg b_i \wedge \bigwedge_{i=k+1}^{5} b_i\right) \bigwedge \left(\bigwedge_{i=0}^{k} b_i \wedge \bigwedge_{i=k+1}^{5} \neg b_i\right)\right)$.

(C) $\bigwedge_{k=0}^{5}\left(\left(\bigwedge_{i=0}^{k}\neg b_i \wedge \bigwedge_{i=k+1}^{5} b_i\right) \bigwedge \left(\bigwedge_{i=0}^{k} b_i \wedge \bigwedge_{i=k+1}^{5} \neg b_i\right)\right)$.

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Question 2. Which of the following statements is true for a pair of primal and dual problems?

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(A) $\exists x(N(x) \wedge W(h,x) \wedge \forall y(N(y) \wedge W(a,y) \to L(x,y)))$.
(B) $\forall x(W(h,x) \to L(x,a)))$.
(C) $\forall x \exists y(L(x,y) \to W(h,y) \wedge W(a,x))$.
(D) $\forall x \forall y(W(h,x) \wedge W(a,y) \to L(x,y)))$.

Question 5. Suppose that $P(x,y)$ means "x is a parent of y" and $M(x)$ means "x is male." If $F(v,w)$ equals

$$M(v) \wedge \exists x \exists y(P(x,y) \wedge P(x,v) \wedge (y \neq v) \wedge P(y,w)),$$

then what is the meaning of the expression $F(v,w)$?

(A) v is an uncle of w.
(B) v is a brother of w.
(C) v is a nephew of w.
(D) v is a grandfather of w.

Question 6. Which of these is NOT a valid inference rule, where A, B and C are any propositional formula?

(A) From A infer $\neg\neg A$. (B) From $\neg B$ and $A \longrightarrow B$ infer $\neg A$.
(C) From A infer $A \wedge B$. (D) From A and $A \longrightarrow B$ infer B.

Question 7. In the branch and bound technique, what is the definition of the incumbent?

(A) None of the other choices is correct.
(B) The upper bound of the objective function.
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I. $(\forall x P(x) \vee \forall x Q(x)) \longrightarrow \forall x(P(x) \vee Q(x))$.

II. $\forall x(P(x) \vee \forall x Q(x)) \longrightarrow (\forall x P(x) \vee \forall x Q(x))$.

III. $(\exists x P(x) \vee \exists x Q(x)) \longrightarrow \exists x(P(x) \vee Q(x))$.

(A) I and II. (B) I only. (C) III only. (D) I and III.

Question 10. By assigning $p = r = 0$, and $q = 1$, the true value of the following propositions

$$(p \longrightarrow q) \wedge (q \longrightarrow r);\ p \longrightarrow q \longrightarrow r$$

are, respectively,

(A) $1; 0$. (B) $0; 0$. (C) $1; 1$. (D) $0; 1$.

Question 11. In the first step of a branch and bound approach to solving integer programming problems is to

(A) Compare the lower bound to any upper bound of your choice.
(B) Graph the problem.
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Variety	Cost (Price/Hec)	Net Profit (Price/Hec)	Man-days/Hec
Wheat	100	50	10
Barley	200	120	30

The farmer has a budget of US\$ 10000 and availability of 1200 man-days during the planning horizon. Find the maximum profit that he can attain.

(A) US\$ 6500 (B) US\$ 1200 (C) US\$ 4500 (D) US\$ 5400

Question 13. A *precondition* (a condition specifies what should be true upon entering the program (i.e., under what inputs the program is expected to work).) of the following program

$r := 1;$
$i := 0;$
while $i < n$ **do**
    $r := r * m;$
    $i := i + 1$

is

(A) $(m > 0) \wedge (n \geq 0)$.
(B) $(m \geq 0) \wedge (n \geq 0)$.
(C) $m \geq 0$.
(D) $n \geq 0$.

Question 14. Four men and four women are nominated for two positions. Exactly one man and one woman are elected. The men are A, B, C, D and the women are E, F, G, H. We know:

- if neither A nor E won, then G won
- if neither A nor F won, then B won
- if neither B nor G won, then C won
- if neither C nor F won, then E won.

Who were the two people elected?

(A) $C; E$.
(B) $C; G$.
(C) $B; G$.
(D) $B; E$.

For questions 15–17, use the following information.

Payoff matrix. Consider a game for 2 players. The game proceeds in a series of identical rounds, in each round the 2 players make a move and depending on the moves either a tie is declared or one player is declared the loser and has to pay the winner a certain amount. A payoff matrix for the player one is defined as the matrix $A = (a_{ij})$ such that $a_{ij} > 0$ if the player I wins, $a_{ij} < 0$ if the player II wins, and $a_{ij} = 0$ if the round is a tie.

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H1G1	0	-2	3	0
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H2G1	-3	0	0	4
H2G2	0	3	-4	0

(B)

	H1G1	H1G2	H2G1	H2G2
H1G1	0	2	-3	0
H1G2	-2	0	0	3
H2G1	3	0	0	-4
H2G2	0	-3	4	0

(C)

	H1G1	H1G2	H2G1	H2G2
H1G1	1	2	-3	0
H1G2	-2	1	0	3
H2G1	3	0	1	-4
H2G2	0	-3	4	1

(D)

	H1G1	H1G2	H2G1	H2G2
H1G1	1	-2	3	0
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H2G1	-3	0	1	4
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Question 16. Each row and column of the payoff matrix A for the player I respectively is a strategy of the player I and the player II. If $y := (y_1, y_2, y_3, y_4)$ is the probability of the 4 strategies that the player II uses, the expected winnings of the player I will be $x^T Ay$, where $x := (x_1, x_2, x_3, x_4)$ is the probability of the 4 strategies that the player I plays. The player II thus wants $\min_y(x^T Ay)$, and the player I can win the game if he can find x maximizing $\min_y(x^T Ay)$. Let

$$z := \min_y(x^T Ay).$$

Which of the following can be a model for finding an optimal strategy for the player I in the Morra game?

(A) max z subject to $\{z+2x_2-3x_3 \leq 0; z-2x_1+3x_4 \leq 0; z+3x_1-4x_4 \leq 0; z-3x_2+4x_3 \leq 0; x_1, x_2, x_3, x_4 \geq 0\}$
(B) max z subject to $\{z-2x_2+3x_3 \leq 0; z+2x_1-3x_4 \leq 0; z-3x_1+4x_4 \leq 0; z+3x_2-4x_3 \leq 0; x_1+x_2+x_3+x_4 = 1; x_1, x_2, x_3, x_4 \geq 0\}$
(C) max z subject to $\{z+2x_2-3x_3 \leq 0; z-2x_1+3x_4 \leq 0; z+3x_1-4x_4 \leq 0; z-3x_2+4x_3 \leq 0; x_1+x_2+x_3+x_4 = 1; x_1, x_2, x_3, x_4 \geq 0\}$
(D) max z subject to $\{2x_2-3x_3 \leq 0; -2x_1+3x_4 \leq 0; 3x_1-4x_4 \leq 0; 3x_2-4x_3 \leq 0; x_1, x_2, x_3, x_4 \in \{0,1\}\}$

Question 17. The optimal value of z is

(A) 2 or 4 (B) 0 (C) 1 (D) 3

Question 18. An optimal solution for the player II is approximately $(y_1, y_2, y_3, y_4) = (0, 0.5715, 0.4285, 0)$. Thus an optimal strategy for the player II is:

(A) 42.85% of the time hide 2 and guess 2.
(B) 57.15% of the time hide 1 and guess 2.
(C) 42.85% of the time hide 1 and guess 1.
(D) 57.15% of the time hide 2 and guess 1.

Question 19. Consider the linear pogramming problem

$$\max\ 5x_1 + 2x_2 + x_3$$

$$\begin{array}{lrcrcrcl} \text{subject to} & x_1 & + & 3x_2 & - & x_3 & \leq & 6 \\ & & & x_2 & + & x_3 & \leq & 4 \\ & 3x_1 & + & x_2 & & & \leq & 7 \end{array}$$

The dual problem is:

(A) min $5x_1 + 2x_2 + x_3$ subject to $\{x_1 + 3x_3 \geq 6; 3x_1 + x_2 + x_3 \geq 4; x_2 - x_1 \geq 7\}$
(B) min $6x_1 + 4x_2 + 7x_3$ subject to $\{x_1 + 3x_3 \geq 5; 3x_1 + x_2 + x_3 \geq 2; x_2 - x_1 \geq 1\}$
(C) min $6x_1 + 4x_2 + 7x_3$ subject to $\{x_1 + 3x_3 \geq 5; 3x_1 + x_2 + x_3 \geq 2; -x_2 + x_1 \geq 1\}$
(D) min $6x_1 + 4x_2 + 7x_3$ subject to $\{x_1 + 3x_2 - x_3 \geq 5; x_2 + x_3 \geq 2; 3x_1 + x_2 \geq 1\}$

Question 20. Which of the following statements is true?

(A) If we can obtain an optimal solution to a linear programming problem by using interior-point methods, strong duality holds for the problem.
(B) It is always possible to obtain an optimal solution to a linear programming problem by using the simplex method while it is not the case where we use the interior-point methods.
(C) We begin the simplex algorithm and the interior-point methods at a vertex of the feasible polyhedron.
(D) In the interior-point methods, the simplex tableaux must be established in order to obtain valid cuts.