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HW8

Q1
2.5 Points

Consider the problem of finding a 5−star graph:

Input: an undirected graph $G = (V, E)$.
Output: a set of six vertices $\{u, v_1, v_2, ..., v_5\}$ such that $(uv_i) \in E$ for all $1 \leq i \leq 5$, and $(v_i v_j) \notin E$ for all $1 \leq i, j \leq 5$, if such set exists, or return NO otherwise.

True or False: this problem is NP-complete.

- (●) True.
- ( ) False.

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Q2
2.5 Points

Let A, B be problems such that A is NP-complete and B does not belong
to the class NP. You are told that A $\rightarrow$ B. Which of the following are true? Circle all that apply.

- [x] B is NP-hard.
- [x] If an algorithm L efficiently solves B, then there is an efficient algorithm to solve SAT.
- [ ] Given an input I of A, one can find a solution to it in polynomial time.

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Q3

2.5 Points

Consider an instance of LP with multiple solutions. This is, there are multiple vectors x in the feasible region such that $f(x) = c^T x$ is maximum. Let x_1, x_2 be two such solutions.

$\lambda x_1 + (1-\lambda)x_2$ is also a solution for

- All $\lambda \in \mathbb{R}$.
- **All $0 \leq \lambda \leq 1$.**
- All $\lambda > 0$.
- None of the other options is correct.

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Q4

3 Points

Consider the following instance of LP:

$$\begin{aligned} &\max x + y \\ \text{s.t.: } &ax + by \leq 1 \\ &x, y \geq 0 \end{aligned}$$

where $a, b \in \mathbb{R}$ are parameters. This problem is infeasible if

- $a > 0, b < 0$.
- $a < 0, b < 0$.
- $a > 0, b > 0$.
- **This instance is always feasible.**

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Q5

3 Points

Consider the following instance of LP:

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$$\text{s.t.: } ax + by \leq 1$$
$$x, y \geq 0$$

where $a, b \in \mathbb{R}$ are parameters. This problem is unbounded if

- (●) $a > 0, b < 0.$
- ( ) $a < 0, b < 0.$
- ( ) $a > 0, b > 0.$
- ( ) This instance is always bounded.

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Q6

3 Points

Consider the following instance of LP:

$$\max x + y$$
$$\text{s.t.: } ax + by \leq 1$$
$$x, y \geq 0$$

where $a, b \in \mathbb{R}$ are parameters. This problem has a unique optimal solution (x, y) if

- ( ) $a > 0, b > 0.$
- ( ) $a = b$ and $a > 0.$
- (●) $a > 0, b > 0$ and $a \neq b.$
- ( ) This instance always has a unique optimal solution.

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Q7

3.5 Points

Consider the following instance of LP:

$$\begin{aligned} &\max 5x_1 + 9x_2 \\ \text{s.t.: } &x_1 + x_2 \leq 3 \\ &x_1 + 3x_2 \leq 7 \\ &x_1, x_2 \geq 0 \end{aligned}$$

Let (x_1', x_2') be a point in the feasible region, and let (y_1', y_2') be a point in the feasible region of the Dual LP. Which of the following inequalities must be true? Check ALL that apply.

- [ ] $5x_1' + 12x_2' \leq 3y_1' + 7y_2\prime.$
- [x] $5x_1' + 9x_2' \leq 3y_1' + 7y_2\prime.$
- [x] $4x_1' + 8x_2' \leq 4y_1' + 8y_2\prime.$
- [x] $y_1' + y_2\prime \geq 5.$

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Q8 Hitting Set

20 Points

In the Hitting Set problem, we are given a family of sets $\{S_1, S_2, ..., S_n\}$, where each set S_i has at most m elements, and a budget $0 < b \leq n$, and we wish to find a set H of size less or equal than b which intersects every S_i, if such an H exists.

Show that Hitting Set is NP-complete.

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