Instructions: Every question, except Question 3, has exactly one correct answer. Question 3 has two correct answers and carries 2 marks. The rest carry one 1 mark. There are *no negative marks* for wrong answers.

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1. Let $\{p_1, p_2, p_3\}$ be a set of atomic propositions. Does the ω-word $\{p_1\}\{p_1, p_3\}\{p_1\}\{p_1, p_2\}^\omega$ satisfy the LTL formula $(p_1 \, \boldsymbol{U} p_2) \, \boldsymbol{U} p_3$?

   (a) Yes

   (b) No

2. Let $\{p_1, p_2, p_3\}$ be a set of atomic propositions. Does the ω-word $\{p_1\}\{p_2\}\{p_1\}\{p_3\}^\omega$ satisfy the LTL formula $(p_1 \, \boldsymbol{U} p_2) \, \boldsymbol{U} p_3$?

   (a) Yes

   (b) No

3. Let $\{p_1, p_2, p_3\}$ be a set of atomic propositions. Two of the following words satisfy the LTL formula $(p_1 \, \boldsymbol{U}(\neg p_2)) \, \boldsymbol{U} \, (p_1 \, \boldsymbol{U} p_3)$. Find them.

   (a) $\{p_1\}\{p_2\}\{p_1, p_3\}^\omega$

   (b) $\{p_1, p_2\}\{p_1\}\{p_1, p_3\}^\omega$

   (c) $\{\}\{p_1, p_2\}\{p_1, p_2, p_3\}^\omega$

   (d) $\{p_1\}\{\}\{p_2\}\{p_1, p_3\}^\omega$

4. Let $\{p_1, p_2, p_3\}$ be a set of atomic propositions. Which of the following words satisfies $(\boldsymbol{X} \neg p_1) \, \boldsymbol{U}(\boldsymbol{X} \neg p_2)$?

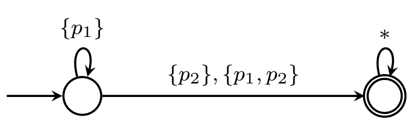
   (a) $\{p_2\}\{p_1, p_2\}\{\}^\omega$

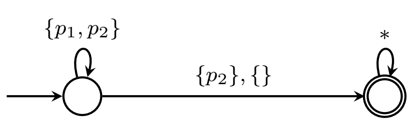
   (b) $\{p_1\}\{p_2\}\{p_1\}\{p_2\}\{p_1\}^\omega$

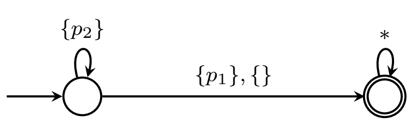
   (c) $\{p_1\}\{p_1, p_2\}\{p_1, p_2\}\{p_3\}^\omega$

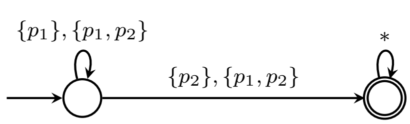
   (d) $\{p_2, p_3\}^\omega$

5. Let $\{p_1, p_2\}$ be a set of atomic propositions. Which of the following NBA represents the LTL formula $(\neg p_1) \, \boldsymbol{U}(\neg p_2)$?

   (a) 

   (b) 

   (c) 

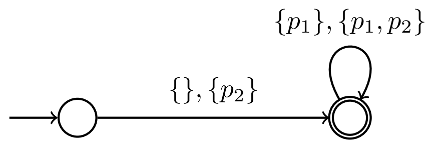
   (d) 

6. Is $\boldsymbol{XF}\, p_1$ equivalent to $\boldsymbol{F}\, p_1$?

   (a) Yes

   (b) No

7. Which of the following LTL formulas is equivalent to this NBA?



   (a) $(\neg p_2)\, \boldsymbol{U} p_1$

   (b) $\boldsymbol{F}(\neg p_1) \wedge \boldsymbol{XG}\; p_1$

   (c) $p_2\, \boldsymbol{U} p_1$

   (d) $\boldsymbol{X} p_2$

8. Let ϕ and ψ be LTL formulas recognizing ω-languages over an alphabet Σ. The LTL formula $\neg(\phi\, \boldsymbol{U} \psi)$ is language equivalent to one of the following formulas. Which one is it?

   (a) $(\neg\phi)\, \boldsymbol{U}(\neg\psi)$

   (b) $(\neg\psi)\, \boldsymbol{U}(\neg\phi)$

   (c) $((\neg\psi)\, \boldsymbol{U}(\neg\phi \;\wedge\; \neg\psi)) \;\vee\; G(\neg\psi)$

   (d) $((\neg\psi)\, \boldsymbol{U}(\neg\phi \;\wedge\; \neg\psi)) \;\vee\; G(\neg\phi)$

9. Let $\{p_1, p_2, p_3\}$ be atomic propositions. Is $(p_1\, \boldsymbol{U}(p_2 \vee p_3))$ equivalent to $((p_1\, \boldsymbol{U} p_2) \vee (p_1\, \boldsymbol{U} p_3))$?

   (a) Yes

   (b) No