Problem 1 (6 points). You are given three sets, \( A = \{a, b, c\} \), \( B = \{1, 2, 3\} \), and \( C = \{\text{red, white, blue}\} \), and the following relations:

- \( R \subseteq A \times B = \{(a, 1), (b, 1), (c, 3)\} \),
- \( S \subseteq B \times C = \{(1, \text{red}), (2, \text{blue}), (3, \text{red})\} \),
- \( T \subseteq C \times A = \{(\text{red}, a), (\text{white}, c)\} \).

For each of the following operations compute the result if the operation makes sense, or, if it doesn’t make sense, please explain why.

1. \( R; S \)
2. \( S; T \)
3. \( R; R^{-1} \)
4. \( R^{-1}; R \)
5. \( R^{-1}; T^{-1} \)
6. \( R; T \)

Problem 2 (6 points). Exercises 17, 19, 22 p. 593.

Problem 3 (4 points). Exercises 4, 11 p. 608.

Problem 4 (5 points) You are given relation \( R = \{(a, b), (b, c), (c, b), (d, c)\} \) on the universal set \( U = \{a, b, c, d, e\} \). Please construct the following:

- the reflexive closure of \( R \).
- the symmetric closure of \( R \).
- the transitive closure of \( R \).
- the “equivalence closure” of \( R \) (i.e. the smallest equivalence relation that contains \( R \)).
You may list pairs included in the resulting relations or draw the relations, each as a separate diagram.

**Problem 5 (2 points)**. Is symmetric closure of a transitive relation transitive? If yes, please prove it. If not, please give a counterexample.

**Problem 6 (3 points)**. Exercises 6, 7, 9 p. 647.

**Problem 7 (6 points)**. Exercise 2 p. 680.

**Problem 8 (2 points)**. Exercises 3b, 5b p. 696.

**Problem 9 (6 points)**. Exercise 19 p. 696.

That’s all, folks!