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1. List the ordered pairs in the relation R from $A = \{0, 1, 2, 3, 4\}$ to $B = \{0, 1, 2, 3\}$, where $(a, b) \in R$ if and only if

   a) $a = b$.

   b) $a + b = 4$.

   c) $a > b$.

   d) $a \mid b$.

   e) $\gcd(a, b) = 1$.

   f) $\text{lcm}(a, b) = 2$.

3. For each of these relations on the set $\{1, 2, 3, 4\}$, decide whether it is reflexive, whether it is symmetric, whether it is antisymmetric, and whether it is transitive.

   a) $\{(2, 2), (2, 3), (2, 4), (3, 2), (3, 3), (3, 4)\}$

   b) $\{(1, 1), (1, 2), (2, 1), (2, 2), (3, 3), (4, 4)\}$

   c) $\{(2, 4), (4, 2)\}$

   d) $\{(1, 2), (2, 3), (3, 4)\}$

   e) $\{(1, 1), (2, 2), (3, 3), (4, 4)\}$

   f) $\{(1, 3), (1, 4), (2, 3), (2, 4), (3, 1), (3, 4)\}$

4. Determine whether the relation R on the set of all people is reflexive, symmetric, antisymmetric, and/or transitive, where $(a, b) \in R$ if and only if

a) a is taller than b.

b) a and b were born on the same day.

c) a has the same first name as b.

d) a and b have a common grandparent.

7. Determine whether the relation R on the set of all integers is reflexive, symmetric, antisymmetric, and/or transitive, where $(x, y) \in R$ if and only if

a) $x \neq y$.   **b)** $xy \geq 1$.

c) $x = y + 1$ or $x = y - 1$.

d) $x \equiv y \pmod 7$.   **e)** x is a multiple of y.

f) x and y are both negative or both nonnegative.

g) $x = y^2$.   **h)** $x \geq y^2$.

32. Let R be the relation $\{(1, 2), (1, 3), (2, 3), (2, 4), (3, 1)\}$, and let S be the relation $\{(2, 1), (3, 1), (3, 2), (4, 2)\}$. Find $S \circ R$.

$R_1 = \{(a, b) \in \mathbf{R}^2 \mid a > b\}$, the greater than relation,

$R_2 = \{(a, b) \in \mathbf{R}^2 \mid a \geq b\}$, the greater than or equal to relation,

$R_3 = \{(a, b) \in \mathbf{R}^2 \mid a < b\}$, the less than relation,

$R_4 = \{(a, b) \in \mathbf{R}^2 \mid a \leq b\}$, the less than or equal to relation,

$R_5 = \{(a, b) \in \mathbf{R}^2 \mid a = b\}$, the equal to relation,

$R_6 = \{(a, b) \in \mathbf{R}^2 \mid a \neq b\}$, the unequal to relation.

35. Find

   a) $R_2 \cup R_4$.   **b)** $R_3 \cup R_6$.

   c) $R_3 \cap R_6$.   **d)** $R_4 \cap R_6$.

   e) $R_3 - R_6$.   **f)** $R_6 - R_3$.

   g) $R_2 \oplus R_6$.   **h)** $R_3 \oplus R_5$.

37. Find

   a) $R_2 \circ R_1$.   **b)** $R_2 \circ R_2$.

   c) $R_3 \circ R_5$.   **d)** $R_4 \circ R_1$.

   e) $R_5 \circ R_3$.   **f)** $R_3 \circ R_6$.

   g) $R_4 \circ R_6$.   **h)** $R_6 \circ R_6$.

44. List the 16 different relations on the set $\{0, 1\}$.

46. Which of the 16 relations on $\{0, 1\}$, which you listed in Exercise 44, are

a) reflexive? b) irreflexive?

c) symmetric? d) antisymmetric?

e) asymmetric? f) transitive?