CS 173, Spring 19 Examlet 4, white

Name:____

NetID:____________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.

$$\begin{tikzcd} A \arrow[r] \arrow[d] & C \arrow[d] & E \\ B \arrow[r] & D \arrow[ul] & F \end{tikzcd}$$

Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that S is the set of all binary strings (i.e. finite sequences of 1's and 0's). Suppose that $\sim$ is the relation on S where $a \sim b$ if and only if a and b contain the same number of 1's. For example, `0101` $\sim$ `1000001`. List three members of [`111`].

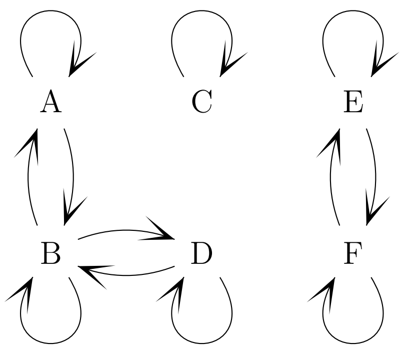
3. (5 points) Let T be the relation defined on set of pairs $(x, y) \in \mathbb{R}^2$ such that $(x, y)T(p, q)$ if and only if $x \leq p$ or $y \leq q$. Is T antisymmetric? Informally explain why it is, or give a concrete counter-example showing that it is not.

Name:____

NetID:____________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) A relation is a partial order if it has which three properties? (Naming the properties is sufficient. You don't have to define them.)

3. (5 points) Suppose that R is a relation on the integers such that xRy for all integers x and y. Is R an equivalence relation?

CS 173, Spring 19 Examlet 4, white

Name:____

NetID:____________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.

$$\begin{tikzcd} A \arrow[r] & C & E \arrow[l] \\ B \arrow[r] & D & F \arrow[l] \end{tikzcd}$$

Reflexive:	☐	Irreflexive:	☐
Symmetric:	☐	Antisymmetric:	☐
Transitive:	☐		

2. (5 points) Let's define the ~~equivalence~~ relation $\sim$ on $\mathbb{N}^3$ such that $(x, y, z) \sim (p, q, r)$ if and only $(x, y, z) = \alpha(p, q, r)$ for some integer α. ~~List three members of [(1, 2, 3)]~~ List three elements that are related to $(1, 2, 3)$ in either direction.

3. (5 points) Suppose that R is the relation on the set of integers such that aRb if and only if $|a - b| \leq 13$ Is R transitive? Informally explain why it is, or give a concrete counter-example showing that it is not.

Name:____

NetID:________________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.

$$\begin{tikzcd}
A \arrow[r] \arrow[d] \arrow[dr] & C \arrow[d] & E \arrow[d] \\
B \arrow[r] & D & F
\end{tikzcd}$$

Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Let R be the relation on the integers such that xRy if and only if $\lfloor x/4 \rfloor = \lfloor y/4 \rfloor$. List the values in $[8]$.

3. (5 points) Let T be a reflexive relation defined on the integers. Let S be the relation on the integers such that aSb if and only if there is an integer k such that aTk and kTb. Is S reflexive? (I.e. is S reflexive for any reflexive relation T?) Informally explain why it is, or give a concrete counter-example showing that it is not.

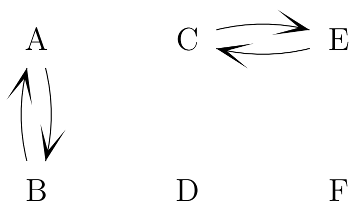
CS 173, Spring 19 **Examlet 4, white**

Name:____

NetID:______________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Can a relation be irreflexive, symmetric, and also transitive? Either give such a relation or briefly explain why it's not possible to construct one.

3. (5 points) Suppose that R is a relation on the integers such xRy if and only if $x = y$. Is R a partial order?

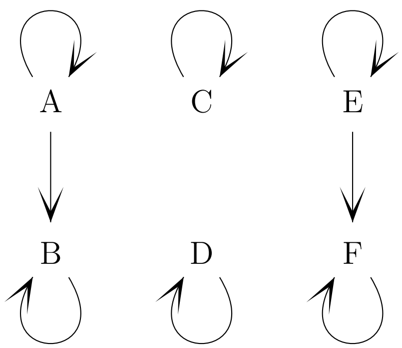
CS 173, Spring 19 Examlet 4, white

Name:____

NetID:____________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that R is a relation on a set A. Using precise mathematical words and notation, define what it means for R to be symmetric.

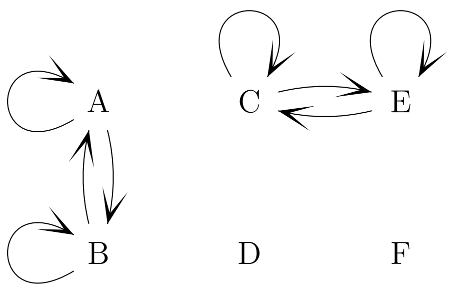
3. (5 points) Let T be the relation defined on $\mathbb{N}$ such that aTb if and only if $a = b+2k$ for some natural number k. Is T antisymmetric? Informally explain why it is, or give a concrete counter-example showing that it is not.

Name:____

NetID:______________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Let's define the equivalence relation $\sim$ on $\mathbb{N}^3$ such that $(x, y, z) \sim (p, q, r)$ if and only $x + y + z = p + q + r$. List three members of $[(1, 2, 3)]$.

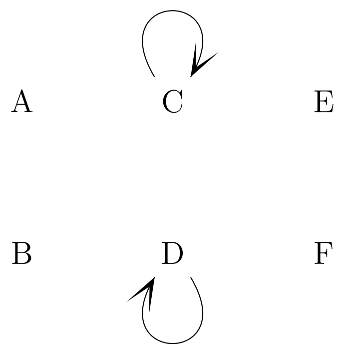
3. (5 points) Suppose that R is a relation on the integers such xRy if and only if $xy = 1$ for all integers x and y. Is R a partial order?

Name:______________________________________

NetID:____________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) A relation is an equivalence relation if it has which three properties? (Naming the properties is sufficient. You don't have to define them.)

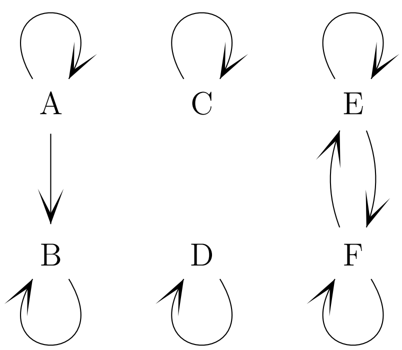
3. (5 points) Suppose that $\succeq$ is the relation between subsets of the integers such that $A \succeq B$ if and only if $A - B \neq \emptyset$. (A and B are sets of integers, so $A - B$ is a set difference.) Is $\succeq$ transitive? Informally explain why it's true or give a concrete counter-example.

Name:____

NetID:____________________ **Lecture:** **B**

Discussion: **Friday** **11** **12** **1** **2** **3** **4**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive:	☐	Irreflexive:	☐
Symmetric:	☐	Antisymmetric:	☐
Transitive:	☐		

2. (5 points) Let R be the equivalence relation on the real numbers such that xRy if and only if $\lfloor x \rfloor = \lfloor y \rfloor$. Give three members of the equivalence class $[13]$.

3. (5 points) Let T be the relation defined on set of pairs $(x, y) \in \mathbb{R}^2$ such that $(x, y)T(p, q)$ if and only if $x \leq p$ or $y \leq q$. Is T transitive? Informally explain why it is, or give a concrete counter-example showing that it is not.

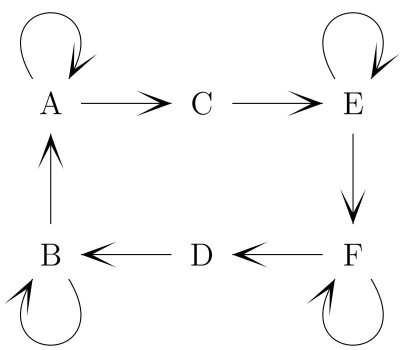
CS 173, Fall 18 Examlet 4, Part B

Name: ____

NetID: ______________________ **Lecture:** **B**

Discussion: **Friday** **11** **12** **1** **2** **3** **4**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that R is a relation on a set A. Using precise mathematical words and notation, define what it means for R to be antisymmetric.

3. (5 points) Let T be the relation defined on set of pairs $(x, y) \in \mathbb{R}^2$ such that $(x, y)T(p, q)$ if and only if $x \leq p$ and $y \leq q$. Is T antisymmetric? Informally explain why it is, or give a concrete counter-example showing that it is not.

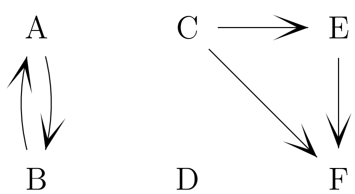
CS 173, Spring 18 Examlet 4, Part B

Name: ____

NetID: ______________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Recall that $\mathbb{N}^2$ is the set of all pairs of natural numbers. Let's define the equivalence relation $\sim$ on $\mathbb{N}^2$ as follows: $(x, y) \sim (p, q)$ if and only $|x - y| = |p - q|$. List three members of $[(2, 3)]$.

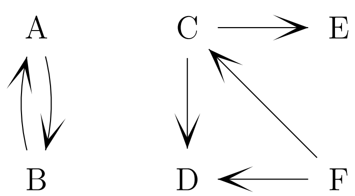
3. (5 points) Suppose that R is a relation on the integers such xRy if and only if $x = y$. Is R an equivalence relation?

Name:____

NetID:______________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Can a relation be symetric and also antisymmetric? Either give such a relation or briefly explain why it's not possible to construct one.

3. (5 points) Let J be the set of open intervals of the real line, i.e $J = \{(x, y) \in \mathbb{R}^2 \mid x < y\}$. Let's define the "disjoint" relation D on J by $(a, b)D(c, d)$ if and only if $b \leq c$ or $d \leq a$. Is D transitive? Informally explain why it is, or give a concrete counter-example showing that it is not.

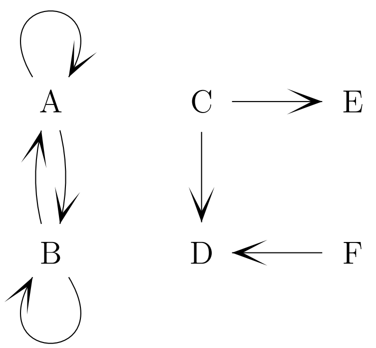
CS 173, Spring 18 Examlet 4, Part B

Name:____

NetID:____________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that R is a partial order on a set A. What additional property is required for R to be a linear order (aka total order)? Give specific details of the property, not just its name.

3. (5 points) Suppose that R is a relation on the integers such xRy if and only if $2 \mid (x + y + 1)$. Is R transitive?

CS 173, Spring 18 Examlet 4, Part B

Name:____

NetID:____________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.

A C E

B D F

(that is, 6 nodes and no arrows at all)

Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Let R be the equivalence relation on the real numbers such that xRy if and only if $\lfloor x \rfloor = \lfloor y \rfloor$. Give three members of the equivalence class $[13]$.

3. (5 points) Suppose that R is a relation on pairs of integers such that $(x, y)R(a, b)$ if and only if $x - a \geq 2$ and $y \geq b$. Is R a partial order?

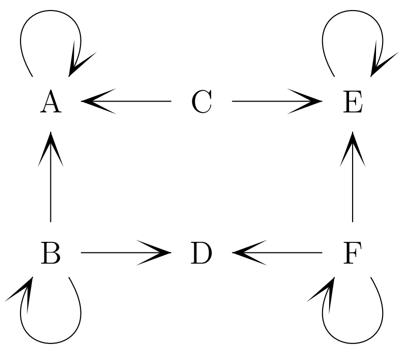
CS 173, Spring 18 Examlet 4, Part B

Name:____

NetID:____________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) **Notice that this problem was corrected early in the exam. This is the corrected version.** Let's define the relation $\sim$ on $\mathbb{Z}$ sucn that $x \sim y$ if and only $|x - y| = 3$. List all elements related to 7.

3. (5 points) Let S be the relation defined on set of pairs $(x, y) \in \mathbb{R}^2$ such that $(x, y)S(p, q)$ if and only if $x^2 + y^2 \leq p^2 + q^2$. Is S antisymmetric? Informally explain why it is, or give a concrete counter-example showing that it is not.

CS 173, Spring 18 Examlet 4, Part B

Name:____

NetID:____________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.

$$\begin{tikzcd} A \arrow[r] & C \arrow[r] & E \arrow[d] \\ B \arrow[u] & D \arrow[l] & F \arrow[l] \end{tikzcd}$$

Reflexive:	☐	Irreflexive:	☐
Symmetric:	☐	Antisymmetric:	☐
Transitive:	☐		

2. (5 points) Suppose that R is an equivalence relation on a set A. Using precise set notation, define $[x]_R$, i.e. the equivalence class of x under the relation R.

3. (5 points) Let J be the set of open intervals of the real line, i.e $J = \{(x, y) \in \mathbb{R}^2 \mid x < y\}$. Let's define the "touches" relation T on J by $(a, b)T(c, d)$ if and only if $a = d$ or $b = c$. Is T transitive? Informally explain why it is, or give a concrete counter-example showing that it is not.

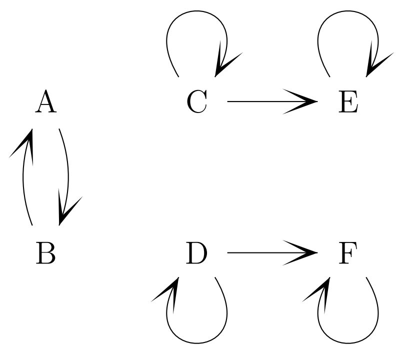
CS 173, Fall 17 Examlet 4, Part B

Name:____

NetID:____________________ **Lecture: A B**

Discussion: Thursday Friday 9 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Let $\sim$ be the relation defined on set of pairs $(x, y) \in \mathbb{R}^2$ such that $(x, y) \sim (p, q)$ if and only if $x^2 + y^2 = p^2 + q^2$. Find three elements in the equivalence class $[(0, 1)]$

3. (5 points) Suppose that $\preceq$ is the relation between subsets of the integers such that $A \preceq B$ if and only if $A - B = \emptyset$. (A and B are sets of integers, so $A - B$ is a set difference.) Is $\preceq$ antisymmetric? Informally explain why it's true (e.g. use a Venn diagram) or give a concrete counter-example.

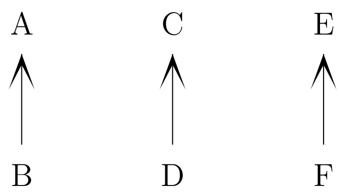
CS 173, Fall 17 Examlet 4, Part B

Name:____

NetID:________________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) A relation is a partial order if it has which three properties? (Naming the properties is sufficient. You don't have to define them.)

3. (5 points) Suppose that T is the relation on the set of integers such that aTb if and only if $\gcd(a, b) = 3$. Is T transitive? Informally explain why it is, or give a concrete counter-example showing that it is not.

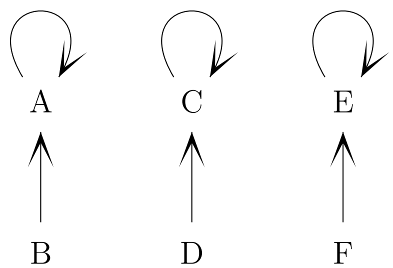
CS 173, Fall 17 Examlet 4, Part B

Name:____

NetID:______________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that R is a relation on a set A. Using precise mathematical words and notation, define what it means for R to be symmetric.

3. (5 points) Suppose that R is the relation on $\mathbb{Z}^4$ such that $(a, b, c, d)R(w, x, y, z)$ if and only if $c = w$, $d = x$, $a = y$, and $b = z$. Is R symmetric? Informally explain why it's true or give a concrete counter-example.

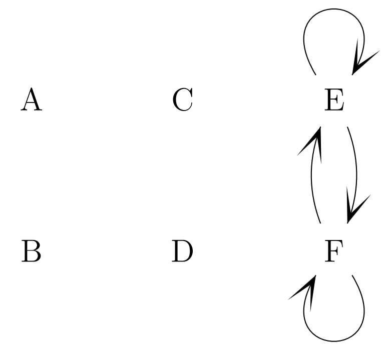
CS 173, Fall 17 Examlet 4, Part B

Name:____

NetID:____________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Let R be the relation on the integers such that aRb if and only if $2a \equiv -3b \pmod 5$. Find three elements in the equivalence class $[7]$.

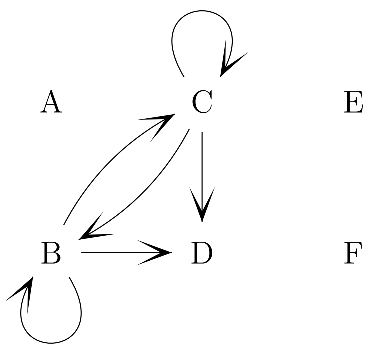
3. (5 points) Suppose that R is the relation on $\mathbb{Z}^3$ such that $(a, b, c)R(x, y, z)$ if and only if $c = x$, $a = y$, and $b = z$. Is R transitive? Informally explain why it's true or give a concrete counter-example.

Name:____

NetID:______________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that S is the set of all binary strings (i.e. finite sequences of 1's and 0's). Suppose that $\sim$ is the relation on S where $a \sim b$ if and only if a and b are the same length. For example, `01011` $\sim$ `00010`. List three members of [`1111`].

3. (5 points) Let T be the relation on $\mathbb{R}^2$ such that $(x, y)T(p, q)$ if and only if $(x, y) = \alpha(p, q)$ for some real number α. Is T symmetric? Informally explain why it is, or give a concrete counter-example showing that it is not.

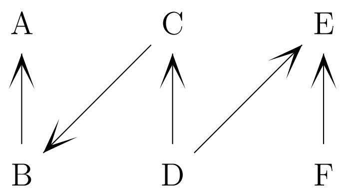
CS 173, Fall 17 Examlet 4, Part B

Name:____

NetID:________________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **9** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Can a relation with at least one related pair (i.e. at least one arrow in a diagram) be irreflexive, symmetric, and also transitive? Either give such a relation or briefly explain why it's not possible to construct one.

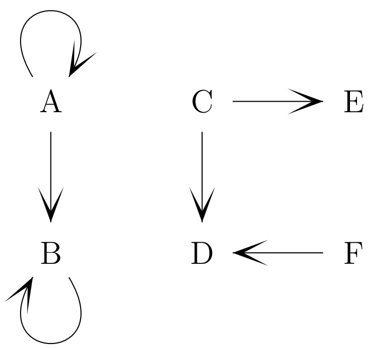
3. (5 points) Suppose that $\succeq$ is the relation between subsets of the integers such that $A \succeq B$ if and only if $A - B \neq \emptyset$. (A and B are sets of integers, so $A - B$ is a set difference.) Is $\succeq$ transitive? Informally explain why it's true or give a concrete counter-example.

Name:______________________________

NetID:________________ **Lecture: A B**

Discussion: Thursday Friday 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Recall that $\mathbb{Z}^2$ is the set of all pairs of integers. Let's define the equivalence relation $\sim$ on $\mathbb{Z}^2$ as follows: $(a, b) \sim (p, q)$ if and only $ab = pq$. List three members of $[(5, 6)]$.

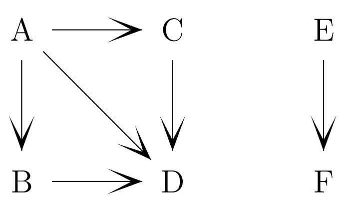
3. (5 points) Let T be the relation defined on set of pairs $(x, y) \in \mathbb{R}^2$ such that $(x, y)T(p, q)$ if and only if $x \leq p$ and $y \leq q$. Is T antisymmetric? Informally explain why it is, or give a concrete counter-example showing that it is not.

Name:____

NetID:____________________ **Lecture:** **A** **B**

Discussion: **Thursday** **Friday** **10** **11** **12** **1** **2** **3** **4** **5** **6**

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that R is a relation on a set A. Using precise mathematical words and notation, define what it means for R to be antisymmetric.

3. (5 points) Suppose that R is an equivalence relation on the integers. Is it true that $y \in [x]_R$ if and only if $x \in [y]_R$, for any integers x and y? Informally explain why it's true or give a concrete counter-example.

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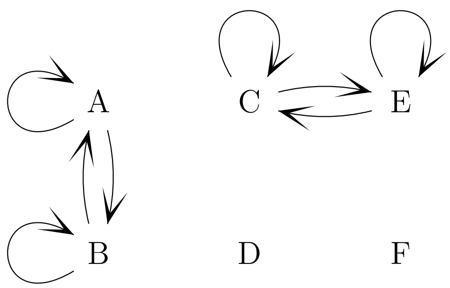

Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that R is a relation on a set A. Using precise mathematical words and notation, define what it means for R to be symmetric.

3. (5 points) Suppose that R is the relation on the set of integers such that aRb if and only if $|a - b| \leq 13$ Is R transitive? Informally explain why it is, or give a concrete counter-example showing that it is not.

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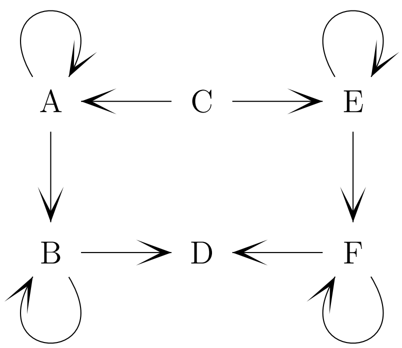

Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Suppose that S is the set of all binary strings (i.e. finite sequences of 1's and 0's). Suppose that $\sim$ is the relation on S where $a \sim b$ if and only if a and b contain the same number of 1's. For example, `0101` $\sim$ `1000001`. List three members of [`111`].

3. (5 points) Let T be the relation defined on set of pairs $(x, y) \in \mathbb{R}^2$ such that $(x, y)T(p, q)$ if and only if $x - p \leq y - q$. Is T transitive? Informally explain why it is, or give a concrete counter-example showing that it is not.

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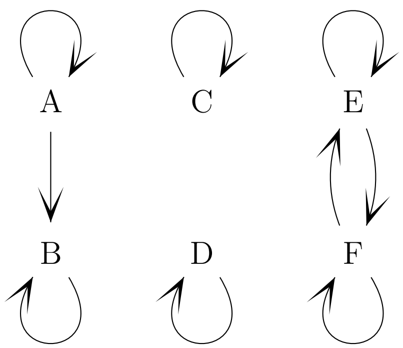
1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Let's define the equivalence relation $\sim$ on $\mathbb{R}$ sucn that $x \sim y$ if and only $|x - y| \in \mathbb{Z}$. List three members of $[1.7]$.

3. (5 points) Let T be the relation defined on set of pairs $(x, y) \in \mathbb{R}^2$ such that $(x, y)T(p, q)$ if and only if $xp + yq = 0$. Is T irreflexive? Informally explain why it is, or give a concrete counter-example showing that it is not.

Name:____

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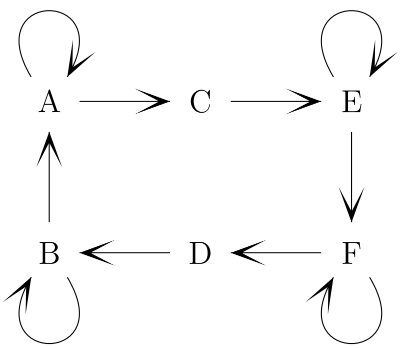
Discussion: Thursday Friday 10 11 12 1 2 3 4 5 6

1. (5 points) Check all boxes that correctly characterize this relation on the set $\{A, B, C, D, E, F\}$.



Reflexive: ☐ Irreflexive: ☐

Symmetric: ☐ Antisymmetric: ☐

Transitive: ☐

2. (5 points) Can a relation be reflexive, symmetric, and also antisymmetric? Either give such a relation or briefly explain why it's not possible to construct one.

3. (5 points) Let R be the relation on $\mathbb{Z}$ such that xRy if and only if $|x| + |y| = 2$

   Is R transitive? Informally explain why it is, or give a concrete counter-example showing that it is not.