Provide a clear and organized presentation.

1. Determine if each of the following relations is reflexive, symmetric, or transitive:
i) $\quad x R y$ means that the plane shape $x$ is similar to the plane shape $y$.

## All

ii) $\quad x R y$ means person $x$ is a next door neighbor to person $y$. Symmetric only
iii) $\quad x R y$ means planet $x$ is in the same solar system as planet $y$.

## All

2. Consider the following relations:
i) $\quad f R g$ means that the graph of the function $f$ is the mirror image of the graph of $g$ through the line $y=x$. Under what conditions is this relation reflexive? Symmetric? Transitive? (an appropriate answer might be always, or never)

Reflexive: $f$ is its own inverse
Symmetric: always
Transitive: $f=h$ (but this implies $f=g=h$ )
ii) $\quad x R y$ means the real number $x$ is not equal to the real number $y$.

Reflexive: Never
Symmetric: always
Transitive: $\boldsymbol{x} \neq \boldsymbol{z}$
iii) $\quad x R y$ means the natural number $x$ is a factor or the natural number $y$.

Reflexive: always
Symmetric: $x=y$
Transitive: always
3. Determine the explicit formula for the following sequence two different ways (the reverse side of the page is blank):

$$
a_{n}=a_{n-1}+12 a_{n-2} \text { and } a_{0}=2, a_{1}=3
$$

i)

$$
\begin{aligned}
& r^{2}-r-12=0 \\
& (r-4)(r+3)=0 \\
& a_{n}=\alpha_{1} \cdot 4^{n}+\alpha_{2} \cdot(-3)^{n} \quad \text { with } \quad \alpha_{1}+\alpha_{2}=2 \\
& \text { and } 4 \alpha_{1}-3 \alpha_{2}=3 \\
& a_{n}=\frac{9}{7} \cdot 4^{n}+\frac{5}{7} \cdot(-3)^{n}
\end{aligned}
$$

ii)

$$
\begin{aligned}
& f(x)=a_{0}+a_{1} x+a_{2} x^{2}+a_{3} x^{3}+\cdots \\
& f(x)=2+3 x+\left(a_{1}+12 a_{0}\right) x^{2}+\left(a_{2}+12 a_{1}\right) x^{3}+\cdots \\
& f(x)=2+3 x+\left(a_{1} x^{2}+a_{2} x^{3}+\cdots\right)+\left(12 a_{0} x^{2}+12 a_{1} x^{3}+\cdots\right) \\
& f(x)=2+3 x+x\left(a_{1} x+a_{2} x^{2}+\cdots\right)+12 x^{2}\left(a_{0}+a_{1} x+\cdots\right) \\
& f(x)=2+3 x+x\left(a_{0}+a_{1} x+a_{2} x^{2}+\cdots\right)+12 x^{2}\left(a_{0}+a_{1} x+\cdots\right)-a_{0} x \\
& f(x)=2+3 x+x\left(a_{0}+a_{1} x+a_{2} x^{2}+\cdots\right)+12 x^{2}\left(a_{0}+a_{1} x+\cdots\right)-2 x \\
& f(x)=2+x+x\left(a_{0}+a_{1} x+a_{2} x^{2}+\cdots\right)+12 x^{2}\left(a_{0}+a_{1} x+\cdots\right) \\
& f(x)=2+3 x+x f(x)+12 x^{2} f(x) \\
& f(x)=\frac{2+3 x}{1-x-12 x^{2}}
\end{aligned}
$$

With a bit of partial fraction decomposition, we have that:

$$
f(x)=\frac{5}{7} \cdot \frac{1}{1+3 x}+\frac{9}{7} \cdot \frac{1}{1-4 x}
$$

So that:

$$
a_{n}=\frac{5}{7} \cdot(-3)^{n}+\frac{9}{7} \cdot 4^{n}
$$

4. My cat Pythagoras two pet mice and my other cat Theta has three rats. My third cat, Jolie, wishes to play with some of these critters. Use generating functions to determine how many ways can she choose an odd number of these critters?
$\left(1+x+x^{2}\right)\left(1+x+x^{2}+x^{3}\right)$
$=1+2 x+3 x^{2}+3 x^{3}+2 x^{4}+x^{5}$
Adding the coefficients of the red terms, we have that she can do this in $2+3+1=6$ ways.
5. Consider two functions $g: A \rightarrow B$ and $f: B \rightarrow C$. Let $f \circ g$ be 1-1. Is $g$ necessarily $1-1$ ? If so, prove it. Otherwise, provide a counterexample.

$$
\begin{aligned}
\text { Let } g\left(x_{1}\right) & =g\left(x_{2}\right) \\
f\left(g\left(x_{1}\right)\right) & =f\left(g\left(x_{2}\right)\right) \\
(f \circ g)\left(x_{1}\right) & =(f \circ g)\left(x_{2}\right) \\
x_{1} & =x_{2}
\end{aligned}
$$

6. Consider the functions $g: A \rightarrow B$ and $f: B \rightarrow C$. Let both $f$ and $f \circ g$ both be onto. Is $g$ necessarily onto? If so, prove it. Otherwise, provide a counterexample.

7. Use the following Venn diagrams to provide an example of the type of function identified:
i) $\quad f$ is $1-1$, but not onto:

ii) $\quad f$ is onto, but not 1-1:

iii) $\quad f$ is neither 1-1 nor onto:

iv) $\quad f$ is both 1-1, and onto:

8. What is the difference between a Hamiltonian circuit and a Euler circuit?

A Hamiltonian circuit is a path that begins and ends at the same vertex but hits all of the vertrices only once (except where we start), whereas an Euler circuit is a path that begins and ends at the same vertex but crosses all of the edges only once.

