

# Warm-Up: Odd Dice

Prepared by Mark on March 3, 2025

## Instructor's Handout

This handout contains solutions and notes.

Recompile without solutions before distributing.

### Problem 1:

We say a set of dice  $\{A, B, C\}$  is *nontransitive* if, on average,  $A$  beats  $B$ ,  $B$  beats  $C$ , and  $C$  beats  $A$ . In other words, we get a counterintuitive “rock - paper - scissors” effect.

Create a set of nontransitive six-sided dice.

*Hint:* All sides should be numbered with positive integers less than 10.

#### Solution:

One possible set can be numbered as follows:

- Die  $A$ : 2, 2, 4, 4, 9, 9
- Die  $B$ : 1, 1, 6, 6, 8, 8
- Die  $C$ : 3, 3, 5, 5, 7, 7

Another solution is below:

- Die  $A$ : 3, 3, 3, 3, 3, 6
- Die  $B$ : 2, 2, 2, 5, 5, 5
- Die  $C$ : 1, 4, 4, 4, 4, 4

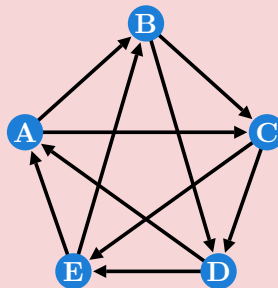
### Problem 2:

Now, consider the set of six-sided dice below:

- Die  $A$ : 4, 4, 4, 4, 4, 9
- Die  $B$ : 3, 3, 3, 3, 8, 8
- Die  $C$ : 2, 2, 2, 7, 7, 7
- Die  $D$ : 1, 1, 6, 6, 6, 6
- Die  $E$ : 0, 5, 5, 5, 5, 5

On average, which die beats each of the others? Draw a diagram.

#### Solution:



### Problem 3:

Now, say we roll each die twice. What happens to the graph from the previous problem?

#### Solution:

The direction of each edge is reversed!