Yumeko Dice Control

By SoundStorm

This is a short doc outlining a high tier feat performed by three characters in Kakegurui - Tsugiko, Souko, and most importantly, Yumeko. Since Yumeko is the most relevant of these characters, I will be focusing on her version of the feat. I believe it surpasses most of semi realistic SCD in CPI, LA and sensory. I haven't seen anyone else mention this feat before, so if anyone would like to discuss it with me or ask any questions, my discord is soundstorm7.

Souko, Tsugiko and Yumeko use a special dice roll ability in chapters 100-104.5. This ability involves controlling the dice to land on the numbers you want when using a dice shaker.


SNAKE EYES, EVEN.
YESSS!!



However, to control the rolls of a non-loaded dice like this is virtually impossible. There have been many efforts made to try and control dice rolls, but they're mostly inconclusive. In fact, a prominent study made in 2020 showed that a machine that was purpose-made for controlling dice throws was unable to achieve any meaningful results under a variety of conditions. Still, certain techniques are theorised to marginally increase the likelihood of rolling a certain number, however, in order to do this you must:

1. Roll the dice by hand, not by dice shaker
2. Have a specialised environment and surface to roll the dice on

None of these apply to this situation, so controlling the dice using these techniques is impossible (it'd be impossible for these techniques to get such consistent results anyway). However, it's definitely not down to luck or intuition, since it's stated to be a skill. The fact that it is based on skill is further backed up by the fact that Souko fails to do it consistently once her focus is broken, and the fact that Souko is unable to hear other noises like Kabura right next to her whilst performing the skill means it clearly requires high cognitive effort. It also states that there's nothing supernatural about the technique, as Tsugiko mentions it's not magic.



The manga also acknowledges its impossibility and that normal people wouldn't be able to pull it off, so it's not as if these things work differently in the Kakegurui universe.


...IS NORMALLY IMPOSSIBLE FOR EVERYONE.
MANIPULATING NON-LOADED DICE...


I'M SURE SHE CAN'T DO THAT TEN TIMES OUTTA TEN.
I DIDN'T THINK SOUKO HAD THAT KINDA SKILL—
FINESSING AN EVEN OR ODD ROLL IS ONE THING, BUT SNAKE EYES?
SO MUCH SO THAT IN CRAPS, THEY ACTUALLY LET THE PLAYERS ROLL THEM.
...BUT SHE'S NOT SHOWING IT ONE BIT.
SHE MUST BE SWEATING EVERY SINGLE ROLL...

So how would controlling the dice in this situation even be achieved? Well, according to chaos theory, the illusion of randomness in a dice roll is created from the fact that countless factors affect the roll, and even the tiniest change in any of them will have a butterfly effect that causes a major change in the results. This includes the force applied, shaking duration, shaking pattern, air resistance, collision angles, etc. This makes it impossible for any normal human to control the outcome of a dice roll in a shaker cup, since dice are far too sensitive to changes in many different factors.

So, in order to control the results of the dice roll, then they'd need to constantly factor in all these aspects in real time, use countless calculations to predict and visualise the trajectory of the dice, determine whether it aligns with how they need the dice to be moving in order to get the desired end result, and adjust their shakes on a micro level to ensure it does align. What I'm describing here is a similar process an advanced physics engine would have to run to predict how the dice will land, but with the added step of having to manipulate the roll too. So this feat literally requires the mental modelling of a complex physics simulation in real time, hence insane CPI and VSI. And they can't even see the dice while they're doing it, so they'd have to be perceiving the specific information about the initial position, momentum, rotation, etc of the dice based on subtle vibrations and sounds, which is very high levels of observation and perception. Oh, and Yumeko hadn't even played dice before this, so she literally learnt how to do it on the spot from watching Tsugiko and Souko do it a few times at only 6 years old and then immediately implementing it just a few moments after witnessing it. Learning such a difficult skill so quickly is incredible learning ability, observation, perception, and inductive reasoning.



She also shows her dice roll control at other times, such as when she controlled the 10-sided die at Yumemi's idol show, so we know it definitely wasn't a fluke.


NUMBER THIRTY-ONE, PLEASE STAND UP!
OOH! ♡ RIGHT ON TARGET, MARY-SAN!


AND WITH-OUT ANY PRAC-TICE EITHER! WHEW! ♡
SHE'S CON-TROLLING HER DICE ROLLS WITHOUT LOADING THEM AT ALL!

Rough Calculation

It's possible to get a rough calculation of the number of calculations per second needed for this feat to be pulled off, but because it's highly speculative, I'll use a lowball for each value in order to work out the **minimum** number of calculations as compensation. Actual physics engines would probably perform a much higher number of calculations, but since I know people will complain I'm glazing the feat, I'll manually determine a lower number of calculations.

Before we go through the process she would need to do in one timestep, we need to determine how long one timestep actually is, and therefore calculate the update rate. To accurately model the exact movements of the dice, including every factor, to the level of precision necessary to accurately predict the results, the update rate would have to be very high. The fastest and most chaotic part of the dice roll would be the collisions of the dice against each other or the shaker. Major changes can occur in the position and velocity of the dice in under a millisecond at these points, meaning the update rate would have to reach peaks of around 1000 Hz in order to track these changes accurately. However, since I'm making an underestimate here, and the dice spend a significant proportion of their time not colliding, the update rate can be lowered to a lower bound of 200 Hz, making the timestep 5 milliseconds. Now, here are the steps she would need to go through within one timestep:

0. *Pre-timestep*

Before calculations can be done, information must be purely gathered for a few moments in order to have something to base the calculations in step 1 on. This step happens once per complete dice roll and is not factored into the timestep.

1. *Determine the current states of dice.*

This involves perceiving the vibrations and sounds to pinpoint their position, velocity, and spin in this timestep. Note that only approximate values can be calculated.

Essential values to be calculated:
Position (3 axes) + sum of external forces + velocity (3 axes) + momentum + rotational position (3 axes) + angular displacement + angular velocity (3 axes) + energy loss ≈ 16 calculations per die
2 dice ≈ 32 calculations

2. *Predict the trajectory of dice.*

In order to know how exactly she needs to manipulate the dice, she needs to use the current state of the dice to predict how the states will change over time. This means doing the calculations in step 1 for each dice state in the future. First, we need to determine how far into the future she needs to predict. She needs to know where and how exactly the dice will collide with the walls of the container or each other beforehand to allow for adjustment. To predict an immediate bounce before it happens, perhaps she would need to predict around 50 ms ahead.

However, to perform larger physical adjustments in order to manoeuvre the dice towards a final result, predicting around 0.5 seconds ahead would be the bare minimum to allow for the time needed to move. Since one timestep is 5 ms, and 0.5 seconds is equivalent to 500 ms, that's predicting 100 steps ahead per timestep. For every step, she'll do the same number of calculations for step 1, so 16 x 100 = 1600 calcs per die.
2 dice = 3200 calculations

3. *Compare it to the desired trajectory.*

She then must compare this prediction to what is needed to reach the desired results.

Essential values to be calculated:
Position deviation (3 axes), velocity deviation (3 axes), rotational position deviation (3 axes), angular velocity deviation (3 axes) ≈ 12 calculations per die.
2 dice = 24 calculations

4. *Adjust dice via micro-movements.*

She must adjust the current state of the dice to help align the trajectory of the dice with the desired one.

Essential values to be calculated:
Necessary force direction, necessary force magnitude ≈ 2 calculations per die.
2 dice = 4 calculations.

Results:

Total calculations per timestep = 3260
Timesteps per second = 200
Calculations per second = 3260 x 200 = 652000.

This is a heavy underestimate, lowball values were chosen at pretty much every opportunity. But the fact that I have chosen to lowball it so much should compensate for the theoretical nature of these calculations.

FAQs:

Didn't Yumeko cheat in the dice game?
Before playing the game against Tsugiko, Yumeko stuck some small grains of rice to the 6-face of both dice. This seems to have been an effort to load the dice to be more likely to land face down on 6, and therefore have the 1 facing up, by shifting the dice's centre of mass. However, in order to have a noticeable effect on the results, a standard die would need to be loaded by about 4 grams. Grains of rice weigh around 0.03 grams, so over a hundred grains of rice would need to be stuck to the face of each die in order to have a noticeable effect, which is obviously not the case. It is also not strong enough as an adhesive to load the dice. It's clear that Yumeko, who had never played dice before, just wanted a way to increase her odds of succeeding, even if only slightly, but due to how small the effect is, she would still need to do all the same calculations. Furthermore, the grains were removed by Tsugiko after the first two rolls and yet Yumeko was still able to control the dice. Similarly, Yumeko controlled the results of Yumemi's 10-sided dice despite never having a chance to touch it before rolling it.

Why did Yumeko refer to the game as a gamble if she was controlling the dice?
It may seem like Yumeko mustn't have been controlling the dice if she was talking about gambling and chance, but it's important to remember that Yumeko couldn't know for certain that she would be able to successfully control the dice. It was her first time playing dice, after all, and she just saw Souko - which is who she just learnt dice control from - fail to control the dice after losing focus. There's really no guarantee in her mind that she'll succeed, no matter how flawlessly she calculates. Even after she succeeds twice, the grains of rice are then removed, so she'd be unsure if she'd succeed without the grains of rice.

Doesn't this contradict Yumeko's values, and therefore the narrative?
Not at all, this is pretty much explained by the answer to the previous question. Yumeko was taking what she would perceive as a risky gamble, betting on the extent of her own ability (which she has no idea, having never played dice), and the reliability of this skill (which she also has reason to doubt after watching Souko and Tsugiko fail while using it), while still putting her best effort into winning. One of Yumeko's core values is that she wishes every party to try their best to win, while ensuring neither win nor loss is guaranteed. Some people mistakenly believe that Yumeko using her insane cognition to win is out of character, but this is not true. She demonstrates this behaviour in multiple gambles, like Double Memory and Tower of Doors. She also shows that she hates when people don't try their best, like how she responds to Yumemi's defeatist attitude in Active Station. She hates even more when people try to lose, shown in how she acts towards Midari compared with other cheaters. So this is very in character for Yumeko.