Dice Fairness Validation Report

Press It! Craps — statistical validation of the 3D physics dice engine

Report date: 19 July 2026 · Engine: LibGDX + Bullet Physics · Method: 10,000 real physics rolls, Pearson chi-square goodness-of-fit

Executive summary

The dice in Press It! Craps are not produced by a random-number generator. Every roll is the outcome of a real-time 3D rigid-body physics simulation of two casino-style dice thrown across a walled felt table. To confirm the engine behaves like a genuinely fair pair of dice, the physics engine was run **10,000 times** with no rendering and no human input, and the resulting distribution was tested against the mathematically fair distribution.

VERDICT	ROLLS SIMULATED	TOTALS X^2	PER-DIE X^2
FAIR	10,000	5.95 / 23.209	4.81 / 15.086

Both chi-square statistics fall **far below** their rejection thresholds ($\alpha = 0.01$), so the observed rolls are statistically consistent with fair dice. Every die face appeared within a fraction of a percent of the ideal 16.67%, and the two-dice totals traced the classic 2–12 pyramid. All 10,000 rolls settled successfully (0 failures) in 13.1s.

How the dice work

In a real casino, fair dice are precision-balanced cubes so that every face is equally likely. Press It! models that physically: two 3D dice are dropped onto a felt table and thrown toward the far wall, then tumble and settle under simulated gravity, friction and restitution. The result is read from whichever face points up once the dice come to rest — it is never chosen in advance and is never influenced by your bets or bankroll.

Engine parameters

Physics engine	LibGDX + Bullet (btDiscreteDynamicsWorld) — rigid-body simulation
Integration	stepSimulation, fixed 1/120 s timestep, up to 10 sub-steps per frame
Gravity	18 m/s² downward
Linear / angular damping	0.30 / 0.50
Die size / mass	0.8 m cube / 2.5 (relative mass)
Die restitution / friction	0.55 / 0.65
Wall restitution / friction	0.45 / 0.60
Table	20 m × 6.5 m felt, 10 m walls (dice cannot escape)
Settlement rule	both dice below 0.4 m/s for 25 consecutive frames, then face locked
Face read-out	the die face whose normal points up (+Y) at rest is the result
Randomness source	Math.random() — seeds the throw only, never the outcome

Where the natural variation comes from

Like a human throw, no two rolls start the same. Each throw randomizes three independent things — and this randomness only seeds the *launch*; the landing is decided purely by the physics:

Hand / wrist position	Launch point jittered ±0.75 m across the table; the two dice offset ±0.56 m apart; each die's initial orientation fully randomized (yaw, pitch & roll).
Throw velocity	Forward impulse ≈ −100 ± 7.5 toward the far wall, a 4–6 upward arc, and ±1 lateral spread; the second die gets an additional independent ±5 / +1 / ±1 offset so the two never fly identically.
Wrist snap (spin)	Independent angular (torque) impulse on all three axes, ±7.5 each, per die — producing the tumble.

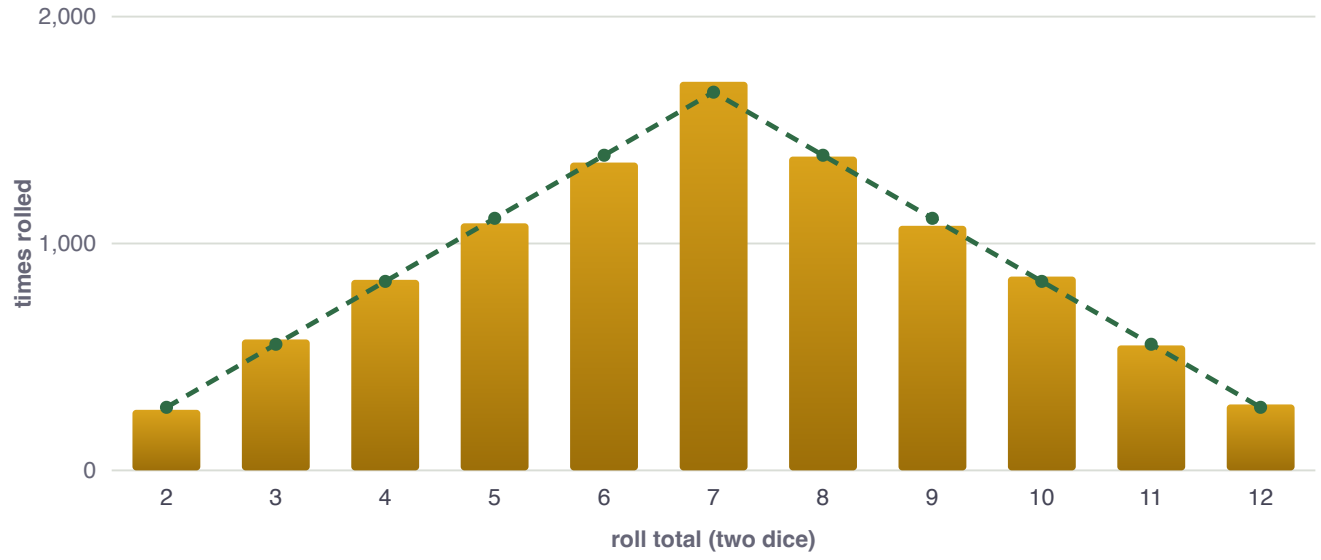
> Because the two dice receive independent position, velocity and spin, and because the settling result is read from physics rather than assigned, the engine cannot “aim” for a number — exactly the property this report measures.

Test methodology

An on-device instrumentation test drives the *actual* production physics class (`Dice3DWorld`) with no graphics: it throws the dice, steps the simulation until both settle, reads the two up-faces, and records them. This repeats 10,000 times. The tallies are then scored with a **Pearson chi-square goodness-of-fit** test — the same routine used by the in-app fairness dashboard (`DiceFairness`).

- **Null hypothesis (H_0):** rolls are drawn from the fair distribution — two-dice totals follow the 1,2,3,4,5,6,5,4,3,2,1-out-of-36 combinatorics; individual faces are uniform (1/6 each).
- **Statistic:** $\chi^2 = \Sigma$ (observed – expected)² / expected.
- **Degrees of freedom:** totals = 10 (11 categories – 1); per-die = 5 (6 faces – 1).
- **Decision rule ($\alpha = 0.01$):** reject fairness only if χ^2 exceeds the critical value — 23.209 for totals, 15.086 for per-die. The 1% level is deliberately strict, so ordinary sampling noise is not mistaken for bias.
- **Sample adequacy:** the smallest expected cell (totals 2 and 12) is 278 — far above the “≥5” rule for the chi-square approximation to hold.

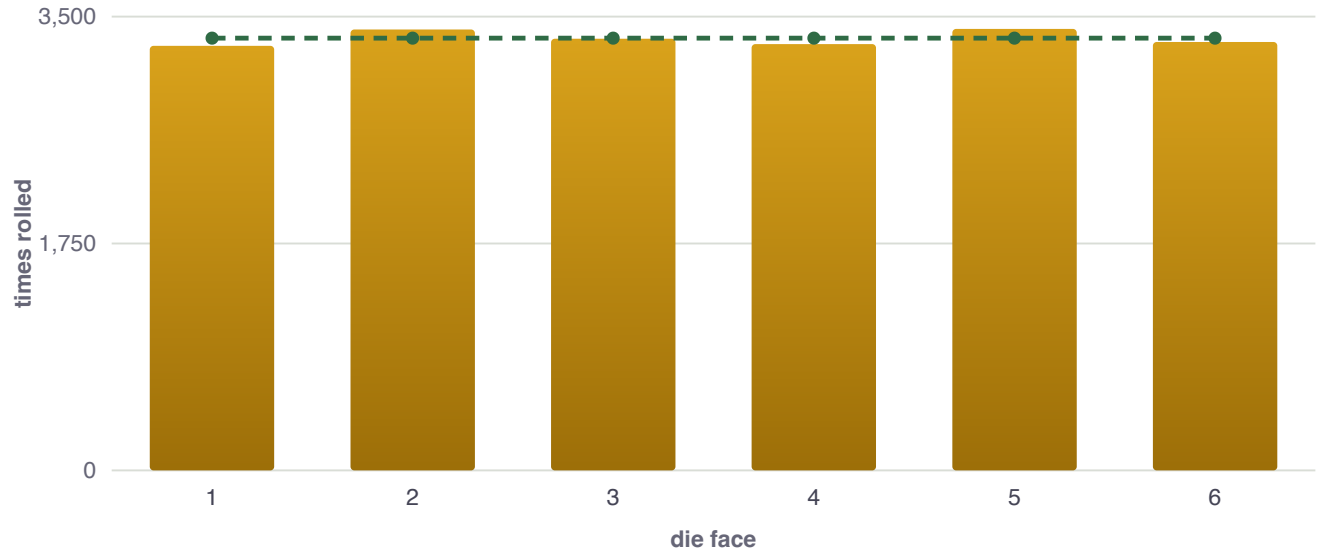
Results — two-dice totals (2–12)



TOTAL	FAIR ODDS	OBSERVED	OBS %	EXPECTED	DEVIATION	X² PART
2	1/36	267	2.67%	277.8	-3.9%	0.42
3	2/36	577	5.77%	555.6	+3.9%	0.83
4	3/36	840	8.40%	833.3	+0.8%	0.05
5	4/36	1,089	10.89%	1,111.1	-2.0%	0.44
6	5/36	1,357	13.57%	1,388.9	-2.3%	0.73
7	6/36	1,713	17.13%	1,666.7	+2.8%	1.29
8	5/36	1,383	13.83%	1,388.9	-0.4%	0.02
9	4/36	1,078	10.78%	1,111.1	-3.0%	0.99
10	3/36	854	8.54%	833.3	+2.5%	0.51
11	2/36	551	5.51%	555.6	-0.8%	0.04
12	1/36	291	2.91%	277.8	+4.8%	0.63
Total	**36/36**	**10,000**	**100%**	**10,000**	**—**	**5.95**

Chi-square = 5.95 against a rejection threshold of 23.209 (df = 10, α = 0.01). Consistent with fair.

Results — individual die faces (1–6)



FACE	OBSERVED	OBS %	EXPECTED	DEVIATION	X² PART
1	3,274	16.37%	3,333.3	-1.8%	1.06
2	3,400	17.00%	3,333.3	+2.0%	1.33
3	3,329	16.64%	3,333.3	-0.1%	0.01
4	3,288	16.44%	3,333.3	-1.4%	0.62
5	3,405	17.03%	3,333.3	+2.1%	1.54
6	3,304	16.52%	3,333.3	-0.9%	0.26
Total	**20,000**	**100%**	**20,000**	—	**4.81**

Each roll contributes two die samples (10,000 rolls → 20,000 faces). Chi-square = 4.81 against 15.086 (df = 5, α = 0.01). Consistent with uniform.

Interpretation & limitations

The data show **no detectable bias** in the physics dice at a 10,000-roll sample and a strict 1% significance level. Stated honestly:

- “Fail to reject” means no bias was detectable at this sample size and significance — it is strong evidence of fairness, not a mathematical proof that bias is impossible.
- The test exercises the exact production physics code and native Bullet library, so the emulator result reflects the same engine shipped to devices.
- The throw used fully randomized starting orientation (no imposed “dice set”). The optional cosmetic dice-set feature changes only the starting face shown, not the physics outcome.
- Each roll re-initializes the dice, so samples are independent — a requirement of the chi-square test.

> This is why the app says the dice are **transparent & validated**, not “provably fair” — there is no cryptographic commit-reveal. Instead the in-app dashboard lets every player run the same fairness check on their own accumulated rolls.

Reproducibility

Anyone can re-run this validation:

- Test: `com.emberdigital.pressitcraps.DicePhysicsFairnessTest` (`app/src/androidTest/…/DicePhysicsFairnessTest.kt`)
- Engine under test: `Dice3DWorld.kt` · Analysis: `DiceFairness.kt`
- Command: `adb shell am instrument -w -e class com.emberdigital.pressitcraps.DicePhysicsFairnessTest com.emberdigital.pressitcraps.test/androidx.test.runner.AndroidJUnitRunner`