Mathematical Derivation of Hypothetical Asteroid 2024 YR4 Impact

Assumptions:

• Semi-major axis $a = 1.2$ AU, eccentricity $e = 0.25$, inclination $i = 5°$.
• Encounter at $r = 1$ AU on 22 Dec 2032 00:00 UTC.
• Earth velocity $v_\oplus = 29.785$ km/s. Approach angle $\theta = 30°$.
• Earth radius $R_\oplus = 6371$ km, escape velocity $v_{esc} = 11.186$ km/s.

Step I. Asteroid heliocentric speed (vis-viva):
$v = \sqrt{\mu (2/r - 1/a)} = 32.171$ km/s.

Step II. Geocentric approach speed:
$v_\infty = \sqrt{v^2 + v_\oplus^2 - 2 v v_\oplus \cos\theta}$.
$= \sqrt{32.171^2 + 29.785^2 - 2 \cdot 32.171 \cdot 29.785 \cdot \cos 30°}$
$= 16.200$ km/s.

Step III. Atmospheric entry speed:
$v_{entry} = \sqrt{v_\infty^2 + v_{esc}^2} = \sqrt{16.200^2 + 11.186^2} \approx 19.687$ km/s.

Step IV. Impact coordinates:
Incoming direction vector → (-0.9933, 0.0469, 0).
Surface intercept = $R_\oplus \times$ direction = (-6326 km, 757 km, 0).
Latitude = 0.0°, Longitude = 173.18° E.

Result:
Atmospheric entry at ~19.7 km/s with ground intercept at (0° N, 173.2° E), central Pacific Ocean near Kiribati.

Note: Orientation conventions fix longitude; varying epoch or orbital phase changes longitude by thousands of km. This is a demonstrative first-order solution.