

Idealized Models, Dissipative Reality, and the Fallacy of the Unconditional Premise:

A Comprehensive Theoretical and Empirical Refutation of J. H. Mandlbaur's *Angular Energy* and *Rebuttals*

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Abstract

In two self-published manuscripts hosted on ResearchGate—*Angular Energy* [1] and its companion defence, *Rebuttals* [2]—J. H. Mandlbaur contends that the law of conservation of angular momentum is false. His argument rests on a single pedagogical thought experiment: when a hand-held ball on a string revolving at $\omega_1 = 2$ rps (120 rpm) has its radius reduced tenfold from $r_1 = 0.5$ m to $r_2 = 0.05$ m in open air over $\Delta t \approx 1$ s, the idealized zero-torque conservation equation $L_2 = L_1$ yields $\omega_2 = 100\omega_1 = 200$ rps (12,000 rpm). Because a hand-held classroom ball on a string does not reach the rotational speed of a Formula One engine, Mandlbaur proclaims a *reductio ad absurdum* of classical mechanics and proposes that rotational kinetic energy (“angular energy”) is conserved instead. This treatise provides an exhaustive, mathematically rigorous refutation of both manuscripts. Part I exposes the foundational errors in *Angular Energy* and its ten-point Discussion section: (1) the formal logical fallacy of severing a conditional physical theorem ($\sum \vec{\tau}_{\text{ext}} = \vec{0} \Rightarrow \vec{L}_2 = \vec{L}_1$) from its governing boundary condition, violating Duhem–Quine conjunction falsification and succumbing to the principle of explosion (*ex falso quodlibet*) and the ludic fallacy; (2) the exact differential equations governing aerodynamic drag power ($P_{\text{drag}} \propto r^{-3}$), guide-tube capstan and azimuthal friction ($\tau_{\text{pivot}} \propto r^{-3}$), coupled two-body hand-wobble inertia, and centripetal string tension ($T \propto r^{-3}$, surging to 3,948–7,895 N); (3) the violation of Noether’s theorem and the work-energy theorem inherent in Mandlbaur’s “angular energy” hypothesis; (4) established vacuum verifications of variable-radius angular momentum conservation, including spacecraft yo-yo de-spin mechanisms and Keplerian orbits; and (5) a point-by-point refutation of the ten rhetorical rules in the Discussion section of *Angular Energy*. Part II reconstructs the missing interlocutor comments behind all twenty-six numbered entries in *Rebuttals* and delivers a surgical refutation of each claim, followed by a complete taxonomic synthesis in the Appendix.

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1 Introduction and Epistemological Context

Few episodes in contemporary internet science communication illustrate the perils of divorcing textbook equations from their physical boundary conditions as starkly as the campaign waged by John H. Mandlbaur. Across numerous online forums and repositories, Mandlbaur has promoted a five-page manuscript titled *Angular Energy* [1] (also circulated under the title *Mathematical Proof That Angular Momentum Is Not Conserved* [3]) alongside a four-page compendium of twenty-six canned counter-arguments titled *Rebuttals* [2]. His claims have even prompted formal pedagogical analyses in the peer-reviewed physics education literature examining the dissipative mechanics of the ball-on-a-string demonstration [5, 6].

Remarkably, despite titling his flagship paper *Angular Energy* and asserting in its abstract that “*Angular energy is the term that has been invented to describe what is in fact conserved during rotational motion*” [1], the phrase “angular energy” **never appears once in the body of the manuscript**—neither in the Introduction, Thought Experiment, Conclusion, nor Discussion—and is never given a formal mathematical definition or governing equation. Instead, the manuscript relies entirely on an anecdotal claim about a qualitative lecture demonstration, insulated by ten rhetorical rules in its Discussion section and twenty-six pre-scripted replies in *Rebuttals* [2].

Reading *Rebuttals* in isolation is an unusual experience because it records only one side of an ongoing debate. Entries begin abruptly with conversational fragments such as “*I disagree*” (Rebuttal 4), “*Yes, of course it solves problems*” (Rebuttal 11), “*On the contrary, it is very easy to determine what is, or is not ad hominem*” (Rebuttal 12), or “*It seems you are addressing example 1*” (Rebuttal 18). Because Mandlbaur compiled these responses from recurring online disputes without preserving the critiques that prompted them, a complete scholarly refutation must both reconstruct the interlocutor’s objection for each item and dismantle Mandlbaur’s reply.

Before dissecting all twenty-six items in *Rebuttals*, Part I establishes the formal logical, mechanical, and empirical refutation of *Angular Energy* [1]—including its ten-point Discussion section—upon which every single rebuttal depends.

2 Part I: Deconstruction of *Angular Energy*

2.1 Formal Proof of Misapplication, Duhem–Quine Falsification, and the Ludic Fallacy

In *Angular Energy* [1], Mandlbaur sets out thirteen algebraic steps for a ball of mass m whirling on a string whose radius is shortened from $r_1 = 0.5$ m to $r_2 = 0.05$ m ($r_1/r_2 = 10$) over $\Delta t = 1$ s, starting from $\omega_1 = 2$ rps (120 rpm). Beginning with his uncited Equation (1),

$$L_2 = L_1, \tag{1}$$

together with $L = I\omega$ (Equation 2) and the point-mass moment of inertia $I = mr^2$ (Equation 3), he arrives at:

$$\omega_2 = \left(\frac{r_1}{r_2}\right)^2 \omega_1 = 10^2 \times 2 \text{ rps} = 200 \text{ rps} = 12,000 \text{ rpm}. \tag{2}$$

Observing that a hand-held classroom demonstration does not spin at 12,000 rpm, Mandlbaur concludes that Equation (1) is empirically falsified, declaring: “*The law of conservation of angular momentum is false*” [1].

2.1.1 Euler’s Second Law and the Formal Contradiction of False Equivalence

In classical mechanics, the angular momentum $\vec{L}$ of a particle with linear momentum $\vec{p} = m\vec{v}$ at position $\vec{r}$ relative to an inertial origin is $\vec{L} = \vec{r} \times \vec{p}$ [10, 11, 12]. Differentiating with respect to time yields Euler’s second law, the fundamental governing equation of rotational dynamics [10, 13]:

$$\frac{d\vec{L}}{dt} = \sum \vec{\tau}_{\text{ext}}, \quad (3)$$

where $\sum \vec{\tau}_{\text{ext}} = \vec{r} \times \vec{F}_{\text{ext}}$ is the net external torque acting on the system. Integrating Equation (3) over a finite time interval $[t_1, t_2]$ yields the general angular impulse–momentum theorem:

$$\vec{L}(t_2) - \vec{L}(t_1) = \int_{t_1}^{t_2} \sum \vec{\tau}_{\text{ext}}(t) dt. \quad (4)$$

From Equation (4), the scalar conservation relation $L_2 = L_1$ arises strictly as a **conditional corollary** that holds if and only if the angular impulse of the net external torque vanishes over $[t_1, t_2]$:

$$\int_{t_1}^{t_2} \sum \vec{\tau}_{\text{ext}}(t) dt = \vec{0} \iff \vec{L}(t_2) = \vec{L}(t_1). \quad (5)$$

The foundational mathematical contradiction in Mandlbaur’s argument can be demonstrated via a formal five-step deductive proof:

- **Premise 1 (Governing Law):** By Equation (4) and the mean value theorem for integrals over the pull duration $\Delta t = t_2 - t_1 > 0$, $L_2 = L_1 + \tau_{\text{ext}} \Delta t$, where $\tau_{\text{ext}} = \frac{1}{\Delta t} \int_{t_1}^{t_2} \sum \tau_{\text{ext}}(t) dt$ is the mean net external torque. Therefore, $L_2 = L_1$ is exclusively valid when $\tau_{\text{ext}} = 0$.
- **Premise 2 (Idealized Predictive Model):** Mandlbaur calculates a predicted final angular momentum L_p (and corresponding angular velocity $\omega_p = 12,000$ rpm) using $L_p = L_1$, which mathematically requires $\tau_{\text{ext}} = 0$.
- **Premise 3 (Observed Open-Air System):** The observed system is a hand-held ball on a string revolving in ambient air, whose actual final angular momentum is $L_{\text{obs}} = L_1 + \tau_{\text{obs}} \Delta t$, where $\tau_{\text{obs}} = \frac{1}{\Delta t} \int_{t_1}^{t_2} (\tau_{\text{drag}} + \tau_{\text{pivot}} + \tau_{\text{wobble}}) dt$ is the mean net external torque from atmospheric drag, string friction, and pivot instability.
- **Step 1:** Mandlbaur demands that the zero-torque prediction directly match the open-air observation: $\omega_{\text{obs}} = \omega_p \iff L_{\text{obs}} = L_p$.
- **Step 2:** Substituting the governing expressions for L_{obs} and L_p into $L_{\text{obs}} = L_p$ (for $\Delta t > 0$) yields:

$$L_1 + \tau_{\text{obs}} \Delta t = L_1 \implies \tau_{\text{obs}} \Delta t = 0 \implies \tau_{\text{obs}} = 0. \quad (6)$$

- **Step 3:** However, direct observation undeniably confirms $\tau_{\text{obs}} < 0$ ($\tau_{\text{obs}} \neq 0$), because a ball whirled on a string at constant radius rapidly slows down and stops within seconds when no energy is added.
- **Step 4 (Explicit Contradiction):** Assuming $L_{\text{obs}} = L_p$ simultaneously requires $\tau_{\text{obs}} = 0$ (from Equation 1) and $\tau_{\text{obs}} \neq 0$ (from the choice of a dissipative open-air apparatus), introducing the formal contradiction $(\tau_{\text{obs}} = 0) \wedge (\tau_{\text{obs}} \neq 0)$ into the premise set.
- **Conclusion:** By the principle of explosion (*ex falso quodlibet*) [15], any conclusion derived from contradictory premises $(P \wedge \neg P)$ is logically worthless. Testing a zero-torque equation against a non-zero-torque reality creates a false equivalence and exemplifies what Taleb terms the **ludic fallacy**—misapplying simplified, idealized textbook game models to complex, unmodeled real-world systems [18].

2.1.2 The Duhem–Quine Thesis and the Failure of *Reductio ad Absurdum*

In formal logic, a deductive argument is *valid* if its conclusion follows from its premises, but it is *sound* if and only if it is valid **and** all of its premises are true in the domain of application [15, 16]. When a theoretical prediction O ($\omega_2 = 12,000$ rpm) is derived from the conjunction of a core physical law H ($d\vec{L}/dt = \sum \vec{\tau}_{\text{ext}}$) and an auxiliary boundary assumption A ($\sum \vec{\tau}_{\text{ext}} = \vec{0}$), the implication takes the form:

$$(H \wedge A) \Rightarrow O. \quad (7)$$

When empirical observation yields $\neg O$ (the hand-held ball does not reach 12,000 rpm), *modus tollens* and De Morgan’s law yield:

$$\neg O \Rightarrow \neg(H \wedge A) \equiv (\neg H \vee \neg A). \quad (8)$$

As formalized by the Duhem–Quine thesis in the philosophy of science [17], an empirical discrepancy falsifies the conjunction $(H \wedge A)$, meaning *either* the core law H is false *or* the auxiliary boundary assumption A is false. Because A ($\sum \vec{\tau}_{\text{ext}} = \vec{0}$) is patently violated by a hand-held ball on a string in air, $\neg A$ is trivially true. Treating a violated auxiliary assumption A as infallible in order to proclaim $\neg H$ is an elementary logical fallacy in the execution of *reductio ad absurdum*.

2.2 Exact Dynamics and Mechanical Limits of the Ball-on-a-String Apparatus

To appreciate the magnitude of the external torques and forces omitted by Mandlbaur’s Equation (1), consider a standard demonstration ball of mass $m = 0.050\text{--}0.100$ kg and diameter $d = 0.040$ m (radius $R_b = 0.020$ m, cross-sectional area $A = \pi d^2/4 = 1.257 \times 10^{-3}$ m², sphere drag coefficient $C_d \approx 0.47$) whirled in room-temperature air ($\rho = 1.225$ kg/m³) [5].

2.2.1 Aerodynamic Drag, Guide-Tube Friction, and Exact Analytical Integration

In polar coordinates (r, θ) , a ball retracted at constant radial speed $\dot{r} = -u = -(r_1 - r_2)/\Delta t = -0.45$ m/s has velocity $\vec{v} = -u\hat{r} + r\omega\hat{\theta}$ and total speed $v = \sqrt{u^2 + r^2\omega^2}$. Throughout the pull, $(u/r\omega)^2 \leq (0.45/6.283)^2 = 0.0051$ (0.5%), so the small-pitch-angle condition $|\dot{r}| \ll r\omega$ holds to better than 99.7% accuracy ($v \approx v_\theta = r\omega$). The ball therefore experiences a quadratic aerodynamic drag force opposing its motion:

$$F_{\text{drag}} = \frac{1}{2}\rho C_d A v_\theta^2 = \frac{1}{2}\rho C_d A r^2 \omega^2 = \kappa r^2 \omega^2, \quad (9)$$

where $\kappa \equiv \frac{1}{2}\rho C_d A \approx 3.62 \times 10^{-4}$ kg/m for the ball alone. Its lever arm about the rotation axis is r , generating a continuous retarding external torque $\tau_{\text{drag}} = -rF_{\text{drag}} = -\kappa r^3 \omega^2$ (supplemented at large radii by the distributed aerodynamic drag of the whirling string of diameter d_s , $\tau_{\text{str}} = -\frac{1}{8}\rho C_{d,\text{cyl}} d_s r^4 \omega^2$ [5]). Under the idealized $\omega \propto r^{-2}$ scaling across a tenfold radius reduction ($r_1 = 0.50$ m $\rightarrow$ $r_2 = 0.05$ m):

- **Angular velocity:** $\omega \propto r^{-2}$ (increases 100 $\times$, from 12.57 rad/s to 1,256.6 rad/s).
- **Tangential speed:** $v_\theta = r\omega \propto r^{-1}$ (increases 10 $\times$, from 6.28 m/s to 62.83 m/s = 226.2 km/h).
- **Aerodynamic drag force:** $F_{\text{drag}} \propto v_\theta^2 \propto r^{-2}$ (increases 100 $\times$, from 0.0143 N to 1.43 N on the ball alone).
- **Aerodynamic power dissipation:** $P_{\text{drag}} = |\tau_{\text{drag}}\omega| = F_{\text{drag}}v_\theta \propto r^{-3}$ (increases 1,000 $\times$, from 0.090 W to 89.7 W).

Simultaneously, as the taut string sweeps azimuthally around the rim of the stationary guide tube (or human fingers) of effective contact radius r_{tube} under radial tension $T(r) = m(r\omega^2 - \ddot{r}) =$

$mr\omega^2$ (since $\ddot{r} = 0$ for constant u), sliding contact against the rim with effective azimuthal friction coefficient μ_θ produces an external pivot braking torque [5, 6]:

$$\tau_{\text{pivot}} = -\mu_\theta r_{\text{tube}} T(r) = -\mu_\theta r_{\text{tube}} mr\omega^2. \quad (10)$$

Substituting $L = mr^2\omega$ ($\omega = L/(mr^2)$) into Euler's law $dL/dt = \tau_{\text{drag}} + \tau_{\text{pivot}}$ with $dt = -dr/u$ yields an exact, separable first-order differential equation:

$$\frac{dL}{dt} = -\frac{\kappa}{m^2 r} L^2 - \frac{\mu_\theta r_{\text{tube}}}{mr^3} L^2 \implies \frac{dL}{L^2} = \left(\frac{\kappa}{m^2 u} \frac{1}{r} + \frac{\mu_\theta r_{\text{tube}}}{mu} \frac{1}{r^3} \right) dr. \quad (11)$$

Integrating Equation (11) from r_1 to r_2 yields the exact analytical solution for the final angular velocity $\omega(r_2)$ under combined aerodynamic drag and guide-tube friction:

$$\omega(r_2) = \frac{(r_1/r_2)^2 \omega_1}{1 + \frac{\kappa r_1^2 \omega_1}{mu} \ln\left(\frac{r_1}{r_2}\right) + \frac{\mu_\theta r_{\text{tube}} \omega_1}{2u} \left[\left(\frac{r_1}{r_2}\right)^2 - 1 \right]}. \quad (12)$$

Equation (12) illuminates two critical experimental regimes:

1. **Low-Friction Mechanized Rig** ($\mu_\theta r_{\text{tube}} \rightarrow 0$): When pivot friction and hand wobble are minimized by a rigid mechanical bearing (as in Torsten Hehl's apparatus discussed in Rebuttal 25), the pure aerodynamic drag term $\Lambda_{\text{drag}} = \frac{\kappa r_1^2 \omega_1}{mu} \ln(r_1/r_2) \approx 0.116$ (for $m = 0.05$ kg, $u = 0.45$ m/s) reduces the ideal 12,000 rpm by 10.4% to $\omega(r_2) \approx 10,750$ rpm—in striking quantitative agreement with Hehl's measured $> 10,000$ rpm spin-up!
2. **Hand-Held Guide Tube** ($\mu_\theta r_{\text{tube}} > 0$): In a simple tube or hand-pinched cord, the $(r_1/r_2)^2$ factor in the pivot-friction denominator term directly cancels the $(r_1/r_2)^2$ spin-up factor in the numerator, imposing a hard asymptotic ceiling $\omega_{\text{max}} < \frac{2u}{\mu_\theta r_{\text{tube}}}$ regardless of how small r_2 becomes.

2.2.2 Thousandfold Centripetal Tension Surge, Coupled Hand Wobble, and Geometric Limits

Under the idealized $L = mr^2\omega = \text{const}$ assumption, centripetal string tension $T(r) = mr\omega(r)^2$ scales inversely with the **cube** of the radius:

$$T(r) = \frac{L_1^2}{mr^3} = T_1 \left(\frac{r_1}{r} \right)^3. \quad (13)$$

Reducing the radius tenfold causes the required centripetal tension to surge by a factor of $10^3 = 1,000$:

- For a $m = 0.05$ kg ball, tension rises from $T_1 = 3.95$ N to $T_2 = 3,948$ N (≈ 402 kgf).
- For a standard $m = 0.10$ kg demonstration ball, tension rises from $T_1 = 7.90$ N to:

$$T_2 = (0.10 \text{ kg})(0.05 \text{ m})(1,256.6 \text{ rad/s})^2 \approx 7,895 \text{ N} \quad (\approx 805 \text{ kgf}). \quad (14)$$

This thousandfold tension surge triggers four additional mechanical barriers predicted by classical mechanics [5]:

1. **Coupled Two-Body Hand Wobble and Biomechanical Damping:** A human hand and forearm (effective co-orbiting mass $M \approx 1.0$ kg) cannot maintain a mathematically fixed point-pivot in space against a rotating lateral load of hundreds or thousands of Newtons. As the pinch point yields into a small wobble circle of radius $R(\omega) \geq 0.01$ m

(1 cm), the hand and ball form a coupled two-body system with total moment of inertia [5]:

$$I_{\text{sys}}(r, \omega) = mr^2 + MR(\omega)^2 + \frac{2}{5}mR_b^2. \quad (15)$$

At $r_1 = 0.50$ m, the ball dominates ($mr_1^2 = 0.0125$ kg · m² vs. $MR_0^2 = 0.0001$ kg · m²). At $r_2 = 0.05$ m, however, the ball’s orbital inertia drops 100-fold to $mr_2^2 = 0.000125$ kg · m²—making even a 1 cm hand wobble comparable to the ball’s inertia, while expansion of $R(\omega)$ under load transfers angular momentum into the hand and dissipates it rapidly via viscoelastic wrist damping.

2. **Axial Capstan Friction:** As the string bends through $\phi \approx \pi/2$ over the lip of the guide tube during retraction, the axial pulling force required at the hand is multiplied by the Euler–Eytelwein capstan factor $T_{\text{pull}} = Te^{\mu_k \pi/2}$, further limiting human retraction speed u .
3. **Conical Pendulum Sag:** In Earth’s gravitational field g , a ball whirling at orbital radius r on a string of slant length $\ell = r/\cos\theta_{\text{sag}}$ sweeps a cone at angle $\theta_{\text{sag}} = \arctan(\frac{g}{r\omega^2}) = \arcsin(\frac{g}{\ell\omega^2})$ below the horizontal plane ($\theta_{\text{sag}} \approx 7.1^\circ$ at $t = 0$), coupling gravitational and axial forces during the initial pull [5].
4. **Finite Rigid-Body Inertia and Geometric Hard Stop:** Because the ball is attached to the string, it rotates once about its own centre of mass per orbit ($\omega_{\text{spin}} = \omega$). By Steiner’s parallel-axis theorem, a sphere of physical radius R_b has moment of inertia $I_b(r) = mr^2 + \frac{2}{5}mR_b^2$, and its centre of mass cannot physically approach the rotation axis closer than $r_{\text{min}} = r_{\text{tube}} + R_b$, bounding $I(r_1)/I(r_2)$ well below $(r_1/r_2)^2 = 100$.

2.3 Noether’s Theorem and the Work-Energy Refutation of “Angular Energy”

In *Angular Energy* (p. 3), Mandlbaur characterizes conservation of angular momentum as an unverified “*assumption*” or “*hypothesis*” [1]. In modern theoretical physics, conservation of angular momentum is not an ad hoc assumption; by Emmy Noether’s 1918 theorem (*Invariante Variationsprobleme*) [14], every differentiable symmetry of the action of a physical system generates a conserved current. Specifically, conservation of angular momentum is the direct mathematical consequence of the **rotational invariance (isotropy) of physical space**. For a particle subject to a time-dependent radial holonomic constraint $r = r(t)$ with Lagrangian $\mathcal{L}(\theta, \dot{\theta}, t) = \frac{1}{2}m(\dot{r}(t)^2 + r(t)^2\dot{\theta}^2)$, rotational isotropy about the pivot axis requires $\partial\mathcal{L}/\partial\theta = 0$, so the Euler–Lagrange equation immediately yields:

$$\frac{d}{dt} \left(\frac{\partial\mathcal{L}}{\partial\dot{\theta}} \right) = \frac{\partial\mathcal{L}}{\partial\theta} = 0 \implies p_\theta = mr(t)^2\dot{\theta} = L = \text{const.} \quad (16)$$

To disprove conservation of angular momentum in a torque-free system, one would have to prove that empty space itself possesses a preferred directional bias. By contrast, conservation of mechanical energy follows from **time-translation invariance** ($\partial\mathcal{L}/\partial t = 0$). When an external agent actively shortens the radial constraint $r(t)$ over time ($\dot{r} < 0$), time-translation invariance of the constrained ball subsystem is explicitly broken ($\partial\mathcal{L}/\partial t = mrr\dot{\theta}^2 + m\dot{r}\ddot{r} \neq 0$), injecting mechanical power into the orbital motion while rotational symmetry about the pivot axis remains unbroken ($\partial\mathcal{L}/\partial\theta = 0$).

Furthermore, conservation of angular momentum follows directly from the Newtonian Work-Energy Theorem. As the experimenter pulls the string inward from r_1 to $r_2 < r_1$, the radial displacement $dr < 0$ is parallel to the inward tension force $F_r = -T$. Thus the experimenter performs positive mechanical work on the ball:

$$W_{\text{pull}} = \int_{r_1}^{r_2} (-T) dr = \int_{r_2}^{r_1} T(r) dr > 0. \quad (17)$$

Integrating Equation (17) with $T(r) = L_1^2/(mr^3)$ shows that the 100-fold increase in kinetic energy ($E_{\text{rot},2} = 100 E_{\text{rot},1}$) is supplied entirely by the mechanical work performed by the pulling hand:

$$W_{\text{pull}} = \int_{r_1}^{0.1r_1} \left(-\frac{L_1^2}{mr^3} \right) dr = 99 E_{\text{rot},1}. \quad (18)$$

Conversely, under Mandlbaur’s own hypothesis that rotational kinetic energy is conserved ($v_\theta = v_1 = \text{const}$, so $\Delta E_{\text{rot}} = 0$) in an ideal frictionless pull from r_1 to r_2 , centripetal tension is $T(r) = mv_1^2/r$. Integrating $T(r)$ from r_1 to r_2 proves that the pulling hand *still* performs positive mechanical work:

$$W_{\text{pull}}^{(\text{CoAE})} = \int_{r_2}^{r_1} \frac{mv_1^2}{r} dr = mv_1^2 \ln\left(\frac{r_1}{r_2}\right) = 2 \ln\left(\frac{r_1}{r_2}\right) E_{\text{rot},1} \approx 4.605 E_{\text{rot},1} \quad (\text{for } r_1/r_2 = 10). \quad (19)$$

Yet Mandlbaur claims that in this frictionless system $\Delta E_{\text{rot}} = 0$! Where does $4.605 E_{\text{rot},1}$ of positive mechanical work go when there is no friction and kinetic energy does not increase? Mandlbaur’s “Conservation of Angular Energy” violates the First Law of Thermodynamics (Conservation of Total Energy)!

Table 1: Comparison of Physical Scaling Laws for a Tenfold Radius Reduction ($r_1 = 0.50 \text{ m} \rightarrow r_2 = 0.05 \text{ m}$, $\omega_1 = 2 \text{ rps}$, $m = 0.05 \text{ kg}$)

Physical Quantity	Ideal CoAM ($\tau_{\text{ext}} = 0$)	Mandlbaur “CoAE”	Real Open-Air Apparatus ($\tau_{\text{ext}} \neq 0$)
Angular Velocity ω_2	$100 \omega_1$ (12,000 rpm)	$10 \omega_1$ (1,200 rpm)	Variable (400–10,750 rpm, governed by pull rate u , drag, and bearing friction; Eq. 12)
Tangential Speed $v_{\theta,2}$	$10 v_{\theta,1}$ (62.8 m/s)	$1 v_{\theta,1}$ (6.28 m/s)	Increases substantially ($v_{\theta,2} > v_{\theta,1}$) whenever pulled rapidly through a low-friction guide
String Tension T_2	$1,000 T_1$ (3,948 N)	$10 T_1$ (39.5 N)	Rises steeply ($T = mr\omega^2$), amplifying capstan friction and hand wobble
Pulling Work W_{pull}	$99 E_{\text{rot},1}$ (+97.7 J)	$4.61 E_{\text{rot},1}$ (+4.55 J) [†]	Partitioned between ΔE_{rot} and dissipative heat $Q_{\text{drag}} + Q_{\text{friction}} + Q_{\text{wobble}}$
Energy Balance	$\Delta E_{\text{rot}} = W_{\text{pull}}$	Violates $\Delta E_{\text{rot}} = W_{\text{pull}}$	$\Delta E_{\text{rot}} = W_{\text{pull}} - W_{\text{dissipated}}$ (exact)

[†]Under Mandlbaur’s constant-speed model ($v_\theta = v_1$), pulling against $T = mv_1^2/r$ requires positive work $W_{\text{pull}} = 2 \ln(10) E_{\text{rot},1} \approx 4.61 E_{\text{rot},1}$ (Eq. 19), yet he claims $\Delta E_{\text{rot}} = 0$ in a frictionless system—making $4.61 E_{\text{rot},1}$ of mechanical work vanish into thin air.

2.4 Established Variable-Radii Vacuum Verifications: Yo-Yo De-Spin and Orbits

In *Angular Energy* (p. 3), Mandlbaur asserts: “*There are no scientifically verified empirical experiments directly confirming that angular momentum is conserved in a variable radii system*” and challenges critics (Discussion Point 6) to show an example in a vacuum [1]. This assertion betrays an omission of literature review across both astrodynamics and celestial mechanics:

1. **Spacecraft Yo-Yo De-Spin Mechanisms in Hard Vacuum:** Variable-radius conservation of angular momentum has been routinely verified and engineered in the hard vacuum of space since the dawn of the space age via **yo-yo de-spin mechanisms** [23, 24, 25]. As derived in NASA Technical Note D-708 by J. V. Fedor (1961) [23], a spinning spacecraft or sounding rocket wraps two weighted cables around its cylindrical circumference. When pyrotechnic releases free the weights, they unwind tangentially and radially outward into the vacuum of space, drastically increasing the system’s moment of inertia $I(r)$ and transferring the spacecraft’s angular momentum strictly according to $I_1\omega_1 = I_2\omega_2$ (while simultaneous conservation of rotational energy holds only because no external radial pulling agent adds or removes mechanical work during passive cord deployment) [23, 24]. Missions ranging from early NASA sounding rockets to the *Galileo* and *Dawn* spacecraft have relied on yo-yo de-spin cables to reduce spin rates to pre-calculated targets without expending propellant. If Mandlbaur’s scaling ($\omega \propto r^{-1}$ instead of $\omega \propto r^{-2}$) were valid, every spacecraft yo-yo de-spin cable ever deployed in vacuum would have missed its target spin rate by orders of magnitude.
2. **Keplerian Elliptical Orbits in Vacuum:** Nature performs continuous variable-radius experiments in the hard vacuum of space: planetary, lunar, and cometary orbits around the Sun [10, 11]. Because gravity is a central force ($\vec{r} \times \vec{F}_g = \vec{0}$), external torque vanishes and orbiting bodies conserve angular momentum $L = mr^2\dot{\theta} = \text{const}$ (Kepler’s Second Law of Equal Areas, $\dot{A} = L/(2m) = \text{const}$). Halley’s Comet, for example, varies its orbital radius by a factor of 60 : 1 between perihelion ($r_p = 0.586$ AU) and aphelion ($r_a = 35.1$ AU). Across this 60 : 1 radial excursion, its angular velocity $\dot{\theta}(r) = L/(mr^2)$ scales precisely as r^{-2} (3,600 : 1) and its azimuthal velocity $v_\theta(r) = r\dot{\theta} = L/(mr)$ scales precisely as r^{-1} (reaching 54.6 km/s at perihelion vs. 0.91 km/s at aphelion, where $\dot{r} = 0$). Under Mandlbaur’s constant-speed “angular energy” hypothesis ($v_\theta = \text{const}$), comets and planets would travel at the same speed at aphelion as at perihelion, overturning four centuries of observational astronomy.

2.5 Refutation of the Ten-Point Discussion Section in *Angular Energy*

On pages 3–4 of *Angular Energy* [1], Mandlbaur appends ten numbered statements designed to pre-empt criticism. Each collapses under scrutiny:

1. **Discussion Point 1 (“12,000 rpm is the theoretical prediction for a ball on a string”):** False equivalence. Twelve thousand RPM is the prediction for an *idealized zero-torque system* ($\sum \vec{\tau}_{\text{ext}} = \vec{0}$), not for an open-air, hand-held string subject to aerodynamic drag, guide-tube friction, and pivot wobble (Eq. 12).
2. **Discussion Point 2 (“No frictional force goes from negligible at 2 rps to preventing 90% of movement within one second”):** Directly refuted by the cubic scaling laws derived in Section 2.2: under $\omega \propto r^{-2}$, aerodynamic drag power scales as $P_{\text{drag}} \propto r^{-3}$ (rising 1,000-fold) and string tension scales as $T \propto r^{-3}$ (rising 1,000-fold to 3,948–7,895 N), which causes guide-tube friction $\tau_{\text{pivot}} = -\mu_\theta r_{\text{tube}} T$ to scale as r^{-3} and diverge as $r_2 \rightarrow 0$.
3. **Discussion Point 3 (“Since 20 rps [1,200 rpm] is reasonably achieved, it is reasonable to neglect friction”):** Logical non sequitur. Even if a brisk pull reaches $\sim 1,200$ rpm ($10\omega_1$), 90% of the initial angular momentum has been bled off by external braking torques

$(\int \tau_{\text{ext}} dt = -0.9 L_1)$, proving that friction and drag are the dominant terms in the angular impulse balance, not “negligible”!

4. **Discussion Point 4 (“No experiment shows radius reduced to 10% achieving 12,000 rpm”):** As shown in Equation (12), reducing r tenfold in open air while maintaining $> 10,000$ rpm requires a rigid, low-friction mechanical bearing and high-strength cord; when Torsten Hehl built such a mechanized rig (see Rebuttal 25), it indeed exceeded 10,000 rpm!
5. **Discussion Point 5 (“The string would break long before 12,000 rpm, so it is unreasonable to claim it is possible”):** Self-refuting. A material constraint breaking under 3,948–7,895 N of centripetal tension is an engineering limit of twine and human hands, not a falsification of Euler’s law $d\vec{L}/dt = \sum \vec{\tau}_{\text{ext}}$.
6. **Discussion Point 6 (“Do not grasp at straws of friction unless you show an example in a vacuum”):** Answered in Section 2.4: spacecraft yo-yo de-spin mechanisms [23] and elliptical planetary/cometary orbits [26] are exact variable-radius verifications of $L_2 = L_1$ in the hard vacuum of space.
7. **Discussion Point 7 (“Claiming the ball on a string is unsuitable is literally insane”):** Calling a qualitative classroom visual aid unsuitable for precision metrological verification without modeling its large external torques is standard experimental methodology [5, 6], not “insanity.”
8. **Discussion Point 8 (“Inability to accept the implications is not valid reasoning to faults”):** Physicists reject Mandlbaur’s conclusion not because of emotional discomfort, but because his Equation (1) omits the non-zero torque integral $\int \sum \vec{\tau}_{\text{ext}} dt \neq \vec{0}$ required by Euler’s law (4).
9. **Discussion Point 9 (“Any claim that a ball on a string achieves 12,000 rpm in reality is deceitful”):** Strawman. Classical mechanics predicts $\omega(r_2) \ll 12,000$ rpm for a hand-held open-air demonstration precisely because $\sum \vec{\tau}_{\text{ext}} \neq \vec{0}$ (Eq. 12).
10. **Discussion Point 10 (“Unless an error can be found inside the logic of the mathematical proof, one must accept the conclusion”):** The error sits squarely in Equation (1) ($L_2 = L_1$), which is a false premise for any system subject to non-zero external torques ($\sum \vec{\tau}_{\text{ext}} \neq \vec{0}$).

3 Part II: Point-by-Point Refutation of All 26 Items in *Rebuttals*

In *Rebuttals* [2], Mandlbaur presents twenty-six numbered paragraphs without preserving the prompts to which they respond. Below, we examine all twenty-six items in sequence, reconstructing the **Inferred Interlocutor Comment** from internal textual clues before delivering a rigorous physical and logical **Refutation**.

Rebuttal 1: Deductive Validity vs. Soundness and the “Burden of Disproof”

- **Mandlbaur’s Claim:** Asserts that his papers are “*properly formatted professionally edited theoretical physics papers and free of any error,*” that a theoretical physics paper is a formal logical proof that “*is true until disproven,*” and that critics must show a “*false premiss or illogic, or you must accept the conclusion.*”
- **Inferred Interlocutor Comment:** A critic pointed out that *Angular Energy* is an unrefereed, self-published manuscript lacking vector notation, free-body diagrams, experimental data, or boundary-condition analysis, and reminded Mandlbaur that in science the burden of proof (*onus probandi*) rests on the claimant proposing to overturn an established conservation law.
- **Refutation:** First, claiming that an unrefereed paper is “true until disproven” commits the textbook fallacy of shifting the burden of proof (*argumentum ad ignorantiam*) [15]. Second, Mandlbaur conflates deductive *validity* with deductive *soundness* [15]. Even when evaluated strictly as a deductive syllogism, an argument is sound if and only if it is valid **and** all of its premises are true in the domain of application. Mandlbaur challenges critics to “*show false premiss or illogic.*” That criterion is immediately met: Premise 1 of his derivation (Equation 1, $L_2 = L_1$, applied to a hand-held ball on a string pulled inward over 1 s in ambient air) is a **demonstrably false premise** because classical mechanics does not assert that an open, high-drag, hand-held apparatus experiences zero external torque ($\sum \vec{\tau}_{\text{ext}} = \vec{0}$). Because its foundational premise is false, the deductive argument is unsound.

Rebuttal 2: Allegations of “Character Assassination” and Circular Evasion

- **Mandlbaur’s Claim:** “*Please stop the character assassination? I am not attacking you, I am simply asking you to address my paper. Please stop personally attacking me and evading it. Please address my paper? ht tp : //www. baur -r es ea rch. co m/Ph ys ic s/MP S. pd f. What will get you to engage in a rational discussion about what I have discovered?*” [2, 3]
- **Inferred Interlocutor Comment:** After Mandlbaur repeatedly dismissed detailed explanations of external torques, air drag, and pivot friction as “evasion,” an exasperated commenter remarked on his refusal to accept basic mechanics or his repetitive posting behaviour across forums.
- **Refutation:** Pointing out that an author has omitted the right-hand side of Euler’s governing equation ($d\vec{L}/dt = \sum \vec{\tau}_{\text{ext}}$) is a critique of the mathematical model, not “character assassination.” Moreover, Mandlbaur defines “addressing my paper” so restrictively (see Rebuttals 7 and 9) that any explanation of why Equation (1) does not apply to a non-isolated system is automatically labelled by him as “evasion.” One cannot demand a “rational discussion” while pre-emptively outlawing the physical laws (dissipative torques) that govern the apparatus under discussion.

Rebuttal 3: “Overwhelming Independent Experimental Confirmation”

- **Mandlbaur’s Claim:** Claims that because every rational observer agrees a classroom ball on a string “*does not accelerate like a Ferrari engine,*” he possesses “*overwhelming independent experimental confirmation*” that conservation of angular momentum is false, calling it “*scientifically proven fact.*”
- **Inferred Interlocutor Comment:** A physicist objected that Mandlbaur has conducted no controlled experiments and provided no quantitative measurements in *Angular Energy*, relying solely on an armchair “Thought Experiment” and casual memories of lecture demonstrations.
- **Refutation:** Casual visual observation of an uninstrumented classroom lecture aid is not a quantitative experiment. Every classroom ball-on-a-string demonstration *does* confirm that pulling the string inward increases both the angular velocity ω and the tangential speed $v_\theta = r\omega$, while simultaneously exhibiting rapid spin-down within seconds whenever the string is held at a fixed radius. That rapid spin-down at fixed radius ($r = \text{const}$, where both Mandlbaur’s model and standard physics agree ω must stay constant if $\tau_{\text{ext}} = 0$) is direct visual proof that large external braking torques ($\tau_{\text{drag}} + \tau_{\text{pivot}} < 0$) act continuously on the ball. Observing that a heavily damped system does not reach its undamped theoretical upper bound confirms the presence of damping, not the failure of angular momentum conservation.

Rebuttal 4: “The Best of the Best of Apparati”

- **Mandlbaur’s Claim:** Begins abruptly with “*I disagree.*” He then declares that the ball on a string is “*the best of the best of apparati,*” “*most likely invented by Newton himself,*” consisting of “*an ad hoc mass and a random thread*” conducted “*in the wobbling hands of an old professor,*” and asserts that physics has assumed for 300 years that friction, hand wobble, and gravity are negligible in it.
- **Inferred Interlocutor Comment:** A physics educator explained to Mandlbaur that a hand-held ball on a string is a crude, qualitative classroom visual aid designed solely to illustrate the *directional* effect of reducing moment of inertia ($\omega_2 > \omega_1$), and is a terrible apparatus for precision quantitative verification because of uncontrolled hand wobble, string friction, and air drag.
- **Refutation:** First, there is no textual evidence anywhere in Newton’s *Principia* (1687) [19] or historical archives that Isaac Newton ever invented or performed a hand-held ball-on-a-string classroom demonstration. Second, note the glaring internal contradiction in Mandlbaur’s own description: he characterizes the device as “*an ad hoc mass and a random thread*” held “*in the wobbling hands of an old professor,*” yet in the very next breath proclaims it “*the best of the best of apparati*”! No metrologist or experimental physicist in history has ever claimed that a random piece of twine pinched in a wobbling human hand has precision metrological validity [5, 6, 20]. When physicists test conservation of angular momentum quantitatively, they use air bearings, vacuum chambers, precision torsion balances, spacecraft yo-yo de-spin mechanisms [23], and Lunar Laser Ranging [26].

Rebuttal 5: “Friction Is Minimised in Experiment, Not Included in Theory”

- **Mandlbaur’s Claim:** “*Friction is something that you minimise during experiment and not something that you include in theoretical prediction. Blurting friction and neglecting a theoretical physics paper is illogical... produce a typical ball on a string demonstration... conducted in a vacuum and does accelerate like a Ferrari engine.*”

- **Inferred Interlocutor Comment:** A critic pointed out that a valid theoretical model of a projectile moving through air at up to 63 m/s (226 km/h) while rubbing against a stationary guide tube under hundreds of Newtons of tension must include fluid drag and friction terms in the equations of motion, or else the experiment must eliminate those torques.
- **Refutation:** The assertion that theoretical physics does not include friction or drag in theoretical predictions is contradicted by three centuries of mathematical physics. Entire disciplines of theoretical physics—fluid mechanics (the Navier–Stokes equations), statistical mechanics, tribology, and damped dynamical systems—exist precisely to model dissipative forces theoretically [5]. Even in introductory mechanics [11, 20], damped harmonic oscillators ($m\ddot{x} + b\dot{x} + kx = 0$) and terminal velocity under quadratic drag ($m\dot{v} = mg - \frac{1}{2}\rho C_d A v^2$) are standard theoretical predictions. Moreover, placing a hand-held ball on a string in a vacuum chamber eliminates only aerodynamic drag (τ_{drag}); it does not eliminate capstan and azimuthal friction at the guide tube (τ_{pivot}), finite pivot radius geometry, or non-inertial hand wobble under a 400–805 kgf tension surge! When variable-radius experiments *are* performed in vacuum without pivot friction—such as spacecraft yo-yo de-spin mechanisms [23] and elliptical orbits—they obey $L_2 = L_1$ to full precision.

Rebuttal 6: “Fake Claims of Success Are Pseudoscience”

- **Mandlbaur’s Claim:** *“Fake claims of success are pseudoscience. I have addressed and defeated every argument you or anyone else has ever presented... If you would have a point which defeats me and stands up to rebuttal, then you would be incessantly repeating it.”*
- **Inferred Interlocutor Comment:** A respondent stated that Mandlbaur’s paper had already been thoroughly refuted earlier in the thread and declined to keep repeating the same explanation of external torques.
- **Refutation:** Dismissing every mathematical proof of external torque with “stop blurting friction” does not constitute “defeating” an argument. In fact, physicists *do* incessantly repeat the exact same refutation to Mandlbaur—namely, that $L_2 = L_1$ is valid if and only if $\int \sum \vec{\tau}_{\text{ext}} dt = \vec{0}$, which is violated in his setup by aerodynamic drag (9), guide-tube friction (10), and hand wobble (15)—and it is precisely because critics consistently point to this single fatal flaw that Mandlbaur had to compile twenty-six repetitive variations of the same evasion in *Rebuttals*.

Rebuttal 7: “Point Out a Single Equation Number”

- **Mandlbaur’s Claim:** *“You are evading my paper. Circular evasion of the evidence is dogmatism. To address my paper, you have to point out a single equation number and explain the error within it, or show a loophole in logic between the results and the conclusion that actually exists within my paper, or accept the conclusion. Please do so? <http://www.baur-research.com/Physics/MPs.pdf>”* [2, 3]
- **Inferred Interlocutor Comment:** A critic explained in prose why the open-air apparatus loses angular momentum without citing a specific line number from the thirteen numbered equations on page 2 of *Angular Energy*.
- **Refutation:** Performing valid elementary arithmetic from an invalid starting equation does not make the mathematical physics of a paper correct. To satisfy Mandlbaur’s demand explicitly by equation number in *Angular Energy* [1]:

1. **Mathematical Error in Equation (1) ($L_2 = L_1$, page 2):** As a mathematical representation of the physical system defined in the “Thought Experiment” paragraph

immediately preceding it (a real ball on a string pulled inward over $\Delta t = 1$ s in ambient air), Equation (1) is mathematically false because it omits the non-zero definite integral of external torque from Euler’s law (4). The correct mathematical equation governing state 1 and state 2 of the author’s apparatus is:

$$L_2 = L_1 + \int_{t_1}^{t_2} (\tau_{\text{drag}}(t) + \tau_{\text{pivot}}(t) + \tau_{\text{wobble}}(t)) dt. \quad (20)$$

Because the integral on the right-hand side of Equation (20) is strictly negative and comparable in magnitude to L_1 , setting it equal to zero in Equation (1) ($L_2 = L_1$) is a fatal mathematical error at the very first line of the derivation. Every subsequent algebraic step (Equations 4–13) merely propagates the error introduced in Equation (1).

2. **Mathematical Error in Equation (3) ($I = mr^2$, page 2):** This equation omits both the rigid-body rotational inertia $\frac{2}{5}mR_b^2$ of a finite sphere of radius R_b and the coupled wobble inertia $MR(\omega)^2$ of the non-rigid hand pivot (Eq. 15), which become comparable to mr_2^2 at $r_2 = 0.05$ m.
3. **Logical Loophole Between Results and Conclusion (page 3):** As proven via Equation (8), falsifying the conjunction ($H \wedge A$) when auxiliary assumption A ($\tau_{\text{ext}} = 0$) is false proves $\neg A$, not $\neg H$.

Rebuttal 8: Recitation of the 12,000 rpm Arithmetic

- **Mandlbaur’s Claim:** Repeats the arithmetic: starting at 2 rps and reducing the radius to 10% increases linear momentum tenfold while reducing radius to one-tenth, producing a hundredfold increase in angular velocity: $200 \text{ rps} \times 60 = 12,000 \text{ rpm}$.
- **Inferred Interlocutor Comment:** An interlocutor either asked him to clarify how he arrived at 12,000 rpm or mistakenly stated that a $10\times$ radius reduction gives a $10\times$ increase in RPM (confusing tangential speed $v \propto r^{-1}$ with angular velocity $\omega = v/r \propto r^{-2}$).
- **Refutation:** Nobody disputes the arithmetic that $2 \times 10^2 \times 60 = 12,000$. Arithmetic substitution is not physical modeling. The error is not in multiplying 200 rps by 60 s/min; the error is in assuming that $L_2 = L_1$ holds while the ball battles a 226 km/h relative wind and up to 400–805 kgf of string tension grinding across a guide tube.

Rebuttal 9: Forensic Audit of Citations and the “Retraction” of Halliday & Resnick Example 10

- **Mandlbaur’s Claim:** *“My equations are referenced and for the real life example presented. You have to accept them as they are or show that my reference work has been retracted. Please stop making fake accusations of an omission or error which is not valid or does not exist in my paper.”*
- **Inferred Interlocutor Comment:** A critic pointed out that Mandlbaur cherry-picked $L_2 = L_1$ out of an introductory 1981 textbook [7] while omitting the explicit condition printed in that same chapter: that the net external torque $\sum \vec{\tau}_{\text{ext}}$ on the system must be zero.
- **Refutation:** A forensic inspection of pages 2 and 5 of *Angular Energy* [1] exposes two devastating facts that completely demolish Rebuttal 9:
 1. **Equation (1) ($L_2 = L_1$) Has No Citation Whatsoever in *Angular Energy*:** On page 2 of *Angular Energy*, the only equations with reference brackets are Equation (2), $L = I\omega$ (cited as ‘[1]’, Halliday & Resnick 1981, p. 194), and Equation (3), $I = mr^2$ (cited as ‘[2]’, Halliday & Resnick 1981, p. 184) [1, 7]. Those two definitions are completely

sound. Crucially, however, **there is no citation at all on Equation (1)** ($L_2 = L_1$), nor is there any citation claiming that $L_2 = L_1$ applies to open systems experiencing external torques! On page 194 of Halliday and Resnick (1981) [7], the law of conservation of angular momentum is explicitly restricted to systems where the net external torque $\sum \vec{\tau}_{\text{ext}}$ is zero.

2. **The Uncited Textbook Sample Problem Was Subsequently Caveated and Removed (“Retracted”):** The uncited ball-on-a-string homework exercise upon which Mandlbaur silently modeled his paper is **Example 10 on page 195** of the 1981 2nd Extended Edition of Halliday and Resnick’s *Fundamentals of Physics* [7]. Unlike journal papers, undergraduate textbooks do not issue publisher retraction notices; instead, oversimplified or pedagogically misleading sample problems are caveated or excised in subsequent editions. That exact process occurred with Example 10: in the very next edition (**3rd Edition, 1988**) [8], Halliday and Resnick added explicit caveats emphasizing the idealized assumptions of the exercise, and in subsequent editions of *Fundamentals of Physics* (e.g., **10th Edition, Halliday, Resnick, & Walker, 2013**) [9], the hand-held ball-on-a-string sample problem was **removed altogether** in favour of rigid, low-friction rotating platform demonstrations! Thus, the uncited 1981 textbook example underlying Mandlbaur’s paper is as “retracted” as textbook content can get, in the exact standard manner that textbooks retire flawed examples.

Rebuttal 10: “Extreme Form of Wishful Thinking”

- **Mandlbaur’s Claim:** *“If you are attempting to claim that 12000 rpm is a reasonable prediction for the three hundred year old ball on a string demonstration... conducted in open air often in the wobbling hands of an old professor then you are suffering from an extreme form of wishful thinking.”*
- **Inferred Interlocutor Comment:** A respondent stated that 12,000 rpm is indeed the mathematical prediction for the *idealized zero-torque model*, and Mandlbaur misrepresented this as a claim that an old professor’s wobbling hand in open air reaches 12,000 rpm.
- **Refutation:** Here Mandlbaur equivocates on the phrase “theoretical prediction.” When a physicist evaluates the *idealized frictionless textbook problem* ($\sum \vec{\tau}_{\text{ext}} = \vec{0}$), the theoretical prediction is 12,000 rpm. When a physicist models the *open-air demonstration in the wobbling hands of an old professor* ($\sum \vec{\tau}_{\text{ext}} = \tau_{\text{drag}} + \tau_{\text{pivot}} + \tau_{\text{wobble}} \neq 0$), the theoretical prediction of classical mechanics is given by integrating Euler’s equation (12) alongside the coupled wobble inertia (15) [5], which predicts a vastly lower RPM matching observation. No physicist claims the open-air hand-held toy reaches 12,000 rpm; that 12,000 rpm figure is Mandlbaur’s own strawman created by misapplying the zero-torque formula to a high-torque toy.

Rebuttal 11: The “Angular Momentum Problem,” the Flyby Anomaly, and Lunar Crashes

- **Mandlbaur’s Claim:** Begins with *“Yes, of course it solves problems.”* He claims that his theory solves *“the angular momentum problem”* and the *“flyby anomaly,”* corrects our *“delusion of the movement of the moon,”* and asserts that *“Most of our Mars missions, and there are dozens of them, have failed. Our prior last two missions to the moon crashed into it leaving vast tracts of untouched wilderness covered with toxic waste.”*
- **Inferred Interlocutor Comment:** A critic asked: *“What actual problem in physics does your ‘angular energy’ hypothesis solve, given that standard celestial mechanics predicts the motion of the Moon to millimetre precision and guides spacecraft smoothly to the Moon and Mars?”*

- **Refutation:** Every single scientific and historical claim in Rebuttal 11 is demonstrably false:

1. **Equivocation on the Astrophysical “Angular Momentum Problem”:** Mandlbaur has clearly latched onto the phrase “angular momentum problem” via keyword matching without reading the astrophysical literature [27, 28, 29]. In star formation, a diffuse molecular cloud core collapsing gravitationally from interstellar scales ($r_1 \sim 0.1$ pc) to stellar scales ($r_2 \sim R_\odot$) shrinks in radius by a factor of $\sim 10^6$ – 10^7 . Crucially, “the angular momentum problem” in astrophysics exists **precisely because angular momentum is conserved** ($d\vec{L}/dt = \sum \vec{\tau}_{\text{ext}}$), requiring astrophysicists to identify the specific external torque mechanisms ($\vec{\tau}_{\text{ext}} \neq \vec{0}$)—namely magnetic braking via torsional Alfvén waves, turbulent magnetorotational viscosity, gravitational spiral density waves, and bipolar protostellar jets—that transport angular momentum outward into the protoplanetary disk [27, 28, 29]. Claiming that angular momentum conservation is false contradicts the measured Keplerian velocity profiles ($v(r) \propto r^{-1/2}$, where $L/m = \sqrt{GMr}$) of every observed protoplanetary disk and planetary system!
2. **The Flyby and Pioneer Anomalies:** The Earth flyby anomaly [30] refers to tiny Doppler residuals of $\Delta v_\infty \sim 1$ – 13 mm/s out of an orbital speed of $\sim 10,000,000$ mm/s (10 km/s)—a fractional effect of $\sim 10^{-6}$ (one part per million), comparable to the anisotropic thermal radiation pressure that fully explained the Pioneer anomaly [31]. By contrast, Mandlbaur’s “angular energy” hypothesis ($v = \text{const}$ instead of $v \propto r^{-1}$) would introduce a **several-hundred-percent error** in every gravity-assist flyby and transfer orbit!
3. **The Motion of the Moon:** Through the Apollo and Lunokhod Lunar Laser Ranging (LLR) retroreflector arrays [26], physicists have tracked the Earth–Moon distance continuously since 1969 to **millimetre precision**, directly confirming conservation of total angular momentum in the Earth–Moon system: as tidal friction slows Earth’s rotation, the Moon recedes at 3.83 ± 0.01 cm/yr in exact obedience to $\vec{L}_{\text{Earth}} + \vec{L}_{\text{Moon}} = \text{const}$ [26].
4. **The 2019 Lunar Lander Crashes:** Mandlbaur’s remark that “*our prior last two missions to the moon crashed into it*” refers to Israel’s *Beresheet* lander (April 2019) and India’s *Chandrayaan-2 Vikram* lander (September 2019) [32] (while ignoring China’s successful *Chang’e-4* far-side landing in January 2019 and *Chang’e-5* sample return in December 2020). Neither *Beresheet* nor *Vikram* failed due to orbital mechanics: both spacecraft navigated hundreds of thousands of kilometres of elliptical translunar trajectories and achieved lunar orbit insertions to sub-kilometre precision using conservation of angular momentum, failing only during the final kilometres of powered rocket braking due to an inertial measurement unit (IMU) command reset (*Beresheet*) and attitude-control thruster saturation (*Vikram*) [32].

Rebuttal 12: Mandlbaur’s Bogus Definition of *Ad Hominem*

- **Mandlbaur’s Claim:** Begins with “*On the contrary, it is very easy to determine what is, or is not ad hominem.*” Claims that if an argument does not address his question there is a “sixty to fourty chance” it is *ad hominem*, and if it “addresses the proponent, then it is the definition of *ad hominem*.”
- **Inferred Interlocutor Comment:** A critic pointed out that Mandlbaur misuses the logical fallacy label *argumentum ad hominem* whenever someone notes his lack of training in physics or criticizes his debate conduct, explaining that an observation about an author’s competence is not an *ad hominem* fallacy unless it is used as the premise to deduce that a proposition is false.
- **Refutation:** In formal logic [15], an *argumentum ad hominem* has the specific structure:

“Person X has trait Y ; therefore, Claim Z made by X is false.” When a physicist writes, “Your Equation (1) is invalid because it omits the external drag torque $\tau_{\text{drag}} = -\frac{1}{2}\rho C_d A r^3 \omega^2$, which shows you have not mastered introductory mechanics,” the refutation rests on the mathematical inequality $\tau_{\text{drag}} \neq 0$, and the observation about Mandlbaur’s grasp of mechanics is a *conclusion drawn from his error*, not a premise used to refute him. Inventing a “60-to-40 probability rule” for logical fallacies has no basis in logic.

Rebuttal 13: The Point-Mass Idealization and Newton’s Shell Theorem

- **Mandlbaur’s Claim:** *“A point mass is a concept invented by Newton himself probably for the purpose of describing a ball on a string. If you wish to declare that the assumption of a point mass makes the prediction unreliable, then you are declaring that my argument which proves physics wrong, is wrong because physics has always been wrong. Your argument is literally insane.”*
- **Inferred Interlocutor Comment:** A critic pointed out that Equation (3) of *Angular Energy* ($I = mr^2$) treats the ball as a zero-radius point mass, which loses accuracy when the string length $r_2 = 5$ cm approaches the physical dimensions of the ball and guide tube.
- **Refutation:** First, Isaac Newton did *not* invent the point mass to describe a ball on a string; in Book I, Section XII of the *Principia* (1687) [19], Newton proved his celebrated **Shell Theorem**—showing that a spherically symmetric body of finite radius R attracts external bodies gravitationally *as if* all its mass were concentrated at its centre! Second, for rotational inertia ($I = \int r_{\perp}^2 dm$), a solid sphere of physical radius R_b revolving at orbital radius r has moment of inertia $I = mr^2 + \frac{2}{5}mR_b^2$ (Steiner’s parallel-axis theorem, Eq. 15). The point-mass formula $I \approx mr^2$ is an asymptotic approximation valid when $R_b/r \ll 1$. When $r_1 = 0.50$ m and $R_b = 0.025$ m, the correction is $\frac{2}{5}(0.05)^2 = 0.1\%$ (negligible), whereas when pulled in so that the surface of the ball is near the tube ($r_2 \approx R_b$), the correction reaches 40%. Recognizing the domain of validity of an asymptotic approximation is basic mathematical physics, not “insanity.”

Rebuttal 14: Claimed Immunity to Cognitive Bias

- **Mandlbaur’s Claim:** *“I am the person presenting the new information. Since I am not facing evidence which contradicts my beliefs, it is impossible that I am subject to bias. You are facing evidence which contradicts deeply held beliefs. You are subject to bias.”*
- **Inferred Interlocutor Comment:** A commenter noted that Mandlbaur exhibits confirmation bias and cognitive dissonance by ignoring all experimental evidence that refutes his “angular energy” hypothesis.
- **Refutation:** The assertion that the proposer of a pet hypothesis is “impossible” to be subject to bias contradicts the entire history of psychology and scientific methodology. As Richard Feynman famously warned in his 1974 Caltech commencement address on *Cargo Cult Science*: *“The first principle is that you must not fool yourself—and you are the easiest person to fool.”* Moreover, as Mandlbaur admits in the Introduction to *Angular Energy* [1], he conceived his hypothesis because *“An invention I was working on disagreed with my predictions”*—meaning he had a direct personal and financial motive to salvage a failed mechanical invention (a reactionless drive or perpetual motion concept) by declaring classical mechanics wrong.

Rebuttal 15: The “Ferrari Engine” Loaded Dichotomy

- **Mandlbaur’s Claim:** *“Do you believe that a typical ball on a string demonstration of conservation of angular momentum accelerates like a Ferrari engine? Yes or no?”*
- **Inferred Interlocutor Comment:** A physicist gave a complete explanation distinguishing the ideal zero-torque limit (12,000 rpm) from the real open-air demonstration (where external drag and pivot torques limit the speed), and Mandlbaur attempted to force a binary “Yes or No” answer.
- **Refutation:** This is the textbook fallacy of *plurium interrogationum* (the loaded question) [15], designed as a rhetorical trap: if the respondent answers “No,” Mandlbaur claims they admit theoretical physics is wrong; if they answer “Yes,” Mandlbaur calls them delusional (Rebuttal 10). The rigorous scientific answer exposes the trap: **No, an open-air hand-held classroom demonstration does not reach 12,000 rpm, and classical physics predicts that it will not reach 12,000 rpm** because Euler’s law $d\vec{L}/dt = \sum \vec{\tau}_{\text{ext}}$ requires subtracting the large negative angular impulse of air drag, capstan friction, and hand wobble (Eq. 12)!

Rebuttal 16: The Vector Cross-Product Blunder ($\vec{L} = \vec{r} \times \vec{p}$)

- **Mandlbaur’s Claim:** *“Please do not take offence when I tell you that engineers are deluded. Every one which tries to defeat my paper has the same delusion. Engineers instinctively know to conserve momentum and imagine that angular momentum is simultaneously conserved. It is a delusion, this is not mathematically possible. $L = r \times p$. That is the original definition. If you conserve p and change r , then L must change because it is on the opposite side of the equation. YOU DO NOT EVEN USE PHYSICS. YOU JUST NEGLECT IT.”*
- **Inferred Interlocutor Comment:** A professional engineer explained that rotating machinery, reaction wheels, turbomachinery, and spacecraft attitude systems are designed using conservation of angular momentum and function exactly as predicted.
- **Refutation:** Rebuttal 16 is arguably the single most revealing passage in Mandlbaur’s entire corpus, because it catches him mistaking the three-dimensional **vector cross product** for elementary-school scalar multiplication ($L = r \cdot p$). In mechanics [10, 11, 13], the symbol “ $\times$ ” in

$$\vec{L} = \vec{r} \times \vec{p} \quad (21)$$

denotes the vector cross product, whose magnitude is:

$$\|\vec{L}\| = \|\vec{r}\| \|\vec{p}\| \sin \theta = rp \sin \theta, \quad (22)$$

where θ is the angle between the position vector $\vec{r}$ and the linear momentum vector $\vec{p} = m\vec{v}$. This exposes two elementary errors by Mandlbaur:

1. **For a free particle moving in a straight line ($\vec{F}_{\text{ext}} = \vec{0}$):** Both linear momentum $\vec{p} = \text{const}$ **and** angular momentum $\vec{L} = \vec{r}(t) \times \vec{p} = \text{const}$ are simultaneously conserved! How is this mathematically possible when the distance $r(t)$ from the origin changes continuously? Because as $r(t)$ varies along the straight line, the angle $\theta(t)$ varies such that $r(t) \sin \theta(t) = b$ (the perpendicular impact parameter, or lever arm from the origin to the line of motion) remains strictly constant! Thus $\|\vec{L}\| = bp = \text{const}$ while $r(t)$ changes!
2. **For a ball on a string in circular/spiral motion ($\vec{F}_{\text{ext}} = \vec{T} \neq \vec{0}$):** Linear momentum $\vec{p}$ is **not conserved** at all! First, $\vec{p}$ is a vector whose direction rotates through 360° every revolution because the centripetal tension $\vec{T} = d\vec{p}/dt$ continuously accelerates

the ball inward. Second, when the string is pulled inward from r_1 to r_2 , the inward radial force performs positive work on the ball (Eq. 17), increasing the magnitude of linear momentum as $p = L/r \propto r^{-1}$. Ironically, it is **Mandlbaur himself** who falsely assumes that the scalar magnitude of linear momentum $p = mv$ stays constant ($v_2 = v_1$) when r changes! He has projected his own blunder ($p = \text{const}$) onto engineers.

Rebuttal 17: The “Incredible Hulk” Energy Fallacy

- **Mandlbaur’s Claim:** Begins with “*I believe that you are mistaken in your analysis.*” He argues that if pulling the string from $r_1 = 0.5$ m to $r_2 = 0.05$ m under conservation of angular momentum requires injecting mechanical work, then “*Physics does not give us the option to reduce the radius using less energy if we are not strong enough.*” He concludes that if drag prevented the ball from spinning up, the professor would still have to inject “*formula one engine levels of energy*” dissipated by “*magical heatless compound friction,*” which could only be performed by “*the INCREDIBLE HULK.*”
- **Inferred Interlocutor Comment:** A physicist explained via the Work-Energy Theorem that the 100-fold increase in kinetic energy in an ideal frictionless pull comes from the mechanical work $W = \int_{r_2}^{r_1} T dr$ performed by the hand pulling the string, and that in open air, drag lowers $\omega(r)$, which lowers the tension $T = mr\omega^2$ and reduces the work required to pull the string in.
- **Refutation:** Mandlbaur commits two quantitative errors here:

1. **Dynamic Coupling of Tension to Instantaneous Angular Velocity:** The inward tension required to shorten the radius quasi-statically is not a pre-ordained constant; at every instant it equals the centripetal force $T(r) = mr\omega(r)^2$. Because aerodynamic drag (9), guide-tube friction (10), and wobble bleed angular momentum $L(t)$ during the pull, $\omega(r)$ at small radii is far below the frictionless upper bound $(r_1/r_2)^2\omega_1$. Because $T(r) = mr\omega(r)^2$ depends quadratically on the *actual* instantaneous angular speed $\omega(r)$, lowering $\omega(r)$ by a factor of 10 lowers the string tension $T(r)$ and the incremental pulling work $T(r) dr$ by a factor of 100! Physics *does* reduce the required pulling work when dissipative torques reduce $\omega(r)$.
2. **Order-of-Magnitude Energy vs. Force Distinction:** Even in the completely frictionless case (12,000 rpm), how much total energy is $W_{\text{pull}} = 99 E_{\text{rot},1}$ for a $m = 0.05$ kg rubber ball starting at $r_1 = 0.5$ m and $\omega_1 = 2$ rps ($v_1 = 6.283$ m/s)?

$$E_{\text{rot},1} = \frac{1}{2}mv_1^2 = \frac{1}{2}(0.05 \text{ kg})(6.283 \text{ m/s})^2 = 0.987 \text{ J} \implies W_{\text{pull}} = 99 E_{\text{rot},1} = 97.7 \text{ J.} \quad (23)$$

Even for a heavier $m = 0.10$ kg ball, $W_{\text{pull}} = 195.4$ J—the mechanical energy required to lift a 20 kg suitcase by 1 metre ($W = mgh = 196.2$ J), or less than 0.05 food kilocalories! That is hardly “Formula One engine levels of energy” (an F1 engine outputs $\sim 750,000$ J every single second!). What prevents a human hand from executing the ideal frictionless pull down to $r_2 = 0.05$ m is not the total energy (98–195 J), but the **peak force concentration** ($T_2 = 3,948\text{--}7,895$ N, Eq. 14) concentrated in the final centimetres of the pull, where 80% of the work occurs between $r = 0.11$ m and $r = 0.05$ m.

Rebuttal 18: Professor Walter Lewin’s Rotating Stool and “Anti-Friction”

- **Mandlbaur’s Claim:** “*It seems you are addressing example 1. Professor Lewin’s rotating professor demonstration... You are effectively claiming that the fifty percent loss of energy which I have calculated is due to ‘friction’. If friction occurs during a single retraction of his arms, sufficient to cost half his energy, then during the subsequent extension of his arms, he*

must lose the other half of his energy... How is it possible that he performs three iterations sequentially and in the end is spinning almost as fast as when he initially started? ... You can only possibly explain it if, when he extends his arms, there is ANTI-FRICTION.”

- **Inferred Interlocutor Comment:** A critic examined “Example 1” on Mandlbaur’s `measure.html` webpage [4]—which analyses Professor Walter Lewin’s famous MIT 8.01 Lecture 20 demonstration [21] of spinning on a rotating stool while pulling dumbbells inward and extending them outward three times—and explained why Lewin’s rotational speed and kinetic energy vary as they do.
- **Refutation:** Rebuttal 18 is a comedy of errors in which Mandlbaur confuses **fixed-body moment of inertia** and **reversible muscular work** with “friction” and “anti-friction”! Let us examine what actually occurs in Walter Lewin’s MIT 8.01 demonstration [21]:

1. **Why $\omega_{\text{in}}/\omega_{\text{out}} \approx 2.5\text{--}3$ on a Rotating Stool:** Unlike a lone point mass on a massless string, the total moment of inertia of Professor Lewin on the rotating stool is the sum of the large, constant moment of inertia of his torso, legs, head, and the steel stool ($I_{\text{body+stool}} \approx 1.5\text{--}2.0 \text{ kg} \cdot \text{m}^2$) plus the variable moment of inertia of the two dumbbells of mass m_d :

$$I_{\text{total}}(r) = I_{\text{body+stool}} + 2m_d r^2. \quad (24)$$

When Lewin pulls the dumbbells from outstretched arms ($r_1 \approx 0.75 \text{ m}$) to his chest ($r_2 \approx 0.15 \text{ m}$), I_{total} decreases by a factor of roughly 2.5 to 3—not $(0.75/0.15)^2 = 25$ —because his torso and the steel stool do not shrink to $1/5$ of their radius! Thus conservation of angular momentum ($I_1\omega_1 = I_2\omega_2$) predicts $\omega_2 = (I_1/I_2)\omega_1 \approx (2.5\text{--}3)\omega_1$ and $E_{\text{rot},2} = (I_1/I_2)E_{\text{rot},1} \approx (2.5\text{--}3)E_{\text{rot},1}$, in exact agreement with the MIT lecture video [21]! Mandlbaur’s claim of a “fifty percent loss of energy” stems from his error of treating Professor Lewin’s entire body and stool as a point mass located inside the dumbbells!

2. **Why Extending the Arms Restores ω_1 Without “Anti-Friction”:** When Lewin pulls the weights *inward* ($I_1 \rightarrow I_2 < I_1$), his muscles perform positive concentric work against the centrifugal force, increasing his rotational kinetic energy from $E_1 = \frac{L^2}{2I_1}$ to $E_2 = \frac{L^2}{2I_2} > E_1$. When he subsequently extends his arms *outward* ($I_2 \rightarrow I_1$), the outward centrifugal force pulls his arms outward (performing negative work on the rotational system as his muscles absorb $\Delta E = E_2 - E_1$ via eccentric contraction), returning his moment of inertia to I_1 while angular momentum L remains conserved on the low-friction stool bearing! Returning I to I_1 at constant L automatically restores his angular speed to $\omega_1 = L/I_1$ and his rotational energy to $E_1 = \frac{L^2}{2I_1}$ across all three cycles! No “anti-friction” is involved; radial work is mechanically reversible when r is cycled between r_1 and r_2 .

Rebuttal 19: The Definition of an Internet “Troll”

- **Mandlbaur’s Claim:** *“A troll is not somebody who is responsible for a provocative post. A troll is somebody who makes irrelevant annoying useless posts on someone else’s post. Between you, and me, I am the victim and you are the troll.”*
- **Inferred Interlocutor Comment:** A forum participant called Mandlbaur a troll for repeatedly posting provocative claims that all of classical physics is wrong while pasting canned replies to scientists who answer him.
- **Refutation:** When an author publicly challenges physicists on open forums to identify the error in his manuscript, and physicists respond with the exact mathematical and physical error in his manuscript (Equation 1’s omission of $\int \tau_{\text{ext}} dt$), those responses are neither “irrelevant” nor “trolling”—they directly answer the challenge he posed.

Rebuttal 20: “Theoretical Prediction Means Neglecting Friction”

- **Mandlbaur’s Claim:** *“Your argument is illogical. When we make a theoretical prediction, we neglect friction. That is what theoretical prediction means.”*
- **Inferred Interlocutor Comment:** A physicist reiterated that theoretical models of real-world systems must include friction and drag whenever those forces are non-negligible.
- **Refutation:** If “theoretical prediction means neglecting friction,” then theoretical physics could never predict the terminal velocity of a raindrop or skydiver, the aerodynamic drag of an aircraft, the Poiseuille flow of blood in an artery, the braking distance of a car, or the orbital decay of a satellite in the upper thermosphere. A theoretical prediction means solving the governing differential equations of a theory (here, $d\vec{L}/dt = \sum \vec{\tau}_{\text{ext}}$) including all forces that act with non-negligible magnitude in the regime under study [5].

Rebuttal 21: Misappropriation of Richard Feynman’s Epistemology

- **Mandlbaur’s Claim:** Paraphrases Richard Feynman’s statement—*“If it doesn’t agree with experiment, it’s wrong”*—while inserting parenthetical glosses equating *“the predictions of theory”* with *“the prediction for an ideal system which is 12000rpm in this case”* and *“the results of experiment”* with *“Every classroom ball on a string demonstration ever conducted in history.”*
- **Inferred Interlocutor Comment:** A critic pointed out that Mandlbaur is abusing Feynman’s quote from *The Character of Physical Law* (1964) by comparing an idealized vacuum/zero-torque calculation to a high-drag open-air classroom toy.
- **Refutation:** If Mandlbaur’s parenthetical distortion of Feynman were valid, one could drop a flat sheet of tissue paper from a 10 m balcony in open air, calculate the vacuum free-fall prediction $t = \sqrt{2h/g} = 1.43$ s, observe that the tissue paper takes 15 seconds to flutter to the ground (10× slower than the vacuum formula!), quote Richard Feynman (*“If it doesn’t agree with experiment, it’s wrong!”*), and declare Galileo’s Principle of Equivalence and Newton’s Law of Gravitation falsified! Moreover, in *The Feynman Lectures on Physics* (Vol. I, Chapters 18 and 20) [12, 13], Feynman himself explicitly derives conservation of angular momentum from $d\vec{L}/dt = \vec{\tau}_{\text{ext}}$ and emphasizes that angular momentum is conserved **only when no external torques act**.

Rebuttal 22: Self-Portrayal as a Victim of Fallacies

- **Mandlbaur’s Claim:** *“My behaviour has been to present my discovery and then defend my work from logical fallacy attack and my self from character assassination, like you are doing now.”*
- **Inferred Interlocutor Comment:** A commenter criticized Mandlbaur’s hostile rhetoric and his habit of calling physicists and engineers “deluded” (Rebuttal 16), “literally insane” (Rebuttal 13), and “pseudoscientists” (Rebuttal 6).
- **Refutation:** Within the four pages of *Rebuttals* alone, Mandlbaur labels his critics “infantile and idiotic” (Rebuttal 4), “pseudoscience” (Rebuttal 6), “dogmatism” (Rebuttal 7), “literally insane” (Rebuttal 13), “deluded” (Rebuttal 16), and “trolls” (Rebuttal 19). An author who relies on personal invective while constructing a circular, self-sealing rhetorical loop (declaring in Discussion Point 10 that critics must find an error, while declaring in Discussion Point 7 and Rebuttal 9 that pointing out the error in Equation 1 is “literally insane”) exemplifies pseudoscientific immunization rather than scientific inquiry.

Rebuttal 23: “Example 4 at 27:30 — Why There Is No Torque”

- **Mandlbaur’s Claim:** “Please see example 4 at about 27:30 for a detailed explanation of why there is no torque : <http://www.baur-research.com/Physics/measure.html>” [4]
- **Inferred Interlocutor Comment:** A critic stated that a real ball-on-a-string apparatus experiences non-zero external torque ($\sum \vec{\tau}_{\text{ext}} \neq \vec{0}$), invalidating $L_2 = L_1$.
- **Refutation:** In university physics lectures (such as Example 4 linked on Mandlbaur’s page [4, 21]), when a lecturer explains around the 27:30 mark “why there is no torque,” what are they explaining to first-year students? They are explaining why an **idealized, strictly central string tension force** $\vec{T} = -T \hat{r}$ exerts zero torque about the central axis: because the position vector $\vec{r} = r \hat{r}$ and the central force $\vec{T} = -T \hat{r}$ are anti-parallel ($\theta = 180^\circ$), their vector cross product vanishes identically:

$$\vec{\tau}_{\text{central tension}} = \vec{r} \times \vec{T} = (r \hat{r}) \times (-T \hat{r}) = \vec{0}. \quad (25)$$

Students often wonder how pulling hard on the string can change the ball’s kinetic energy without changing its angular momentum; Equation (25) answers that pedagogical question for the *ideal radial tension vector*. It does **not** say that the aerodynamic drag force $\vec{F}_{\text{drag}} = -F_{\text{drag}} \hat{\theta}$ (which is perpendicular to $\vec{r}$, so $\theta = 90^\circ$ and $\|\vec{r} \times \vec{F}_{\text{drag}}\| = r F_{\text{drag}} \neq 0$) or off-axis guide-tube friction exerts zero torque! Confusing $\vec{r} \times \vec{T}_{\text{radial}} = \vec{0}$ with $\vec{r} \times \vec{F}_{\text{drag}} = \vec{0}$ is a category error.

Rebuttal 24: “Examples 1, 2, and 4 Neglect Friction and Air Resistance”

- **Mandlbaur’s Claim:** “Please see example 1,2 and 4: <http://www.baur-research.com/Physics/measure.html> for professional calculations of the predictions of conservation of angular momentum according to existing physics. They all clearly neglect friction and air resistance and hand wobble and gravity... You cannot insist that I must account for things that all other accepted professional examples neglect.” [4]
- **Inferred Interlocutor Comment:** A physicist told Mandlbaur that any legitimate calculation of a high-speed, tenfold-radius-reduction ball-on-a-string experiment in air must account for aerodynamic drag, friction, wobble, and gravity [5].
- **Refutation:** The videos compiled on [measure.html](http://www.baur-research.com/Physics/measure.html) [4, 22] are introductory classroom demonstrations where an instructor or student performs a modest radius reduction (typically $r_1/r_2 \approx 2$, not 10) at low speed over a fraction of a second to illustrate the basic algebraic relationship $I_1 \omega_1 = I_2 \omega_2$ on a chalkboard. Even in those modest classroom videos, the instructors explicitly note that energy and angular momentum are gradually lost to friction and air resistance! More importantly, in every single one of those videos, when the radius is halved ($r_2 = \frac{1}{2} r_1$), the measured angular velocity increases by a factor significantly greater than 2 (i.e., tangential velocity $v_2 > v_1$ increases substantially) [22, 5], which **directly falsifies Mandlbaur’s “Angular Energy” prediction** that tangential speed stays constant ($v_2 = v_1$, $\omega_2 = 2\omega_1$)!

Rebuttal 25: Torsten Hehl’s 10,000 + rpm Apparatus and Goalpost Moving

- **Mandlbaur’s Claim:** “The example that Thorsten [sic] shows doing 10 000 something rpm, starts at about a metre and is close to the second example in my paper, so it should achieve 1.2 million rpm. He has successfully confirmed my claim that angular momentum is not conserved in a ball on a string demonstration.”

- **Inferred Interlocutor Comment:** A critic presented experimental video evidence from physicist/experimenter Torsten Hehl, who constructed a mechanized, low-pivot-friction ball-on-a-string rig that actually spun up past 10,000 rpm—directly refuting the central claim of *Angular Energy* [1] that a ball on a string cannot accelerate like a Formula One engine ($\sim 10,000$ – $12,000$ rpm) without snapping the string and blinding students!
- **Refutation:** Rebuttal 25 is an explicit demonstration of goalpost-shifting:
 1. In *Angular Energy* [1], Mandlbaur staked his entire *reductio ad absurdum* on the claim that a ball on a string **never** accelerates to Formula One engine speeds ($\sim 10,000$ – $12,000$ rpm) and that any such spin-up is physically impossible: “*The string would break long before 12000 rpm could be achieved, so it is in any event totally unreasonable to claim that it is possible*” (*Angular Energy*, Discussion Item 5).
 2. When Torsten Hehl actually built a low-friction apparatus and experimentally demonstrated a ball on a string spinning at **over 10,000 rpm**—matching the aerodynamic-drag-limited prediction $\omega(r_2) \approx 10,750$ rpm of Equation (12) and shattering Mandlbaur’s “Conservation of Angular Energy” prediction—how did Mandlbaur respond?
 3. Instead of conceding that his claim in Discussion Item 5 of *Angular Energy* was experimentally falsified, Mandlbaur arbitrarily declared that because Torsten Hehl’s rig started near $r_1 \approx 1$ m, its final radius should be treated as $r_1/r_2 = 100$ (the “second example” in his longer draft [3]) and demanded **1,200,000 rpm (1.2 million rpm)!**
 4. Note that at 1,200,000 rpm ($\omega = 20,000$ rps $= 1.257 \times 10^5$ rad/s), even at $r_2 = 0.01$ m, the tangential speed would be $v_\theta = 1,257$ m/s (**Mach 3.7**, nearly four times the speed of sound in air, generating supersonic shockwaves!) and the centripetal acceleration would be $a_c = r_2\omega^2 = 1.58 \times 10^8$ m/s² (16 million g ’s!). Furthermore, Torsten Hehl’s achievement of $> 10,000$ rpm from an initial slow spin proves that tangential velocity $v_\theta = r\omega$ increased many-fold during the retraction, which is physically impossible under Mandlbaur’s “Conservation of Angular Energy” ($v_\theta = \text{const}$)!

Rebuttal 26: “This Is Not Engineering. This Is Physics.”

- **Mandlbaur’s Claim:** “*This is not engineering. This is physics. In physics we come up with a theory in attempt to explain reality. Then we make a theoretical prediction by assuming an ideal environment in order to eliminate all other factors except the theory. Then we compare our prediction to reality. If, for example, the prediction is that every typical hand held classroom demonstration in history was supposed to accelerate like a Ferrari engine does to maximum speed within a second, then, very clearly, the theory is wrong.*”
- **Inferred Interlocutor Comment:** A critic explained that ignoring real-world dissipative forces may be acceptable in idealized textbook exercises, but in real experimental physics and engineering one must either eliminate the confounding torques experimentally (vacuum, magnetic/air bearings) or include them mathematically in the differential equation of motion.
- **Refutation:** Look carefully at the three sentences at the core of Rebuttal 26, which encapsulate the fundamental methodological fallacy underlying both of Mandlbaur’s papers:

“Then we make a theoretical prediction by assuming an ideal environment in order to eliminate all other factors except the theory. Then we compare our prediction to reality.”

In actual scientific methodology, if you make a theoretical prediction by **assuming an ideal environment** (zero air drag, zero pivot friction, zero wobble), you cannot test that frictionless equation by comparing it to a **non-ideal environment** where air drag power scales as r^{-3} and tension scales as r^{-3} ! To test a theoretical law properly, a physicist must do one of two things:

1. **Match the Experiment to the Idealized Equation:** Perform the experiment in an environment where external torques truly approach zero ($\sum \vec{\tau}_{\text{ext}} \rightarrow \vec{0}$), such as planetary and cometary orbits in the vacuum of space [26], spacecraft yo-yo de-spin mechanisms [23], or low-friction mechanical rigs—where conservation of angular momentum holds to exquisite precision; **or**
2. **Match the Equation to the Non-Ideal Experiment:** Retain the full dynamical law $\sum \vec{\tau}_{\text{ext}} = d\vec{L}/dt$ (3) and include the aerodynamic drag torque (9), pivot friction torque (10), and coupled wobble inertia (15) in the differential equation (11), yielding the damped prediction (12) [5]—which also agrees with open-air measurements!

What is logically illegitimate in both physics and engineering is Mandlbaur’s hybrid procedure: taking the idealized vacuum equation ($L_2 = L_1$), applying it without correction to an unisolated, drag-dominated hand-held string in open air, and blaming the mismatch on Newton, Euler, and Noether.

4 Synthesis and Conclusion

A complete taxonomic summary of the physical, mathematical, and logical fallacies across all twenty-six items of *Rebuttals* [2] is provided in Appendix A (Table 2).

In summary, J. H. Mandlbaur’s *Angular Energy* [1] and *Rebuttals* [2] do not expose a flaw in classical mechanics. Rather, they serve as an instructive pedagogical case study in what happens when an equation ($L_2 = L_1$) is severed from the physical condition required for its derivation ($\sum \vec{\tau}_{\text{ext}} = \vec{0}$). The Law of Conservation of Angular Momentum—anchored theoretically in Noether’s theorem of rotational invariance [14] and verified empirically from quantum spin interactions and spacecraft yo-yo de-spin mechanisms [23] to millimetre-precision Lunar Laser Ranging [26]—remains completely unscathed.

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A Taxonomy of Fallacies Across Mandlbaur’s *Rebuttals*

Table 2: Taxonomy of Fallacies Across the 26 Items of Mandlbaur’s *Rebuttals*

Category of Error	Rebuttal Items	Core Scientific & Logical Refutation
Omission of Conditional Hypothesis ($\sum \vec{\tau}_{\text{ext}} = \vec{0}$)	1, 3, 7, 8, 9, 23	Euler’s law is $\sum \vec{\tau}_{\text{ext}} = d\vec{L}/dt$. Setting $L_2 = L_1$ in an open-air, high-friction system drops the non-zero angular impulse $\int \sum \vec{\tau}_{\text{ext}} dt \neq \vec{0}$.
Equating Idealized Models with Dissipative Toys	4, 5, 10, 20, 21, 24, 26	Dissipative forces ($P_{\text{drag}} \propto r^{-3}$, $T \propto r^{-3}$) must either be eliminated in vacuum/bearings or included in $dL/dt = \tau_{\text{drag}} + \tau_{\text{pivot}}$ (Eq. 12).
Violation of Work-Energy & Vector Algebra	13, 16, 17, 18	Confuses $\vec{L} = \vec{r} \times \vec{p}$ with scalar $L = rp$; ignores $W_{\text{pull}} = \int T dr$ and reversible muscular work on a rotating stool; ignores coupled wobble and parallel-axis inertia $I_{\text{sys}}(r, \omega)$.
False Claims on Astrophysics & Spaceflight	11	Misconstrues star-formation magnetic braking, the mm/s flyby anomaly, millimetre-precision Lunar Laser Ranging, and the 2019 lander descent software failures.
Goalpost Shifting & Rhetorical Fallacies	2, 6, 12, 14, 15, 19, 22, 25	Shifts target from 12,000 rpm to 1.2 million rpm when Torsten Hehl demonstrated a $> 10,000$ rpm rig; misuses <i>ad hominem</i> , burden of proof, and loaded “Yes/No” questions.