# Orbital Mechanics: Foundations

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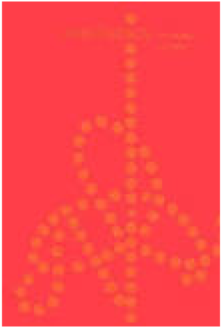
# Overview

1. Wikipedia Proof
2. Background
3. Backup Slides

# Sample Texts


Goldstein 1980



Symon 1971

# Classic Text #2

## LETTERS TO THE EDITOR

Letters are selected for their expected interest for our readers. Some letters are sent to reviewers for advice; some are accepted or declined by the editor without review. Letters must be brief and may be edited, subject to the author's approval of significant changes. Although some comments on published articles and notes may be appropriate as letters, most such comments are reviewed according to a special procedure and appear, if accepted, in the Notes and Discussions section. (See the "Statement of Editorial Policy" in the January issue.) Running controversies among letter writers will not be published.

### THE DISORDER METAPHOR

The metaphor "disorder" for entropy is more than 100 years old. Already in 1882, Hermann von Helmholtz characterized entropy as "Unordnung." [1] Was he the first? Who actually introduced the metaphor and when? We would appreciate any references prior to 1882. And because this metaphor is controversial and potentially misleading, who was the first to discuss its shortcomings?

[1] Hermann Helmholtz, *Wissenschaftliche Abhandlungen* (Barth, Leipzig, 1883), Vol. 2, p. 972. The paper, entitled "The thermodynamics of chemical processes," was reprinted from the Sitzungsberichten der Akademie der Wissenschaften zu Berlin for February 2, 1882. Helmholtz wrote as follows: "Unordered motion, in contrast, would be such that the motion of each individual particle need have no similarity to that of its neighbors. We have ample ground to believe that heat-motion is of the latter kind, and one may in this sense characterize the magnitude of the entropy as the measure of the disorder [literally, of the "Unordnung"]."

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### ERRORS IN GOLDSTEIN'S *CLASSICAL MECHANICS*

The review[1] of the 3rd edition of Goldstein's *Classical Mechanics*[2] (with coauthors Poole and Safko) in the July 2002 issue of AJP elicits the following comments. Despite this book's having played the role for so long of "...the acknowledged standard text for the introductory Classical Mechanics course in graduate level physics curricula throughout the U.S." (as stated in the new Preface), some serious errors have remained through all three editions, with one of the worst now promoted to the front cover. The diagram on the front cover (which also appears on p. 80) is supposed to represent the nature of attractive central-force orbits for bounded motion; the motion depicted is, however, an impossible one. Whereas the actual path at a turning point must always be concave toward the center of force, the diagram in question has the orbit convex toward the center of force at some of the turning points (where the orbit is tangent to the inner circle). This path is clearly impossible. The same error is repeated in Fig. 3.13 on p. 91. (For a correct version of this kind of motion, see the diagram on the cover of the 4th edition of *Classical Dynamics* by Marion and Thornton.[3])

I believe that at least a part of the reason that this egregious error has not been widely noticed in the 50+ years of use of this text is the deplorable fact that virtually all mechanics texts have for a long time not included any treatment of normal and tangential components of acceleration (often called "arc coordinates" or "intrinsic coordinates"), restricting their treatments to Cartesian, cylindrical, and spherical coordinates. Consequently, the relation $F_n = m v^2/R$, where $R$ is the radius of curvature and $F_n$ is the normal component of the force, relating the component of force *in* toward the center of curvature to the acceleration $v^2/R$ in that direction, appears (amazingly) not to be widely known among physicists (and, even when it is known, it is not at the forefront of their awareness). Because an attractive force is always directed in toward the center of force, the direction toward the center of curvature at the turning points must be toward the center of force.

Although this error has persisted in this text for more than 50 years, its remaining presence on the front cover is surely intolerable and should be corrected as soon as possible.

[1] Stephen R. Addison, "Review of *Classical Mechanics*," 3rd ed., by Herbert Goldstein, Charles Poole, and John Safko, Am. J. Phys. **70**, 782–783 (2002).
[2] Herbert Goldstein, Charles Poole, and John Safko, *Classical Mechanics* (Addison–Wesley, New York, 2002), 3rd ed.
[3] Jerry B. Marion and Stephen T. Thornton, *Classical Dynamics of Particles and Systems* (Saunders, Fort Worth, 1995), 4th ed.

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### AUTHORS' REPLY

We wish to thank Professor Martin Tiersten for informing us about errors in three figures of central force motion orbits that have persisted through all three editions of the Goldstein Mechanics text. We are in the process of listing errata for the third edition on our Web site ⟨http://astro.physics.sc.edu/Goldstein/⟩, and we will include there some brief comments on orbits arising from central force motion.

We would appreciate it if Professor Tiersten and other members of the physics community would send us any other errors that they notice so that we can list them on the Web site and correct them in future printings.

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# Goldstein Errata

1. Errata report on Herbert Goldstein's Classical Mechanics 2e[1]
2. Errata, corrections and comments on Classical Mechanics, 3e[2]
3. Errors in Goldstein's Classical Mechanics[3]

[1] osti˙6712863
[2] goldstein3errata
[3] Tiersten 2003

# The Satellite Orbit Tier List


Laboratory 2008

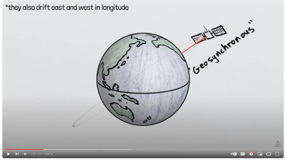
# Select YouTube Videos

The Satellite Orbit Tier List

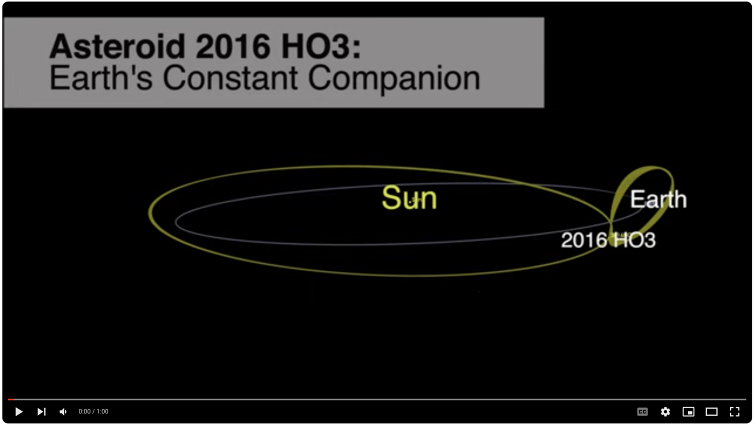

Geostationary, Molniya, Tundra, Polar & Sun Synchronous Orbits Explained


Classical Orbital Elements (COEs)


Geosynchronous Orbits are WEIRD

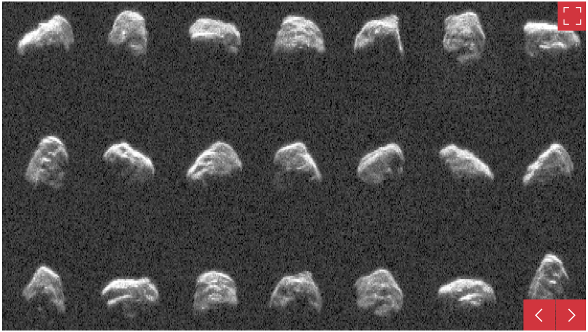


# Asteroid Is Earth's Constant Companion



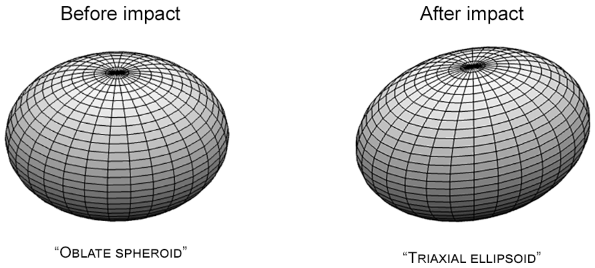

**Laboratory 2008**

# Radar Tracks Two Large Asteroid Close Approaches



**JPL 2024b**

# Asteroid's Orbit, Shape Changed After Impact




**JPL 2024a**

# Bertrand’s Theorem

## Bertrand's theorem

16 languages

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From Wikipedia, the free encyclopedia

In classical mechanics, **Bertrand's theorem** states that among central-force potentials with bound orbits, there are only two types of central-force (radial) scalar potentials with the property that all bound orbits are also closed orbits.[1][2]

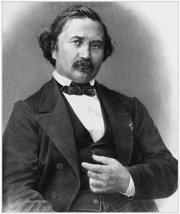
The first such potential is an inverse-square central force such as the gravitational or electrostatic potential:

$$V(r) = -\frac{k}{r} \text{ with force } f(r) = -\frac{dV}{dr} = -\frac{k}{r^2}.$$

The second is the radial harmonic oscillator potential:

$$V(r) = \frac{1}{2}kr^2 \text{ with force } f(r) = -\frac{dV}{dr} = -kr.$$

The theorem is named after its discoverer, Joseph Bertrand.



Joseph Bertrand

enwiki:1188516830

# No Bertrand Theorem

# Professional Societies: Computational Mechanics


# Bibliography I

[1] Herbert Goldstein. Classical mechanics. 1980.

[2] JPL. NASA Study: Asteroid's Orbit, Shape Changed After DART Impact. https://www.jpl.nasa.gov/news/nasa-study-asteroids-orbit-shape-changed-after-dart-impact. 2024-09-14. Mar. 2024.

[3] JPL. NASA's Planetary Radar Tracks Two Large Asteroid Close Approaches. https://www.jpl.nasa.gov/news/nasas-planetary-radar-tracks-two-large-asteroid-close-approaches. 2024-09-14. July 2024.

# Bibliography II

[4] NASA Jet Propulsion Laboratory. Asteroid 2016 HO3 - Earth's Constant Companion. https://www.youtube.com/watch?v=SbbAnVU4rmY. [Online; accessed 19-July-2008]. 2008.

[5] K.R. Symon. Mechanics. Addison-Wesley series in physics. Addison-Wesley Publishing Company, 1971. ISBN: 9780201073928. URL: https://books.google.com/books?id=JVk_4udwNtkC.

[6] Martin Tiersten. “Errors in Goldstein's Classical Mechanics”. In: American Journal of Physics 71.2 (2003), p. 103.

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