Errata Sheet for Herbert Goldstein's *ClassicalMechanics*, Second Edition

by Michael A. Unseren and Forrest M. Hoffman†

Engineering Physics and Mathematics Division

and Environmental Sciences Division†

Oak Ridge National Laboratory‡

Oak Ridge, Tennessee 37831

August 9, 1993

Submitted to ————-

‡ Managed by Martin Marietta Energy Systems,Inc., under contract DE–AC05–84OR21400 with the U.S. Department of Energy.

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Abstract

An errata sheet for Herbert Goldstein's textbook *Classical Mechanics*, Second Edition (Copyright 1980, ISBN 0–201–02918–9) is presented. Some of the errors in current printings of the text were corrected in the second printing; however, after communicating with Addison Wesley, the publisher for *Classical Mechanics*, it was discovered that the corrected galley proofs had been lost by the printer and that no one had complained of any errors in the eleven years since the second printing. The errata sheet corrects errors from all printings of the second edition.

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1. Introduction

During a two semester graduate course in classical mechanics, we began to notice errors in Herbert Goldstein's text *Classical Mechanics*, Second Edition (Copyright 1980, ISBN 0–201–02918–9). Taking a closer look, we discovered that many of the errors were not contained in the second printing of the second edition but were contained in our twentieth printing. After communicating with Addison Wesley, the publisher for *Classical Mechanics*, we found out that the printer had lost the corrected galley proofs from the second printing and that no one had ever complained of errors in the eleven years and approximately 55,000 copies sold since. It became clear that Addison Wesley intended neither to correct the errors nor to create an errata sheet for the text.

Since *Classical Mechanics* is used in almost every graduate physics program in the U.S. and is referenced by many practicing engineers and physicists worldwide, we felt it necessary to create our own errata sheet for the text and to publish it so that others could benefit from our work. Below are the corrected equations and phrases we have found to be in error in the text.

2. Errata

- Page 2, below equation (1–4)†:

In most instances the mass of the particle is constant and Eq. (1–4) reduces to

- Page 8, $\mathbf{v}'$ equation, middle of page†:

$$\mathbf{v}_i' = \frac{d\mathbf{r}_i'}{dt}$$

† a dagger indicates an error in all printings of the second edition.

- Page 18, equation (1–48):

$$\sum_i \mathbf{F}_i \cdot \delta \mathbf{r}_i = \sum_{i,j} \mathbf{F}_i \cdot \frac{\partial \mathbf{r}_i}{\partial q_j} \delta q_j$$
$$= \sum_j Q_j \delta q_j, \qquad (1-48)$$

- Page 19, above equation (1–51):

$$\frac{d}{dt}\left(\frac{\partial \mathbf{r}_i}{\partial q_j}\right) = \frac{\partial \dot{\mathbf{r}}_i}{\partial q_j} = \sum_k \frac{\partial^2 \mathbf{r}_i}{\partial q_j \partial q_k}\dot{q}_k + \frac{\partial^2 \mathbf{r}_i}{\partial q_j \partial t},$$
$$= \frac{\partial \mathbf{v}_i}{\partial q_j},$$

- Page 19, above equation (1–52)†:

$$\sum_j \left\{ \frac{d}{dt}\left(\frac{\partial}{\partial \dot{q}_j}\left(\sum_i \frac{1}{2} m_i v_i^2\right)\right) - \frac{\partial}{\partial q_j}\left(\sum_i \frac{1}{2} m_i v_i^2\right) - Q_j \right\} \delta q_j.$$

- Page 24, first line of equation (1–69)†:

$$Q_j = \sum_i \mathbf{F}_{if} \cdot \frac{\partial \mathbf{r}_i}{\partial q_j} = -\sum \nabla_v \mathscr{F} \cdot \frac{\partial \mathbf{r}_i}{\partial q_j}$$

- Page 24, second line of equation (1–69):

$$= -\sum \nabla_v \mathscr{F} \cdot \frac{\partial \dot{\mathbf{r}}_i}{\partial \dot{q}_j}, \qquad \text{by } (1-51),$$

- Page 27, last equation in example 1†:

$$\frac{d}{dt}\left(mr^2\dot{\theta}\right) = mr^2\ddot{\theta} + 2mr\dot{r}\dot{\theta} = rF_\theta$$

- Page 45, equation (2–19):

$$I = \int_1^2 L\left(q_i, \dot{q}_i, t\right) dt \tag{2-19}$$

- Page 46, equation (2–20):

$$\sum_k a_{lk} dq_k + a_{lt} dt = 0, \tag{2-20}$$

- Page 50, second equation from the bottom of the page:

$$r\ddot{\theta} = \ddot{x}$$

- Page 55, third equation from the top of the page†:

$$\frac{d}{dt}\frac{\partial L}{\partial \dot{q}_j} - \frac{\partial L}{\partial q_j} = 0,$$

- Page 60, equation reference below equation (2–51)†:

and (2–51) can be rewritten as

- Page 61, above equation (2–53)†:

The quantity in the parentheses is oftentimes called the *energy function** and will be

- Page 61, second line below equation (2–55):

$\dot{q}$ while L_1 is homogeneous of the first degree in $\dot{q}$. There is no reason intrinsic to

- Page 61, first line of first footnote:

* The energy function h is identical in value with the Hamiltonian H (see Chapter 8). It is

- Page 72, footnote†:

Formally: $\dot{\mathbf{r}} = \dot{r}\mathbf{n}_r + r\dot{\theta}\mathbf{n}_\theta$, hence $\mathbf{r} \times \dot{\mathbf{r}} = 0$ requires $\dot{\theta} = 0$.

- Page 75, below equation (3–20):

E, l, r_0, θ_0. These constants are not the only ones that can be considered. We

- Page 77, below equation (3–15′)†:

(For positive k the minus sign ensures that the force is *toward* the center of force.)

- Page 87, equation (3–36):

$$\theta = \int_{r_0}^{r} \frac{dr}{r^2\sqrt{\frac{2mE}{l^2} - \frac{2mV}{l^2} - \frac{1}{r^2}}} + \theta_0 \qquad (3-36)$$

- Page 91, the equation above equation (3–43), equation (3–43), and equation (3–43′)†:

$$\left.\frac{d^2V'}{dr^2}\right|_{r=r_0} = -\left.\frac{df}{dr}\right|_{r=r_0} + \frac{3l^2}{mr_0^4} > 0.$$

$$\left.\frac{df}{dr}\right|_{r=r_0} < -\frac{3f\,(r_0)}{r_0}, \qquad (3-43)$$

$$\left.\frac{d\ln f}{d\ln r}\right|_{r=r_0} > -3 \qquad (3-43')$$

where $\frac{f(r_0)}{r_0}$ is assumed to be negative and given by dividing Eq. (3–41) by r_0.

- Page 92, above equation (3–44)†:

$$\frac{(n+1)\,k}{r_0^{n+2}} < \frac{3k}{r_0^{n+2}}$$

where $\frac{k}{r_0^{n+2}}$ is assumed to be positive.

- Page 95, equation (3–52)*:

$$e = B\frac{l^2}{mk}. \tag{3 - 52}$$

- Page 95, equation (3–53):

$$\theta = \theta' - \int \frac{du}{\sqrt{\frac{2mE}{l^2} + \frac{2mku}{l^2} - u^2}}, \tag{3 - 53}$$

- Page 131, above equation (4–5):

$$\mathbf{i} = (\mathbf{i} \cdot \mathbf{i}')\,\mathbf{i}' + (\mathbf{i} \cdot \mathbf{j}')\,\mathbf{j}' + (\mathbf{i} \cdot \mathbf{k}')\,\mathbf{k}'$$

- Page 149, equation (4–54):

$$\delta = -\alpha^* \frac{\beta}{\gamma^*}, \tag{4 - 54}$$

- Page 155, the α, β, γ, and δ equations between equation (4–71) and equations (4–72′) should be labeled as equations (4–72).

- Page 157, section number in heading at the top of the page:

4–5 THE CAYLEY–KLEIN PARAMETERS AND RELATED QUANTITIES **157**

- Page 159, sentence above equation (4–82)†:

homogeneous, the Eqs. (4–81) can have a nontrivial solution only when the determinant of

* an asterisk indicates an error in only the second printing of the second edition.

- Page 163, second paragraph, sixth line†:

equation (4–82), it follows that the inverse matrix $\mathbf{A}^{-1} = \tilde{\mathbf{A}}$ has the same

- Page 173, below equation (4–116)†:

where $\mathbf{N}$ is the transpose of the matrix on the right in Eq. $(4-105')$ with elements $N_{ij} = \epsilon_{ijk}\eta_k$.

- Page 175, sixth line below equation (4–122)†:

the matrix $\tilde{\mathbf{A}}$ in the time dt is thus a change from the unit matrix and therefore

- Page 175, ninth line below equation (4–122)†:

using the antisymmetry property of $\boldsymbol{\epsilon}$. In terms of the permutation symbol ϵ_{ijk} the

- Page 175, tenth line below equation (4–122):

elements of $\boldsymbol{\epsilon}$ are such that (cf. Eq. 4–105)

- Page 175, second equation below equation (4–122)†:

$$-\boldsymbol{\epsilon}_{ij} = -\epsilon_{ijk} d\Omega_k = \epsilon_{ikj} d\Omega_k.$$

- Page 176, $\omega_{x'}$ and $\omega_{y'}$ equations in equation (4–125):

$$\begin{aligned} \omega_{x'} &= \dot{\phi}\sin\theta\sin\psi + \dot{\theta}\cos\psi \\ \omega_{y'} &= \dot{\phi}\sin\theta\cos\psi - \dot{\theta}\sin\psi \end{aligned} \qquad (4-125)$$

- Page 186, ω_x equation in problem 19:

$$\omega_x = \dot{\theta}\cos\phi + \dot{\psi}\sin\theta\sin\phi,$$

- Page 189, second paragraph, seventh line†:

almost all problems soluble in practice will allow for such a separation. In such case

- Page 192, equation (5–10):

$$T'_{ijk\ldots}\left(\mathbf{x}'\right) = a_{il}a_{jm}a_{kn}\ldots T_{lmn\ldots}\left(\mathbf{x}\right). \tag{5 − 10}$$

- Page 196, third equation:

$$I = \frac{2T}{\omega^2}$$

- Page 197, above last equation†:

The inertia tensor for the origin O, in the dyadic form of Eq. (5–16), can be written

- Page 198, second equation:

$$I_{xy} = I_{yx}.$$

- Page 211, footnote equation†:

$$\dot{\boldsymbol{\omega}} = \boldsymbol{\Omega} \times \boldsymbol{\omega},$$

- Page 212, second equation†:

$$\Omega = \frac{\omega_3}{305.81039} \approx \frac{\omega_3}{306}$$

- Page 212, second sentence below second equation†:

of precession of approximately 306 days or about 10 months. If some circumstance disturbed the

- Page 213, equation (5–50):

$$T = \frac{I_1}{2}\left(\dot{\theta}^2 + \dot{\phi}^2 \sin^2\theta\right) + \frac{I_3}{2}\left(\dot{\psi} + \dot{\phi}\cos\theta\right)^2, \qquad (5-50)$$

- Page 221, below equation (5–77b):

$\theta, \phi, \psi, \dot{\theta}, \dot{\phi}$, and say, either $\dot{\psi}$ or ω_3 at the time $t = 0$. Because they are cyclic the

- Page 227, fourth line of middle paragraph†:

nonvanishing correction term in Eq. (5–84) to the potential for a sphere. Now, the

- Page 228, equation (5–87)†:

$$V = -\frac{GMm}{r} + \frac{GM}{2r^3}\left[3I_r - (I_1 + I_2 + I_3)\right]. \qquad (5-87)$$

- Page 228, equation (5–88)†:

$$V = -\frac{GMm}{r} + \frac{GM\left(I_3 - I_1\right)}{r^3} P_2\left(\gamma\right). \qquad (5-88)$$

- Page 229, equation (5–89)†:

$$V_2 = \frac{GM\left(I_3 - I_1\right)}{r^3} P_2\left(\gamma\right). \qquad (5-89)$$

- Page 240, equation in problem 19b†:

$$\sin\theta' = \frac{\Omega}{\dot{\phi}}\sin\theta'',$$

- Page 241, problem 25, sixth line†:

To prove this statement, calculate θ and $\dot{\phi}$ as a function of time for a heavy symmetrical

- Page 241, problem 25, Ω equation†:

$$\Omega = \frac{I_3 - I_1}{I_1}\omega_3$$

- Page 246, line above equation (6–11)†:

consequently can have a nontrivial solution only if the determinant of the coefficients

- Page 248, fourth line†:

and subtract the result from the similar product of Eq. (6–16) from the left with $\mathbf{a}_l^\dagger$.

- Page 256, equation, middle of the page:

$$\boldsymbol{\eta} = \tilde{\mathbf{B}}\mathbf{y}, \qquad \tilde{\boldsymbol{\eta}} = \tilde{\mathbf{y}}\mathbf{B},$$

- Page 259, equation (6–53)†:

$$|\mathbf{V} - \omega^2\mathbf{T}| = \begin{vmatrix} k-\omega^2 m & -k & 0 \\ -k & 2k-\omega^2 M & -k \\ 0 & -k & k-\omega^2 m \end{vmatrix} = 0. \tag{6 – 53}$$

- Page 276, last paragraph†:

On the other hand, the transformation represented by Eqs. (7–2) and (7–4),

- Page 277, second paragraph, ninth line†:

systems moving uniformly relative to each other. Measurements made entirely

- Page 278, second paragraph, third and fourth lines†:

coincide at zero time, as seen by observers in both systems. Let one system, call it the primed system, move uniformly with velocity **v** relative to the other, unprimed

- Page 285, equation (7–30)†:

$$L_{44} = \left(1 - \beta^2\right)^{-\frac{1}{2}} \equiv \gamma. \tag{7 - 30}$$

- Page 300, fifth line from the bottom†:

measured in the rest system [of the particle] is always shorter than the corresponding time interval

- Page 311, equation (7–103)†:

$$P_\mu P_\mu = -\left(m_1^2 + m_2^2\right) c^2 + 2 p_{1\mu} p_{2\mu}. \tag{7 - 103}$$

- Page 344, above equation (8–17)†:

q and t. The conjugate momenta, considered as a column matrix **p**, is then by Eq.

- Page 350, above equation (8–41)†:

$\dot{x}'$, with the single component of **a** being mv_0. The new Hamiltonian is now

- Page 363, below equation (8–70)†:

Equations (8–69) and (8–70) are exactly Hamilton's equations of motion, Eqs.

- Page 383, above equation (9–15)†:

rather than $\dot{Q}_i$. This can be accomplished by writing F in Eq. (9–11) as

- Page 385, q_2 equation, bottom of page†:

$$q_2 = -\frac{\partial F'}{\partial p_2},$$

- Page 423, the second and third lines are interchanged:

conceptions of special relativity; it is purely a problem of nonrelativistic

Newtonian mechanics. That the symmetry group may involve a space of higher

- Page 431, second equation in problem 5:

$$P = \frac{\alpha q^2}{2}\left(1 + \frac{p^2}{\alpha^2 q^2}\right)$$

- Page 607, elements (3,1) and (3,2) of $\mathbf{A}$ in equation (B–3y)†:

$$\mathbf{A} = \begin{pmatrix} -\sin\psi\sin\phi + \cos\theta\cos\phi\cos\psi & \sin\psi\cos\phi + \cos\theta\sin\phi\cos\psi & -\cos\psi\sin\theta \\ -\cos\psi\sin\phi - \cos\theta\cos\phi\sin\psi & \cos\psi\cos\phi - \cos\theta\sin\phi\sin\psi & \sin\psi\sin\theta \\ \sin\theta\cos\phi & \sin\theta\sin\phi & \cos\theta \end{pmatrix} \tag{B-3y}$$

- Page 607, below equation defining matrix $\mathbf{G}$†:

again leading to Eq. (B–3y).

- Page 607, below equation (B–4y)†:

From the matrix product $\mathbf{Q} = \mathbf{Q}_\psi \mathbf{Q}_\theta \mathbf{Q}_\phi$ (or by the translation equations (B–1y))

- Page 608, second line below equation (B–6y)†:

(B–2y), or by following through the physical meanings of the component parts of

- Page 609, line above equations (B–13xyz)†:

Euler parameters. From Eq. (4–65) and Eq. (B–12xyz) it follows that the Euler parameters are

3. Summary

It is hoped that these errata will be a useful supplement to Dr. Goldstein's timeless textbook, a cornerstone of the subject of classical mechanics. While this errata sheet is probably not complete, the authors will continue to collect errors from the text.

4. Acknowledgments

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5. End Notes

[1] Indicates an error in all printings of the second edition.

[2] Indicates an error in only the second printing of the second edition.