Errata List and New Additions for the AIAA Education Series Text Book

# ANALYTICAL MECHANICS OF SPACE SYSTEMS

3rd Edition

authored by H. Schaub & J. L. Junkins

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This file contains various typos that were found in the 3rd edition of the text book. Please use these pages to update your book copy. Where possible, the changes are highlighted in red. If you find typos that are not listed here, please contact the author at

hanspeter.schaub@colorado.edu

and email the typo type, as well as the typo location within the manuscript. A revision history is provided at the end of the document.

- p. 25, Problem 1.7 : Change to read:
  A person in Problem 1.5 has boarded a high-speed...
- p. 28, Problem 1.14 : Change to read:
  ... with the trajectory $\boldsymbol{r}_m j = h\hat{\boldsymbol{n}}_3 - tv_0\hat{\boldsymbol{n}}_2$, where $v_0$ is a constant velocity magnitude.
- p. 35, Eq. (2.13) : Change G to S to make it read:

$$F = -\nabla V_S = -kx$$

- p. 66, first paragraph of section 2.6, 3rd to last line : Should read "...be used to perform a braking maneuver."
- p. 67, first line of page : Should read "Using Eq. (2.64), we can write the linear momentum..."
- p. 77, Problem : Should read "... is given in Eq. (2.113). Draw a..."
- p. 92, Eq. 3.43 : Change to

$$\sin(\varphi_1 - \theta_1) = \frac{\sin\phi_2}{\sin\left(\pi - \varphi_2\right)}\sin(\theta_3 + \phi_1)$$

- p. 92, Eq. 3.44 : Change to

$$\sin(\varphi_3 - \phi_3) = \frac{\sin\theta_2}{\sin\left(\pi - \varphi_2\right)}\sin(\theta_3 + \phi_1)$$

- p. 92, Eq. 3.45 : Change to

$$\cos(\varphi_1 - \theta_1) = \frac{\cos\phi_2 - \cos\theta_2\cos\varphi_2}{\sin\theta_2\sin\left(\pi - \varphi_2\right)}$$

- p. 92, Eq. 3.46 : Change to

$$\cos(\varphi_3 - \phi_3) = \frac{\cos\theta_2 - \cos\phi_2\cos\varphi_2}{\sin\phi_2\sin(\pi - \varphi_2)}$$

- p. 93, lower third of page : Should read "Using the transformations in Eq. (3.35), the relative (3-2-1) Euler angles are"
- p. 99, 4th line of Example 3.3 : Should read "Using Eq. (3.34), the direction cosine ..."
- p. 104, second equation from top: Remove prime symbol of 2nd $\Phi$ to read:

$$\beta_i' = e_i \sin\left(\frac{\Phi'}{2}\right) = e_i \sin\left(\frac{\Phi}{2} - \pi\right) = \cdots$$

- p. 105, last 2 lines before Eq. (3.95a): Should read "... developed by Shepperd in Ref. [19]."
- p. 105, first line after Eq. (3.95d): Should read "Then Shepperd takes the square root ..."
- p. 106, first line fo Example 3.6: Should read "Let's use Shepperd's method to find ..."
- p. 107, Eq. (3.98), the (1,2) element of the 4x4 matrix: Should read

$$-\beta_1''$$

- p. 108, first line of Example 3.8: Should read "Using Shepperd's method, the direction cosine ..."
- p. 117, 3rd to last line from bottom of page: Should read "Substituting Eq. (3.91) into Eq. (3.137), the MRP ..."
- p. 121, 4th line from top of page: Should read "... been provided by Hurtado in Ref. [34]."
- p. 124, Eq. (3.160): Change it to read:

$$[C] = ([I] - [S])^2([I] + [S])^{-2} = ([I] + [S])^{-2}([I] - [S])^2$$

- p. 127, 2 lines above Eq. (3.172): Change it to read:
is set at $\beta_0 = a$, and the projection plane is defined through $\beta_0 = a + 1$. The ...
- p. 130, Eq. (3.188): Make the LHS $\tau$ bold it to read:

$$\dot{\boldsymbol{\tau}} = \cdots$$

- p. 140, 2nd to last line of equations in Example 3.14: Adjust the 2nd entry of $\hat{\boldsymbol{v}}_1$ to read:

$${}^{\mathcal{B}}\hat{\boldsymbol{v}}_1 = \begin{pmatrix} 0.8190 \\ -0.5282 \\ 0.2242 \end{pmatrix}^{\mathcal{B}}$$

- p. 146, Eq. (3.231): Identity matrix should be 4x4 to make equation read:

$$f(s) = \det([K] - s[I_{4x4}]) = 0$$

- p. 150, Ref. [19]: Should read "Sheppeard, S. W., ..."
- p. 156, first line at top of page: Remote the "hat" symbol to read:
  expression $q_i = \tan(\Phi/2)e_i$, which is ...
- p. 156, 3rd line of Problem 3.25: Remote the "hat" symbol to read:
  ... the expression $\sigma_i = \tan(\Phi/4)e_i$, which is ...
- p. 185, Caption of Figure 4.11 b): Change to "Body with "$I_1 = I_2 = I_3$"
- p. 205, first sentence of Ex. 4.10: Change to read:
  The $N$-VSCMG equations of motion in Eqs. (4.136) and (4.137) contain both ...
- p. 205, 4th line of Ex. 4.10: Change to read:
  ..., then the differential equation in Eq. (4.137).
- p. 206, top of page: Make $\sigma$ bold in first equation to read

$$\boldsymbol{f}_\sigma = \frac{1}{4}[B(\boldsymbol{\sigma})]\boldsymbol{\omega}$$

- p. 206, 3rd Equation from top: Make $\gamma$ bold to read

$$\boldsymbol{f}_\gamma = \dot{\boldsymbol{\gamma}}$$

- p. 206, 5th Equation from top: Add $\Omega$ subscript $i$ to read

$$\boldsymbol{f}_{\Omega_i} = u_{s_i} - J_{s_i}\dot{\gamma}_i\omega_{t_i}$$

- p. 210, sentence after Eq. (4.159): Change text to read:
  Note that the first and fourth term in the parentheses are zero due...
- p. 224, Prob 4.25: Change equation references to read:
  Starting with Eq. (4.183), show how the characteristic equation in Eqs. (4.186) and (4.187) are found.
- p. 225, Ex. 56, line after Eq. (5.55): Change to:
  ... the holonomic (and scleronoic) constraint...
- p. 228, Eq. (5.2): 2nd to last line of this equation should read

$$+(r\ddot{\phi}\cos\theta + 2\dot{r}\dot{\phi}\cos\theta - 2r\dot{\phi}\dot{\theta}\sin\theta)\hat{\boldsymbol{e}}_\phi$$

- p. 228, Eq. (5.3): Should read

$$\ddot{\boldsymbol{r}} = (\ddot{d} - d\dot{\phi}^2)\hat{\boldsymbol{e}}_d + (d\ddot{\phi} + 2\dot{d}\dot{\phi})\hat{\boldsymbol{e}}_\phi + \ddot{z}\hat{\boldsymbol{n}}_3$$

- p. 234, 4th equation from bottom of page: Add $\theta$ to read

$$\cdots = 2\lambda\delta\theta(-xy + xy) = 0$$

- p. 238, top of page: Change equation reference to read
  ..., we can combine Eqs. (5.28) and (5.29) to write...

- p. 243, first equation at top of page: remove $\hat{\boldsymbol{\imath}}_r$ inside the large brackets to read

$$(\boldsymbol{F}_g - m\ddot{\boldsymbol{r}}) = m\left(-\frac{\mu}{r^2} - \ddot{r} + r\dot{\theta}^2\right)\hat{\boldsymbol{\imath}}_r - m(2\dot{r}\dot{\theta} - r\ddot{\theta})\hat{\boldsymbol{\imath}}_\theta$$

- p. 243, 2nd equation at top of page: remove $\hat{\boldsymbol{\imath}}_r$ inside the large brackets to read

$$(\boldsymbol{F}_g - m\ddot{\boldsymbol{r}}) \cdot \hat{\boldsymbol{\imath}}_r = m\left(-\frac{\mu}{r^2} - \ddot{r} + r\dot{\theta}^2\right) = \ldots$$

- p. 253, Eq. (5.101): Replace $n$ with $m$ to read

$$\psi_j(q_1, \cdots, q_n, t) = 0 \qquad j = 1, 2, \cdots, m$$

- p. 267, last equation of Example 5.13: Rewrite this equation to read

$$\cos\theta\ddot{x} + r\ddot{\theta} = -g\sin\theta$$

- p. 272, 1st equation at top of page: Add $m$ to read:

$$\mathcal{L} = T - V = \frac{m}{2}\dot{r}^2 + \frac{1}{2}mr^2\dot{\theta}^2 - \frac{k_1}{2}r^2 - \frac{k_2}{4}r^4$$

- p. 281, Eq. (5.213): Add $m_i$ to read:

$$T_1 = \sum_{i=1}^{N} m_i \left\{\frac{\partial \boldsymbol{R}_i}{\partial t}\right\}^T [V_i]\dot{\boldsymbol{q}} \qquad \text{(linear in } \dot{\boldsymbol{q}}\text{)}$$

- p. 281, Eq. (5.214): Add $m_i$ to read:

$$T_0 = \frac{1}{2}\sum_{i=1}^{N} m_i \left\{\frac{\partial \boldsymbol{R}_i}{\partial t}\right\}^T \left\{\frac{\partial \boldsymbol{R}_i}{\partial t}\right\} \qquad \text{(does not contain } \dot{\boldsymbol{q}}\text{)}$$

- p. 281, Eq. (5.217): Add $m_i$ to read:

$$\boldsymbol{G}(\boldsymbol{q}, \dot{\boldsymbol{q}}) = [\dot{M}]\dot{\boldsymbol{q}} + \frac{\mathrm{d}}{\mathrm{d}t}\left(\sum_{i=1}^{N} m_i \left\{\frac{\partial \boldsymbol{R}_i}{\partial t}\right\}^T [V_i]\right) - \mathrm{col}\left(\frac{1}{2}\dot{\boldsymbol{q}}^T\left[\frac{\partial M}{\partial q_1}\right]\dot{\boldsymbol{q}}, \frac{1}{2}\dot{\boldsymbol{q}}^T\left[\frac{\partial M}{\partial q_2}\right]\dot{\boldsymbol{q}}, \ldots, \frac{1}{2}\dot{\boldsymbol{q}}^T\left[\frac{\partial M}{\partial q_n}\right]\dot{\boldsymbol{q}}\right) - \frac{\partial}{\partial \boldsymbol{q}}(T_0 + T_1 - V)$$

- p. 281, Eq. (5.218): Add $m_i$ to read:

$$\boldsymbol{G}(\boldsymbol{q}, \dot{\boldsymbol{q}}) = \left[\dot{\boldsymbol{q}}^T C^{(1)}\dot{\boldsymbol{q}}, \dot{\boldsymbol{q}}^T C^{(2)}\dot{\boldsymbol{q}}, \ldots, \dot{\boldsymbol{q}}^T C^{(n)}\dot{\boldsymbol{q}}\right]^T + \frac{\mathrm{d}}{\mathrm{d}t}\left(\sum_{i=1}^{N} m_i \frac{\partial \boldsymbol{R}_i}{\partial t}[V_i]\right) - \frac{\partial}{\partial \boldsymbol{q}}(T_0 + T_1 - V)$$

- p. 334, 5th equation from bottom of page): Add a prime symbol on last term to read:

$$\cdots + I_{\text{tip}}[\ddot{\theta} + \ddot{v}'(L,t)] = 0$$

- p. 335, Problem 6.2): In first sentence, replace axial with transverse to read:
... to a vertical, distributed transverse load $p(x,t)$ as shown ...

- p. 379, caption of Fig. 3.e): change to:
... as $V(x) \to 0$ as ...

- p. 380, Eq. (8.15): remove the transpose operator to make it read:

$$\dot{V} = \frac{\partial V}{\partial \boldsymbol{x}}\dot{\boldsymbol{x}} = \frac{\partial V}{\partial \boldsymbol{x}}\boldsymbol{f}(\boldsymbol{x})$$

- p. 390, Eq. (8.36): add brackets about $\boldsymbol{\omega} \times \boldsymbol{\omega}_r$ to read:

$$\dot{V} = \delta\boldsymbol{\omega}^T(-[\tilde{\omega}][I]\boldsymbol{\omega} + [I](\boldsymbol{\omega} \times \boldsymbol{\omega}_r) - [I]\dot{\boldsymbol{\omega}}_r + \boldsymbol{Q}))$$

- p. 409, 3rd line above Eq. (8.87): Change to:
... is actually ${}^{\mathcal{B}}\mathrm{d}/\mathrm{d}t\delta(\boldsymbol{\omega})$. The same holds...

- p. 439, 2nd line after Eq. (4.174): Change to:
... was developed in Eq. (4.128) and is expressed as

- p. 440, 1st line from top: Change to:
After substituting Eqs. (4.137) and (8.177) into ...

- p. 415, 2nd equation of Example 8.14: Change to read:

$$\lim_{t\to\infty} \boldsymbol{z} = \frac{1}{K_I P}\Delta\boldsymbol{L} = \cdots$$

- p. 445, Eq. (8.195): Add a dot over $\eta$ to read:

$$\dot{\boldsymbol{\eta}} = \cdots$$

- p. 446, Eq. (8.198) : Change the transpose operator on $[D_1]$ matrices to read:

$$\mathcal{O} = \frac{1}{\bar{h}^2}\frac{\boldsymbol{L}_r^T[D_1][D_1]^T\boldsymbol{L}_r}{||\boldsymbol{L}_r||^2}$$

- p. 450, top of page: In the two equations near the top of the page, replace cos to sin in the last column, and remove the 0.1 scaling values in the second row to read:

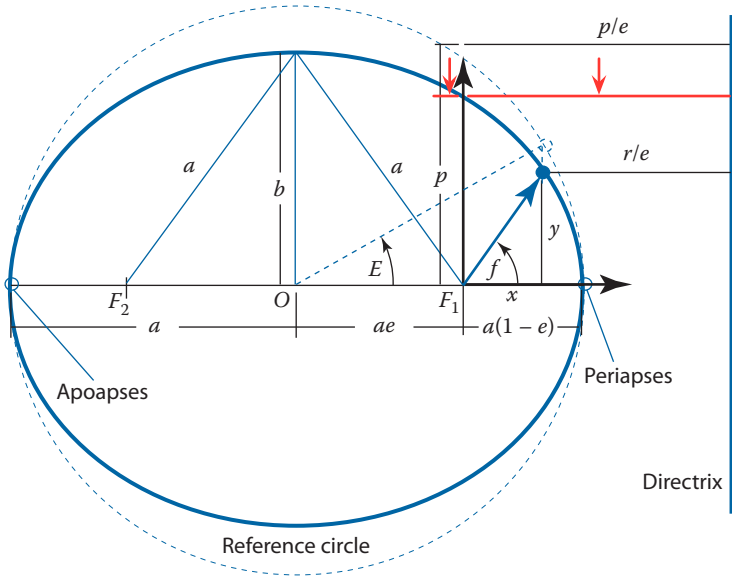
$$\dot{\boldsymbol{\Omega}}_d = \begin{bmatrix} 0.1\sin(0.02t) & 0.1\cos(0.02t) & -0.1\cos(0.03t) & -0.1\sin(0.03t) \end{bmatrix} \text{ deg/s}^2$$
$$\dot{\boldsymbol{\gamma}}_d = \begin{bmatrix} \sin(0.02t) & \cos(0.02t) & -\cos(0.03t) & -\sin(0.03t) \end{bmatrix} \text{ deg/s}$$

- p. 466, Problem 8.3: Change spherical to planar to make it say:
Consider the unforced planar pendulum equations...

- p. 467, Problem 8.4: Change spherical to planar to make it say:
Consider the unforced planar pendulum equations...

- p. 467, Problem 8.5: Change spherical to planar to make it say:
Consider the inverted planar pendulum problem...

- p. 473, Figure 9.2: The $p$ and $p/e$ distances are incorrectly indicated. The guidelines should be adjusted as shown in red below.




- p. 473, 7th line from bottom of page: Change to:
...has a constant ratio $e$ to the ...

- p. 499, 3rd line after Eq. (9.102): change to read
... with $a < 0$ have positive energies. To minimize ...

- p. 504, lines directly above and below Eq. (9.113) and (9.114) : Change "$\mathcal{O}$ frame" expression to "$\mathcal{P}$ frame" instead

- p. 507, Eq. (9.124): Add a negative sign to read

$$\dot{y} = -a\sqrt{e^2 - 1}\cosh(H)\dot{H}$$

- p. 507, Eq. (9.125): Change the right hand side of this equation to read:

$$\cdots = \frac{1}{r}\sqrt{\frac{\mu}{(-a)}}$$

- p. 508, Eq. (9.132): Equation should read

$$e = |\boldsymbol{e}|$$

- p. 516, line belowEq. (9.188): Eq. reference should read
Using Eqs. (9.15) and (9.140), ...

- p. 572, 2nd line: Change to read
... other than $V_0(\boldsymbol{r})$. This could...

- p. 576, Below Eq. (11.14): Should read:
... to be the body center of mass [see Eq. (2.81)], then ...

- p. 590, Eq. (11.71): Add a cubed in the denominator to read

$$\ddot{\boldsymbol{r}}_i = G\sum_{j=1}^{N}\frac{m_j}{r_{ij}^3}\boldsymbol{r}_{ij}$$

- p. 616, Example 12.3, line above first equation: Should read "... is defined in Eq. (11.63) and is given by"

- p. 616, Example 12.3, line above last equation on page: Should read "... Using Eq. (9.147), we note that"

- p. 621, Eq. (12.103): make the "v" bold to read:

$$2h\frac{\partial h}{\partial \boldsymbol{v}} = \cdots$$

- p. 626, Eq. 138 2nd line should start with a "+", not a negative sign, to read:

$$\begin{aligned}\frac{\mathrm{d}\omega}{\mathrm{d}t} = \frac{\partial\omega}{\partial\boldsymbol{v}}\boldsymbol{a}_d = &-\frac{1}{he}\left(\frac{r}{p}(\cos f + e) + e\right)\boldsymbol{r}^T\boldsymbol{a}_d \\ &+\frac{r}{h^2 e}(p+r)\sin f\,\boldsymbol{v}^T\boldsymbol{a}_d - \frac{r\sin\theta}{h\tan i}\,\hat{\boldsymbol{i}}_h^T\boldsymbol{a}_d\end{aligned}$$

- p. 631, Example 12.4, last line on page: Should read "... orbit elements defined in Eq. (9.157)"

- p. 632, Eq. (12.166): The $t_0$ would be $t$ to make the equation read

$$\frac{\mathrm{d}^n\boldsymbol{x}(t)}{\mathrm{d}t^n} = A^n\boldsymbol{x}(t)$$

- p. 635, Eq. (12.184): Change to:

$$[\dot{\Phi}(t,t_0)] = [A(t)][\Phi(t,t_0)] \qquad [\Phi(t_0,t_0)] = [I_{n\times n}$$

- p. 635, Eq. (12.187): Change to:

$$\cdots + \sum_{n=1}^{\infty}\frac{\mathrm{d}^n[\Phi(t,t_0)]}{\mathrm{d}t^n}\bigg|_{t=t_0}\frac{(t-t_0)^n}{n!}$$

- p. 639, Eq. (12.224): Change to:

$$\cdots + \int_{t_0}^{t}([A(\tau)][\Psi(\tau,t_0)] + [C(\tau)]\mathrm{d}\tau$$

- p. 640, Eq. (12.225): Change to:

$$[\dot{\Psi}(t,t_0)] = [A(t)][\Psi(t,t_0)] + [C(t)], \qquad [\Psi(t_0,t_0)] = [I_{n\times n}$$

- p. 649, 1st line on page: Rephrase to read "Comparing this equation with the usual state transition matrix..."
- p. 653, lines 3-4 of Example 13.1: Should read:
  ... that was discussed in Example 9.6. Therefore, we can ...
- p. 660, 5th line into Section 13.4: Should read:
  ... that connects two points in space with ...
- p. 671, Eq. (72): Change to:
$$a = -\sqrt{\frac{2\mu c}{r_1 r_2}}$$
- p. 694, Eq. (13.114): After the 2nd equal sign, the $r$ should be typeset in a non-bold font
$$h = |\boldsymbol{r}_{\female} \times \boldsymbol{v}_2| = r_{\female} \cdot v_2 \cdot \sin(90 \text{ deg} - \sigma_2) = r_{\female} \cos \sigma_2$$
- p. 791, 3rd line of Problem 14.3: change text to:
  ... equations of motion in Eq. (14.12) and the linear ...