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# Engineering Dynamics: A Comprehensive Introduction—Errata

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### Chapter 2:

- i)* **[First printing only]** In tutorial 2.4, the solution for the critically damped case (starting at the bottom of page 33) solves for  $\lambda_1, \lambda_2 = -\zeta\omega_0$ . This is propagated through to the solution (Eq. (2.26)), which makes it appear as if  $\zeta$  is a variable in the solution. This is misleading as  $\zeta$  can only equal 1 in this case. The two equation should be rewritten without  $\zeta$  (3 instances).
- ii)* **[First and second printing]** In problem 2.11, the forces described in the hint should not be bold.
- iii)* **[First printing only]** In problem 2.16, the downward acceleration should be  $g - \frac{c}{m}\dot{y}^2$ .
- iv)* **[First and second printing]** In problem 2.16, the problem statement should be changed to add the assumption that the rock is released from rest. The phrase ‘without the use of a computer’ should be interpreted as ‘without the use of numerical integration.’

### Chapter 3:

- i)* **[First printing only]** In Section 3.4.1, the final equation on Page 68 defining the transformation matrix should be in terms of the scalar component magnitudes, not the unit vectors. That is, the elements of the two matrices should not be bold. It should thus read:

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix}_{\mathcal{B}} = \begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}_{\mathcal{A}}$$

- ii)* **[First printing only]** In Section 3.8.4 on page 93 describing the vector Taylor series the vector (and components) were mistakenly written at  $t+a$  rather than  $t$ . Thus, the sentence before Eq. (3.68), that equation, and the following two equations should be written:

First, write the vector  $\mathbf{r}(t)$  as components in a frame  $\mathcal{A} = (O, \mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3)$ :

$$\mathbf{r}(t) = r_1(t)\mathbf{a}_1 + r_2(t)\mathbf{a}_2 + r_3(t)\mathbf{a}_3. \quad (1)$$

Then take the Taylor series of the scalar magnitude of each component. For  $i = 1, 2, 3$ , we have

$$r_i(t) = r_i(a) + \left. \frac{d}{dt} r_i \right|_{t=a} (t-a) + \frac{1}{2!} \left. \frac{d^2}{dt^2} r_i \right|_{t=a} (t-a)^2 + \dots$$

Expanding and rearranging each coefficient in Eq. (3.68) yields

$$\begin{aligned} \mathbf{r}(t) = & r_1(a)\mathbf{a}_1 + r_2(a)\mathbf{a}_2 + r_3(a)\mathbf{a}_3 \\ & + \left. \frac{d}{dt}r_1 \right|_{t=a} (t-a)\mathbf{a}_1 + \left. \frac{d}{dt}r_2 \right|_{t=a} (t-a)\mathbf{a}_2 + \left. \frac{d}{dt}r_3 \right|_{t=a} (t-a)\mathbf{a}_3 \\ & + \frac{1}{2!} \left. \frac{d^2}{dt^2}r_1 \right|_{t=a} (t-a)^2\mathbf{a}_1 + \frac{1}{2!} \left. \frac{d^2}{dt^2}r_2 \right|_{t=a} (t-a)^2\mathbf{a}_2 + \frac{1}{2!} \left. \frac{d^2}{dt^2}r_3 \right|_{t=a} (t-a)^2\mathbf{a}_3 \\ & + \dots \end{aligned}$$

- iii) **[First and second printing]** In the caption of Figure 3.32 on page 97, the units of  $\mu$  should be  $\text{m}^{-1}$  (two times).
- iv) **[First and second printing]** On page 99, after equation (3.77), should read  $\dot{\theta}_0 = 0.01 \text{ rad/s}$  (not  $\text{m/s}$ ).
- v) **[First printing only]** In Problem 3.2,  $\mathbf{F}_3 = (5 - 4\sqrt{6})\mathbf{e}_y \text{ N}$ .
- vi) **[First and second printing]** In Problem 3.28, assume (at the instant shown) the rocket's velocity is aligned with the thrust vector.
- vii) **[First printing only]** [Figure 3.45 is missing a downward gravity arrow labelled  \$g\$ .](#)

#### Chapter 4:

- i) **[First printing only]** In Example 4.1 on pgs. 115-116, the expressions for  $x(t)$  and  $\dot{x}(t)$  should be written relative to the initial time  $t_2$ ,

$$\begin{aligned} x(t) &= \frac{-\bar{F}_P(t_1, t_2)}{m_P \omega_0} \sin[\omega_0(t - t_2)] \\ \dot{x}(t) &= \frac{-\bar{F}_P(t_1, t_2)}{m_P} \cos[\omega_0(t - t_2)] \end{aligned}$$

- ii) **[First printing only]** On page 138, the first unnumbered equation should not have a minus sign.
- iii) **[First printing only]** In Tutorial 4.3, the second-to-last line on page 140 should say "The magnitude of the *specific* angular impulse..." Also, the two moment expressions on page 141 should be divided by the satellite mass to correspond to the change in specific angular momentum, i.e., the left-hand-side of the two unnumbered equations should be  $\|\bar{\mathbf{M}}_{A/O}(t_1, t_2)\|/m_P$  and  $\|\bar{\mathbf{M}}_{B/O}(t_1, t_2)\|/m_P$ , respectively.
- iv) **[First and second printing]** In Problem 4.5, the groove is semi-circular when viewed from above. Also, ignore the coefficient of friction corresponding to the horizontal component of the normal force

required to make the puck travel around the groove: i.e., assume the only source of friction arises from the vertical component of the normal force.

- v) **[First printing only]** In Problem 4.11 on page 146, the feedback equation for the base motion should be for the acceleration  $\ddot{u}$  of the base and not  $\mu$ , i.e., the equation should read

$$\ddot{u} = -\frac{g \sin \theta + k\theta + b\dot{\theta}}{\cos \theta}$$

- vi) **[First and second printing]** In Problem 4.13, for clarity, the problem statement, and part (a), should both say ‘linear impulse’.

### Chapter 5:

- i) **[First printing only]** Top of page 155 should not be gray box, up to the start of Example 5.3.
- ii) **[First printing only]** On page 163, in Example 5.8, the middle un-numbered equation has a typo; the sign is wrong on the last term. It should read:

$$T\mathbf{b}_1 - \mu_c N\mathbf{b}_1 + N\mathbf{b}_2 - m_P g \sin \theta \mathbf{b}_1 - m_P g \cos \theta \mathbf{b}_2 = 0$$

- iii) **[First and second printing]** On page 169, Section 5.5, the boxed equation in Definition 5.8 should have a triangle over the equal since since it is a definition.
- iv) **[First printing only]** On page 183, in Figure 5.18, right side, the length of the string should be longer so that the height of the white particle is the same as the height of the black particle.
- v) **[First printing only]** On page 183, the ellipse in Figure 5.19 should be taller so that it only intersects the circle at point P, i.e., it completely encloses the circular orbit of radius  $\rho$ .
- vi) **[First printing only]** In Problem 5.14, page 184, the value given for  $C$  in part (b) is actually the square root of the correct value.  $C$  should equal 0.33, not -0.58.

### Chapter 6:

- i) **[First and second printing]** On page 193, the first line after Equation (6.7), the right-side of the inline equation should use  $\mathbf{F}_{j,i}$  not  $\overline{\mathbf{F}}_{j,i}$ .

- ii) **[First printing only]** Equation 6.10 on page 193 should use  $\overline{\mathbf{F}}^{(\text{ext})}(t_1, t_2)$  instead of  $\overline{\mathbf{F}}^{(\text{ext})}$ . The following line should read “where  $\overline{\mathbf{F}}^{(\text{ext})}(t_1, t_2)$  is the total external impulse acting on the system from  $t_1$  to  $t_2$ .”
- iii) **[First and second printing]** On page 196, the final line of text before Equation 6.14 is incorrect. It should say: “A consequence of this definition is that the sum of the mass-weighted positions of all of the particles in the collection relative to the center of mass is zero.”
- iv) **[First and second printing]** The first equation in Example 6.7 (page 202) is missing the total mass term ( $m_G$ ). It should read:

$$m_G \frac{\mathcal{I} d^2}{dt^2} \mathbf{r}_{G/O} = \mathbf{F}_G^{(\text{ext})}$$

- v) **[First printing only]** The second line of Equation 6.23 on page 203 should be

$$= \frac{-k(m_1 + m_2)}{m_1 m_2} (\|\mathbf{r}_{2/1}\| - l_0) \hat{\mathbf{r}}_{2/1}.$$

- vi) **[First printing only]** Figure 6.14(b) on page 214 is incorrect. It should be altered as below.

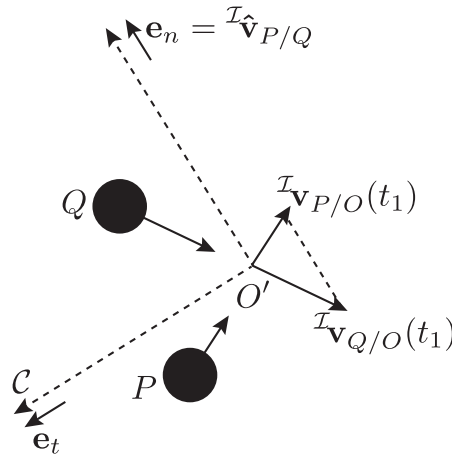


Figure 1 Corrected figure 6.14(b).

- vii) **[First printing only]** On page 235, the unnumbered equation in the second bullet of the Key Ideas should use  $\overline{\mathbf{F}}^{(\text{ext})}(t_1, t_2)$  instead of  $\overline{\mathbf{F}}^{(\text{ext})}$ . The following line should read “where  $\overline{\mathbf{F}}^{(\text{ext})}(t_1, t_2)$  is the total external impulse from  $t_1$  to  $t_2$ .”

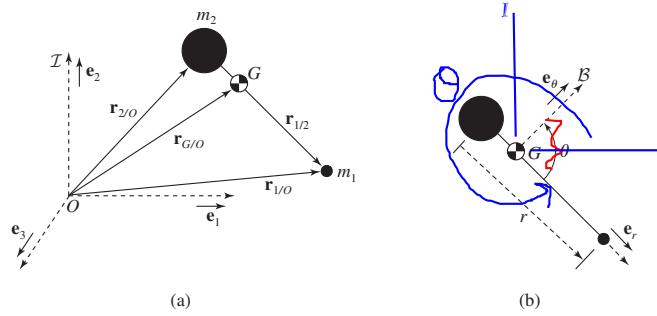
- viii) **[First printing only]** In Problem 6.7 on p. 239, the lower summation index should be  $i$  not  $j$ , so that it reads  $\sum_{i=1}^N$ .
- ix) **[First and second printing]** In Problem 6.15 on p. 242, the given values for parameters  $x_0$  and  $l_0$  do not match the problem description (that initially the springs are compressed). If they are reversed, so that  $x_0 = 5\text{m}$  and  $l_0 = 10\text{m}$  the problem is much more physical, although the solution remains unchanged.
- x) **[First printing only]** In Problem 6.23 on p. 244, the value for the exhaust velocity should be 2.75 km/s, not 1 km/s.
- xi) **[First printing only]** In Problem 6.24 on p. 244, the value for the spring rest length should be  $l_0 = 1\text{ m}$ , and the damper constant should be  $b = 25\text{ N}\cdot\text{s}/\text{m}$ . The second-to-last sentence should read "...in the rocket, starting with the spring at its rest length."
- xii) **[First printing only]** In Problem 6.25 on p. 244, the second and third sentences should read "Assume the model rocket weighs 2 kg and the fuel weighs 3 kg. Assume a mass flow rate of 0.1 kg/s and an exhaust velocity of 500 m/s."

### Chapter 7:

- i) **[First and second printing]** In Example 7.1 on pp. 249-250, both the figure (in terms of the placement of the center of mass) and the final equation of motion are only correct if we assume  $m_P = m_Q$ . In the case where they are unequal, the equation of motion becomes:
- $$\ddot{\theta} = \frac{g}{l(m_P + m_Q)} \left( m_P \cos\left(\theta + \frac{\pi}{3}\right) - m_Q \sin\left(\theta + \frac{\pi}{6}\right) \right)$$
- ii) **[First printing only]** In Example 7.4 on p. 254 there is a typo in the third equation (definition of the angular momentum of the center of mass about the origin). The unnumbered equation reads " $\mathcal{I}\mathbf{h}_{G/O} = \mathbf{r}_G \times \dots$ " but should be " $\mathcal{I}\mathbf{h}_{G/O} = \mathbf{r}_{G/O} \times \dots$ ".
- iii) **[First printing only]** In Example 7.8 on p. 265 there is a typo in the expression for  $T_{G/O}$ . The square should be on  $\dot{y}_G$  not outside the parenthesis, i.e.,

$$T_{G/O} = \frac{1}{2} m_G \|\mathcal{I}\mathbf{v}_{G/O}\|^2 = \frac{1}{2} m_G (\dot{x}_G^2 + \dot{y}_G^2).$$

- iv) **[First printing only]** In Example 7.11 on p. 273, the unit vectors of the polar frame have been defined as  $\mathbf{e}_r$  and  $\mathbf{e}_\theta$  so the  $\mathbf{b}_1$  and  $\mathbf{b}_2$  are



**Figure 7.10** Two bodies of masses  $m_1$  and  $m_2$  in orbit about their common center of mass in the plane orthogonal to  $\mathbf{e}_3$ . (a) Inertial frame  $\mathcal{I} = (O, \mathbf{e}_1, \mathbf{e}_2, \mathbf{e}_3)$ . (b) Polar frame  $\mathcal{B} = (G, \mathbf{e}_r, \mathbf{e}_\theta, \mathbf{e}_3)$ .

Figure 2 Annotated correction to Figure 7.10(b)

incorrect. The equations for  $\mathbf{r}_{P/G}$  and  ${}^{\mathcal{I}}\mathbf{v}_{P/G}$  should be written

$$\mathbf{r}_{P/G} = -\frac{r}{2}\mathbf{e}_r$$

$${}^{\mathcal{I}}\mathbf{v}_{P/G} = -\frac{\dot{r}}{2}\mathbf{e}_r - \frac{r}{2}\dot{\theta}\mathbf{e}_\theta.$$

Likewise, in the sentence that follows, the unit vector  $\mathbf{b}_1$  should be replaced by  $\mathbf{e}_r$ .

- v) **[First printing only]** In Example 7.11 on p. 274, the final conditions in the last paragraph are not correct. The rotation rate at infinity should be  $\dot{\theta}(\infty) = 2h_G/r_0^2$ . The expression for the nonconservative work should be

$$W^{(\text{nc,int})} = \frac{mh_G^2}{r_0^2} - \frac{m}{4} \left( \dot{r}(0)^2 + \frac{4h_G^2}{r(0)^2} \right) - \frac{1}{2}k(r(0) - r_0).$$

- vii) **[First printing only]** On p. 274, penultimate paragraph there should be a leading Eqs. before (7.11) and (7.12).
- viii) **[First printing only]** On p. 275, Figure 7.10(b), the depiction of  $\theta$  is not correct. It should be the angle measured counter-clockwise from the  $\mathbf{e}_1$  axis to the  $\mathbf{e}_r$  axis. The figure should be corrected as annotated here.
- ix) **[First printing only]** On p. 277 the final equation for the angular momentum relative to the center of mass is incorrect. The correct equation is

$${}^{\mathcal{I}}\mathbf{h}_G = \frac{m_1 m_2}{m_1 + m_2} r^2 \dot{\theta} \mathbf{e}_3,$$



- ix*) **[First printing only]** On p. 277 in the description following the second unnumbered equation for  ${}^{\mathcal{I}}\mathbf{h}_G$ , the specific angular momentum from Tutorial 4.2 should be  $h_O$  rather than  $h_P$ .
- x*) **[First printing only]** On p. 287, everywhere in the last bullet should use  $E_O$  instead of  $E$  (four times).
- xi*) **[First and second printing]** On p. 289, Problem 7.4.b, the problem should read “If friction is introduced between the particle and block (assume no friction between the block and the horizontal surface).”
- xii*) **[First printing only]** On p. 289, Problem 7.5, the last sentence before the hint should read “...when the baton falls, assuming it starts nearly upright.”
- xiii*) **[First printing only]** On p. 290, Problem 7.7, the text of the problem should read “initial speed  $v_0$ ” rather than “initial velocity  $v_0$ ”. Also, in part (a), it should read “final speed  $v_f$ ” rather than “final velocity  $v_f$ ”. Part (b) is correct as written.

### Chapter 8:

- i*) **[First printing only]** On p. 298, in Example 8.2, the equation at the bottom of the page should be

$${}^{\mathcal{I}}\mathbf{v}_{O'/O} = -\omega_B \mathbf{e}_3 \times (-R\mathbf{e}_2) = -R\omega_B \mathbf{e}_1$$

Likewise, both of the  $\mathbf{b}$  unit vectors in the preceding paragraph should be  $\mathbf{e}$  unit vectors.

- ii*) **[First printing only]** On p. 315, In the second equation, the velocity should be with respect to frame  $\mathcal{B}$  rather than  $\mathcal{I}$ . The equation should thus be:

$${}^{\mathcal{B}}\mathbf{a}_{P/L} = -\frac{f_l}{m_P} \hat{\mathbf{r}}_{P/L} - 2\omega_r \mathbf{b}_3 \times {}^{\mathcal{B}}\mathbf{v}_{P/L} - \omega_r^2 \mathbf{b}_3 \times (\mathbf{b}_3 \times \mathbf{r}_{P/L}).$$

- iii*) **[First and second printing] Original Kindle Edition Only** Problem 8.1(a),  ${}^{\mathcal{I}}\mathbf{v}_{P/O'}$  should be  ${}^{\mathcal{I}}\mathbf{v}_{P/O}$ .
- iv*) **[First printing only]** On p. 330, in Problem 8.3, the radius  $r_B$  from the problem statement is missing from Figure 8.24. It is the radius of the back gear, which has center  $O''$ . Also, the rotation of the crank is drawn as going clockwise and so the rotation rate should be -2 rpm.
- v*) **[First printing only]** p. 331, Problem 8.4, the problem does not constrain the initial orientation of the astronaut’s velocity vector with respect to the station’s velocity vector. To remove ambiguity, the problem should state that when the astronaut is at  $O'$  (when  $r = 0$ ), she starts moving in the same direction as  ${}^{\mathcal{I}}\mathbf{v}_{O'/O}$ .

- vi)* **[First and second printing]** p. 331, Problem 8.4, the solution will include  $v_0$  also.
- vii)* **[First printing only]** p. 331, Problem 8.7. Delete the word “massless” from the first line.
- viii)* **[First printing only]** p. 332, Problem 8.8, the first letters of itemized problem statements (a) and (b) should be capitalized.
- ix)* **[First printing only]** p. 333, Problem 8.10, the first line should read “Consider a disk of radius  $R = 1$  m that is...”

### Chapter 9:

- i)* **[First and second printing]** On page 352, the second line should read, “its signed magnitude  $h_G$ , which can be positive or negative depending on the sign of the angular velocity. We do so...”
- ii)* **[First printing only]** On p. 365, in the middle of the page, the phrase “...fixed, implying that  ${}^I\mathbf{a}_{P/O} = 0$  in Eq. (9.30)” should read “...fixed. Although  ${}^I\mathbf{a}_{P/O} \neq 0$ , it is perpendicular to the ramp, implying  $\mathbf{r}_{Q/G} \times {}^I\mathbf{a}_{Q/O} = 0$  in Eq. (9.30), where  $Q$  is replaced by  $P$  here.”
- iii)* **[First printing only]** On p. 384, the sentence before Eq. (9.61) should read “...two unknowns  $\dot{\theta}$  and  ${}^I\omega^B$ .”
- iv)* **[First printing only]** On p. 389, all of the expressions for the moment about the center of mass,  $\mathbf{M}_G$ , are missing the unit vector in the  $\mathbf{b}_3$  direction, which should appear at the end of each equation (4 times).
- v)* **[First printing only]** On p. 399, Problem 9.5. In figure, the distance  $l$  should go to the center of the bar, not the edge. Also, the arrow on  $\theta$  should be reversed.
- vi)* **[First printing only]** On p. 401, Problem 9.7, the area moment of inertia should be  $J = a^4/12$ .
- vii)* **[First printing only]** On p. 405, Problem 9.19 the equation of motion for the motor has an incorrect sign on the motor torque. It should read:

$$I_G\ddot{\theta} = -b\dot{\theta} + ki.$$

Also, in text for part (b) it should read “the inductance  $L$  to 0.75 H” rather than “the inductance  $h$  to 0.75 H”.

### Chapter 10:

- i)* **[First printing only]** On p. 418, the second-to-last equation should start “ $\ddot{\beta} - \dot{\theta}^2$ ...”

- ii) **[First printing only]** On p. 422 the third unnumbered equation from the top should have  $\sqrt{x^2 + y^2}$  in the denominator instead of  $x^2 + y^2$  (two times).
- iii) **[First printing only]** On p. 430, the paragraph following Eq. (10.37), in the second-to-last sentence,  $C_{ij} = \mathbf{b}_i \cdot \mathbf{e}_j$  should be  ${}^{\mathcal{I}}C_{ij}^{\mathcal{B}} = \mathbf{b}_j \cdot \mathbf{e}_i$
- iv) **[First printing only]** On p. 439, in the first row of Eq. (10.50) and in the first of the following unnumbered set of three equations,  $\csc \theta$  should be  $\sec \theta$  (two times).
- v) **[First printing only]** On p. 448, the second and third unnumbered equations, and the line between them, should read as follows:

$${}^{\mathcal{I}}C_{ij}^{\mathcal{B}} = \mathbf{e}_i \cdot \mathbf{b}_j \quad i, j = 1, 2, 3.$$

Using the fact that  $\mathbf{b}_j = \mathbf{e}_j$  prior to the rotation, we can substitute for  $\mathbf{b}_j$  from Eq. (10.60) to obtain

$${}^{\mathcal{I}}C_{ij}^{\mathcal{B}} = \mathbf{e}_i \cdot (\mathbf{e}_j \cos \theta - (\mathbf{e}_j \times \mathbf{k}) \sin \theta + (\mathbf{e}_j \cdot \mathbf{k})\mathbf{k}(1 - \cos \theta)).$$

- vi) **[First printing only]** On p. 448, the last unnumbered equation should read

$$\begin{aligned} {}^{\mathcal{I}}C_{11}^{\mathcal{B}} &= \cos \theta + k_1^2(1 - \cos \theta) \\ {}^{\mathcal{I}}C_{12}^{\mathcal{B}} &= -k_3 \sin \theta + k_1 k_2(1 - \cos \theta) \\ {}^{\mathcal{I}}C_{13}^{\mathcal{B}} &= k_2 \sin \theta + k_1 k_3(1 - \cos \theta) \\ {}^{\mathcal{I}}C_{21}^{\mathcal{B}} &= k_3 \sin \theta + k_1 k_2(1 - \cos \theta) \\ {}^{\mathcal{I}}C_{22}^{\mathcal{B}} &= \cos \theta + k_2^2(1 - \cos \theta) \\ {}^{\mathcal{I}}C_{23}^{\mathcal{B}} &= -k_1 \sin \theta + k_2 k_3(1 - \cos \theta) \\ {}^{\mathcal{I}}C_{31}^{\mathcal{B}} &= -k_2 \sin \theta + k_3 k_1(1 - \cos \theta) \\ {}^{\mathcal{I}}C_{32}^{\mathcal{B}} &= k_1 \sin \theta + k_3 k_2(1 - \cos \theta) \\ {}^{\mathcal{I}}C_{33}^{\mathcal{B}} &= \cos \theta + k_3^2(1 - \cos \theta). \end{aligned}$$

- vii) **[First printing only]** On p. 449, Eqs. (10.63)–(10.66) should read

$$\begin{aligned} \theta &= 2 \arccos \left( \frac{\sqrt{1 + {}^{\mathcal{I}}C_{11}^{\mathcal{B}} + {}^{\mathcal{I}}C_{22}^{\mathcal{B}} + {}^{\mathcal{I}}C_{33}^{\mathcal{B}}}}{2} \right) \\ k_1 &= \frac{{}^{\mathcal{I}}C_{32}^{\mathcal{B}} - {}^{\mathcal{I}}C_{23}^{\mathcal{B}}}{2 \sin \theta} \\ k_2 &= \frac{{}^{\mathcal{I}}C_{13}^{\mathcal{B}} - {}^{\mathcal{I}}C_{31}^{\mathcal{B}}}{2 \sin \theta} \\ k_3 &= \frac{{}^{\mathcal{I}}C_{21}^{\mathcal{B}} - {}^{\mathcal{I}}C_{12}^{\mathcal{B}}}{2 \sin \theta}. \end{aligned}$$

- viii) **[First printing only]** On p. 462, Problem 10.7, change “when it reaches the bottom of the funnel” to “when it reaches a height of  $h/2$ . (Note that a solution exists only for sufficiently small  $s_0$ .)”
- ix) **[First printing only]** On p. 463, Problem 10.12 is worded incorrectly. The proper wording is “...Sensors on the plane measure the position and velocity of the released vehicle relative to the C-130,  $\mathbf{r}_{P/O'}$  and  ${}^B\mathbf{v}_{P/O'}$ . The C-130 telemeters...”

### Chapter 11:

- i) **[First printing only]** On p. 467, in the second-to-last sentence of Example 11.1, “Because  $m = \rho \int_{\mathcal{B}} dV...$ ” should be “Because  $m = \rho \int_{\mathcal{B}} dV...$ ”.
- ii) **[First printing only]** On p. 471, the first equation at the top of the page has two sign errors. It should read:

$$0 = -2m_P l^2 \dot{\theta} \dot{\phi} \cos \phi - m_P l^2 \ddot{\theta} \sin \phi + h \dot{\phi}$$

- iii) **[First printing only]** On p. 471, Eq. (11.5) has a sign error. It should read

$$\ddot{\theta} + 2\dot{\theta} \dot{\phi} \cot \phi - \frac{h \dot{\phi}}{m_P l^2 \sin \phi} = 0$$

- iv) On p. 488, Example 11.9 - while there is no explicit error in this example, it should be pointed out that the constant of motion defined by Eqs. 11.31 and 11.33 can only be constant if  $\Omega$  is *not* assumed to be constant (this is not a stated assumption in the example, but is one that students may tend to make based on previous examples in the chapter). So, if integrating the equations of motion give by 11.30 and 11.32, and treating  $\Omega$  as constant, you will get a slightly incorrect motion, and the constant will not be conserved. In order to conserve the constant, you must integrate the complete system, including the expression for  $\dot{\Omega}$  that can be derived from 11.31:

$$\dot{\Omega} = -\ddot{\psi} \sin(\theta) - \dot{\psi} \dot{\theta} \cos(\theta)$$

There also exists a second constant of motion, obtained by considering the same angular momentum balance, but using  $\mathcal{I}$  frame components, in which case a zero exists in the right-hand side in the  $\mathbf{e}_3$  component, and the quantity:

$$I_1 \dot{\psi} \cos^2(\theta) + I_2 \left( \Omega + \dot{\psi} \sin(\theta) \right) \sin(\theta)$$

can be shown to be conserved. Just as for the original constant, this quantity is also only conserved when  $\Omega$  is allowed to vary.

- v) **[First printing only]** On p. 492, the first line after Eq. (11.43) should be "As long as  $\omega_n^2 > 0$  . . . "
- vi) **[First printing only]** On p. 494, Eq. (11.45),  $\csc \theta$  should be  $\sec \theta$ .
- vii) **[First printing only]** On p. 496, the unnumbered equation before (11.53) should have  $dm$  instead of  $i$  (four times).
- viii) **[First and second printing]** On p. 497, Eq. (11.54) contains an error. The equation is for rotation about a point  $Q$ , and so the moment term on the right-hand side should be about  $Q$ :  $[\mathbf{M}_Q]_B$ .
- ix) **[First printing only]** On p. 501, Example 11.13, in the first line of the long equation at the bottom of the page, the leading  $I_2$  in the second row of the first matrix should be deleted, so it reads  $\frac{d}{dt}(I_2\dot{\psi} \sin \theta + h)$ .
- x) On p. 502, Example 11.13, just as with the comment above for Example 11.9, the constant of motion in Eq. 11.63 will only be constant if  $h$  is allowed to be time-varying, and if the numerical integration includes a term for  $\dot{h}$  derived from this equation.
- xi) **[First printing only]** On p. 509, Example 11.16, first equation on page should be

$$\mathbf{r}_{O/G_2} = -\frac{l_2}{2}\mathbf{c}_1 - l_1\mathbf{b}_1 - \frac{h}{2}\mathbf{a}_1$$

- xii) **[First and second printing]** On page 516, in the first line below the two unnumbered equations below Equation (11.80), the first inline equation should be  $\omega_1(t_0) = -\omega_0$ .
- xiii) **[First and second printing]** On page 516, in Equation (11.81), the first term should be negative and the second term positive, so it reads

$${}^I\mathbf{h}_G = -I_O\omega_0 \cos \omega_n t \mathbf{b}_1 + I_O\omega_0 \sin \omega_n t \mathbf{b}_2 + J\omega_s \mathbf{b}_3$$

- xiv) **[First and second printing]** On page 517, the paragraph after Eq. 11.86.  ${}^I\mathbf{h}_G = h_G\mathbf{e}_3$ , not  $\mathbb{I}_G\mathbf{e}_3$ .
- xv) **[First and second printing]** On page 518, in the first line below the third unnumbered equation, the inline equation should be  $\psi = h_G/I_O$ .
- xvi) **[First printing only]** On p. 529, in Problem 11.11, Figure 11.30, arrow on rotary pendulum for angle  $\psi$  should point the other way.
- xvii) **[First and second printing]** On p. 530, in Problem 11.13(d), the given spring constant results in physically non-intuitive and non-illustrative system motion. A stiffer spring (at least 10 N/m) produces much better results.

- xviii)* **[First printing only]** On p. 531, in Problem 11.17, Figure 11.34 makes it look as if the cord is attached to an arbitrary point along the rod, whereas it should be attached at the end of the rod (point  $A$ ).
- xix)* **[First printing only]** On p. 533, in Problem 11.19, the value given for  $D$  is actually the value of  $D/I_T$ , so that the problem should read “... $D/I_T = 0.5$ ...”
- xx)* **[First and second printing]** On p. 533, in Problem 11.19, the initial condition for  $\omega_2$  should be given as  $\omega_2(0) = 2$  rad/s.

### Chapter 12:

- i)* **[First printing only]** On p. 540, in the first unnumbered equation, all of the “ $\cos \omega_d t$ ” terms should be replaced by “ $\cos(\omega_d t)$ ” (three times) and all of the “ $\sin \omega_d t$ ” terms should be replaced by “ $\sin(\omega_d t)$ ” (three times).
- ii)* **[First printing only]** On p. 540, in the second line of the second unnumbered equation, the “ $\cos 2\omega_d t$ ” term should be replaced by “ $\cos(2\omega_d t)$ ” and the “ $\sin \omega_d t$ ” term should be replaced by “ $\sin(2\omega_d t)$ ”.
- iii)* **[First printing only]** On p. 541, the last equation on p. 541 should be

$$x(t) = \frac{g}{\omega_0^2} + e^{-\zeta\omega_0 t} \left( \frac{\sqrt{2gl\omega_0^2 - g\zeta}}{\omega_0^2 \sqrt{1 - \zeta^2}} \sin(\omega_d t) - \frac{g}{\omega_0^2} \cos(\omega_d t) \right).$$

- iv)* **[First printing only]** On p. 553, the first of the two unnumbered equations before Eq. (12.19) should be “ $\dot{y}_1 = y_2$ ”.
- v)* **[First printing only]** On p. 558, the final unnumbered equation and the preceding sentence should be “...from the initial conditions  $y(0)$  and  $\dot{y}(0)$ ”:

$$\begin{aligned} y(0) &= c_1 v_1 + c_2 v_2 \\ \dot{y}(0) &= \lambda_1 c_1 v_1 + \lambda_2 c_2 v_2. \end{aligned}$$

### Chapter 13:

- i)* **[First printing only]** On p. 583, bottom of the page, boxed equation should read

$$f_k(\mathbf{r}_{1/O}, \mathbf{r}_{2/O}, \dots, \mathbf{r}_{N/O}, t) = 0, \quad k = 1, \dots, K.$$

- ii)* **[First printing only]** On p. 591, the right side of the first unnumbered equation should be

$$\underbrace{\sum_{i=1}^{N_C} \sum_{j=1}^N \mathbf{F}_j^{(act)}}_{\triangleq Q_i} \cdot \frac{\mathcal{I} \partial \mathbf{r}_{j/O}}{\partial q_i} \delta q_i,$$

### Appendix A:

- i)* **[First printing only]** On p. 625, the sentence following Definition A.2 should read “Figure A.2 shows examples of continuous functions with continuous and discontinuous derivatives.”
- ii)* **[First printing only]** On pgs. 628-630, Examples A.1, A.2, and A.3 should be in gray background like all other examples.

### Appendix B:

- i)* **[First and second printing]** On p. 642ff., the operators called “scalar tensor triple products”  $(\mathbf{a} \cdot (\mathbf{b} \otimes \mathbf{c}))$  and  $(\mathbf{a} \otimes \mathbf{b}) \cdot \mathbf{c}$  are more commonly known as the left and right dot products (or vector dyadic dot products).
- ii)* **[First and second printing]** On p. 644,  $[\mathbf{a} \cdot \mathbb{T}]_{\mathcal{I}}$  is given as  $[\mathbf{a}]_{\mathcal{I}}^T [\mathbb{T}]_{\mathcal{I}}$ , which would result in a row matrix. In order to ensure that the output is a column matrix, the whole expression must be transposed. The equation should read:

$$[\mathbf{a} \cdot \mathbb{T}]_{\mathcal{I}} = ([\mathbf{a}]_{\mathcal{I}}^T [\mathbb{T}]_{\mathcal{I}})^T = [\mathbb{T}]_{\mathcal{I}}^T [\mathbf{a}]_{\mathcal{I}}$$

- iii)* **[First and second printing]** On p. 644, final equation,  $[\mathbb{T} \times \mathbf{a}]_{\mathcal{I}}$  is given as  $-[\mathbb{T}]_{\mathcal{I}} [\mathbf{a} \times]_{\mathcal{I}}$ , but the negative sign is incorrect. The expression should read:

$$[\mathbb{T} \times \mathbf{a}]_{\mathcal{I}} = [\mathbb{T}]_{\mathcal{I}} [\mathbf{a} \times]_{\mathcal{I}}$$

### Appendix C:

- i)* **[First printing only]** On p. 647, Example C.1 should have gray background like all other examples.
- ii)* **[First and second printing]** On p. 655, the unnumbered equations at the top of the page should read as follows:

$$\begin{aligned} k_2 &= f(y_n + \frac{h}{2}k_1, t_n + \frac{1}{2}h) \\ k_3 &= f(y_n + \frac{h}{2}k_2, t_n + \frac{1}{2}h) \\ k_4 &= f(y_n + hk_3, t_n + h). \end{aligned}$$

- iii)* [**First printing only**] On p. 658, fifth line of text, “TSPAN” should be “TSPAN”.
- iv)* [**First printing only**] On p. 658, seven lines from the bottom, lowercase “l” should be uppercase “L” (two times).