

# Errata Sheet for *Fluid Mechanics: Fundamentals and Applications, Ed. 4* – Çengel and Cimbala

Latest update: 07/20/2021

This is a list of errors (and *enhancements*) in the textbook. If you find any additional errors in the book, or have suggestions for improvement, please contact **John M. Cimbala** at 814-863-2739 or [jmc6@psu.edu](mailto:jmc6@psu.edu) to report it. [By way of acknowledgment, the person (other than the authors) who first reports an error is listed in brackets, unless requested otherwise.]

We categorize the changes as *major errors*, *minor errors*, or *enhancements*:

- **Major errors** are important and significant (e.g., incorrect equations or numerical values or someone's name mis-spelled) – *these must be changed*.
- **Minor errors** are spelling or typo errors and other minor changes – *these may be skipped without impacting understanding of the material*.
- **Enhancements** are changes that clarify something and/or help you to understand the material better (e.g., improvements to a figure or wording changes) – *these may be skipped since they are not really errors, but are useful changes that enhance understanding of the material*.

**Note:** The publisher reprints the books as inventory gets low, so if you have a newer printing, some of these errors may have already been fixed.

NOTE: Errors listed since the previous posting of this file (03/06/2019) are highlighted in yellow.

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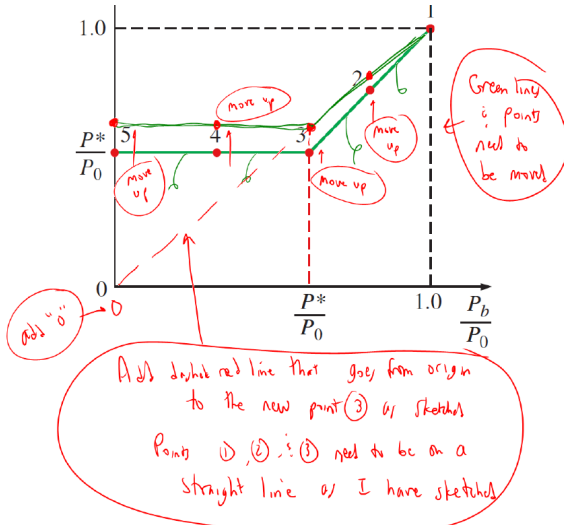
## Major Errors:

- p. 61, Example 2-7 in the equation, 2<sup>nd</sup> line: Change “1000 kg/m<sup>2</sup>” to “1000 kg/m<sup>3</sup>”.
  - p. 81, Label at bottom of the picture in Figure 2-9: Change “1.006” to “1.0006”. [Mohsen Hassan Vand]
  - p. 92, First line of middle paragraph: Change “plate of arbitrary shape” to “plate of arbitrary symmetric shape”. [Mohsen Hassan Vand]
  - p. 138, line 12: Change “and the” to “from which we can calculate the”. [Mohsen Hassan Vand]
  - p. 217, line 3 of assumptions: Change “ $P/\rho k =$ ” to “ $P/\rho^k =$ ” (the  $k$  needs to be a superscript). [Mohsen Hassan Vand]
  - p. 238, Problem 5-53, line 3: Change “minimum flow” to “maximum flow”. [Jang Ye Chan]
  - p. 242, Problem 5-92: Change the answer from “39.2 kW” to “15.7 kW”. [Walter Malec]
  - p. 429, Problem 8-61: Change the answers from “424 kPa, 16.2 kPa” to “423 kPa, 17.3 kPa”. [Walter Malec]
  - p. 453, Example 9-3: Background info: If a flow is incompressible, the incompressible continuity equation must apply. But Sérgio Dalmás pointed out (correctly) that the converse is not necessarily true. In other words, a flow that satisfies the incompressible continuity equation may not be incompressible. Therefore, this example problem needs to be modified as follows: [Sérgio Dalmás]
    - Last line of problem statement: Change “can be approximated as incompressible.” to “satisfies the incompressible continuity equation.”.
    - In SOLUTION statement: Change “is incompressible.” to “satisfies the incompressible continuity equation.”.
    - In Analysis, the two lines between the two equations: Change to: “The incompressible continuity equation in Cartesian coordinates is Eq. 9-17, which we check:”.
    - In Analysis, the two lines after the second equation, just before the Discussion: Change to: “So, we see that **the incompressible continuity equation is indeed satisfied at any instant in time.**”
    - In Discussion, add the following sentence at the end: “This flow is not necessarily incompressible since a solution with unsteady density may exist that satisfies the more general *compressible* continuity equation, Eq. 9-8.”
  - p. 648, Fig. 11-58 caption: Change “Fetsco” to “Festo”.
  - p. 672, equation right in the middle of the page: Change “1000 m<sup>2</sup>/s<sup>3</sup>” to “1000 m<sup>2</sup>/s<sup>2</sup>”. [Mohsen Hassan Vand]
  - p. 676, Eq. 12-21: Change the denominator on the left side of the equation from “ $T$ ” to “ $T_0$ ”.
  - p. 680, Second equation in the Analysis (the equation for  $P_0$ ): Change “646.9 K” to “646.9 R” and change “630 K” to “630 R”.
  - p. 712, last line in the paragraph after Eq. (12-75): A division sign is missing in that in-line equation. Change “ $V \sqrt{kRT}$ ” to “ $V/\sqrt{kRT}$ ”.
  - P. 713, equation above Eq. (12-77): Change “ $PA_c$ ” to “ $PA$ ” (there should not be a subscript  $c$ ).
  - p. 716, last line in the paragraph after Eq. (12-93): A division sign is missing in that in-line equation. Change “ $1 \sqrt{f}$ ” to “ $1/\sqrt{f}$ ”.
  - p. 728, Prob. 12-112. Change Answer “728 kPa” to “718 kPa”.
  - p. 729, Equation in Problem 12-132, line 2: In the first term of the equation, insert “/” (divide by sign) after “ $RT$ ” (like the / after the  $a$  in the second term of that same equation). [Mohsen Hassan Vand]
  - p. 962, Eq. for  $P_{02}/P_{01}$ : In the numerator inside the square brackets, change  $Ma_1$  to  $Ma_2$ .
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## Minor Errors:

- p. 36, Problem 1-71, line 6: Change “is = 1000” to “= 1000”. [Mohsen Hassan Vand]
- p. 43, Caption of Figure 2-9, line 1: Change “six” to “five”. [Mohsen Hassan Vand]
- p. 43, Caption of Figure 2-9, line 4: Change “thermal, mechanical, kinetic” to “thermal, mechanical”. [Mohsen Hassan Vand]
- p. 47, Equation 2-21: Change “=” to “≈”. [Mohsen Hassan Vand]
- p. 52, Fig. 2-25: Move the x-axis label “Rate of deformation,  $du/dy$ ” to the left, to the center of the axis.
- p. 53, Fig. 2-25: Move the x-axis label “Rate of deformation,  $du/dy$ ” to the left, to the center of the axis.
- p. 55, Fig. 2-29: Change the label “Carbon Dioxide” to “Carbon dioxide”
- p. 67, Problem 2-68, line 2: Change “weight” to “mass”. [Mohsen Hassan Vand]
- p. 101, The blue definition starting with “The buoyant...”, line 1: Change “on a body of uniform density immersed” to “on a body immersed”. [Mohsen Hassan Vand]
- p. 113, Assumptions, line 1: Change “The increase in the rotational speed is very slow so that” to “Enough time has elapsed so that”. [Mohsen Hassan Vand]
- p. 113, Assumptions, line 2: Change “container always acts” to “container acts”.
- p. 178, line 2 of problem 4-34: Change “ $0.6x + 0.2t - 1.4$ ” to “ $(0.6x, 0.2t, -1.4)$ ”. [Mohsen Hassan Vand]
- p. 207, equation 5-44: Change “constant” to “ $f(t)$ ”. [Mohsen Hassan Vand]
- p. 210, line 3 of figure 5-33 caption: Change “points along the” to “points in the”. [Mohsen Hassan Vand]
- p. 242, Prob. 5-93: Change “Consider a fully filled tank of semi-circular cross section tank with radius  $R$  and width of  $b$  into the page, as shown in Fig. P5-93” to “Consider a fully filled hemisphere shaped tank with radius  $R$ , as shown in Fig. P5-93”.
- p. 258, 1<sup>st</sup> line after Eq. 6-23: Delete space before “ $A_c$ ”
- p. 265, top caption in Fig 6-24: Change “Streamline” to “Streamsurface”. [Mohsen Hassan Vand]
- p. 284, Prob. 6-23, 3<sup>rd</sup> line: Delete space after “ $u_{max}$ ”
- p. 330, line under Eq. 1 in the example problem: Change “a viscosity” to “a kinematic viscosity”. [Mohsen Hassan Vand]
- p. 353, line above Eq. 8-1: Change “That is,” to “That is, for an incompressible fluid,”. [Mohsen Hassan Vand]
- p. 357, 2<sup>nd</sup> line after Eq. 8-9: Add slight space before  $d$  (twice)
- p. 361, Eq. 8-30: Add slight space before the first  $d$  (after the second equal sign, after the first  $\rho g$ ).
- p. 363, line just above SOLUTION: Change “(LPM)” to “(Lpm)”.
- p. 371, Table 8-2, last line: Move “steel” a little left for consistency with above terms.
- p. 374, Eq. 8-55, 2<sup>nd</sup> line: Add more space around “and”
- p. 376, last calculation: Add slight space before “ $\Delta P$ ”
- p. 378, Example 8-6, line just above SOLUTION: Change “(LPM)” to “(Lpm)”
- p. 379, 4<sup>th</sup> line: Remove blue color in “≈”.
- p. 379, 4<sup>th</sup> line: Change “LPM.” to “Lpm” (Two corrections here: Change two capitalizations and delete the period at end)
- p. 424, Reference 4, line 4: Change “Biomechanicol” to “Biomechanical”. [Mohsen Hassan Vand]
- p. 430, Prob. 8-75, last line, Answer: Make “6” not italic
- p. 449, last line: Change “as  $\vec{v} \cdot \vec{v}$  changes” to “as  $\rho \vec{v} \cdot \vec{v}$  changes”. [Mohsen Hassan Vand]
- p. 506, Prob. 9-28: Line 2: Change “The axial” to “Suppose the axial”. [Sérgio Dalmás]
- p. 506, Prob. 9-28: Line 3 to 4: Change “as sketched” to “as sketched (note that the sketch is simplified)”. [Sérgio Dalmás]
- p. 521, Fig 10-2: The left corner of the white rectangle in the middle of this figure should be rounded a little (not squared off as it is now). [Mohsen Hassan Vand]
- p. 535, the equation in Fig 10-26: In the crossed-off term (the last term in the equation), the  $V$  needs an arrow over it since it is a vector.
- p. 538, Caption of Fig. 10-31, line 4: Change “black curve” to “green curve”. [Mohsen Hassan Vand]
- p. 581, Prob. 9-28: Line 2 to 3 below Eq. (2): Change “is implicit for” to “gives”. [Sérgio Dalmás]
- p. 615, two lines above Eq. 11-1: Add slight space between “ $P$ ” and “ $dA$ ” similar to how currently there is a slight space between  $\tau_w$  and  $dA$ .
- p. 620, line 6 from the bottom: Change “to an end when the two” to “to an end if the two”. [Mohsen Hassan Vand]
- p. 648, line 7 of the section **Glidors**: Change “weight” to “mass”. [Mohsen Hassan Vand]
- p. 678, horizontal axis of lower portion of Fig. 12-14: The axis label “ $x$ ” was partially cut off.
- p. 679, Fig. 12-15, bottom figure: The location of the  $P^*/P_0$  value on the vertical axis is not correct. It needs to be shifted up slightly more than half-way up, just like the horizontal scale. In fact, the green line created by points 1, 2, and 3, if extended to the left, should hit the origin of the plot (0,0). Also, there should be a label “0” at the origin of the horizontal axis.

Sketched below:



- p. 684, line 1 of item 4: Change the second greater than sign to a greater than or equal to sign, i.e., change “ $P_E > P_b > 0$ ” to “ $P_E \geq P_b \geq 0$ ”. [Mohsen Hassan Vand]
- p. 684, end of line 6 of item 4: Change “When  $P_b > P_F$ ” to “When  $P_F < P_b < P_E$ ”. [Mohsen Hassan Vand]
- p. 692, line 12 of the first full paragraph: Change “effects” to “geometric effects”. [Mohsen Hassan Vand]
- p. 708, line 5 from the bottom: Change “below 490 K” to “below stagnation temperature 490 K”. [Mohsen Hassan Vand]
- p. 708, line 4 from the bottom: Change “flow velocity” to “Mach number”. [Mohsen Hassan Vand]
- p. 708, line 3 from the bottom: Change “temperature reaches” to “stagnation temperature reaches”. [Mohsen Hassan Vand]
- p. 716, Eq. 12-93: Change “ $D$ ” to “ $D_h$ ”.
- p. 736, Eq. 13-2: Remove “(m)”. [Mohsen Hassan Vand]
- p. 844, bottom portion of Fig. 14-87: Remove the label “ $\rho$ ” which should not be there.
- p. 857, Eq. 14-49: Add an overbar over the  $V$  (like the overbar over the  $V$  in the line immediately above that equation). [Mohsen Hassan Vand]
- p. 859, line 2: The “ $a$ ” in the equation needs to be italic. Change “ $(1 - a)$ ” to “ $(1 - a)$ ”. [Mohsen Hassan Vand]
- p. 912, line 2 from the bottom: The tilde is upside down! Change it to the correct tilde, i.e., “ $Re \sim 10,000$ ”. [Mohsen Hassan Vand]
- p. 961, last row of Table A-13: The “infinity” symbols are cut off. Should be  $\infty$  (two places).

### Enhancements:

- p. 11, line under the equation: change “the **speed of sound**” to “the local **speed of sound**”. [Mohsen Hassan Vand]
- p. 19, line 3 under the equation: Change “the energy required” to “the energy (amount of heat) required”. [Mohsen Hassan Vand]
- p. 33, left column, line 4 above the bottom of Summary section: Change “term *uniform* implies” to “terms *uniform* or *homogeneous* imply”. [Mohsen Hassan Vand]
- p. 160, last line: Change “temperature gradients” to “density gradients”. [Mohsen Hassan Vand]
- p. 170, line 2 under equation 4-50: Change “the absolute” to “the local absolute”. [Mohsen Hassan Vand]
- p. 194, line 3 under equation 5-17: Change “for a control volume” to “for a (fixed) control volume”. [Mohsen Hassan Vand]
- p. 250, 4 lines above Eq. 6-1: Change “*second body exerts*” to “*second body simultaneously exerts*”. [Mohsen Hassan Vand]
- p. 265, line 2 of Analysis: Change “work entirely.” to “work.”. [Mohsen Hassan Vand]
- p. 420, Fig. 8-89: Remove background color on the figure per style. Keep background color for Discussion section below the figure.
- p. 460, Bottom part of Fig 9-23: Move the label “ $dy/ds$ ” down vertically so that it is just *below* the dashed line. [Mohsen Hassan Vand]
- p. 536, line 4 of the example problem: Change “modeled as an irrotational” to “modeled as a viscous but irrotational”. [Mohsen Hassan Vand]
- p. 625, Fig. 11-19: Move the statement in the box “A hemisphere at...” to the beginning of the caption.
- p. 628, This is a subtle point, but necessary to keep the units consistent with the variables (e.g., work is kJ, not kJ/year which would be *power* not work). Apply to all equations in the example problem that have “/year” (I counted 6 occurrences within the equation and 6 occurrences at the end of the equation):
  - In all occurrences *within* the equation, delete “/year”. E.g., in first equation, change “18,000 km/year” to “18,000 km”.
  - In all occurrences *at the end of* the equation, change “/year” to “(per year)”. E.g, in first equation, change “ $= 7.092 \times 10^6$  kJ/year” to “ $= 7.092 \times 10^6$  kJ (per year)”.
- p. 633, Fig. 11-32: Move this figure to the previous page next to where it is first mentioned or to the top of the existing page.

- p. 643, Figure 11-49 caption, line 7: Change “low pressure region” to “low  $P$ , low  $T$  region”. [Mohsen Hassan Vand]
- p. 649, Last section, beginning of line 7: Change “fluid)” to “fluid particles)”. [Mohsen Hassan Vand]
- p. 649, Last section, middle of line 7: Change “It separates” to “The flow separates”. [Mohsen Hassan Vand]
- p. 663, Prob. 11-114, 1st equation line: Add some space before “for”.
- p. 671, 2 lines above Eq. 12-12: change “the speed of sound” to “the local speed of sound”. [Mohsen Hassan Vand]
- p. 686, Fig 12-23: Change the squiggly red line to a straight red line as in Fig 12-26. [Mohsen Hassan Vand]
- p. 702, line 4: Change “and thus can be neglected” to “and thus goes away”. [Mohsen Hassan Vand]
- p. 716, line just above Eq. 12-93: change “explicit Haaland” to “explicit Churchill equation or the explicit Haaland”.
- p. 727, Fig P12-102: Change the squiggly red line to a straight red line and make it bolder as in Fig 12-26.
- p. 761, caption of Fig 13-33: Remove the last sentence in its entirety, i.e. remove “All flows are from left to right.”. [Mohsen Hassan Vand]
- p. 801, line 10 from the bottom: Change “efficiency.” to “efficiency and potential cavitation”. [Mohsen Hassan Vand]
- p. 810, caption of Fig 14-27: Remove the last sentence in its entirety, i.e. remove “Flow is from left to right.”. [Mohsen Hassan Vand]
- p. 856, line above eq. 14-47: Change “of change of kinetic energy of” to “of kinetic energy flow of”. [Mohsen Hassan Vand]
- p. 856, Eq. 14-47: Remove the second and third terms and both of their = signs. The beginning of the final equation should look like this:

$$\dot{W}_{\text{available}} = \frac{1}{2} V^2 \dot{m} = \dots \text{ [Mohsen Hassan Vand]}$$

- p. 858, three lines above Eq. 14-53: Change “Thus,  $P_3 \neq P_4$ .” to “Thus,  $P_3 \neq P_4$ . In fact,  $P_3 > P_4$ .”. [Mohsen Hassan Vand]
- p. 930, Fig. 15-76: Fig. (b) should be enlarged such that the right side of the figure is aligned horizontally with the end of Fig. (a). In other words, the left side of (b) should align exactly with  $x = 0$  as it does now, but the right side of (b) should align exactly with  $x = 0.6$  also. Enlarge (b) such that both of these alignment criteria are met.