IMPORTANT ERRATA for A GENERAL RELATIVITY WORKBOOK (1st Printing)
(last updated 5/31/2017)

- Inside front cover, under “Useful Formulae,” left side for Riemann tensor in a LIF should be $R_{a \beta \mu \nu}$, not $R^a_{\beta \mu \nu}$.
- Page 4, figure 1.2, label under point $B$: “$t_B = c(0.02 \text{ s})$” should be “$c(t_B) = c(0.02 \text{ s})$”.
- Page 10, P1.5, 3rd line from the bottom: “$(1 + x) = 1 + nx”$ should be “$(1 + x) \approx 1 + nx$”.
- Page 14, section about defining inertial reference frames: In general relativity, technically one can use the described method to define a locally inertial reference frame (that is, a frame that is inertial to a specified accuracy within a sufficiently small region of space and time).
- Page 38, equation 3.32: change $p_1$ to $p_3$.
- Page 40, line immediately following equation 3.37, $p^i$ should be $p_3$.
- Page 42, problem P3.3, second line: “$(v < c = 135 \text{ MeV})$” should be “$(m_e = 135 \text{ MeV})$”.
- Page 51, line between equations 4.29 and 4.30: “left” should be “right” and vice versa.
- Page 54, second line above equation 5.1: should be “neighboring point $Q$” not “neighboring point $P$”.
- Page 58, seventh line: “we define a vector $ds$” should be “we define a vector $e_\theta$”.
- Page 60, figure 5.4, the basis vector $e_\theta$ should be $e_\phi$.
- Page 62, second line of equation 5.30: $(-\gamma \beta)^i$ should be simply $(\gamma \beta)^i$.
- Page 62, Exercise 5.2.1 should be numbered 5.5.1.
- Page 64, problem P5.4, part b, 2nd line: change “coordinates in the cartesian” to “components in the cartesian”.
- Page 64, problem P5.4, part e: $\Delta x$ should be $e_\phi$.
- Page 64, problem P5.6, 5th line from the problem’s end: replace $\theta$ with $r$.
- Due to a computer glitch, the page numbers in chapter 6 are out of sequence: they should read 65-76 instead of 81-92. This means that pages having numbers in the range 81-92 appear in chapter 6 and also in chapters 7 and 8. Index entries for items in chapter 6 point you to the correct (mismatched) page in chapter 6. For example, “Covector” in the index points you to pages 82-86, but it means the pages with those numbers in chapter 6, not the pages with the same numbers in chapter 7.
- Page 79, equations 7.4b and 7.4c: Technically, the $x, y, z$ subscripts should be superscripts.
- Page 79, 2nd line from the bottom: change “But the left” to “But the right”.
- Page 80, between equations 7.7 and 7.8, $m^2 = -p^\mu p_\mu$ not $p^\mu p_\mu$.
- Pages 88, 354, 360-362, 364, 365, 368, 373, 377, 384, 390, 408, 412, 471, often several times per page: “Lorentz gauge” should be “Lorentz gauge”, after Ludwig Lorenz, not Hendrik Lorentz. (This error appears in many books.)
- Page 91: equation 8.11 got all screwed up somehow. The correct equation should look like this:

$$0 = \frac{d}{d\sigma} \left[ -g_{\mu\nu} \frac{dx^\mu}{d\sigma} \right] + \frac{1}{2} \frac{\partial g_{\mu\nu}}{\partial x^2} \frac{dx^\mu}{d\sigma} \frac{dx^\nu}{d\sigma}$$

- Page 93, Figure 8.2: points A and B and the worldline of the free particle should all lie on the $t$ axis.
- Page 94, equation 8.22 should read

$$\tau_{ab} \equiv \int_{\tau_0}^{\tau} L(\sigma) d\sigma \quad \text{where} \quad L = \sqrt{-g_{\mu\nu} x^\mu x^\nu}$$

- Page 107, four lines above equation 9.9 (end of the previous paragraph): $h$ should be $r_c$.
- Page 109, figure 9.2: The $\Delta \tau$ labeling the interval on the left vertical worldline should be $\Delta \tau_{E0}$.
- Page 113, 10th line: “$t \approx h$” should be “$t \approx h$”.
- Page 117, figure 10.1, left diagram: The horizontal line should be labeled $\tilde{E}$.
- Page 118, second line below equation 10.11: The $r'$ should simply be $r$.
- Page 130, figure 11.2: The $\tilde{E}$ label should be next to the lower horizontal line, and the upper horizontal line should be labeled with an $r$ at its right end.
- Page 132, line following “Spatial Curvature”: change $g_{\mu \nu} = 1 - 2GM/r$ to $g_{\mu \nu} = -(1 - 2GM/r)$.
- Page 141, problem P11.4, 6th line above equation 11.33: “Darmour” should be “Damour”.
- Page 144, equation 12.5 and the line above: change “flat space” to “flat spacetime”.
- Page 149, box 12.4, title and 2nd line of exercise: change “flat space” to “flat spacetime”.
- Page 155, footnote: the link is broken: use http://adsabs.harvard.edu/full/2001ASPC..252..21C.
- Page 165, equation 13.27: change $\sqrt{1 + \frac{2GM}{r_0 u (u + 1)}}$ to $\sqrt{1 - \frac{2GM}{r_0 u (u + 1)}}$.
- Page 178, problem P14.8, 7th line from bottom: $2GM$ for a solar-mass black hole is about 10 $\mu s$, not 40 ms.
- Page 202, 12th line from the bottom: change “coordinate differences” to “component differences”.
- Page 203, 3rd full paragraph, 3rd line from bottom: again “coordinate” should be “component”.
- Page 204, equation 17.16: the expression on the far right should have a $dx^\sigma$ outside the square brackets.

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• Page 205, in the first line of equation 17.22, the lower indices of the Christoffel symbols on the far left and the far right are set in the wrong way with the right hand side; the indices should be consistent with the definition in equation 17.3. (This does not matter, though, because of box 17.3.)
• Page 205, equation 17.25: Change the superscript ν index to a superscript σ index (two times).
• Page 207, line below equation 17.31: change $\partial_\mu g_{\nu\sigma}$ to $\partial_\sigma g_{\mu\nu}$.
• Page 209, equation 17.38: change $\partial_\rho \partial_\sigma g_{\nu\mu}$ to $\partial_\nu \partial_\mu g_{\rho\sigma}$.
• Page 226, first line of box 19.3: “and $R_{\mu\nu\rho\sigma} = - R_{\mu\rho\nu\sigma}$” should be “and $R_{\rho\mu\nu\sigma} = - R_{\rho\sigma\mu\nu}$”.
• Page 227, equation 19.17, second term in parentheses: superscript γ should be σ: that is, $- \partial_\nu \Gamma_{\mu\rho}^{\sigma} = - \partial_\rho \Gamma_{\mu\nu}^{\sigma}$.
• Page 230, problem P19.8, 4th line below equation 19.28: change “metric component” to “tensor component”.
• Page 232, fourth paragraph, third line: change “last chapter” to “chapter 18”.
• Page 237, box 20.3, first line: Change “moving particles” to “moving particles with mass m”.
• Page 237, box 20.3, second paragraph, second line: Delete “mass m” and “. (The derivation in this box really only works if all particles have the same mass.)
• Page 241, problem P20.1, last line: $k_g$ is $1.536 \times 10^{-40}$ kg/K, not $1.536 \times 10^{-49}$ kg/K.
• Page 251, problem 21.8a, 2nd line from end of part: $d^2x/dt^2$ should be $d^2x/d\tau^2$.
• Page 251, problem 21.8f, 2nd line from end of part: $- g^0/8\pi G$ should be $g^0/8\pi G$. There are also some sign errors in the solutions manual (from forgetting that $g_{0\mu}$ is negative).
• Page 255, first paragraph, last line: Change “all objects” to “all non-rotating objects”.
• Page 256, below equation 22.9: Add (for clarity) “where $\Box$ (the four-dimensional del operator) $\equiv \eta^{\mu\nu} \partial_\mu \partial_\nu = - \partial_i \partial_i + \nabla^2$”.
• Page 257, 7th line below equation 22.14: change $- G \rho_g(\tau) dV$ to $- G \rho_g(\hat{\tau}) dV$.
• Page 263, P22.1, part a, fourth line: change “$h_\alpha$” to “$h_\alpha$”.
• Page 263, P22.6, part b, first and third lines: replace $\Phi_G$ with $\Phi_G$.
• Page 271, 5th line from the top: change $ds^2 = A(x^0)^2 + ds^2 = - A(x^0)^2$ (put a negative sign before A).
• Page 277, P23.5, line before part a: replace $R_{\mu\nu} = T_{\mu\nu} - \frac{1}{3} g_{\mu\nu} T$ with $R_{\mu\nu} = 8\pi G (T_{\mu\nu} - \frac{1}{3} g_{\mu\nu} T)$.
• Page 278, 3rd line below equation 23.51: $K_g$ should be $K_g$.
• Page 278, equation 23.52: right side should be $-8\pi G \sigma$, not $-8\pi G \sigma$.
• Page 287, last line: change “$\approx$” to “$=$”.
• Page 288, equation 24.6: replace $r^{1/2}$ by $r_G = H_0 / r_G$.
• Page 289, 12th line from the end: the average “galactic separation” to “inverse average galactic separation”.
• Page 295, line below equation 25.3: change $2g_{\mu\nu} dt d\tau$ to $2g_{\mu\nu} dt d\tau$.
• Page 296, third line below equation 25.14: Change $\sin(\bar{\tau}/R)$ to $\sin(\bar{\tau}/R)$.
• Page 297, caption of figure 25.1, 5th line: change “$q(\bar{\tau}) = R$” to “$\chi \equiv \bar{\tau}/R$.”
• Page 300, last entry in fourth line for R22: should be $\frac{4}{30} C_0 D_0$ not $\frac{4}{30} C_0 D_0$.
• Page 316, problem P26.9, part a: change “scale factor $R$” to “curvature scale $R$”.
• Page 316, problem P26.10, just before part a: change “Hubble constant” to “Hubble parameter”.
• Page 320, equation 27.16: replace L with $L_\sigma$, to distinguish the luminosity measured in the source frame with $L$ in the previous paragraph, which is the inferred luminosity in the observer’s frame.
• Page 321, figure 27.3(b): Label the vertical axis “$\alpha(t)$ (unitless)”.}

• Page 328, line below equation 28.1: change $4\pi G \rho_{v(1000, \gamma)} / 3 H_0^2$ to $8\pi G \rho_{v(1000, \gamma)} / 3 H_0^2$.
• Page 331, third paragraph in the Photon Decoupling section, third line: change “directly proportional” to “inversely proportional”. Also note that $\tau a$ is a constant (see equation 26.10), and $T$ at the present is 2.73 K.
• Page 337, fifth line above exercise 28.5.1: Change $\rho_{m0}/m_p$ to $\rho_{m0}/m_p$, and add to next line after the close parenthesis “. $\rho_{m0}$ is the normal-matter portion of the current total matter density $\rho_{m0}$.”
• Page 341, 9th line before the end: change $10^{-7}$ to $10^{-5}$.
• Page 343, third paragraph, fifth line: Change “$\rho \approx$” to “$\rho \approx$”.
• Page 343, third paragraph, fourth line from the bottom: For clarity change “$t_r \sim \left[ \frac{1}{8}\pi G \rho \right]^{-1/2} \sim \left[ \frac{1}{8}\pi G \rho \right]^{-1/2}$ to “$t_r \sim \left[ \frac{1}{8}\pi G \rho \right]^{-1/2} \sim \left[ \frac{1}{8}\pi G \rho \right]^{-1/2}$, and also put a period after “box 29.5”.
• Page 360, 3rd line from the end: “$a+b$, where $a$ and $b$ are constants” should be “$a+b$, where $a$ is a constant”.
• Page 365, 3rd line above equation 31.13: “(–$g_{\mu\nu}$)_{1/2}” should be “(–$g_{\mu\nu}$)_{1/2}”.
• Page 367, end of second paragraph about Gravitational Wave Detectors. Note that LIGO in fact did detect gravitational waves from a pair of coalescing black holes in September of 2015 (announced on Feb. 11, 2016).
• Page 367, last paragraph: Change “New Gravitational-wave Observatory (NGO)” and other references to NGO to “eLISA” (which apparently has become the preferred name). Also change “late 2020s” to “early 2030s”.
• Page 378, equation 32.7a: “$h_a(t, z) = -$ should be “$h_a(t, z) = -$”.
• Page 378, equation 32.8a: “$A = -1$” should be “$A = 1$”.

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• Page 378, equation 32.8b: change all “1” subscripts to “0” and all “4” subscripts to “3”.
• Page 385, equation 33.7: The second term on the right should be negative.
• Page 386, second line above equation 33.10: change “subtracting the trace from each nonzero element” to “subtracting symmetric fractions of the trace from each remaining nonzero diagonal element”.
• Page 387, equation 33.15: delete the extra factor of 2 in the second term on the right.
• Page 387, equation 33.16: Note that the $\hat{n}$ vectors depend on $\theta$ and $\phi$, so whatever $\theta$-dependence remains after the integration over $\phi$ must be carried into the integral over $\theta$. (Some find the notation confusing.)
• Page 391, exercise 33.4.1: “by raising” should be “by raising or lowering”.
• Page 391, third line below equation 33.37: Change $A_{ij}$ to $A^{ij}$ (we aren’t traceless yet).
• Page 397, equation 33.15: delete the extra factor of 2 in the second term on the right.
• Page 398, 2nd line above equation 34.1: "xy plane" not "xz plane".
• Page 398, next to last line: Change $/$GM$^{22}$ to $/$GM$^{22}$.
• Page 399, line before equation 34.8: reference should be to equation 33.12, not 33.4.
• Page 400, equation 34.16: $A_{i+}$ = 7.7 $\times 10^{-21}$, not 8.7 $\times 10^{-21}$.
• Page 400, caption of figure 34.1, 1st line: change "PSR B1913-16" to "PSR B1913+16".
• Page 405, exercise 34.5.1, 2nd line: Change $GM$ to $GMa$.
• Page 409, second line after equation 35.9: delete "except that the sign of the $\Gamma^{\alpha}_{\mu\nu}$ term is reversed."
• Page 413, equation 35.24a: change $\tilde{\nabla} \times \tilde{\nabla} \times \tilde{\epsilon}$ to $\tilde{\nabla} \times (\tilde{\nabla} \times \tilde{\epsilon})$.
• Page 416, equation 35.29, 2nd line, left side: change $+ \Gamma^{\alpha}_{\mu\nu} u^\mu s^\nu$ to $+ \Gamma^{\alpha}_{\mu\nu} u^\mu s^\nu$.
• Page 418, last line of first paragraph: Change “rotating star or black hole” to “rotating black hole”.
• Page 441, 5th line below the “Cosmic Censorship” heading: change “$\cos \theta a^2 = 0$” to simply “$\cos \theta = 0$”.
• Page 447, problem P38.5, equation 38.28: change $\phi(r) = 2\sqrt{GMa}$... to $\phi(r) = \sqrt{2GMa}$...