Respostas de alguns exercícios selecionados do livro:
Eletromagnetismo: Eletrostática e Magnetostática
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Capítulo 2

2.1) a. $\frac{2}{x^2}+\frac{2}{x}+(2x+3)\left(-\frac{2}{x^3}-\frac{1}{x^2}\right)$;
b. $-\frac{5}{4x^{\frac{9}{4}}(x^3+3x+1)}-\frac{3x^2+3}{x^{\frac{5}{4}}(x^3+3x+1)^2}$;
c. $\frac{2e^{2x}+12x^2\cos(4x^3)}{2e^{2x}+\operatorname{sen}(4x^3)}$;
d. $\cos\left(\ln\left(2x^2\right)+\frac{1}{x}\right)\left(\frac{2}{x}-\frac{1}{x^2}\right)$;
e. $3\cos(3x)\left(x^{\frac{1}{4}}-e^{2x}\right)+\operatorname{sen}(3x)\left(\frac{1}{4x^{\frac{3}{4}}}-2e^{2x}\right)$;
f. $-\frac{\frac{1}{2\sqrt{x}}-\operatorname{sen}(x)}{\ln\left(\sqrt{x}-\cos(x)\right)^2\left(\sqrt{x}-\cos(x)\right)}$;
g. $\frac{20x^3}{\sqrt{x}+7x-2}-\frac{\left(5x^4-3\right)\left(\frac{1}{2\sqrt{x}}+7\right)}{\left(\sqrt{x}+7x-2\right)^2}$;
h. $\frac{(x-1)(3x+2)(2-x)}{x^{\frac{3}{2}}+2x^2}+\frac{(x+3)(3x+2)(2-x)}{x^{\frac{3}{2}}+2x^2}+\frac{3(x+3)(x-1)(2-x)}{x^{\frac{3}{2}}+2x^2}+\frac{3(x+3)(x-1)(3x+2)}{x^{\frac{3}{2}}+2x^2}+\frac{(x+3)(x-1)(3x+2)(2-x)\left(\frac{3\sqrt{x}}{2}+4x\right)}{\left(x^{\frac{3}{2}}+2x^2\right)^2}$;
i. $-\left(1+\tan\left(-e^{2x}+\ln x\right)^2\right)\left(-2e^{2x}+\frac{1}{x}\right)$;
j. $-\cos\left(-\ln\left(x^2+1\right)+2x\right)\left(-\frac{2x}{x^2+1}+2\right)\cos\left(x^2-2e^{2x}\right)+\operatorname{sen}\left(-\ln\left(x^2+1\right)+2x\right)\operatorname{sen}\left(x^2-2e^{2x}\right)\left(2x-2e^{2x}\right)$.

2.3) a. $-88,9043$; b.$119,6136$; c. $3,64$; d. $-320,5765$ (cil), $-320,5765\,\operatorname{sen}\theta$ (esf); e. $\pm\infty$ (sinal contrário a z); f. $-9,6$ (para $r=5$).

2.5) a. $\overrightarrow{A}=2\overrightarrow{a_x}-3\overrightarrow{a_y}+7\overrightarrow{a_z}$; b. $\overrightarrow{B}=4\overrightarrow{a_x}-2\overrightarrow{a_y}-3\overrightarrow{a_z}$; c. $\overrightarrow{A}+\overrightarrow{B}=6\overrightarrow{a_x}-5\overrightarrow{a_y}+4\overrightarrow{a_z}$; d. $\overrightarrow{A}-\overrightarrow{B}=-2\overrightarrow{a_x}-\overrightarrow{a_y}+10\overrightarrow{a_z}$.

2.7) a. $l_1=4,24; l_2=4,36$; b. $A=18,06$.

2.9) $A=36,01$; $h=7,13$.

2.11) $d=5,19$; $A_1=23,28$; $A_2=20,98$; $A_3=29,93$; $v=21,662$.

2.13) a. $\theta=154,77°$; b. $\theta=167,72°$; c. $\theta=92,56°$.

2.15) a. $\left|\overrightarrow{V}_{P_1}\right|=25,69$; $\left|\overrightarrow{V}_{P_2}\right|=9,7$; $\left|\overrightarrow{V}_{P_3}\right|=288,4$; $\left|\overrightarrow{V}_{P_4}\right|=84,38$;
b. $\overrightarrow{a}_{V_{P_1}}=0,23\overrightarrow{a_r}+0,93\overrightarrow{a_\phi}-0,27\overrightarrow{a_z}$; $\overrightarrow{a}_{V_{P_2}}=-0,31\overrightarrow{a_r}-0,93\overrightarrow{a_\phi}+0,21\overrightarrow{a_z}$; $\overrightarrow{a}_{V_{P_3}}=0,042\overrightarrow{a_r}+0,999\overrightarrow{a_\phi}-0,032\overrightarrow{a_z}$; $\overrightarrow{a}_{V_{P_4}}=-0,071\overrightarrow{a_r}-0,996\overrightarrow{a_\phi}+0,063\overrightarrow{a_z}$;
c. $\overrightarrow{V}_{P_1}\cdot\overrightarrow{V}_{P_2}=-247,86$; $\overrightarrow{V}_{P_2}\cdot\overrightarrow{V}_{P_3}=-2609,64$; $\overrightarrow{V}_{P_3}\cdot\overrightarrow{V}_{P_4}=-24214,89$; $\overrightarrow{V}_{P_4}\cdot\overrightarrow{V}_{P_1}=-2089,08$;
d. $\overrightarrow{V}_{P_1}\times\overrightarrow{V}_{P_2}=-14,37\overrightarrow{a_r}+8,79\overrightarrow{a_\phi}+18\overrightarrow{a_z}$; $\overrightarrow{V}_{P_2}\times\overrightarrow{V}_{P_3}=-658,62\overrightarrow{a_r}+51,54\overrightarrow{a_\phi}-756\overrightarrow{a_z}$; $\overrightarrow{V}_{P_3}\times\overrightarrow{V}_{P_4}=2311,92\overrightarrow{a_r}+9,12\overrightarrow{a_\phi}+720\overrightarrow{a_z}$; $\overrightarrow{V}_{P_4}\times\overrightarrow{V}_{P_1}=453,72\overrightarrow{a_r}-9,48\overrightarrow{a_\phi}+360\overrightarrow{a_z}$.

2.17) a. Uma solução é $P\left(0,\frac{\pi}{2}\pm k\pi,z\right)$; b. Uma solução é $P(1,58;\phi;0)$; c. $\overrightarrow{a_r}$, sim para $r=0$; $\overrightarrow{a_\phi}$, sim para $z=0$; $\overrightarrow{a_z}$, não; d. $\left|\overrightarrow{E}\right|=54,04$, $\theta_{EB}=20,74°$; e. $\left|\overrightarrow{E}\right|=107,72$, $\theta_{EB}=56,10°$; f. $\left|\overrightarrow{E}\right|=6,98$, $\theta_{EB}=53,34°$.

Capítulo 3

3.1) a. $F=2,295\times10^9 N$; b. $\overrightarrow{F}=34,05\overrightarrow{a_x}-41,91\overrightarrow{a_y}+68,10\overrightarrow{a_z}\,N$; c. $\overrightarrow{a_F}=0,39\overrightarrow{a_x}-0,488\overrightarrow{a_y}+0,78\overrightarrow{a_z}\,N$.

3.3) a. $x=U\sqrt{\frac{2(l-d)m\epsilon_0}{\rho_S Q+mg\epsilon_0}}$; b. $x=\frac{9{,}171\times10^{-5}}{\sqrt{10^{-6}Q+4{,}427\times10^{-13}}}$(metros).

3.5) a. $\overrightarrow{F}=5,93\times10^{-5}\left\{\left[-\frac{1}{\sqrt{(10-z_0)^2+r^2}}+\frac{1}{\sqrt{(-10-z_0)^2+r^2}}\right]\overrightarrow{a_z}+\left[\frac{10-z_0}{r\sqrt{(10-z_0)^2+r^2}}-\frac{-10-z_0}{r\sqrt{(-10-z_0)^2+r^2}}\right]\overrightarrow{a_r}\right\}N$, com $r=\sqrt{x_0^2+y_0^2}$, e o ponto em que a carga se encontra definido por (x_0,y_0,z_0);b. $\overrightarrow{F}=1,073\times10^{-4}\overrightarrow{a_r}=1,073\times10^{-4}\overrightarrow{a_y}\,N$; c. $\overrightarrow{F}=1,073\times10^{-4}\overrightarrow{a_r}=1,073\times10^{-4}\overrightarrow{a_x}\,N$; d. $\overrightarrow{F}=1,068\times10^{-4}\overrightarrow{a_r}=7,551\times10^{-5}\overrightarrow{a_x}+7,551\times10^{-5}\overrightarrow{a_y}\,N$.

3.7) $\overrightarrow{E}=4,31\overrightarrow{a_y}\,V/m$; a. $57,08\%$; b. $78,36\%$; c. $129,43\%$.

3.9) a. $Q_1=2,1808\,mC$; b. $Q_1=545,26\mu C$; c. $Q_1=8,7232\,mC$.

3.11) $Q_1=-3,953Q_2$.

3.13) a. $Q = 3,045\,C$; b. $Q = 0$.
3.15) a. $\overrightarrow{E} = \frac{\rho_L}{\pi\epsilon_0 z}\overrightarrow{a_z}$; b. $\overrightarrow{E} = \frac{\rho_L}{\pi\epsilon_0 y}\overrightarrow{a_y}$; c. $\overrightarrow{E} = \frac{\rho_L}{\pi\epsilon_0 x}\overrightarrow{a_x}$.
3.17) a. $\overrightarrow{E} = -508,35\times10^3\overrightarrow{a_z}\,V/m$; b. $\overrightarrow{E} = -507,91\times10^3\overrightarrow{a_z}\,V/m$; c. $\overrightarrow{E} = -508,13\times10^3\overrightarrow{a_z}\,V/m$; d. $\overrightarrow{E} = 508,35\times10^3\overrightarrow{a_z}\,V/m$.
3.19) $\overrightarrow{E} = 11,3\times10^{12}\rho\,\overrightarrow{a_z}\,V/m$.
3.21) $x^3 = y^2 + C$; $y\,\mathrm{sen}\,y = x\cos x + C$.

Capítulo 4
4.1) $\overrightarrow{D} = \frac{\rho_L}{2\pi r}\overrightarrow{a_r}$.
4.3) $\overrightarrow{D} = \frac{\rho_S a^2}{r^2}\overrightarrow{a_r}$.
4.5) $\overrightarrow{D} = 4,102\times10^{-5}\overrightarrow{a_y} - 2,547\times10^{-5}\overrightarrow{a_z}\,C/m^2$; $\overrightarrow{D} = 6,647\times10^{-5}\overrightarrow{a_y} - 2,1257\times10^{-8}\overrightarrow{a_z}\,C/m^2$.
4.7) a. $\Psi = 4,167\,\mu C$; b. $\Psi = 0,2297\,\mu C$; c. $\Psi = 1,086\,\mu C$.
4.9) a. $Q = \frac{12\pi\rho_0 a^{5/3}}{10}\,C$; b. $Q = 3\pi\rho_0 a^5\,C$; c. $\overrightarrow{D} = \frac{12\rho_0}{10a^{1/3}}\overrightarrow{a_r}\,C/m^2$ e $\overrightarrow{D} = 3\rho_0 a^3\overrightarrow{a_r}\,C/m^2$.
4.11) a. $D = 0$; b. $\overrightarrow{D} = \rho_S\overrightarrow{a_x}$; c. $D = 0$.
4.13) a. 0; b. 0; c. 0.
4.15) a. $D_r = \frac{0,478}{r}\,C/m^2$; b. $D_r = \frac{0,478+5\times10^{-9}a}{r}\,C/m^2$; c. $D_r = \frac{0,478+5\times10^{-9}a+2\times10^{-3}b}{r}\,C/m^2$.
4.17) a. ∞; b. indefinido; c. indefinido.
4.19) a. $184,89$; b. $1153,46$; c. $31,95$.
4.21) $\overrightarrow{D} = \left(\frac{x^3}{3} + 2xy - x\sqrt{z}\right)\overrightarrow{a_x}$; Uma solução é $\overrightarrow{D} = \frac{x^3}{3}\overrightarrow{a_x} + \left(y^2 - y\sqrt{z}\right)\overrightarrow{a_y}$.

Capítulo 5
5.1) a. $W = 2,2\times10^{-3}\,J$ andando primeiro em x; b. $W = -1,55\times10^{-3}\,J$ andando primeiro em x; c. $W = 3,27\times10^{-3}\,J$ andando primeiro em x.
5.3) Andando primeiro na direção do eixo y, depois no eixo x e depois no eixo z.
5.5) $W = 3280\,J$.
5.7) a. $4\times10^{-5}\,J$; b. $4\times10^{-5}\,J$; c. $4\times10^{-5}\,J$.
5.9) a. $\forall A$, $B = -9A$; b. $A = 0$, $B = -50$; c. $A = 1,2403$, $B = -1,2403$.
5.11) $V = \frac{\rho_S}{2\epsilon_0}\left[z\ln\left(r+\sqrt{r^2+z^2}\right) - z + \sqrt{r^2+z^2}\right]$; $V = \frac{\rho_S}{2\epsilon_0}\left[10\ln\left(r+\sqrt{r^2+100}\right) - 10 + \sqrt{r^2+100}\right]$; $V = \frac{\rho_S}{2\epsilon_0}\left[100\ln\left(r+\sqrt{r^2+10000}\right) - 100 + \sqrt{r^2+10000}\right]$.
5.13) a. $\overrightarrow{E} = -8xy\overrightarrow{a_x} - \left(4x^2+3z\right)\overrightarrow{a_y} - 3y\overrightarrow{a_z}\,V/m$, $\rho = -8\epsilon_0 y\,C/m^3$; b. $\overrightarrow{E} = -\left(3\cos\phi - 2ze^{-r}\right)\overrightarrow{a_r} + 3\,\mathrm{sen}\,\phi\overrightarrow{a_\phi} - 2e^{-r}\overrightarrow{a_z}\,V/m$, $\rho = \frac{2ze^{-r}(1-r)\epsilon_0}{r}\,C/m^3$; c. $\overrightarrow{E} = -\left(5\cos\theta - \frac{\mathrm{sen}\,\phi}{r^2} + 2r\theta\right)\overrightarrow{a_r} + \left(5\,\mathrm{sen}\,\theta - r\right)\overrightarrow{a_\theta} - \frac{\cos\phi}{r^2\,\mathrm{sen}\,\theta}\overrightarrow{a_\phi}\,V/m$, $\rho = -\epsilon_0\left(6r^2\theta + r\tan\theta - \frac{\mathrm{sen}\,\phi}{r^3\,\mathrm{sen}^2\,\theta}\right)\,C/m^3$.
5.15) $\overrightarrow{E} = \frac{5(8x-2)^2}{9[2x(8x-2)-8x^2]}\overrightarrow{a_x} + \frac{26(2y+3)^2}{49[2y(2y+3)-2y^2]}\overrightarrow{a_y}\,V/m$.
5.17) $Q = 0$.
5.19) a. $V = 5,513\times10^{-3}V$; b. $\overrightarrow{E} = 2,205\times10^{-4}\overrightarrow{a_r} + 6,366\times10^{-4}\overrightarrow{a_\theta}\,V/m$; c. $V = 0,5513\,V$; $\overrightarrow{E} = 0,2205\overrightarrow{a_r} + 0,6366\overrightarrow{a_\theta}\,V/m$.
5.21) $V = \frac{Qd\cos\theta}{4\pi\epsilon_0 r^2}$.
5.23) a. $W_E = 0,017975\,J$; b. $W_E = -0,027\,J$; c. $W_E = -0,089\,J$.
5.25) $W_E = \frac{\epsilon_0}{2}\left[\frac{16}{15}x^5y^3z + \frac{4}{3}xy^3z + x^3yz^3\right]\,J$.
5.27) $W_E = \frac{\pi^3 r}{25\epsilon_0}\,J$.

Capítulo 6
6.1) a. $a = 9,962\times10^{18}\,m/s^2$; b. $U(t) = 9,962\times10^{18}t\,m/s$; c. $y(t) = 4,981\times10^{18}t^2\,m$; d. $U(y) = 4,464\times10^9\sqrt{y}\,m/s$; e) $E = 2,723\times10^{-12}\,J$; f) $\overrightarrow{J} = \frac{3,586\times10^{19}}{\sqrt{y}}\overrightarrow{a_y}\,A/m^2$; $I = \frac{3,586\times10^{10}}{\sqrt{y}}\,A$; $\rho = \frac{8,035}{y}\,C/m^3$.

6.3) a. $I = 0$; $I = 9 \times 10^{-2}\,A$; $I = 3r^3\,A$; b. $I = \frac{0{,}0232}{z}\,A$; $I = 0{,}003\,A$; $I = 1{,}138r\,A$; c. $I = \frac{5\pi}{8}\cos\theta\,\mathrm{sen}\,\theta\,A$; $I = 0$; $I = 0{,}463r^3\,A$; d. $I = -\frac{\pi}{6}\,\mathrm{sen}^2\,\theta\,A$; $I = 61{,}261\cos\phi\,A$; $I = -0{,}933r^2\,A$; e) $\nabla \cdot \overrightarrow{J} = 9r\,\mathrm{sen}\,\phi\,C/s.m^3$; $\nabla \cdot \overrightarrow{J} = \frac{2\cos\phi}{r} - \frac{5\,\mathrm{sen}\,\phi}{z^2} C/s.m^3$; $\nabla \cdot \overrightarrow{J} = 6\cos\theta\,\mathrm{sen}\,\phi - \frac{r^2\left(\cos^2\theta - \mathrm{sen}^2\,\theta\right)}{\mathrm{sen}\,\theta} C/s.m^3$; $\nabla \cdot \overrightarrow{J} = \frac{2\cos\theta\,\mathrm{sen}\,\phi}{r} - \frac{2\cos\theta}{r^2} - \frac{2r\,\mathrm{sen}\,\phi}{\mathrm{sen}\,\theta} C/s.m^3$; f. $\frac{dQ_i}{dt} = 0$; $\frac{dQ_i}{dt} = 346{,}41\,A$; $\frac{dQ_i}{dt} = -10^{-4}\,A$; $\frac{dQ_i}{dt} = -2 \times 10^4 \cos\theta\,A$.

6.5) a. Para todos, $V_1 = -4{,}605\,V$; e respectivamente, no segundo terminal: $V_2 = 0{,}627\,V$; $V_2 = 5{,}11\,V$; $V_2 = 20{,}899\,V$; $V_2 = -1{,}36\,V$; b. $\overrightarrow{E} = -\left(10z + 1/z\right)\overrightarrow{a_z}\,V/m$; c. $\overrightarrow{J} = -1{,}5 \times 10^7 \left(10z + 1/z\right)\overrightarrow{a_z}\,A/m^2$; $\overrightarrow{J} = -5{,}8 \times 10^7 \left(-10z + 1/z\right)\overrightarrow{a_z}\,A/m^2$; $\overrightarrow{J} = -3{,}82 \times 10^7 \left(-10z + 1/z\right)\overrightarrow{a_z}\,A/m^2$; $\overrightarrow{J} = -7 \times 10^4 \left(-10z + 1/z\right)\overrightarrow{a_z}\,A/m^2$; d. $I = -493{,}6\,A$; $I = -42423{,}58\,A$; $I = -1{,}84\,MA$; $I = 454{,}5\,A$.

6.7) $E_x = 6{,}75\,V/m$; $E_y = -2{,}244\,V/m$.

6.9) a) $\left|\overrightarrow{P}\right| = 4{,}675 \times 10^{-11}\,V/m$; b. $|\overrightarrow{p}| = 1{,}355 \times 10^{-37}\,Cm$; c.$8{,}47 \times 10^{-19}\,m$.

6.11) $P_{t_2} = \frac{\chi_{e_2}}{\chi_{e_1}} P_{t_1}$; $P_{n_2} = \frac{\chi_{e_2}\epsilon_{R_1}}{\chi_{e_1}\epsilon_{R_2}} P_{n_1}\,C/m^2$.

6.13) $\overrightarrow{E}_2 = 3\overrightarrow{a_x} - 20\overrightarrow{a_y} + \frac{8}{3}\overrightarrow{a_z}\,V/m$.

6.15) $\epsilon_R = 2$.

6.17) a. $\overrightarrow{E} = \frac{1{,}798 \times 10^7}{r}\overrightarrow{a_r}\,V/m$; b. $\overrightarrow{E} = \frac{8{,}99 \times 10^6}{r}\overrightarrow{a_r}\,V/m$; c. $\overrightarrow{E} = \frac{8{,}99 \times 10^6}{r}\overrightarrow{a_r}\,V/m, 0 < r < 1{,}5$; $\overrightarrow{E} = \frac{2{,}996 \times 10^6}{r}\overrightarrow{a_r}\,V/m, r > 1{,}5$; d. $\overrightarrow{E} = \frac{2{,}996 \times 10^6}{r}\overrightarrow{a_r}\,V/m, 0 < r < 1{,}5$; $\overrightarrow{E} = \frac{1{,}798 \times 10^6}{r}\overrightarrow{a_r}\,V/m, 1{,}5 < r < 2{,}5$; $\overrightarrow{E} = \frac{4{,}494 \times 10^6}{r}\overrightarrow{a_r}\,V/m, r > 2{,}5$; e. $\overrightarrow{E} = \frac{1{,}7975 \times 10^4}{(r+1)r}\overrightarrow{a_r}\,V/m$.

6.19) $C = \epsilon_2 \left(\frac{d}{\frac{\epsilon_2}{\epsilon_1} - 1}\right)\left(d - \left(\frac{d}{\frac{\epsilon_2}{\epsilon_1} - 1}\right)\ln\frac{\epsilon_2}{\epsilon_1}\right)\,F$.

6.21) $C = \epsilon S d$, $d = d_2 - d_1$; $d_1, d_2 > 0$.

6.23) $\epsilon_{R_1} = 8{,}056 \times 10^{-6}$, $\epsilon_{R_2} = 2{,}4167 \times 10^{-5}$.

6.25) a. $C = 29{,}184pF$; b. $C = 93{,}4pF$; c. $C = 30{,}44pF$; d. $C = 47{,}425pF$; e. $C = 2{,}93pF$; f. $C = 26{,}4pF$.

6.27) a. $6{,}28$; b. $C = 17{,}51pF$; c. $d = 1{,}094cm$; d. $c = 1{,}095cm$.

6.29) a., b., c. $C = C_0 \frac{\epsilon_R\left(\frac{1}{a} - \frac{1}{b}\right)}{\frac{\epsilon_R}{a} + \frac{(a+b)(1-\epsilon_R)}{2} - \frac{1}{b}}$; d., e., f. $C = C_0 \frac{\frac{1}{a} - \frac{1}{b}}{\frac{(a+b)}{2} - \frac{1}{b}}$.

6.31) a. $b = 1{,}047cm$; b. $c = 1{,}04cm$; c. $\epsilon_R = 37{,}29$; d. $\epsilon_R = 1{,}7092$.

6.33) a.$C = 14{,}78\,pF/m$; b. Não muda; c. Não muda; d. $V_0 = 135317{,}997\,V$; e. $\rho_L = 177{,}36\,pC/m$.

Capítulo 7

7.1) a. $V_1 = 83{,}571\,V$; $V_2 = 75{,}268\,V$; $V_3 = 55\,V$; $V_4 = 59{,}018\,V$; $V_5 = 42{,}5\,V$; $V_6 = 24{,}732\,V$; $V_7 = 30\,V$; $V_8 = 10{,}982\,V$; $V_9 = 1{,}429\,V$; b. $I = 0{,}3511\,A$; c. $\Psi = 2{,}744 \times 10^{-9}\,C$.

7.3) a. $\overrightarrow{E}_x = 2625\overrightarrow{a_y}\,V/m$; b. $I = 1{,}3125\,A$; c. $\Psi = 2.3242 \times 10^{-10}\,C$.

7.7) $\overrightarrow{E} = \frac{V_3 - V_1}{h_1 + h_3}\overrightarrow{a_x} + \frac{V_4 - V_2}{h_2 + h_4}\overrightarrow{a_y}\,V/m$.

7.9) $\overrightarrow{E}_1 = -181{,}1\overrightarrow{a_x} - 300\overrightarrow{a_y}\,V/m$; $\overrightarrow{E}_2 = -183{,}7\overrightarrow{a_x} - 300\overrightarrow{a_y}\,V/m$; $\overrightarrow{E}_3 = -118{,}9\overrightarrow{a_x} - 65{,}12\overrightarrow{a_y}\,V/m$; $\overrightarrow{E}_4 = -500\overrightarrow{a_x} - 168546\overrightarrow{a_y}\,V/m$; $\overrightarrow{E}_5 = -666{,}67\overrightarrow{a_x} - 234{,}88\overrightarrow{a_y}\,V/m$.

7.11) $V_1 = 88{,}567\,V$; $V_2 = 49{,}256\,V$; $V_3 = 54{,}269\,V$; $V_4 = 49{,}256\,V$.

7.13) $V_1 = 48{,}369\,V$; $V_2 = 24{,}163\,V$; $V_3 = -8{,}159\,V$; $V_4 = 6{,}443\,V$; $V_5 = 1{,}611\,V$.

Capítulo 8

8.1) a. $y\nabla^2 V + \frac{\partial V}{\partial y}$; b. $(x+y)\nabla^2 V + \frac{\partial V}{\partial y} + \frac{\partial V}{\partial x}$; c. $z(x+y)\nabla^2 V + 2z\left(\frac{\partial V}{\partial x} + \frac{\partial V}{\partial y}\right) + (x+y)\left(2\frac{\partial V}{\partial z} + z\frac{\partial^2 V}{\partial z^2}\right)$;d. $xyz\nabla^2 V + yz\frac{\partial V}{\partial x} + xz\frac{\partial V}{\partial y} + xy\frac{\partial V}{\partial z}$.

8.3) a. Não satisfaz; b. Não satisfaz; c. Não satisfaz; d. Não satisfaz.

8.5) $k = \frac{-1 \pm \sqrt{1 + \frac{256}{\mathrm{sen}^2\,\theta}}}{2}$, $p = \frac{1 \pm \sqrt{1 + \frac{256}{\mathrm{sen}^2\,\theta}}}{2}$, $\theta \neq k\pi$.

8.7) a. $V = -5y + 50\,V$; b. $V = -5y + 55\,V$.

8.9) $V = -22{,}76\ln r + 215{,}77\,V$.

8.11) $V = -4{,}286z + 167{,}143\,V$.

8.13) $V = 900\phi - 471{,}24\,V$; $\overrightarrow{E} = -\frac{900}{r}\overrightarrow{a_\phi}\,V/m$.

8.15) a. $E_r = 10913,5\,V/m$; b. $E_r = 8730,8\,V/m$; c. $V\,(r) = -218,27\ln r + 20,12\,V$.
8.17) $V = \frac{V_0}{\frac{1}{a}-\frac{1}{b}}\left(-\frac{1}{r}+\frac{1}{b}\right)$; $C = \frac{4\pi\epsilon}{\frac{1}{a}-\frac{1}{b}}$.
8.19) $V = -\frac{37,5}{r} + 181,25\,V$.
8.21) $V = -75,93\ln\left(\operatorname{cossec}\theta - \operatorname{cotg}\theta\right) + 83,08\,V$.
8.23) $V = 900\phi - 471,24\,V$.
8.25) $V = -2258,9\left(x^2 - \frac{4\cos(3\pi x/2)}{9\pi^2}\right) + 4619,453x - 101,72\,V$; $V\,(1) = 4517,733V$.
8.27) $V = -114,223\,V$.

Capítulo 9

9.1) $\overrightarrow{H} = \frac{I}{2\pi}\left[\left(\frac{-x_0}{x_0^2+(z_0-z)^2} + \frac{-(y_0-y)}{x_0^2+(y_0-y)^2}\right)\overrightarrow{a_x} + \frac{x_0}{x_0^2+(y_0-y)^2}\overrightarrow{a_y} + \frac{(z_0-z)}{x_0^2+(z_0-z)^2}\overrightarrow{a_z}\right]\,A/m$.
9.5) $y < -1$; $\overrightarrow{H} = \frac{3}{2\pi}\left[-\left(\frac{y+1}{x^2+(y+1)^2} - \frac{y}{x^2+y^2} + \frac{y-1}{x^2+(y-1)^2}\right)\overrightarrow{a_x} + \left(\frac{x}{x^2+(y+1)^2} - \frac{x}{x^2+y^2} + \frac{x}{x^2+(y-1)^2}\right)\overrightarrow{a_y}\right]\,A/m$;
$-1 < y < 0$; $\overrightarrow{H} = \frac{3}{2\pi}\left[-\left(-\frac{y+1}{x^2+(y+1)^2} - \frac{y}{x^2+y^2} + \frac{y-1}{x^2+(y-1)^2}\right)\overrightarrow{a_x} + \left(\frac{x}{x^2+(y+1)^2} - \frac{x}{x^2+y^2} + \frac{x}{x^2+(y-1)^2}\right)\overrightarrow{a_y}\right]\,A/m$;
$0 < y < 1$; $\overrightarrow{H} = \frac{3}{2\pi}\left[-\left(-\frac{y+1}{x^2+(y+1)^2} + \frac{y}{x^2+y^2} + \frac{y-1}{x^2+(y-1)^2}\right)\overrightarrow{a_x} + \left(\frac{x}{x^2+(y+1)^2} - \frac{x}{x^2+y^2} + \frac{x}{x^2+(y-1)^2}\right)\overrightarrow{a_y}\right]\,A/m$;
$y > 1$; $\overrightarrow{H} = \frac{3}{2\pi}\left[-\left(-\frac{y+1}{x^2+(y+1)^2} + \frac{y}{x^2+y^2} - \frac{y-1}{x^2+(y-1)^2}\right)\overrightarrow{a_x} + \left(-\frac{x}{x^2+(y+1)^2} - \frac{x}{x^2+y^2} + \frac{x}{x^2+(y-1)^2}\right)\overrightarrow{a_y}\right]\,A/m$;
$(x,0,0)\,, x \neq 0$; $\overrightarrow{H} = \frac{-3}{2\pi x}\overrightarrow{a_x}\,A/m$.
9.7) $\overrightarrow{H} = K_0\overrightarrow{a_x}\,A/m$ para $z > 2y$ e $\overrightarrow{H} = -K_0\overrightarrow{a_x}\,A/m$ para $z < 2y$.
9.9) $\overrightarrow{H} = \frac{1,125\left(k^2\ln k^2\sqrt{k^2+9}+18+6k^2-2k^2\ln\left(3+\sqrt{k^2+9}\right)\sqrt{k^2+9}\right)}{\sqrt{k^2+9}}\overrightarrow{a_z}\,A/m$.
9.13) $\overrightarrow{H} = \frac{NI}{2\pi r_0}\overrightarrow{a_\phi}\,A/m$, $r_0 =$ raio médio do toróide.
9.15) a. $z > 0,\, r < 0,3m,\, \overrightarrow{H} = 0$; $z > 0,\, r > 0,3m,\, \overrightarrow{H} = -\frac{3}{\pi r}\overrightarrow{a_\phi}\,A/m$; $z < 0,\, r > 0, \overrightarrow{H} = \frac{2}{\pi r}\overrightarrow{a_\phi}\,A/m$; b. $z > 0,\, 0 < r < 0,3m,\, \overrightarrow{H} = -\frac{3}{\pi r}\overrightarrow{a_\phi}\,A/m$; $z > 0,\, r > 0,3m,\, \overrightarrow{H} = -\frac{6}{\pi r}\overrightarrow{a_\phi}\,A/m$; $z < 0,\, r > 0, \overrightarrow{H} = \frac{2}{\pi r}\overrightarrow{a_\phi}\,A/m$; c. Para o item a., tem-se $z > 0,\, r < 0,3m,\, \overrightarrow{H} = \frac{z\overrightarrow{a_r}+\overrightarrow{a_z}}{(z^2+1)^{3/2}}\,A/m$; $z > 0,\, r > 0,3m,\, \overrightarrow{H} = \frac{z\overrightarrow{a_r}-\frac{3}{\pi r}\overrightarrow{a_\phi}+\overrightarrow{a_z}}{(z^2+1)^{3/2}}\,A/m$; $z < 0,\, r > 0, \overrightarrow{H} = \frac{z\overrightarrow{a_r}+\frac{2}{\pi r}\overrightarrow{a_\phi}+\overrightarrow{a_z}}{(z^2+1)^{3/2}}\,A/m$; e para o item b., tem-se $z > 0,\, 0 < r < 0,3m,\, \overrightarrow{H} = \frac{z\overrightarrow{a_r}-\frac{3}{\pi r}\overrightarrow{a_\phi}+\overrightarrow{a_z}}{(z^2+1)^{3/2}}\,A/m$; $z > 0,\, r > 0,3m,\, \overrightarrow{H} = \frac{z\overrightarrow{a_r}-\frac{6}{\pi r}\overrightarrow{a_\phi}+\overrightarrow{a_z}}{(z^2+1)^{3/2}}\,A/m$; $z < 0,\, r > 0, \overrightarrow{H} = \frac{z\overrightarrow{a_r}+\frac{2}{\pi r}\overrightarrow{a_\phi}+\overrightarrow{a_z}}{(z^2+1)^{3/2}}\,A/m$.
9.17) a. $\nabla \times \overrightarrow{F} = \frac{3y^2z}{x+1}\overrightarrow{a_x} - \left(\frac{x^3y^2}{2z^{1/2}} + \frac{y^3z}{(x+1)^2}\right)\overrightarrow{a_y} - 2x^3yz^{1/2}\overrightarrow{a_z}$;
b. $\nabla \times \nabla \times \overrightarrow{F} = \left(-x^3z^{1/2} - \frac{x^3y^2}{4z^{3/2}} + \frac{y^3}{(x+1)^2}\right)\overrightarrow{a_x} + \left(\frac{3y^2}{x+1} + 6x^2yz^{1/2}\right)\overrightarrow{a_y} + \left(-\frac{3x^2y^2}{2z^{1/2}} + \frac{2y^3z}{(x+1)^3} - \frac{6yz}{x+1}\right)\overrightarrow{a_z}$;
c. $\nabla \cdot \nabla \times \overrightarrow{F} = 0$;
d. $\nabla \times \left(\nabla \cdot \overrightarrow{F}\right)\overrightarrow{a_x} = \frac{3x^2y^2}{z^{1/2}}\overrightarrow{a_y} - \frac{3y^2}{x+1}\overrightarrow{a_z}$;
e. $\nabla \times \nabla\left(\nabla \cdot \overrightarrow{F}\right) = 0$.
9.19) $\overrightarrow{J} = kr^{3/4}\,\overrightarrow{a_\phi}$.
9.21) a. F_z é constante na direção $\overrightarrow{a_z}$; b. F_z é constante na direção $\overrightarrow{a_x}$ e na direção $\overrightarrow{a_y}$; c. F_z é constante em todas as direções.
9.27) a. $\overrightarrow{B} = 0$; b. $\frac{\partial\overrightarrow{B}}{\partial z} = \infty\,Wb/m\ (z < 0)$; $\frac{\partial\overrightarrow{B}}{\partial z} = -\infty\,Wb/m\ (z > 0)$; c. $\frac{\partial\overrightarrow{B}}{\partial z} = \infty\,Wb/m\ (z < 0)$; $\frac{\partial\overrightarrow{B}}{\partial z} = -\infty\,Wb/m\ (z > 0)$; d. $\frac{\partial\overrightarrow{B}}{\partial z} = -7,23 \times 10^{-12}z\,\overrightarrow{a_x}\,Wb/m$; e. $\frac{\partial\overrightarrow{B}}{\partial z} = 1,394 \times 10^{-11}z\,\overrightarrow{a_x}\,Wb/m$.
9.29) a. $V_m = 1,5\,A$; b. $V_m = 0$.
9.31) a. $z = 0,1\,m$; b. $z = 0,01061\,m$.
9.33) $\overrightarrow{A} = \frac{3\times10^{-7}}{r\sqrt{r^2+z^2}}\overrightarrow{a_z}\,A/m$.
9.35) a. $\overrightarrow{B} = ze^{-rz}\overrightarrow{a_\phi}\,Wb/m^2$; b. $\overrightarrow{H} = \frac{ze^{-rz}}{\mu_0}\overrightarrow{a_\phi}\,A/m$; c. $\overrightarrow{J} = -\frac{1}{\mu_0}\left[\left(e^{-rz} - rze^{-rz}\right)\overrightarrow{a_r} - \frac{z}{r}\left(e^{-rz} + rze^{-rz}\right)\overrightarrow{a_\phi}\right]\,A/m^2$; d. $I = 0\,A$; e. $\Phi = \frac{\left(1-e^{-r}\right)}{r}\,Wb$.

Capítulo 10

10.1) $\overrightarrow{B} = 16,67\,\overrightarrow{a_y}\,kWb/m^2$, sua direçao neste caso implica que a carga é jogada inicialmente em $z < 0$, de forma que a força inicial é em $\overrightarrow{a_z}$.

10.3) $Q = 33,333\,C$.

10.5) a. $a_{cp} = 6 \times 10^6\,m/s^2$; b. $r = 2,67 \times 10^6\,m$; c. $E_c = 8 \times 10^{-5}\,J$.

10.7) $r = 83,333\,km$; $a_y = 1\,m/s^2$; $a_{cp} = 1,2 \times 10^5\,m/s^2$; para $t = 2\,s$, $y = 2\,m$, $x = 56288,6\,m$, $z = 21893,56\,m$; para $t = 5\,s$, $y = 12,5\,m$, $x = -23277,2\,m$, $z = 163349,7\,m$.

10.9) $B_0 = -3,78 \times 10^{-6}\,Wb/m^2$.

10.11) a. $W = -0,1\,J$; b. $W = 0$; c. $W = 0,1\,J$; d. $W = 0$, $W = 0$, $W = 0$.

10.13) a. $\overrightarrow{F} = -9 \times 10^{-3} x\,\overrightarrow{a_y}\,N$; b. $\overrightarrow{F} = 0\,N$; c. a. $\overrightarrow{F} = 1,414 \times 10^{-8}\,\overrightarrow{a_r}\,N$.

10.17) $F/l = 10^{-7}\,N/m$.

10.19) $\overrightarrow{F} = -5 \times 10^{-3}\pi\,\overrightarrow{a_z}\,N$.

10.21) Supondo $\overrightarrow{H_1}$ e $\overrightarrow{H_2}$ gerados de forma similar a superfícies infinitas de correntes, $F/l = \mu_0 K_1 K_2 b\,(\overrightarrow{a}_{K_1} \times \overrightarrow{a}_{B_2})\ N/m$.

10.23) Supondo os raios como correntes filamentares cilíndricas de raio $r = 10^{-3}\,m$, $\overrightarrow{F} = \frac{\mu_0 I_1 I_2}{2\pi d} = 2,5 \times 10^{-9}\pi\,N$.

10.25) $\overrightarrow{T} = I B_0 S \overrightarrow{a_x}\,Nm$.

10.27) $\overrightarrow{T} = 7,5 \times 10^{-3}\pi\,\overrightarrow{a_x}\,Nm$; muda de π.

10.29) a. $\overrightarrow{H} = 7,36 \times 10^{-46}\left(\frac{z\overrightarrow{a_r} - 6\times10^{-11}\overrightarrow{a_z}}{(3,6\times10^{-21}+z^2)^{3/2}}\right) A/m$, $\overrightarrow{B} = 9,25 \times 10^{-52}\left(\frac{z\overrightarrow{a_r} - 6\times10^{-11}\overrightarrow{a_z}}{(3,6\times10^{-21}+z^2)^{3/2}}\right) Wb/m^2$; b. $T = 5,564 \times 10^{-55}\,Nm$; c. $B = 2,16 \times 10^{37}\,Wb/m^2$.

10.31) b. Para a velocidade angular, $8,82 \times 10^{16} ppm$ e para o momento orbital, $2,55 \times 10^{-35} ppm$.

10.33) $W_H = 6,4 \times 10^{-3}\,J$.

10.35) $W_H = 5,2 \times 10^{-5}\,J$.

10.37) $H = 48860,25\sqrt{\frac{1}{SL}}$.

10.39) $L = \frac{39,5 N^2 a^2}{9a + 10l}\,\mu H$.

10.41) a. $L = 3,95 \times 10^{-5}\,H$; b. $L = 2,51 \times 10^{-5}\,H$.

10.43) a. $\frac{L}{l} = 9,17 \times 10^{-7}\,H/m$; b. $\frac{L}{l} = 1,84 \times 10^{-6}\,H/m$.

10.45) a. $L = 1,702\,H$; b. $L = 4,12\,H$ (241,75% a mais); c. $L = 1,411\,H$; d. $L = 3,762\,H$ (266,61% a mais).

10.47) $M_{12} = 4,44 \times 10^{-5}\,H$.

Capítulo 11

11.1) $|z| < 2$; $\overrightarrow{H} = -300\overrightarrow{a_y}\,A/m$; $\overrightarrow{B} = -3600\mu_0\overrightarrow{a_y}\,Wb/m^2$; $\overrightarrow{M} = -3300\overrightarrow{a_y}\,A/m$; $|z| > 2$; $\overrightarrow{H} = 0$; $\overrightarrow{B} = 0$; $\overrightarrow{M} = 0$.

11.3) $|x| < 3$; $\overrightarrow{H} = 300x\,\overrightarrow{a_y}\,A/m$; $\overrightarrow{B} = 300x\mu_0\,\overrightarrow{a_y}\,Wb/m^2$; $\overrightarrow{M} = 0$;

a. $x > 3$; $\overrightarrow{H} = 1,8\overrightarrow{a_y}\,A/m$; $\overrightarrow{B} = 1,8 \times 10^{-2}\mu_0\overrightarrow{a_y}\,Wb/m^2$; $\overrightarrow{M} = -1,782\overrightarrow{a_y}\,A/m$; $x < -3$; $\overrightarrow{H} = -1,8\overrightarrow{a_y}\,A/m$; $\overrightarrow{B} = -1,8 \times 10^{-2}\mu_0\overrightarrow{a_y}\,Wb/m^2$; $\overrightarrow{M} = 1,782\overrightarrow{a_y}\,A/m$;

b. $x > 3$; $\overrightarrow{H} = 1,8\overrightarrow{a_x}\,A/m$; $\overrightarrow{B} = 1,782\mu_0\overrightarrow{a_x}\,Wb/m^2$; $\overrightarrow{M} = -1,8 \times 10^{-2}\overrightarrow{a_x}\,A/m$; $x < -3$; $\overrightarrow{H} = -1,8\overrightarrow{a_x}\,A/m$; $\overrightarrow{B} = -1,782\mu_0\overrightarrow{a_x}\,Wb/m^2$; $\overrightarrow{M} = 1,8 \times 10^{-2}\overrightarrow{a_x}\,A/m$;

c. $x > 3$; $\overrightarrow{H} = 1,8\overrightarrow{a_x}\,A/m$; $\overrightarrow{B} = 1,818\mu_0\overrightarrow{a_x}\,Wb/m^2$; $\overrightarrow{M} = 1,8 \times 10^{-2}\overrightarrow{a_x}\,A/m$; $x < -3$; $\overrightarrow{H} = -1,8\overrightarrow{a_x}\,A/m$; $\overrightarrow{B} = -1,818\mu_0\overrightarrow{a_x}\,Wb/m^2$; $\overrightarrow{M} = -1,8 \times 10^{-2}\overrightarrow{a_x}\,A/m$;

d. $x > 3$; $\overrightarrow{H} = 1,8\overrightarrow{a_x}\,A/m$; $\overrightarrow{B} = 180\mu_0\overrightarrow{a_x}\,Wb/m^2$; $\overrightarrow{M} = 178,2\overrightarrow{a_x}\,A/m$; $x < -3$; $\overrightarrow{H} = -1,8\overrightarrow{a_x}\,A/m$; $\overrightarrow{B} = -180\mu_0\overrightarrow{a_x}\,Wb/m^2$; $\overrightarrow{M} = -178,2\overrightarrow{a_x}\,A/m$.

11.5) a. $\overrightarrow{H} = 663,15\overrightarrow{a_\phi}\,A/m$; $\overrightarrow{B} = 4,167 \times 10^{-3}\overrightarrow{a_\phi}\,Wb/m^2$; $\overrightarrow{M} = 2652,6\overrightarrow{a_\phi}\,A/m$; b. $\overrightarrow{H} = 378,94\overrightarrow{a_\phi}\,A/m$; $\overrightarrow{B} = 1,43 \times 10^{-3}\overrightarrow{a_\phi}\,Wb/m^2$; $\overrightarrow{M} = 757,88\overrightarrow{a_\phi}\,A/m$; c. $\overrightarrow{H} = 0$; $\overrightarrow{B} = 0$; $\overrightarrow{M} = 0$; d. $\frac{\Phi}{l} = 8,84 \times 10^{-6}\,Wb$.

11.7) a. $\overrightarrow{H} = 795,78\overrightarrow{a_\phi}\,A/m$; $\overrightarrow{B} = 0,2\overrightarrow{a_\phi}\,Wb/m^2$; $V_m\,(0°) = 0\,A$; $V_m\,(60°) = -41,67\,A$; $V_m\,(120°) = -83,34\,A$; $V_m\,(180°) = -125\,A$; $V_m\,(240°) = -166,68\,A$; $V_m\,(300°) = -208,35\,A$; $V_m\,(360°) = -250\,A$; b. $\overrightarrow{H} = 795,78\overrightarrow{a_\phi}\,A/m$; $\overrightarrow{B} = 20\overrightarrow{a_\phi}\,Wb/m^2$; $V_m\,(0°) = 0\,A$; $V_m\,(60°) = -41,67\,A$; $V_m\,(120°) = -83,34\,A$; $V_m\,(180°) = -125\,A$; $V_m\,(240°) = -166,68\,A$; $V_m\,(300°) = -208,35\,A$; $V_m\,(360°) = -250\,A$.

11.9) a. $\chi_{m_1} = 7$; b. $\overrightarrow{B_1} = 8\mu_0\overrightarrow{H_1}$; c. $\overrightarrow{M_1} = 7\overrightarrow{H_1}$; d. $W_H = 5,37 \times 10^{-3}\,v\ (J)$, v =volume; e. $\overrightarrow{H_2} = 5\overrightarrow{a_x} - 12\overrightarrow{a_y} + 12\overrightarrow{a_z}$; $\overrightarrow{B_2} = 20\mu_0\overrightarrow{H_2}$; $\overrightarrow{M_2} = 19\overrightarrow{H_2}$.

11.11) $\overrightarrow{B} = 0,4\overrightarrow{a_r} + 0,001\overrightarrow{a_\phi} - 0,0025\overrightarrow{a_z}$.

11.15) $\overrightarrow{H_2} = 12\overrightarrow{a_x} - 36,8\overrightarrow{a_y} + 25,6\overrightarrow{a_z}$.

11.17) a. $V_m = 55942,96\,Aesp$; b. $V_m = 36207,75$ (diminuído de $19735,21 Aesp$); c. Não é possível manter o mesmo fluxo se houver dispersão.

11.19) a. $\Phi = 1,14 \times 10^{-3}\,Wb$; b. $W_H = 1,55\,J$; c. $\Phi = 1,5 \times 10^{-3}\,Wb$; d. $W_H = 1,97\,J$.

11.21) a. $\Phi = 1,975 \times 10^{-4}\,Wb$; b. $W_H = 1,94 \times 10^{-2}\,J$; c. $\Phi = 2,03 \times 10^{-4}\,Wb$; d. $W_H = 1,814\,J$.

11.23) a. $\Phi = 8,15 \times 10^{-4}\,Wb$; b. $W_H = 0,2643\,J$; c. $\Phi = 1,272 \times 10^{-3}\,Wb$; d. $W_H = 0,5961\,J$; e. $\Phi = 3,804 \times 10^{-4}\,Wb$, $W_H = 0,058\,J$; $\Phi = 3,9 \times 10^{-4}\,Wb$, $W_H = 0,056\,J$.

11.25) a. $I = 89,2\,mA$; b. $\Phi = 2,75 \times 10^{-5}\,Wb$; c. $W_H = 0,003\,J$; d. $F = 3\,N$; e. $I = 0,116\,A$.

11.27) a. $I = 211,85\,A$; b. $W_H = 2,8 \times 10^{-4}\,J$; c. $I = 199,48\,A$.

11.29) $P = 159,87\,N$.

11.31) $B = 0,0884\,Wb/m^2$.

11.33) $L = 3,027 \times 10^{-5}\,H$.

11.35) a. $L = 8,04 \times 10^{-3}\,H$; b. $L = 160,85\,H$; c. $L = 1608,5\,H$; d. $L = 1,38\,H$; e. $L = 2,66\,H$.