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c49945 # Instructor's Solutions Manual Solutions to All Exercises to Accompany Electronics and Communications for Scientists and Engineers

p5005 Second Edition

p5010 by Martin Plonus

s0010 Chapter 1: Solutions to problems

o0010 **1.1** $W: \frac{m\ell^2}{t^2},\ F: \frac{m\ell}{t^2},\ \int F \cdot d\ell = \frac{m\ell}{t^2} \cdot \ell = \frac{m\ell^2}{t^2} = W$

p0020 $V: \frac{W}{Q},\ E: \frac{F}{Q},\ V = -\int E \cdot d\ell = \frac{F}{Q} \cdot \ell = \frac{m\ell}{Qt^2} \cdot \ell = \frac{m\ell^2}{Qt^2} = V$; can replace Q by It

o0015 **1.2** $E = 5V/0.001\ \text{m} = 5000\ \text{V/m},\ F = QE = -1.6 \cdot 10^{-19} \cdot 5000\ \text{V/m} = 8 \cdot 10^{-16}$ Newtons

o0020 **1.3** Integrating $F = ma$ twice, we obtain $t = \sqrt{\frac{2ms}{F}} = \sqrt{\frac{2 \cdot 9.11 \cdot 10^{-31} \cdot 0.05}{1.9 \cdot 10^{-17}}} = 6.9 \cdot 10^{-8}$ s, where $F = EQ = VQ/\ell = 12\ \text{V} \cdot 1.6 \cdot 10^{-19}/10\ \text{cm} = 1.9 \cdot 10^{-17}\ \text{N}$.

o0025 **1.4** $V = RI,\ I = V/R,\ R = V/I$

o0030 **1.5** $P = VI,\ P = I^2R,\ P = V^2/R$

o0035 **1.6** $V = RI = 4\Omega \cdot 1.5A = 6$ volts

o0040 **1.7** Cross-sectional area of wire is $A = \pi r^2 = 3.14 \cdot (6.5 \cdot 10^{-4}\ \text{m})^2 = 1.33 \cdot 10^{-6}\text{m}^2$. Using (1.6) $\ell = \frac{RA}{\rho} = \frac{4\Omega \cdot 1.33 \cdot 10^{-6}\text{m}^2}{10^{-6}\Omega\text{–m}} = 5.32$ m.

o0045 **1.8** From (1.6) $R/\ell = \rho/A = 1.7 \cdot 10^{-8}\Omega\text{ - m}/2.081 \cdot 10^{-6}\text{m}^2 = 8.17 \cdot 10^{-3}\Omega/\text{m}$

o0050 **1.9** $P = VI = 300 \cdot 220 = 66{,}000$ watts (W).

o0055 **1.10** $P = I^2R = (5)^2 \cdot 10 = 250\,\text{W}$

o0060 **1.11** $V = IR = 5 \cdot 10 = 50\text{V}.\ P = V^2/R = (50)^2/10 = 250\,\text{W}$.

o0065 **1.12** $W' = I^2RT = (4)^2 \cdot 5 \cdot 10 = 800$ joules (J).

o0070 **1.13** 1 hp = 1000/1.341 = 746 watts; 1 BTU/s = 1000/0.984 = 1055 W; 1 cal/s = 1000/239 = 4.18 W.

o0075 **1.14** 1 kWh = 3,600,000 W-s. Since 1 W-s = 0.738 ft-lb, then 1 kWh = $3.6 \cdot 10^6 \cdot 0.738 = 2.66 \cdot 10^6$ ft-lbs.

o0080 **1.15** Heat required to raise 250 g of water 90° C is $H = 90 \cdot 250 = 22{,}500$ calories. Also from (1.9) $H = V^2T/R$ W-s $= 0.239V^2T/R$ calories. Therefore, $22,\ 500 = 0.239(110)^2T/15$. Solving $T = 22{,}500 \cdot 15/0.239 \cdot (110)^2 = 116.7\text{s} = 1.945$ minutes.

o0085 **1.16** Rating of heater is $P = IV = (120/10)120 = 1.44\ \text{kW} \cdot 8 \cdot 24 \cdot 30 = 8294$ cents/month.

o0090 **1.17** $12\text{V} - 9\text{V} = 3\ \text{V} = V_{R1}$.

o0095 **1.18** $1\ \text{A} - 0.5\ \text{A} = 0.5\ \text{A} = I_{R1}$.

o0105 o0100 **1.19** **(a)** $W = Pt = VIt = 120 \cdot 120/10 \cdot 5 = 7200\,\text{J}$

o0110 **(b)** $(169.7)^2 \cdot 5/2 \cdot 10 = 7199$ J.

o0115 **1.20** A DC voltage of 120 V is equivalent in delivering power to a resistor as an AC voltage with peak value of $V_P = 169.7$ V.

o0125 o0120 **1.21** **(a)** $p(t) = v^2/R = V_P^2\cos^2\ 10t/R$;

p0140 $P_{\text{ave}} = \frac{1}{T}\int_0^T \left(V_P^2/R\right)\cos^2\ 10t\,dt = \frac{1}{T}\frac{V_p^2}{R}\frac{1}{10}\left[\frac{1}{2}10^T + \frac{1}{4}\sin 20T\right] = V_p^2/2R.$

o0130 **(b)** Power flow is always from source to resistor.

o0140 o0135 **1.22** **(a)** Using formula in text following (1.15), spacing between plates is $\ell = \varepsilon A/C = 6 \cdot 8.85 \cdot 10^{-12} \cdot 10^{-2}\text{m}^2/0.05 \cdot 10^{-6} = 1.06 \cdot 10^{-5}\text{m}$.

o0145 **(b)** Electric field strength between plates. $V/\ell = 100\ \text{V}/1.06 \cdot 10^{-5}\,\text{m} = 9.43 \cdot 10^6\text{V/m}$ which exceeds the breakdown strength of mica, which is $6 \cdot 10^6\text{V/m}$.

o0150 **(c)** $6 \cdot 10^6\text{V/m} \cdot 1.06 \cdot 10^{-5}\text{m} = 63.6\text{V}$.

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o0155 **1.23** $v=0,\ t<0;\ v=\frac{1}{c}\int idt=\frac{1}{5\mu F}\int_0^t 20mAdt=\frac{1}{5\cdot 10^{-6}}20\cdot 10^{-3}t=4\cdot 10^3 t,\ 0\le t\le 3$ ms;
$v=v(t=3\ \text{ms})=4\cdot 10^3 t=4\cdot 10^3\cdot 3\cdot 10^{-3}=12\text{V},\ t>3\ \text{ms}.$

o0160 **1.24** $W_c=CV_p^2\sin^2 2\pi t/2$. Max when $\sin 2\pi t=1$, $5\cdot 10^{-6}\cdot(200)^2/2=0.1\ \text{J}=W_{c_1\max}$.

o0165 **1.25** $i=\frac{1}{L}\int_{-\infty}^{t}2dt=\frac{2\text{V}}{2\cdot 10^{-3}H}t=10^3 t$ A for $0\le t\le 3$ ms;
$i|_{t>3\ \text{ms}}=i(t=3\ \text{ms})+\frac{1}{L}\int_3^\infty 0dt=10^3 t|_{t=3\ \text{ms}}+0=3$ A for $t>3$ ms.

o0175 o0170 **1.26** **(a)** $I_L=.9V/3\Omega=.3\text{A},\ R_i=(V_B-V_L)/I_L=(1.5-.9)/.3=.6/.3=2\Omega.$

o0180 **(b)** $(1.5+0.9)/2=1.2\ \text{V}.$

o0185 **(c)** $I_{\text{ave}}=V_{\text{ave}}/3\Omega=0.4\text{A}.$

o0195 o0190 **1.27** **(a)** $P_{\text{ave}}=I_{\text{ave}}\cdot V_{\text{ave}}=0.4\cdot 1.2=0.48\ \text{W}.$

o0200 **(b)** $\text{W-h}=0.48\cdot 6=2.88\ \text{W-h}.$

o0205 **(c)** Battery cost in cents/kW-h $=120/2.88\cdot 10^{-3}=41{,}667$ cents/kW-h. This is 41, 667/8 = 5208 as expense as energy supplied by electric utilities.

o0210 **1.28** $v_s=6\text{V},\ R_i=v_{oc}/i_{sc}=6/2=3\Omega$

o0215 **1.29** $i_s=i_{sc}=2\text{A},\ R_i=v_{oc}/i_{sc}=3\Omega$

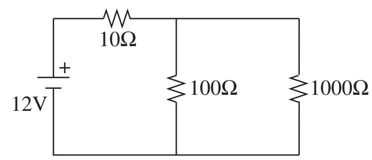
o0220 **1.30** Current flowing in the series circuit is$12/(1+2+3)=2\text{A};\ V_{R_1}=2\text{V},\ V_{R_2}=4\text{V},$
$V_{R_3}=6\text{V}.$

o0225 **1.31** $\frac{1}{R_{eq}}=\frac{1}{1}+\frac{1}{2}+\frac{1}{3},\ R_{eq}=6/11\Omega;\ V=IR_{eq}=11\cdot 6/11=6\text{V};\ I_{R_1}=6\text{A},\ I_{R_2}=3\text{A},\ I_{R_3}=2\text{A}.$

o0235 o0230 **1.32** **(a)** $I_{\text{battery}}=12/\left(10+\frac{100\cdot 1000}{100+1000}\right)=0.12\ \text{A},$

o0240 **(b)** $I_{10\Omega}=0.12\text{A},I_{100\Omega}=0.12\cdot\frac{1000}{100+1000}=0.11\text{A},I_{1000\Omega}=0.12\cdot\frac{100}{100+1000}=0.011\ \text{A}$

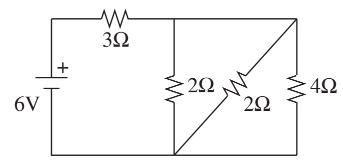
o0245 **(c)** $V_{10\Omega}=(0.12\ \text{A})(10\Omega)=1.2\text{V},\ V_{100\Omega}=V_{1000\Omega}=12\text{V}-1.2\text{V}=10.8\ \text{V}$



o0255 o0250 **1.33** **(a)** $I_{3\Omega}=6/\left(3+\frac{1\cdot 4}{1+4}\right)=1.58\text{A},\ I_{2\Omega}=1.58\left(\frac{2\cdot 4}{2+4}\right)/\left(2+\left(\frac{2\cdot 4}{2+4}\right)\right)=0.63\ \text{A},$
$I_{4\Omega}=1.58\frac{1}{1+4}=0.32\text{A}$

o0260 **(b)** $V_{3\Omega}=1.58\cdot 3=4.7\ \text{V},\ V_{2\Omega}=V_{4\Omega}=6-4.7=1.3$

o0265 **(c)** $P=V_{\text{bat.}}\cdot I_{\text{bat.}}=6\ \text{V}\cdot 1.58\ \text{A}=9.47\ \text{W}$



o0270 **1.34** $6=2i_1+10i_1-10i_2$ but $i_2=-3\text{A},\ i_1=-24/12=-2\text{A}$

o0275 **(a)** $i_{10\Omega}=i_1-i_2=-2-(-3)=1\ \text{A},\ V_{10\Omega}=i_{10}\cdot 10=1\cdot 10=10\ \text{V}$

o0280 **(b)** $i_{2\Omega}=i_1=-2\ \text{A},\ V_{2\Omega}=-2\cdot 2=-4\ \text{V}$

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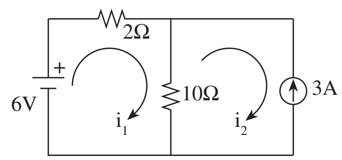


o0285 **1.35** Switching off the current source, we obtain $i'_{10\Omega} = (6/2+10) = \frac{1}{2}$ A and $V'_{10\Omega} = 6\cdot\frac{10}{2+10} = 5$ V

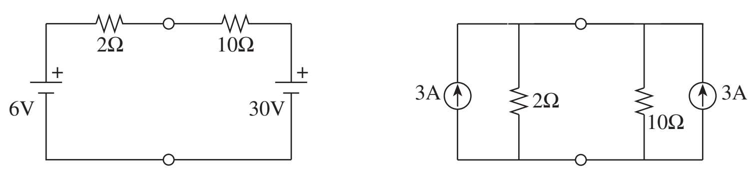
p0305 Switching off the voltage source, we obtain $i''_{10\Omega} = 3\cdot\frac{2}{2+10} = \frac{1}{2}$ A and $V''_{10\Omega} = 3\cdot\frac{2\cdot 10}{2+10} = 5$ V

o0290 **(a)** $i_{10\Omega} = i' + i'' = \frac{1}{2} + \frac{1}{2} = 1$ A, $V_{10\Omega} = V' + V'' = 5 + 5 = 10$ V

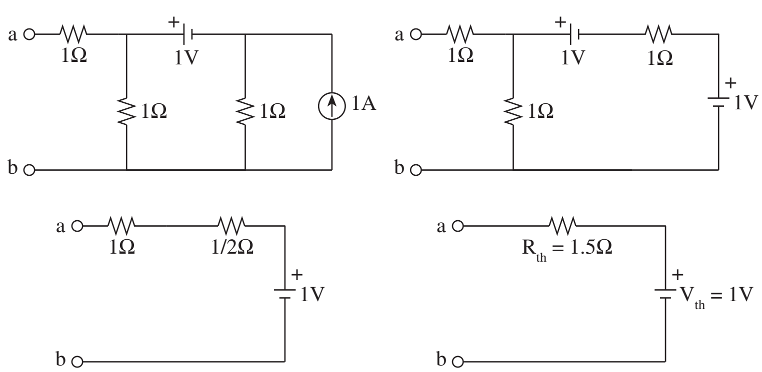
o0295 **(b)** Similarly $i'_{2\Omega} = 6/(2+10) = \frac{1}{2}$ A, $V'_{2\Omega} = 6\cdot 2/(2+10) = 1$ V, $i''_{2\Omega} = 3\cdot 10/(2+10) = 2.5$ A, $V''_{2\Omega} = 3\cdot\frac{2\cdot 10}{2+10} = 5$ V, $i_{2\Omega} = i' + i'' = \frac{1}{2} - 2.5 = -2$ A, $V_{2\Omega} = V' + V'' = 1 - 5 = -4$ V

o0300 **1.36** $i_{2\Omega} = (6-30)/2(2+10) = -24/12 = -2$ A $\qquad i_{10\Omega} = (3+3)\frac{2}{2+10} = 1$ A

p0325 $V_{2\Omega} = (-2)(2) = -4$ V $\qquad V_{10\Omega} = (1)\cdot 10 = 10$ V



o0305 **1.37**



o0310 **1.38** It should have the value of $R_{th} = 1.5\Omega$. $P_{\max} = IV = \left(\frac{1}{1.5+1.5}\right)\left(1\frac{1.5}{1.5+1.5}\right) = 1/6$ W.

o0315 **1.39** Using superposition, the open-circuit voltage at x-y is $V_{oc} = V_{th} = 12\cdot\frac{40\|50}{10+(40\|50)} + 1\cdot 30\,\|\,(20+10\|40)\cdot\frac{40\|10}{20+40\|10} = 8.276 + 4.138 = 12.414$ V, where $40\|50 = 40\cdot 50/(40+50) = 22.22\Omega$, $10\|40 = 8\Omega$

p0345 $R_{th} = 10\|40\|50 = 8\|50 = 8\cdot 50/(8+50) = 6.896\Omega$

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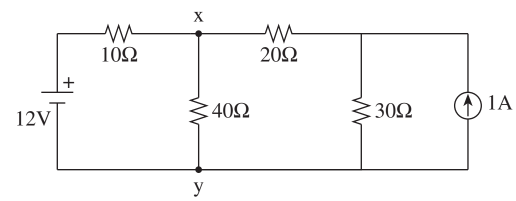
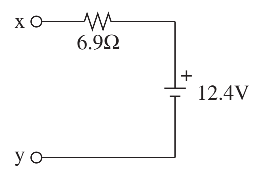


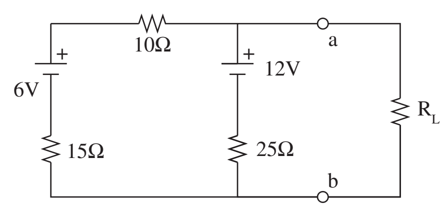
p0350 R_{th} obtained by short-circuiting the 12 V source and open-circuiting the 1 A source.



o0325 o0320 **1.40** **(a)** $R_{th} = 25 \| (10 + 25) = 12.5\Omega$, therefore $R_L = 12.5\Omega$

o0330 **(b)** $V_{th} = \frac{6}{15+10} \cdot 25 + 12 - \frac{12}{10+15+25} \cdot 25 = 3 + 12 - 6 = 9\text{V}$, therefore
$P_{\max} = I \cdot V = \frac{9}{12.5+12.5} \cdot 9 \cdot \frac{12.5}{12.5+12.5} = 1.62$ W

o0335 **(c)** $P_{R_L=10\Omega} = I \cdot V = \frac{9}{10+12.5} \cdot 9 \cdot \frac{10}{10+12.5} = 1.60$ W



o0340 **1.41** For maximum power transfer to a load, the equivalent source and load resistances must be matched, that is, equal to each other.

o0345 **1.42** $i_{R_1} = V/R_1$

o0350 **1.43** $i_2 = (R_2 i_i - V_2)/(R_2 + R_3) = [2 \cdot (-0.33) - 2]/(2 + 3) = -2.66/5 = -0.532$ A

o0355 **1.44** $i_3 = \begin{vmatrix} 8 & -2 & 1 \\ -2 & 5 & -2 \\ -5 & 0 & -3 \end{vmatrix} \div 199 = \frac{-5(4-5)-3(40-4)}{199} = -\frac{103}{199} = -0.517\text{A}$

o0360 **1.45** $i_1 = -0.33$ A

o0365 **1.46** $i_{R5} = i_1 - i_3 = -0.33 - (-0.52) = 0.19$ A

o0370 **1.47** Yes, it results in a matrix with positive diagonal terms and negative off-diagonal terms. This helps when checking the equations for errors.

o0380 o0375 **1.48** **(a)** $q_0 = CV = 2\mu F \cdot 12\text{V} = 24 \cdot 10^{-6}$ coulombs (c).

o0385 **(b)** $i_o = v_o/R = 12\text{V}/100\Omega = 0.12$ A.

o0390 **(c)** $\tau = RC = 100\,\Omega \cdot 2\mu F = 200\mu\text{s}$.