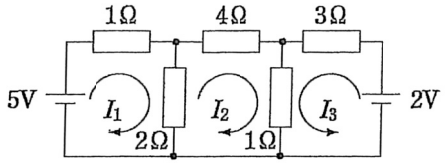
第１章　ワークシート解答

１．　(1)



$$\begin{matrix} 3I_1 - 2I_2 + 0 = 5 \\ -2I_1 + 7I_2 + I_3 = 0 \\ 0 + I_2 + 4I_3 = 2 \end{matrix} \rightarrow \begin{bmatrix} 3 & -2 & 0 \\ -2 & 7 & 1 \\ 0 & 1 & 4 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 2 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 3 & -2 & 0 \\ -2 & 7 & 1 \\ 0 & 1 & 4 \end{vmatrix} = 84 - 3 - 16 = 65$$

$$I_1 = \frac{\begin{vmatrix} 5 & -2 & 0 \\ 0 & 7 & 1 \\ 2 & 1 & 4 \end{vmatrix}}{\Delta} = \frac{140 - 4 - 5}{65} = \frac{131}{65}$$

$$I_2 = \frac{\begin{vmatrix} 3 & 5 & 0 \\ -2 & 0 & 1 \\ 0 & 2 & 4 \end{vmatrix}}{\Delta} = \frac{-6 - (-40)}{65} = \frac{34}{65}$$

$$I_3 = \frac{\begin{vmatrix} 3 & -2 & 5 \\ -2 & 7 & 0 \\ 0 & 1 & 2 \end{vmatrix}}{\Delta} = \frac{42 - 10 - 8}{65} = \frac{24}{65}$$

$I_{R1(1\Omega)} = I_1 = \frac{131}{65} = 2.02\,\mathrm{A}$　　（答）　2.02A，右向き

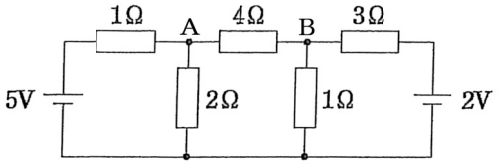
$I_{R2(4\Omega)} = I_2 = \frac{34}{65} = 0.523\,\mathrm{A}$　　（答）　0.523A，右向き

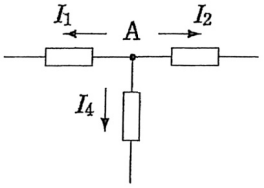
$I_{R3(3\Omega)} = I_3 = \frac{24}{65} = 0.369\,\mathrm{A}$　　（答）　0.369A，左向き

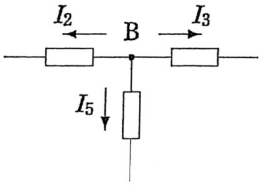
$I_{R4(1\Omega)} = I_1 - I_2 = \frac{97}{65} = 1.49\,\mathrm{A}$　　（答）　1.49A，下向き

$I_{R5(1\Omega)} = I_2 + I_3 = \frac{34}{65} + \frac{24}{65} = \frac{58}{65} = 0.892\,\mathrm{A}$　　（答）　0.892A，下向き

(2)







A 点 : $\dfrac{V_A-5}{1}+\dfrac{V_A}{2}+\dfrac{V_A-V_B}{4}=0 \quad \rightarrow \quad 7V_A-V_B=20$ …①

B 点 : $\dfrac{V_B-V_A}{4}+\dfrac{V_B}{1}+\dfrac{V_B-2}{3}=0 \quad \rightarrow \quad -3V_A+19V_B=8$ …②

①, ②より

$V_B=7V_A-20$

$-3V_A+133V_A-380=8$

$130V_A=388$

$V_A=\dfrac{388}{130}=\dfrac{194}{65}$

$V_B=\dfrac{58}{65}$

$I_{R1(1\Omega)}=I_1=\dfrac{V_A-5}{R_1}=\dfrac{194}{65}-\dfrac{325}{65}=-\dfrac{131}{65}=-2.02\,\mathrm{A}$ （答） 2.02A, 右向き

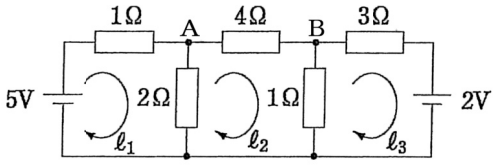
$I_{R2(4\Omega)}=\dfrac{V_A-V_B}{R_2}=\dfrac{\frac{194}{65}-\frac{58}{65}}{4}=\dfrac{1}{4}\times\dfrac{136}{65}=\dfrac{34}{65}=0.523\,\mathrm{A}$ （答） 0.523A, 右向き

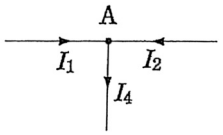
$I_{R4(2\Omega)}=\dfrac{V_A}{R_4}=\dfrac{1}{2}\times\dfrac{194}{65}=\dfrac{97}{65}=1.49\mathrm{A}$ （答） 1.49A, 下向き

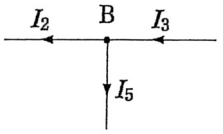
$I_{R3(3\Omega)}=\dfrac{V_B-2}{R_3}=\dfrac{\frac{58}{65}-2}{3}=\dfrac{1}{3}\times\dfrac{58-130}{65}=-\dfrac{24}{65}=-0.369\mathrm{A}$ （答） 0.369A, 左向き

$I_{R5(1\Omega)}=\dfrac{V_B}{R_5}=\dfrac{58}{65}=0.892\,\mathrm{A}$ （答） 0.892A, 下向き

(3)







A 点

$$I_1 + I_2 = I_4 \quad \cdots①$$

$$I_1 + 2I_4 = 5 \quad \cdots②$$

B 点

$$I_3 = I_2 + I_5 \quad \cdots③$$

$$3I_3 + I_5 = 2 \quad \cdots④$$

AB 間

$$-4I_2 + I_5 - 2I_4 = 0 \quad \cdots⑤$$

①②より

$$I_1 = I_4 - I_2$$

$$I_4 - I_2 + 2I_4 = -I_2 + 3I_4 = 5 \quad \cdots⑥$$

③④より

$$I_5 = I_3 - I_2$$

$$3I_3 + I_3 - I_2 = 4I_3 - I_2 = 2 \quad \cdots⑦$$

③⑤より

$$I_5 = I_3 - I_2$$

$$-4I_2 + I_3 - I_2 - 2I_4 = -5I_2 + I_3 - 2I_4 = 0 \quad \cdots⑧$$

⑦⑧より

$$I_3 = 5I_2 + 2I_4$$

$$4\left(5I_2 + 2I_4\right) - I_2 = 20I_2 + 8I_4 - I_2 = 19I_2 + 8I_4 = 2 \quad \cdots⑨$$

⑥⑨より

$$I_2 = 3I_4 - 5$$

$$19\left(3I_4 - 5\right) + 8I_4 = 57I_4 - 95 + 8I_4 = 2$$

したがって，$65I_4 = 97 \quad \rightarrow \quad I_{4(2\Omega)} = \dfrac{97}{65} = 1.49\,\mathrm{A}$　　（答）　1.49A，下向き

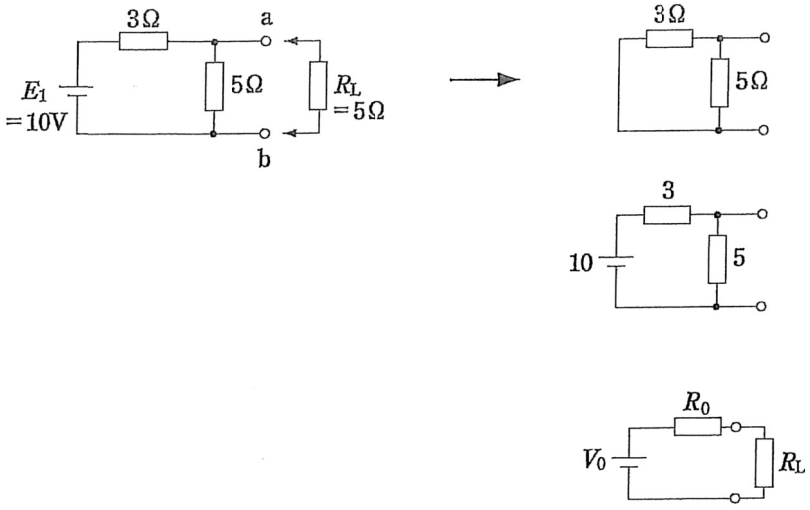
$$I_{2(4\Omega)} = 3I_4 - 5 = 3 \times \frac{97}{65} - 5 = -\frac{34}{65} = -0.523\,\mathrm{A}$$　　（答）　0.523A，右向き

$$I_{3(3\Omega)} = 5I_2 + 2I_4 = 5 \times \left(-\frac{34}{65}\right) + 2 \times \frac{97}{65} = \frac{24}{65} = 0.369\,\mathrm{A}$$　　（答）　0.369A，左向き

$$I_{5(1\Omega)} = I_3 - I_2 = \frac{24}{65} - \left(-\frac{34}{65}\right) = \frac{58}{65} = 0.892\,\mathrm{A}$$　　（答）　0.892A，下向き

$$I_{1(1\Omega)} = I_4 - I_2 = \frac{97}{65} - \left(-\frac{34}{65}\right) = \frac{131}{65} = 2.02\,\mathrm{A}$$　　（答）　2.02A，右向き

2．



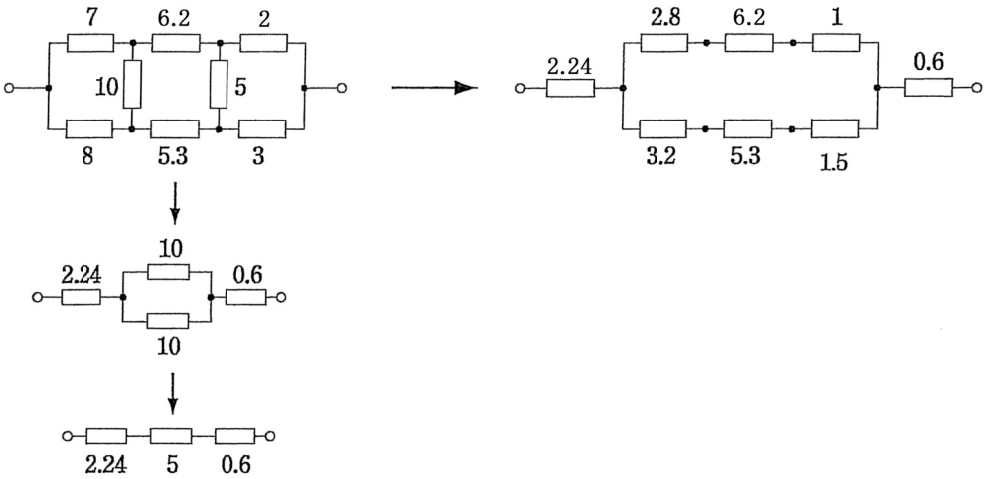
$$R_0 = \frac{3 \times 5}{3 + 5} = \frac{15}{8}\,\Omega$$

$$V_0 = \frac{5}{3 + 5} \times 10 = \frac{50}{8}\,\mathrm{V}$$

したがって，

$$I_{R_\mathrm{L}} = \frac{V_0}{R_0 + R_\mathrm{L}} = \frac{\dfrac{50}{8}}{\dfrac{15}{8} + 5} = \frac{50}{55} = 0.909\,\mathrm{A}$$　　（答）　0.909A

3. (1)



$$R_1 = \frac{7 \times 8}{7 + 8 + 10} = \frac{56}{25} = 2.24\,\Omega$$

$$R_2 = \frac{7 \times 10}{25} = \frac{70}{25} = 2.8\,\Omega$$

$$R_3 = \frac{8 \times 10}{25} = \frac{80}{25} = 3.2\,\Omega$$

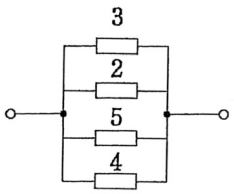
$$R_4 = \frac{2 \times 3}{5 + 2 + 3} = \frac{6}{10} = 0.6\,\Omega$$

$$R_5 = \frac{5 \times 3}{10} = \frac{15}{10} = 1.5\,\Omega$$

$$R_6 = \frac{5 \times 2}{10} = \frac{10}{10} = 1\,\Omega$$

$R_0 = 7.84\,\Omega$ (答) $7.84\,\Omega$

(2)



$$R = \frac{1}{\frac{1}{3} + \frac{1}{2} + \frac{1}{5} + \frac{1}{4}} = \frac{60}{20 + 30 + 12 + 15} = \frac{60}{77} = 0.779\,\Omega$$ (答) $0.779\,\Omega$

4.

$$I_{\mathrm{R}} = \frac{r}{r+R} I$$

$$R_{\mathrm{R}} = R I_{\mathrm{R}}{}^2 = R \frac{r^2}{(r+R)^2} I^2 \qquad (答)$$

電力P_{R}が最大となる条件は$\frac{dP_{\mathrm{R}}}{dR} = 0$より

$$\frac{dP_{\mathrm{R}}}{dR} = \frac{d}{dR}\left\{ r^2 I^2 \frac{R}{(r+R)^2} \right\}$$

$$= r^2 I^2 \left\{ \frac{(r+R)^2 - 2R(r+R)}{(r+R)^4} \right\}$$

$$= r^2 I^2 \frac{r+R-2R}{(r+R)^3} = r^2 I^2 \frac{r-R}{(r+R)^3} = 0$$

したがって，$R = r$のときP_{R}が最大

$$P_{\mathrm{R\,max}} = r \frac{r^2}{(r+r)^2} I^2$$

$$= \frac{r^3}{(2r)^2} I^2$$

$$= \frac{r}{4} I^2 \qquad (答)$$

5. (1) 証明は，１－４－１項を参照。

(2) 式1－63より$R_2 R_3 = R_1 R_4$となるから

$$2 \times 5 = 10 \times R_4$$

$$R_4 = 1$$

したがって，$R_4 = 1\Omega$　　(答)