## Appendix B – Solutions

### Problem B.1

Answer:
\[ R = 5.5 \, \Omega \]

### Problem B.2

Answer:
(a) \[ R = 6 \, \Omega \]
(b) \[ R = 0 \, \Omega \]
(c) \[ R = \infty \]

### Problem B.3

The current \( i_0 = 0 \) if and only if the voltage across the 3 \( \Omega \)-resistor is equal to the voltage across the \( R \) resistor when the "\( i_0 \)-wire" is removed! Hence, we have

\[
\frac{3}{3+2} = \frac{R}{R+4}
\]

\[ 3R + 12 = 5R \]

\[ 2R = 12 \]

\[ R = 6 \, \Omega \]

### Problem B.4

Let \( C_s \) denote the capacitance of two capacitors with capacitance \( C_1 \) and \( C_2 \), respectively, connected in series. \( C_1 \) and \( C_2 \) must have the same charge \( Q \). Hence, the voltages across \( C_1 \) and \( C_2 \) are \( \frac{Q}{C_1} \) and \( \frac{Q}{C_2} \), respectively. The voltage across both capacitors is

\[
\frac{Q}{C_s} = \frac{Q}{C_1} + \frac{Q}{C_2}
\]

Hence, we have

\[
\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}
\]

Two capacitors connected in parallel have same voltage \( V \):

\[
V = \frac{Q}{C_1} = \frac{Q}{C_2} = \frac{Q_1 + Q_2}{C_p}
\]

Hence, \( VC_p = Q_1 + Q_2 = VC_1 + VC_2 = V(C_1 + C_2) \)

or

\[ C_p = C_1 + C_2 \]
3µF and 6µF yield \( C_s = 2\mu F \)

\( C_s = 2\mu F \) in parallel with 2µF yields \( C = 4\mu F \)

**Problem B.5**

(a)

![Diagram](image)

(b) \[ Z(f_0) = \frac{(R+j\omega_0 L)}{R+j\omega_0 L+j\omega_0 RC} = \frac{R+j\omega_0 L}{1-\omega_0^2 LC-j\omega_0 RC} \] \[ = \frac{R(1-\omega_0^2 LC)+\omega_0^2 RLC}{(1-\omega_0^2 LC)^2+\omega_0^2 R^2 C^2} + j\frac{\omega_0 L(1-\omega_0^2 LC)-\omega_0 R^2 C}{(1-\omega_0^2 LC)^2+\omega_0^2 R^2 C^2} \]

\[ X(f_0) = 0 \] yields

\[ \omega_0 L(1-\omega_0^2 LC) = \omega_0 R^2 C \]

Assuming \( \omega_0 \neq 0 \):

\[ \omega_0^2 LC = 1 - R^2 C/L \]

Hence, we have the resonance frequency

\[ f_0 = \frac{1}{2\pi \sqrt{LC}} \sqrt{1 - R^2 C/L} \]

(c) If \( R = 0 \), then the resonance frequency is

\[ f_0 = \frac{1}{2\pi \sqrt{LC}} \]

and

\[ Z(f_0) = \infty \]

**Problem B.6**

The current \( i_0 \) is zero if and only if we remove the “\( i_0 \)-wire” and then find that the voltage over the 2 Ω resistor is equal to the voltage over the capacitor. Hence, we have \( i_0 = 0 \) if and only if

\[ \frac{2}{2+j^2} = \frac{1}{j^2+R} \]
\[ \frac{1}{1+j} = \frac{1}{1+j2R} \]
\[ 2R = 1 \]
\[ R = \frac{1}{2} \Omega \]

**Problem B.7**

\[ H(f) = \frac{\frac{R}{1+j\omega C}}{\frac{R}{1+j\omega C} + \frac{10R}{1+j\omega C}} \]
\[ = \frac{R}{R+j\omega RC + \frac{10R}{1+j\omega RC}} \]
\[ = \frac{1}{1 + \frac{10(j\omega RC)}{1+j\omega RC}} \]

Let \( \alpha = \frac{1}{10} \), then
\[ H(f) = \frac{1}{11}. \]

**Problem B.8**

The voltage across the 3 \( \Omega \) resistor is \( 4 \cdot 3 = 12 \) V. Hence, the current through the 4 \( \Omega \) resistor is \( \frac{12}{4} = 3 \) A and the source current \( I = 4 + 3 = 7 \) A.