Feedback — Problem Set II

You submitted this homework on **Tue 26 Mar 2013 3:40 PM CDT -0500**. You got a score of **0.00** out of **12.00**. However, you will not get credit for it, since it was submitted past the deadline.

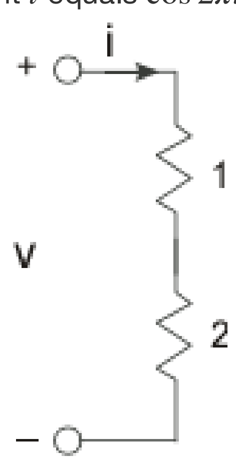
Starting this problem set, you will only be given a total of three attempts. Explanations and answers to the problem set will be available after the due date. Since the homework problems will become gradually more challenging as the course proceeds, we highly recommend you to start the habit of printing out the problems and working on them with paper and pencil. Also, please be sure to read the problem statements carefully and double check your expressions before you submit.

A pdf version of this problem set is available for you to print.

Note: all mathematical expressions have to be exact, even when involving constants. Such an expression is required when a function and/or a variable is required in the answer. For example, if the answer is $\sqrt{3}x$, you must type `sqrt(3)*x`, not `1.732*x` for the answer to be graded as correct.

Question 1

In the following circuit, the current i equals $\cos 2\pi t$. What is the voltage v?



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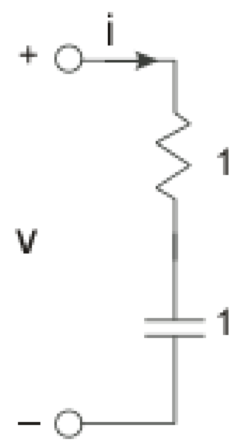
Question Explanation

The voltage equals the sum of the voltage across the 1Ω resistor plus the voltage across the 2Ω resistor. These voltages are $\cos 2\pi t$ and $2\cos 2\pi t$ respectively. Therefore, $v = 3\cos 2\pi t$.

Question 2

In the following circuit, the current i equals $\cos 2\pi t$. What is the voltage v?



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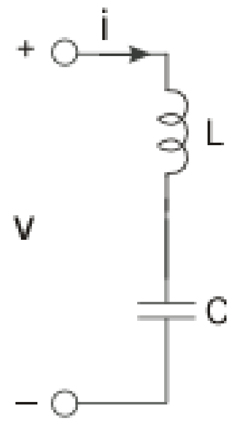
Question Explanation

Since the v-i relationship for a capacitor is $v(t) = \frac{1}{C}\int_{-\infty}^{t} i(\alpha)\,d\alpha$, the voltage across the capacitor equals $\frac{1}{2\pi}\sin 2\pi t$. Therefore, the voltage v equals $\cos 2\pi t + \frac{1}{2\pi}\sin 2\pi t$.

Question 3

In the following circuit, the current i equals $\cos 2\pi t$. What is the voltage v? Please assume 1F for C and 1H for L.



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Question Explanation

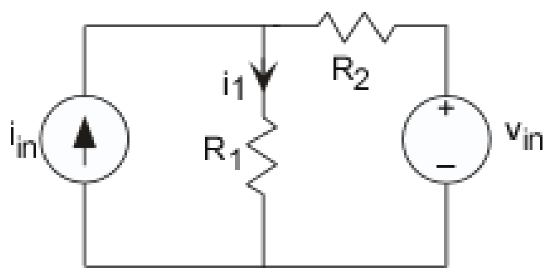
The v-i relationship for the inductor is $v(t) = \frac{d\,i(t)}{dt}$, which makes the voltage across the inductor equal $-2\pi\sin 2\pi t$. The total voltage v equals the sum of the inductor and capacitor voltages:

$$-2\pi \sin 2\pi t + \frac{1}{2\pi} \sin 2\pi t = \left(-2\pi + \frac{1}{2\pi}\right) \sin 2\pi t \ .$$

Question 4

One of the most important consequences of circuit laws is the **Superposition Principle**: The current or voltage defined for any element equals the sum of the currents or voltages produced in the element by the independent sources. This Principle has important consequences in simplifying the calculation of circuit variables in multiple source circuits.

Solve the following circuit for i1 as a function of iin, R1, R2, and vin. Use any technique you like; probably the simplest is best. Use the spelling and capitalization of the variables provided in the question to write your answer. *i.e.* Write `iin` for i_{in}, `vin` for v_{in} and `R1, R2` for the resistors.



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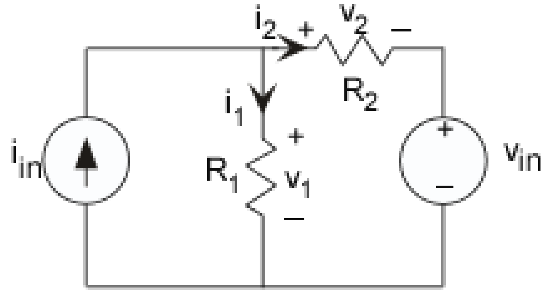
Question Explanation

First, define the voltages and currents for the resistors.

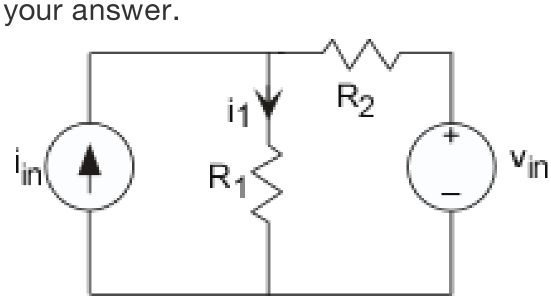


Use KVL and KCL.
KCL: $i_{\text{in}} = i_1 + i_2$
KVL: $v_{\text{in}} = v_1 - v_2$
Using the v-i relations $v_1 = R_1 i_1$ and $v_2 = R_2 i_2$ in the KVL equation and substituting $i_{\text{in}} - i_1$ for i_2, we have $v_{\text{in}} = R_1 i_1 - R_2(i_{\text{in}} - i_1)$. Simplifying this equation gives us the answer: $i_1 = \dfrac{v_{\text{in}} + R_2 i_{\text{in}}}{R_1 + R_2}$.

Question 5

You should have found that the current i_1 is a linear combination of the two source values: $i_1 = C_1 v_{\text{in}} + C_2 i_{\text{in}}$. This result means that we can think of the current as a superposition of two components, each of which is due to a source. We can find each component by setting the other sources to zero. Thus, to find the voltage source component, you can set the current source to zero (an open circuit) and use the usual tricks. To find the current source component, you would set the voltage source to zero (a short circuit) and find the resulting current. You then simply add the two results to obtain the current.

Calculate the current i_1 using the Superposition Principle as a function of `iin, R1, R2`, and `vin`. Use the spelling and capitalization of the variables provided in the question to write your answer.



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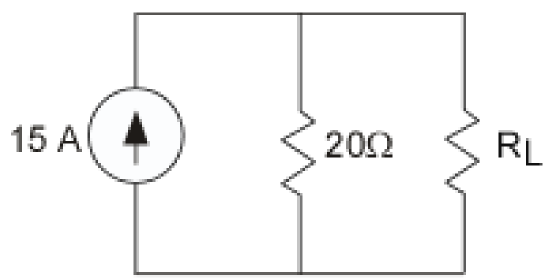
Question Explanation

In turn, set all but one source to zero, find the current due to that source, and add up the individual answers. Setting v_{in} to zero leaves $i_1 = \frac{R_2}{R_1 + R_2} i_{\text{in}}$ (found by current divider). Setting i_{in} to zero leaves $i_1 = \frac{R_1}{R_1 + R_2} \cdot \frac{1}{R_1} v_{\text{in}} = \frac{1}{R_1 + R_2} v_{\text{in}}$. Now, adding together these component answers we obtain the final answer $i_1 = \frac{R_2}{R_1 + R_2} i_{\text{in}} + \frac{1}{R_1 + R_2} v_{\text{in}}$.

Question 6

For the following circuit, find the value of R_L that results in a current of 5A passing through it.



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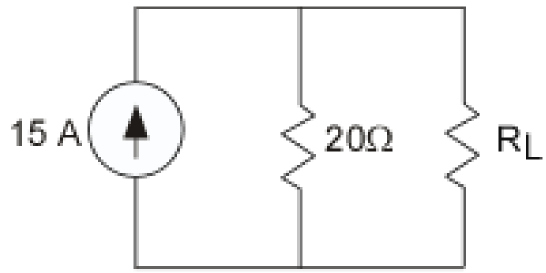
Question Explanation

The current passing through R_L equals $\dfrac{20}{20+R_L} \cdot 15$ (current divider). Setting this equal to 5, we obtain $R_L = 40$.

Question 7

For the following circuit, you found in the previous question the value of R_L that results in a current of 5A passing through it.



In this case, what is the power dissipated in the load resistor R_L? A numeric answer is wanted, though it will have units of watts you should not include the unit in the answer.

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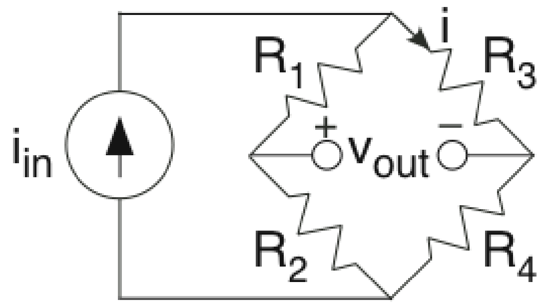
Question Explanation

We found that $R_L = 40\Omega$ yielded a current of 5A passing through it. The power equals $R_L i^2 = 40 * 25 = 1000$ watts.

Question 8

In the following circuit, known as a **bridge circuit**, what voltage does v_{out} "see" when nothing is connected to the output terminals?



State your answer in terms of `R1, R2, R3, R4` and `iin`, taking care to note the spelling and capitalization of variables.

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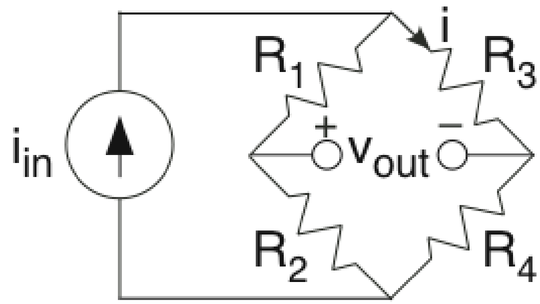
Question Explanation

The voltage v_{out} equals the difference between two voltages: v_2, the voltage across R_2 minus v_4, the voltage across R_4. Using first current divider then the v-i relationship for the resistor R_2, we find that $v_2 = \frac{R_3 + R_4}{R_1 + R_2 + R_3 + R_4} i_{\text{in}} \cdot R_2$ and that $v_4 = \frac{R_1 + R_2}{R_1 + R_2 + R_3 + R_4} i_{\text{in}} \cdot R_4$. That makes $v_{\text{out}} = \frac{(R_3 + R_4)R_2 - (R_1 + R_2)R_4}{R_1 + R_2 + R_3 + R_4} i_{\text{in}} = \frac{R_2 R_3 - R_1 R_4}{R_1 + R_2 + R_3 + R_4} i_{\text{in}}$.

Question 9

For the following three questions, you will be asked to find the equivalent resistance. The expressions for the answers are complicated. A simple way to check whether answer has *any* chance of being correct is to make sure your results has units of ohms.

In the following circuit, suppose that $R_1 = 1\Omega$, $R_2 = 2\Omega$, $R_3 = 2\Omega$, and $R_4 = 4\Omega$. Find the current i when the current source i_{in} is $\mathrm{Im}\left[(4+2j)e^{j2\pi 20t}\right]$. Express your answer as a single sinusoid.



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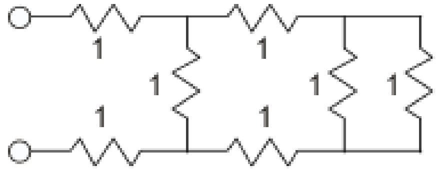
Question Explanation

First of all, convert the mixed expression for the source to polar form. Since $4+2j = \sqrt{20}e^{j\tan^{-1}\ 1/2}$, the source can be more conveniently written as $\mathrm{Im}\left[\sqrt{20}e^{j(2\pi 20t+\tan^{-1}\ 1/2)}\right]$. Using current divider (as we did in the previous problem), $i = \dfrac{R_1+R_2}{R_1+R_2+R_3+R_4}\,i_{\text{in}} = \dfrac{1}{3}\,i_{\text{in}}$. Therefore, the current i equals $\mathrm{Im}\left[\dfrac{\sqrt{20}}{3}e^{j(2\pi 20t+\tan^{-1}\ 1/2)}\right] = \dfrac{\sqrt{20}}{3}\sin(2\pi 20t+\tan^{-1}\tfrac{1}{2})$.

Question 10

Find the equivalent resistance for the following circuit using the series and parallel combination rules. Express your answer numerically as a decimal.



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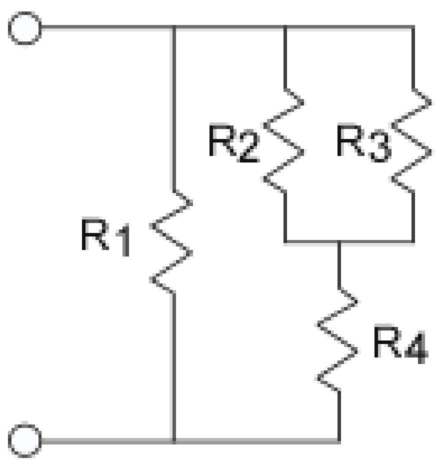
Question Explanation

Begin at the right end and work your way back to the terminals. We first have $1\|1 = \frac{1}{2}\,\Omega$. This equivalent resistor is in series with two 1Ω resistors, giving an equivalent resistance of $2\,\frac{1}{2}\,\Omega$. This combination is in parallel with a 1Ω resistor, giving an equivalent resistance of $1\|\frac{5}{2} = \dfrac{1\cdot\frac{5}{2}}{1+\frac{5}{2}} = \dfrac{\frac{5}{2}}{\frac{7}{2}} = \dfrac{5}{7}\,\Omega$. Finally, this equivalent resistance is in series with two 1Ω resistors, giving a total equivalent resistance of $2\,\frac{5}{7}\,\Omega$.

Question 11

Find the equivalent resistance for the following circuit using the series and parallel combination rules. Express your answer as an expression of R1, R2, R3 and R4.



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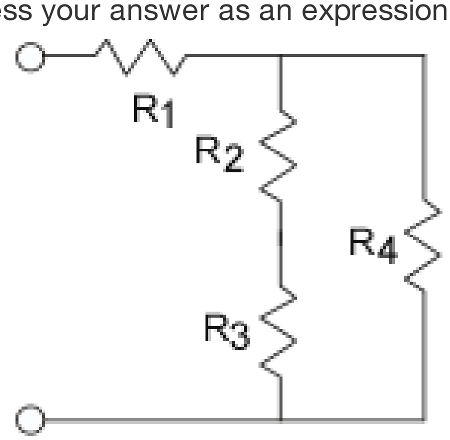
Question Explanation

Starting from the right, the send away from the terminals, we have $R_2 \| R_3$ in series with R_4, giving an equivalent resistance of $\frac{R_2 R_3}{R_2+R_3} + R_4 = \frac{R_2 R_3 + R_2 R_4 + R_3 R_4}{R_2 + R_3}$. This resistance is in parallel with R_1, making the total equivalent resistance

$$\frac{\frac{R_2R_3+R_2R_4+R_3R_4}{R_2+R_3} \cdot R_1}{\frac{R_2R_3+R_2R_4+R_3R_4}{R_2+R_3} + R_1} = \frac{(R_2R_3 + R_2R_4 + R_3R_4)R_1}{R_2R_3 + R_2R_4 + R_3R_4 + R_1R_2 + R_1R_3}.$$

Question 12

Find the equivalent resistance for the following circuit using the series and parallel combination rules. Express your answer as an expression of R1, R2, R3 and R4.



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Question Explanation

Starting at the end of the circuit away from the terminals, we have R_4 in parallel with the series combination of R_2 and R_3. This combination is in series with R_1. Therefore, the equivalent resistance is

$$R_1 + (R_2 + R_3)\|R_4 = R_1 + \frac{(R_2 + R_3)R_4}{R_2 + R_3 + R_4} = \frac{R_1R_2 + R_1R_3 + R_1R_4 + R_2R_4 + R_3R_4}{R_2 + R_3 + R_4}$$

.

NOTE: The units of the result are indeed ohms: we have $\frac{\Omega^2}{\Omega} = \Omega$.