Find: v_x.

Analysis: We observe that the second mesh current must be equal to the current source:

$$i_2 = I_S$$

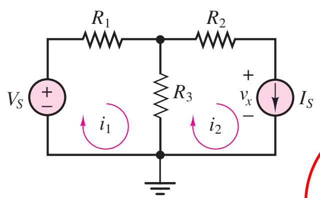

Figure 3.23 Illustration of mesh analysis in the presence of current sources

Thus, the unknown voltage, v_x, can be obtained applying KVL to mesh 2:

$$(i_2 - i_2)R_3 - i_2R_2 - v_x = 0$$

$$v_x = I_S\,(R_2 + R_3)$$

To find the current i_1 we apply KVL to mesh 1:

$$V_S - i_1R_1 - (i_1 - i_2)\,R_2 = 0$$

$$V_S + i_2R_2 = i_1\,(R_1 + R_2)$$

but, since $i_2 = I_S$,

$$i_1 = \frac{V_S + I_SR_2}{(R_1 + R_2)} = \frac{10 + 2 \times 2}{5 + 2} = 2\ \text{A}$$

$$(i_1 - i_2)\,R_3 - i_2\,R_2 - v_x = 0$$

$$v_x = (i_1 - i_2)\,R_3 - i_2\,R_2 = i_1\,R_3 - i_2\,(R_2 + R_3)$$

To find the current i_1 we apply KVL to mesh 1:

$$V_S - i_1\,R_1 - (i_1 - i_2)\,R_3 = 0$$

$$V_S + i_2\,R_3 = i_1\,(R_1 + R_3)$$

but since $i_2 = I_S$

$$i_1 = \frac{V_S + I_SR_3}{(R_1 + R_3)} = \frac{10 + 2\cdot 4}{5 + 4} = 2\ \text{A}$$

Comments: Note that the presence of the current source reduces the number of unknown mesh currents by one. Thus, we were able to find v_x without the need to solve simultaneous equations.

CHECK YOUR UNDERSTANDING

Find the value of the current i_1 if the value of the current source is changed to 1 A.

Answer: 1.71 A

3.4 NODE AND MESH ANALYSIS WITH CONTROLLED SOURCES

LO1, LO2

The methods just described also apply, with relatively minor modifications, in the presence of dependent (controlled) sources. Solution methods that allow for the presence of controlled sources are particularly useful in the study of *transistor amplifiers* in Chapters 8 and 9. Recall from the discussion in Section 2.1 that a dependent source generates a voltage or current that depends on the value of another voltage or current in the circuit. When a dependent source is present in a circuit to be analyzed by node or mesh analysis, we can initially treat it as an ideal source and write the node or mesh equations accordingly. In addition to the equation obtained in this fashion, there is an equation relating the dependent source to one of the circuit voltages or currents. This **constraint equation** can then be substituted in the set of equations obtained by the techniques of node and mesh analysis, and the equations can subsequently be solved for the unknowns.