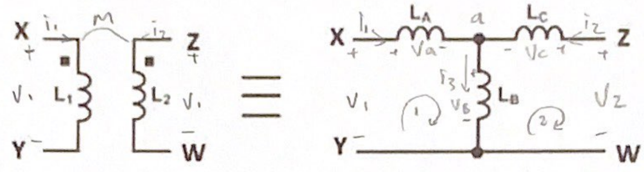
Part 2:

Q1. Fig 1 below shows 2 equivalent circuits (a) and (b). In circuit (a) the 2 coupled inductors have self-inductances L_1 and L_2 as shown and a mutual inductance M. Find L_A, L_B and L_C in terms of L_1, L_2 and M.

i_1, i_2, V_1, V_2 must be equal



(a) (b)

Figure 1

Figure A:

$$V_1 = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt}$$

$$V_2 = L_2 \frac{di_2}{dt} + M \frac{di_1}{dt}$$

Figure B:

$$i_1 + i_2 = I_3$$

KVL Loop 1

$$V_1 - V_A - V_B = 0$$

$$V_1 - L_A \frac{di_1}{dt} - L_B \frac{dI_3}{dt} = 0$$

$$V_1 - L_A \frac{di_1}{dt} - L_B \frac{d(i_1 + i_2)}{dt} = 0$$

$$V_1 = (L_A + L_B) \frac{di_1}{dt} + L_B \frac{di_2}{dt}$$

KVL Loop 2

$$V_B + V_C - V_2 = 0$$

$$L_B \frac{dI_3}{dt} + L_C \frac{di_2}{dt} - V_2 = 0$$

$$L_B \frac{d(i_1 + i_2)}{dt} + L_C \frac{di_2}{dt} - V_2 = 0$$

$$V_2 = (L_B + L_C) \frac{di_2}{dt} + L_B \frac{di_1}{dt}$$

$L_A + L_B = L_1$ $\quad$ $L_B + L_C = L_2$

$L_B = M$ $\quad$ $L_B = M$

$L_A = L_1 - L_B \rightarrow L_A = L_1 - M$

$L_B = M$

$L_C = L_2 - L_B \rightarrow L_C = L_2 - M$

$L_A = L_1 - M$
$L_B = M$
$L_C = L_2 - M$

Part 2:

Q2. Use a series of source transformations to find the current i_o in the circuit given in the Fig 2 below.

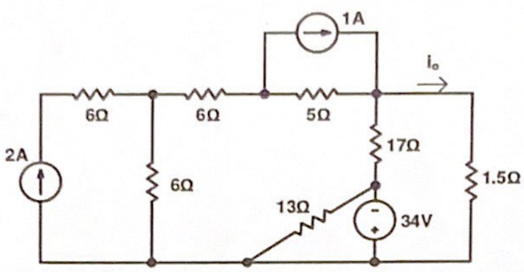
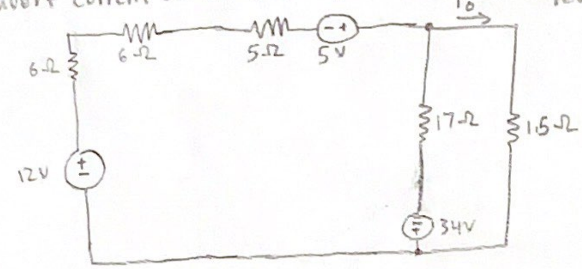


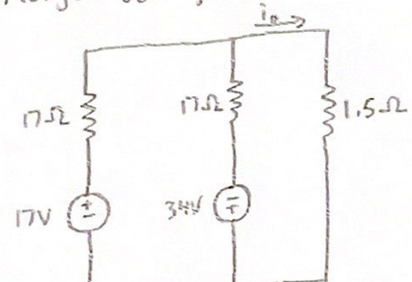
Figure 2

12V 6Ω
5V 5Ω

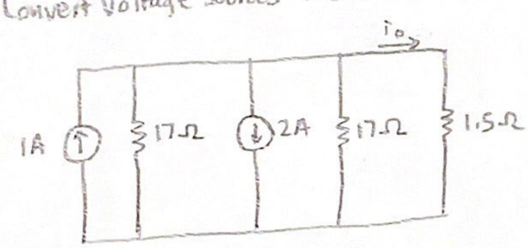
① Convert current sources → voltage sources, remove 13Ω resistor



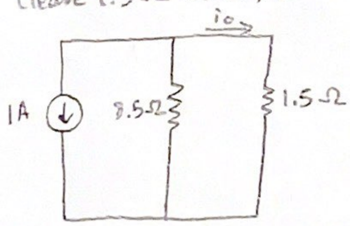
② Merge Voltage Sources + Resistors



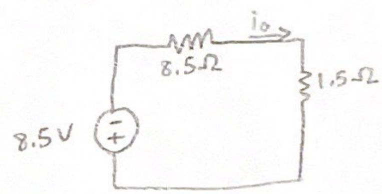
③ Convert voltage sources → current sources



④ Merge Current Sources + Resistors
(leave 1.5Ω alone, need it to calculate i_o)



⑤ Convert current source → Voltage source



Note: i_o should be negative due to sign convention

$8.5\Omega + 1.5\Omega = 10\Omega$ (resistors in series)

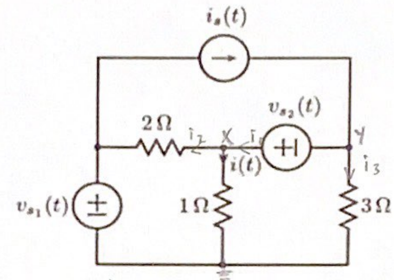
$$i_o = \frac{-8.5V}{10\Omega}$$

$i_o = -0.85A$

$i_o =$ -0.85A

Part 2:

Q3. Refer circuit below. Find i(t) (current flowing through the 1 ohm resistor) in terms of $i_s(t)$, $v_{S1}(t)$, $v_{S2}(t)$.



$$i(t) = \frac{V_x}{1}$$

KCL @ Node X

$$i_1 = i_2 + i(t)$$

$$i_1 = \frac{V_x - V_{s_1}(t)}{2} + \frac{V_x}{1}$$

KCL @ Node Y

$$i_s(t) = i_1 + i_3$$

$$i_s(t) = i_1 + \frac{V_y}{3}$$

$$i_s(t) = i_1 + \frac{V_x - V_{s2}(t)}{3}$$

$$i_s(t) = \left[\frac{V_x - V_{s_1}(t)}{2} + \frac{V_x}{1}\right] + \left[\frac{V_x - V_{s2}(t)}{3}\right]$$

$$i_s(t) = \frac{11V_x - 3s_1(t) - 2s_2(t)}{3}$$

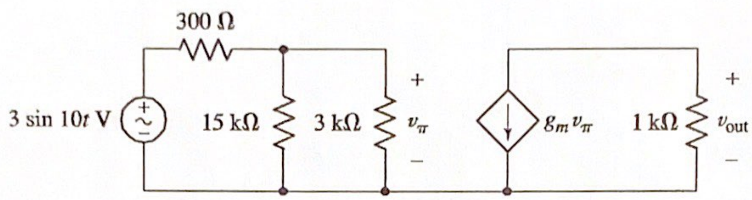
$$V_x = \frac{6i_s(t) + 3s_1(t) + 2s_2(t)}{11}$$

$$i(t) = \frac{6i_s(t) + 3s_1(t) + 2s_2(t)}{11}$$

$$\boxed{i(t) = \frac{6i_s(t) + 3V_{s_1}(t) + 2V_s(t)}{11}}$$

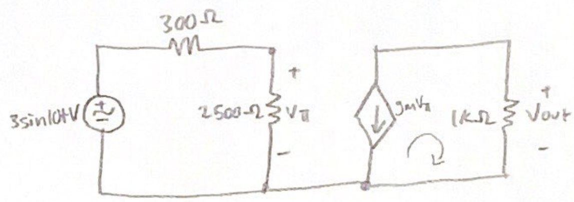
Part 2:

Q4. The circuit below is a commonly used equivalent circuit used to model the ac behavior of a bipolar junction transistor amplifier circuit. If $g_m = 38$ m℧ compute v_{out}.



15kΩ ∥ 3kΩ

$$\frac{(15000)(3000)}{15000 + 3000} = 2500\,\Omega$$



Voltage Divider Method

$$V_X = V_{total} \cdot \frac{R_X}{R_{total}}$$

$$V_\pi = 3\sin 10t \cdot \frac{2500}{2500 + 300}$$

$$V_\pi = 3\sin 10t\,(0.8929)$$

$$V_\pi = 2.6787 \sin 10t \text{ V}$$

$V = IR$

$$V_{out} = (-g_m V_\pi)(1000)$$

$$V_{out} = \left[(-38 \times 10^{-3}) \times 2.6787 \sin 10t\right](1000)$$

$$V_{out} = -101.8 \sin 10t \text{ V}$$

$\boxed{v_{out} = -101.8 \sin 10t \text{ V}}$