**Question 1)** The inductance of two LR circuits are placed next to each other, as shown in the figure. The value of the self-inductance of the inductors, resistance, mutual-inductance and applied voltages are specified in the given circuit. After both the switches are closed simultaneously the total work done by the batteries against the induced EMF in the inductors by the time the currents reach their steady-state values is _____ mJ.

$R_1 = 5\Omega$

$R_2 = 10\Omega$

$V_1 = 5V$

$L_1 = 10mH$

$M = 5mH$

$L_2 = 20mH$

$V_2 = 20V$

I_1

I_2
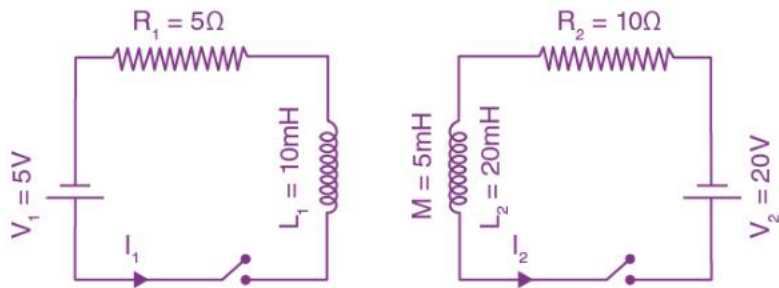
Solution:

Given,

Mutual Inductance, $M = 5mH$

$L_1 = 10 \text{ mH}$

$V_1 = 5 \text{ V}$

$L_2 = 20 \text{ mH}$

$V_2 = 20 \text{ V}$

$I_1 = V_1/R_1 = 5/5 = 1A$

$I_2 = V_2/R_2 = 20/10 = 2A$

After both the switches are closed simultaneously, the total work done by the batteries against the induced EMF = Increase in the magnetic energy

Therefore, $W = \Delta U = (\frac{1}{2}) L_1 I_1^2 + (\frac{1}{2}) L_2 I_2^2 + M I_1 I_2$

$= (\frac{1}{2})(10 \times 10^{-3})1^2 + (\frac{1}{2})(20 \times 10^{-3})(2^2) + (5 \times 10^{-3}) \times 1 \times 2$

$= (5 + 40 + 10) \times 10^{-3}$

$= 55 \text{ mJ}$