5) a) • Imagine that $I_2 > 0$ and increasing $\left(\frac{dI_2}{dt} > 0\right)$.

Then the magnetic field due to coil 2 points up.

As I_2 increases, the flux through coil 1 increases.

By Lenz's law the induced current must be negative (in such a way the magnetic field produced by coil 1 points downward). $\frac{dI_1}{dt} > 0$

Therefore $\mathcal{E}_1$ is negative as well:

$$\mathcal{E}_1 = -L_1 \frac{dI_1}{dt} - M \frac{dI_2}{dt} \quad (1)$$

The same argument applies for the second equation (imagine $I_1 > 0$, $\frac{dI_1}{dt} > 0$)

$$\mathcal{E}_2 = -L_2 \frac{dI_2}{dt} - M \frac{dI_1}{dt} \quad (2)$$

• If $I_2 < 0$ [redacted] $\frac{dI_2}{dt}$, both signs would be positive:

$$\mathcal{E}_1 = -L_1 \frac{dI_1}{dt} + M \frac{dI_2}{dt} \quad (3)$$

$$\mathcal{E}_2 = -L_2 \frac{dI_1}{dt} + M \frac{dI_1}{dt} \quad (4)$$

(3) and (4) are obtained by changing the signs in (1) and (2): $I_2 \to -I_2$, $\mathcal{E}_2 \to -\mathcal{E}_2$