

71. (a) We assume the current is changing at (nonzero) rate di/dt and calculate the total emf across both coils. First consider the coil 1. The magnetic field due to the current in that coil points to the right. The magnetic field due to the current in coil 2 also points to the right. When the current increases, both fields increase and both changes in flux contribute emf's in the same direction. Thus, the induced emf's are

$$\mathcal{E}_1 = -(L_1 + M) \frac{di}{dt} \quad \text{and} \quad \mathcal{E}_2 = -(L_2 + M) \frac{di}{dt} .$$

Therefore, the total emf across both coils is

$$\mathcal{E} = \mathcal{E}_1 + \mathcal{E}_2 = -(L_1 + L_2 + 2M) \frac{di}{dt}$$

which is exactly the emf that would be produced if the coils were replaced by a single coil with inductance $L_{\text{eq}} = L_1 + L_2 + 2M$.

- (b) We imagine reversing the leads of coil 2 so the current enters at the back of coil rather than the front (as pictured in the diagram). Then the field produced by coil 2 at the site of coil 1 is opposite to the field produced by coil 1 itself. The fluxes have opposite signs. An increasing current in coil 1 tends to increase the flux in that coil, but an increasing current in coil 2 tends to decrease it. The emf across coil 1 is

$$\mathcal{E}_1 = -(L_1 - M) \frac{di}{dt} .$$

Similarly, the emf across coil 2 is

$$\mathcal{E}_2 = -(L_2 - M) \frac{di}{dt} .$$

The total emf across both coils is

$$\mathcal{E} = -(L_1 + L_2 - 2M) \frac{di}{dt} .$$

This the same as the emf that would be produced by a single coil with inductance $L_{\text{eq}} = L_1 + L_2 - 2M$.