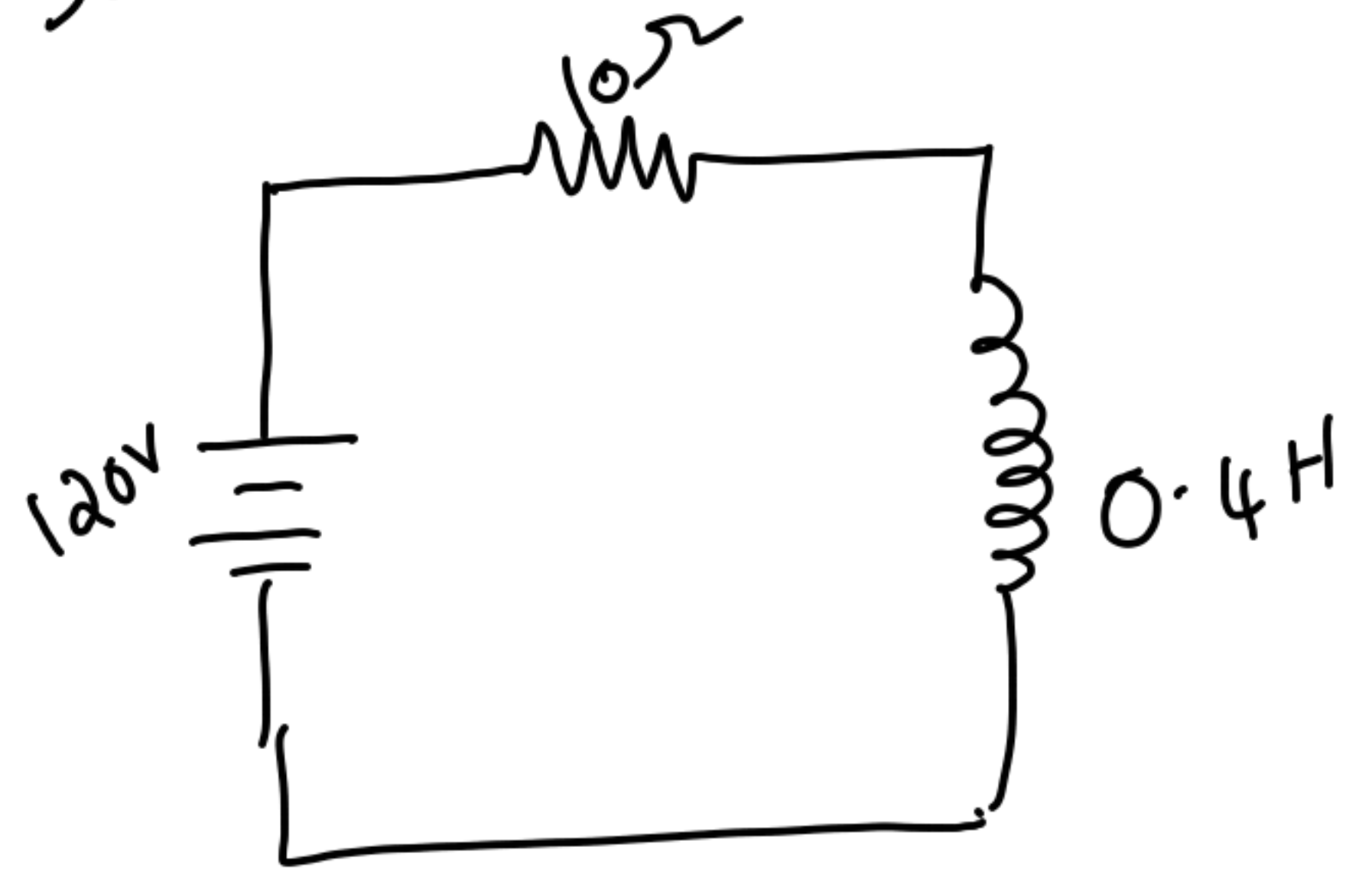


1) A coil of inductance 0.4H and Resistance of 10Ω is connected to a 120V DC Supply. Determine

- a) the final Value of the current
- b) time constant of the circuit
- c) the Value of current after a time equal to the time constant from the instant the supply voltage is connected.

Soln



a) Final Value of current

$$I_0 = \frac{V_s}{R}$$

$$I_0 = \frac{120}{10} = 12\text{A}$$

b) time constant

$$\tau = \frac{L}{R}$$

$$\tau = \frac{0.4}{10}$$

$$\tau = 0.04 \text{ s}$$

c) Find current at $t = \tau$, charging.

$$i = I_0 (1 - e^{-t/\tau})$$

$$i = 12 (1 - e^{-\cancel{t}/\cancel{\tau}})$$

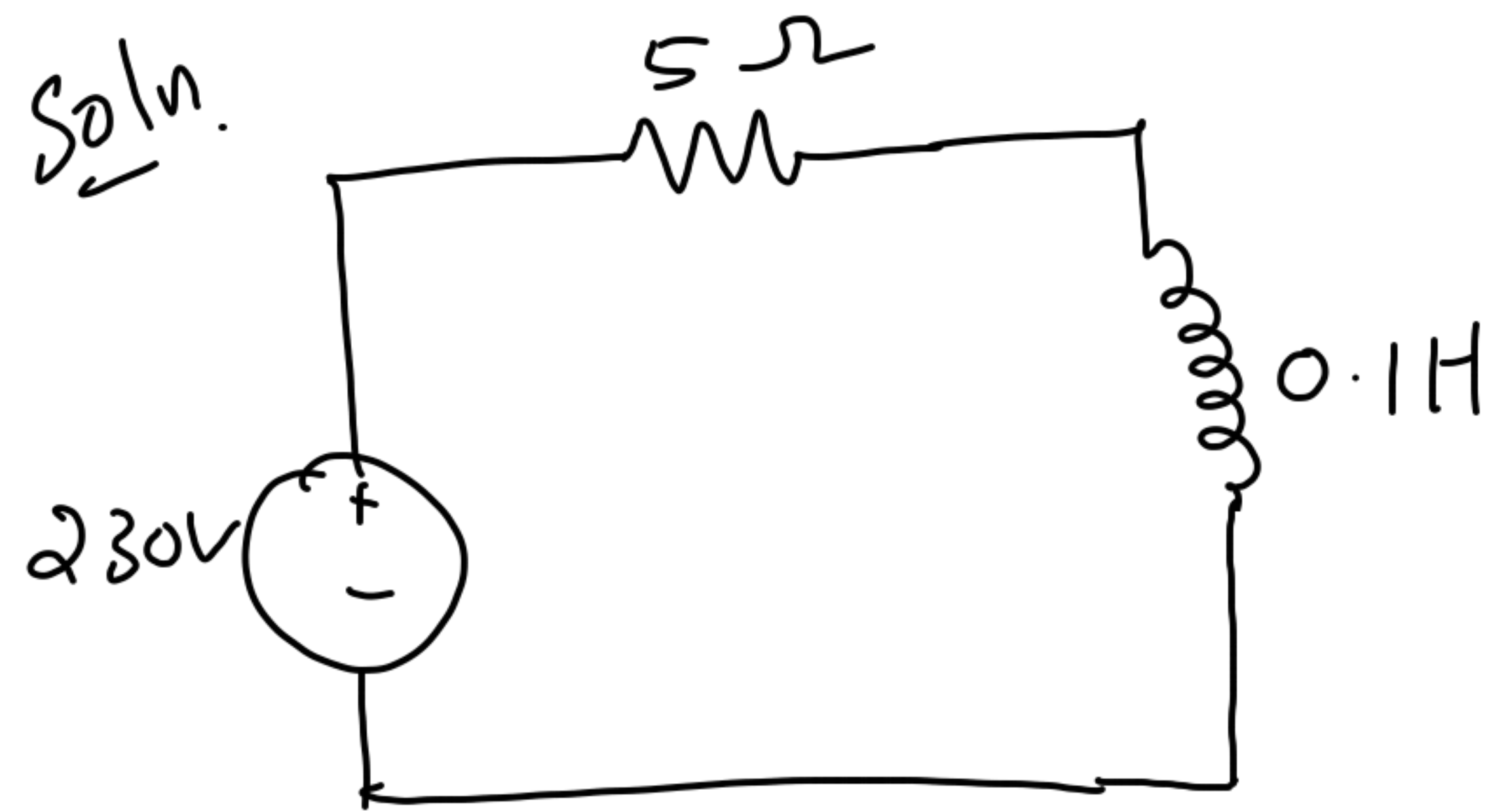
$$i = 12 (1 - e^{-1})$$

$$i = 12 (1 - 0.368)$$

$$i = \underline{\underline{7.58 \text{ A}}}$$

2) A coil of Resistance 5Ω and inductance of $0.1H$ is Switched on to a $230V$ Supply. Calculate the rate of rise of current at $t=0$ and at $t=2\tau$. Also calculate the Steady state Value of the Circuit current.

Soln.



Steady State Value.

$$I_0 = \frac{V_s}{R} = \frac{230}{5} = 46A$$

To calculate Rate of Rise of Current.

$$i = I_0(1 - e^{-t/\tau})$$

$$\text{To find } \tau = \frac{L}{R} = \frac{0.1}{5} = 0.02s$$

$$i = 46(1 - e^{-t/0.02})$$

$$i = 46 - 46 e^{-t/0.02}$$

Differentiate above equation with respect to time.

$$\frac{di}{dt} = 0 - 46 \cdot \left(\frac{-1}{0.02} \right) e^{-t/0.02}$$

$$\left[e^{-tx} = -x e^{-tx} \right]$$

$$x = \frac{1}{0.02}$$

$$\frac{di}{dt} = 2300 e^{-t/0.02} \quad \text{--- ①}$$

When $t = 0$,

$$\frac{di}{dt} = 2300 e^{-0/0.02}$$

$$\frac{di}{dt} = 2300 e^0$$

$$\frac{di}{dt} = 2300 \times 1$$

$$\frac{di}{dt} = 2300 \text{ A/s}$$

When $t = 2\tau$

$$\frac{di}{dt} = 2300 e^{-2\tau/0.02}$$

$$= 2300 e^{-2 \times 0.02/0.02}$$

$$\frac{di}{dt} = 2300 e^{-2}$$

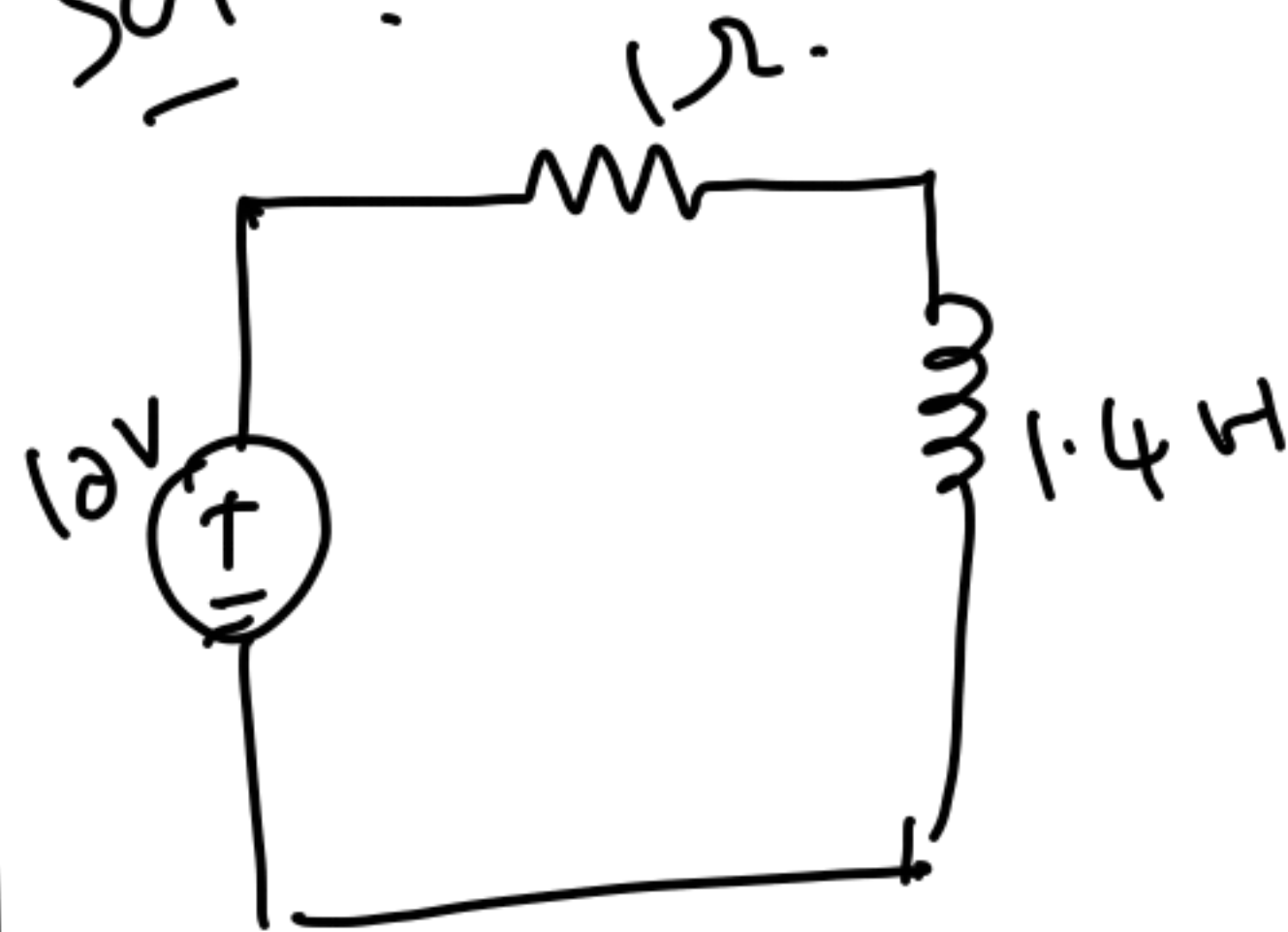
$$= 2300 \times 0.135 = 311.27 \text{ A/s}$$

3) A coil having an inductance of 1.4 H and a Resistance of 1Ω is connected to a 12 V supply through a switch.

a) What will be the value of the current 400 ms after switching on the supply?

b) After the current has reached steady state, the supply is disconnected. How long does it take for the current to drop to half of its steady state value?

Soln.



a) Calculate current, at $t = 400 \text{ ms}$
(Charging)

$$\tau = \frac{L}{R} = \frac{1.4}{1} = 1.4 \text{ s}$$

$$I_0 = \frac{V_s}{R} = \frac{12}{1} = 12 \text{ A}$$

$$i = I_0 (1 - e^{-t/\tau})$$

$$i = 12 \left(1 - e^{-\frac{400 \times 10^{-3}}{1.4}} \right)$$

$$i = 2.98 \text{ A}$$

b) To find t discharge.

$$i = I_0 e^{-t/\tau}$$

$$i = 12 e^{-t/1.4}$$

$$\frac{12}{2} = 12 e^{-t/1.4}$$

$$6 = 12 e^{-t/1.4}$$

$$\frac{6}{12} = e^{-t/1.4}$$

$$0.5 = e^{-t/1.4}$$

Taking natural log on both side.

$$\ln(0.5) = \frac{-t}{1.4}$$

$$-0.69 = \frac{-t}{1.4}$$

$$t = 1.4 \times 0.69$$

$$t = 0.97 \text{ Sec}$$