CHAPTER 3

P3.5*

$$i = C\frac{dv}{dt}$$

$$\frac{dv}{dt} = \frac{i}{C} = \frac{100 \times 10^{-6}}{2000 \times 10^{-6}} = 0.05 \text{ V/s}$$

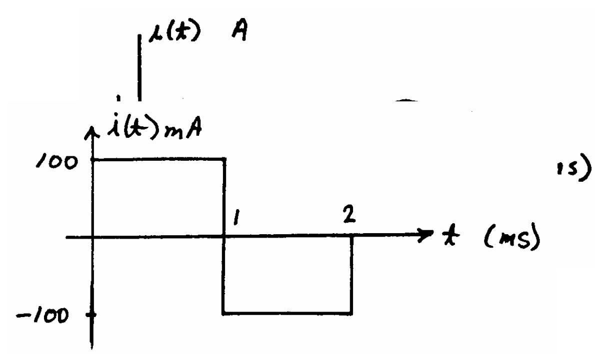
$$\Delta t = \frac{\Delta v}{dv/dt} = \frac{100}{0.05} = 2000 \text{ s}$$

P3.6 $Q = Cv = 5 \times 10^{-6} \times 10^{3} = 5 \text{ mC}$

$$W = \frac{1}{2}Cv^2 = \frac{1}{2} \times 5 \times 10^{-6} \times \left(10^{3}\right)^2 = 2.5 \text{ J}$$

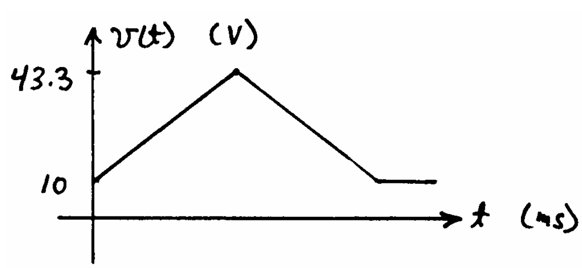
$$P = \frac{\Delta W}{\Delta t} = \frac{2.5}{10^{-6}} = 2.5 \text{ MW}$$

P3.11

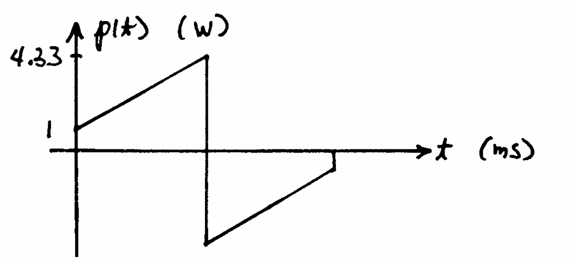


$$v(t) = \frac{1}{C}\int_0^t i(t)dt + v(0)$$

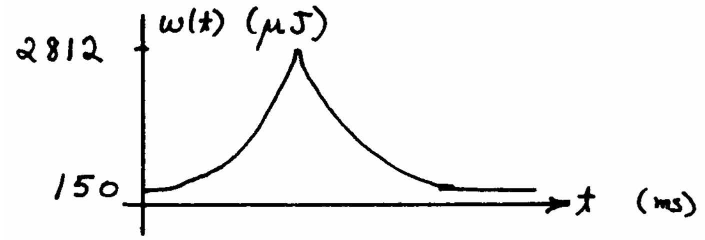
$$v(t) = 0.333 \times 10^{6}\int_0^t i(t)dt + 10$$



$$p(t) = v(t)i(t)$$



$$w(t) = \frac{1}{2}Cv^2(t)$$



$$= 1.5 \times 10^{-6} \times v^2(t)$$

P3.21* (a) $C_{eq} = 1 + \dfrac{1}{1/2 + 1/2} = 2\ \mu\text{F}$

(b) The two 4-μF capacitances are in series and have an equivalent capacitance of $\dfrac{1}{1/4 + 1/4} = 2\ \mu\text{F}$. This combination is a parallel with the 2-μF capacitance, giving an equivalent of 4 μF. Then the 6 μF is in series, giving a capacitance of $\dfrac{1}{1/6 + 1/4} = 2.4\ \mu\text{F}$. Finally, the 3 μF is in parallel, giving an equivalent capacitance of $C_{eq} = 3 + 2.4 = 5.4\ \mu\text{F}$.

P3.25 $C_{eq} = \dfrac{1}{1/C_1 + 1/C_2} = 2/3\ \mu\text{F}$

The charges stored on each capacitor and on the equivalent capacitance are equal.

$$Q = C_{eq} \times 12\ \text{V} = 8\ \mu\text{C}$$

$$v_1 = \frac{Q}{C_1} = 8\ \text{V}$$

$$v_2 = \frac{Q}{C_2} = 4\ \text{V}$$

As a check, we verify that $v_1 + v_2 = 12\ \text{V}$.

P3.30* The charge Q remains constant because the terminals of the capacitor are open-circuited.

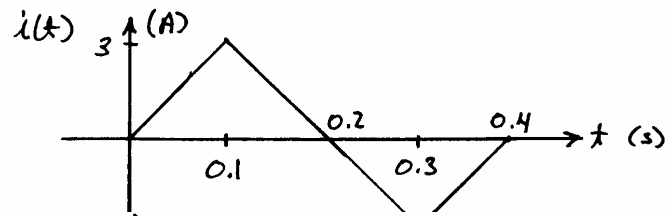
$$Q = C_1 V_1 = 1000 \times 10^{-12} \times 1000 = 1\ \mu\text{C}$$

$$W_1 = (1/2) C_1 (V_1)^2 = 500\ \mu\text{J}$$

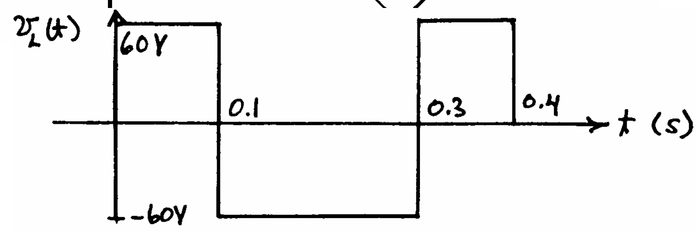
After the distance between the plates is doubled, the capacitance becomes $C_2 = 500\ \text{pF}$.

The voltage increases to $V_2 = \dfrac{Q}{C_2} = \dfrac{10^{-6}}{500 \times 10^{-12}} = 2000\ \text{V}$ and the stored energy is $W_2 = (1/2) C_2 (V_2)^2 = 1000\ \mu\text{J}$. The additional energy is supplied by the force needed to pull the plates apart.

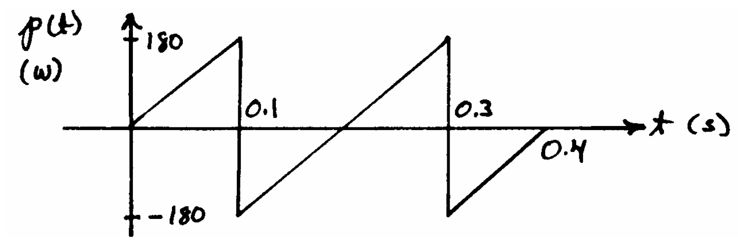
P3.40* $L = 2\,\text{H}$



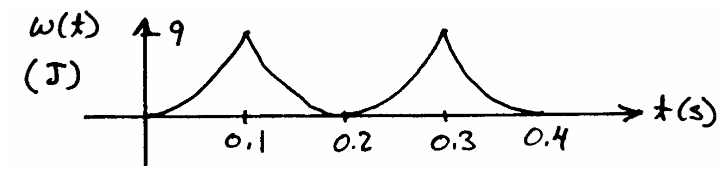
$$v_L(t) = L\frac{di_L(t)}{dt}$$



$$p(t) = v_L(t)i_L(t)$$



$$w(t) = \frac{1}{2}L[i_L(t)]^2$$



P3.48 $i_L(t_0) = \frac{1}{L}\int_0^{t_0} v_L(t)dt + i_L(0)$ $\quad i_L(2) = \frac{1}{3}\int_0^2 5dt + 0 = 3.333\,\text{A}$

$p(2) = v_L(2)i_L(2) = 16.67\ \text{W}$ $\quad w(2) = \frac{1}{2}Li_L^2(2) = 16.67\ \text{J}$

P3.54 (a) The 2 H inductors and 0.5 H inductor have no effect because they are in parallel with a short circuit. Thus, $L_{eq} = 1\,\text{H}$.

(b) The two 2-H inductances in parallel are equivalent to 1 H. Also, the 1 H in parallel with the 3 H inductance is equivalent to 0.75 H. Thus,

$$L_{eq} = 1 + \frac{1}{1/(1+1) + 1/(2+0.75)} = 2.158\,\text{H}.$$

P3.59 (a) $v_R(t) = Ri(t) = 0.1\cos(10^5)$

$$v_L(t) = L\frac{di(t)}{dt} = -100\sin(10^5)$$

$$v(t) = v_R(t) + v_L(t)$$

$$= 0.1\cos(10^5 t) - 100\sin(10^5 t)$$

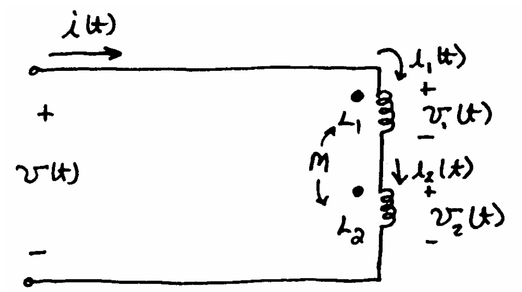
In this case to obtain 1% accuracy, the resistance can be neglected.

(b) For $i(t) = 0.1\cos(10t)$, we have

$$v_R(t) = 0.1\cos(10t)$$
$$v_L(t) = -0.01\sin(10t)$$
$$v(t) = 0.1\cos(10t) - 0.01\sin(10t)$$

Thus in this case, the parasitic resistance cannot be neglected.

P3.64* (a)



As in Figure 3.23a, we can write

$$v_1(t) = L_1\frac{di_1(t)}{dt} + M\frac{di_2(t)}{dt}$$
$$v_2(t) = M\frac{di_1(t)}{dt} + L_2\frac{di_2(t)}{dt}$$

However, for the circuit at hand, we have $i(t) = i_1(t) = i_2(t)$.

Thus,

$$v_1(t) = (L_1 + M)\frac{di(t)}{dt}$$
$$v_2(t) = (L_2 + M)\frac{di(t)}{dt}$$

Also, we have $v(t) = v_1(t) + v_2(t)$.

Substituting, we obtain $v(t) = (L_1 + 2M + L_2)\dfrac{di(t)}{dt}$.

Thus, we can write $v(t) = L_{eq}\dfrac{di(t)}{dt}$, in which

$$L_{eq} = L_1 + 2M + L_2.$$

(b) Similarly, for the dot at the bottom end of L_2, we have

$$L_{eq} = L_1 - 2M + L_2$$