Problem 1:

[a] $v = L\dfrac{di}{dt}$

$$\frac{di}{dt} = 18[t(-10e^{-10t}) + e^{-10t}] = 18e^{-10t}(1 - 10t)$$

$$v = (50 \times 10^{-6})(18)e^{-10t}(1 - 10t)$$

$$= 0.9e^{-10t}(1 - 10t)\,\text{mV}, \quad t > 0$$

[b] $p = vi$

$$v(200\,\text{ms}) = 0.9e^{-2}(1 - 2) = -121.8\,\mu\text{V}$$

$$i(200\,\text{ms}) = 18(0.2)e^{-2} = 487.2\,\text{mA}$$

$$p(200\,\text{ms}) = (-121.8 \times 10^{-6})(487.2 \times 10^{-3}) = -59.34\,\mu\text{W}$$

[c] delivering

[d] $w = \dfrac{1}{2}Li^2 = \dfrac{1}{2}(50 \times 10^{-6})(487.2 \times 10^{-3})^2 = 5.93\,\mu\text{J}$

[e] The energy is a maximum where the current is a maximum:

$$\frac{di_L}{dt} = 18[t(-10)e^{-10t} + e^{-10t}) = 18e^{-10t}(1 - 10t)$$

$$\frac{di_L}{dt} = 0 \quad \text{when} \quad t = 0.1\,\text{s}$$

$$i_{\max} = 18(0.1)e^{-1} = 662.2\,\text{mA}$$

$$w_{\max} = \frac{1}{2}(50 \times 10^{-6})(662.2 \times 10^{-3})^2 = 10.96\,\mu\text{J}$$

Problem 2 :

[a] $$v = \frac{1}{0.5 \times 10^{-6}} \int_0^{500\times10^{-6}} 50 \times 10^{-3} e^{-2000t}\, dt - 20$$

$$= 100 \times 10^3 \frac{e^{-2000t}}{-2000} \Big|_0^{500\times10^{-6}} - 20$$

$$= 50(1 - e^{-1}) - 20 = 11.61\,\text{V}$$

$$w = \tfrac{1}{2}Cv^2 = \tfrac{1}{2}(0.5)(10^{-6})(11.61)^2 = 33.7\,\mu\text{J}$$

[b] $v(\infty) = 50 - 20 = 30\text{V}$

$$w(\infty) = \frac{1}{2}(0.5 \times 10^{-6})(30)^2 = 225\,\mu\text{J}$$

Problem 3:

$5 \| (12 + 8) = 4\,\text{H}$

$4 \| 4 = 2\,\text{H}$

$15 \| (8 + 2) = 6\,\text{H}$

$3 \| 6 = 2\,\text{H}$

$6 + 2 = 8\,\text{H}$

Problem 4:

$$\left(\frac{1}{C+C_{eq}}+\frac{1}{C}\right)^{-1}=C_{eq}$$

Solving this gives the answer

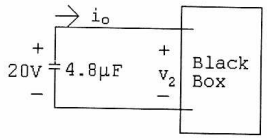
Problem 5:

$C_1 = 10 + 2 = 12\,\mu\text{F}$

$\frac{1}{C_2} = \frac{1}{12\,\mu} + \frac{1}{8\,\mu} \quad \therefore \quad C_2 = 4.8\,\mu\text{F}$

$v_o(0) + v_1(0) = -5 + 25 = 20\,\text{V}$

[a]



$$\begin{aligned} v_2 &= -\frac{1}{4.8\times10^{-6}}\int_0^t 1.92\times10^{-3}e^{-20x}\,dx + 20 \\ &= -400\frac{e^{-20x}}{-20}\Big|_0^t + 20 \\ &= 20(e^{-20t}-1)+20 \\ &= 20e^{-20t}\,\text{V}, \qquad t \geq 0 \end{aligned}$$

[b]
$$\begin{aligned} v_o &= -\frac{1}{8\times10^{-6}}\int_0^t 1.92\times10^{-3}e^{-20x}\,dx - 5 \\ &= -240\frac{e^{-20x}}{-20}\Big|_0^t - 5 \\ &= 12(e^{-20t}-1)-5 \\ &= 12e^{-20t}-17\,\text{V}, \qquad t \geq 0 \end{aligned}$$

[c]
$$\begin{aligned} v_1 &= -\frac{1}{12\times10^{-6}}\int_0^t 1.92\times10^{-3}e^{-20x}\,dx + 25 \\ &= -160\frac{e^{-20x}}{-20}\Big|_0^t + 25 \\ &= 8(e^{-20t}-1)+25 \\ &= 8e^{-20t}+17\,\text{V}, \qquad t \geq 0 \end{aligned}$$

[d]
$$\begin{aligned} i_1 &= -10\times10^{-6}\frac{d}{dt}[8e^{-20t}+17] \\ &= -10\times10^{-6}(-20)8e^{-20t} \\ &= 1.6e^{-20t}\,\text{mA}, \qquad t>0 \end{aligned}$$

[e]
$$\begin{aligned} i_2 &= -2\times10^{-6}\frac{d}{dt}[8e^{-20t}+17] \\ &= -2\times10^{-6}(-20)8e^{-20t} \\ &= 0.32e^{-20t}\,\text{mA}, \qquad t>0 \end{aligned}$$

CHECK: $i_1 + i_2 = 1.92e^{-20t}\,\text{mA} = i_o$

Problem 6:

[a] $v_{ab} = L_1 \frac{d(i_1 - i_2)}{dt} + M\frac{di_2}{dt}$

$$0 = L_1\frac{d(i_2 - i_1)}{dt} - M\frac{di_2}{dt} + M\frac{d(i_1 - i_2)}{dt} + L_2\frac{di_2}{dt}$$

Collecting coefficients of $[di_1/dt]$ and $[di_2/dt]$, the two mesh-current equations become

$$v_{ab} = L_1\frac{di_1}{dt} + (M - L_1)\frac{di_2}{dt}$$

and

$$0 = (M - L_1)\frac{di_1}{dt} + (L_1 + L_2 - 2M)\frac{di_2}{dt}$$

Solving for $[di_1/dt]$ gives

$$\frac{di_1}{dt} = \frac{L_1 + L_2 - 2M}{L_1L_2 - M^2}v_{ab}$$

from which we have

$$v_{ab} = \left(\frac{L_1L_2 - M^2}{L_1 + L_2 - 2M}\right)\left(\frac{di_1}{dt}\right)$$

$$\therefore \quad L_{ab} = \frac{L_1L_2 - M^2}{L_1 + L_2 - 2M}$$

[b] If the magnetic polarity of coil 2 is reversed, the sign of M reverses, therefore

$$L_{ab} = \frac{L_1L_2 - M^2}{L_1 + L_2 + 2M}$$

Problem 7:

Cap of 2 & 3 mf are in series, so their Ceq = 1.2 mf.
Q = CV , so Q = 110X1X 10^{-3} = 0.11 C
Since 1 mf & 1.2 mf are in parallel,
0.11 C = 2.2X10^{-3} V
V = 50 V
Q1 = 50 X 10^{-3} = 0.05 C
Qconn = 0.11 -0.05 = 0.06 C.

Problem 8:

With no finger touching and equal 10 pF capacitors

$$v(t) = \frac{10}{20}(v_s(t)) + 0 = 0.5v_s(t)$$

With a finger touching

Let C_e = equivalent capacitance of person touching lamp

$$C_e = \frac{(10)(100)}{110} = 9.091 \text{ pF}$$

Then $C + C_e = 10 + 9.091 = 19.091$ pF

$$\therefore \quad v(t) = \frac{10}{29.091}v_s = 0.344v_s$$

$$\therefore \quad \Delta v(t) = (0.5 - 0.344)v_s = 0.156v_s$$