SOLUTIONS

6-12) $w(t) = \frac{1}{2} C\left[v_c(t)\right]^2$

$$v_c(t) = 15\cos(2\pi \cdot 1000t)$$
$$v_c(.0005) = 15\cos(2\pi \cdot 0.5)$$
$$= 15\cos(\pi)$$
$$= -15V$$

$$w(0.0005) = \frac{1}{2} \cdot 3.3\mu F \cdot (-15V)^2$$
$$\boxed{w(0.5ms) = 371.25\mu J}$$

$$v_c(0.75ms) = 0V$$
$$\boxed{w(0.75ms) = 0J}$$

$$v_c(1ms) = 15V$$
$$\boxed{w(1ms) = 371.25\mu J}$$

6-28) for inductor: $v_L(t) = L\frac{d}{dt} i_L(t)$

$$i_L(t) = i_L(0) + \frac{1}{L}\int_0^t v_L(x)dx$$
$$i_L(0) = 1mA$$
$$v_L(t) = 50e^{-5000t} mV$$
$$= .05e^{-5000t} V$$
$$= 1mA + \frac{1}{10mH}\int_0^t .05e^{-5000x} V dx$$
$$= 1mA - \frac{.05V}{50{,}000mH}\left[e^{-5000x}\right]_0^t$$
$$= 1mA - \frac{.05V}{50H}\left[e^{-5000t} - 1\right]$$
$$= 1mA - 1mA\left[e^{-5000t} - 1\right]$$
$$\boxed{i_L(t) = 2mA - \left[e^{-5000t}\right]mA}$$

$i_L > 0$ for $t > 0$
$v_L > 0$ for all t

$\therefore$ $p > 0 \Rightarrow$ $\boxed{\text{absorbing power}}$

6-14) (3)
$$i_C(t) = C\frac{d}{dt}V_C(t)$$
$$= 10\,\mu F \cdot \frac{d}{dt}\left[50 - 25e^{-5000t}\right]V$$
$$= 10\,\mu F \cdot \left[125{,}000e^{-5000t}\right]\frac{V}{s}$$

$$\boxed{i_C(t) = 1250e^{-5000t}\ mA}$$

$$p_C(t) = i_C(t)\,V_C(t)$$
$$= 1250e^{-5000t}\,mA \cdot \left[50 - 25e^{-5000t}\right]V$$
$$\boxed{p_C(t) = \left[62.5e^{-5000t} - 31.25e^{-10{,}000t}\right]W}$$

for $t > 0$, $p_C(t) > 0$, $\therefore$ capacitor is $\boxed{\text{absorbing}}$ power

6-20) (4)
$$V_L(t) = L\frac{d}{dt}i_L(t)$$

$L = 2mH$

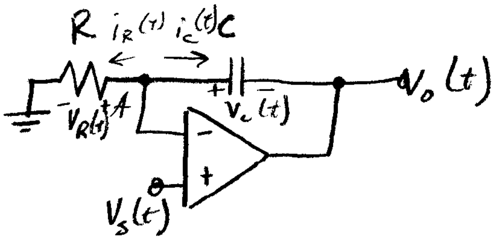
$i_L(t) = \left[100t \cdot e^{-1000t}\right]A$

$$= 2mH\frac{d}{dt}\left[100t \cdot e^{-1000t}\right]A$$

$$= 2mH\left[100e^{-1000t} - 100{,}000te^{-1000t}\right]\frac{A}{S}$$
$$\boxed{V_L(t) = \left[.2e^{-1000t} - 200te^{-1000t}\right]V}$$

t	$i_L(t)$	$V_L(t)$	$P_L(t)$
0.5ms	30.3mA	60.7mV	absorbing
1ms	38.8mA	0V	neither
2ms	27.1mA	-27.1mV	delivering

5) 6-21)



by Op-Amp Constraints

$V_A(t) = V_s(t)$

$i_R(t) = -i_c(t)$ (with KCL)

$i_R(t) = \frac{V_A(t)}{R}$

$$i_R(t) = -i_c(t)$$

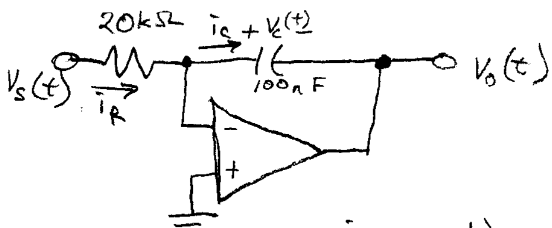
$$-\frac{V_A(t)}{R} = C\frac{d}{dt}\left[V_A(t) - V_o(t)\right]$$

$$-\frac{V_s(t)}{R} = C\frac{d}{dt}V_A(t) - C\frac{d}{dt}V_o(t)$$

$$\frac{d}{dt}V_o(t) = \frac{d}{dt}V_s(t) + \frac{V_s(t)}{RC}$$

$$\boxed{V_o(t) - V_o(0) = V_s(t) - V_s(0) + \frac{1}{RC}\int_0^t V_s(x)\,dx}$$

6) 6-26)



inverting integrator

$$V_o(t) = -\frac{1}{RC}\int_0^t V_s(x)\,dx$$

$$= -\frac{1}{RC}\int_0^t 5\sin(\omega x)\,dx$$

$$= -\frac{5}{\omega RC}\left[-\cos(\omega x)\right]_0^t$$

$$= -\frac{5}{\omega RC}\left[-\cos(\omega t) + 1\right]$$

$$\boxed{V_o(t) = -\frac{2500\,s^{-1}}{\omega}\left[1 - \cos(\omega t)\right]V}$$

$$\frac{5}{RC} = \frac{5}{20k\Omega \cdot 100nF} = \frac{5}{2ms} = 2500\,s^{-1}$$

largest magnitude occurs when $1-\cos(\omega t)$ an an extreme, or where $\cos(\omega t) = -1$

$|V_o(t)|$ must be less than 15V

$$-15V \leq -\frac{2500\,s^{-1}}{\omega}\overbrace{\left[1-(-1)\right]}^{2}V \leq 15V$$

$$-15V\cdot\omega \leq -5000\,s^{-1}V \leq 15V\cdot\omega$$

$$\boxed{\omega \geq 333\ \text{rad/s}} \quad \underbrace{\geq -\omega}_{\text{nonsense, ignore}}$$