1. $i = C\dfrac{dv}{dt}$

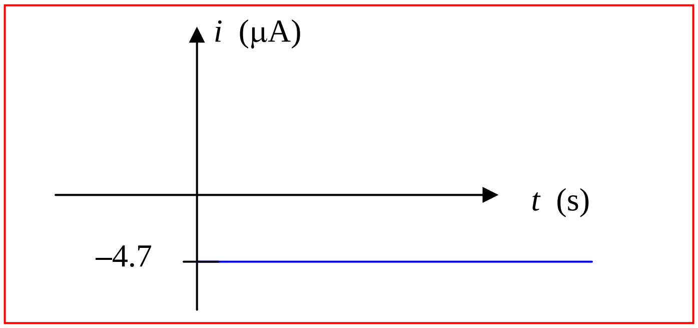
(a) $\boxed{i = 0}$ (DC)

(b) $i = C\dfrac{dv}{dt} = -\left(10\times10^{-6}\right)\left(115\sqrt{2}\right)\left(120\pi\right)\sin 120\pi t = \boxed{-613\sin 120\pi t \text{ mA}}$

(c) $i = C\dfrac{dv}{dt} = -\left(10\times10^{-6}\right)\left(4\times10^{-3}\right)e^{-t} = \boxed{-40e^{-t} \text{ nA}}$

2. $i = C\dfrac{dv}{dt}$

$v = \dfrac{6-0}{0-6}t + 6 = 6 - t$, therefore $i = C\dfrac{dv}{dt} = -4.7\times10^{-6}$ μA



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

(a) $\frac{dv}{dt} = 30\left[e^{-t} - te^{-t}\right]$ therefore $i = 10^{-3}\frac{dv}{dt} = \boxed{30(1-t)e^{-t} \quad \text{mA}}$

(b)

$$\frac{dv}{dt} = 4\left[-5e^{-5t}\sin 100t + 100e^{-5t}\cos 100t\right]$$

therefore $i = 10^{-3}\frac{dv}{dt} = \boxed{4e^{-5t}\left(100\cos 100t - 5\sin 100t\right) \quad \text{mA}}$

4. $W = \frac{1}{2}CV^2$

(a) $\left(\frac{1}{2}\right)\left(2000\times10^{-6}\right)1600 = \boxed{1.6\text{ J}}$

(b) $\left(\frac{1}{2}\right)\left(25\times10^{-3}\right)\left(35\right)^2 = \boxed{15.3\text{ J}}$

(c) $\left(\frac{1}{2}\right)\left(10^{-4}\right)\left(63\right)^2 = \boxed{198\text{ mJ}}$

(d) $\left(\frac{1}{2}\right)\left(2.2\times10^{-3}\right)\left(2500\right) = \boxed{2.75\text{ J}}$

(e) $\left(\frac{1}{2}\right)\left(55\right)\left(2.5\right)^2 = \boxed{171.9\text{ J}}$

(f) $\left(\frac{1}{2}\right)\left(4.8\times10^{-3}\right)\left(50\right)^2 = \boxed{6\text{ J}}$

5. (a) $C = \dfrac{\varepsilon A}{d} = \dfrac{8.854 \times 10^{-12}\left(78.54 \times 10^{-6}\right)}{100 \times 10^{-6}} = \boxed{6.954\, pF}$

(b) $Energy, E = \dfrac{1}{2}CV^2 \;\therefore V = \sqrt{\dfrac{2E}{C}} = \sqrt{\dfrac{2\left(1\times 10^{-3}\right)}{6.954\times 10^{-12}}} = \boxed{16.96 \text{ kV}}$

(c) $E = \dfrac{1}{2}CV^2 \;\therefore C = \dfrac{2E}{V^2} = \dfrac{2\left(2.5 \times 10^{-6}\right)}{\left(100^2\right)} = 500\, pF$

$C = \dfrac{\varepsilon A}{d} \;\therefore \varepsilon = \dfrac{Cd}{A} = \dfrac{\left(500 \times 10^{-12}\right)\left(100 \times 10^{-6}\right)}{\left(78.54 \times 10^{-6}\right)} = 636.62\, pF.m^{-1}$

\Relative permittivity : $\dfrac{\varepsilon}{\varepsilon_0} = \dfrac{636.62\times 10^{-12}}{8.854\times 10^{-12}} = \boxed{71.9}$

6. (a) For $V_A = -1V$, $W = \sqrt{\dfrac{2K_s\varepsilon_0}{qN}(V_{bi} - V_A)} = \sqrt{\dfrac{2(11.8)(8.854\times10^{-12})}{(1.6\times10^{-19})(1\times10^{24})}(0.57+1)}$

$$= 45.281\times10^{-9}\,m$$

$$C_j = \frac{11.8(8.854\times10^{-12})(1\times10^{-12})}{45.281\times10^{-9}} = \boxed{2.307\,fF}$$

(b) For $V_A = -5V$, $W = \sqrt{\dfrac{2K_s\varepsilon_0}{qN}(V_{bi} - V_A)} = \sqrt{\dfrac{2(11.8)(8.854\times10^{-12})}{(1.6\times10^{-19})(1\times10^{24})}(0.57+5)}$

$$= 85.289\times10^{-9}\,m$$

$$C_j = \frac{11.8(8.854\times10^{-12})(1\times10^{-12})}{85.289\times10^{-9}} = \boxed{1.225\,fF}$$

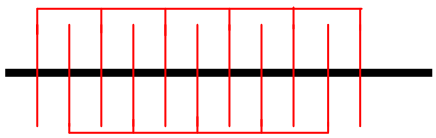
(c) For $V_A = -10V$,

$$W = \sqrt{\frac{2K_s\varepsilon_0}{qN}(V_{bi} - V_A)} = \sqrt{\frac{2(11.8)(8.854\times10^{-12})}{(1.6\times10^{-19})(1\times10^{24})}(0.57+10)}$$

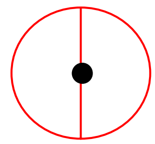
$$= 117.491\times10^{-9}\,m$$

$$C_j = \frac{11.8(8.854\times10^{-12})(1\times10^{-12})}{117.491\times10^{-9}} = \boxed{889.239\,aF}$$

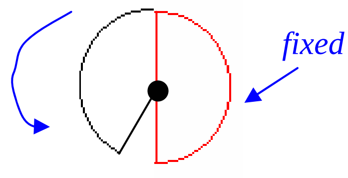
7. We require a capacitor that may be manually varied between 100 and 1000 pF by rotation of a knob. Let's choose an air dielectric for simplicity of construction, and a series of 11 half-plates:



Top view



Side view with no overlap between plates



Side view with a small overlap between plates.

Constructed as shown, the half-plates are in parallel, so that each of the 10 pairs must have a capacitance of 1000/ 10 = 100 pF when rotated such that they overlap completely. If we arbitrarily select an area of 1 cm^2 for each half-plate, then the gap spacing between each plate is $d = \varepsilon A/C = (8.854\times10^{-14}\text{ F/cm})(1\text{ cm}^2)/\ (100\times10^{-12}\text{ F}) = 0.8854$ mm. This is tight, but not impossible to achieve. The final step is to determine the amount of overlap which corresponds to 100 pF for the total capacitor structure. A capacitance of 100 pF is equal to 10% of the capacitance when all of the plate areas are aligned, so we need a pie-shaped wedge having an area of 0.1 cm^2. If the middle figure above corresponds to an angle of 0^o and the case of perfect alignment (maximum capacitance) corresponds to an angle of 180^o, we need to set out minimum angle to be 18^o.

8. (a) Energy stored $= \int_{t_0}^{t} v \cdot C \frac{dv}{dt} = C\int_0^{2\times10^{-3}} 3e^{-\frac{t}{5}} \cdot \left(-\frac{3}{5}e^{-\frac{t}{5}}\right)dt = \boxed{-1.080\mu J}$

(b) $V_{max} = 3$ V

Max. energy at t=0, $= \frac{1}{2}CV^2 = 1.35mJ \therefore 37\% E_{\max} = 499.5\mu J$

V at 37% E_{max} = 1.825 V

$v(t) = 1.825 = 3e^{-\frac{t}{5}} \therefore t = 2.486s \Rightarrow \approx \boxed{2s}$

(c) $i = C\frac{dv}{dt} = 300\times10^{-6}\left(-\frac{3}{5}e^{-\frac{1.2}{5}}\right) = \boxed{-141.593\mu A}$

(d) $P = vi = 2.011\left(-120.658\times10^{-6}\right) = \boxed{-242.6\mu W}$

9. (a) $$v = \frac{1}{C}.\frac{\pi}{2}\left(1\times10^{-3}\right)^2 = \frac{1}{47\times10^{-6}}.\frac{(3.14159)}{2}\left(1\times10^{-3}\right)^2 = \boxed{33.421mV}$$

(b) $$v = \frac{1}{C}.\left(\frac{\pi}{2}\left(1\times10^{-3}\right)^2 + 0\right) = \frac{1}{47\times10^{-6}}.\frac{(3.14159)}{2}\left(1\times10^{-3}\right)^2 = \boxed{33.421mV}$$

(c) $$v = \frac{1}{C}.\left(\frac{\pi}{2}\left(1\times10^{-3}\right)^2 + \frac{\pi}{4}\left(1\times10^{-3}\right)^2\right) = \frac{1}{47\times10^{-6}}.\left(\frac{3\pi}{4}\left(1\times10^{-3}\right)^2\right) = \boxed{50.132mV}$$

10. $$V = \frac{1}{C}\int_0^{200ms} i\,dt = \frac{1}{C}\left[\left(-\frac{7\times10^{-3}}{\pi}\cos\pi t\right)\right]_0^{200ms} = \frac{0.426}{C}$$

$$E = \frac{1}{2}CV^2 = 3\times10^{-6} = \frac{181.086\times10^{-9}}{2C} \therefore C = \frac{181.086\times10^{-9}}{2\left(3\times10^{-6}\right)} = \boxed{30181\mu F}$$

11.

(a) $c = 0.2\mu\text{F},\ v_c = 5 + 3\cos^2 200t\text{V};\ \therefore i_c = 0.2\times 10^{-6}(3)(-2)\,200\sin 200t\cos 200t$

$\therefore i_c = \boxed{-0.12\sin 400t\text{mA}}$

(b) $w_c = \dfrac{1}{2}cv_c^2 = \dfrac{1}{2}\times 2\times 10^{-7}(5+3\cos^2 200t)^2\ \therefore w_{c\max} = 10^{-7}\times 64 = \boxed{6.4\mu\text{J}}$

(c) $v_c = \dfrac{1}{0.2}\times 10^6\int_0^t 8e^{-100t}\times 10^{-3}dt = 10^3\times 40(-0.01)(e^{-100t}-1) = \boxed{400(1-e^{100t})\text{V}}$

(d) $\boxed{v_c = 500 - 400e^{-100t}\ \text{V}}$

12. $v_c(0) = 250\text{V},\ c = 2\text{mF}\ (a)\ v_c(0.1) = 250 + 500\int_0^{0.1} 5dt$

$$\therefore v_c(0.1) = 500\text{V}; v_c(0.2) = 500\int_{0.1}^{0.2} 10dt = 1000\text{V}$$

$$\therefore v_c(0.6) = 1750\text{V}, v_c(0.9) = 2000\text{V}$$

$$\therefore 0.9 < t < 1: v_c = 2000 + 500\int_{0.9}^{t} 10dt = 2000 + 5000(t - 0.9)$$

$$\therefore v_c = 2100 = 2000 + 5000(t_2 - 0.9) \therefore t_2 = 0.92 \therefore \boxed{0.9 < t < 0.92s}$$

13.

(a) $$w_c = \frac{1}{2}\mathrm{C}v^2 = \frac{1}{2}\times 10^{-6} v^2 = 2\times 10^{-2} e^{-1000t} \;\therefore v = \pm 200 e^{-500t}\,\mathrm{V}$$

$$i = \mathrm{C}v' = 10^{-6}(\pm 200)(-500)e^{-500t} = \mp 0.1 e^{-500t}$$

$$\therefore \mathrm{R} = \frac{-v}{i} = \frac{200}{0.1} = \boxed{2k\Omega}$$

(b) $$\mathrm{P}_R = i^2\mathrm{R} = 0.01\times 2000 e^{-1000t} = 20 e^{-1000t}\,\mathrm{W}$$

$$\therefore \mathrm{W_R} = \int_0^\infty 20 e^{-1000t} dt = -0.02 e^{-1000t}\Big|_0^\infty = \boxed{0.02\mathrm{J}}$$

14. (a) Left circuit:

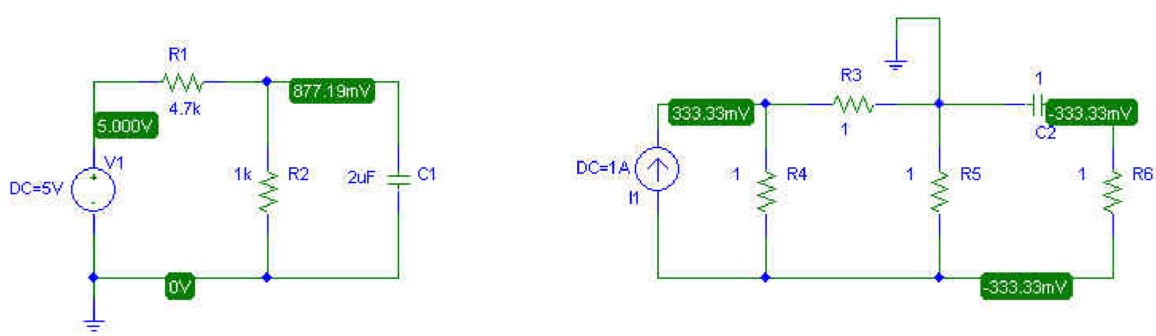
By Voltage division, $V_C = \frac{1k}{4.7k + 1k}(5) = \boxed{0.877V}$

Right circuit:

$V_1 = 1(1 // 2) = \frac{2}{3}V$

By Voltage Division, $V_2 = \frac{1}{3}V \therefore \boxed{V_C = -\frac{1}{3}V}$

(b)



15. $v = L\dfrac{di}{dt}$

(a) $\boxed{v = 0}$ since i = constant (DC)

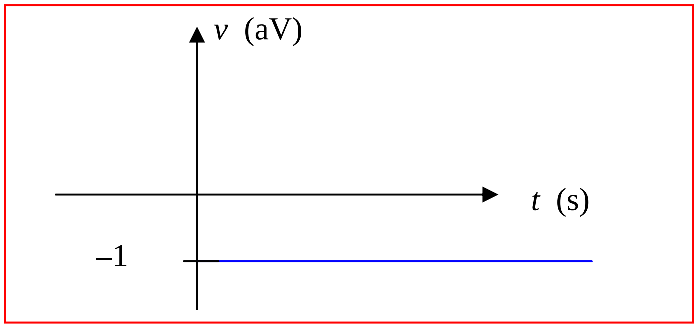
(b) $v = -10^{-8}\left(115\sqrt{2}\right)\left(120\pi\right)\sin 120\pi t = \boxed{-613\sin 120\pi t \quad \mu\text{V}}$

(c) $v = -10^{-8}\left(115\sqrt{2}\right)\left(24\times 10^{-3}\right)e^{-6t} = \boxed{-240e^{-6t} \quad \text{pV}}$

16. $v = L\dfrac{di}{dt}$

$$i = \left[\frac{(6-0)\times 10^{-9}}{(0-6)\times 10^{-3}}\right]t + 6\times 10^{-9} = 6\times 10^{-9} - 10^{-6}t \text{, therefore}$$

$$v = L\frac{di}{dt} = -\left(10^{-12}\right)\left(10^{-6}\right) = -10^{-18}\ \text{V} \ = \ -1\ \text{aV}$$



17. $v = L\dfrac{di}{dt}$

(a) $L\dfrac{di}{dt} = \left(5\times10^{-6}\right)30\times10^{-9}\left[e^{-t} - te^{-t}\right] = \boxed{150\left(1-t\right)e^{-t} \quad \text{fV}}$

(b)

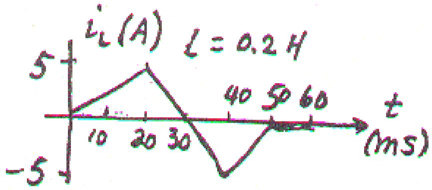
$$L\frac{di}{dt} = \left(5\times10^{-6}\right)\left(4\times10^{-3}\right)\left[-5e^{-5t}\sin 100t + 100e^{-5t}\cos 100t\right]$$

therefore $\boxed{v = \;100e^{-5t}\left(20\cos 100t - \sin 100t\right) \quad \text{pV}}$

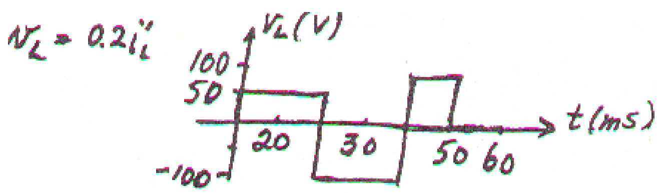
18. $W = \frac{1}{2}LI^2$. Maximum energy corresponds to maximum current flow, so

$$W_{\max} = \frac{1}{2}\left(5\times10^{-3}\right)\left(1.5\right)^2 = \boxed{5.625 \text{ mJ}}$$

19.



(a)



(b) $P_L = v_L i_L \;\therefore\; P_{L\max} = (-100)(-5) = 500\text{W at } t = \boxed{40^- \text{ ms}}$

(c) $P_{L\min} = 100(-5) = -500\text{W at } \boxed{t = 20^+ \text{ and } 40^+ \text{ ms}}$

(d) $W_L = \frac{1}{2} L i_L^2 \;\therefore\; W_L(40\text{ms}) = \frac{1}{2} \times 0.2(-5)^2 = \boxed{2.5\text{J}}$

20.

$$\mathrm{L} = 50\times 10^{-3}, t < 0: \ i = 0; \ t > 0 \ \ i = 80te^{-100t}\,\mathrm{mA} = 0.08te^{-100t}\,\mathrm{A}$$

$$\therefore \mathrm{i}' = 0.08\mathrm{e}^{-100\mathrm{t}} - 8te^{-100t} \ \therefore 0.08 = 8t, \boxed{t_m, = 0.01s}, |i|_{\max} = 0.08\times 0.01e^{-1}$$

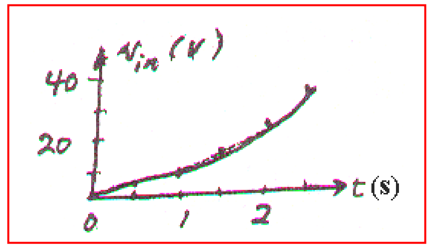
$$\therefore \boxed{|i|_{\max} = 0.2943\mathrm{mA}}; \ v = 0.05i' = e^{-100t}(0.004 - 0.4t)$$

$$\therefore v' = e^{-100t}(-0.4) - 100e^{-100t}(0.004 - 0.4t) \therefore -0.4 = 0.4 - 40t, \ t = \frac{0.8}{40} = 0.02s$$

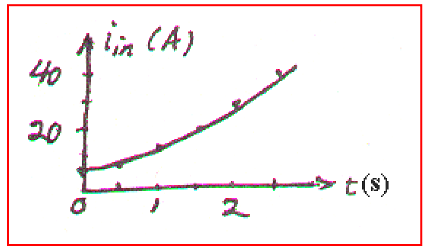
$$v = e^{-2}(0.004 - 0.008) = -0.5413\mathrm{mV} \ \text{ this is minimum} \therefore |v|_{\max} = \boxed{0.004\mathrm{V} \text{ at } \mathrm{t}{=}0}$$

21.

(a) $t>0:\ i_s = 0.4t^2\text{A} \therefore v_{in} = 10i_s + 5i_s' = \boxed{4t^2 + 4t\text{V}}$



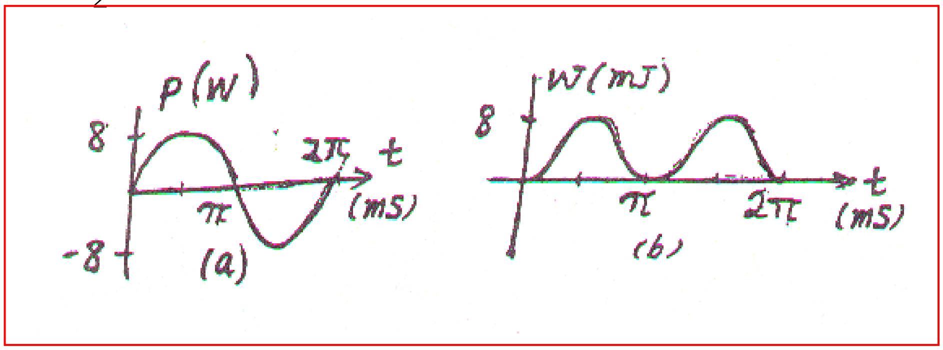
(b) $i_{in'} = 0.1v_s + \frac{1}{5}\int_0^t 40t dt + 5 = \boxed{4t + 4t^2 + 5\text{A}}$



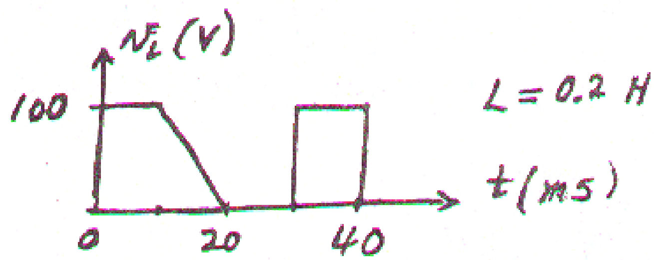
22. $v_L = 20\cos 1000t\text{V},\ \text{L} = 25\text{mH},\ i_L(0) = 0$

(a) $i_L = 40\int_0^t 20\ \cos\ 1000t dt = 0.8\sin\ 1000t\text{A} \therefore \boxed{p = 8\sin 2000t\ \text{W}}$

(b) $w = \frac{1}{2}\times 25\times 10^{-3}\times 0.64\sin^2 1000t = \boxed{8\sin^2 1000t\ \text{mJ}}$



23.



(a) $0 < t < 10\text{ ms}: \; i_L = -2 + 5\int_0^t 100 dt = -2 + 500t \therefore i_L(10\text{ms}) = 3\text{A}, i_L(8\text{ms}) = \boxed{2\text{A}}$

(b) $i_L(0) = 0 \therefore i_L(10\text{ms}) = 500 \times 0.01 = 5\text{A} \therefore i_L(20\text{ms}) = 5 + 5\int_{0.01}^{0.02} 10^4(0.02 - t)dt$

$\therefore i_L(20\text{ms}) = 5 + 5\times 10^4 (0.02t - 0.5t)_{0.01}^{0.02} = 5 + 5\times 10^4(0.0002 - 0.00015) = 7.5\text{A}$

$\therefore w_L = \frac{1}{2} \times 0.2 \times 7.5^2 = \boxed{5.625\text{J}}$

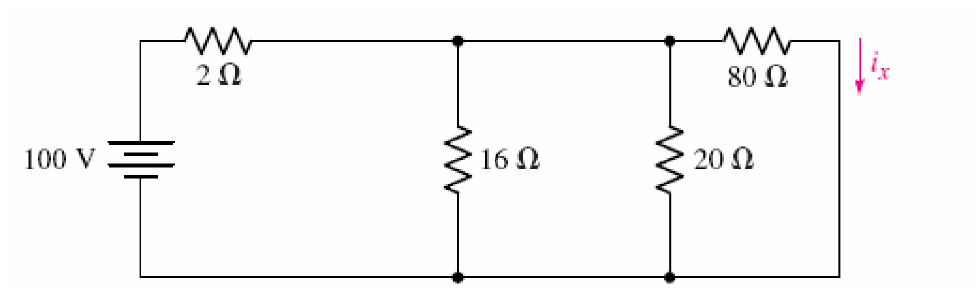
(c) If the circuit has been connected for a long time, L appears like short circuit.

$$V_{8\Omega} = \frac{8}{2+8}(100V) = 80V$$

$$I_{2\Omega} = \frac{20V}{2\Omega} = 10A$$

$$\therefore \boxed{i_x = \frac{80V}{80\Omega} = 1A}$$

24. After a very long time connected only to DC sources, the inductors act as short circuits. The circuit may thus be redrawn as



And we find that $i_x = \left(\dfrac{\frac{80}{9}}{80+\frac{80}{9}}\right)\left(\dfrac{100}{2+8}\right) = \boxed{1\text{ A}}$

25. $\mathrm{L} = 5\mathrm{H}, \mathrm{V}_L = 10(e^{-t} - e^{-2t})\mathrm{V}, i_L(0) = 0.08\mathrm{A}$

(a) $v_L(1) = 10(e^{-1} - e^{-2}) = \boxed{2.325^{+}\,\mathrm{V}}$

(b) $i_L = 0.08 + 0.2\int_0^t 10(e^{-t} - e^{-2t})dt = 0.08 + 2(-e^{-t} + 0.5e^{-2t})_0^t$

$i_L = 0.08 + 2(-e^{-t} + 0.5e^{-2t} + 1 - 0.5) = 1.08 + e^{-2t} - 2e^{-t} \therefore i_L(1) = \boxed{0.4796\mathrm{A}}$

(c) $i_L(\infty) = \boxed{1.08\mathrm{A}}$

26.

(a)

$$v_x = 120 \times \frac{40}{12+20+40} + 40 \times 5 \times \frac{12}{12+20+40}$$

$$= \frac{200}{3} + \frac{100}{3} = \boxed{100\text{V}}$$

(b)

$$v_x = \frac{120}{12+15\|60} \times \frac{15}{15+60} \times 40 + 40 \times 5 \frac{15\|12}{15\|12+60}$$

$$= \frac{120}{12+12} \times \frac{1}{5} \times 40 + 200 \frac{6.667}{66.667}$$

$$= 40 + 20 = \boxed{60\text{V}}$$

27.

(a) $w_L = \frac{1}{2} \times 5 \times 1.6^2 = \boxed{6.4\text{J}}$

(b) $w_c = \frac{1}{2} \times 20 \times 10^{-6} \times 100^2 = \boxed{0.1\text{J}}$

(c) Left to right (magnitudes): 100, 0, 100, 116, 16, 16, 0 (V)

(d) Left to right (magnitudes): 0, 0, 2, 2, 0.4, 1.6, 0 (A)

28.

(a)

$$v_s = 400t^2\text{V}, t > 0;\ i_L(0) = 0.5\text{A};\ t = 0.4s$$

$$v_c = 400 \times 0.16 = 64\text{V}, w_c\ \frac{1}{2} \times 10^{-5} \times 64^2 = \boxed{20.48\text{mJ}}$$

(b) $$i_L = 0.5 + 0.1\int_0^{0.4} 400t^2 dt = 0.5 + 40 \times \frac{1}{3} \times 0.4^3 = 1.3533\text{A}$$

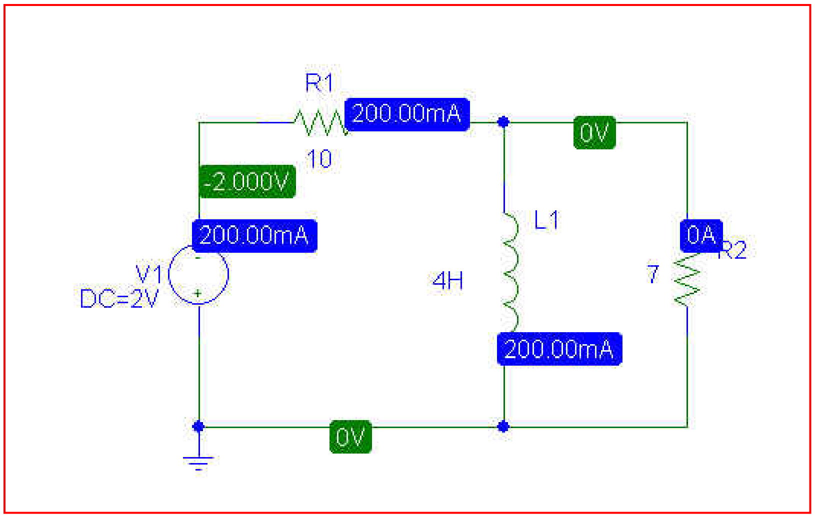
$$\therefore w_L = \frac{1}{2} \times 10 \times 1.3533^2 = \boxed{9.1581\text{J}}$$

(c) $$i_R = 4t^2,\ \text{P}_R = 100 \times 16t^4\ \therefore w_R = \int_0^{0.4} 1600t^4 dt = 320 \times 0.4^5 = \boxed{3.277\text{J}}$$

29. (a) $\boxed{P_{7\Omega} = 0W}; P_{10\Omega} = \frac{V^2}{R} = \frac{(2)^2}{10} = \boxed{0.4W}$

(b) PSpice verification

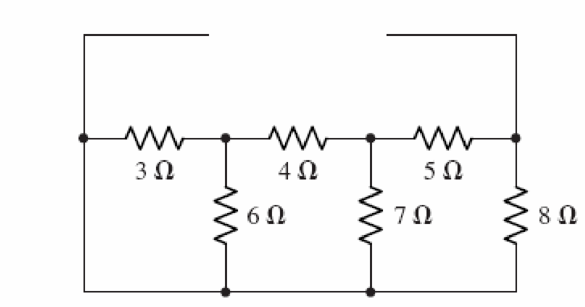
We see from the PSpice simulation that the voltage across the 10-Ω resistor is –2 V, so that it is dissipating 4/10 = 400 mW.



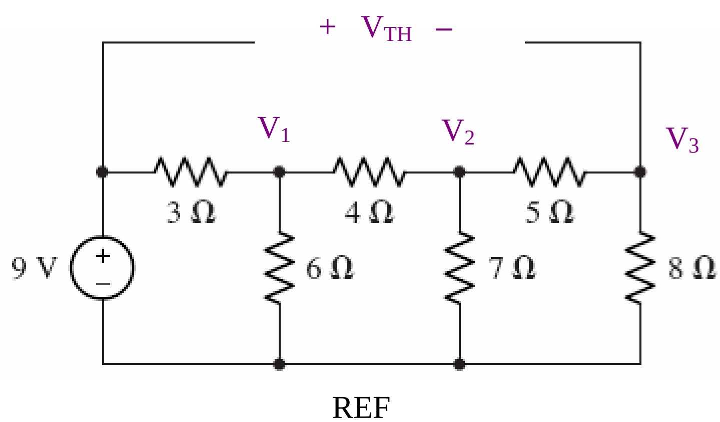
The 7-Ω resistor has zero volts across its terminals, and hence dissipates zero power.

Both results agree with the hand calculations.

30. (a) We find R_{TH} by first short-circuiting the voltage source, removing the inductor, and looking into the open terminals.



Simplifying the network from the right, 3 || 6 + 4 = 6 Ω, which is in parallel with 7 Ω. 6 || 7 + 5 = 8.23 Ω. Thus, R_{TH} = 8.23 || 8 = $\boxed{4.06\ \Omega.}$ To find V_{TH}, we remove the inductor:



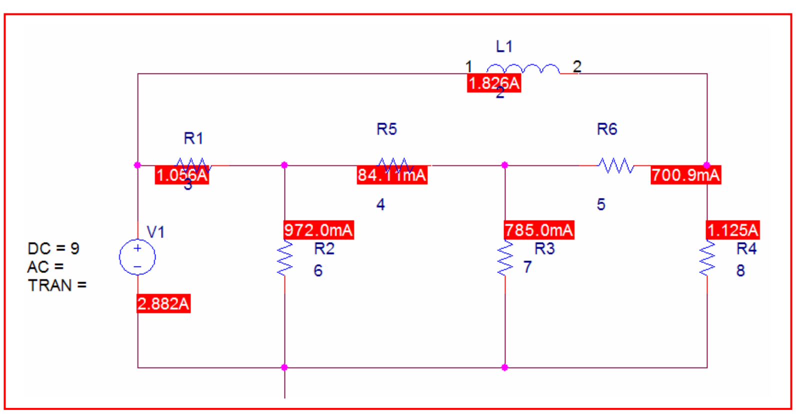
Writing the nodal equations required:

$(V_1 - 9)/3 + V_1/6 + (V_1 - V_2)/4 = 0$
$(V_2 - V_1)/4 + V_2/7 + (V_2 - V_3)/5 = 0$
$V_3/8 + (V_3 - V_2)/5 = 0$

Solving, V_3 = 1.592 V, therefore $V_{TH} = 9 - V_3 = \boxed{7.408\ \text{V.}}$

(b) i_L = 7.408/4.06 = $\boxed{1.825\ \text{A}}$ (inductor acts like a short circuit to DC).

(c)



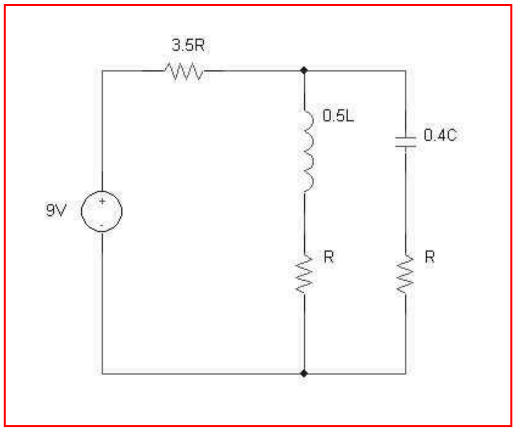
31.

$$C_{equiv} \equiv 10\mu + \left(\frac{1}{\frac{1}{10\mu} + \frac{1}{10\mu}} \right) \text{in series with } 10\mu \text{ in series with } 10\mu + \left(\frac{1}{\frac{1}{10\mu} + \frac{1}{10\mu}} \right)$$

$$\equiv \boxed{4.286\mu F}$$

32. $L_{equiv} \equiv (77p // (77p + 77p)) + 77p + (77p // (77p + 77p)) = \boxed{179.\dot{6}pH}$

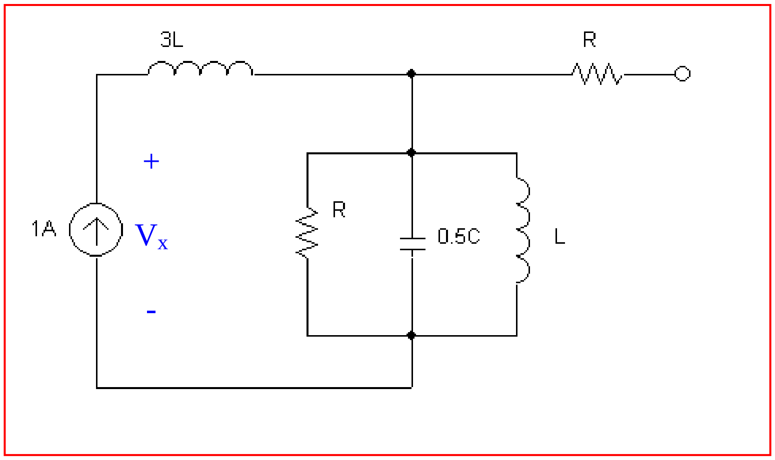
33. (a) Assuming all resistors have value R, all inductors have value L, and all capacitors have value C,



(b) At dc, 20µF is open circuit; 500µH is short circuit.

Using voltage division, $V_x = \dfrac{10k}{10k + 15k}(9) = \boxed{3.6V}$

34. (a) As all resistors have value R, all inductors value L, and all capacitors value C,



(b) $\boxed{V_x = 0 \text{ V}}$ as L is short circuit at dc.

35. C_{equiv} = { [(100 n + 40 n) || 12 n] + 75 n} || {7 μ + (2 μ || 12 μ)}

$$\boxed{C_{equiv} \equiv 85.211nF}$$

36. L_{equiv} = {[(17 p || 4 n) + 77 p] || 12 n} + {1 n || (72 p + 14 p)}

$$\boxed{L_{equiv} \equiv 172.388\, pH}$$

37. $C_T - C_x = (7 + 47 + 1 + 16 + 100) = 171\mu F$

$$E_{C_T - C_x} = \frac{1}{2}(C_T - C_x)V^2 = \frac{1}{2}(171\mu)(2.5)^2 = 534.375\mu J$$

$$E_{C_x} = E_{C_T} - E_{C_T - C_x} = (534.8 - 534.375)\mu J = 425nJ$$

$$\therefore E_{C_x} = 425n = \frac{1}{2}C_x V^2 \Rightarrow C_x = \frac{425n(2)}{(2.5)^2} = \boxed{136nF}$$

38.

(a) For all L = 1.5H, $L_{equiv} = 1.5 + \left(\dfrac{1}{\frac{1}{1.5} + \frac{1}{1.5}} \right) + \left(\dfrac{1}{\frac{1}{1.5} + \frac{1}{1.5} + \frac{1}{1.5}} \right) = \boxed{2.75H}$

(b) For a general network of this type, having N stages (and all L values equiv),

$$\boxed{L_{equiv} = \sum_{N=1}^{n} \frac{L^N}{NL^{N-1}}}$$

39.

(a) $$L_{equiv} = 1 + \left(\frac{1}{\frac{1}{2}+\frac{1}{2}} \right) + \left(\frac{1}{\frac{1}{3}+\frac{1}{3}+\frac{1}{3}} \right) = \boxed{3H}$$

(b) For a network of this type having 3 stages,

$$L_{equiv} = 1 + \frac{1}{\frac{2+2}{(2)^2}} + \frac{1}{\frac{3+3}{(3)^2}+\frac{1}{3}} = 1 + \frac{(2)^2}{2(2)} + \frac{(3)^3}{3(3)^2}$$

Extending for the general case of N stages,

$$L_{equiv} = 1 + \frac{1}{\frac{1}{2}+\frac{1}{2}} + \frac{1}{\frac{1}{3}+\frac{1}{3}+\frac{1}{3}} + \ldots + \frac{1}{\frac{1}{N}+\ldots\frac{1}{N}}$$

$$= 1 + \frac{1}{2(1/2)} + \frac{1}{3(1/3)} + \ldots + \frac{1}{N(1/N)} = \boxed{N}$$

40. $$C_{equiv} = \frac{(3p)(0.25p)}{3p + 0.25p} = \boxed{0.231pF}$$

41. $$L_{equiv} = \frac{(2.\dot{3}n)(0.\dot{3}n)}{2.\dot{6}n} = \boxed{0.291\dot{6}nH}$$

42. (a) $\boxed{\text{Use 2 x 1}\mu\text{H in series with 4 x 1}\mu\text{H in parallel.}}$

(b) $\boxed{\text{Use 2 x 1}\mu\text{H in parallel, in series with 4 x 1}\mu\text{H in parallel.}}$

(c) $\boxed{\text{Use 5 x 1}\mu\text{H in parallel, in series with 4 x 1}\mu\text{H in parallel.}}$

43.

(a) $$\mathrm{R} = 10\Omega : 10 \| 10 \| 10 = \frac{10}{3}, \ \frac{10}{3} + 10 + 10 \| 10 = \frac{55}{3}$$

$$\therefore \mathrm{R}_{eq} = \frac{55}{3} \| 30 = \boxed{11.379\Omega}$$

(b) $$\mathrm{L} = 10\mathrm{H} \ \therefore \mathrm{L}_{eq} = \boxed{11.379\mathrm{H}}$$

(c) $$\mathrm{C} = 10\mathrm{F} : \frac{1}{1/30 + 1/10 + 1/20} = 5.4545$$

$$\therefore \mathrm{C}_{eq} = 5.4545 + \frac{10}{3} = \boxed{8.788\mathrm{F}}$$

44.

(a) $oc: \mathrm{L}_{eq} = 6 \| 1 + 3 = \boxed{3.857\mathrm{H}}$

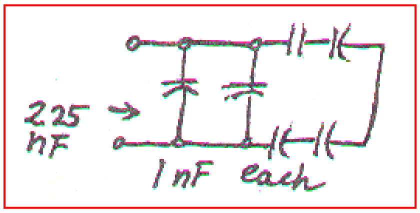
$sc: \mathrm{L}_{eq} = (3\|2+1)\|4 = 2.2| \ |4 = \boxed{1.4194\mathrm{H}}$

(b) $oc: 1 + \dfrac{1}{1/4 + 1/2} = \dfrac{7}{3}, c_{eq} = \dfrac{1}{3/7 + 1/2} = \boxed{1.3125\mathrm{F}}$

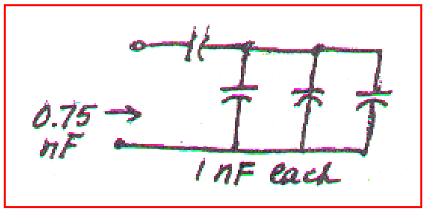
$sc: \dfrac{1}{1/5+1} = \dfrac{5}{6}, \mathrm{C}_{eq} = 4 + \dfrac{5}{6} = \boxed{4.833\mathrm{F}}$

45.

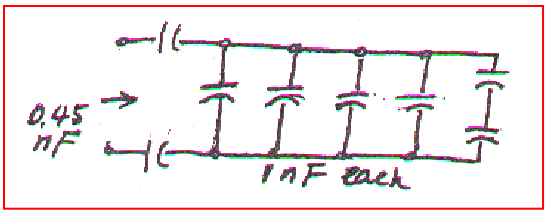
(a)



(b)



(c)



46. $i_s = 60e^{-200t}\text{mA},\ i_1(0) = 20\text{mA}$

(a) $6\|4 = 2.4\text{H} \therefore v = \text{L}_{eq} i_s' = 2.4 \times 0.06(-200)e^{-200t}$

or $\boxed{v = -28.8e^{-200t}\text{V}}$

(b) $i_1 = \frac{1}{6}\int_o^t -28.8e^{-200t}dt + 0.02 = \frac{4.8}{200}(e^{-200t} - 1) + 0.02$

$= \boxed{24e^{-200t} - 4\text{mA}(t > 0)}$

(c) $i_2 = i_s - i_1 = 60e^{-200t} - 24e^{-200t} + 4 = \boxed{36e^{-200t} + 4\text{mA}(t > 0)}$

47. $v_s = 100e^{-80t}V, v_1(0) = 20\text{V}$

(a) $i = C_{eq}v_s' = 0.8\times10^{-6}(-80)100e^{-80t} = \boxed{-6.4\times10^{-3}e^{-80t}\text{A}}$

(b) $v_1 = 10^6(-6.4\times10^{-3})\int_o^t e^{-80t}dt + 20 = \dfrac{6400}{80}(e^{-80t} - 1) + 20$

$\therefore v_1 = \boxed{80e^{-80t} - 60\text{V}}$

(c) $v_2 \dfrac{10^6}{4}(-6.4\times10^{-3})\int_o^t e^{-80t}dt + 80 = \dfrac{1600}{80}(e^{-80t} - 1) + 80$

$= \boxed{20e^{-80t} + 60\text{V}}$

48.

(a)

$$\boxed{\begin{aligned} &\frac{v_c - v_s}{20} + 5\times10^{-6} v_c' + \frac{v_c - v_L}{10} = 0 \\ &\frac{v_L - v_c}{10} + \frac{1}{8\times10^{-3}}\int_o^t v_L \, dt + 2 = 0 \end{aligned}}$$

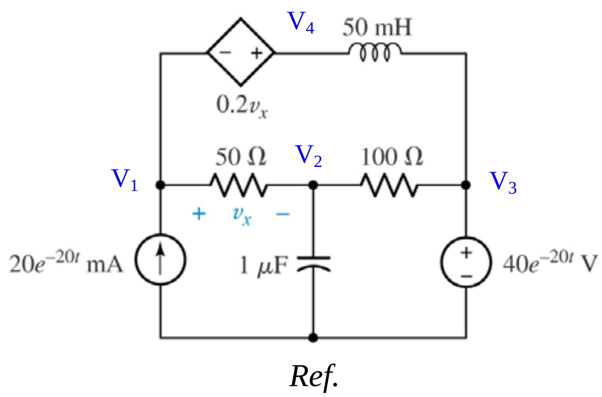
(b)

$$\boxed{\begin{aligned} &20 i_{20} + \frac{1}{5\times10^{-6}}\int_o^t (i_{20} - i_L)\, dt + 12 = v_s \\ &\frac{1}{5\times10^{-6}}\int_o^t (i_L - i_{20})\, dt - 12 + 10 i_L + 8\times10^{-3} i_L' = 0 \end{aligned}}$$

49.

$$v_c(t)\text{: } 30\text{mA: } 0.03\times 20 = 0.6\text{V}, v_c = 0.6\text{V}$$
$$9\text{V: } v_c = 9\text{V}, \; 20\text{mA: } v_c = -0.02\times 20 = 0.4\text{V}$$
$$0.04\cos 10^3 t\text{: } v_c = 0$$
$$\therefore \boxed{v_c(t) = 9.2\text{V}}$$
$$v_L(t)\text{: } 30\text{mA}, 20\text{mA},$$
$$9\text{V: } v_L = 0; \; 0.04\cos 10^3 t\text{: } v_L = -0.06\times 0.04(-1000)\sin 10^3 t = \boxed{2.4\sin 10^3 t\text{V}}$$

50. We begin by selecting the bottom node as the reference and assigning four nodal voltages:



1, 4 Supernode: $$\boxed{20\times10^{-3}\, e^{-20t} = \frac{V_1 - V_2}{50} + 0.02\times10^{3}\int_0^t \left(V_4 - 40e^{-20t}\right)dt'}\quad [1]$$

and: $V_1 - V_4 = 0.2\ V_x$ or $\boxed{0.8V_1 + 0.2\ V_2 - V_4 = 0}$ [2]

Node 2: $$\boxed{0 = \frac{V_2 - V_1}{50} + \frac{V_2 - 40e^{-20t}}{100} + 10^{-6}\frac{dV_2}{dt}}\quad [3]$$

51. (a) $R_i = \infty,\ R_o = 0,\ A = \infty \therefore v_i = 0 \therefore i = Cv_s'$

also $0 + Ri + v_o = 0 \therefore v_o = -RCv_s'$

$-v_i + Ri - Av_i = 0,\ \boxed{v_s = \frac{1}{c}\int idt + v_i}$

(b) $v_o = -Av_i \therefore v_i = \frac{-1}{A}v_o \therefore i = \frac{1+A}{R}v_i$

$$\therefore v_s = \frac{1}{c}\int idt - \frac{1}{A}v_o = -\frac{1}{A}v_o + \frac{1+A}{RC}\int -\frac{v_o}{A}dt$$

$$\therefore Av_s' = -v_o' - \frac{1+A}{RC}v_o \text{ or } \boxed{v_o' + \frac{1+A}{RC}v_o + Av_s' = 0}$$

52. Place a current source in parallel with a 1-MΩ resistor on the positive input of a buffer with output voltage, *v*. This feeds into an integrator stage with input resistor, R_2, of 1-MΩ and feedback capacitor, C_f, of 1 μF.

$$i = C_f \frac{dv_{c_f}}{dt} = 1.602 \times 10^{-19} \times \frac{ions}{\sec}$$

$$0 = \frac{V_a - V}{1 \times 10^6} + C_f \frac{dv_{c_f}}{dt} = \frac{V_a - V}{1 \times 10^6} + 1.602 \times 10^{-19} \frac{ions}{\sec}$$

$$0 = \frac{-V}{R_2} + C_f \frac{dv_{c_f}}{dt} = \frac{-V}{1 \times 10^6} + 1.602 \times 10^{-19} \frac{ions}{\sec}$$

Integrating current with respect to t, $\frac{1}{R_2}\int_0^t v dt' = C_f \left(V_{c_f} - V_{c_f}(0)\right)$

$$\frac{1.602 \times 10^{-19} \times ions}{R_2} = C_f V_{c_f}$$

$$V_{c_f} = V_a - V_{out} \Rightarrow V_{out} = \frac{-R_1}{R_2 C_f} \times 1.602 \times 10^{-19} \times ions \Rightarrow V_{out} = \frac{-1}{C_f} \times 1.602 \times 10^{-19} \times ions$$

R_1 = 1 MΩ, C_f = 1μF

53. $\mathrm{R} = 0.5\mathrm{M}\Omega,\ \mathrm{C} = 2\mu\mathrm{F},\ \mathrm{R}_i = \infty,\ \mathrm{R}_o = 0,\ v_o = \cos 10t - 1\mathrm{V}$

(a) Eq. (16) is: $\left(1+\frac{1}{\mathrm{A}}\right)v_o = -\frac{1}{\mathrm{RC}}\int_o^t\left(v_s + \frac{v_o}{\mathrm{A}}\right)dt - v_c(0)$

$\therefore \left(1+\frac{1}{\mathrm{A}}\right)v_o' = -\frac{1}{\mathrm{RC}}\left(v_s + \frac{v_o}{\mathrm{A}}\right) \therefore \left(1+\frac{1}{\mathrm{A}}\right)(-10\sin 10t) = -1\left(v_s + \frac{1}{\mathrm{A}}\cos 10t - \frac{1}{\mathrm{A}}\right)$

$\therefore v_s = \left(1+\frac{1}{\mathrm{A}}\right)10\sin 10t + \frac{1}{\mathrm{A}} - \frac{1}{\mathrm{A}}\cos 10t$ Let $\mathrm{A} = 2000$

$\therefore \boxed{v_s = 10.005\sin 10t + 0.0005 - 0.0005\cos 10t}$

(b) Let $\mathrm{A} = \infty \therefore v_s = \boxed{10\sin 10t\mathrm{V}}$

54. Create a op-amp based differentiator using an ideal op amp with input capacitor C_1 and feedback resistor R_f followed by inverter stage with unity gain.

$$V_{out} = +\frac{R}{R} R_f C_1 \frac{dvs}{dt} = 60 \times \frac{1mV}{rpm} / \min$$

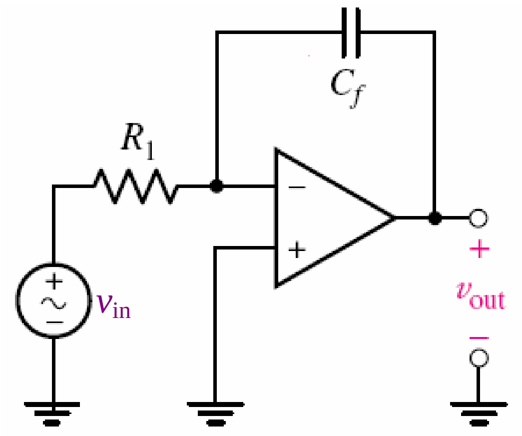
$R_f C_1$=60 so choose R_f = 6 MΩ and C_1 = 10 μF.

55. (a) $$0 = \frac{1}{L}\int v dt + \frac{V_a - V_{out}}{R_f}$$

$$V_a = V = 0, \therefore \frac{1}{L}\int v_L dt = \frac{V_{out}}{R_f} \Rightarrow \boxed{V_{out} = \frac{-R_f}{L}\int_0^t v_s dt'}$$

(b) In practice, capacitors are usually used as capacitor values are more readily available than inductor values.

56. One possible solution:



$$v_{out} = -\frac{1}{R_1 C_f}\int v_{in}\,dt$$

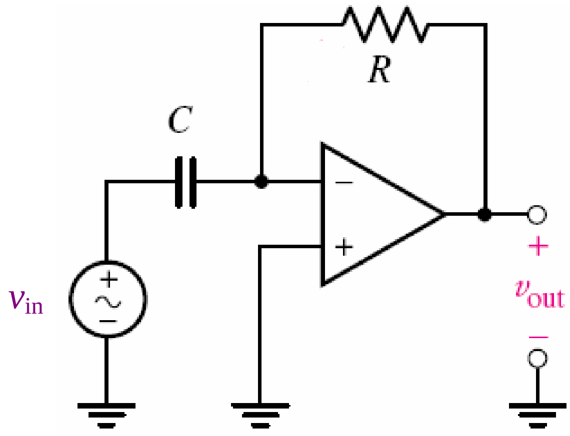
we want $v_{out} = 1$ V for $v_{in} = 1$ mV over 1 s.

In other words, $1 = -\frac{1}{R_1 C_f}\int_0^1 10^{-3}\,dt = -\frac{10^{-3}}{R_1 C_f}$

Neglecting the sign (we can reverse terminals of output connection if needed), we therefore need $R_1C_f = 10^{-3}$.

$\boxed{\text{Arbitrarily selecting } C_f = 1\ \mu\text{F, we find } R_1 = 1\ \text{k}\Omega.}$

57. One possible solution of many:



$$v_{out} = -RC\frac{dv_{in}}{dt}$$

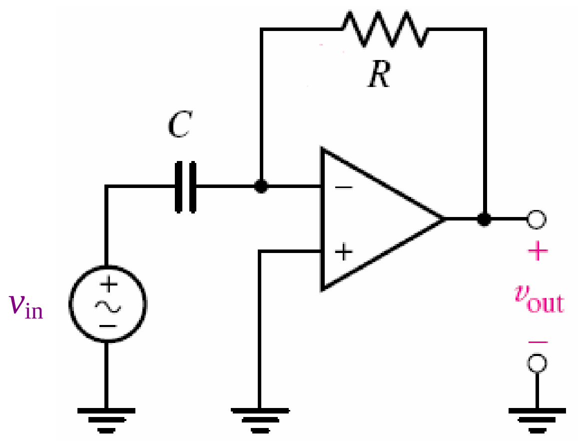
$$\text{maximum}\left(\frac{dv_{in}}{dt}\right) = \frac{100\text{ mV}}{60\text{s}}.$$

In other words, $|v_{out}| = 1\text{ V} = RC\left(\frac{100\text{ mV}}{60\text{s}}\right)$

$$or\ RC = 600$$

Arbitrarily selecting $\boxed{\text{C = 1000 µF, we find that R = 600 kΩ.}}$

58. One possible solution of many:



$$v_{out} = -RC\frac{dv_{in}}{dt}$$

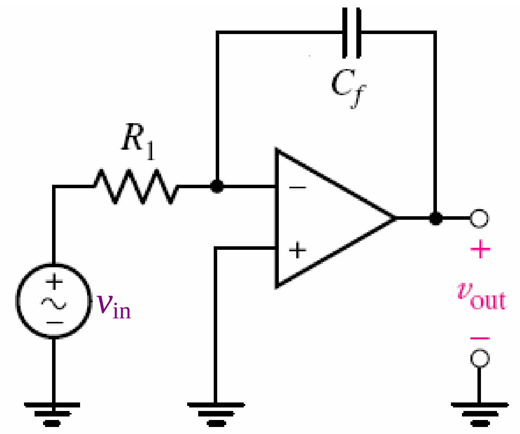
At 1 litre/s, $\left(\frac{dv_{in}}{dt}\right) = \frac{100\text{ mV}}{\text{s}}$.

In other words, $|v_{out}| = 1\text{ V} = RC\left(\frac{100\text{ mV}}{1\text{s}}\right)$

$or\ RC = 10$

Arbitrarily selecting $\boxed{\text{C} = 10\ \mu\text{F, we find that R} = 1\text{ M}\Omega.}$

59. One possible solution:



The power into a 1 Ω load is I^2, therefore energy = W = $I^2\Delta t$.

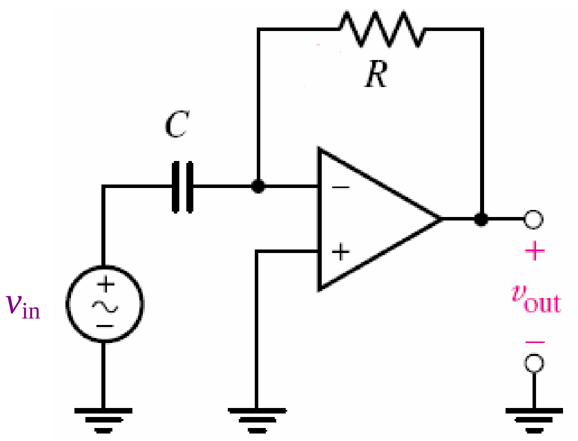
$$|v_{out}| = \frac{1}{R_1 C_f}\int I^2 dt$$

we want $v_{out} = 1$ mV for $v_{in} = 1$ mV (corresponding to 1 A^2).

Thus, $10^{-3} = RC\left(10^{-3}\right)$, so $RC = 1$

Arbitrarily selecting C = 1 μF, we find that we need R = 1 MΩ.

60. One possible solution of many:



$$v_{out} = -RC\frac{dv_{in}}{dt}$$

Input: 1 mV = 1 mph, 1 mile = 1609 metres.
Thus, on the input side, we see 1 mV corresponding to 1609/3600 m/s.

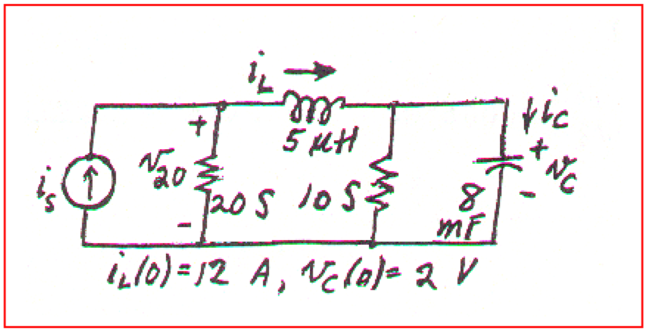
Output: 1 mV per m/s^2. Therefore,

$$|v_{out}| = 2.237RC = 1$$
$$so \;\; RC = 0.447$$

Arbitrarily selecting C = 1 μF, we find that R = 447 kΩ.

61.

(a)



(b)

$$20v_{20} + \frac{1}{5\times10^{-6}}\int_o^t (v_{20} - v_c)dt + 12 = i_s$$

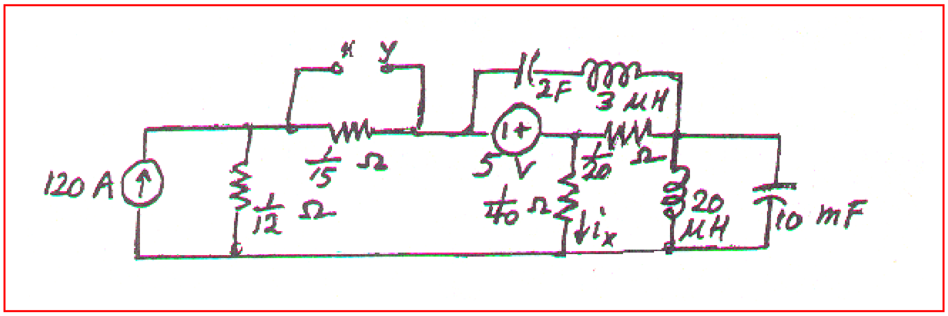
$$\frac{1}{5\times10^{-6}}\int_o^t (v_c - v_{20})dt - 12 + 10v_c + 8\times10^{-3}v_c' = 0$$

(c)

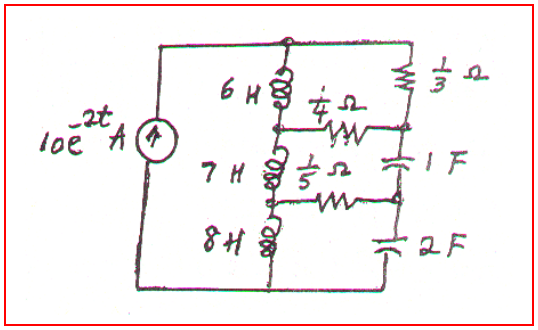
$$\frac{i_L - i_s}{20} + 5\times10^{-6}\, i_L' + \frac{i_L - i_c}{10} = 0$$

$$\frac{i_c - i_L}{10} + \frac{1}{8\times10^{-3}}\int_o^t i_c dt + 2 = 0$$

62.

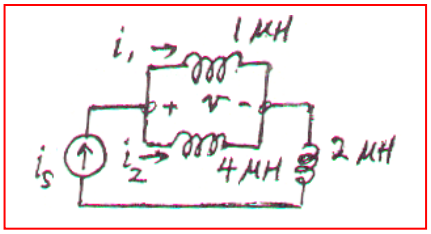


63.



64.

(a)



(b) "Let $i_s = 100e^{-80t}$ A and $i_1(0) = 20$ A in the circuit of (new) Fig. 7.62.

(a) Determine $v(t)$ for all t.
(b) Find $i_1(t)$ for $t \geq 0$.
(c) Find $v_2(t)$ for $t \geq 0$."

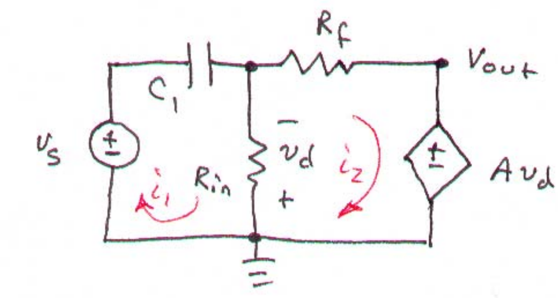
(c) (a) $\mathrm{L}_{eq} = 1 \| 4 = 0.8\mu\mathrm{H} \therefore v(t) = \mathrm{L}_{eq}\, i_s' = 0.8 \times 10^{-6} \times 100(-80)r^{-80t}\mathrm{V}$

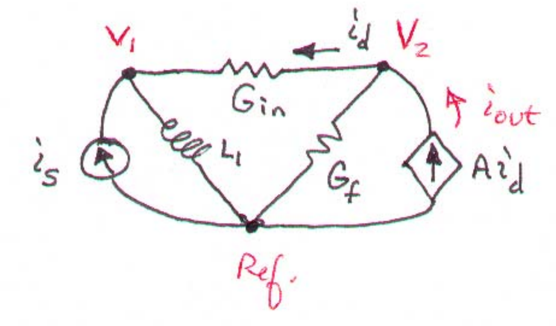
$\therefore \mathrm{v(t)} = \boxed{-6.43^{-80\mathrm{t}}\mathrm{mV}}$

(b) $i_1(t) = 10^6 \int_o^t -6.4 \times 10^{-3} e^{-80t} dt + 20 \therefore i_1(t) = \dfrac{6400}{80}(e^{-80t} - 1) = \boxed{80e^{-80t} - 60\mathrm{A}}$

(c) $i_2(t) = i_s - i_1(t) \therefore i_2(t) = \boxed{20e^{-80t} + 60\mathrm{A}}$

65.





In creating the dual of the original circuit, we have lost both v_s and v_{out}. However, we may write the dual of the original transfer function: i_{out}/ i_s. Performing nodal analysis,

$$i_S = \frac{1}{L_1}\int_0^t V_1 dt' + G_{in}(V_1 - V_2) \qquad [1]$$

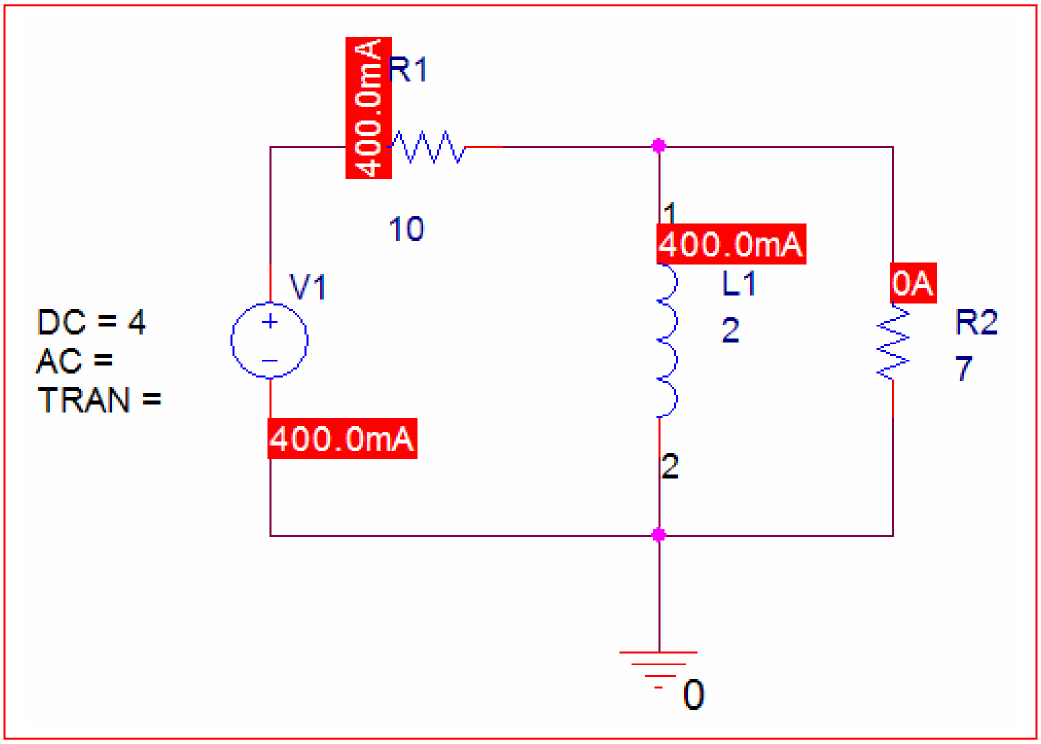
$$i_{out} = Ai_d = G_f V_2 + G_{in}(V_2 - V_1) \qquad [2]$$

Dividing, we find that

$$\boxed{\frac{i_{out}}{i_S} = \frac{G_{in}(V_2 - V_1) + G_f V_2}{\frac{1}{L_1}\int_0^t V_1 dt' + G_{in}(V_1 - V_2)}}$$

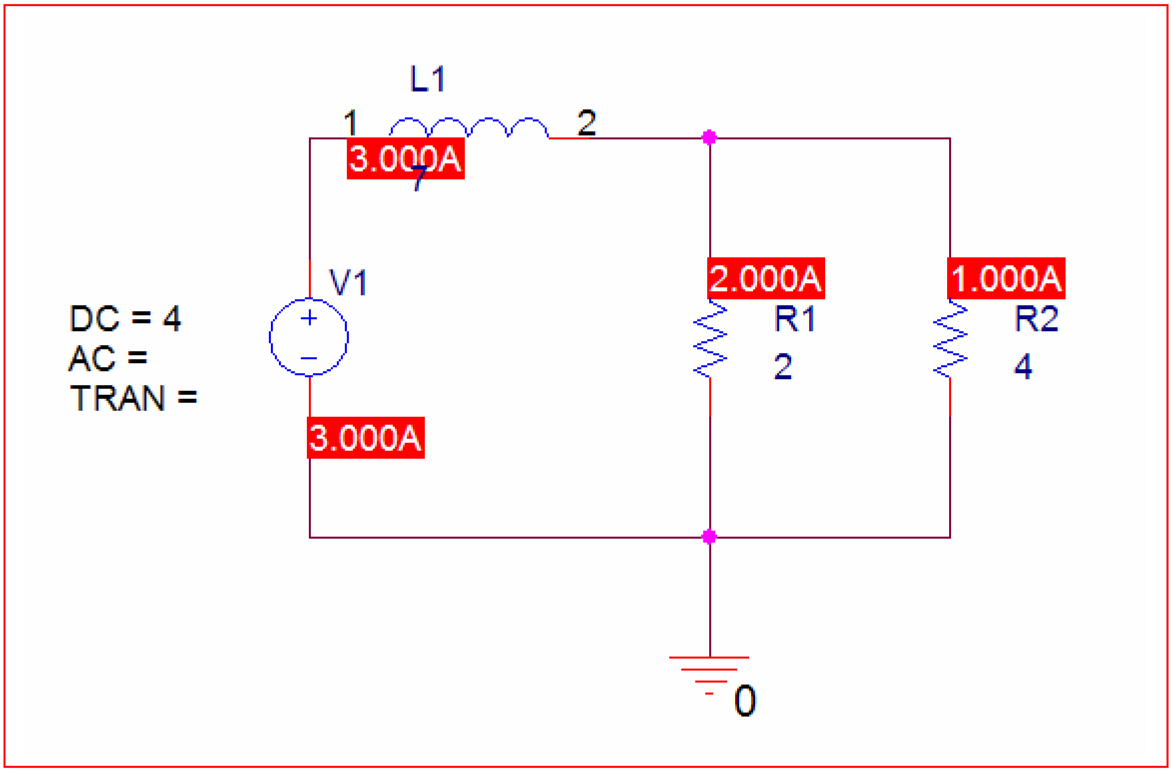
66. I_L = 4/10 = 400 mA. $W = \frac{1}{2} L I_L^2 = \boxed{160 \text{ mJ}}$

PSpice verification:



67. $I_L = 4/(4/3) = 3$ A. $W = \frac{1}{2}LI_L^2 = \boxed{31.5 \text{ J}}$

PSpice verification:



68. We choose the bottom node as the reference node, and label the nodal voltage at the top of the dependent source V_A.

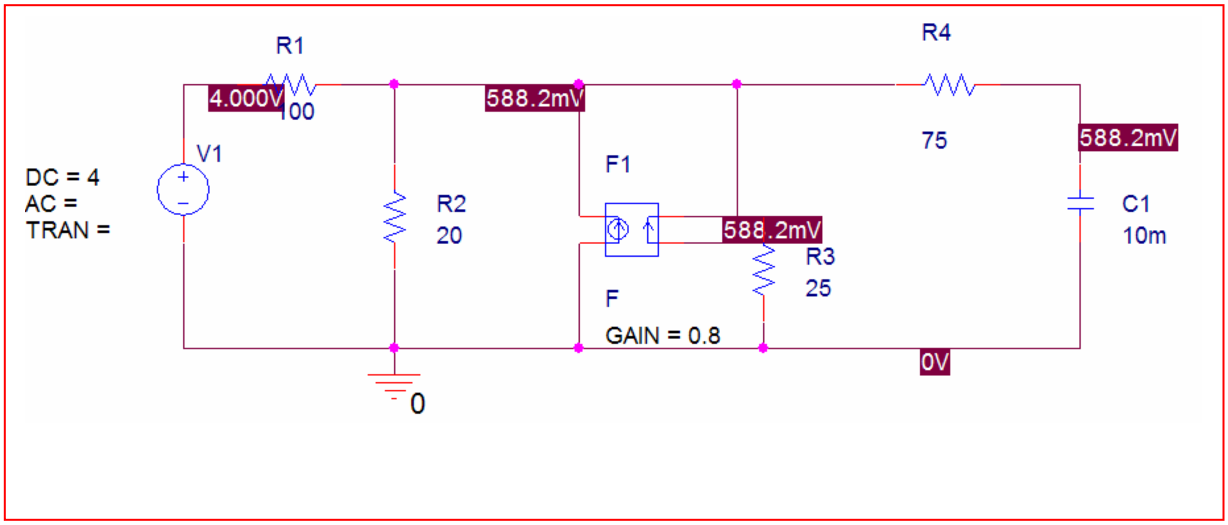
Then, by KCL,

$$\frac{V_A - 4}{100} + \frac{V_A}{20} + \frac{V_A}{25} = 0.8\frac{V_A}{25}$$

Solving, we find that V_A = 588 mV.

Therefore, V_C, the voltage on the capacitor, is 588 mV (no DC current can flow through the 75 Ω resistor due to the presence of the capacitor.)

Hence, the energy stored in the capacitor is $\frac{1}{2}CV^2 = \frac{1}{2}\left(10^{-3}\right)\left(0.588\right)^2 = \boxed{173\ \mu\text{J}}$

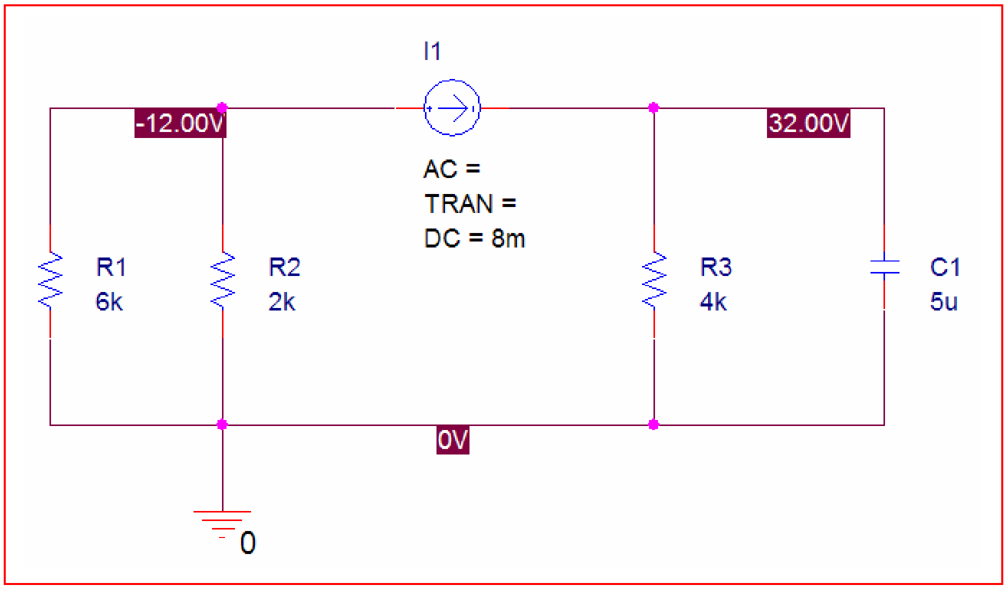


69. By inspection, noting that the capacitor is acting as an open circuit,

the current through the 4 kΩ resistor is 8 mA. Thus, Vc = (8)(4) = 32 V.

Hence, the energy stored in the capacitor = $\frac{1}{2}CV^2 = \frac{1}{2}\left(5\times10^{-6}\right)\left(32\right)^2 = \boxed{2.56\text{ mJ}}$

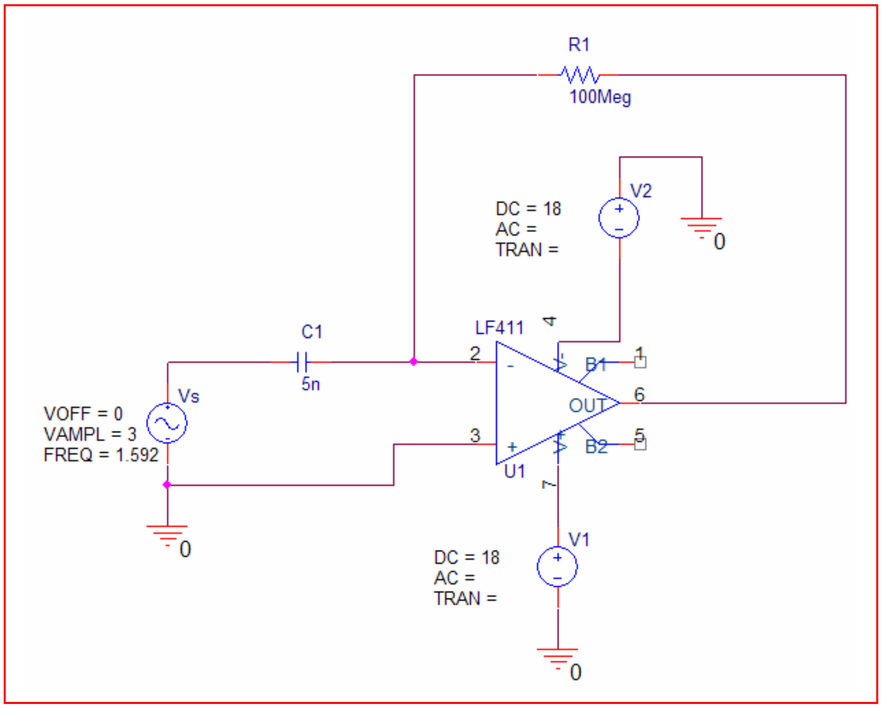
PSpice verification:

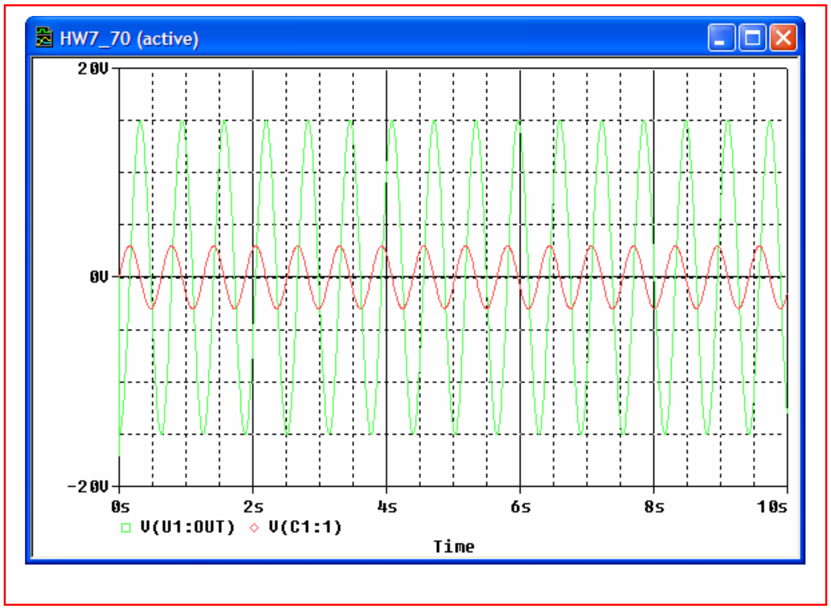


70. $C_1 = 5$ nF, $R_f = 100$ MΩ.

$$v_{out} = -R_f C_1 \frac{dv_s}{dt} = -\left(5\times10^{-9}\right)\left(10^{8}\right)\left(30\cos100t\right) = \boxed{-15\cos10t \text{ V}}$$

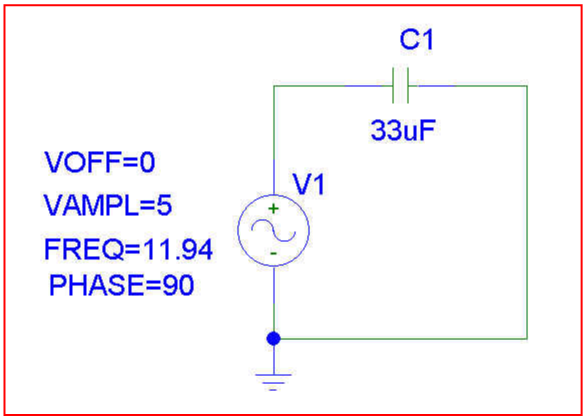
Verifying with PSpice, choosing the LF411 and ±18 V supplies:

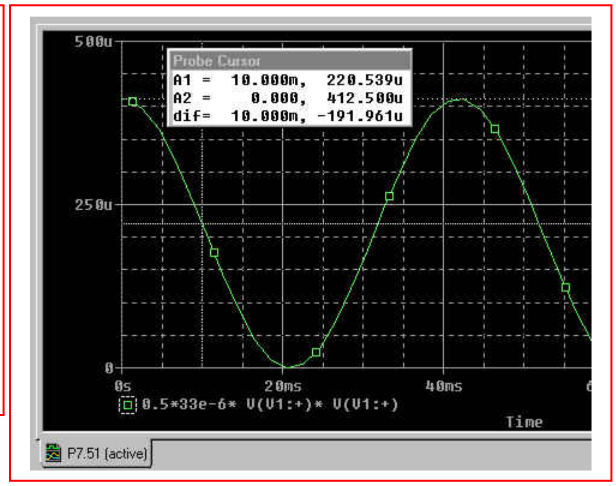




71. PSpice verification

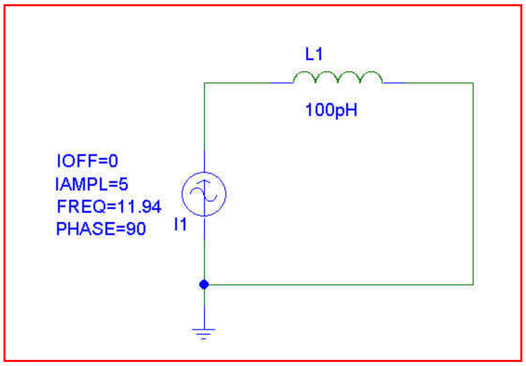
$w = \frac{1}{2} Cv^2 = 0.5\,(33\times10^{-6})[5 \cos(75\times10^{-2})]^2 = 220.8\ \mu\text{J}$. This is in agreement with the PSpice simulation results shown below.

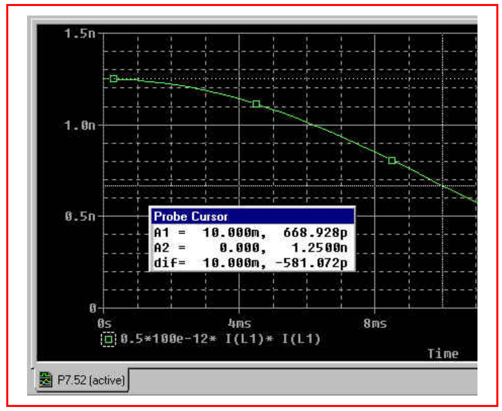




72. PSpice verification

$w = \frac{1}{2} Li^2 = 0.5\,(100\times10^{-12})[5\cos(75\times10^{-2})]^2 = 669.2$ pJ. This is in agreement with the PSpice simulation results shown below.





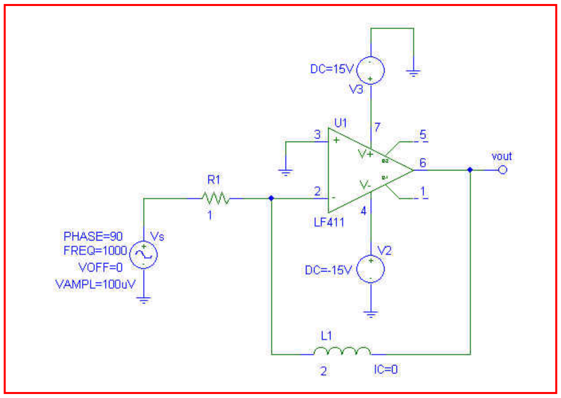
73. $$0 = \frac{V_a - V_s}{R_1} + \frac{1}{L}\int v_{L_f}\,dt$$

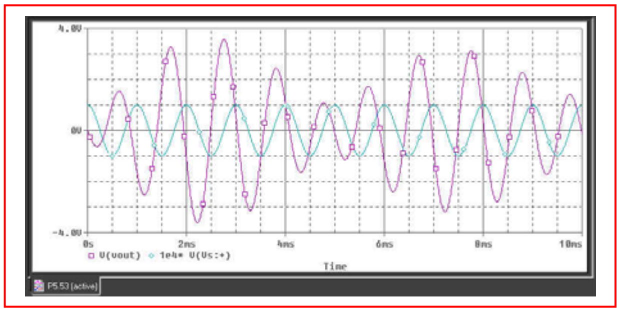
$$V_a = V_b = 0, \qquad 0 = \frac{-V_s}{R_1} + \frac{1}{L}\int v_{L_f}\,dt$$

$$V_{L_f} = V_a - V_{out} = 0 - V_{out} = \frac{L}{R_1}\frac{dVs}{dt}$$

$$V_{out} = -\frac{L_f}{R_1}\frac{dVs}{dt} = -\frac{L_f}{R_1}\frac{d}{dt}\left(A\cos 2\pi 10^3 t\right) \Rightarrow L_f = 2R_1; \boxed{Let\_\text{R = 1 }\Omega\text{ and L = 1 H.}}$$

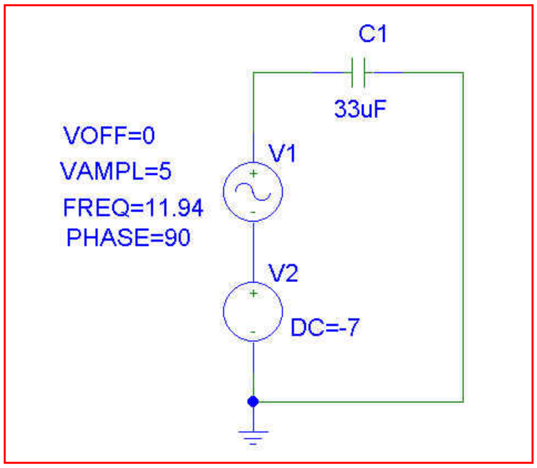
PSpice Verification: clearly, something rather odd is occuring in the simulation of this particular circuit, since the output is not a pure sinusoid, but a combination of several sinusoids.

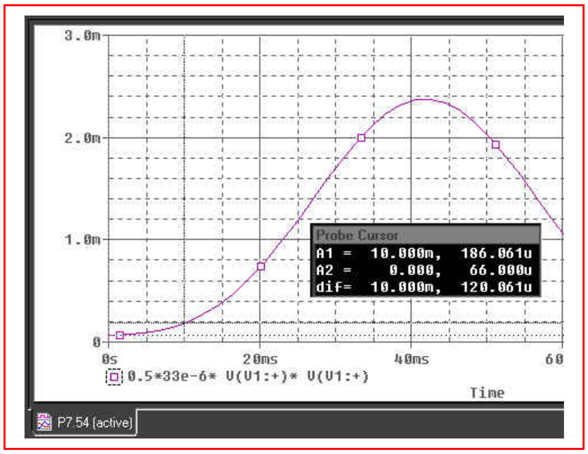




74. PSpice verification

$w = \frac{1}{2} Cv^2 = 0.5\,(33\times10^{-6})[5 \cos(75\times10^{-2}) - 7]^2 = 184.2\ \mu J$. This is in reasonable agreement with the PSpice simulation results shown below.





75. PSpice verification

$w = ½\,Li^2 = 0.5\,(100\times10^{-12})[5\cos(75\times10^{-2}) - 7]^2 = 558.3$ pJ. This is in agreement with the PSpice simulation results shown below.