1. RC step response

$R = 2k\Omega$ Amplitude of $V_{in} = 2V$

$C = 0.1\mu F$

1) $V_{in} = 2u(t)$ 5 points

$V_{out} = 2(1 - e^{-\frac{1}{RC}t})u(t) = 2(1 - e^{-5000t})u(t)$

2) See attached figure. 5 points

3). $t(10\% V_{out}) = 21 \times 10^{-6} s = 21 \mu s = 0.021 ms$

$t(50\% V_{out}) = 0.139 \times 10^{-3} s = 0.139 ms$ 10 points

$t(90\% V_{out}) = 0.461 \times 10^{-3} s = 0.461 ms$

$t_r = t(90\% V_{out}) - t(10\% V_{out}) = 0.44 ms$

$t_{fall} = 0.44 ms$

$t_{PLH} = 0.139 ms$. $t_{PHL} = 0.139 ms$ 5 points

4)

2) LRC step response $R = 2k\Omega$ $C = 0.1\mu F$ $L = 0.8 H$. $V_{in} = 2u(t)$

1). $V_{in} = L\frac{di}{dt} + R \cdot i + V_{out}$ 10 points

$i = C \frac{dV_{out}}{dt}$

$\Rightarrow \frac{V_{out}(S)}{V_{in}(S)} = \frac{1}{LCS^2 + RCS + 1} = \frac{1/LC}{S^2 + 2 \cdot \frac{R}{2L} S + \left(\frac{1}{\sqrt{LC}}\right)^2} = \frac{1.25 \times 10^7}{S^2 + 2 \times 1250 S + (3535.5)^2}$

$\Rightarrow W_n = 3535.5$ $\xi = 0.3535$, $W_d = 3307$, $\sigma = \xi \cdot W_n = 1250$

$V_{out} = 2\left(1 - e^{-1250t}(\cos 3307t + 0.378 \sin 3307t)\right)$ points

2).

3). Td Calculated: $T_d = \frac{1}{f_d} = \frac{2\pi}{W_d} = 1.9$ ms.

4) $f_n = \frac{W_n}{2\pi} = \frac{1}{2\pi\sqrt{LC}}$, $\xi = \frac{R}{2L \cdot W_n} = \frac{R}{2}\sqrt{\frac{C}{L}}$

5) $f_n = 563$ Hz, $\xi = 0.3535$ calculated

6) $M_p = e^{-\pi\xi/\sqrt{1-\xi^2}}$ $0 \le \xi < 1 \Rightarrow \xi = \sin\left(\tan^{-1} - \frac{\ln M_p}{\pi}\right)$. $M_p = 0.60$

7) $R\uparrow \rightarrow \xi\uparrow$ and $W_d \downarrow \Rightarrow M_p \downarrow$ but $t_s\uparrow$. If R is too big, no over

8) $C\uparrow \rightarrow \omega_n \downarrow,\ \zeta \uparrow,\ \omega_d = \sqrt{\frac{1}{LC}} \cdot \sqrt{1-\frac{R^2C}{4L}} = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}} \downarrow$

$\rightarrow M_p \downarrow$ and $t_d \uparrow$. If C is too big, no overshoot.