# SIMON FRASER UNIVERSITY
# SCHOOL OF ENGINEERING SCIENCE

## Summer 2007
## ENSC 320: ELECTRIC CIRCUITS II

Midterm Examination No. 2
July 11, 2007

*Duration: 50 minutes. Attempt all three problems. Questions are* **not** *equally weighted. Closed book and closed notes. Calculators, PDAs, laptops, and wireless phones are not permitted.*

1. **(30 points)** For the ideal op amp circuit shown in Fig. 1:
   - Find the transfer function in terms of $R_1$, $R_2$, and $C$.
   - If it is desired to obtain
   $$H(s) = \frac{s+4}{s+2}$$
   with $C = 1\ \mu F$, then find $R_1$ and $R_2$.
   - Find the circuit's step response.

2. **(50 points)** Consider the circuits shown in Fig. 2, where $R_1 = 50\ \Omega$, $R_2 = 200\ \Omega$ and $C = 2.5\ mF$.
   - Find its transfer function.
   - Let $v_{in}(t) = 10e^{-2t}u(t)\ V$ and $v_c(0_-) = 4\ V$.
     - Find the zero-state response, the zero-input response, and the complete response
     - Find the forced response and the natural response.
     - Find the steady-state response and the transient response.
   - If $v_{in}(t) = 10e^{-10t}u(t)\ V$ and $v_c(0_) = 0\ V$, is the forced response well defined. Justify your answer.

3. **(20 points)** Consider the circuits shown in Fig. 3, where $R = 0.25\ \Omega$ and $C = 1\ F$.
   - Find the transfer function $H(s)$ and the impulse response $h(t)$.
   - If $i_{in}(t) = 3e^{-t}u(t)\ A$, find $v_c(t)$ using the convolution integral.

Figure 1:

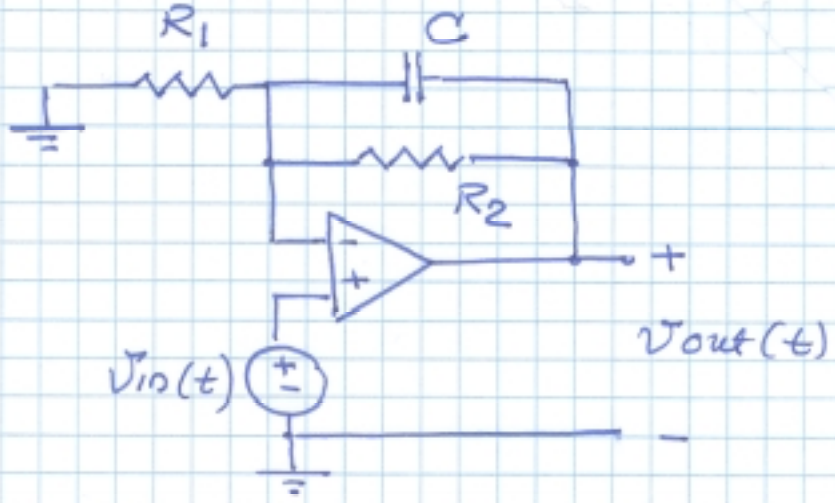


Figure 2.

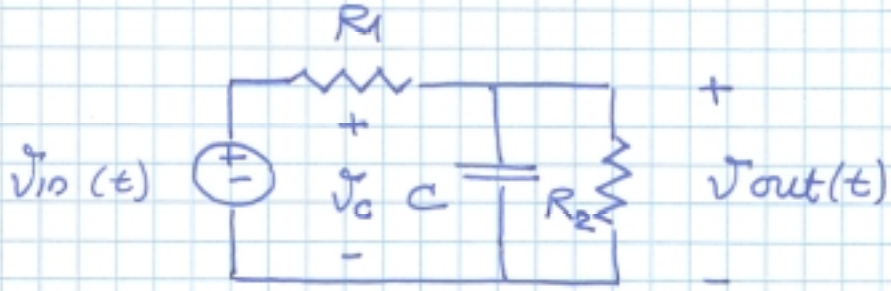


Figure 3:

**TABLE 13.1 Laplace Transform Pairs**

| Item number | $f(t)$ | $\mathcal{L}[f(t)] = F(s)$ |
|---|---|---|
| 1 | $K\delta(t)$ | $K$ |
| 2 | $Ku(t)$ or $K$ | $\frac{K}{s}$ |
| 3 | $r(t)$ | $\frac{1}{s^2}$ |
| 4 | $t^n u(t)$ | $\frac{n!}{s^{n+1}}$ |
| 5 | $e^{-at}u(t)$ | $\frac{1}{s+a}$ |
| 6 | $te^{-at}u(t)$ | $\frac{1}{(s+a)^2}$ |
| 7 | $t^n e^{-at}u(t)$ | $\frac{n!}{(s+a)^{n+1}}$ |
| 8 | $\sin(\omega t)u(t)$ | $\frac{\omega}{s^2+\omega^2}$ |
| 9 | $\cos(\omega t)u(t)$ | $\frac{s}{s^2+\omega^2}$ |
| 10 | $e^{-at}\sin(\omega t)u(t)$ | $\frac{\omega}{(s+a)^2+\omega^2}$ |
| 11 | $e^{-at}\cos(\omega t)u(t)$ | $\frac{s+a}{(s+a)^2+\omega^2}$ |
| 12 | $t\sin(\omega t)u(t)$ | $\frac{2\omega s}{(s^2+\omega^2)^2}$ |
| 13 | $t\cos(\omega t)u(t)$ | $\frac{s^2-\omega^2}{(s^2+\omega^2)^2}$ |
| 14 | $\sin(\omega t+\phi)u(t)$ | $\frac{s\sin(\phi)+\omega\cos(\phi)}{s^2+\omega^2}$ |
| 15 | $\cos(\omega t+\phi)u(t)$ | $\frac{s\cos(\phi)-\omega\sin(\phi)}{s^2+\omega^2}$ |
| 16 | $e^{-at}[\sin(\omega t)-\omega t\cos(\omega t)]u(t)$ | $\frac{2\omega^3}{[(s+a)^2+\omega^2]^2}$ |
| 17 | $te^{-at}\sin(\omega t)u(t)$ | $2\omega\frac{s+a}{[(s+a)^2+\omega^2]^2}$ |
| 18 | $e^{-at}\left[C_1\cos(\omega t)+\left(\frac{C_2-C_1a}{\omega}\right)\sin(\omega t)\right]u(t)$ | $\frac{C_1 s+C_2}{(s+a)^2+\omega^2}$ |
| 19 | $2\sqrt{A^2+B^2}\,e^{-at}\cos\left[\omega t-\tan^{-1}\left(\frac{B}{A}\right)\right]$ | $\frac{A+jB}{s+a+j\omega}+\frac{A-jB}{s+a-j\omega}$ |
| 20 | $2\sqrt{A^2+B^2}\,te^{-at}\cos\left[\omega t-\tan^{-1}\left(\frac{B}{A}\right)\right]$ | $\frac{A+jB}{(s+a+j\omega)^2}+\frac{A-jB}{(s+a-j\omega)^2}$ |