NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

BACHELOR OF ENGINEERING (HONS) DEGREE

Supplementary examinations
August 2011

TEE 2101 **Network Theory**

Duration of Examination 3 Hours

Instructions to candidates:
1. Answer any five questions only.
2. Each question carries equal marks.
3. Draw the circuits clearly and explain all your steps in any solution.
4. Start the answers for the new question on a fresh page.

QUESTION 1

a) The voltage $v = 12\cos(60t + 45^{o})$ is applied to a 0,1 H inductor. Find the steady-state current through the inductor. [10]

b) Determine the z-parameters for the circuit shown in Figure 1b. [10]

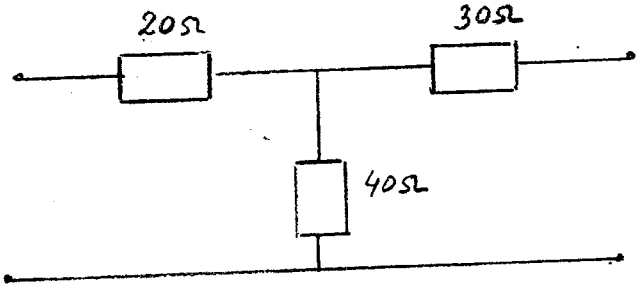


Figure 1B

QUESTION 2

Use the Laplace transform to solve the differential equation below:

$d^{2} v(t)/dt + 6dv(t)/dt + 8v(t) = 2\,u(t)$

subject $v(0) = 1$, $v(0) = -2$ [20]

QUESTION 3

Discuss in detail the series and the parallel circuits. [20]

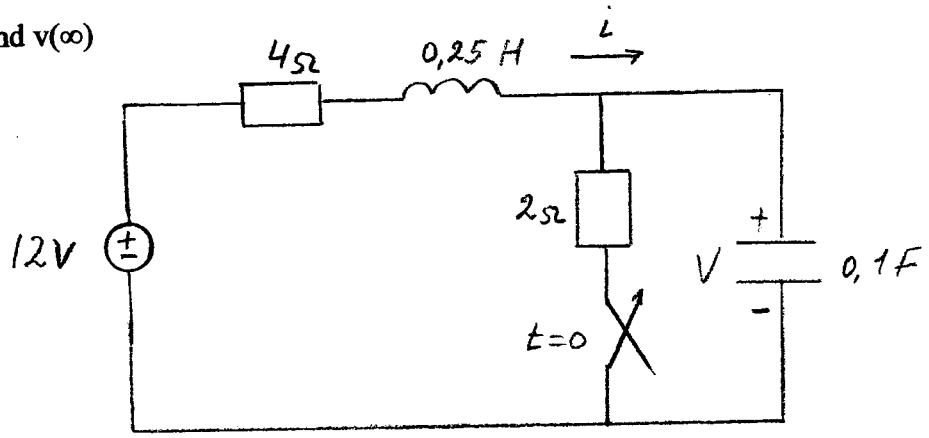
QUESTION 4

The switch in the circuit below has been closed for a long time. It is open at t = 0.
Find:

a) i (0^+) and v(0^+)

b) di(0^+)/ dt and dv(0^+)/dt

c) i(∞) and v(∞) [20]



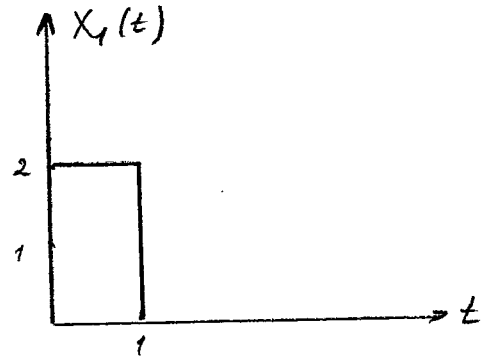
QUESTION 5

a) Briefly give the expression and waveform representation of each of the following functions: unit step function, unit impulse function and ramp function. [15]

b) A series RLC circuit has R = 30 Ohm, X_c = - 50 Ohm and X_L = 90 Ohm. Find the impedance of the circuit. [5]

QUESTION 6

Find the convolution of the two signals in Figure Q6. [20]



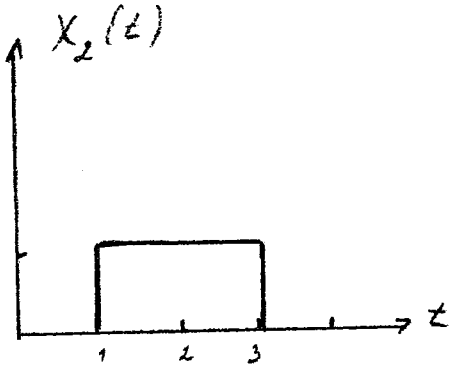
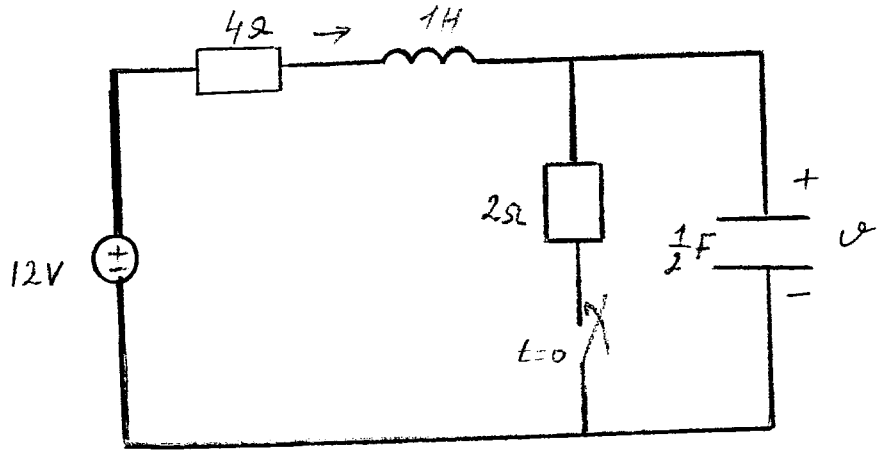


Figure 6

QUESTION 7

Find the complete response v and i for t > 0 for the circuit below. [20]



QUESTION 8

Find i_x in the circuit shown using nodal analysis. [20]

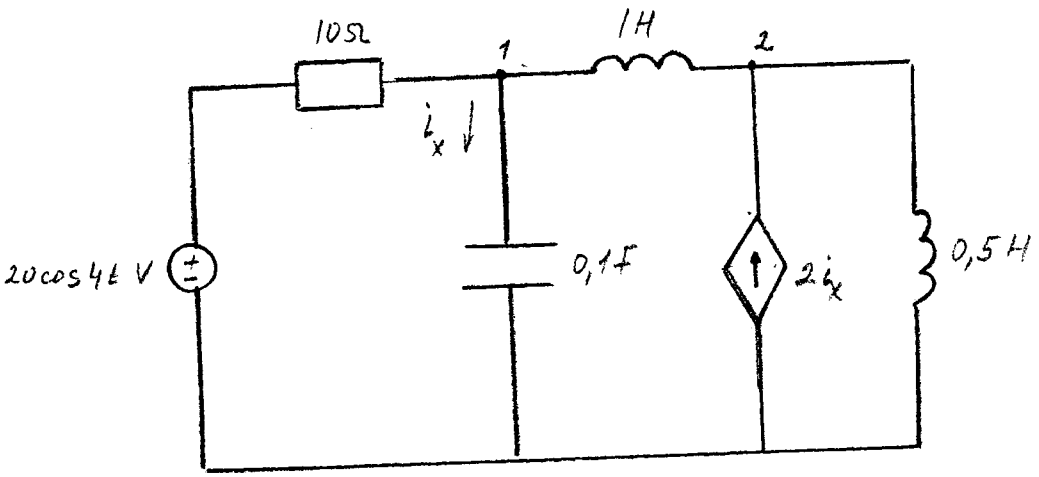


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TABLE 15.1 Properties of the Laplace transform.

Property	$f(t)$	$F(s)$
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(s) + a_2 F_2(s)$
Scaling	$f(at)$	$\frac{1}{a} F\left(\frac{s}{a}\right)$
Time shift	$f(t-a)u(t-a)$	$e^{-as} F(s)$
Frequency shift	$e^{-at} f(t)$	$F(s+a)$
Time differentiation	$\frac{df}{dt}$	$sF(s) - f(0^-)$
	$\frac{d^2 f}{dt^2}$	$s^2 F(s) - sf(0^-) - f'(0^-)$
	$\frac{d^3 f}{dt^3}$	$s^3 F(s) - s^2 f(0^-) - sf'(0^-) - f''(0^-)$
	$\frac{d^n f}{dt^n}$	$s^n F(s) - s^{n-1} f(0^-) - s^{n-2} f'(0^-) - \cdots - f^{(n-1)}(0^-)$
Time integration	$\int_0^t f(t)\,dt$	$\frac{1}{s} F(s)$
Frequency differentiation	$tf(t)$	$-\frac{d}{ds} F(s)$
Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(s)\,ds$
Time periodicity	$f(t) = f(t + nT)$	$\frac{F_1(s)}{1 - e^{-sT}}$
Initial value	$f(0^+)$	$\lim_{s\to\infty} sF(s)$
Final value	$f(\infty)$	$\lim_{s\to 0} sF(s)$
Convolution	$f_1(t) * f_2(t)$	$F_1(s)F_2(s)$

TABLE 15.2 Laplace transform pairs.

$f(t)$	$F(s)$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
e^{-at}	$\frac{1}{s+a}$
t	$\frac{1}{s^2}$
t^n	$\frac{n!}{s^{n+1}}$
te^{-at}	$\frac{1}{(s+a)^2}$
$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$
$\sin \omega t$	$\frac{\omega}{s^2 + \omega^2}$
$\cos \omega t$	$\frac{s}{s^2 + \omega^2}$
$\sin(\omega t + \theta)$	$\frac{s \sin\theta + \omega \cos\theta}{s^2 + \omega^2}$
$\cos(\omega t + \theta)$	$\frac{s \cos\theta - \omega \sin\theta}{s^2 + \omega^2}$
$e^{-at} \sin \omega t$	$\frac{\omega}{(s+a)^2 + \omega^2}$
$e^{-at} \cos \omega t$	$\frac{s+a}{(s+a)^2 + \omega^2}$

TABLE 17.1 Properties of the Fourier transform.

Property	$f(t)$	$F(\omega)$
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(\omega) + a_2 F_2(\omega)$
Scaling	$f(at)$	$\frac{1}{\lvert a\rvert} F\left(\frac{\omega}{a}\right)$
Time shift	$f(t-a)u(t-a)$	$e^{-j\omega a} F(\omega)$
Frequency shift	$e^{j\omega_0 t} f(t)$	$F(\omega - \omega_0)$
Modulation	$\cos(\omega_0 t)\, f(t)$	$\frac{1}{2}[F(\omega+\omega_0) + F(\omega-\omega_0)]$
Time differentiation	$\frac{df}{dt}$	$j\omega F(\omega)$
	$\frac{d^n f}{dt^n}$	$(j\omega)^n F(\omega)$
Time integration	$\int_{-\infty}^{t} f(t)\,dt$	$\frac{F(\omega)}{j\omega} + \pi F(0)\,\delta(\omega)$
Frequency differentiation	$t^n f(t)$	$(j)^n \frac{d^n}{d\omega^n} F(\omega)$
Reversal	$f(-t)$	$F(-\omega)$ or $F^*(\omega)$
Duality	$F(t)$	$2\pi f(-\omega)$
Convolution in t	$f_1(t) * f_1(t)$	$F_1(\omega) F_2(\omega)$
Convolution in ω	$f_1(t) f_1(t)$	$\frac{1}{2\pi} F_1(\omega) * F_2(\omega)$

TABLE 17.2 Fourier transform pairs.

$f(t)$	$F(\omega)$
$\delta(t)$	1
1	$2\pi\delta(\omega)$
$u(t)$	$\pi\delta(\omega) + \frac{1}{j\omega}$
$u(t+\tau) - u(t-\tau)$	$2\frac{\sin\omega\tau}{\omega}$
$\lvert t\rvert$	$\frac{-2}{\omega^2}$
$\operatorname{sgn}(t)$	$\frac{2}{j\omega}$
$e^{-at}u(t)$	$\frac{1}{a+j\omega}$
$e^{at}u(-t)$	$\frac{1}{a-j\omega}$
$t^n e^{-at}u(t)$	$\frac{n!}{(a+j\omega)^{n+1}}$
$e^{-a\lvert t\rvert}$	$\frac{2a}{a^2+\omega^2}$
$e^{j\omega_0 t}$	$2\pi\delta(\omega-\omega_0)$
$\sin\omega_0 t$	$j\pi[\delta(\omega+\omega_0) - \delta(\omega-\omega_0)]$
$\cos\omega_0 t$	$\pi[\delta(\omega+\omega_0) + \delta(\omega-\omega_0)]$
$e^{-at}\sin\omega_0 t\,u(t)$	$\frac{\omega_0}{(a+j\omega)^2+\omega_0^2}$
$e^{-at}\cos\omega_0 t\,u(t)$	$\frac{a+j\omega}{(a+j\omega)^2+\omega_0^2}$

TABLE 18.1 Conversion of two-port parameters

	z	y	h	g	T	t
z	z_{11} z_{12} z_{21} z_{22}	$\frac{y_{22}}{\Delta_y}$ $-\frac{y_{12}}{\Delta_y}$ $-\frac{y_{21}}{\Delta_y}$ $\frac{y_{11}}{\Delta_y}$	$\frac{\Delta_h}{h_{22}}$ $\frac{h_{12}}{h_{22}}$ $-\frac{h_{21}}{h_{22}}$ $\frac{1}{h_{22}}$	$\frac{1}{g_{11}}$ $-\frac{g_{12}}{g_{11}}$ $\frac{g_{21}}{g_{11}}$ $\frac{\Delta_g}{g_{11}}$	$\frac{A}{C}$ $\frac{\Delta_T}{C}$ $\frac{1}{C}$ $\frac{D}{C}$	$\frac{d}{c}$ $\frac{1}{c}$ $\frac{\Delta_t}{c}$ $\frac{a}{c}$
y	$\frac{z_{22}}{\Delta_z}$ $-\frac{z_{12}}{\Delta_z}$ $-\frac{z_{21}}{\Delta_z}$ $\frac{z_{11}}{\Delta_z}$	y_{11} y_{12} y_{21} y_{22}	$\frac{1}{h_{11}}$ $-\frac{h_{12}}{h_{11}}$ $\frac{h_{21}}{h_{11}}$ $\frac{\Delta_h}{h_{11}}$	$\frac{\Delta_g}{g_{22}}$ $\frac{g_{12}}{g_{22}}$ $\frac{g_{21}}{g_{22}}$ $\frac{1}{g_{22}}$	$\frac{D}{B}$ $-\frac{\Delta_T}{B}$ $-\frac{1}{B}$ $\frac{A}{B}$	$\frac{a}{b}$ $-\frac{1}{b}$ $-\frac{\Delta_t}{b}$ $\frac{d}{b}$
h	$\frac{\Delta_z}{z_{22}}$ $\frac{z_{12}}{z_{22}}$ $-\frac{z_{21}}{z_{22}}$ $\frac{1}{z_{22}}$	$\frac{1}{y_{11}}$ $-\frac{y_{12}}{y_{11}}$ $\frac{y_{21}}{y_{11}}$ $\frac{\Delta_y}{y_{11}}$	h_{11} h_{12} h_{21} h_{22}	$\frac{g_{22}}{\Delta_g}$ $-\frac{g_{12}}{\Delta_g}$ $-\frac{g_{21}}{\Delta_g}$ $\frac{g_{11}}{\Delta_g}$	$\frac{B}{D}$ $\frac{\Delta_T}{D}$ $-\frac{1}{D}$ $\frac{C}{D}$	$\frac{b}{a}$ $\frac{1}{a}$ $\frac{\Delta_t}{a}$ $\frac{c}{a}$
g	$\frac{1}{z_{11}}$ $-\frac{z_{12}}{z_{11}}$ $\frac{z_{21}}{z_{11}}$ $\frac{\Delta_z}{z_{11}}$	$\frac{\Delta_y}{y_{22}}$ $\frac{y_{12}}{y_{22}}$ $-\frac{y_{21}}{y_{22}}$ $\frac{1}{y_{22}}$	$\frac{h_{22}}{\Delta_h}$ $-\frac{h_{12}}{\Delta_h}$ $-\frac{h_{21}}{\Delta_h}$ $\frac{h_{11}}{\Delta_h}$	g_{11} g_{12} g_{21} g_{22}	$\frac{C}{A}$ $-\frac{\Delta_T}{A}$ $\frac{1}{A}$ $-\frac{B}{A}$	$\frac{c}{d}$ $-\frac{1}{d}$ $\frac{\Delta_t}{d}$ $-\frac{b}{d}$
T	$\frac{z_{11}}{z_{21}}$ $\frac{\Delta_z}{z_{21}}$ $\frac{1}{z_{21}}$ $\frac{z_{22}}{z_{21}}$	$-\frac{y_{22}}{y_{21}}$ $-\frac{1}{y_{21}}$ $-\frac{\Delta_y}{y_{21}}$ $-\frac{y_{11}}{y_{21}}$	$-\frac{\Delta_h}{h_{21}}$ $-\frac{h_{11}}{h_{21}}$ $-\frac{h_{22}}{h_{21}}$ $-\frac{1}{h_{21}}$	$\frac{1}{g_{21}}$ $\frac{g_{22}}{g_{21}}$ $\frac{g_{11}}{g_{21}}$ $\frac{\Delta_g}{g_{21}}$	A B C D	$\frac{d}{\Delta_t}$ $\frac{b}{\Delta_t}$ $\frac{c}{\Delta_t}$ $\frac{a}{\Delta_t}$
t	$\frac{z_{22}}{z_{12}}$ $\frac{\Delta_z}{z_{12}}$ $\frac{1}{z_{12}}$ $\frac{z_{11}}{z_{12}}$	$-\frac{y_{11}}{y_{12}}$ $-\frac{1}{y_{12}}$ $-\frac{\Delta_y}{y_{12}}$ $-\frac{y_{22}}{y_{12}}$	$\frac{1}{h_{12}}$ $\frac{h_{11}}{h_{12}}$ $\frac{h_{22}}{h_{12}}$ $\frac{\Delta_h}{h_{12}}$	$-\frac{\Delta_g}{g_{12}}$ $-\frac{g_{22}}{g_{12}}$ $-\frac{g_{11}}{g_{12}}$ $-\frac{1}{g_{12}}$	$\frac{D}{\Delta_T}$ $\frac{B}{\Delta_T}$ $\frac{C}{\Delta_T}$ $\frac{A}{\Delta_T}$	a b c d

$\Delta_z = z_{11}z_{22} - z_{12}z_{21}$, $\Delta_h = h_{11}h_{22} - h_{12}h_{21}$, $\Delta_T = AD - BC$

$\Delta_y = y_{11}y_{22} - y_{12}y_{21}$, $\Delta_g = g_{11}g_{22} - g_{12}g_{21}$, $\Delta_t = ad - bc$