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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	ENGINEERING MATHEMATICS II
COURSE CODE	:	BEE 11403
PROGRAMME CODE	:	BEJ / BEV
EXAMINATION DATE	:	JULY 2020
DURATION	:	4 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS
		OPEN BOOK EXAMINATION

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

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Q1 (a) Consider the *R-L* circuit with a source of emf, $E(t)$ as shown in **Figure Q1**. The values of resistance, $R = 15\,\Omega$, inductor, $L = 5$ H, voltage source, $E(t) = 10$ V and the initial current is $i(0) = i_0$. Show that the current $i\,(t)$, flowing in the circuit at time t can be written in terms of i_0 using the linear differential equation method.

(11 marks)

(b) The following equation represents a second-order non-homogeneous ordinary differential equation with constant coefficients,

$$\frac{d^2y}{dx^2} - 2\frac{dy}{dx} - 8y = 12\cos 2x - 4\sin 2x$$

By using the method of undetermined coefficient, construct the general solution for the above second-order ordinary differential equation.

(14 marks)

Q2 A system is given by a circuit network as shown in **Figure Q2.**

(a) Show that the linear differential equations for the system are given by,

$$i_1'(t) = 0.5i_1 - 3i_2 + 5e^{-2t}$$
$$i_2'(t) = 2i_1 - 6i_2$$

(6 marks)

(b) By considering the initial conditions, $i_1(0) = -i_2(0) = 1$, calculate the particular solution of the linear differential equations system.

(19 marks)

Q3 (a) By applying the definition of Laplace Transform, solve the Laplace transform of

$$f(t)=\begin{cases} e^{-2t} & 0\le t<5 \\ -t & t\ge 5 \end{cases}$$

(10 marks)

(b) A second-order differential equation is given as follows:

$$f''(t)-9f(t)=g(t)$$

where $g(t)$ is a non-continuous function represented by,

$$g(t)=5H(t)+H(t-1).$$

Solve the differential equation using Laplace Transform, if the initial conditions are $f(0)=0$ and $f'(0)=1$.

(20 marks)

- END OF QUESTIONS -

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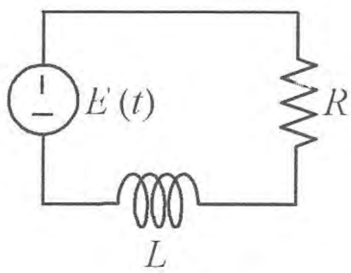

Figure Q1

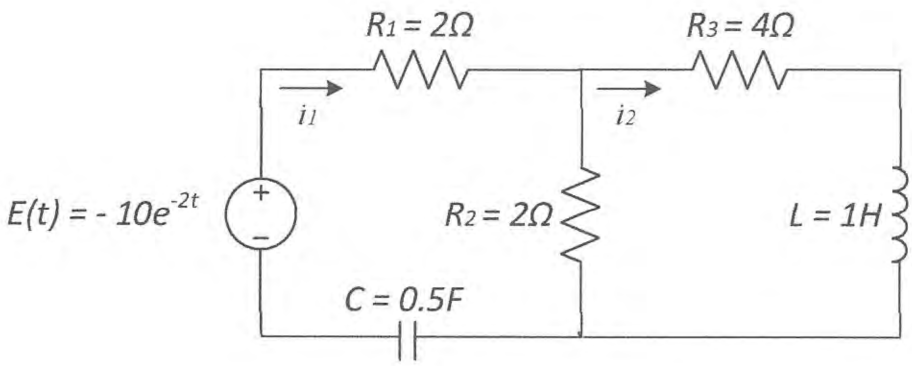

Figure Q2

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FORMULAS

Second-order Differential Equation

The roots of characteristic equation and the general solution for differential equation $ay'' + by' + cy = 0$.

Characteristic equation: $am^2 + bm + c = 0$.		
Case	The roots of characteristic equation	General solution
1.	Real and different roots: m_1 and m_2	$y = Ae^{m_1 x} + Be^{m_2 x}$
2.	Real and equal roots: $m = m_1 = m_2$	$y = (A + Bx)e^{mx}$
3.	Complex roots: $m_1 = \alpha + \beta i$, $m_2 = \alpha - \beta i$	$y = e^{\alpha x}(A\cos\beta x + B\sin\beta x)$

The method of undetermined coefficients for a system of first-order linear differential equations

For non-homogeneous for a system of first-order linear differential equations $\mathbf{Y}'(x) = A\,\mathbf{Y}(x) + \mathbf{G}(x)$, the particular integral solution $\mathbf{Y}_p(x)$ is given by:

$\mathbf{G}(x)$	$\mathbf{Y}_p(x)$	$\mathbf{G}(x)$	$\mathbf{Y}_p(x)$
$\mathbf{u}$	$\mathbf{a}$	$\mathbf{u}e^{\lambda x}$	$\mathbf{a}e^{\lambda x}$
$\mathbf{u}x + \mathbf{v}$	$\mathbf{a}x + \mathbf{b}$	$\mathbf{u}\cos\alpha x$ or $\mathbf{u}\sin\alpha x$	$\mathbf{a}\sin\alpha x + \mathbf{b}\cos\alpha x$

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Power Series Method

$$\sum_{m=0}^{\infty} c_m x^m = c_0 + c_1 x + c_2 x^2 + c_3 x^3 + c_4 x^4 + \cdots$$

Where $c_0,\ c_1,\ c_2$ ... are constants

Representation of Functions in Power Series

$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots \sum_{m=0}^{\infty} \frac{x^m}{m!}, -\infty < x < \infty$
$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \cdots \sum_{m=0}^{\infty} (-1)^m \frac{x^{2m+1}}{(2m+1)!}, -\infty < x < \infty$
$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \cdots \sum_{m=0}^{\infty} (-1)^m \frac{x^{2m}}{(2m)!}, -\infty < x < \infty$
$\ln(1+x) = x - \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots \sum_{m=1}^{\infty} (-1)^{m+1} \frac{x^m}{m!}$
$\frac{1}{1-x} = 1 + x + x^2 + x^3 + \cdots \sum_{m=0}^{\infty} x^m$
$(1+x)^{\alpha} = 1 + \alpha x + \frac{\alpha(\alpha-1)}{2!} x^2 + \frac{\alpha(\alpha-1)(\alpha-2)}{3!} x^3 + \cdots$

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Laplace Transform

$$\mathcal{L}\{f(t)\} = \int_0^\infty f(t)e^{-st}dt = F(s)$$

$f(t)$	$F(s)$	$f(t)$	$F(s)$
a	$\frac{a}{s}$	$\int_0^t f(\tau)\,d\tau$	$\frac{F(s)}{s}$
e^{at}	$\frac{1}{s-a}$	$H(t-a)$	$\frac{e^{-as}}{s}$
$\sin at$	$\frac{a}{s^2+a^2}$	$f(t-a)H(t-a)$	$e^{-as}F(s)$
$\cos at$	$\frac{s}{s^2+a^2}$	$\delta(t-a)$	e^{-as}
$\sinh at$	$\frac{a}{s^2-a^2}$	$f(t)\delta(t-a)$	$e^{-as}f(a)$
$\cosh at$	$\frac{s}{s^2-a^2}$	$\int_0^t f(u)g(t-u)\,du$	$F(s)\cdot G(s)$
t^n, $n=1,2,3,\ldots$	$\frac{n!}{s^{n+1}}$	$y(t)$	$Y(s)$
$e^{at}f(t)$	$F(s-a)$	$y'(t)$	$sY(s)-y(0)$
$t^n f(t)$, $n=1,2,3,\ldots$	$(-1)^n \frac{d^n}{ds^n}F(s)$	$y''(t)$	$s^2Y(s)-sy(0)-y'(0)$

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Electrical Formula

1. The voltage drop across a resistor, R (Ohm's Law): $v_R = iR$
2. The voltage drop across an inductor, L (Faraday's Law): $v_L = L\dfrac{di}{dt}$
3. The voltage drop across a capacitor, C (Coulomb's Law): $v_c = \dfrac{q}{C}$ or $i = C\dfrac{dv_c}{dt}$
4. The relation between current, i and charge, q: $i = \dfrac{dq}{dt}$

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IDENTITY OF TRIGONOMETRY

1.	$\sin A \cos B = \frac{1}{2}[\sin(A+B) + \sin(A-B)]$ $\cos A \sin B = \frac{1}{2}[\sin(A+B) - \sin(A-B)]$ $\cos A \cos B = \frac{1}{2}[\cos(A+B) + \cos(A-B)]$ $\sin A \sin B = -\frac{1}{2}[\cos(A+B) - \cos(A-B)]$
2.	Negative angles: $\sin(-\theta) = -\sin(\theta), \cos(-\theta) = \cos(\theta), \tan(-\theta) = -\tan(\theta)$
3.	$\sin 2\theta = 2\sin\theta\cos\theta$ $\cos 2\theta = \cos^2\theta - \sin^2\theta = 2\cos^2 - 1 = 1 - 2\sin^2\theta$ $\tan 2\theta = \frac{2\tan\theta}{1-\tan^2\theta}$
4.	$\cos n\pi = (-1)^n = \begin{cases} -1, & if\ n\ odd \\ 1, & if\ n\ even \end{cases}$ 12 $\sin n\pi = 0\ for\ n = 0,1,2,\ldots$ $\cos 2n\pi = 1, \quad \sin 2n\pi = 0 \quad for\ n = 0,1,2,\ldots$ $\cos\frac{n\pi}{2} = \begin{cases} 0, & if\ n\ odd \\ (-1)^{n/2}, & if\ n\ even \end{cases}$ $\sin\frac{n\pi}{2} = \begin{cases} (-1)^{\frac{n-1}{2}}, & if\ n\ odd \\ 0\ . & if\ n\ even \end{cases}$