UNIVERSITI SAINS MALAYSIA

Peperiksaan Kursus Semasa Cuti Panjang

Sidang Akademik 2002/2003

April 2003

JEE 234 – TEORI ELEKTROMAGNET

Masa : 3 Jam

ARAHAN KEPADA CALON:

Sila pastikan kertas peperiksaan ini mengandungi **LAPAN** (8) muka surat beserta **Lampiran (2 muka surat)** yang bercetak dan **ENAM** (6) soalan sebelum anda memulakan peperiksaan ini.

Jawab **LIMA** (5) soalan.

Agihan markah diberikan di sut sebelah kanan soalan berkenaan.

Semua soalan hendaklah dijawab di dalam Bahasa Malaysia.

...2/-

1. [a] Jika **A** = $-\hat{\mathbf{a}}_x + 3\,\hat{\mathbf{a}}_y - 2\,\hat{\mathbf{a}}_z$ dan **B** = $2\hat{\mathbf{a}}_x + 3\,\hat{\mathbf{a}}_y - 2\,\hat{\mathbf{a}}_z$, cari:

(i) $|\mathbf{A}|$;

(ii) $|\mathbf{B}|$;

(iii) **A–B**;

(iv) $\mathbf{A} \times \mathbf{B}$;

(v) Sudut θ_{AB} antara **A** dan **B**.

If A = $-\hat{a}_x + 3\,\hat{a}_y - 2\,\hat{a}_z$ *and B* = $2\hat{a}_x + 3\,\hat{a}_y - 2\,\hat{a}_z$, *find:*

(i) $|\mathbf{A}|$;

(ii) $|\mathbf{B}|$;

(iii) ***A–B;***

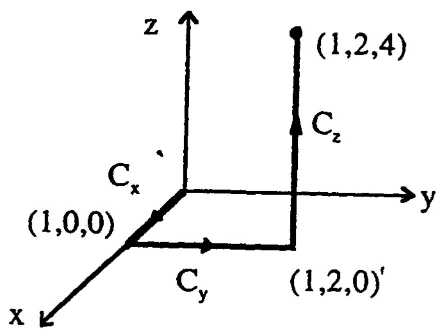
(iv) $A \times B$;

(v) *Angle* θ_{AB} *between* ***A*** *and* ***B***.

(50%)

[b] Bagi **F** = $y\,\hat{\mathbf{a}}_x - x\,\hat{\mathbf{a}}_y$ hitung kamiran garis di sepanjang lintasan yang ditunjukkan dalam Rajah 1 bermula dari (0,0,0) dan berakhir pada (1,2,4).

For ***F*** = $y\,\hat{a}_x - x\,\hat{a}_y$ *calculate the line integral along the path indicated in the Figure 1 starting from (0,0,0) and ending at (1,2,4).*



Rajah 1

Figure 1

(50%)

2. [a] Dapatkan medan elektrik yang terhasil dari cas garis tak terhingga yang mempunyai ketumpatan cas garis seragam ρ_ℓ.

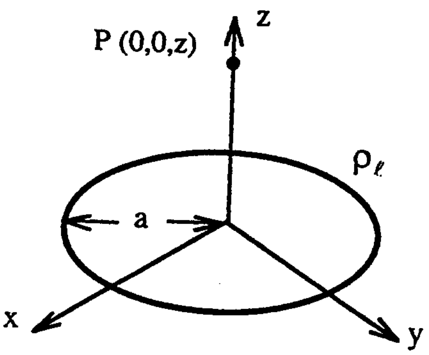
Obtain the electric field arising from an infinite line of charge with a uniform line-charge density ρ_ℓ.

(50%)

[b] Bagi cas gelung bulat seragam yang ditunjukkan dalam Rajah 2, dapatkan medan-E yang dihasilkan pada sebarang titik P (0,0,z) di sepanjang paksi-z, dimulakan dengan mencari nilai keupayaan V. Anggap jejari gelung ialah 'a' dan ketumpatan cas garis ialah ρ_ℓ.

For the uniform circular loop of charge shown in Figure 2, find the E-field it generates at an arbilrary point P (0,0,z) along the z-axis by first finding the potential V. Assume that the radius of the loop is 'a' and the line charge density is ρ_ℓ.

(50%)



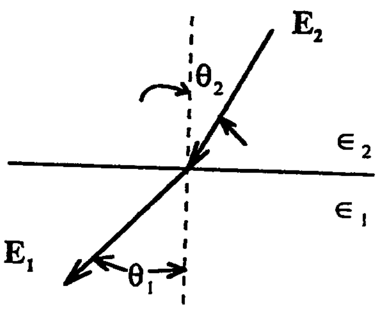
Rajah 2

Figure 2

3. [a] Rajah 3 menunjukkan hubungan antara muka dua dielektrik yang sempurna. Dapatkan magnitud E_2 dan sudut yang terhasil dari permukaan paksi normal, jika magnitud E_1 dan sudutnya diketahui.

Figure 3 shows the interface between two perfect dielectries. Find the magnitude of E_2 and angle it makes with the surface normal, if the magnitude of E_1 and the angle it makes with respect to the surface normal are both known.

(50%)



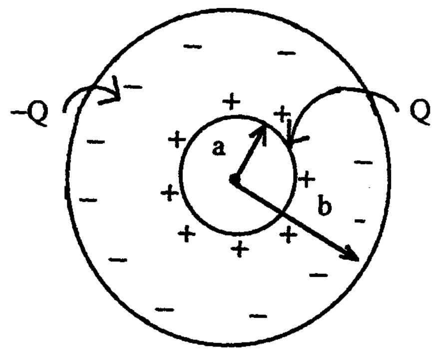
Rajah 3

Figure 3

[b] Hitung medan **E** dan **D** yang dihasilkan oleh dua sfera cas seragam yang sepusat seperti ditunjukkan oleh di Rajah 4. Sfera dalam mempunyai jejari a dan cas Q, sementara sfera luar berjejari b dan cas-Q. Anggap dielektrik antara sfera ialah homogen dan berketelusan $\in$.

*Calculate the **E** and **D** fields generated by two concentric, uniformly charged spheres shown in Figure 4. The inner sphere has radius a and charge Q, and the outer sphere has radius b and charge -Q. Assume that the dielectric between the spheres is homogeneous and has permittivity* $\in$.

(50%)



Rajah 4

Figure 4

4. [a] Menggunakan hukum Biot-Savart, dapatkan ketumpatan fluks magnet **B**, yang dihasilkan oleh arus garis I tak terhingga dan seragam yang mengalir dalam arah + $\hat{a}_z$ di keseluruhan panjang paksi-z.

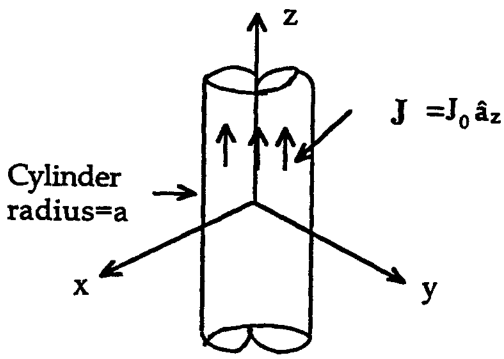
*Apply Biot-Savart law and obtain the magnetic flux density, **B**, arising from a uniform, infinite line of current I flowing in* $+\hat{a}_z$ *direction along the entire z-axis.*

(50%)

[b] Menggunakan hukum Ampere dapatkan ketumpatan fluks magnet **B**, yang dihasilkan oleh silinder tegar tak terhingga, berjejari a dan membawa arus seragam $\mathbf{J} = J_o \hat{a}_z$ [A/m²] untuk kes ρ<a seperti ditunjukkan oleh Rajah 5.

Apply Ampere's law and obtain the magnetic flux density, ***B****, arising from an infinite solid cylinder of radius a carrying a uniform current* $J = J_o \hat{a}_z$ *[A/m²] for* $\rho<a$ *as shown in Figure 5.*

(50%)



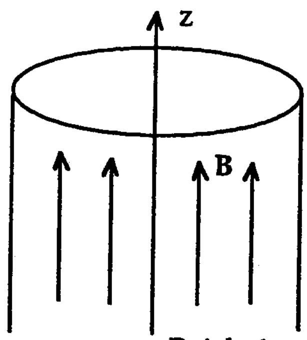
Rajah 5

Figure 5

5. [a] Rajah 6 menunjukkan teras berketelapan tinggi, membawa medan seragam **B** dan berubah terhadap masa diberikan sebagai $\mathbf{B} = B_o \cos \omega t\ \hat{a}_z$. Hitung medan-E yang dihasilkan dalam teras tersebut.

Figure 6 shows a high permeability core that carries a uniform, time-varying ***B*** *field given by* $B = B_o \cos wt\ \hat{a}_z$*. Calculate the E-field generated inside the core.*

(50%)



Rajah 6

Figure 6

[b] Katakan medan-E dalam kawasan bebas sumber ruang bebas diberikan oleh

$$E = E_o \sin(\omega t - \beta z)\ \hat{a}_x$$

Nilai ω dan β ialah pemalar. Dapatkan medan H yang wujud.

Suppose that the E-field in a source-free region of free space is given by

$$E = E_o \sin(\omega t - \beta z)\ \hat{a}_x$$

*where ω and β are constants. Find the **H** field that is also present.*

(50%)

6. [a] Hitung galangan masukan bagi talian penghantaran yang panjangnya 1 m dan ditamatkan oleh beban bergalangan Z_L=20Ω. Anggapkan galangan ciri talian penghantaran ialah 50Ω, pemalar dielektrik berkesan ε_{eH}=1.5 dan frekuensi operasi ialah 50MHz.

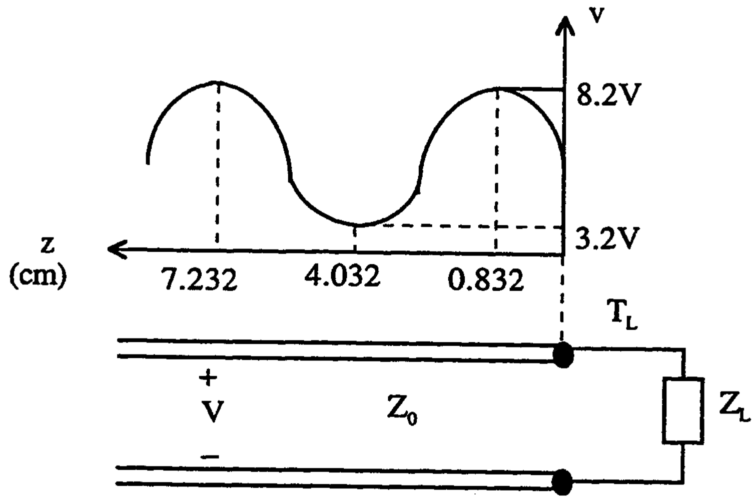
Calculate the input impedance of a 1 m length of transmission line that is terminated in a load impedance of Z_L=20Ω. Assume that the characteristic impedance of the transmission line is 50Ω, its effective dielectric constant is ε_{eH}=1.5 and the frequency of operation is 50MHz.

(50%)

[b] Rajah 7 menunjukkan talian penghantaran tanpa rugi, 50Ω, yang ditamatkan oleh galangan yang tidak diketahui. Mengguna corak VSWR yang diplotkan dalam rajah tersebut, hitung galangan beban.

Figure 7 shows a lossless, 50Ω, transmission line that is terminated with an unknown impedance. Using the VSWR pattern plotted in the figure, calculate the load impedance.

(50%)



Rajah 7

Figure 7

ooOoo

NAME	TITLE	
SMITH CHART FORM 82-BSPR(9-66)	KAY ELECTRIC COMPANY, PINE BROOK, N.J. © 1966. PRINTED IN U.S.A.	DWG. NO. / DATE

IMPEDANCE OR ADMITTANCE COORDINATES

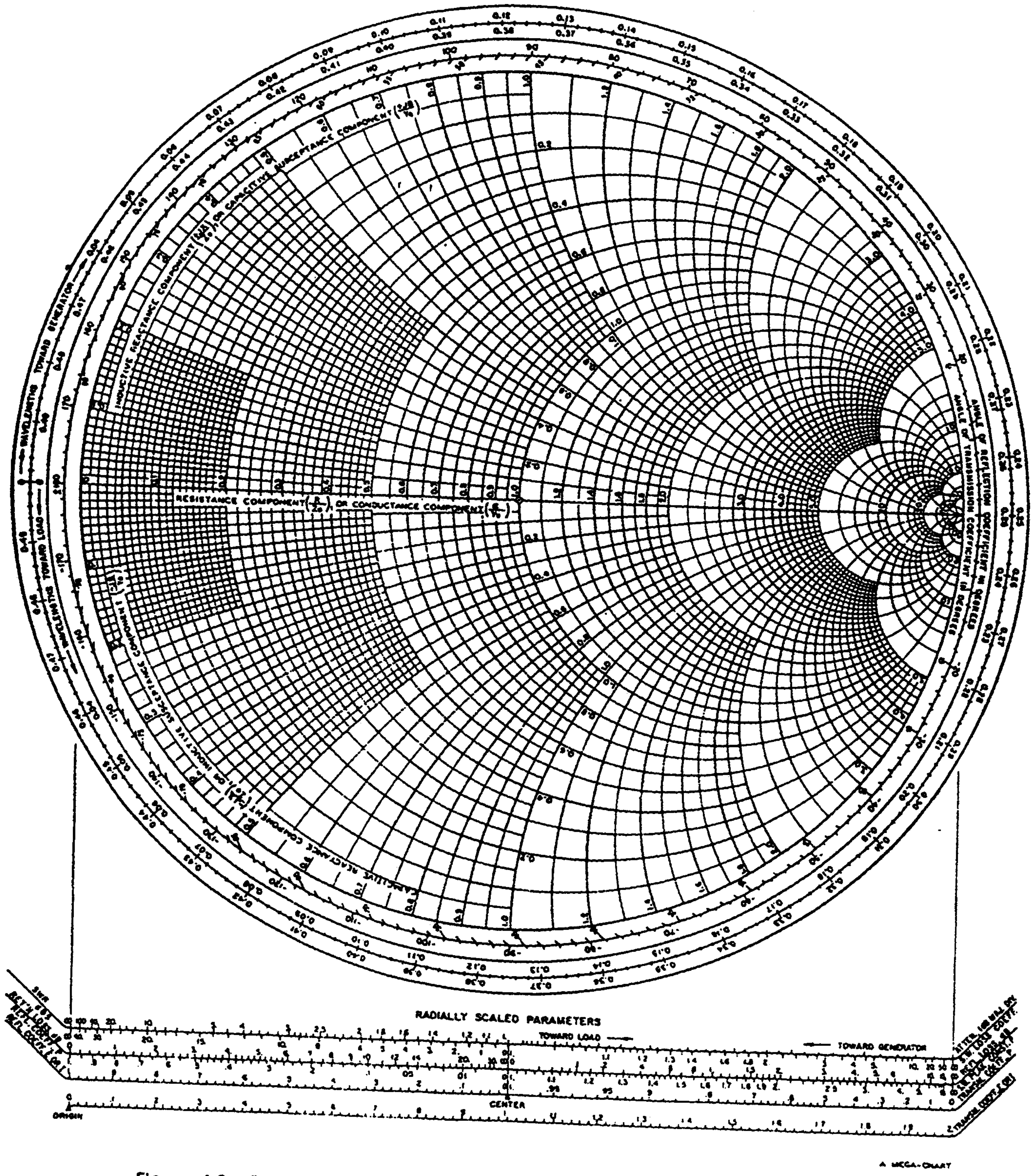


Figure 4.8 Smith chart, reprinted by permission of P. H. Smith, renewal copyright, 1976.

Gradient, Divergence, Curl, and Laplacian Operations

Cartesian Coordinates (x, y, z)

$$\nabla f = \frac{\partial f}{\partial x}\hat{\mathbf{a}}_x + \frac{\partial f}{\partial y}\hat{\mathbf{a}}_y + \frac{\partial f}{\partial z}\hat{\mathbf{a}}_z$$

$$\nabla \cdot \mathbf{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$$

$$\nabla \times \mathbf{A} = \left[\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z}\right]\hat{\mathbf{a}}_x + \left[\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x}\right]\hat{\mathbf{a}}_y + \left[\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}\right]\hat{\mathbf{a}}_z$$

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2}$$

Cylindrical Coordinates (ρ, ϕ, z)

$$\nabla f = \frac{\partial f}{\partial \rho}\hat{\mathbf{a}}_\rho + \frac{1}{\rho}\frac{\partial f}{\partial \phi}\hat{\mathbf{a}}_\phi + \frac{\partial f}{\partial z}\hat{\mathbf{a}}_z$$

$$\nabla \cdot \mathbf{A} = \frac{1}{\rho}\left[\frac{\partial}{\partial \rho}(\rho A_\rho)\right] + \frac{1}{\rho}\frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$$

$$\nabla \times \mathbf{A} = \left[\frac{1}{\rho}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z}\right]\hat{\mathbf{a}}_\rho + \left[\frac{\partial A_\rho}{\partial z} - \frac{\partial A_z}{\partial \rho}\right]\hat{\mathbf{a}}_\phi + \frac{1}{\rho}\left[\frac{\partial}{\partial \rho}(\rho A_\phi) - \frac{\partial A_\rho}{\partial \phi}\right]\hat{\mathbf{a}}_z$$

$$\nabla^2 f = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho\frac{\partial f}{\partial \rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 f}{\partial \phi^2} + \frac{\partial^2 f}{\partial z^2}$$

Spherical Coordinates (r, θ, ϕ)

$$\nabla f = \frac{\partial f}{\partial r}\hat{\mathbf{a}}_r + \frac{1}{r}\frac{\partial f}{\partial \theta}\hat{\mathbf{a}}_\theta + \frac{1}{r\sin\theta}\frac{\partial f}{\partial \phi}\hat{\mathbf{a}}_\phi$$

$$\nabla \cdot \mathbf{A} = \frac{1}{r^2}\left[\frac{\partial}{\partial r}(r^2 A_r)\right] + \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial \theta}(A_\theta \sin\theta)\right] + \frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial \phi}$$

$$\nabla \times \mathbf{A} = \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial \theta}(A_\phi \sin\theta) - \frac{\partial A_\theta}{\partial \phi}\right]\hat{\mathbf{a}}_r$$
$$+ \frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial A_r}{\partial \phi} - \frac{\partial}{\partial r}(rA_\phi)\right]\hat{\mathbf{a}}_\theta + \frac{1}{r}\left[\frac{\partial}{\partial r}(rA_\theta) - \frac{\partial A_r}{\partial \theta}\right]\hat{\mathbf{a}}_\phi$$

$$\nabla^2 f = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial f}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial f}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 f}{\partial \phi^2}$$