
UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

ZCT 213/2 – Optics
[Optik]

Duration: 2 hours
[Masa : 2 jam]

Please ensure that this examination paper contains **SIX** printed pages before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instruction: Answer all **FOUR** questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

Arahan: Jawab semua **EMPAT** soalan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

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1. (a) Show that [Tunjukkan bahawa]

$$\Psi(x, t) = A \cos k(x - vt)$$

is a solution of the 1-D (one-dimensional) differential wave equation
[adalah penyelesaian kepada persamaan pembezaan gelombang 1-D
(satu-dimensi)]

(5/25)

- (b) Write the normalized Jones vectors for the following wave, and describe its state of polarization:

[Tuliskan vektor Jones ternormal bagi gelombang berikut, dan terangkan keadaan pengkutubannya.]

$$\vec{E} = \hat{i}E_0 \sin(kz - \omega t) + \hat{j}E_0 \sin(kz - \omega t + \frac{\pi}{2})$$

(5/25)

- (c) Write the equation for the electric field (in exponential form) of a wave which is right-circularly polarized, and traveling in the z-direction with amplitude $5E_0$.

[Tuliskan persamaan medan elektrik (dalam bentuk eksponen) bagi gelombang terkutub bulat kanan yang bergerak dalam arah z dengan amplitud $5E_0$.]

(5/25)

- (d) Write a short description on linear polarizer.

[Tulis penerangan ringkas mengenai pengkutub satah]

(5/25)

- (e) Unpolarized light passes through 2 linear polarizers, the second of which is oriented at 45° with the first. What intensity gets through the system relative to that of the incident unpolarized light.

[Cahaya tak terkutub melalui dua pengkutub. Paksi bagi pengkutub pertama berkeadaan tegak sementara paksi bagi pengkutub kedua pada 45° terhadap garis tegak. Tentukan keamatan yang melalui sistem relatif terhadap keamatan cahaya tak terkutub tuju.]

(5/25)

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2. (a) Write a short description on *[Tulis penerangan ringkas mengenai]*
- (i) Optical activity *[Keaktifan optik]* (6/25)
- (ii) Faraday effect *[Kesan Faraday]* (6/25)
- (b) The Faraday effect is performed with a piece of flint glass, having a Verdet constant of 0.112 min/G-cm. What is the required length of the glass to produce a 45° rotation of the polarization vector required in a optical isolator when the magnetic field has a value of 9 kG.
[Kesan Faraday dilakukan dengan menggunakan sekeping kaca batu api, dengan pemalar Verdet 0.112 min/G-cm. Apakah panjang kaca yang diperlukan untuk menghasilkan putaran sebanyak 45° bagi vektor pengkutuban dalam pemencil optik sekiranya medan magnet bernilai 9 kG.] (3/25)
- (c) (i) Using Fresnel's explanation of rotation, obtain the relation between the angle of rotation and the difference in refractive index between left- and right-circularly polarized light.
[Dengan menggunakan penjelasan Fresnel tentang pemutaran, dapatkan hubungan antara sudut putaran dan perbezaan indeks biasan antara gelombang terkutub bulat kiri dan gelombang terkutub bulat kanan.] (7/25)
- (ii) What thickness of quartz is required to give an optical rotation of 90° for light at wavelength 760 nm, given $|n_L - n_R| = 6 \times 10^{-5}$.
[Berapakah ketebalan kuarza yang diperlukan untuk menghasilkan putaran optic sebanyak 90° pada jarak gelombang 760 nm, diberi $|n_L - n_R| = 6 \times 10^{-5}$.] (3/25)

3. (a) State Huygens-Fresnel principle.
[Nyatakan prinsip Huygens-Fresnel.]

(4/25)

- (b) (i) The Fraunhofer diffraction intensity for an ideal diffraction grating with N slits is given by
[Keamatan belauan Fraunhofer bagi suatu parutan unggul dengan N celahan diberikan sebagai]

$$I = A_0^2 \left(\frac{\sin^2 \beta}{\beta^2} \right) \left(\frac{\sin^2 N\gamma}{\sin^2 \gamma} \right)$$

Using the above equation, obtain the intensity equation for a double slit (width b and distance between centers of the slits d)

[Dengan menggunakan persamaan di atas, dapatkan persamaan keamatan bagi celah ganda dua (lebar b dan jarak di antara pusat celah-celah d)]

(5/25)

- (ii) Sketch the intensity pattern for a double slit having $\frac{d}{b} = 3$.

Label points on the x -axis with the corresponding values of β and γ

[Lakarkan corak keamatan bagi celah ganda dua dengan $\frac{d}{b} = 3$.

Labelkan titik pada paksi- x dengan nilai β dan γ yang sepadan]

(6/25)

- (c) The refractive indices of a piece of optical glass for the blue and green lines of the mercury spectrum, $\lambda = 4358 \text{ \AA}$ and $\lambda = 5461 \text{ \AA}$, are 1.65250 and 1.62450, respectively. Using the two-constant Cauchy equation, calculate values for

[Indeks biasan sekeping kaca optic garisan biru dan hijau spektrum raksa, $\lambda = 4358 \text{ \AA}$ dan $\lambda = 5461 \text{ \AA}$ masing-masing ialah 1.65250 dan 1.62450. Dengan menggunakan dua pemalar persamaan Cauchy, hitungkan nilai bagi]

- (i) the constants A and B
[pemalar A dan B]

(4/25)

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(ii) the refractive index for the sodium yellow lines at $\lambda = 5893 \text{ \AA}$
[indeks biasan bagi garisan kuning sodium pada $\lambda = 5893 \text{ \AA}$]
 (3/25)

(iii) the dispersion at the same wavelength as in (c) (ii).
[sebaran pada jarak gelombang yang sama seperti di (c) (ii)]
 (3/25)

4. (a) The transmission coefficient t for the TE mode is given by the Fresnel equation
[Pekali penghantaran t bagi mod TE diberikan dengan persamaan Fresnel]

$$t = \frac{2 \cos \theta \sin \theta_i}{\sin(\theta + \theta_i)}$$

Show that the expression for t can also be written as
[Tunjukkan bahawa ungkapan bagi t boleh juga ditulis sebagai]

$$t = \frac{2 \cos \theta}{\cos \theta + \sqrt{n^2 - \sin^2 \theta}}$$

(7/25)

(b) A telescope has an objective lens with diameter 508 cm
[Sebuah teleskop mempunyai kanta objektif dengan garispusat 508 cm.]

(i) What is the minimum angle of resolution for this telescope at wavelength 550 nm?
[Dapatkan sudut minimum pembezaan jelas teleskop ini pada jarak gelombang 550 nm?]
 (4/25)

(ii) What is the distance between two objects on the moon if they can be resolved by this telescope? (Distance between the earth and the moon is $3.844 \times 10^8 \text{ m}$)
[Berapakah jarak antara dua objek di atas bulan sekiranya mereka dapat dileraiakan oleh teleskop ini? (Jarak antara bumi dan bulan ialah $3.844 \times 10^8 \text{ m}$)]
 (4/25)

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- (c) Sketch the vibration spiral for Fresnel half-period zones of a circular opening. Show on the diagram the resultant amplitude when the half period zones cover the whole spherical wavefront

[Lakarkan lingkaran getaran bagi zon setengah kala Fresnel daripada bukaan membulat. Tandakan pada gambarajah amplitud paduan bila zon-zon setengah kala meliputi seluruh depan gelombang sfera.]

(5/25)

- (d) Sketch the Cornu's spiral that include five half-period Fresnel zones. Show on the diagram the resultant amplitude for the unobstructed wave.

[Lakarkan lingkaran Cornu yang meliputi lima zon setengah kala Fresnel. Tandakan pada gambarajah amplitud paduan bagi gelombang yang tidak terhalang.]

(5/25)

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