UNIVERSITI SAINS MALAYSIA

Final Examination
2015/2016 Academic Session

May/June 2016

JIF 212 – Optics
[Optik]

Duration : 3 hours
[Masa : 3 jam]

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

Answer **ALL** questions. You may answer **either** in Bahasa Malaysia or in English.

Read the instructions carefully before answering.

In the event of any discrepancies in the exam questions, the English version shall be used.

*Sila pastikan kertas peperiksaan ini mengandungi **TIGA BELAS** muka surat yang bercetak sebelum anda menjawab sebarang soalan.*

*Jawab **KESEMUA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

Baca setiap arahan dengan teliti sebelum menjawab.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

Answer ALL questions.

1. (a) Define and sketch geometrical diagrams of the following:

(i) Principle of Reversibility

(ii) Huygen's Principle

(iii) Fermat's principle

(30 marks)

(b) A convex mirror used in a store aisle has a focal length of 60 cm. A person in the aisle is 3.0 m from the mirror.

(i) Calculate the image distance.

(ii) If the boy is 1.8 m tall, how tall is the image viewed in the mirror?

(iii) Consider the result from (i) and (ii), describe, in detail, the image of the boy: is it real or virtual, upright or inverted, magnified or minified?

(40 marks)

(c) The speed of light in a particular piece of glass is 2.0×10^{8} ms^{-1}, and the speed of light in water is 2.3×10^{8} ms^{-1}.

(i) Find the index of refraction of the glass and water.

(ii) If the glass is placed over a tank full of water and laser light from air onto the glass at an angle of incident, 40°, find the critical angle for the light traveling from the glass to the water.

(iii) From the question (ii), determine whether or not the light, passes into the water, and, if it does, find the angle of refraction of the light in the water.

(30 marks)

2. (a) Distinguish between geometrical optics and physical optics and give their respective example.

(20 marks)

(b) Sketch a ray diagram to show the position and the nature of the image formed by a convex lens when the object is placed

(i) at F
(ii) between F and 2F
(iii) beyond 2F

(30 marks)

(c) Two thin lenses having focal lengths of +15.0 cm and –15.0 cm are positioned 60.0 cm apart. A bird stands at 25.0 cm in front of the converging len.

(i) Draw a ray diagram and locate the final image.
(ii) Describe, in detail, the image of the bird: is it real or virtual, upright or inverted, magnified or minified?
(iii) If the bird has 10 cm height, what is the height of its final image?

(50 marks)

3. (a) Briefly explain **TWO** conditions for formation of interference fringes.

(20 marks)

(b) Calculate the minimum thickness of a soap film that results in constructive interference in the reflected light if the film is illuminated with having a wavelength of 600 nm.

(20 marks)

(c)

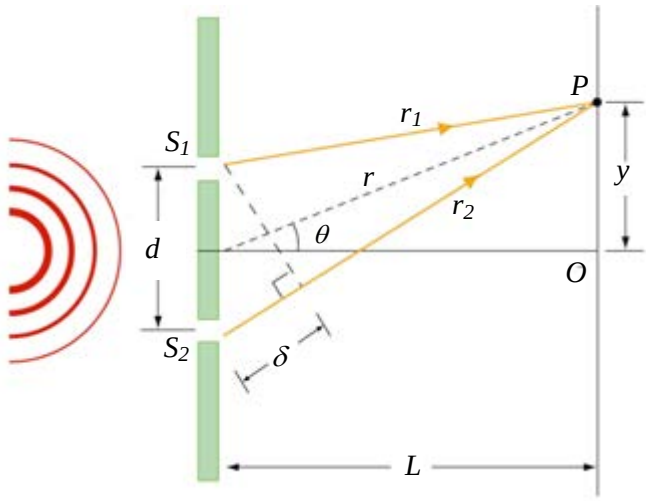


Figure 1

The double-slit interference experiment is shown in Figure 1. Suppose d = 0.100 mm and L = 1.00 m, and the incident light is monochromatic with a wavelength λ = 500 nm,

(i) what is the phase difference between the two waves arriving at a point P on the screen when $\theta = 0.80°$?

(ii) what is the phase difference between the two waves arriving at a point P on the screen when y = 4.00 mm?

(iii) if $\phi = 1 / 3$ rad, what is the value of θ?

(iv) if the path difference is $\delta = \lambda / 4$, what is the value of θ?

(40 marks)

(d) A monochromatic light with a wavelength of λ= 600 nm passes through a single slit which slit width 0.800 mm.

(i) What is the distance between the slit and screen if the first minimum in the diffraction pattern is 1.00 mm from the center of the screen?

(ii) Calculate the width of the central maximum.

(20 marks)

4. (a) (i) Define Fraunhofer Diffraction

(ii) Define Fresnel Diffraction

(iii) State **THREE** differences between Fraunhofer and Fresnel diffractions.

(35 marks)

(b)

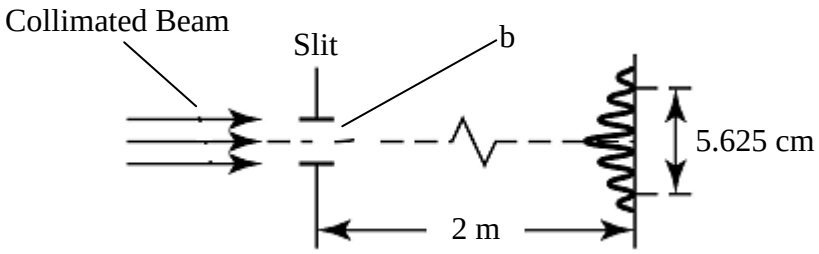


Figure 2

The width of a rectangular slit is measured by means of its diffraction pattern at a distance of 2 m from the slit is shown in Figure 2. When illuminated with a laser beam (λ = 632.8 nm), the distance between the third minima on either side of the principle maximum is measured. An average of several trials gives 5.625 cm.

(i) Assuming Fraunhofer diffraction is in involved, what is the slit width?

(ii) Is the far-field diffraction justified in this case?

(iii) What is the ratio L/L_{min}?

(25 marks)

(c) With the aid of a diagram, explain the '*obliquity factor*' for Huygens' secondary wavelets.

(20 marks)

(d) Using the Fresnel half-zones, describe the Fresnel light diffraction through small circular openings. Illustrate the observations with different aperture sizes.

(20 marks)

5. (a)

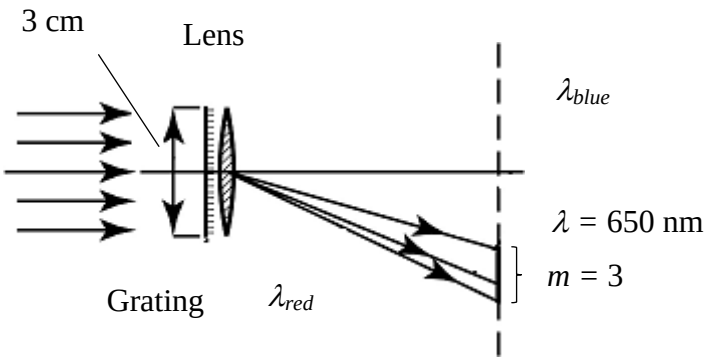


Figure 3

(i) Calculate the dispersion in the wavelength 650 nm for a transmission grating of 3 cm wide, containing 3500 grooves/cm, when it is focused in the third-order spectrum on a screen by a lens of focal length 100 cm.

(ii) Calculate the resolving power of the grating under these conditions.

(30 marks)

(b)

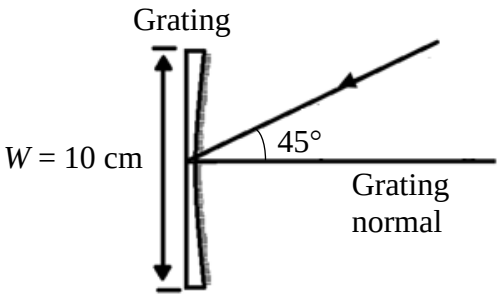


Figure 4

A concave reflection grating of 4 m radius, as shown in Figure 4 is ruled with grooves/mm. Light is incident at an angle of 45° to the central grating normal. Determine, for the first order operation, the (Given $a = 10^{-6}$ m and N = 100, 000 slits)

(i) angular spread about the grating normal of the visible range of wavelengths (400 to 700 nm),

(ii) theoretical resolving power if the grating is width, 10 cm.

(iii) plate factor at wavelength, 550 nm

(iv) radius of the Rowland circle in a Paschen-Runge mounting of the grating.

(40 marks)

(c) The shortest wavelength of light present in a given source is 400 nm. Determine the free spectral range in the first three orders of grating diffraction.

(30 marks)

Jawab SEMUA soalan.

1. (a) *Jelaskan serta lakarkan gambar rajah geometri bagi yang berikut:*

(i) Prinsip Kebolehbalikan

(ii) Prinsip Huygen

(iii) Prinsip Fermat

(30 markah)

(b) *Cermin cembung yang digunakan di lorong kedai mempunyai panjang fokus -60 cm. Seorang budak berada adalah 3.0 m dari cermin tersebut.*

(i) Hitung jarak lokasi imej.

(ii) Jika tinggi budak itu ialah 1.8 m, berapa tinggi imej dilihat dalam cermin?

(iii) Pertimbangkan keputusan daripada (i) dan (ii), jelaskan secara terperinci, imej seseorang itu: adakah ia benar atau maya, tegak atau terbalik, dibesarkan atau dikecilkan.

(40 markah)

(c) *Kelajuan cahaya di dalam sekeping kaca ialah* $2.0\times10^{8}\ ms^{-1}$*, dan kelajuan cahaya di dalam air adalah* $2.3\times10^{8}\ ms^{-1}$.

(i) Cari indeks pembiasan kaca dan air.

(ii) Jika kaca tersebut diletakkan di atas tangki yang penuh dengan air dan cahaya laser dari udara ke kaca pada sudut tuju, 40°, cari sudut genting untuk cahaya bergerak dari kaca ke air.

(iii) Dari soalan (ii), tentukan sama ada cahaya menerusi ke dalam air atau tidak, dan, jika ia berlaku, cari sudut pembiasan cahaya di dalam air.

(30 markah)

2. (a) *Bandingkan antara optik geometri dan optik fizikal dan berikan contoh masing-masing.*

(20 markah)

(b) *Lukiskan rajah sinar untuk menunjukkan kedudukan dan jenis imej yang terbentuk oleh kanta cembung apabila objek diletakkan*

(i) *pada F*

(ii) *antara F dan 2F*

(iii) *luar 2F*

(30 markah)

(c) *Dua kanta nipis yang mempunyai panjang fokus +15.0 cm dan –15.0 cm dijarakkan 60.0 cm. Seekor burung berdiri 25.0 cm di hadapan kanta penumpu.*

(i) *Lukiskan satu rajah sinar dan tentukan kedudukan imej.*

(ii) *Huraikan secara terperinci, imej burung: adakah ia nyata atau maya, tegak atau songsang, besar atau kecil.*

(iii) *Jika burung mempunyai ketinggian 10 cm, apakah ketinggian imej akhir?*

(50 markah)

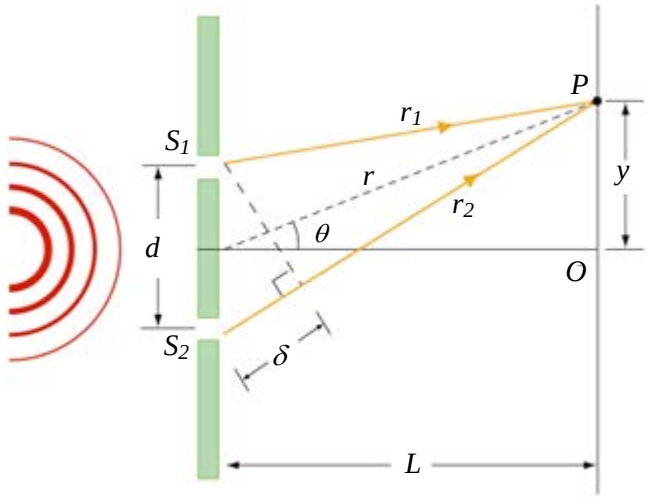
3. (a) *Terangkan secara ringkas* ***DUA*** *syarat bagi pembentukan corak interferens.*

(20 markah)

(b) *Hitung ketebalan minimum saput sabun yang menghasilkan interferens membina dengan cahaya terpantul jika saput itu disinari oleh satu cahaya 600 nm.*

(20 markah)

(c)



Rajah 1

Eksperimen dua celah interferens ditunjukkan Rajah 1, Andaikan d = 0.100 mm dan L = 1.00 m , dan cahaya tuju adalah monokromatik dengan panjang gelombang, λ = 500 nm,

(i) *apakah perbezaan fasa di antara kedua-dua gelombang tiba di titik P pada skrin apabila $\theta = 0.80°$?*

(ii) *apakah perbezaan fasa di antara kedua-dua gelombang tiba di titik P pada skrin apabila y = 4.00 mm?*

(iii) *jika $\phi = 1 / 3$ rad, apakah nilai θ?*

(iv) *jika perbezaan jarak adalah $\delta = \lambda / 4$, apakah nilai θ ?*

(40 markah)

(d) *Satu alur monokromatik dengan panjang gelombang λ = 600 nm melalui celah tunggal dengan lebar celah 0.800 mm.*

(i) *berapakah jarak di antara celah dan skrin jika minimum pertama corak pembelauan 1.00 mm dari pusat skrin?*

(ii) Hitung lebar maksimum pusat.

(20 markah)

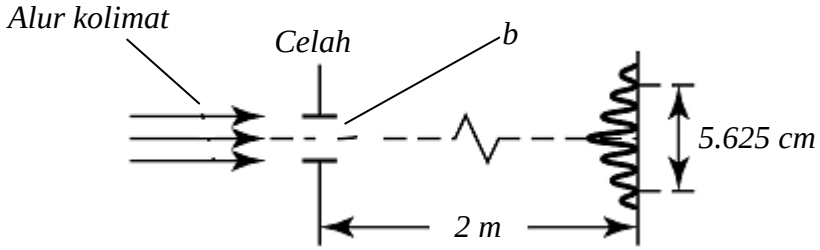
4. (a) (i) Takrif pembelauan Fraunhofer

(ii) Takrif pembelauan Fresnel

*(iii) Nyatakan **TIGA** perbezaan antara pembelauan Fraunhofer dan Fresnel.*

(35 markah)

(b)



Rajah 2

Lebar celah segi empat diukur dalam makmal dengan corak pembelauan pada 2 m dari celah ditunjukkan dalam rajah 2. Apabila alur selari cahaya laser (632.8 nm) disinari secara normal, jarak di antara tertib ketiga minimum pada kedua belah pinggir maksimum diukur. Purata beberapa percubaan bacaan adalah 5.625 cm.

(i) Anggarkan pembelauan Fraunhofer berlaku, berapakah lebar celah?

(ii) Adakah pembelauan medan-jauh wajar dalam kes ini?

(iii) Berapakah nisbah L/L_{min} *?*

(25 markah)

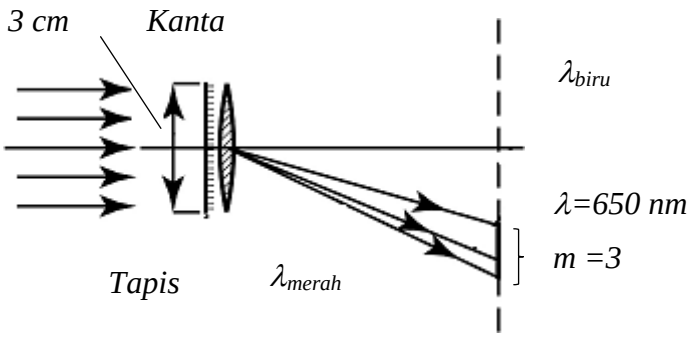
(c) Dengan bantuan gambar rajah, jelaskan 'faktor condongan' bagi gelombang sekunder Huygen.

(20 markah)

(d) *Dengan menggunakan zon-zon setengah kala Fresnel, perihalkan pembelauan Fresnel pada bukaan bulat yang kecil. Jelaskan melalui pemerhatian saiz bukaan yang berlainan.*

(20 markah)

5. (a)



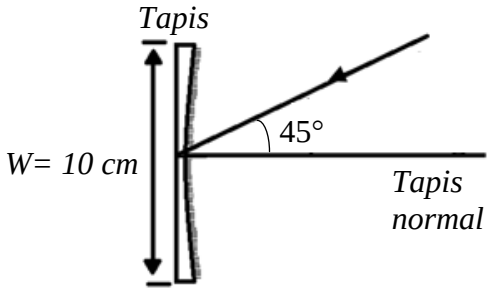
Rajah 3

(i) *Hitungkan sebaran pada gelombang 650 nm untuk satu tapis penghantaran, lebar 3 cm dan mengandungi 3500 garisan/cm jika digunakan dalam spektrum tertib ketiga difokuskan pada skrin oleh kanta berjarak fokus 100 cm.*

(ii) *Hitungkan kuasa peresolusi tapis dalam keadaan ini.*

(30 markah)

(b)



Rajah 4

Satu pantulan penapis cekung berjejari 4 m pada Rajah 4 digaris dengan garisan/mm. Cahaya ditujukan pada sudut 45° secara normal pada pusat tapis. Untuk operasi tertib pertama, tentukan

(Diberi a = 10^{-6} m dan N = 100, 000 celah)

(i) *sebaran sudut secara normal pada gelombang tapis dalam julat cahaya nampak (400 to 700 nm),*

(ii) *teori kuasa peresolusi jika lebar tapis ialah 10 cm,*

(iii) *faktor plat pada gelombang 550 nm,*

(iv) *jejari bulatan Rowland dalam pemasangan tapis Paschen-Runge.*

(40 markah)

(c) *Panjang gelombang terpendek satu cahaya dalam satu sumber tertentu ialah 400 nm. Tentukan julat spektrum bebas bagi tiga tertib pertama pembelauan tapis.*

(30 markah)

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