PRIFYSGOL ABERYSTWYTH UNIVERSITY

ADRAN FFISEG

DEPARTMENT OF PHYSICS

SEMESTER 2 EXAMINATIONS, MAY 2026

PH22010 – Optics

Time allowed – 2 hours

- **Full marks can be attained for complete answers to ALL six questions in Section A and TWO questions from Section B**
- **The numbers in brackets after the questions indicate the allocation of marks for each question.**
- **Only calculators from the Casio FX83, FX85 or FX991 range may be used.**
- **A booklet of mathematical formulae and standard constants will be provided.**
- **Only a 1 side of A4 summary sheet is allowed.**
- **MAE MODD I FYFYRWYR GYFLWYNO ATEBION I'R PAPUR HWN NAILL AI YN Y GYMRAEG NEU'R SAESNEG**
- **STUDENTS MAY SUBMIT ANSWERS TO THIS PAPER IN EITHER WELSH OR ENGLISH**

Once seated, students may complete the front cover of the answer book(s) and the attendance slip ONLY.

DO NOT TURN THE EXAMINATION QUESTION PAPER OVER UNTIL INSTRUCTED TO DO SO.

Section A

Attempt ALL questions in the booklet provided

1 Given the refractive index of the dielectric Silicon nitride is 2.04, calculate: [5]

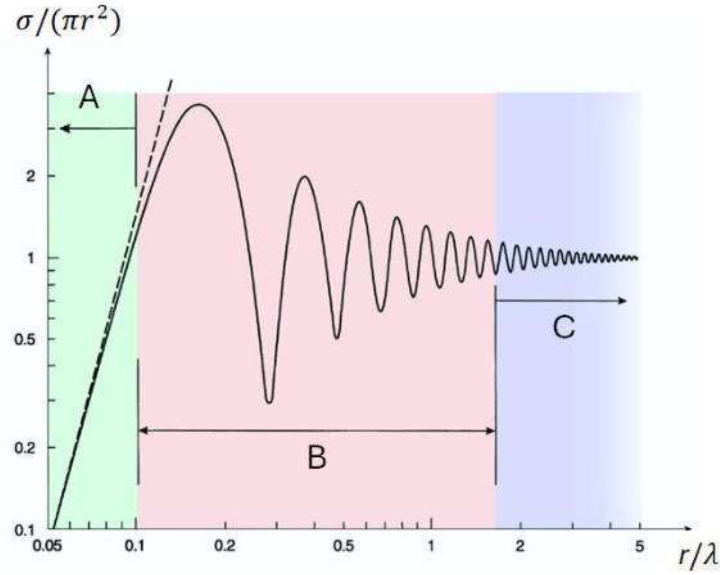
i) The critical angle at a planar dielectric-air interface.

ii) The Brewster angle at the corresponding air-dielectric interface.

2 The figure below shows the light scattering cross-section (σ) from spherical particles as a function of the radius/wavelength ratio (r/λ). [5]

i) State which light scattering mechanisms are predominant in each of the size regimes, marked A, B, and C.

ii) Which regime would be most pertinent when considering the scattering of visible light by gas molecules in the atmosphere?



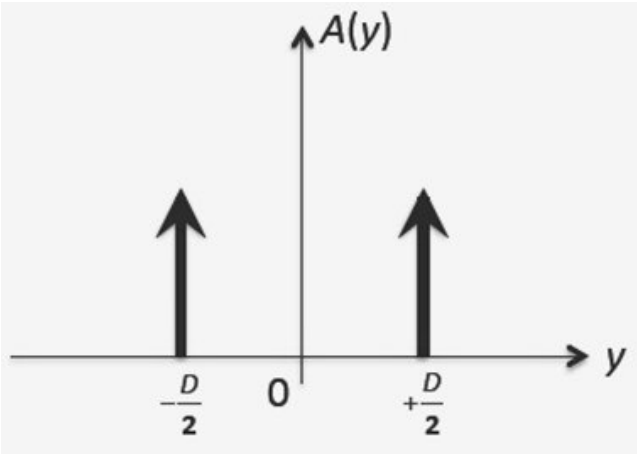
3 Briefly discuss the differences and distinctions between Fresnel and Fraunhofer diffraction. [5]

4 A diffraction grating contains 550 lines per millimetre. For normally incident light (i = 0) of wavelength 600 nm, at what angle would a first order diffraction maximum be observed? For which two angles would a first order diffraction maximum be observed when light is incident at i = 12°? [5]

5 Monochromatic light is normally incident on a system of three identical equally-spaced narrow parallel slits, resulting in a 3-slit interference pattern. [5]

Using appropriate phasor diagrams, determine the relative amplitudes and intensities of the primary and secondary maxima in the pattern, and also the minima.

6 A plane-wave (with wavenumber k) is normally incident in a pair of narrow slits a distance D apart. A suitable aperture function A(y) which describes this system is illustrated below. [5]



Using **Fourier method**, derive an expression for the Fraunhofer pattern from the pair of slits in terms of the spatial frequency parameter q.

(You may find this identity useful: $\cos x = \frac{e^{ix}+e^{-ix}}{2}$)

Section B

Answer TWO questions

7 a) Make a sketch of the *Michelson Interferometer*, illustrating the basic design and operation of the instrument.

[5]

b) In an experiment using a Michelson Interferometer, a fringe pattern is generated and projected onto a screen, using an Argon-ion laser light source, with $\lambda_0 = 488.0$ nm

i) Give a qualitative description of the fringe pattern which will be observed on the screen, and how this will change as the movable mirror is tuned.

[3]

ii) Calculate the distance through which the movable mirror must be tuned in order to progress from the m^{th} to the $(m+1)^{th}$ fringe in the pattern for the λ_0 line.

[2]

iii) In a further coherence experiment, the arms of the instrument are initially set to be of equal length. After the movable mirror has been adjusted by a distance of 0.06 m, the fringe pattern is no longer observable. Briefly explain the physical interpretation of this effect and, hence, calculate a value for the frequency *bandwidth* of the light source.

[5]

8 a) Use a suitably labelled ray diagram to illustrate the operation of a refracting telescope, which uses a converging objective lens and an eyepiece to image a distant object.

[6]

b) Explain what is meant by the *Rayleigh Criterion*. How does this place limitations on the image resolution capability of an astronomical telescope?

[4]

c) The two components of a binary star have an angular separation of 1.5 arc-seconds (or 4.2×10^{-4} degrees) as viewed from Earth. If a refracting telescope with a circular aperture is used to image the star in visible light, calculate the minimum aperture diameter needed in order to clearly resolve the components. State any assumptions made, and give one possible reason why this limiting resolution may not be achieved practically.

[5]

9 a) Using suitable sketches of the electric field vector to illustrate your answers, explain what is meant by the terms *linearly*, *circularly*, and *elliptically* polarised light.

[6]

b) A beryl crystal has ordinary- and extraordinary-ray refractive indices of $n_o = 1.602$ and $n_e = 1.557$ respectively.

i) Calculate the birefringence of the medium, explaining the significance of the sign convention of your answer.

ii) Calculate the thickness of beryl therefore required for a quarter-wave ($\lambda/4$) plate, assuming light of wavelength λ = 550 nm at normal incidence.

[4]

c) Describe the final polarisation state, in each of the cases below, for light at normal incidence on the quarter-wave plate from part (b).

i) Linearly polarised light, with the plate fast-axis at an angle $\theta = 45°$ to the incoming polarisation plane.

ii) Linearly polarised light, with the plate fast-axis parallel ($\theta = 0$) to the incoming polarisation plane.

iii) Linearly polarised light, with the plate fast-axis at an arbitrary angle (between $\theta = 0$ and 45°) to the incoming polarisation plane.

[5]

END OF PAPER