

31.1 Polarisation, analyser chains and phase

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS Malus's law • Brewster angle

Objective

Calculate successive ideal analyser transmissions from the immediate input state; Distinguish linear, circular and elliptical field motion using relative phase; Use Brewster incidence with refractive-index and plane-of-incidence conventions. Original public practice; not an ETS paper.

1 Key knowledge and worked examples

An ideal analyser projects E onto its axis: amplitude $E \cos\theta$, intensity $I \cos^2\theta$. An ideal first filter passes $I_0/2$ for unpolarised input and makes the output linear.

Update polarisation after every filter. Unpolarised input through axes 0° , 45° , 90° gives $I_0/2$, $I_0/4$, $I_0/8$. A middle filter can restore transmission through an otherwise crossed pair.

Equal-amplitude transverse components in quadrature give circular polarisation. Same/opposite phase gives linear; unequal quadrature components give elliptical. A quarter-wave plate needs the appropriate input direction.

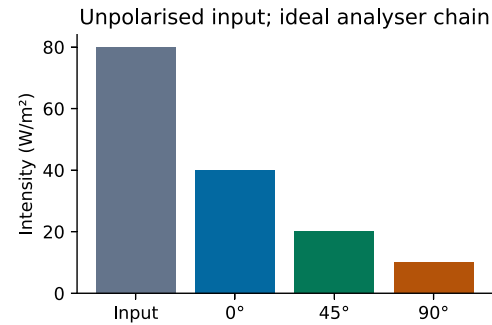
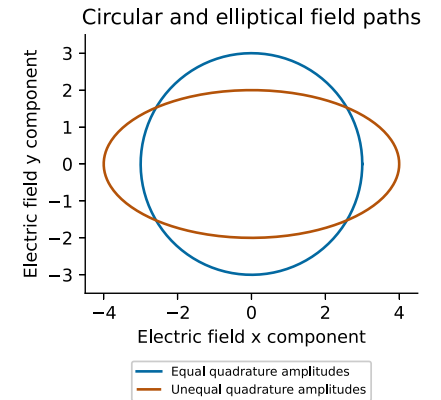
Brewster: $\tan\theta_B = n_2/n_1$ from the normal. Reflected p vanishes; reflected s survives. Use Snell's law for refraction; do not substitute the total-internal-reflection critical-angle rule.

Worked method

An ideal first polariser _____ transmits half of unpolarised incident intensity I_0 . Each later analyser uses the angle from the immediately preceding axis. For axes 0, 30 and 90 degrees,

$$I_f = \frac{1}{2}I_0 \cos^2(30^\circ) \cos^2(60^\circ) = 3I_0/32.$$

The field after each filter points along that filter's axis. Using only the first and last axes would predict zero incorrectly.



2 Practice

2.1 Choose one answer. Unpolarised intensity I_0 passes ideal axes 0° , 30° , 90° . Final intensity is: [1]

- A 0
- B $I_0/8$
- C $3I_0/32$
- D $3I_0/8$
- E $I_0/2$

2.2 Choose one answer. At one point $E_x = 2 \cos\omega t$ and $E_y = 2 \sin\omega t$. The polarisation is: [1]

- A Linear along x
- B Linear at 45°
- C Circular
- D Unpolarised
- E Longitudinal

2.3 Polarised input intensity 24 W/m^2 meets an ideal analyser at 60° . Output is _____ W/m^2 . Show your relation and units. [2]

2.4 Decide whether this claim is true. Justify it: At Brewster incidence for the ideal dielectric model, reflected light from unpolarised input is polarised perpendicular to the plane of incidence. [2]

3 Exam-style questions

3.1 Insert one ideal analyser at angle θ between two crossed ideal polarisers. Derive final intensity for unpolarised input I_0 and find the angle giving maximum output. Compare with removing the middle analyser. [4]