AP PHYSICS 2 • EXERCISE SHEET

13.3 Refraction

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS refraction 折射 • index of refraction 折射率 • total internal reflection 全内反射 • snell's law 斯涅尔定律

Objective

Build the skills to answer exam questions on **refraction**.

You must be able to:

- explain **refraction** 折射 as a change in the speed and direction of light at a boundary
- apply **Snell's law** 斯涅尔定律 $n_1 \sin\theta_1 = n_2 \sin\theta_2$ using the index of refraction
- describe **total internal reflection** 全内反射 and calculate the critical angle

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Refraction

Light changes **speed** at a boundary, so its direction bends — toward the normal entering a **denser** medium (higher n).

■ Snell's law

$n_1 \sin\theta_1 = n_2 \sin\theta_2$, with the angles measured from the normal.

■ Total internal reflection

Going from dense to less dense, beyond the **critical angle** ($\sin\theta_c = n_2/n_1$) all the light reflects back inside.

2 Practice

2.1 Light passes from air ($n = 1.0$) into glass ($n = 1.5$) at 40° to the normal. Find the angle of refraction. [2]

2.2 State what happens to the speed of light entering a denser medium. [1]

2.3 State the condition for total internal reflection to occur. [1]

3 Exam-style questions

3.1 Snell's law is [1]

- **A** $n_1 \sin\theta_1 = n_2 \sin\theta_2$
- **B** $n_1\theta_1 = n_2\theta_2$
- **C** $\sin\theta = n$
- **D** $n = c/v$ only

3.2 Total internal reflection occurs when light travels [1]

- **A** from less dense to more dense at any angle
- **B** from more dense to less dense above the critical angle
- **C** exactly along the normal
- **D** through a vacuum

3.3 Light passes from water ($n = 1.33$) toward air ($n = 1.0$).

(a) Find the critical angle. [3]

(b) State what happens to light striking the surface above this angle. [1]

Solutions

2.1 $\sin\theta_2 = \dfrac{n_1 \sin\theta_1}{n_2} = \dfrac{1.0 \sin 40^\circ}{1.5} = 0.428 \Rightarrow \theta_2 = 25^\circ$.

2.2 it decreases.

2.3 the light must go from a denser to a less dense medium at an angle above the critical angle.

3.1 A.

3.2 B.

3.3 (a) $\sin\theta_c = \dfrac{n_2}{n_1} = \dfrac{1.0}{1.33} = 0.752 \Rightarrow \theta_c = 48.8^\circ$. (b) it is totally internally reflected.