Optics

WORKSHEET #1

Name: _____

1. A projectile is fired at an angle of 28.0° to the horizon. Its initial velocity is 298 m/s. What is the range of the projectile?

$v_{vert} = 298\ m/s \cdot \sin(28.0°) = 139.9025257\ m/s$, $v_{horiz} = 298\ m/s \cdot \cos(28.0°) = 263.1183827\ m/s$

$v = v_i + at$

$t = -2v_i / a = -2 \cdot 139.9025257\ m/s / -9.8\ m/s^2 = 28.55153586\ s$

$d_{horix} = v_{horiz} \cdot t = 263.1183827\ m/s \cdot 28.55153586\ s = 7512.433938\ m =$ **7510 m or 7.51 km**

2. A beam of light with a wavelength of 575 nm while traveling in air is incident on a slab of material. The angle of incidence is 28.0°. The refracted beam makes an angle of 20.4°. Find (a) the index of refraction for the slab and (b) the wavelength of the light in the slab.

a. $n_1\sin(\theta_1) = n_2\sin(\theta_2)$

$1.0003 \cdot \sin(28.0°) = n_2 \cdot \sin(20.4°)$

$n_2 = 1.0003 \cdot \sin(28.0°) / \sin(20.4°) = 1.3472463 =$ **1.35**

b. $c = n_1v_1 = n_1\lambda_1 f$ $\quad c = n_2v_2 = n_2\lambda_2 f$

$n_2\lambda_2 = n_1\lambda_1$

$\lambda_2 = n_1\lambda_1 / n_2 = 1.0003 \cdot 575\ nm / 1.3472463 = 426.9245349\ nm =$ **427 nm**

3. A beam of laser light, wavelength 678.8 nm in air, is incident on a block of polystyrene at an angle of 29.7°. Find (a) the angle of refraction and (b) the wavelength of the light in the plastic.

a. $n_1\sin(\theta_1) = n_2\sin(\theta_2)$

$1.0003 \cdot \sin(29.7°) = 1.57 \cdot \sin(\theta_2)$

$\theta_2 = \sin^{-1}(1.0003 \cdot \sin(29.7°)/1.57) = 18.4014737° =$ **18.4°**

b. $n_2\lambda_2 = n_1\lambda_1$

$\lambda_2 = n_1\lambda_1/n_2 = 1.0003 \cdot 678.8\ nm / 1.57 = 432.4863949\ nm =$ **432 nm**

4. A light wave with a wavelength of 612 nm in a vacuum travels through a bit of fused quartz which has an index of refraction of *n* =1.458. Find the speed of light in the quartz.

$n_{quartz} = c/v_{quartz}$
$v_{quartz} = c/n_{quartz} = 3.00\times10^8$ m/s / 1.458 = 205 761 316.87 m/s = $\boxed{2.06\times10^8 \text{ m/s}}$

5. Find the speed of light in (a) flint glass, (b) water, and (c) zircon.

a. $v_{flint} = c/n_{flint} = 3.00\times10^8$ m/s / 1.65 = 181 818 181.82 m/s = $\boxed{1.82\times10^8 \text{ m/s}}$
b. $v_{water} = c/n_{water} = 3.00\times10^8$ m/s / 1.33 = 225 563 909.77 m/s = $\boxed{2.26\times10^8 \text{ m/s}}$
c. $v_{zircon} = c/n_{zircon} = 3.00\times10^8$ m/s / 1.94 = 154 639 175.26 m/s = $\boxed{1.55\times10^8 \text{ m/s}}$

6. Light of wavelength 436 nm in air enters a fishbowl filled with water, then exits through the crown-glass wall of the container. Find the wavelengths of the light in (a) the water and (b) the crown glass.

a. $\lambda_2 = n_1\lambda_1 / n_2 = 1.0003 \cdot 436$ nm / 1.33 = 327.9178947 nm = $\boxed{328 \text{ nm}}$
b. $\lambda_3 = n_1\lambda_1 / n_3 = 1.0003 \cdot 436$ nm / 1.52 = 286.9281579 nm = $\boxed{287 \text{ nm}}$

7. A 589 nm beam of light is incident on the surface of some clean ice at an angle of 40.0° with the normal. Part of the light is reflected and part is refracted. Find the angle between the reflected and refracted light.

$\theta_{reflection} = \theta_{incidence} = 40.0°$
$n_2\sin\theta_2 = n_1\sin\theta_1$
$\sin\theta_2 = n_1\sin\theta_1 / n_2 = 1.0003 \cdot \sin(40.0°) / 1.31 = 0.4908247679$
$\theta_2 = \sin^{-1}(0.4908247679 = 29.3948056°$
$\theta = 180.0° - 40.0° - 29.3948056° = 110.6051944° = \boxed{110.6°}$