Optics

WORKSHEET #3

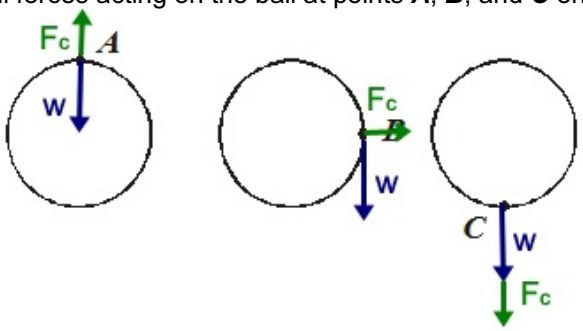
Name: _____

1. A ball is rotated in a vertical circle as shown. The ball has a mass of 1.50 kg, the very light-weight string is 85.0 cm in length. The ball's velocity at the top is the minimum speed needed to maintain the circular path. (a) What is this minimum speed?

a. $mv^2/r = mg$

$v = (gr)^{\frac{1}{2}} = (9.8\ m/s^2 \cdot 0.850\ m)^{\frac{1}{2}} = 2.8861739\ m/s =$ **2.89 m/s**

(b) Draw and label all forces acting on the ball at points ***A***, ***B***, and ***C*** on the drawing below.



(c) What will be the tension in the string when the ball is at point ***A***? (d) What will be the tension at point ***B***? (e) What will be the tension at point ***C***?

c. $T = w - F_c = mg - mv^2/r = 1.5\ kg \cdot 9.8\ m/s^2 - 1.5\ kg \cdot (2.8861739\ m/s)^2 / 0.85\ m =$ **0 N**

d. $T = F_c = mv^2/r = 1.5\ kg \cdot (2.8861739\ m/s)^2 / 0.85\ m =$ **14.7 N**

e. $T = w + F_c = 1.5\ kg \cdot 9.8\ m/s^2 + 1.5\ kg \cdot (2.8861739\ m/s)^2 / 0.85\ m =$ **29.4 N**

2. A beam of light, wavelength 585 nm in air, is incident on a block of crown glass at an angle of 28.5°. Find (a) the speed of light in the glass (b) the angle of refraction and (c) the wavelength of the light in the glass.

a. $n = c/v$

$v = c/n = 3.00\times10^8\ m/s / 1.52 = 1.97368421\times10^8\ m/s =$ **1.97×10^8 m/s**

b. $n_2\sin\theta_2 = n_1\sin\theta_1$

$\theta_2 = \sin^{-1}(n_1\sin\theta_1 / n_2) = \sin^{-1}(1.0003 \cdot \sin(28.5°)/1.52) = 18.301325° =$ **18.3°**

c. $\lambda_2 = n_1\lambda_1$

$\lambda_2 = n_1\lambda_1/n_2 = 1.0003 \cdot 585\ nm / 1.52 = 384.9838816\ nm =$ **385 nm**

3. An AM radio signal is broadcast at a frequency of 1319 kHz. (a) What is its wavelength? (b) What is the period of the wave?

a. $\lambda = c/f = 3.00\times10^{8}$ m/s / 1319×10^{3} Hz = 227.4450341 m = **227 m**

b. $T = 1/f = 1/1319$ kHz = 7.581501137×10^{-7} s = **0.758 μs**

4. A screen is separated from a double-slit setup by a distance of 2.15 m. The slit spacing is 0.0150 mm. The first-order maximum is 4.05 cm from the centerline. Find (a) the wavelength, (b) the distance between adjacent fringes.

a. $x = m\lambda L/d$

$\lambda = xd/mL = (1.50\times10^{-5}\text{ m})(4.05\times10^{-2}\text{ m}) / (1 \cdot 2.15\text{ m}) = 2.82558\times10^{-7}$ m = **283 nm**

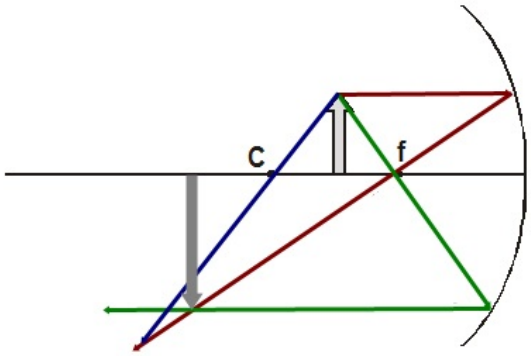
b. **4.05 cm** (maxima are equidistant)

5. Find the minimum film thickness for constructive interference in reflected light for a thin film. The film's index of refraction is 1.45. It is illuminated by light that has wavelength of 585 nm.

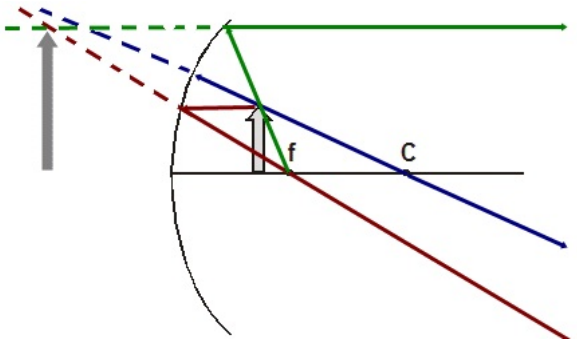
$2t = \frac{1}{2}\lambda_f = (1/(2n))\lambda$

$t = (1/(4n))\lambda = (1/(4\cdot1.45))585\text{ nm} = 100.862\text{ nm}$ = **101 nm**

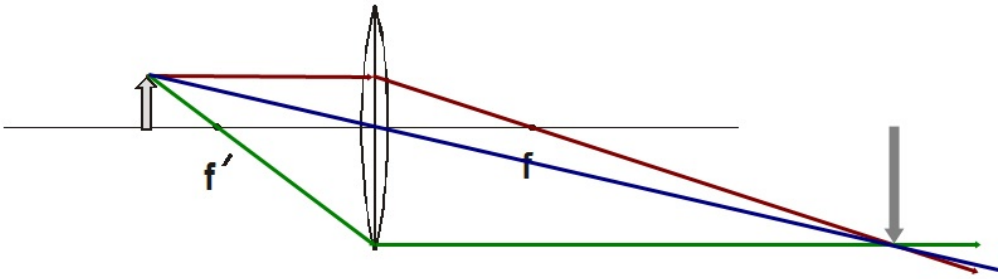
6. Construct the image on the drawing below via ray tracing.



7. Construct the image on the drawing below via ray tracing.



8. Construct the image for an object placed as shown below.



9. A double convex thin lens has a focal length of 50.0 cm. A 2.70 cm tall object is placed 18.0 cm from the lens, find (a) the image distance, (b) the magnification, (c) the image height.

a. $d_o^{-1} + d_i^{-1} = f^{-1}$
$(18\text{ cm})^{-1} + d_i^{-1} = (50\text{ cm})^{-1}$
$d_i = ((50\text{ cm})^{-1} - (18\text{ cm})^{-1}) = -28.125\text{ cm} =$ **-28.1 cm**

b. $M = -d_i/d_o = -(-28.125\text{ cm} / 18.0\text{ cm}) = 1.5625 =$ **1.56**

c. $h_i = M \cdot h_o = 1.5625 \cdot 2.70\text{ cm} = 4.21875\text{ cm} =$ **4.22 cm**