## Physics 111 Homework for Friday 2/20/2015

## Tuesday, February 17, 2015

Chapter 20
Questions

- none


## Multiple-Choice

- none


## Problems

20.15 We find the critical angle from
$n_{1} \sin \theta_{1}=n_{2} \sin \theta_{2} \rightarrow n_{1} \sin \theta_{c}=n_{2} \sin 90 \rightarrow \sin \theta_{c}=\frac{1.00}{1.33} \rightarrow \theta_{c}=48.8^{\circ}$. The radius of the ring of light is given from $r=d \tan \theta_{c}=8^{\prime} \tan 48.8=9.1^{\prime}$
20.16 We use Snell's Law with $n_{\text {water }} \sin \theta_{1}=n_{\text {air }} \sin \theta_{2} \rightarrow 1.33 \sin \theta_{1}=\sin \theta_{2}$. Defining $x$ as the distance from the normal to the surface to where the ray originates, we can express $\theta_{1}$ in terms of $d$ and $x$ and $\theta_{2}$ in terms of $x$ and $d^{\prime}$ as follows: $\tan \theta_{1}=\frac{x}{d}$ and $\tan \theta_{2}=\frac{x}{d^{\prime}}$. Since the angles involved are small, we can use the small angle approximation to get $\sin \theta_{1} \approx \tan \theta_{1}=\frac{x}{d} \rightarrow x=d \sin \theta_{1}$ and
$\sin \theta_{2} \approx \tan \theta_{2}=\frac{x}{d^{\prime}} \rightarrow x=d^{\prime} \sin \theta_{2}$. Therefore,
$x=d \sin \theta_{1}=d^{\prime} \sin \theta_{2}=d^{\prime} \frac{n_{\text {water }}}{n_{\text {air }}} \sin \theta_{1}$. Thus the apparent depth is given as $d^{\prime}=\frac{n_{\text {air }}}{n_{\text {water }}} d$. A ray diagram is shown below.

20.17 From the diagram below we apply Snell's Law at the upper surface where we want the ray to strike at the critical angle. We have therefore
$n_{p i p e} \sin \theta_{c}=n_{\text {air }} \sin 90=1.0 \sin 90 \rightarrow \theta_{c}=\sin ^{-1}\left(\frac{1.00}{1.30}\right)=50.3^{\circ}$. From the geometry we see that the angle of refraction of light off of the front surface of the pipe, $\alpha$ is $\alpha=90^{\circ}-\theta_{c}=90^{\circ}-50.3^{\circ}=39.7^{\circ}$. Therefore $\theta$ can be found by applying Snell's Law on the front surface and we have

$$
n_{\text {air }} \sin \theta=n_{p \dot{p e}} \sin \alpha \rightarrow \theta=\sin ^{-1}\left(\frac{n_{p i p e} \sin \alpha}{n_{\text {air }}}\right)=\left(\frac{1.30 \sin 39.7}{1.00}\right)=54.2^{\circ} .
$$



## Wednesday, February 18, 2015

## Chapter 21

## Questions

21.5 A plane mirror reverses left and right but not up and down. A converging lens when it produces a real image reverses up and down (if the object is upright, it's image is inverted.) This is one difference between the lens and the plane mirror. However, the converging lens also reverses left and right. To see this draw a ray diagram and see where the lines go. This is the same as the plane mirror.
21.12 See class notes for the explanation.

## Multiple-Choice

21.1 B
21.2 A
21.3 D
21.4 A
21.5 B
21.6 C
21.7 A
21.17 C

## Problems

21.1 Since the sun is essentially at infinity, the image distance is the focal length of the lens, which is 24 cm . Thus, the power $P=\frac{1}{f}=\frac{1}{0.24 m}=4.2 \mathrm{D}$.
21.2 Since the focal length of the lens is $-0.2 \mathrm{~m}\left(P=\frac{1}{f} \rightarrow f=\frac{1}{P}=\frac{1}{-5 D}=-0.2 \mathrm{~m}\right)$, using the lens equation we have
$\frac{1}{f}=\frac{1}{d_{o}}+\frac{1}{d_{i}} \rightarrow \frac{1}{-0.2 m}=\frac{1}{0.12 m}+\frac{1}{d_{i}} \rightarrow d_{i}=-0.075 \mathrm{~m}=-7.5 \mathrm{~cm}$. The image is
virtual, located 7.5 cm behind the lens on the same side as the object. Compared to the insect's size as seen at the near point (taken to be 25 cm ), the magnification is $M=\frac{25 \mathrm{~cm}}{f}=\frac{25 \mathrm{~cm}}{20 \mathrm{~cm}}=1.25$. A ray diagram follows:

21.5 To focus on objects very far away, use $d_{o}=\infty$ and then $d_{i}=f=d=4 \mathrm{~cm}$. So the camera is designed to focus at infinity with no extension of the lens. Then to focus on an object at do $=50 \mathrm{~cm}$, we need $\frac{1}{50}+\frac{1}{4+x}=\frac{1}{4}$, where we have used $f$ $=4 \mathrm{~cm}$ and the image is now located at $4+x$. Solving for $x$, we find $x=0.35 \mathrm{~cm}$.
21.7 A creature swimming in a dish
a. The focal length is given by the thin lens equation
$\frac{1}{f}=\frac{1}{d_{o}}+\frac{1}{d_{i}}=\frac{1}{0.36 m}+\frac{1}{4.5 m} \rightarrow f=0.33 \mathrm{~m}$.
b. The velocity of the creature is magnified by the lens. Thus the magnification is $M=\frac{-d_{i}}{d_{0}}=\frac{-4.5}{0.36}=-12.5$. Thus the magnitude of the velocity on the screen is magnified by this same factor. In the dish the velocity is $1 \mathrm{~cm} / \mathrm{s}$ therefore the velocity on the screen is $12.5 \mathrm{~cm} / \mathrm{s}$.

