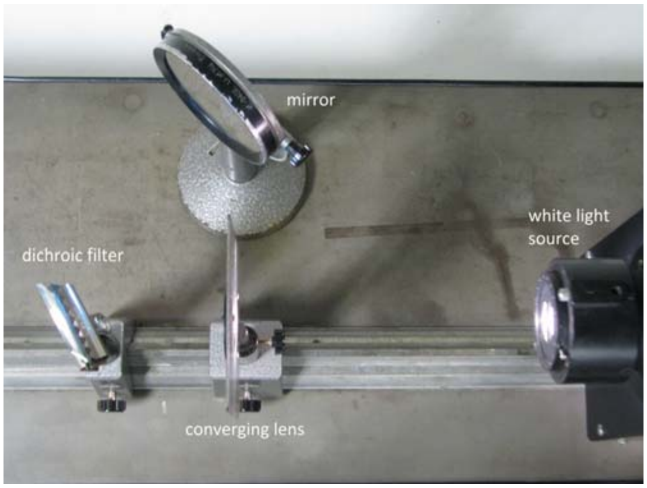
Question #361

We pick up where we left off this week with a follow-up color mixing question to Question #360.

This week's apparatus consists of a white light source, a *dichroic* filter, specifically designed to pass yellow light, and an ordinary mirror. Below are pictures of the side- and top-view of the setup, each of which can be clicked on to be viewed in more detail.

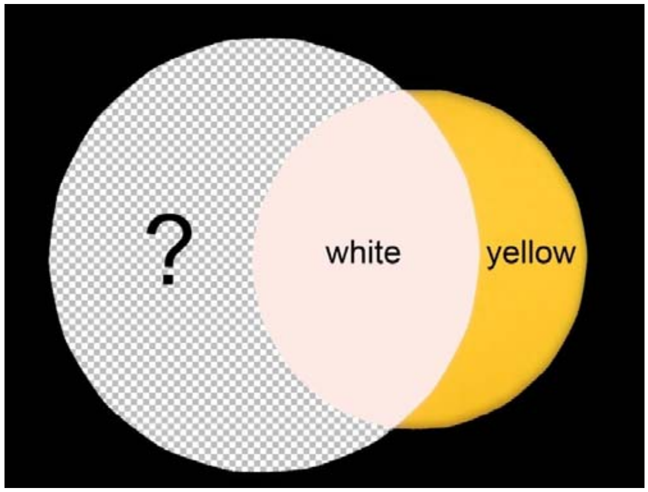


Dichroic filters are like their other color-filter brethren in that they are negative filters and they remove frequencies from being transmitted, like paints and pigments. However, rather than *absorbing* these frequencies (like how your skin does on a hot day) dichroic filters *reflect* them backwards so that they are not absorbed in the filter, according to the law of reflection. Thus, if we position the mirror correctly, we can reflect the filtered color back onto the screen!

First, with the mirror removed, we observe this particular dichroic filter passes a deeply saturated yellow, just as advertised.

When the mirror is placed correctly and the two colors combine, they recreate the original color of the light source -- white!

Question: It seems easy, but so did Question #360. What color is reflected by the dichroic filter above?



- (a) The reflected color is purple. Since dichroic filters create negative colors, yellow + purple = white.
- (b) The reflected color is blue. Light mixing uses additive colors; yellow + blue = white.
- (c) The reflected color will be a shade of orange; since yellow is a mixture of red and green (using additive colors), the dichroic will reflect some red and some green (but not exactly yellow).
- (d) You can't fool me now! There is not enough information given to determine the answer.

Click here for Answer #361 after February 1, 2010.

Question of the Week

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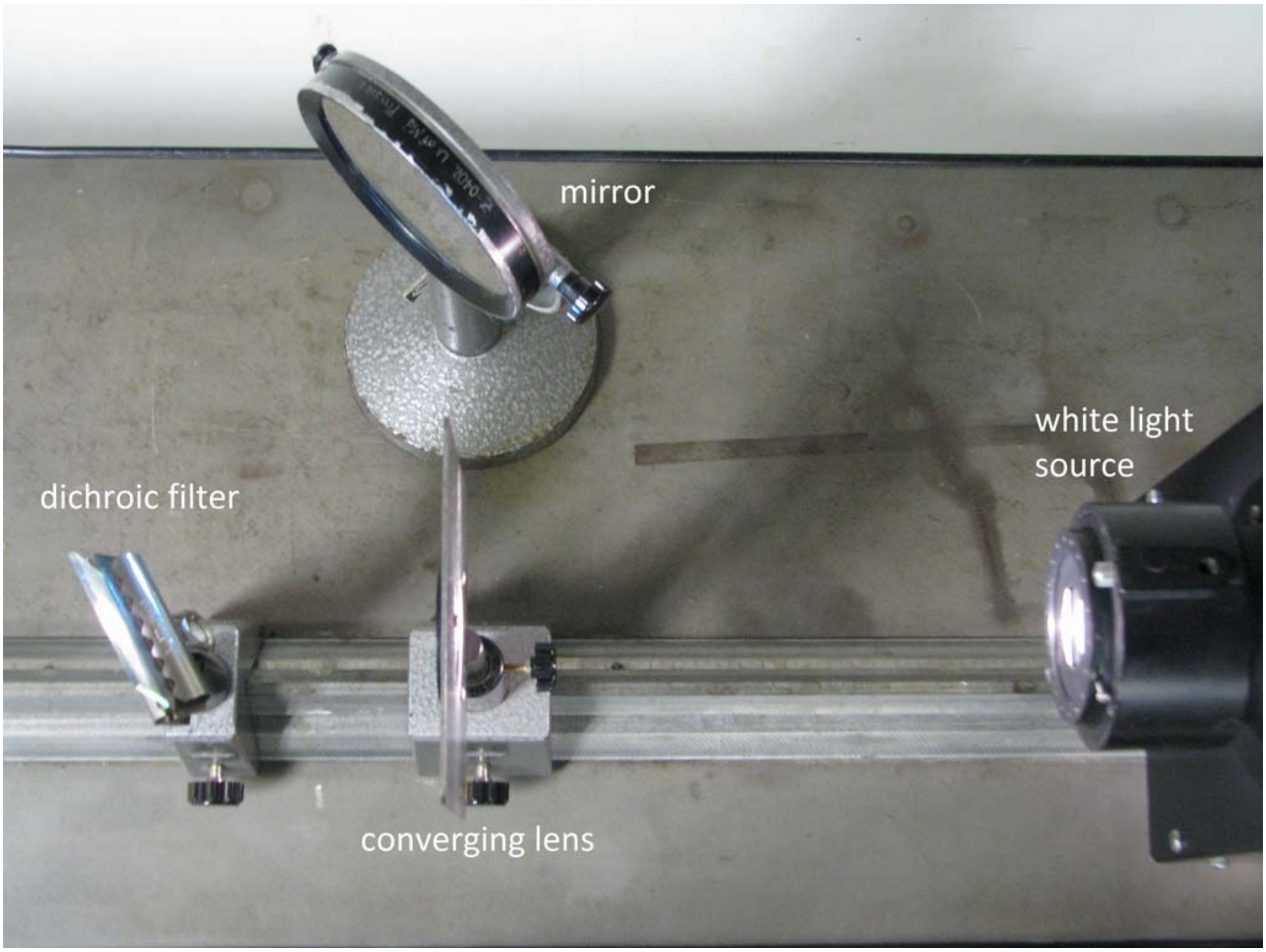
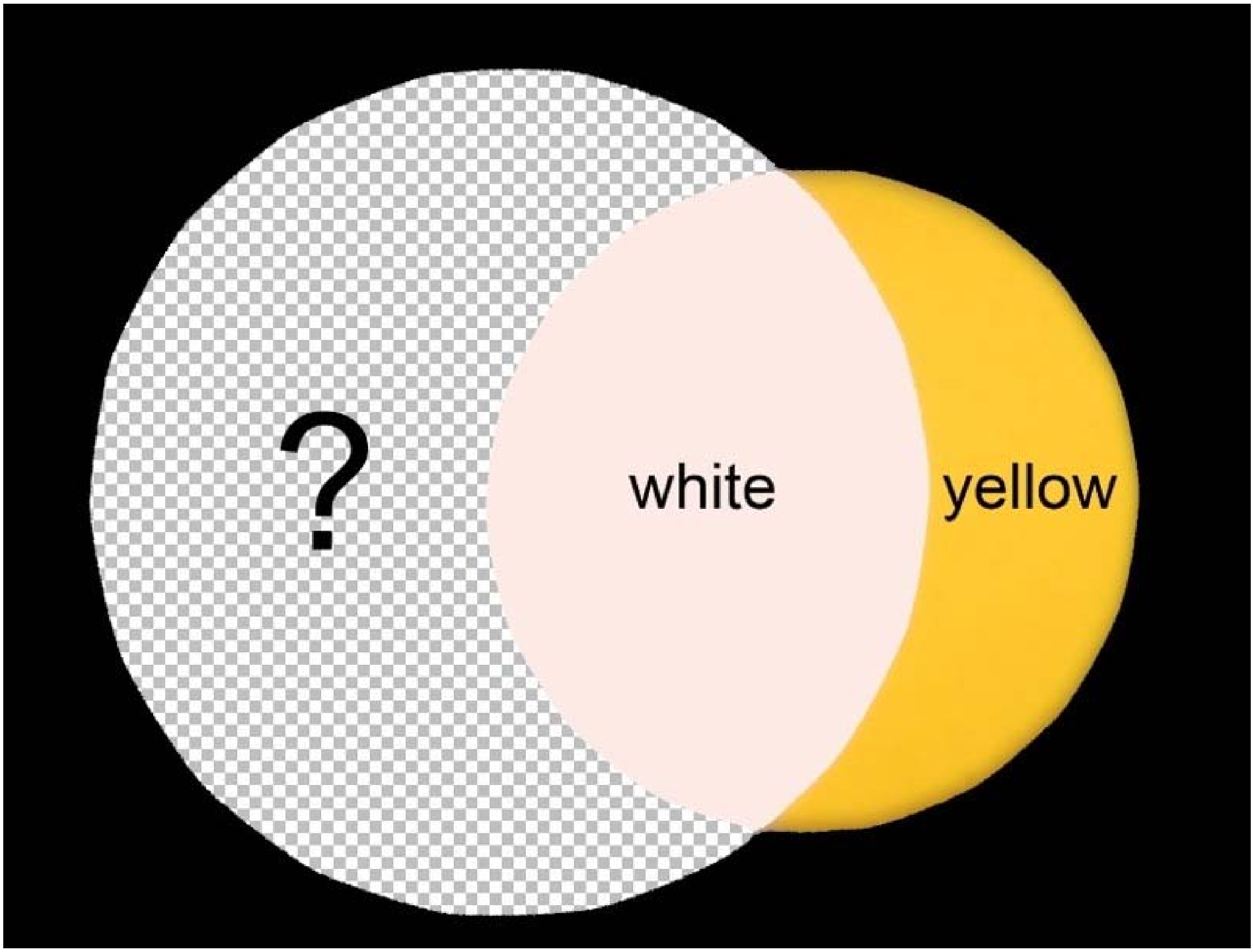
For questions and comments regarding the *Question of the Week* contact
Dr. Richard E. Berg by e-mail or using phone number or regular mail address
given on the Lecture-Demonstration Home Page.

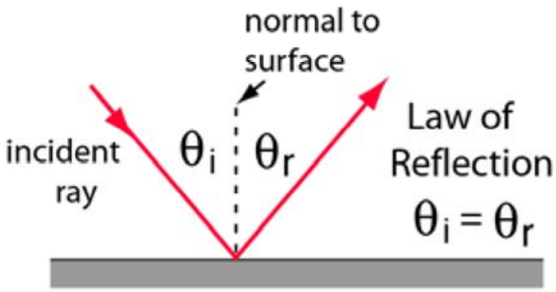

white
light
source
mirror
YELLOW
dichroic
filter
converging
lens

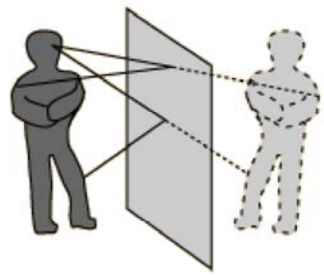

mirror
white light
source
dichroic filter
converging lens


?
white
yellow

Law of Reflection

A light ray incident upon a reflective surface will be reflected at an angle equal to the incident angle. Both angles are typically measured with respect to the normal to the surface. This law of reflection can be derived from Fermat's principle.





The law of reflection gives the familiar reflected image in a plane mirror where the image distance behind the mirror is the same as the object distance in front of the mirror.

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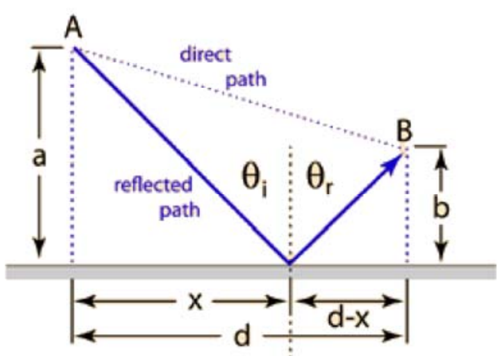
Reflection concepts

Mirror concepts

Fermat's Principle: Light follows the path of least time. Of course the straight line from A to B is the shortest time, but suppose it has a single reflection. The law of reflection can be derived from this principle as follows:



The pathlength from A to B is

$$L = \sqrt{a^2 + x^2} + \sqrt{b^2 + (d-x)^2}$$

Since the speed is constant, the minimum time path is simply the minimum distance path. This may be found by setting the derivative of L with respect to x equal to zero.

$$\frac{dL}{dx} = \frac{1}{2}\frac{2x}{\sqrt{a^2 + x^2}} + \frac{1}{2}\frac{2(d-x)(-1)}{\sqrt{b^2 + (d-x)^2}} = 0$$

This reduces to $$\frac{x}{\sqrt{a^2+x^2}} = \frac{(d-x)}{\sqrt{b^2+(d-x)^2}}$$ which is $$\sin\theta_i = \sin\theta_r$$

$$\theta_i = \theta_r$$ **Law of Reflection**

This derivation makes use of the calculus of maximum-minimum determination, the derivative of a square root, and the definitions of the triangle trig functions.

Fermat's Principle for Refraction

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Fermat's Principle and Refraction

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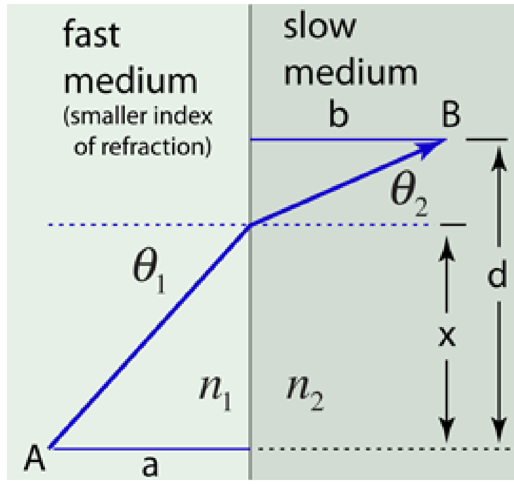
Reference
Meyer-Arendt

Fermat's Principle: Light follows the path of least time. Snell's Law can be derived from this by setting the derivative of the time =0. We make use of the index of refraction, defined as n=c/v.

$$t = \frac{\sqrt{a^2+x^2}}{v} + \frac{\sqrt{b^2+(d-x)^2}}{v'}$$

$$\frac{dt}{dx} = \frac{x}{v\sqrt{a^2+x^2}} - \frac{(d-x)}{v'\sqrt{b^2+(d-x)^2}}$$

$$0 = \frac{\sin\theta_1}{v} - \frac{\sin\theta_2}{v'}$$



Snell's Law

$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1}$$

This derivation makes use of the calculus of maximum-minimum determination and the definitions of the triangle trig functions.

Fermat's Principle for Reflection