PHYS-115(3) (Kaldon-16406) **Name** _____
WMU - Winter 2001
Exam 3 - 100,000 points **Book Title** _____
Section: **3a** A to F **3b** G to M **3c** N to S **3d** T to Z 03/28/2001•Rev.4

State Any Assumptions You Need To Make -- Show All Work -- Circle Any Final Answers
Use Your Time Wisely - Work on What You Can - Be Sure to Write Down Equations
BOLDFACE Variables Are Vectors - Feel Free to Ask Any Questions

Track 7 • Any Colour You Like PINK FLOYD—THE DARK SIDE OF THE MOON (50,000 points)

1.) (a) For a particular kind of glass, $n_2 = 1.55$. If light came in from the air side, $n_1 = 1.00$, at an angle $\theta_1 = 45°$, then find the angle θ_2.

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

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

$$\theta_2 = \sin^{-1}\left(\frac{n_1 \sin\theta_1}{n_2}\right) = \sin^{-1}\left(\frac{1.00 \sin 45°}{1.55}\right) = 27.1°$$

(b) If you could see the Pink Floyd *The Dark Side of the Moon* CD cover in color, the white ray at the left splits in colored rays (ROYGBIV) with *red* at the top and *violet* at the bottom. This is due to the phenomena called *dispersion*. If the index of refraction for red light is $n_{red} = 1.5500$ and violet light is it $n_{violet} = 1.5656$, explain whether the order of colors as shown on the CD cover is correct or inverted.

Violet light has the larger index of refraction, so at the air-to-glass interface, the angle in the glass is LESS than the red light (and so comes in lower in the diagram). So when it arrives at the edge of the glass, it comes it at a larger angle to the normal, so it gets bent MORE than red light in air (and it is still lower in the diagram).

So the CD cover is CORRECT.

(c) Given the information in (a) and (b), briefly explain whether the picture on the CD cover is accurate or flawed. You may wish to do a couple of calculations to prove your point. Do not write long paragraphs – make short comments that are easy to read. Use the Worksheet on Page 5 if you need more room.

RED $$\theta_c = \sin^{-1}\left(\frac{n_1}{n_2}\right) = \sin^{-1}\left(\frac{1.00}{1.55}\right) = 40.2°$$

VIOLET $$\theta_c = \sin^{-1}\left(\frac{1.00}{1.5656}\right) = 39.7°$$

We can find the Critical Angle going from glass back to air, and by eyeballing the picture, the angles appear less that these. And the angles in air are all larger than their counterparts in the glass, so the CD cover is ACCURATE.

(d) Before there were Compact Disc players, we had things called "albums" and "LP records". People I knew in the dorm at Northwestern University would play *The Dark Side of the Moon* on their huge speakers at 300 W. With the speakers blasting that loud, find the current in the speaker wire at 12.0 V.A.C. and find how much current that represents coming from the 120. V.A.C. electrical outlet.

$$P = IV$$

$$I = \frac{P}{V} = \frac{300.W}{12.0V} = 25.0A$$

$$I = \frac{300.W}{120.V} = 2.50A$$

(e) With the primary side of a transformer at 120. V.A.C. and the secondary side at 12.0 V.A.C., find the number of windings on the primary side if there are 100. windings on the secondary side.

$$N_1V_1 = N_2V_2$$

$$N_1 = \frac{N_2V_2}{V_1} = \frac{(100.)(12.0V)}{(120.V)} = 10.turns$$

Time to Get Serious About Starship and Keanu Reeves? (50,000 points)

2.) Sirius – the Dog Star – is 8.60 light years from Earth. (a) How many meters is this?

$$d = ct$$

$$= (2.998 \times 10^8 m/s)(8.60 years)(365.25 days/year)$$

$$(24 hour/day)(3600 \sec/hour)$$

$$= 8.136 \times 10^{16} m$$

Sir·i·us (sĭr′ē-əs) *noun*
A star in the constellation Canis Major, the brightest star in the sky, approximately 8.6 light-years distant from Earth. Also called *Dog Star, Sothis.*
[Latin *Sīrius*, from Greek *Seirios*, from *seirios*, burning.]

Dogstar / Happy Ending

(b) The Jefferson Starship is heading to Sirius at a speed of 0.860 that of light. How many years will they think the trip takes?
(This is the Classical Physics answer – when we do Special Relativity, you'll see this answer gets complicated.)

$$d = vt$$

$$t = \frac{d}{v} = \frac{8.136 \times 10^{16} m}{0.860\left(2.998 \times 10^{8} m/s\right)} = 315{,}600{,}000 \sec$$

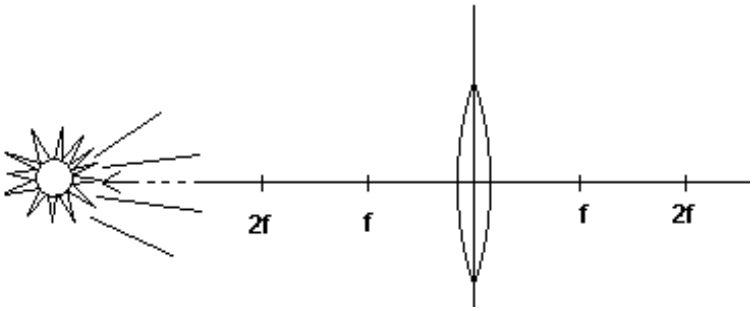
OR $$t = \frac{d}{v} = \frac{8.60 LY}{0.860c} = 10.00 years$$

(c) Show that Music Impresario Dick Clark sees the same amount of time pass on the Earth whether you use the distance as seen from Earth or convert the time as seen on the Jefferson Starship.

We haven't done Special Relativity Yet.

Jefferson Airplane / Freedom at Point Zero

(d) The light from Sirius shines on a lens with a focal length $f = 10{,}000.\ mm = 10.0\ m$. Although the star is huge, it is very far away and so the in-focus image will still be that of a point. Where is the image, q, of Sirius located? *If you did not get an answer to (a), use* $p = \infty$.



$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{\infty} + \frac{1}{q}$$

$$\frac{1}{f} = \frac{1}{q}$$

$$q = f = 10.0m$$

But of course this is true – parallel rays from the star converge on the focal point on the right!

(e) This lens contains an anti-reflection coating ($n_{coating} = 1.38$) on glass ($n_{glass} = 1.55$) in air ($n_{air} = 1.00$). If the coating is 200. nm thick, for what wavelength of light is this an anti-reflection coating in air?

We haven't done Physical Optics Yet.