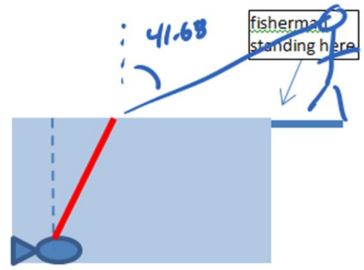
University Physics 2 – Spring 2012 – Test 2 – 02/24/12 SOLUTION KEY

Calculation Problems – Choose 5 out of 6 problems (20 points each)

Note: All focal lengths are given as "focal length magnitudes" – you'



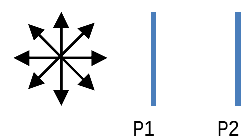
1) The fish are starting to fight back – they are arming themselves with poison dart guns with laser sights. A fish is **1 meter** below the surface of the water (n_w=1.33), and is **2 meters** horizontally from shore. The fish aims the laser at an angle of **30 degrees** with respect to the vertical direction – and the beam lands right between the eyes of a fisherman standing at the water's edge.

a) Calculate how high off the ground the fisherman's eyes are.

b) Should the fish shoot the dart gun at that initial 30 degree angle – or should there be a different aiming angle (if so, calculate it)?

> a) snell's law: $(1.33)\sin(30) = (1)\sin(\theta)$ $\theta = 41.68^0$ horizontal distance from fish vertical to where beam exits: $x = (1)\tan(30) = 0.577m$ horizontal distance from beam exit to land = 2-0.577 = 1.423 height fisherman: $\tan(41.68) = 1.423 / x_2$ $x_2 = 1.6m$
>
> b) shouldn't aim at 30 – that's LIGHT … needs to aim directly to eyes: $\tan\theta = 2/2.6$ $\theta = 37.6^0$ (angled more toward horizontal – directly at eyes)

2) Unpolarized light (of intensity I_0) enters a system with two polarizers (P1 and P2) as shown:



a) P1 has a vertical polarization direction – what intensity (relative to the original of I_0) will pass through P1?

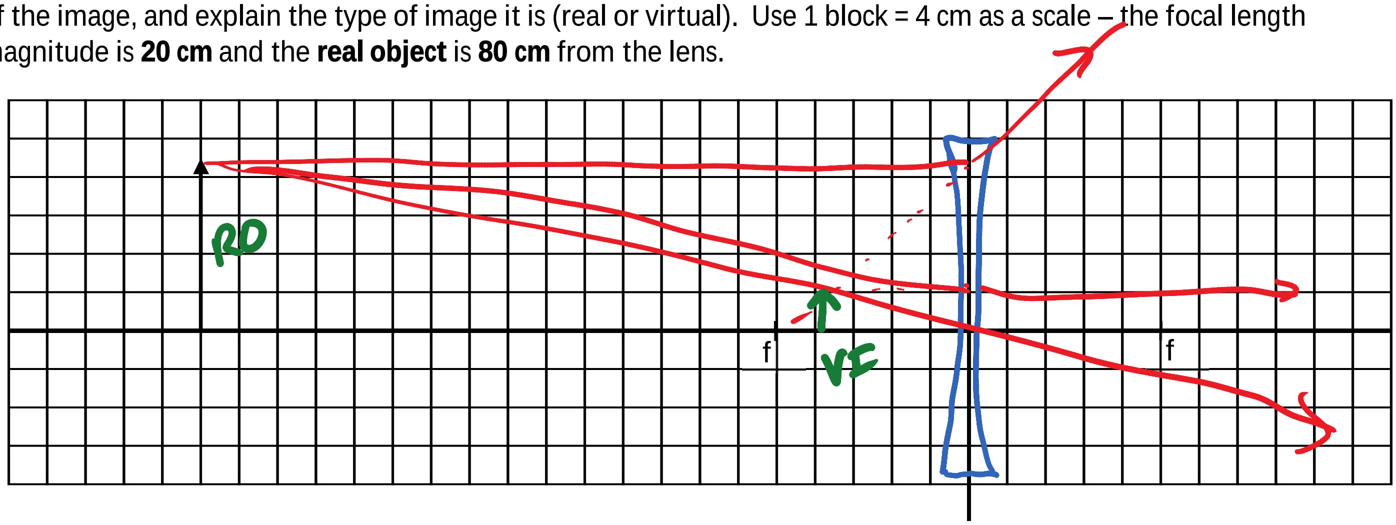
b) If P2 has a horizontal polarization direction – what intensity (relative to the original of I_0) will pass through P2?

c) Can you find an angle for P2 (relative to P1) so that an intensity of $0.4I_0$ will pass through P2 – if so, calculate that angle, if not, explain.

d) Can you find an angle for P2 (relative to P1) so that an intensity of $0.6I_0$ will pass through P2 – if so, calculate that angle, if not, explain.

> a) $0.5I_0$ – unpolarized to polarized drops by ½ b) same as a) c) $0.4 = 0.5\cos^2\theta$ $\theta = 26.57^0$
>
> d) no .. that's more than the original 50% drop

3) a) Consider the following object-lens scenario – sketch (reasonably accurately, but doesn't require a straight edge) the ray diagrams to locate the image formed from this real object. **Calculate** the image distance and the magnification of the image, and explain the type of image it is (real or virtual). Use 1 block = 4 cm as a scale – the focal length magnitude is **20 cm** and the **real object** is **80 cm** from the lens.



b) If the object moved closer to the lens – would the image move closer or further away – explain?

a) s=+80 f=-20 s'=(80)(-20)/((80)-(-20)) = -16 cm Virtual Image – upright – smaller mag=-s'/s = 16/80 = 0.2 .. thus 1/5th size but + mag = upright
b) RO+diverging system – image always smaller closer upright virtual .. so would move closer to lens.

4) a) A real object is placed **50 cm** to the left of a converging lens with a focal length magnitude of **25 cm**. There is a diverging lens with a focal length magnitude of **20 cm** placed a distance of **15 cm** to the right of the converging lens. Calculate where the final image is for this two lens system, what type (real/virtual) it is, what the orientation is (upright/inverted), and the overall magnification relative to the original object height. [No drawings are required.]
b) Could you change the focal length magnitude of that diverging lens to create the opposite type (real/virtual) of final image – and if so, explain conceptually how big or how small the new focal length magnitude would be.

a) s1=+50 f1=+25 s1'=(50)(25)/((50)-(25)) = +50 cm but second lens is only 15 cm from first lens – thus Virtual Object!! s2=-(50-15) = -35cm f2=-20 s2' = (-35)(-20)/((-35)-(-20)) = - 46.7 cm **VIRTUAL** final image – upright relative to original object mag1=-1 mag2=-1.33 overall mag = +1.33 = **bigger and upright** b) for diverging lens – if f>s lens is weak, creates real image .. so if s>f can have strong lens and virtual image – so focal length needs to be bigger than 35 cm!

5) A double-slit system contains two slits that are separated by a distance of **200,000 nm**. Blue light of wavelength **400 nm** shines on the double slit, and an interference pattern (series of equally spaced bright and dark spots) appears on a screen that is **2.4 meters** away. The central bright spot of the pattern is labeled y=0 on the screen. [1 nm = 10^{-9} m] [*Wow, those angles are probably pretty small ..*]
a) What is the angle (in degrees) to the 2nd bright spot away from the central bright?
b) How far apart (in meters) on the screen are the third bright spot on one side and the 4th dark spot on the other side?
c) If the individual slits in the double slit were made wider (but still having the same separation between the two slits) – what change would you notice on the pattern of bright spots on the screen?

a) $(200,000)\sin\theta = (2)(400) \quad \theta = 0.229^0$
b) small angle approx. : b-b distance $y_{BB} = \lambda L/d = (400)(2.4)/200000 = 0.0048m = 0.48cm$ there are 6.5 bright to bright distances – thus $\Delta y = 6.5(0.48) = 3.12cm$
c) would start to see the intensity of the brights that are farther away from the center bright getting more dim

6) Multiple multiple-slit problems:
a) A diffraction grating has 500 lines per cm and a beam of white light shines on it – a first order (m=1) rainbow appears at some angle away from the original light beam direction. The white light contains light between 400 and 700 nm. Calculate the two angles for the ends of that rainbow, and explain if blue is the smaller or larger angle. [1 cm = 10^{-2} m 1 nm = 10^{-9} m]
b) Wavelength of 600 nm shines on a double slit system (with a slit separation of 6000 nm {hmm, probably a pretty wide pattern}). In the interference pattern on the screen, the 2nd bright spot away from the central bright on the screen shows up at a distance of 10 cm. How far away is the double-slit from the screen?
c) If that above double-slit system was actually a quadruple (four) slit system – with the same separation between adjacent slits .. describe how the 4slit interference pattern would be different from the double slit pattern. There should be at least two major differences between the peaks of the two systems and one similarity.

a) $d = 1cm/500lines = 0.002cm = 20,000nm$ blue = 400 nm $(20,000)\sin\theta_{blue} = 400 \quad \theta_{blue} = 1.146^0$
$(20,000)\sin\theta_{red} = 700 \quad \theta_{red} = 2.006^0$
b) $\sin\theta = 2(600)/60000 \quad \theta = 11.54^0 \quad \tan\theta = y/L \quad L = 10/\tan(11.54) = 49cm = 0.49m$
c) peaks would be in the same location (d = same) – but they would be 4 times taller ($16I_0$ compared to $4I_0$) and would more more narrow

MULTIPLE CHOICE QUESTIONS (7 questions – Choose 6 - 3 points each – total of 20 points for this section – two free points) – (if T/F question and answer is False, then explain):

1) Is it possible to have a real image that is larger than a real object with a converging lens – if so, explain where the object must be placed relative to the lens (if not explain why not).

Yes – object should be between 1 and 2 focal lengths from the lens

2) Is it possible to have a virtual image that is larger than a real object with a diverging lens – if so, explain where the object must be placed relative to the lens (if not explain why not).

NO, RO always creates a smaller closer VI with a diverging lens

3) Is it possible to have a virtual image that is larger than a real object with a converging lens – if so, explain where the object must be placed relative to the lens (if not explain why not).

Yes – object should be less than 1 focal length from the lens

4) Two polarizers (A and B) are rotated 90 degrees from each other – unpolarized light shines on the first polarizer (A). If a third polarizer (C) is placed between those two – can any light escape from the last polarizer (B) – explain.

Yes as long as the polarizer C doesn't line up with either A or B!

5) A diverging lens can never form a real image, true or false (if false, explain).

FALSE – if another lens creates a virtual object (tries to create a real image that is intercepted by the diverging lens)

6) A double slit pattern is projected on a screen, and you mark where the bright spots (maxima) are. If you can increase the width of the individual slits – the bright spots will move away from those previous marks, true or false (if false, explain).

false – the width of the individual slits doesn't affect the location of the bright spots

7) A virtual image created by a converging lens and a real object will always be larger than the object, true or false (if false, explain).

True – (the principle ray that comes from the focal length on the same side as the object always has to aim upward, and then go parallel – thus setting the larger height of the image)

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Chose 5 out of 6 calculation problems – 20 pts each = 100 points

Multiple choice (6 out of 7 – 3 points each) = 20 points (2 free pts!) 120 total

Honor Code Pledge: "I have neither given nor received unauthorized aid in completing this work, nor have I presented someone else's work as my own."

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Note: All focal lengths are given as "focal length magnitudes" – you'll need to assign the appropriate signs!

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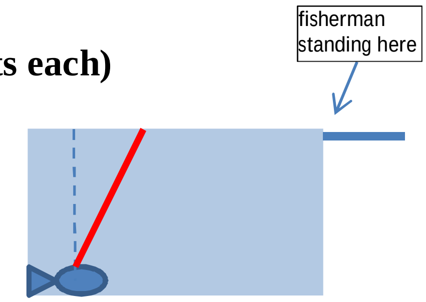

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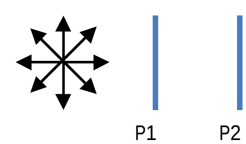

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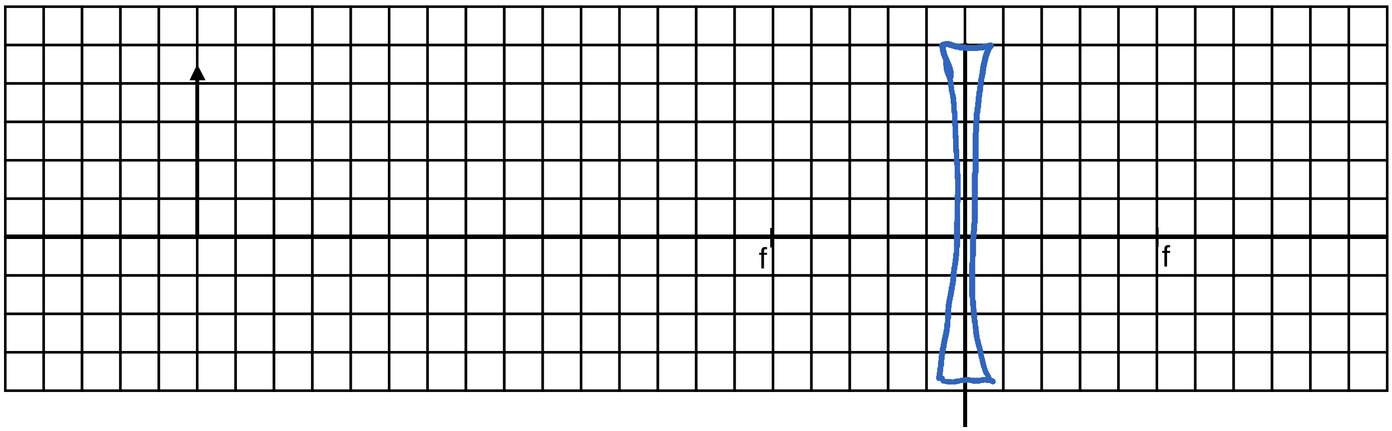

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