PHYSICS 203 **EXAM #2** NAME KEY
30 November 2012

General Instructions: For each problem your solution must be readable and your logic followable. Put a box around any numerical answers.

Constants: $\mu_0 = 1.26 \times 10^{-6}$ H/m $e = 1.60 \times 10^{-19}$ C $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
$c = 3.00 \times 10^{8}$ m/s $n_{water} = 1.33$ $n_{air} = 1.00$ $n_{diamond} = 2.42$
Prefixes: $c = 10^{-2}$ $m = 10^{-3}$ $\mu = 10^{-6}$ $n = 10^{-9}$

PART I - SHORT ANSWER QUESTIONS.
Do the 4 short questions/problems. Worth 7 points each.
30 of 4 9

1. Both ferromagnetic and paramagnetic materials are attracted to permanent magnets. What is the atomic/molecular level difference between these materials? Why does raising the temperature high enough turn a ferromagnetic material into a paramagnetic material?

Ferromagnetic materials have a force between adjacent atoms that tend to line up the magnetic moments (the exchange interaction). Paramagnets do not have this. When the temperature is raised, atomic motion increases. Eventually this breaks the bonds that align the magnetic moments, turning the ferromagnet into a paramagnet.

wavelength in air

2. A thin film of oil, which has an index of refraction of 1.20, floats on top of a puddle of water. What is the minimum thickness of oil that would result in completely destructive interference of reflected 550 nm light?

1.00
1.20 — 2L
1.33

Since n_{oil} is between air & water there is no reflected phase shift. Thus if $2L = \frac{1}{2}\left(\frac{\lambda}{n_{air}}\right)$ get destruction int.

$$L = \frac{1}{4}\frac{\lambda}{n_{air}} = \frac{550\text{nm}}{4(1.20)} = \boxed{115\text{ nm}}$$

3. A parallel plate capacitor has circular plates of radius 0.085 m. An electric field is produced between the plates that varies as: $E = (1200\ V/m)e^{-t/(0.020\ s)}$. What is the maximum induced magnetic field produced between the plates?

$\oint \vec{B}\cdot d\vec{s} = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$ → $B = \frac{\mu_0 \varepsilon_0}{2} r \frac{dE}{dt}$ max at $r = r_{plate}$

$B \cdot 2\pi r = \mu_0 \varepsilon_0 \pi r^2 \frac{dE}{dt}$ → $B = \frac{\mu_0 \varepsilon_0}{2} r_p \left(1200 \frac{V}{m}\right) \cdot \frac{1}{0.020\,s} e^{-t/0.020\,s}$ max when

$B_{max} = \frac{(1.26\times10^{-6}\ \frac{T\cdot m}{A})(8.85\times10^{-12}\ \frac{F}{m})(0.085\ m)\left(1200\ \frac{V}{m}\right)\frac{1}{0.020\,s}}{2}$

$= 2.84\times10^{-14}\ T$

4. A 633 nm wavelength laser beam is shined on a 35 μm diameter hair. A wall (perpendicular to the beam) is 3.40 m away. What is the separation distance of the center of the central spot and the center of the first minimum?

Same equation as single slit diffraction

$a \sin\theta = m\lambda$ for $m = 1$ here $\sin\theta \approx \frac{y}{D}$

$\frac{a\,y}{D} = \lambda$ → $y = \frac{\lambda D}{a} = \frac{633\ nm\,(3.40\ m)}{35\ \mu m} = 0.0615\ m$

Part II – Shorter Questions: Do any **six** of the nine questions based on presentations and your readings from Fischer's book. Be very clear which ones you are omitting or the first 6 with any markings at all will be graded. Worth 2 points each.

1) How long would it take for a radio wave to travel 250 km?

$d = vt$ → $t = \frac{d}{v} = \frac{250\times10^3\ m}{3.00\times10^8\ m/s} = 0.833\ ms$

2) A simple converging lens is used as a magnifying glass. If it has a focal length of 5.0 cm, what angular magnification will this lens produce if the lens is close to the eye and the image is at infinity?

$m_\theta \approx \frac{25\ cm}{f} = \frac{25\ cm}{5.0\ cm} = 5.0$

3) Radioactive dating of rocks gives what sort of age estimate for what are thought to be some oldest rocks on Earth? Within a factor of 10, what is that age? Are the different techniques in agreement with each other?

~ 3.6 billion years ✓ yes

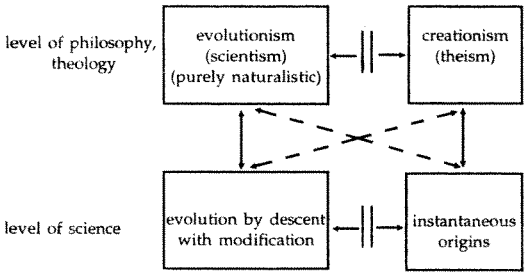
4) What approximation was needed as part of the derivation to find the distance to the image of a light bulb produced by a mirror on the bottom of a pool of water?

$\sin\theta \approx \tan\theta \approx \theta$

5) What is Fischer's working definition of a miracle?

A conspicuous event used to authenticate God or His chosen servant.

6) In the diagram from Fischer reproduced below, what do the vertical lines between the upper and lower boxes mean?



The most obvious connection between the philosophical/theological position is the science described in the box below it.

7) In the diagram from Fischer in the previous question, what do the dashed diagonal lines between the upper and lower boxes mean?

It is possible for a theist to accept evolution (e.g. theistic evolution) and an evolutionist to accept inst. origins (e.g. transpermia)

8) Fischer says science does not address the "Who" question. What does he mean by this?

The methods of science focus on how & why things act as they do.

9) What are two of the weaknesses of biological evolutionary theory cited by Fischer?

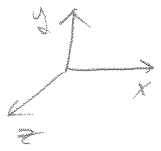
2 of:
- claim that ev. is a Fact rather than explanation
- small fraction of time span available for study
- imperfections in fossil record
- evidence for abrupt changes, but explanations are lacking
- assumptions that similarity in structures means descent
- cultural evidence at odds with ev. devel.
- little progress in quantitative theory

Part III - Problems.
Do all three. Worth 20 points each. Show and explain your work.

1. An electromagnetic wave travels in the + x direction. The wave's electric field component is parallel to the y-axis and is given by: $E_y = (2.00\ V/m) \sin(kx - \omega t)$. The wavelength of this wave is 620 nm.

1/pts each

a) At an instant when the electric field points in the –y direction, what is the direction of the magnetic field?
b) What is the amplitude of the magnetic field?
c) What is the intensity of this wave?
d) The wave strikes a polarizing sheet which has its polarization direction making an angle of 30.0^0 from the +x axis. What is the intensity of the wave after passing through the polarizer?
e) What is the radiation pressure on the polarizer?

a) 

Since $\vec{E} \times \vec{B}$ must point in the wave travel direction, $\vec{B}$ must point in the $-z$ dir. via RHR.

b) $B = \frac{E}{c} = \frac{2.00\ V/m}{3.00\times10^8\ m/s} = 6.67\times10^{-9}\ T$

c) $I = \frac{E_{rms}^2}{\epsilon_0 \mu_0} = \frac{(E_{max}/\sqrt{2})^2}{c\,\mu_0} = \frac{(2.00\ V/m)^2}{2(3\times10^8\ \frac{m}{s})(1.26\times10^{-6}\ \frac{H}{m})} = 5.29\ \frac{mW}{m^2}$

d) $I = I_0 \cos^2\theta$ where θ = angle btwn pol & $\vec{E} = 30^0$

$I = 5.29\ \frac{mW}{m^2} \cos^2 30^0 = 3.97\ mW/m^2$

e) $p = \frac{I_{absorbed}}{c} = \frac{(5.29\ mW/m^2 - 3.97\ mW/m^2)}{3.00\times10^8\ m/s} = 4.41\times10^{-9}\ kg\,m/s$

2. A spherical mirror has |f| = 10.0 cm. When an object is placed at a particular position, the resulting image has a magnification of +0.200. Determine:

4 a) the sign of f.
4 b) the object distance.
3 c) the image distance.
3 d) whether the mirror is concave or convex.
3 e) Is the image on the same side of the mirror as the object, or the opposite side?
3 f e) Suppose you have a lens of the same focal length as the mirror (including sign). If the same object is placed the same distance from this lens as was the case for the mirror, would the image be on the same side of the lens as the object or the opposite side?

a) $m = +0.200 = -\frac{i}{p}$ so $p = -\frac{i}{0.200} = -5.00\,p$

$\frac{1}{f} = \frac{1}{i} + \frac{1}{p} = \frac{1}{-5.00p} + \frac{1}{p} = \frac{-1+5.00p}{-5.00p} = \frac{4.00}{-5.00p}$ or $p = -\frac{4}{5}f$

since p is positive f is negative.

(or virt. images produced by concave mirrors always have $m > 1$)

b) $p = -\frac{4}{5}f = -\frac{4}{5}(-10\text{cm}) = +8.0\text{cm}$

c) $i = -0.200\,p = -0.200(+8.0\text{ cm}) = -1.6\text{cm}$

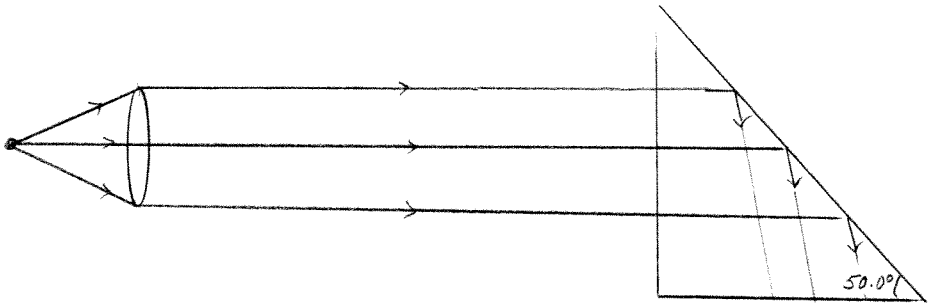
d) convex since $f < 0$

e) It is on the opposite side of the mirror from the object.

f) $m_{\text{lens}} = -\frac{i}{p}$ would be the same, so $i < 0$ which means the same side of the lens.

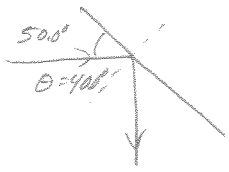
3. A point source of light is placed 15.0 cm from a lens. The light emerges from the lens such that all rays are parallel to the optical axis. These rays then hit a wedge shaped piece of glass, hitting the angled side at the critical angle for total internal reflection.

4/ a) What is the focal length of the lens? Explain.
6 b) What is the index of refraction of the glass?
6 c) At what angle from the normal does the light emerge from the bottom of the wedge?
4/ d) Suppose the entire apparatus is immersed in water (the light is insulated so it doesn't short out). Would all of the light rays leaving the lens still be parallel to the optical axis? Explain.



a) $f = 15.0\ cm$ (parallel rays focus at f, or $\frac{1}{\infty} + \frac{1}{15} = \frac{1}{f}$)

b)

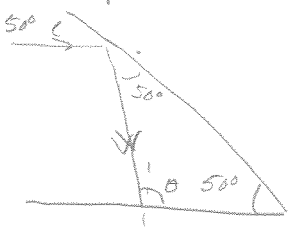


$\theta_c = 40.0°$

$n_{glass} \sin\theta_c = n_{air} \sin 90°$

$n_{glass} = \frac{1}{\sin\theta_c} = \frac{1}{\sin 40°} = 1.56$

c)



From the triangle, $50° + 50° + \theta = 180°$

so $\theta = 80°$ or $10°$ from normal

$n_{glass} \sin 10° = n_{air} \sin\theta_{out}$

$\theta_{out} = \sin^{-1}\left(\frac{1.56 \sin 10°}{1.00}\right) = 15.7°$

d) No – the focal length of the lens depends on both the index of its material as well as the surrounding material. The light would not be at the focal point so the rays would not be parallel.