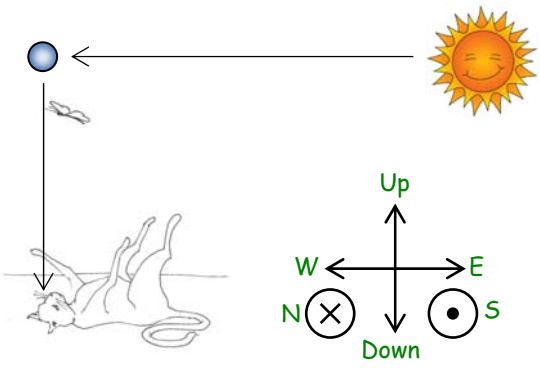
EXAM 3
FRIDAY, APRIL 16, 2010

I. VERY SHORT ANSWER:

1)[3] A cat plays with a butterfly at dawn and looks directly up at light from the sun rising in the east that has been scattered by a molecule in the atmosphere. The light the cat sees is

a) unpolarized (randomly polarized)
b) mostly polarized east/west
c) mostly polarized up/down
d) mostly polarized north/south



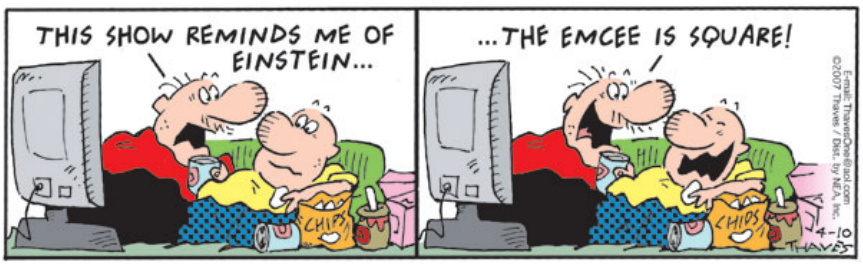
2)[3] Green light (λ_G = 500 nm) is incident on a double slit. The first order maximum diffracts at an angle of 4° and is viewed on a screen 2 m away. If the light is changed from green to red (λ_R = 600 nm),

a) the diffraction pattern will disappear from the screen
b) the first order red light will be diffracted at an angle of 2.6°
c) the first order red light will be diffracted at an angle of 3.3°
d) the first order red light will be diffracted at an angle of 4.8°

3)[4] A real object in front of a lens produces an image with a magnification of m = -2.

a) is the image virtual or real?
b) is the image inverted or upright?
c) is the lens converging or diverging?
d) is the object distance greater than 2f, between f and 2f or less than f?

} Circle the best answer on each line

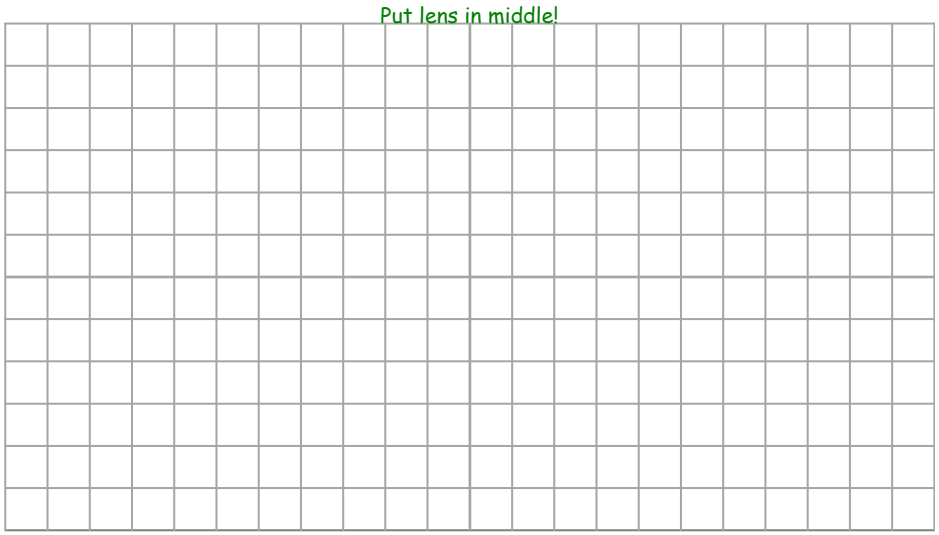


II. SHORT ANSWER:

1)[10] On the grid below, an object 4.0 squares tall is 8 squares in front of a lens with a focal length of -4 squares.

a) Make a scale sketch of the object, lens and at least 2 rays to form the image.

b) Describe the image by choosing from the following pairs:



real or virtual

upright or inverted

larger or smaller

2)[10] Red light (λ = 680 nm) shines through a grating with 5550 slits/cm onto a screen 3.5 m away.

a) What is the distance between adjacent slits on the grating?

b) What is the angle to the first order maximum on the screen?

3)[10] Using the periodic table, fill in the missing particles and the type of decay reaction in the following nuclear reactions. Be sure to include the atomic number, Z, and the mass number, A, and the particle ${}^{A}_{Z}X$.

a) ${}^{103}_{44}Ru \Rightarrow {}^{103}_{45}Rh +$ _____ is _____ decay.

b) ${}^{61}_{28}Ni \Rightarrow {}^{61}_{28}Ni +$ _____ is _____ decay.

c) ${}^{7}_{4}Be +$ _____ $\Rightarrow {}^{7}_{3}Li$ is _____ decay.

d) ${}^{15}_{8}O \Rightarrow$ _____ $+ {}^{0}_{+1}e$ is _____ decay.

e) ${}^{238}_{92}U \Rightarrow$ _____ + _____ is α, alpha decay.

III. Problems (Do 3 of 4):

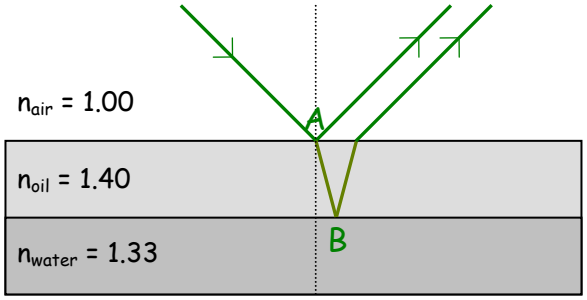
1)[20] An oil film (n_o = 1.40) floating on water (n_w = 1.33) is illuminated by white light at nearly normal incidence. The film is 280 *nm* thick.

a) What is the phase shift for the ray that reflects off the oil at A?

b) What is the phase shift for the ray that reflects off the oil at B?

Color	Wavelength
Violet	410
Blue	470
Green	550
Yellow	580
Orange	610
Red	660

c) Explaining your work as you go, find the wavelength and identify the color of visible light that is most strongly enhanced.



III. Problems (Do 3 of 4):

2)[20] Strontium-90 $\left({}^{90}_{38}\mathrm{Sr}\right)$ is produced in nuclear fission. It decays to ${}^{90}\mathrm{Y}$ with a half-life of 28.8 years.

${}^{90}_{38}\mathrm{Sr}$: m_{atom} = 89.907 737 6 u
${}^{90}\mathrm{Y}$: m_{atom} = 89.907 151 4 u

a) Write down the decay reaction (include the Z of Y).

b) How many atoms are present initially in 2.0 kg of ${}^{90}_{38}\mathrm{Sr}$

c) What is the initial activity of 2.0 kg of ${}^{90}_{38}\mathrm{Sr}$ in Ci and Bq?

d) What is its activity in 1000 yr?

Quantum Mechanic

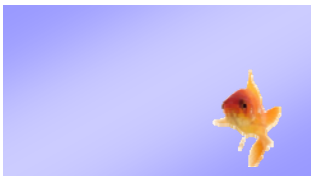
III. Problems (Do 3 of 4):

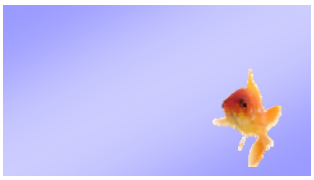
3)[20] Toby, the goldfish, lives in a tank of water (n_w = 1.33) with glass sides (n_g = 1.51).

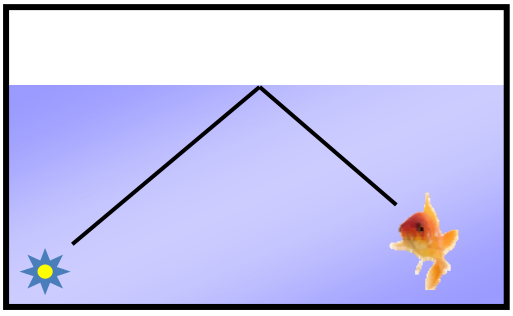
a) As Toby looks up out of the tank (water to air), he sees a light at an angle of 20°. What is the actual angle? Draw the normal, rays and light bulb and label the angles on the top diagram.

b) Is there an angle where he can no longer see out of the water? Explain and find the angle if it exists. Draw the normal and rays and label the angles on the middle diagram.

c) There is a light on the pump in the bottom corner of Toby's tank that he can see reflected off the top surface of the water. At what angle will the reflected light be totally polarized? Draw the polarization directions of the incident and reflected rays and label the angles on the bottom diagram.







III. Problems (Do 3 of 4):

4)[20] A dentist holds a small mirror 1.9 cm from the surface of a patient's tooth. The image is upright and 5.0 times larger than the tooth.

a) Is the image real or virtual?

b) Where is the image located?

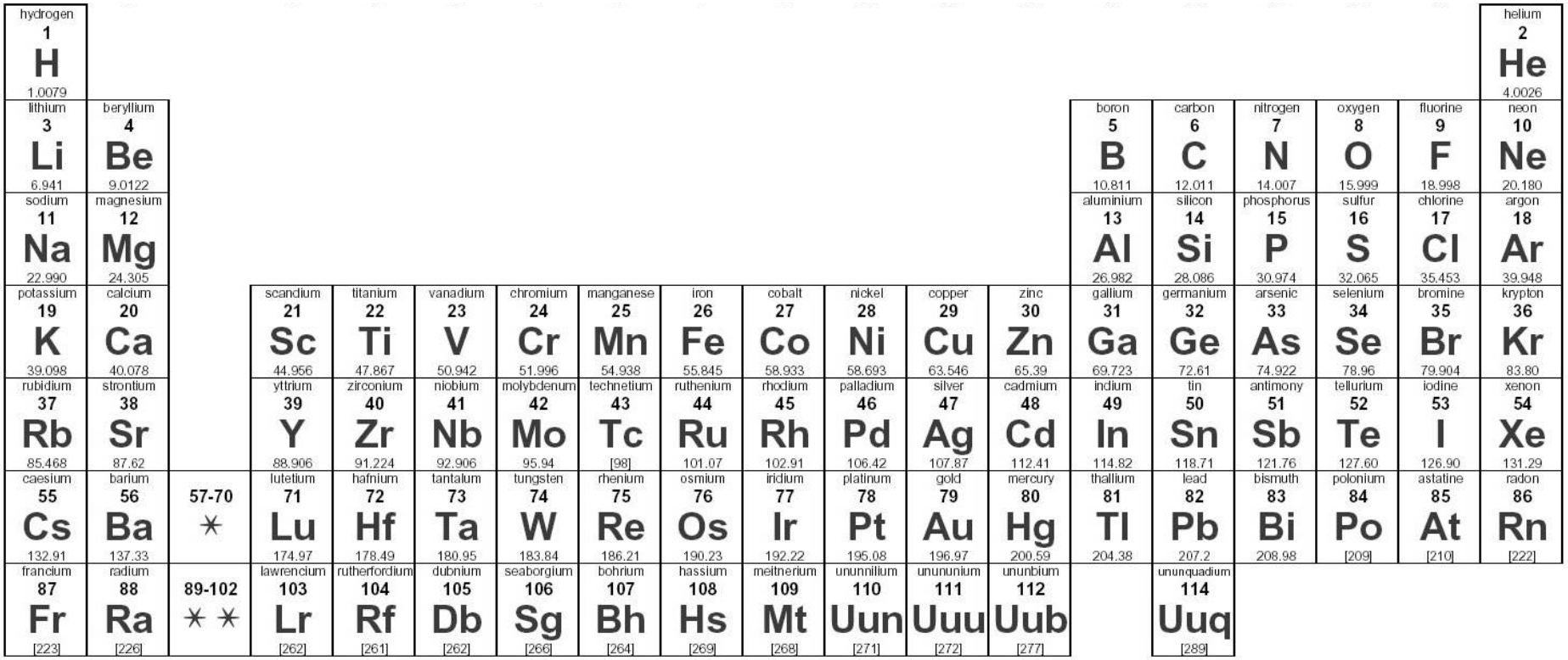
c) Is the mirror convex or concave? What is its focal length?

d) If the mirror is moved closer to the tooth, will the image get larger or smaller?

e) For what range of object distances does the mirror produce an upright image?

Constants to know and love:

$k = 9 \times 10^{9}$ N-m^2/C^2
$G = 6.67 \times 10^{-11}$ N-m^2/kg^2
$e = 1.60 \times 10^{-19}$ C
$m_e = 9.11 \times 10^{-31}$ kg
$m_p = 1.67 \times 10^{-27}$ kg
$c = 3.0 \times 10^{8}$ m/s
$N_A = 6.02 \times 10^{23}$ things/mole
$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N-m^2
$\mu_0 = 4\pi \times 10^{-7}$ T-m/A
m_n=1.0086649 u
m_p=1.0072765 u
m_e=0.0005486 u
1 u = 931.494 MeV/c^2
c^2 =931.494 MeV/u
1 Ci =3 x 10^{10} Bq


hydrogen 1 H 1.0079
helium 2 He 4.0026
lithium 3 Li 6.941
beryllium 4 Be 9.0122
boron 5 B 10.811
carbon 6 C 12.011
nitrogen 7 N 14.007
oxygen 8 O 15.999
fluorine 9 F 18.998
neon 10 Ne 20.180
sodium 11 Na 22.990
magnesium 12 Mg 24.305
aluminium 13 Al 26.982
silicon 14 Si 28.086
phosphorus 15 P 30.974
sulfur 16 S 32.065
chlorine 17 Cl 35.453
argon 18 Ar 39.948
potassium 19 K 39.098
calcium 20 Ca 40.078
scandium 21 Sc 44.956
titanium 22 Ti 47.867
vanadium 23 V 50.942
chromium 24 Cr 51.996
manganese 25 Mn 54.938
iron 26 Fe 55.845
cobalt 27 Co 58.933
nickel 28 Ni 58.693
copper 29 Cu 63.546
zinc 30 Zn 65.39
gallium 31 Ga 69.723
germanium 32 Ge 72.61
arsenic 33 As 74.922
selenium 34 Se 78.96
bromine 35 Br 79.904
krypton 36 Kr 83.80
rubidium 37 Rb 85.468
strontium 38 Sr 87.62
yttrium 39 Y 88.906
zirconium 40 Zr 91.224
niobium 41 Nb 92.906
molybdenum 42 Mo 95.94
technetium 43 Tc [98]
ruthenium 44 Ru 101.07
rhodium 45 Rh 102.91
palladium 46 Pd 106.42
silver 47 Ag 107.87
cadmium 48 Cd 112.41
indium 49 In 114.82
tin 50 Sn 118.71
antimony 51 Sb 121.76
tellurium 52 Te 127.60
iodine 53 I 126.90
xenon 54 Xe 131.29
caesium 55 Cs 132.91
barium 56 Ba 137.33
57-70 *
lutetium 71 Lu 174.97
hafnium 72 Hf 178.49
tantalum 73 Ta 180.95
tungsten 74 W 183.84
rhenium 75 Re 186.21
osmium 76 Os 190.23
iridium 77 Ir 192.22
platinum 78 Pt 195.08
gold 79 Au 196.97
mercury 80 Hg 200.59
thallium 81 Tl 204.38
lead 82 Pb 207.2
bismuth 83 Bi 208.98
polonium 84 Po [209]
astatine 85 At [210]
radon 86 Rn [222]
francium 87 Fr [223]
radium 88 Ra [226]
89-102 * *
lawrencium 103 Lr [262]
rutherfordium 104 Rf [261]
dubnium 105 Db [262]
seaborgium 106 Sg [266]
bohrium 107 Bh [264]
hassium 108 Hs [269]
meitnerium 109 Mt [268]
ununnilium 110 Uun [271]
unununium 111 Uuu [272]
ununbium 112 Uub [277]
ununquadium 114 Uuq [289]
*Lanthanide series
lanthanum 57 La 138.91
cerium 58 Ce 140.12
praseodymium 59 Pr 140.91
neodymium 60 Nd 144.24
promethium 61 Pm [145]
samarium 62 Sm 150.36
europium 63 Eu 151.96
gadolinium 64 Gd 157.25
terbium 65 Tb 158.93
dysprosium 66 Dy 162.50
holmium 67 Ho 164.93
erbium 68 Er 167.26
thulium 69 Tm 168.93
ytterbium 70 Yb 173.04
**Actinide series
actinium 89 Ac [227]
thorium 90 Th 232.04
protactinium 91 Pa 231.04
uranium 92 U 238.03
neptunium 93 Np [237]
plutonium 94 Pu [244]
americium 95 Am [243]
curium 96 Cm [247]
berkelium 97 Bk [247]
californium 98 Cf [251]
einsteinium 99 Es [252]
fermium 100 Fm [257]
mendelevium 101 Md [258]
nobelium 102 No [259]

Optics

$$v = \lambda f = \frac{c}{n}$$

$$\lambda = \frac{\lambda_0}{n} = \frac{\lambda_{vacuum}}{n}$$

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

$$m = -\frac{q}{p}$$

$$I = I_0 \cos^2\theta$$

$$\theta_i = \theta_r$$

$$n_i \sin\theta_i = n_t \sin\theta_t$$

$$\sin\theta_c = \left(\frac{n_t}{n_i}\right)$$

$$\tan\theta_B = \left(\frac{n_t}{n_i}\right)$$

$$d\sin\theta = m\lambda$$

$$d\sin\theta = \left(m + \frac{1}{2}\right)\lambda$$

$$a\sin\theta = m\lambda$$

$$a\sin\Delta\theta \geq 1.22\lambda_0$$

Dr. Jahncke's Equations

$$(m + \tfrac{1}{2})\lambda = (d_2 - d_1) + (\phi_2 - \phi_1)$$

$$m\lambda = (d_2 - d_1) + (\phi_2 - \phi_1)$$

$$(m + \tfrac{1}{2})\lambda_{film} = \left(\frac{2t}{\cos\theta}\right) + \Delta\phi$$

$$m\lambda_{film} = \left(\frac{2t}{\cos\theta}\right) + \Delta\phi$$

Nuclear

$$E = mc^2$$

$$E_B = \Delta mc^2$$

$$\begin{aligned}\Delta m &= m_{final} - m_{initia} \\ &= m_{parts} - m_{nucleus} \\ &= \left(m_{protons} + m_{neutrons}\right) - m_{nucleus}\end{aligned}$$

$$\tau = \frac{1}{\lambda} = \frac{T_{1/2}}{\ln 2}$$

$$R = N\lambda = R_0 e^{-t\lambda} = R_0 e^{-t/\tau}$$

$$N = N_0 e^{-t\lambda} = N_0 e^{-t/\tau} = N_0\left(\frac{1}{2}\right)^{t/T_{1/2}} = N_0\left(2\right)^{-t/T_{1/2}}$$

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