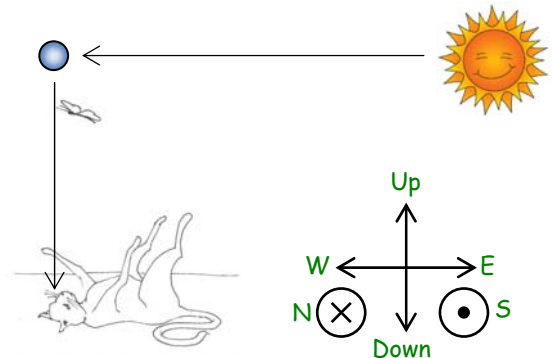


**EXAM 3**  
FRIDAY, APRIL 16, 2010

**I. VERY SHORT ANSWER:**

1)<sup>3</sup> 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



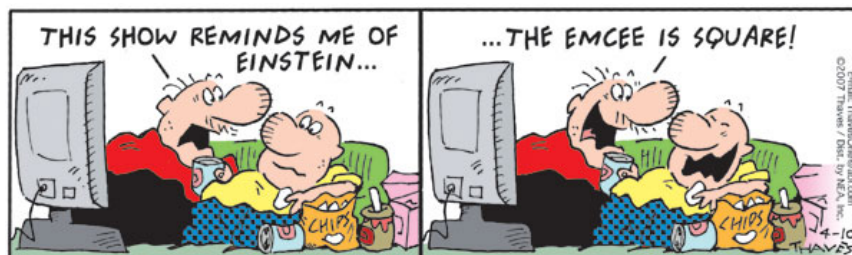
2)<sup>3</sup> Green light ( $\lambda_G = 500 \text{ nm}$ ) is incident on a double slit. The first order maximum diffracts at an angle of  $4^\circ$  and is viewed on a screen 2 m away. If the light is changed from green to red ( $\lambda_R = 600 \text{ nm}$ ),

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

3)<sup>4</sup> 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)<sup>10</sup> 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:

Put lens in middle!



real or virtual

upright or inverted

larger or smaller

2)<sup>10</sup> Red light ( $\lambda = 680 \text{ nm}$ ) 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)<sup>10</sup> 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  ${}^A_ZX$ .

- a)  ${}^{103}_{44}\text{Ru} \Rightarrow {}^{103}_{45}\text{Rh} + \underline{\hspace{2cm}}$  is  $\underline{\hspace{2cm}}$  decay.
- b)  ${}^{61}_{28}\text{Ni} \Rightarrow {}^{61}_{28}\text{Ni} + \underline{\hspace{2cm}}$  is  $\underline{\hspace{2cm}}$  decay.
- c)  ${}^7_4\text{Be} + \underline{\hspace{2cm}} \Rightarrow {}^7_3\text{Li}$  is  $\underline{\hspace{2cm}}$  decay.
- d)  ${}^{15}_8\text{O} \Rightarrow \underline{\hspace{2cm}} + {}^0_{+1}\text{e}$  is  $\underline{\hspace{2cm}}$  decay.
- e)  ${}^{238}_{92}\text{U} \Rightarrow \underline{\hspace{2cm}} + \underline{\hspace{2cm}}$  is  $\alpha, \text{ alpha}$  decay.

**III. PROBLEMS (DO 3 OF 4):**

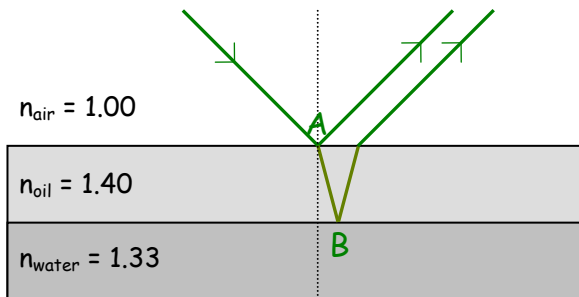
1)<sup>20</sup> An oil film ( $n_o = 1.40$ ) floating on water ( $n_w = 1.33$ ) is illuminated by white light at nearly normal incidence. The film is  $280 \text{ nm}$  thick.

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?

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

COLOR	WAVELENGTH
Violet	410
Blue	470
Green	550
Yellow	580
Orange	610
Red	660



**III. PROBLEMS (DO 3 OF 4):**

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

- Write down the decay reaction (include the Z of Y).
- How many atoms are present initially in 2.0 kg of  $^{90}_{38}\text{Sr}$
- What is the initial activity of 2.0 kg of  $^{90}_{38}\text{Sr}$  in Ci and Bq?
- What is its activity in 1000 yr?

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



Quantum Mechanics

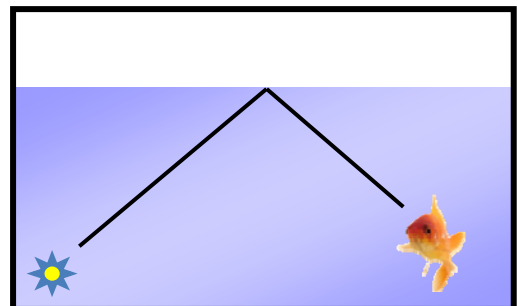
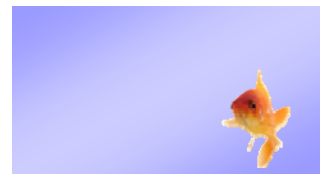
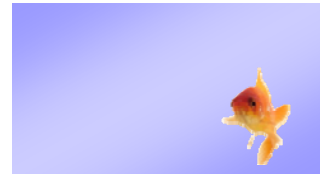
**III. PROBLEMS (DO 3 OF 4):**

3)<sup>20</sup> 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  $20^\circ$ . 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)<sup>20</sup> 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.

- Is the image real or virtual?
- Where is the image located?
- Is the mirror convex or concave? What is its focal length?
- If the mirror is moved closer to the tooth, will the image get larger or smaller?
- For what range of object distances does the mirror produce an upright image?



Constants to know and love:

$$k = 9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$$

$$G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$$

$$e = 1.60 \times 10^{-19} \text{ C}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg}$$

$$c = 3.0 \times 10^8 \text{ m/s}$$

$$N_A = 6.02 \times 10^{23} \text{ things/mole}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$$

$$m_n = 1.0086649 \text{ u}$$

$$m_p = 1.0072765 \text{ u}$$

$$m_e = 0.0005486 \text{ u}$$

$$1 \text{ u} = 931.494 \text{ MeV}/c^2$$

$$c^2 = 931.494 \text{ MeV/u}$$

$$1 \text{ Ci} = 3 \times 10^{10} \text{ Bq}$$

hydrogen 1 <b>H</b> 1.0079	lithium 3 <b>Li</b> 6.941	sodium 11 <b>Na</b> 22.990	potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078	strontium 37 <b>Rb</b> 85.468	rubidium 38 <b>Sr</b> 87.62	cesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33	57-70 *	francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]	actinium 89 <b>Ac</b> [227]	lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [145]	samarium 62 <b>Sm</b> 150.36	europium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium 67 <b>Ho</b> 164.93	erbium 68 <b>Er</b> 167.26	thulium 69 <b>Tm</b> 168.93	ytterbium 70 <b>Yb</b> 173.04	hydrogen 1 <b>H</b> 1.0079	helium 2 <b>He</b> 4.0026																																																																																																																																																																																																																																																																																																																																																	
beryllium 4 <b>Be</b> 9.0122	magnesium 12 <b>Mg</b> 24.305	aluminum 13 <b>Al</b> 26.982	silicon 14 <b>Si</b> 28.086	phosphorus 15 <b>P</b> 30.974	sulfur 16 <b>S</b> 32.065	chlorine 17 <b>Cl</b> 35.453	argon 18 <b>Ar</b> 39.948	potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078	scandium 21 <b>Sc</b> 44.956	titanium 22 <b>Ti</b> 47.867	vanadium 23 <b>V</b> 50.942	chromium 24 <b>Cr</b> 51.996	manganese 25 <b>Mn</b> 54.938	iron 26 <b>Fe</b> 55.845	cobalt 27 <b>Co</b> 58.933	nickel 28 <b>Ni</b> 58.693	copper 29 <b>Cu</b> 63.546	zinc 30 <b>Zn</b> 65.39	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selenium 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	krypton 36 <b>Kr</b> 83.80	xenon 54 <b>Xe</b> 131.29	radon 86 <b>Rn</b> [222]																																																																																																																																																																																																																																																																																																																																																		
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<b>Cf</b> [251]	ehsenium 99 <b>Es</b> [252]	fermium 100 <b>Fm</b> [257]	mendeleevium 101 <b>Md</b> [258]	nobelium 102 <b>No</b> [259]	ununquadium 114 <b>Uuq</b> [289]	ununpentium 115 <b>Uup</b> [291]	ununhexium 116 <b>Uuh</b> [293]	ununseptium 117 <b>Uus</b> [294]	ununoctium 118 <b>Uuo</b> [294]	ununnonium 119 <b>Uun</b> [295]	unbinilium 120 <b>Uub</b> [296]	ununtrium 121 <b>Uut</b> [297]	ununquadrium 122 <b>Uuq</b> [298]	ununpentium 123 <b>Uup</b> [299]	ununhexium 124 <b>Uuh</b> [300]	ununseptium 125 <b>Uus</b> [301]	ununoctium 126 <b>Uuo</b> [302]	ununnonium 127 <b>Uun</b> [303]	unbinilium 128 <b>Uub</b> [304]	ununtrium 129 <b>Uut</b> [305]	ununquadrium 130 <b>Uuq</b> [306]	ununpentium 131 <b>Uup</b> [307]	ununhexium 132 <b>Uuh</b> [308]	ununseptium 133 <b>Uus</b> [309]	ununoctium 134 <b>Uuo</b> [310]	ununnonium 135 <b>Uun</b> [311]	unbinilium 136 <b>Uub</b> [312]	ununtrium 137 <b>Uut</b> [313]	ununquadrium 138 <b>Uuq</b> [314]	ununpentium 139 <b>Uup</b> [315]	ununhexium 140 <b>Uuh</b> [316]	ununseptium 141 <b>Uus</b> [317]	ununoctium 142 <b>Uuo</b> [318]	ununnonium 143 <b>Uun</b> [319]	unbinilium 144 <b>Uub</b> [320]	ununtrium 145 <b>Uut</b> [321]	ununquadrium 146 <b>Uuq</b> [322]	ununpentium 147 <b>Uup</b> [323]	ununhexium 148 <b>Uuh</b> [324]	ununseptium 149 <b>Uus</b> [325]	ununoctium 150 <b>Uuo</b> [326]	ununnonium 151 <b>Uun</b> [327]	unbinilium 152 <b>Uub</b> [328]	ununtrium 153 <b>Uut</b> [329]	ununquadrium 154 <b>Uuq</b> [330]	ununpentium 155 <b>Uup</b> [331]	ununhexium 156 <b>Uuh</b> [332]	ununseptium 157 <b>Uus</b> [333]	ununoctium 158 <b>Uuo</b> [334]	ununnonium 159 <b>Uun</b> [335]	unbinilium 160 <b>Uub</b> [336]	ununtrium 161 <b>Uut</b> [337]	ununquadrium 162 <b>Uuq</b> [338]	ununpentium 163 <b>Uup</b> [339]	ununhexium 164 <b>Uuh</b> [340]	ununseptium 165 <b>Uus</b> [341]	ununoctium 166 <b>Uuo</b> [342]	ununnonium 167 <b>Uun</b> [343]	unbinilium 168 <b>Uub</b> [344]	ununtrium 169 <b>Uut</b> [345]	ununquadrium 170 <b>Uuq</b> [346]	ununpentium 171 <b>Uup</b> [347]	ununhexium 172 <b>Uuh</b> [348]	ununseptium 173 <b>Uus</b> [349]	ununoctium 174 <b>Uuo</b> [350]	ununnonium 175 <b>Uun</b> [351]	unbinilium 176 <b>Uub</b> [352]	ununtrium 177 <b>Uut</b> [353]	ununquadrium 178 <b>Uuq</b> [354]	ununpentium 179 <b>Uup</b> [355]	ununhexium 180 <b>Uuh</b> [356]	ununseptium 181 <b>Uus</b> [357]	ununoctium 182 <b>Uuo</b> [358]	ununnonium 183 <b>Uun</b> [359]	unbinilium 184 <b>Uub</b> [360]	ununtrium 185 <b>Uut</b> [361]	ununquadrium 186 <b>Uuq</b> [362]	ununpentium 187 <b>Uup</b> [363]	ununhexium 188 <b>Uuh</b> [364]	ununseptium 189 <b>Uus</b> [365]	ununoctium 190 <b>Uuo</b> [366]	ununnonium 191 <b>Uun</b> [367]	unbinilium 192 <b>Uub</b> [368]	ununtrium 193 <b>Uut</b> [369]	ununquadrium 194 <b>Uuq</b> [370]	ununpentium 195 <b>Uup</b> [371]	ununhexium 196 <b>Uuh</b> [372]	ununseptium 197 <b>Uus</b> [373]	ununoctium 198 <b>Uuo</b> [374]	ununnonium 199 <b>Uun</b> [375]	unbinilium 200 <b>Uub</b> [376]	ununtrium 201 <b>Uut</b> [377]	ununquadrium 202 <b>Uuq</b> [378]	ununpentium 203 <b>Uup</b> [379]	ununhexium 204 <b>Uuh</b> [380]	ununseptium 205 <b>Uus</b> [381]	ununoctium 206 <b>Uuo</b> [382]	ununnonium 207 <b>Uun</b> [383]	unbinilium 208 <b>Uub</b> [384]	ununtrium 209 <b>Uut</b> [385]	ununquadrium 210 <b>Uuq</b> [386]	ununpentium 211 <b>Uup</b> [387]	ununhexium 212 <b>Uuh</b> [388]	ununseptium 213 <b>Uus</b> [389]	ununoctium 214 <b>Uuo</b> [390]	ununnonium 215 <b>Uun</b> [391]	unbinilium 216 <b>Uub</b> [392]	ununtrium 217 <b>Uut</b> [393]	ununquadrium 218 <b>Uuq</b> [394]	ununpentium 219 <b>Uup</b> [395]	ununhexium 220 <b>Uuh</b> [396]	ununseptium 221 <b>Uus</b> [397]	ununoctium 222 <b>Uuo</b> [398]	ununnonium 223 <b>Uun</b> [399]	unbinilium 224 <b>Uub</b> [400]	ununtrium 225 <b>Uut</b> [401]	ununquadrium 226 <b>Uuq</b> [402]	ununpentium 227 <b>Uup</b> [403]	ununhexium 228 <b>Uuh</b> [404]	ununseptium 229 <b>Uus</b> [405]	ununoctium 230 <b>Uuo</b> [406]	ununnonium 231 <b>Uun</b> [407]	unbinilium 232 <b>Uub</b> [408]	ununtrium 233 <b>Uut</b> [409]	ununquadrium 234 <b>Uuq</b> [410]	ununpentium 235 <b>Uup</b> [411]	ununhexium 236 <b>Uuh</b> [412]	ununseptium 237 <b>Uus</b> [413]	ununoctium 238 <b>Uuo</b> [414]	ununnonium 239 <b>Uun</b> [415]	unbinilium 240 <b>Uub</b> [416]	ununtrium 241 <b>Uut</b> [417]	ununquadrium 242 <b>Uuq</b> [418]	ununpentium 243 <b>Uup</b> [419]	ununhexium 244 <b>Uuh</b> [420]	ununseptium 245 <b>Uus</b> [421]	ununoctium 246 <b>Uuo</b> [422]	ununnonium 247 <b>Uun</b> [423]	unbinilium 248 <b>Uub</b> [424]	ununtrium 249 <b>Uut</b> [425]	ununquadrium 250 <b>Uuq</b> [426]	ununpentium 251 <b>Uup</b> [427]	ununhexium 252 <b>Uuh</b> [428]	ununseptium 253 <b>Uus</b> [429]	ununoctium 254 <b>Uuo</b> [430]	ununnonium 255 <b>Uun</b> [431]	unbinilium 256 <b>Uub</b> [432]	ununtrium 257 <b>Uut</b> [433]	ununquadrium 258 <b>Uuq</b> [434]	ununpentium 259 <b>Uup</b> [435]	ununhexium 260 <b>Uuh</b> [436]	ununseptium 261 <b>Uus</b> [437]	ununoctium 262 <b>Uuo</b> [438]	ununnonium 263 <b>Uun</b> [439]	unbinilium 264 <b>Uub</b> [440]	ununtrium 265 <b>Uut</b> [441]	ununquadrium 266 <b>Uuq</b> [442]	ununpentium 267 <b>Uup</b> [443]	ununhexium 268 <b>Uuh</b> [444]	ununseptium 269 <b>Uus</b> [445]	ununoctium 270 <b>Uuo</b> [446]	ununnonium 271 <b>Uun</b> [447]	unbinilium 272 <b>Uub</b> [448]	ununtrium 273 <b>Uut</b> [449]	ununquadrium 274 <b>Uuq</b> [450]	ununpentium 275 <b>Uup</b> [451]	ununhexium 276 <b>Uuh</b> [452]	ununseptium 277 <b>Uus</b> [453]	ununoctium 278 <b>Uuo</b> [454]	ununnonium 279 <b>Uun</b> [455]	unbinilium 280 <b>Uub</b> [456]	ununtrium 281 <b>Uut</b> [457]	ununquadrium 282 <b>Uuq</b> [458]	ununpentium 283 <b>Uup</b> [459]	ununhexium 284 <b>Uuh</b> [460]	ununseptium 285 <b>Uus</b> [461]	ununoctium 286 <b>Uuo</b> [462]	ununnonium 287 <b>Uun</b> [463]	unbinilium 288 <b>Uub</b> [464]	ununtrium 289 <b>Uut</b> [465]	ununquadrium 290 <b>Uuq</b> [466]	ununpentium 291 <b>Uup</b> [467]	ununhexium 292 <b>Uuh</b> [468]	ununseptium 293 <b>Uus</b> [469]	ununoctium 294 <b>Uuo</b> [470]	ununnonium 295 <b>Uun</b> [471]	unbinilium 296 <b>Uub</b> [472]	ununtrium 297 <b>Uut</b> [473]	ununquadrium 298 <b>Uuq</b> [474]	ununpentium 299 <b>Uup</b> [475]	ununhexium 300 <b>Uuh</b> [476]	ununseptium 301 <b>Uus</b> [477]	ununoctium 302 <b>Uuo</b> [478]	ununnonium 303 <b>Uun</b> [479]	unbinilium 304 <b>Uub</b> [480]	ununtrium 305 <b>Uut</b> [481]	ununquadrium 306 <b>Uuq</b> [482]	ununpentium 307 <b>Uup</b> [483]	ununhexium 308 <b>Uuh</b> [484]	ununseptium 309 <b>Uus</b> [485]	ununoctium 310 <b>Uuo</b> [486]	ununnonium 311 <b>Uun</b> [487]	unbinilium 312 <b>Uub</b> [488]	ununtrium 313 <b>Uut</b> [489]	ununquadrium 314 <b>Uuq</b> [490]	ununpentium 315 <b>Uup</b> [491]	ununhexium 316 <b>Uuh</b> [492]	ununseptium 317 <b>Uus</b> [493]	ununoctium 318 <b>Uuo</b> [494]	ununnonium 319 <b>Uun</b> [495]	unbinilium 320 <b>Uub</b> [496]	ununtrium 321 <b>Uut</b> [497]	ununquadrium 322 <b>Uuq</b> [498]	ununpentium 323 <b>Uup</b> [499]	ununhexium 324 <b>Uuh</b> [500]	ununseptium 325 <b>Uus</b> [501]	ununoctium 326 <b>Uuo</b> [502]	ununnonium 327 <b>Uun</b> [503]	unbinilium 328 <b>Uub</b> [504]	ununtrium 329 <b>Uut</b> [505]	ununquadrium 330 <b>Uuq</b> [506]	ununpentium 331 <b>Uup</b> [507]	ununhexium 332 <b>Uuh</b> [508]	ununseptium 333 <b>Uus</b> [509]	ununoctium 334 <b>Uuo</b> [510]	ununnonium 335 <b>Uun</b> [511]	unbinilium 336 <b>Uub</b> [512]	ununtrium 337 <b>Uut</b> [513]	ununquadrium 338 <b>Uuq</b> [514]	ununpentium 339 <b>Uup</b> [515]	ununhexium 340 <b>Uuh</b> [516]	ununseptium 341 <b>Uus</b> [517]	ununoctium 342 <b>Uuo</b> [518]	ununnonium 343 <b>Uun</b> [519]	unbinilium 344 <b>Uub</b> [520]	ununtrium 345 <b>Uut</b> [521]	ununquadrium 346 <b>Uuq</b> [522]	ununpentium 347 <b>Uup</b> [523]	ununhexium 348 <b>Uuh</b> [524]	ununseptium 349 <b>Uus</b> [525]	ununoctium 350 <b>Uuo</b> [526]	ununnonium 351 <b>Uun</b> [527]	unbinilium 352 <b>Uub</b> [528]	ununtrium 353 <b>Uut</b> [529]	ununquadrium 354 <b>Uuq</b> [530]	ununpentium 355 <b>Uup</b> [531]	ununhexium 356 <b>Uuh</b> [532]	ununseptium 357 <b>Uus</b> [533]	ununoctium 358 <b>Uuo</b> [534]	ununnonium 359 <b>Uun</b> [535]	unbinilium 360 <b>Uub</b> [536]	ununtrium 361 <b>Uut</b> [537]	ununquadrium 362 <b>Uuq</b> [538]	ununpentium 363 <b>Uup</b> [539]	ununhexium 364 <b>Uuh</b> [540]	ununseptium 365 <b>Uus</b> [541]	ununoctium 366 <b>Uuo</b> [542]	ununnonium 367 <b>Uun</b> [543]	unbinilium 368 <b>Uub</b> [544]	ununtrium 369 <b>Uut</b> [545]	ununquadrium 370 <b>Uuq</b> [546]	ununpentium 371 <b>Uup</b> [547]	ununhexium 372 <b>Uuh</b> [548]	ununseptium 373 <b>Uus</b> [549]	ununoctium 374 <b>Uuo</b> [550]	ununnonium 375 <b>Uun</b> [551]	unbinilium 376 <b>Uub</b> [552]	ununtrium 377 <b>Uut</b> [553]	ununquadrium 378 <b>Uuq</b> [554]	ununpentium 379 <b>Uup</b> [555]	ununhexium 380 <b>Uuh</b> [556]	ununseptium 381 <b>Uus</b> [557]	ununoctium 382 <b>Uuo</b> [558]	ununnonium 383 <b>Uun</b> [559]	unbinilium 384 <b>Uub</b> [560]	ununtrium 385 <b>Uut</b> [561]	ununquadrium 386 <b>Uuq</b> [562]	ununpentium 387 <b>Uup</b> [563]	ununhexium 388 <b>Uuh</b> [564]	ununseptium 389 <b>Uus</b> [565]	ununoctium 390 <b>Uuo</b> [566]	ununnonium 391 <b>Uun</b> [567]	unbinilium 392 <b>Uub</b> [568]	ununtrium 393 <b>Uut</b> [569]	ununquadrium 394 <b>Uuq</b> [570]	ununpentium 395 <b>Uup</b> [571]	ununhexium 396 <b>Uuh</b> [572]	ununseptium 397 <b>Uus</b> [573]	ununoctium 398 <b>Uuo</b> [574]	ununnonium 399 <b>Uun</b> [575]	unbinilium 400 <b>Uub</b> [576]	ununtrium 401 <b>Uut</b> [577]	ununquadrium 402 <b>Uuq</b> [578]	ununpentium 403 <b>Uup</b> [579]	ununhexium 404 <b>Uuh</b> [580]	ununseptium 405 <b>Uus</b> [581]	ununoctium 406 <b>Uuo</b> [582]	ununnonium 407 <b>Uun</b> [583]	unbinilium 408 <b>Uub</b> [584]	ununtrium 409 <b>Uut</b> [585]	ununquadrium 410 <b>Uuq</b> [586]	ununpentium 411 <b>Uup</b> [587]	ununhexium 412 <b>Uuh</b> [588]	ununseptium 413 <b>Uus</b> [589]	ununoctium 414 <b>Uuo</b> [590]	ununnonium 415 <b>Uun</b> [591]	unbinilium 416 <b>Uub</b> [592]	ununtrium 417 <b>Uut</b> [593]	ununquadrium 418 <b>Uuq</b> [594]	ununpentium 419 <b>Uup</b> [595]	ununhexium 420 <b>Uuh</b> [596]	ununseptium 421 <b>Uus</b> [597]	ununoctium 422 <b>Uuo</b> [598]	ununnonium 423 <b>Uun</b> [599]	unbinilium 424 <b>Uub</b> [600]	ununtrium 425 <b>Uut</b> [601]	ununquadrium 426 <b>Uuq</b> [602]	ununpentium 427 <b>Uup</b> [603]	ununhexium 428 <b>Uuh</b> [604]	ununseptium 429 <b>Uus</b> [605]	ununoctium 430 <b>Uuo</b> [606]	ununnonium 431 <b>Uun</b> [607]	unbinilium 432 <b>Uub</b> [608]	ununtrium 433 <b>Uut</b> [609]	ununquadrium 434 <b>Uuq</b> [610]	ununpentium 435 <b>Uup</b> [611]	ununhexium 436 <b>Uuh</b> [612]	ununseptium 437 <b>Uus</b> [613]	ununoctium 438 <b>Uuo</b> [614]	ununnonium 439 <b>Uun</b> [615]

Optics

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

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

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

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

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

$$\theta_i = \theta_r$$

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

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

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

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

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

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

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

Nuclear

$$E = mc^2$$

$$E_B = \Delta mc^2$$

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

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

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

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

Dr. Jahncke's Equations

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

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

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

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

Constants to know and love:

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

