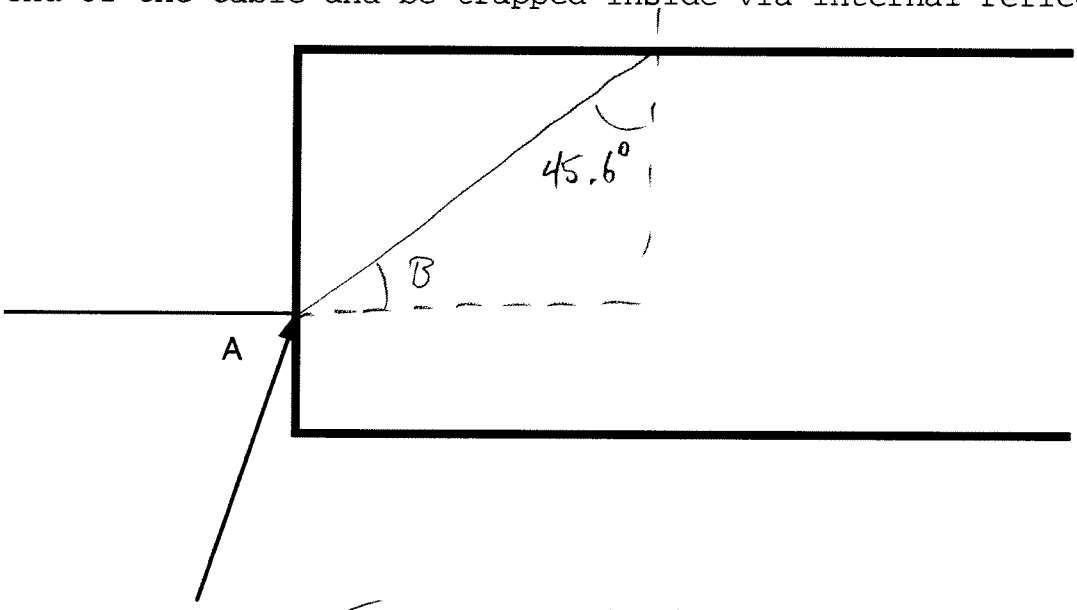
Physics 10164 - Exam #4/5A

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box. If you give more than one answer without indicating which is correct, you will definitely lose points, even if one answer is correct.
Each question is worth 25 points.

1. We observe a rectangular fiber optic cable in air. The cable has an index of refraction of 1.4. What is the maximum angle of incidence (A in the diagram below) for which light can enter the end of the cable and be trapped inside via internal reflection?



For $n = 1.4$, $\theta_c = \sin^{-1}\left(\frac{1}{1.4}\right)$

$= 45.6°$

So $B = 44.4°$

$1.0 \sin A = 1.4 \sin 44.4°$

$\boxed{A = 78.4°}$

If $A = 78°$, $B = 44.3$, so $\angle$ at wall $= 45.7°$

2. A person's face is 15 cm in front of a concave mirror. The person notices that his reflected image is upright and 1.8 times larger than his face. What is the focal length of the mirror?

$p = 15\,cm$

$M = -\frac{q}{p} = +1.8 \Rightarrow q = -1.8p$

$= -27\,cm$

$\frac{1}{15} + \frac{1}{-27} = \frac{1}{f}$

$f = 34\,cm$

3. The cutoff wavelength for an illuminated metal to release electrons is observed to be 455 nm.

a) What is the work function of the metal (in eV)?

b) If the metal is illuminated by light of wavelength 310 nm, what is the maximum velocity of the released electrons?

a) $E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34})(3\times10^{8})}{455\times10^{-9}} = 4.37\times10^{-19}\,J$

$= \boxed{2.73\,eV}$

b) $E_\gamma = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34})(3\times10^{8})}{310\times10^{-9}} = 6.41\times10^{-19}\,J$

$= 4.01\,eV$

$(KE)_{max} = 4.01 - 2.73 = 1.28\,eV$

$= 2.05\times10^{-19}\,J$

$\frac{1}{2}mv^2 = 2.05\times10^{-19}$

$v^2 = \frac{2(2.05\times10^{-19})}{9.11\times10^{-31}} =$

$\boxed{v = 6.7\times10^{5}\ m/s}$

4. Carbon-14 has a half-life of 5700 years and a mass of approximately 14 amu. A sample of wood contains 25 grams of Carbon-14.

a) What is the activity of this sample, in Becquerels?

b) How many years will it take for the activity to be 1.0% of its initial level?

a) $T_{1/2} = 5700 \text{ yrs} = 1.8 \times 10^{11} \text{ s}$

$$\lambda = \frac{0.693}{T_{1/2}} = 3.9 \times 10^{-12}$$

$$N = \frac{m_{TOT}}{m_C} = \frac{0.025}{14\text{ u}} \cdot \frac{1\text{ u}}{1.66 \times 10^{-27}}$$

$$= 1.08 \times 10^{24}$$

$$a = \lambda N = \boxed{4.2 \times 10^{12} \text{ Bq}}$$

$$= (3.9 \times 10^{-12})t$$

b) $0.01 = e$

$$-4.6 = -(3.9 \times 10^{-12})t$$

$$t = 1.18 \times 10^{12} \text{ s}$$

$$= \boxed{37\,000 \text{ yrs}}$$