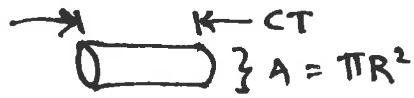
B8B Ex 3.7

A CO_2 laser, $\lambda = 10^{-3}$ cm, 10 Joule light pulse, duration 10nsec.

Beam diameter 2 cm.



a) avg. energy density? $\langle u \rangle = \frac{\text{energy}}{\text{volume}} = \frac{E}{cT\pi R^2}$

$\langle u \rangle = \boxed{11 \frac{kJ}{m^3}}$

avg. poynting flux? $\langle S \rangle = c\langle u \rangle = \boxed{3e12 \frac{W}{m^2}}$

b) Amplitudes of E & B fields?

$\langle u \rangle = \frac{1}{2}\epsilon_0 E_{0x}^2 \Rightarrow E_{0x} = \sqrt{\frac{2\langle u \rangle}{\epsilon_0}}$

$E_{0x} \approx \boxed{5e7 \frac{V}{m}}$

$B_{0x} = \frac{E_{0x}}{c} = \boxed{0.17 \text{ Tesla}}$

* Note: we are assuming polarized light along x-axis, which is correct if beam comes from chamber of laser after hitting a mirror at Brewster's angle....

c) Pressure on absorbing surface? $P = \frac{\langle S \rangle}{c} = \boxed{1e4 \frac{N}{m^2}}$

d) To find max velocity of electron

$F = ma$

$qE_{ox} e^{i\omega t} = m \ddot{x}$

$x = x_0 e^{i\omega t}$, $\dot{x} = i\omega x$, $\underbrace{\ddot{x} = -\omega^2 x = i\omega \dot{x}}$

$$\ddot{x} = \frac{qE_{ox} e^{i\omega t}}{m}$$

$\ddot{x} = i\omega \dot{x}$

$\ddot{x} = -\omega^2 x$

$$i\omega \dot{x} = \frac{qE_{ox} e^{i\omega t}}{m}$$

$$\dot{x} = \frac{-i\, q E_{ox} e^{i\omega t}}{m\omega}$$

The i just gives a $90°$ phase shift, so the max amplitude of velocity is

$$(\dot{x})_{amp} = \frac{qE_{ox}}{m\omega} = \frac{(1.6e{-}19)(5e7)}{(9.1e{-}31)(1.9e14)}$$

$$\boxed{v_{max} = 46 \text{ km/sec}}$$

What is max displacement? Similarly,

$$x_{max} = \frac{qE_{ox}}{m\omega^2} = \boxed{2.4 \text{ Å}}$$