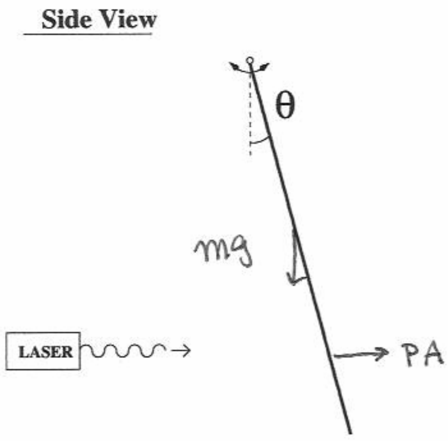

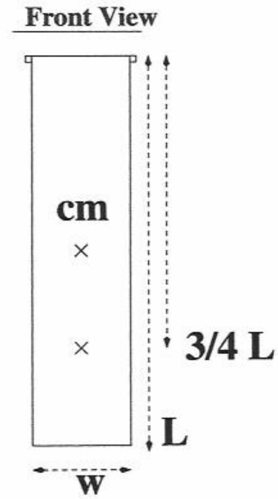

A large, thin, uniform, highly reflective sheet of length L, width w (where $w < L$). and mass m is hung vertically from a horizontal peg (as shown). When the beam (of diameter $D \ll w$) from a powerful green laser is shown on a spot directly between the center of mass and the lower edge of the sheet, the sheet is deflected by a *very small* angle θ ($\sin\theta \approx \tan\theta \approx \theta$).

- 3a) (10 points) How much pressure is exerted on the sheet by the laser?

$$\sum \vec{\tau} = I\vec{\alpha} \qquad A = \pi r^2 = \tfrac{1}{4}\pi D^2$$

$$-mg\frac{L}{2}\sin\theta + PA\frac{3}{4}L\cos\theta = 0$$

$$\frac{1}{2}mgL\sin\theta = \frac{3}{16}\pi D^2 L P\cos\theta$$

$$P = \frac{8}{3}\frac{mg}{\pi D^2}\tan\theta \Rightarrow \boxed{P = \frac{8}{3}\frac{mg}{\pi D^2}\theta}$$

- 3b) (10 points) Find the *amplitudes* of the electric and magnetic fields associated with the light emitted by the laser.

Highly reflective $\Rightarrow P = 2\frac{\langle S\rangle}{c} = \frac{2}{\mu_0}\frac{E_{rms}B_{rms}}{c} = \frac{2}{\mu_0}B_{rms}^2 = 2\epsilon_0 E_{rms}^2$

of Course, $E_{rms} = \frac{E_{max}}{\sqrt{2}}$, $B_{rms} = \frac{B_{max}}{\sqrt{2}}$, So... $P = \frac{B_{max}^2}{\mu_0} = \epsilon_0 E_{max}^2$

$$E_{max} = \sqrt{\frac{8mg\theta}{3\pi\epsilon_0 D^2}}$$

$$B_{max} = \sqrt{\frac{8\mu_0 mg}{3\pi D^2}}$$

• 3c) (10 points) What is the power output of the laser?

$$\mathbb{P} = \int \vec{S} \cdot d\vec{A}$$
$$= \int |\vec{S}||d\vec{A}| \cos\theta$$
$$\simeq S A$$
$$= \frac{PC}{2} \frac{1}{4} \pi D^2$$

$\mathbb{P}$ – Power
P – Pressure

$$\boxed{\mathbb{P} = \frac{1}{3} mgc\, \theta}$$

Given that $C = 3 \times 10^8$ m/s and that laser, though powerful, is probably not military-Industrial powerful, θ is probably really small