Question #81222, Physics / Other

A small ideal mirror of mass m is suspended by a weightless thread of length l. Find the angle through which the thread will be deflected when a short laser pulse with energy E is shot in the horizontal direction at angles to the mirror.

Solution

$$|\boldsymbol{p_f} - \boldsymbol{p_i}| = \frac{2E}{c}$$

Assume $\boldsymbol{p_i} = \mathbf{0}$. Thus,

$$|\boldsymbol{p_f}| = \frac{2E}{c}$$

$$\frac{p_f^2}{2m} = \frac{2E^2}{mc^2}$$

From the conservation of energy:

$$\frac{2E^2}{mc^2} = mgl(1 - \cos\theta)$$

So,

$$\frac{2E^2}{mc^2} = 2mgl\sin^2\frac{\theta}{2}$$

Or

$$\sin\frac{\theta}{2} = \left(\frac{E}{mc}\right)\frac{1}{\sqrt{gl}}$$

The angle through which the thread will be deflected when a short laser pulse with energy E is shot in the horizontal direction at angles to the mirror:

$$\theta = 2\sin^{-1}\left[\left(\frac{E}{mc}\right)\frac{1}{\sqrt{gl}}\right]$$