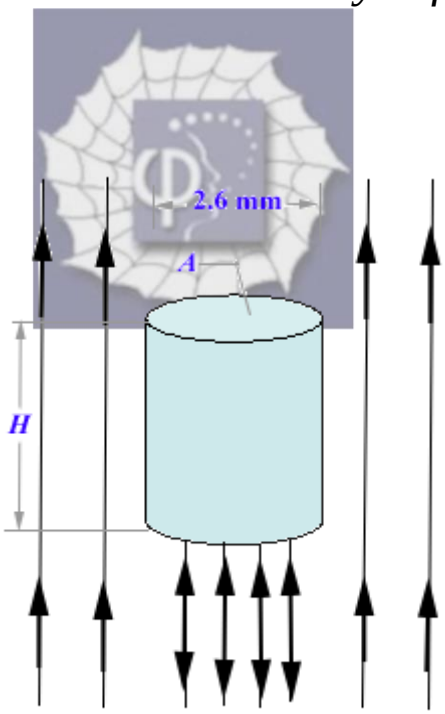
571.

Problem 41.46 (RHK)

A laser has a power output of 4.6 W *and a beam diameter of* 2.6 mm. *The beam is aimed vertically upward on a perfectly reflecting cylinder. We have to find the height of the cylinder so that it is made to 'hover' by the radiation pressure exerted by the beam. We may assume that the density of the cylinder is* 1.2 g cm^{-3}.



Solution:

The intensity of the laser beam of power output 4.6 W and a beam diameter of 2.6 mm will be

$$I = \frac{4.6}{\left(\pi\left(2.6\times10^{-3}\right)^2/4\right)}\ \text{W m}^{-2} = 3.33\times10^{8}\ \text{W m}^{-2}.$$

The force exerted by a laser beam of intensity I when it falls normally on a perfectly reflecting object of cross-sectional area A will be

$$F = \frac{2IA}{c}.$$

The height H of a perfectly reflecting cylinder of density 1.2 g cm^{-3} to be supported by the laser beam as shown in the figure will be determined by equating F and the weight of the cylinder. That is

$$AH\rho g = F,$$

or

$$H = \frac{2I}{c\rho g} = \frac{2\times3.33\times10^{8}}{3\times10^{8}\times1.2\times10^{3}\times9.81}\ \text{m} = 1.88\times10^{-4}\ \text{m}$$

$$= 0.188\ \text{mm}.$$