Q- A pulsed laser fires a 1000-MW pulse horizontally at a 10mg mass suspended vertically from a 4 cm long fiber of negligible mass. If the pulse lasts duration of 200 nanoseconds, and the radiation is completely absorbed by the mass, by what angle is the pendulum deflected?

The deflection of the object is caused by the momentum of the laser pulse transmitted to the object upon absorption.

The momentum of the pulse is given by

P = E/c

Where E is the energy given by the intensity I and the time interval of the pulse and c is the speed of light.

Hence the momentum of the pulse will be given by

$$P = \frac{\left(1000*10^{6}W\right)*\left(200*10^{-9}s\right)}{\left(3*10^{8}s\right)} = 6.667*10^{-7} \quad \text{kg.m/s}$$

This momentum is transferred to the object and hence if the object starts moving with velocity v after the collision of the pulse then according to law of conservation of momentum in horizontal direction we have

mv = P

Or v = $\frac{P}{m} = \frac{6.667*10^{-7}\,kg.m/s}{10*10^{-6}\,kg} = 6.667*10^{-2}\,m/s$

Because of this velocity the object will have kinetic energy and due to which the pendulum will get deflected till the whole kinetic energy will convert to potential energy hence according to law of conservation of energy we will have

Gain in PE = loss in KE

or mg*L(1 - cosθ) = ½ mv^2

Gives $1-\cos\theta = \frac{v^2}{2gL} = \frac{\left(6.667*10^{-2}\right)^2}{2*9.8*0.04} = 5.669*10^{-3}$

Or cos θ = 0.99433

Gives θ = 6.1037 degree

or θ = 0.106 radians