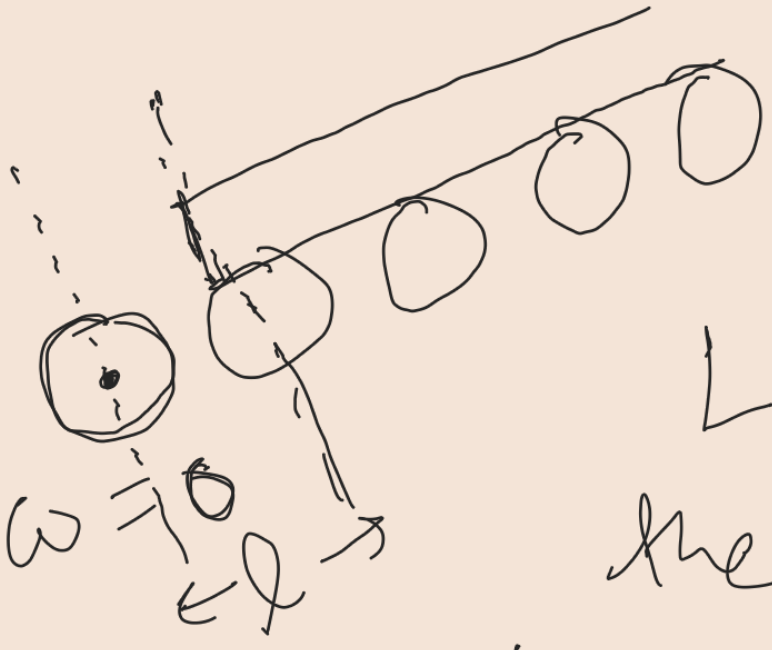


Let take the plank & the roller it is to touch next as our system. on this system, the work doing forces will be gravity component on plank, and kinetic friction on both plank & roller combined.

Now here we are assuming that in a very small interval dt, kinetic friction

is able to rotate roller with final omega of $\left(\frac{v}{r}\right)$, such that pure rolling starts. Now here's the tricky part. Kinetic friction does -ve work on plank & positive on roller. The net work of f_k on plank + roller system must be $(\mu_k N) \times$ (distance slid by plank on roller).

However, we are assuming here that net work of kinetic friction on system is equal to & -ve of work of friction on the roller. That's (NOT) conceptually correct. The way book has assumed it's

↓

work energy equation for plank + roller system is

$Mgl\sin\theta - W_{fr} = \frac{1}{2} I_{cm} \omega^2$

Also, W_f on roller

is $\frac{1}{2} I_{cm} \omega^2 = \frac{1}{2} m \cancel{x^2} \frac{v^2}{\cancel{r^2}}$

From this, $v = \sqrt{\frac{2Mgl\sin\theta}{m}}$.

Yes, it obvious that the distance slid by plank on roller in 'dt' interval is negligible, but still, method is flawed