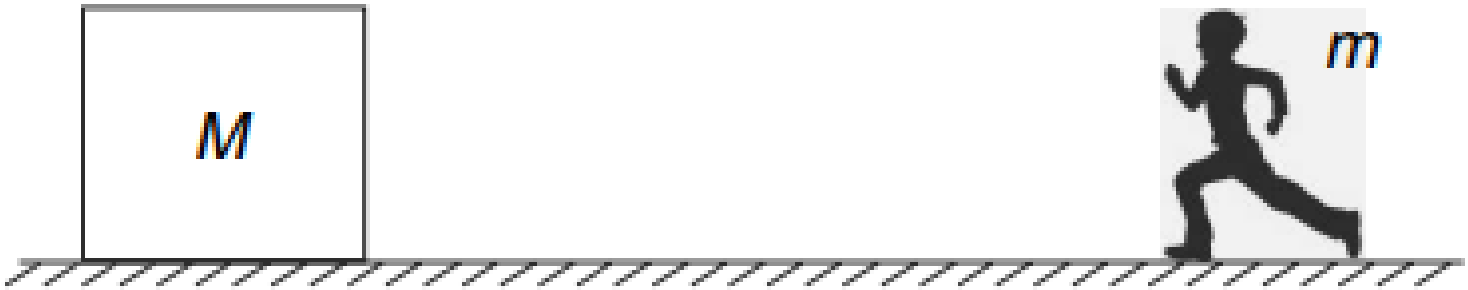
A box of mass M is at rest on a horizontal surface. A boy of mass m ($< M$) wants to push the box by applying a horizontal force on it. The boy knows that he will not be able to push the box as the coefficient of friction μ between his shoes and ground is almost equal to that between the box and the ground. He decides to run, acquire a speed u and then bang into the box. After hitting the box, the boy keeps pushing as hard as possible. What is the maximum distance through which the box can be displaced this way?



Speed immediately after collision

$$(M + m)\, V = mu$$

$$V = \frac{mu}{M + m}$$

Retarding force on $(M + m)$ is $\mu Mg - \mu mg$ after collision

$\therefore$ Retardation $a = \dfrac{\mu g(M - m)}{(M + m)}$

Displacement (s) before stopping can be calculates as $2\, as = V^2$

$$2.\frac{\mu(M - m)g}{(M + m)}.s = \frac{m^2u^2}{(M + m)^2}$$

$$s = \frac{m^2u^2}{2\mu g\left(M^2 - m^2\right)}$$