Q 5. A trolley of mass 200 kg moves with a uniform speed of 36 km/h on a frictionless track. A child of mass 20 kg runs on the trolley from one end to the other (10 m away) with a speed of 4 ms^{-1} relative to the trolley in a direction opposite to its motion, and jumps out of the trolley. What is the final speed of the trolley? How much has the trolley moved from the time the child begins to run?

Sol. According to the question

Mass of the trolley, M = 200 kg

Speed of the trolley, v_1 = 36 km/h = 10 m/s

Mass of the boy, m = 20 kg

Initial momentum of the system of the boy and the trolley

$P_i = (M+m)v_1 = (200+20)10 = 2200 kgms^{-1}$

Let v_2 be the final velocity of the trolley with respect to the ground.

Final velocity of the boy with respect to the ground = v_2 - 4

Final momentum , $P_f = Mv_2 + m(v_2 - 4) = 200v_2 + 20(v_2 - 4)$

$P_f = 200v_2 + 20v_2 - 80 = 220v_2 - 80$

According to the law of conservation of momentum:

Initial momentum = Final momentum

$2200 = 220v_2 - 80$

$\therefore v_2 = \frac{2280}{220} = 10.36 \mathrm{m/s}$

Given , Length of the trolley, l= 10 m

Speed of the boy, V_B = 4 m/s

Time taken by the boy to run, $t = \frac{10}{4} = 2.5s$

$\therefore$ Distance moved by the trolley $= V_B \times t = 10.36 \times 2.5 = 25.9 \mathrm{m}$