Q- A 1000 kg car traveling east at 25 mph gets rear-ended hit by a truck weighing 1500 kg also moving east. After collision the vehicles lock bumpers and continue moving east at 40 mph.

(a) What was the original speed of the truck

Mass of the car m_1 = 1000 kg

Velocity of the car v_1 = 25 mph

Mass of the truck m_2 = 1500 kg

Velocity of the truck v_2 =?

Velocity of combined mass after collision v = 40 mph

The collision may be elastic or inelastic as there is no external force during the short time of impact, momentum of the system remains conserved and hence applying law of conservation of momentum (the direction is the same) we have

Initial momentum of the system = final momentum of the system

Or $m_1v_1 + m_2v_2 = (m_1 + m_2)\, v$

Or $v_2 = [(m_1 + m_2)\, v - m_1v_1]/m_2$

$= [2500*40 - 1000*25]/1500 = 50$ mph $= 50*0.4470$ m/s $= 22.35$ m/s

[1 mph = 0.4470 m/s]

Answer: the speed of the truck before collision is 22.35 m/s.

(b) How much kinetic energy of the system lost during this collision?

The loss of kinetic energy of the system is the initial KE - final KE

Or Loss of KE = (KE of the car + KE of the truck) - KE of the combined mass after collision

Or $$\Delta KE = \left(\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2\right) - \frac{1}{2}(m_1 + m_2)v^2$$

Or $$\Delta KE = \left[\left(0.5*1000*625 + 0.5*1500*2500\right) - 0.5*2500*1600\right]*(0.4470)^2$$ (mph to m/s)

Gives $$\Delta KE = \left[\left(312500 + 1875000\right) - 2000000\right]*(0.4470)^2 = 37464.2J$$

(c) If the time of collision is t = 0.05 s, what is the average force experienced by the car during collision?

According to Newton's second law of motion the rate of change of momentum is equal to the force applied hence

$$F = \frac{\Delta P}{\Delta t}$$

The average force experienced by the car is given by

$$F_1 = \frac{\Delta P_1}{\Delta t} = \frac{m_1v - m_1v_1}{\Delta t} = \frac{1000(40 - 25)*0.4470}{0.05} = 134100 \text{ N}$$

Answer: the average force experienced by the car will be 134100 N