2023-Ph-H2-Q3

Section: Our Dynamic Universe
Topic: Collisions, Explosions and Impulse

Summary:
Two Formula 1 cars collide in a pit lane.

- Car X: $m_X = 760\,\text{kg}, u_X = 12.0\,\text{m s}^{-1}$.
- Car Y: $m_Y = 840\,\text{kg}, u_Y = 4.0\,\text{m s}^{-1}$.
- After collision, car Y moves with $v_Y = 8.5\,\text{m s}^{-1}$.

Tasks:
(a) Find velocity of car X after the collision.
(b) Show collision is inelastic.
(c) Calculate average force X exerts on Y.
(d) Explain how tyre walls protect drivers.

Solution:

(a) Velocity of car X:
Momentum conservation:
$m_X u_X + m_Y u_Y = m_X v_X + m_Y v_Y.$

$760 \cdot 12.0 + 840 \cdot 4.0 = 760 v_X + 840 \cdot 8.5.$

$9120 + 3360 = 760 v_X + 7140.$

$12,480 - 7,140 = 760 v_X \Rightarrow v_X \approx 7.0\,\text{m s}^{-1}.$

(b) Check for inelastic collision:
Total E_k before:

$$E_{k,\text{before}} = \frac{1}{2}(760)(12.0^2) + \frac{1}{2}(840)(4.0^2) = 61,440\,\text{J}.$$

Total E_k after:

$$E_{k,\text{after}} = \frac{1}{2}(760)(7.0^2) + \frac{1}{2}(840)(8.5^2) \approx 48,965\,\text{J}.$$

Since energy is lost, **the collision is inelastic.**

(c) Average force:
Impulse:
$F\Delta t = m_Y(v_Y - u_Y) = 840(8.5 - 4.0) = 3,780\,\text{N} \cdot \text{s}.$

Time $\Delta t = 0.82\,\text{s}.$
$F = \frac{3,780}{0.82} \approx 4.6 \times 10^3\,\text{N}.$

(d) Tyre wall explanation:

- Tyre walls increase **collision time**.
- Since $F = \frac{\Delta p}{\Delta t}$, a larger Δt reduces the average force on the driver.

Guidance for Students:

- Momentum is always conserved in collisions (even if KE is not).
- Use $F = \Delta p / \Delta t$ for impact forces.
- Tyre walls work by **extending time and reducing force.**

Revision Tips:

- Carefully handle units (kg, m/s, N).
- For inelastic collisions, momentum conserved but kinetic energy decreases.
- Draw clear before/after diagrams with velocities.