2022-Ph-H2-Q3

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

Summary:
Two trolleys, X ($m_X = 0.50\,\text{kg}$) and Y ($m_Y = 0.25\,\text{kg}$), initially move together at $u = 0.40\,\text{m s}^{-1}$.
The plunger applies a force $F = 6.25\,\text{N}$ on Y, causing it to move at $1.80\,\text{m s}^{-1}$.
Tasks:
(a)(i) Find the change in momentum of Y.
(a)(ii) Determine the time of force application.
(b) Find velocity of X after separation.
(c) Explain how to check if the interaction is elastic.
(d) Questions on photodiode and photovoltaic effect.

Solution:

(a)(i) Change in momentum:
$\Delta p = m_Y(v - u) = 0.25(1.80 - 0.40) = 0.35\,\text{N s}.$

(a)(ii) Time of force application:
$J = F\Delta t \Rightarrow \Delta t = \dfrac{0.35}{6.25} \approx 0.056\,\text{s}.$

(b) Velocity of X:
Total momentum conserved:
$m_X u + m_Y u = m_X v_X + m_Y v_Y,$

$0.50(0.40) + 0.25(0.40) = 0.50 v_X + 0.25(1.80),$

$0.30 = 0.50 v_X + 0.45 \Rightarrow v_X = -0.30\,\text{m s}^{-1}.$

Answer: $v_X = 0.30\,\text{m s}^{-1}$ **to the left.**

(c) Elastic check:

- Calculate total $E_k = \frac{1}{2}mv^2$ before and after.
- If total KE before = after → elastic. Otherwise, inelastic.

(d)(i) Name of effect: **Photovoltaic effect.**
(d)(ii) Photons excite electrons from valence to conduction band, creating a potential difference.

Guidance for Students:

- Use $J = \Delta p$ to relate force, time, and momentum.
- Apply momentum conservation carefully with directions.
- Check KE to identify collision type.

Revision Tips:

- **Impulse:** $J = F\Delta t = m\Delta v$.
- **Elastic collision:** KE and momentum conserved.
- Understand **band theory** for photodiodes.
