2019 Ph H2 Q1

Section: Our Dynamic Universe
Topic: Motion, Momentum, and Forces

Question Summary

A tennis ball is released from rest under a motion sensor.
The velocity–time graph shows its motion from release until it rebounds.
We calculate:

1. The initial acceleration.
2. The release height.
3. The change in momentum and average force during the bounce.
4. The acceleration–time graph.

(a) (i) Initial acceleration

✅ **Answer:**
$a = -9.8\,\mathrm{ms^{-2}}$

Working:
From the graph, velocity changes from 0 to –4.9 m s⁻¹ in 0.50 s:
$a = \frac{\Delta v}{\Delta t} = \frac{-4.9 - 0}{0.50} = -9.8\,\mathrm{ms^{-2}}.$

(a) (ii) Release height

✅ **Answer:**
$h = 1.2\,\mathrm{m}$

Working:
Displacement is area under the v–t graph up to 0.50 s.
The area is a triangle:
$s = \frac{1}{2} \times 0.50\,\mathrm{s} \times 4.9\,\mathrm{ms^{-1}} = 1.2\,\mathrm{m}.$

(b) (i) Change in momentum

✅ **Answer:**
$\Delta p = 0.51\,\mathrm{kgms^{-1}}$

Working:
Mass $m = 57.0\,\mathrm{g} = 0.0570\,\mathrm{kg}$.
The ball changes from –4.9 m s⁻¹ to +4.0 m s⁻¹:
$\Delta p = m(v-u) = 0.0570(4.0 - (-4.9)) = 0.0570 \times 8.9 = 0.51\,\mathrm{kgms^{-1}}.$

(b) (ii) Average force

✅ **Answer:**
$F = 1.9\,\mathrm{N}$

Working:
Time of contact during bounce = 0.27 s (from graph).
$F = \frac{\Delta p}{\Delta t} = \frac{0.51}{0.27} = 1.9\,\mathrm{N}.$

(c) Acceleration-time graph

Answer:

- **0 → 0.50 s:** Constant negative acceleration $-9.8\,\mathrm{ms^{-2}}$.
- **0.50 → 0.77 s:** Large positive acceleration (during bounce).
- **0.77 → 1.18 s:** Constant negative acceleration $-9.8\,\mathrm{ms^{-2}}$.

Sketch: A horizontal line at –9.8, a sharp positive spike, then back to –9.8.

Quick Tips

- Acceleration is the slope of a v–t graph.
- Displacement = area under v–t graph.
- Momentum change uses $\Delta p = m\Delta v$.