2019 Ph H2 Q1

Section: Our Dynamic Universe

Topic: Motion, Momentum, and Forces

Question Summary

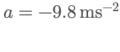
A tennis ball is released from rest under a motion sensor. The velocity-time graph shows its motion from release until it

rebounds.

We calculate:

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

(a) (i) Initial acceleration



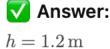
Answer:

From the graph, velocity changes from 0 to $-4.9 \,\mathrm{m \, s^{-1}}$ in 0.50 s:

Working:

$$a = \frac{\Delta v}{\Delta t} = \frac{-4.9 - 0}{0.50} = -9.8 \,\text{ms}^{-2}.$$

(a) (ii) Release height



Displacement is area under the v-t graph up to 0.50 s.

Working:

The area is a triangle:

 $s = \frac{1}{2} \times 0.50 \,\mathrm{s} \times 4.9 \,\mathrm{ms}^{-1} = 1.2 \,\mathrm{m}.$

$\Delta p = 0.51 \,\mathrm{kgms^{-1}}$

Answer:

Working: Mass $m = 57.0 \,\mathrm{g} = 0.0570 \,\mathrm{kg}$

 $\Delta p = m(v-u) = 0.0570(4.0 - (-4.9)) = 0.0570 \times 8.9 = 0.51 \, \mathrm{kgms^{-1}}.$

The ball changes from $-4.9 \,\mathrm{m \, s^{-1}}$ to $+4.0 \,\mathrm{m \, s^{-1}}$:

Answer:

(b) (ii) Average force

 $F = 1.9 \, \text{N}$

 $F = \frac{\Delta p}{\Delta t} = \frac{0.51}{0.27} = 1.9 \text{ N}.$

Answer:

• 0 \rightarrow 0.50 s: Constant negative acceleration $-9.8\,\mathrm{ms}^{-2}$.

(c) Acceleration-time graph

• 0.77 \rightarrow 1.18 s: Constant negative acceleration $-9.8 \,\mathrm{ms}^{-2}$.

0.50 → 0.77 s: Large positive acceleration (during bounce).

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 $\Delta p = m \Delta v$.