FREE SAMPLE: THE FIRST QUESTION

Question One (14 marks)

(a) A 1.00 kg puck moving at 5.00 m s^{-1} strikes a stationary 0.800 kg puck on a frictionless table. After the collision the first puck moves at 3.50 m s^{-1} at 25.0° to its original direction.

Calculate the speed and direction (relative to the original direction of the first puck, with angles measured on the opposite side if appropriate) of the second puck.

[5 marks]

(b) 4 small masses are held by a light frame: 2.00 kg at (1.50, 0.500) m; 0.500 kg at (3.00, 0.500) m; 1.00 kg at (2.00, 1.00) m; 3.00 kg at (0.500, 0) m.

(i) Calculate the position of the centre of mass.

(ii) The 2.00 kg mass is removed. Calculate the new position of the centre of mass and the distance it has moved.

[4 marks]

(c) An astronaut of mass 75.0 kg is at a height of 6.37×10^6 m above Earth's surface. ($G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}; mass of Earth 5.97×10^{24} kg; radius of Earth 6.37×10^6 m.)

(i) Calculate the gravitational field strength at this height and the astronaut's weight there.

(ii) Explain why astronauts in a stable orbit at this height feel weightless even though gravity is still acting on them.

[5 marks]

TESTPAPERS HUB - NOT FOR RESALE OR REDISTRIBUTION

THE WORKED ANSWER TO THAT QUESTION

Question 1 (14 marks) [Translational motion and gravity]

(a) A 1.00 kg puck moving at 5.00 m s^{-1} strikes a stationary 0.800 kg puck on a frictionless table. After the collision the first puck moves at 3.50 m s^{-1} at 25.0° to its original direction. Calculate the speed and direction (relative to the original direction of the first puck, with angles measured on the opposite side if appropriate) of the second puck.

(a) Answer: 2.94 m s^{-1} at 39.0° on the opposite side of the original direction

- Evidence level: Excellence (resolve momentum parallel and perpendicular to the original direction).
- Along the original direction: $1.00 \times 5.00 = 1.00 \times 3.50 \times \cos 25.0° + 0.800\ v_2x$, so $m_2v_2x = 1.83$ kg m s^{-1}.
- Perpendicular: $0 = 1.00 \times 3.50 \times \sin 25.0° + m_2v_2y$, so $m_2v_2y = -1.48$ kg m s^{-1} (opposite side).
- $p_2 = \sqrt{(1.83^2 + 1.48^2)} = 2.35$ kg m s^{-1}, so $v_2 = 2.35 \div 0.800 = 2.94$ m s^{-1} at 39.0° on the other side of the original line.

> **KEY TAKEAWAY**
> Glancing collisions: apply conservation of momentum along and perpendicular to the original line of motion; the perpendicular components must cancel.

(b) 4 small masses are held by a light frame: 2.00 kg at (1.50, 0.500) m; 0.500 kg at (3.00, 0.500) m; 1.00 kg at (2.00, 1.00) m; 3.00 kg at (0.500, 0) m. (i) Calculate the position of the centre of mass. (ii) The 2.00 kg mass is removed. Calculate the new position of the centre of mass and the distance it has moved.

(b) Answer: (i) (1.23, 0.346) m; (ii) (1.11, 0.278) m, a shift of 0.138 m

- Evidence level: Merit (take moments about the axes to find the centre of mass).
- (i) $x_{cm} = \Sigma mx/\Sigma m = 8.00 \div 6.50 = 1.23$ m; $y_{cm} = \Sigma my/\Sigma m = 2.25 \div 6.50 = 0.346$ m.
- (ii) Remaining mass = 4.50 kg, moments 5.00 and 1.25, so the new centre of mass is (1.11, 0.278) m.
- Distance moved $= \sqrt{((1.11 - 1.23)^2 + (0.278 - 0.346)^2)} = 0.138$ m.

> **KEY TAKEAWAY**
> Centre of mass: each coordinate is the mass-weighted average, $x_{cm} = \Sigma mx/\Sigma m$; removing a mass shifts it away from where that mass was.

(c) An astronaut of mass 75.0 kg is at a height of 6.37×10^6 m above Earth's surface. ($G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}; mass of Earth 5.97×10^{24} kg; radius of Earth 6.37×10^6 m.) (i) Calculate the gravitational field strength at this height and the astronaut's weight there. (ii) Explain why astronauts in a stable orbit at this height feel weightless even though gravity is still acting on them.

(c) Answer: (i) 2.45 N kg^{-1} and 184 N; (ii) both are in free fall, so there is no contact force

- Evidence level: Excellence (use Newton's law of gravitation and explain apparent weightlessness).
- (i) $g = GM/r^2$ with $r = 6.37 \times 10^6 + 6.37 \times 10^6 = 1.27 \times 10^7$ m: $g = 3.98 \times 10^{14} \div 1.27 \times 10^{72} = 2.45$ N kg^{-1}.
- Weight $= mg = 75.0 \times 2.45 = 184$ N (compare 736 N at the surface).
- Achievement: (ii) States that the astronaut and the spacecraft are both falling together.

TEST PAPERS HUB · NOT FOR RESALE OR REDISTRIBUTION

• Merit: Links to the force: gravity is the only force acting on both, so they have the same acceleration.

• Excellence: Full explanation: gravity still acts (weight 184 N), but the astronaut and spacecraft both accelerate at gh = 2.45 m s^{-2} towards Earth as they orbit; there is no contact force from the floor (no 'normal reaction'), which is what we feel as weight, so the astronaut feels weightless.

KEY TAKEAWAY

Gravitational field strength g = GM/r^2 with r measured from Earth's centre; in orbit everything is in free fall, so the contact force that we feel as weight is zero.

LOS: Translational motion and gravity (91524)

Free sample from NCEA Level 3 Physics 91524 Mechanics (paper 1 of the set). Full papers with a worked solution for every question: testpapershub.com/c

LIKED THIS SAMPLE?

The full paper is the real thing.

THIS FREE SAMPLE	THE FULL PAPER
A short extract: the opening questions of Paper 1, then their worked answers. 3 pages in all.	Three questions made of several multi-part problems answered in writing (constructed response, no multiple choice), with a worked solution for every part that shows whether it is aimed at Achieved, Merit or Excellence. 12 pages, with a worked solution for every question.

What you get with each paper

- A complete, timed paper in the real exam layout, not just a taste of it.
- A worked solution for every question: numbered steps, why each wrong option is wrong, and a key takeaway.
- 20 different papers in this set. Every one uses new questions, so each extra paper is new practice, not a repeat.
- An A4 PDF emailed straight after payment, made for printing.

Get Paper 1 now

A$11.99 one-off, instant PDF download. Tap or click here.

Or see all 20 NCEA Level 3 Physics 91524 Mechanics papers:
testpapershub.com/collections/ncea-level-3-physics-91524-mechanics/

Getting the most from a practice paper

1. Print it and set the timer shown on the cover. Answer every question before looking at any solution.
2. Mark it against the worked solutions and note the topics that cost you marks.
3. Retry the questions you missed a day later, then use the next paper to check the fix held.

Not sure which paper to start with, or have a question before you buy? Email support@testpapershub.com and a real person will reply, normally within one business day. These are original practice papers, not official past papers, and are not affiliated with any exam authority.