

Centre of mass, impulse and momentum with calculus

AP Physics C (Mechanics and E&M, calculus-based) · Test

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

This test covers impulse and momentum, centre of mass by integration, collisions and the rocket equation. Show all working and give units in final answers. Use $g = 9.81 \text{ m/s}^2$. You have 45 minutes and may use a calculator. Marks are shown in brackets for each part.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 4

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

Question 1 Impulse and momentum (2 marks)

- Define impulse. (1 mark)
- State how impulse is related to the change of momentum. (1 mark)

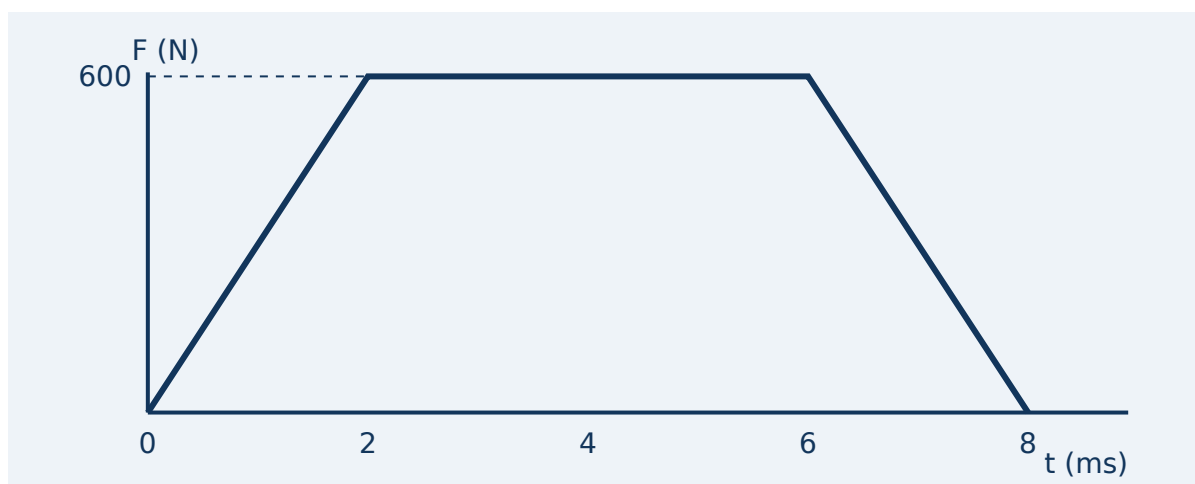
Question 2 Centre of mass of a rod (3 marks)

A rod of length 0.80 m has linear density $\lambda = 5.0x^2 \text{ kg/m}$, with x measured from one end.

- Calculate its mass by integration. (1 mark)
- Calculate $\int x\lambda \, dx$. (1 mark)
- Calculate x_{cm} . (1 mark)

Question 3 Force-time graph (3 marks)

A racket strikes a 0.057 kg ball initially at rest.



Force on the ball against time.

- Calculate the impulse from the area under the graph. (2 marks)
- Calculate the speed of the ball after the strike. (1 mark)

Question 4 Sticking collision (3 marks)

A 0.80 kg trolley moving at 1.5 m/s hits a stationary 0.40 kg trolley and they stick together.

- Calculate their common speed. (1 mark)
- Calculate the initial and final kinetic energies. (1 mark)
- Calculate the energy lost. (1 mark)

Question 5 Elastic collision (3 marks)

A 2.0 kg block moving at 3.0 m/s collides elastically with a 1.0 kg block at rest.

- State the two quantities that are conserved. (1 mark)
- Calculate the final speed of each block. (2 marks)

Question 6 Rocket (2 marks)

A rocket has exhaust speed 2.5×10^3 m/s. Its mass falls to half its initial mass during the burn. Ignore gravity.

- Write the rocket equation. (1 mark)
- Calculate the speed gained. (1 mark)

Question 7 Exploding firework (2 marks)

A firework explodes in mid-air into many pieces. Explain what happens to the motion of the centre of mass of the pieces, ignoring air resistance. (2 marks)

Question 8 Padded gloves (2 marks)

Explain, using impulse, why a baseball catcher's glove is padded and why the hand moves backwards on catching. (2 marks)