

Impulse, momentum and force-time graphs

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to calculate momentum, apply the impulse-momentum theorem and extract impulse from force-time graphs. They cover stops, rebounds, safety devices and sensor data in the style of AP Physics 1 unit 4.

Early problems use one formula at a time; later ones combine signs, graphs and energy ideas. Use $g = 9.81 \text{ m/s}^2$, choose a positive direction and show units in every line.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 4

Problem 1 Momentum of moving objects (easy)

Calculate the momentum of each object.

1. A 1200 kg car travelling at 15 m/s.
2. A 0.058 kg tennis ball travelling at 50 m/s.
3. State which has the larger momentum and the ratio between them.

Problem 2 Impulse from a force (easy)

A constant net force of 250 N acts on a trolley for 0.040 s.

1. Calculate the impulse.
2. State its direction and its unit in terms of kg, m and s.

Problem 3 Change in momentum (easy)

A 2.0 kg trolley speeds up from 3.0 m/s to 7.0 m/s in the same direction.

1. Calculate its change in momentum.
2. State the impulse on it.
3. Calculate the average net force if this takes 0.50 s.

Problem 4 Matching units (easy)

1. Show that 1 N s is equivalent to 1 kg m/s.
2. State which of N s, kg m/s and N/s could be a unit of impulse.

Problem 5 Speed from impulse (easy)

Chiamaka in Lagos kicks a 0.45 kg football that is at rest and gives it an impulse of 9.0 N s.

1. Calculate its launch speed.

2. Calculate its speed if the ball had been 0.90 kg.

Problem 6 Stopping a cricket ball (easy)

A fielder brings a 0.16 kg ball travelling at 30 m/s to rest in 0.020 s.

1. Calculate the ball's change in momentum.
2. Calculate the average force on the ball.

Problem 7 Bouncing off a wall (medium)

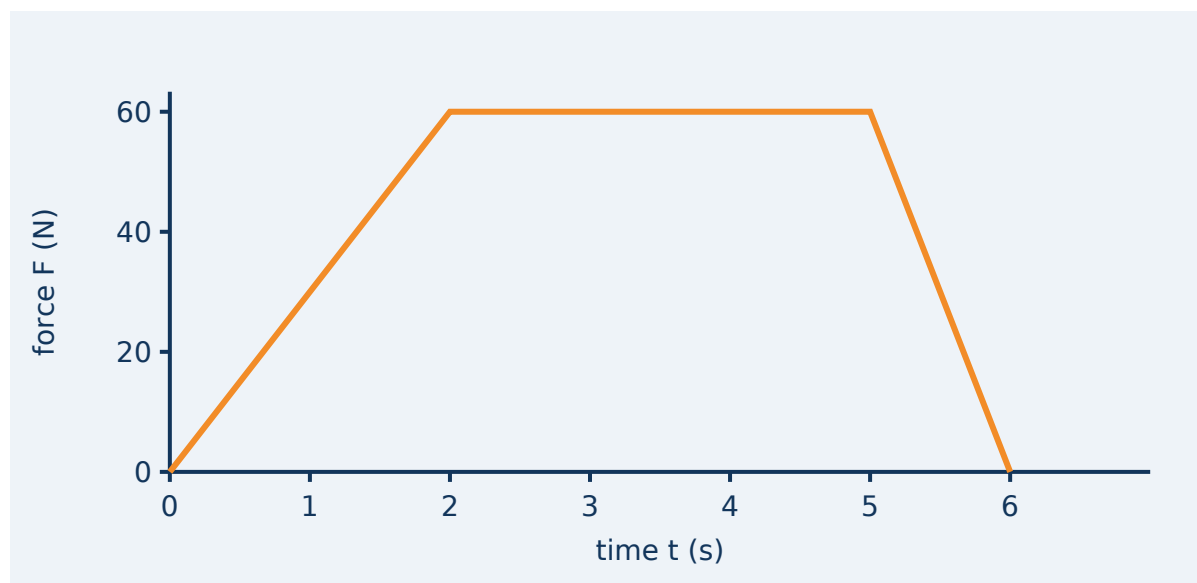
A 0.15 kg ball hits a wall at 20 m/s and rebounds at 12 m/s along the same line. The contact lasts 0.010 s. Take the initial direction as positive.

1. Calculate the change in momentum.
2. Calculate the average force on the ball and state its direction.

Problem 8 Area under a graph (medium)

The graph shows the net force on a 30 kg cart that starts at rest on a frictionless track.

1. Calculate the impulse delivered during the first 2.0 s.
2. Calculate the total impulse over the six seconds.
3. Calculate the final speed of the cart.



Net force on a cart during six seconds.

Problem 9 Airbag in a crash (medium)

A 70 kg driver travelling at 14 m/s is brought to rest.

1. Calculate the average force when an airbag stops the driver in 0.10 s.
2. Calculate the average force when the driver hits the dashboard and stops in 0.020 s.
3. State how many times larger the second force is.

Problem 10 Impulse of gravity (medium)

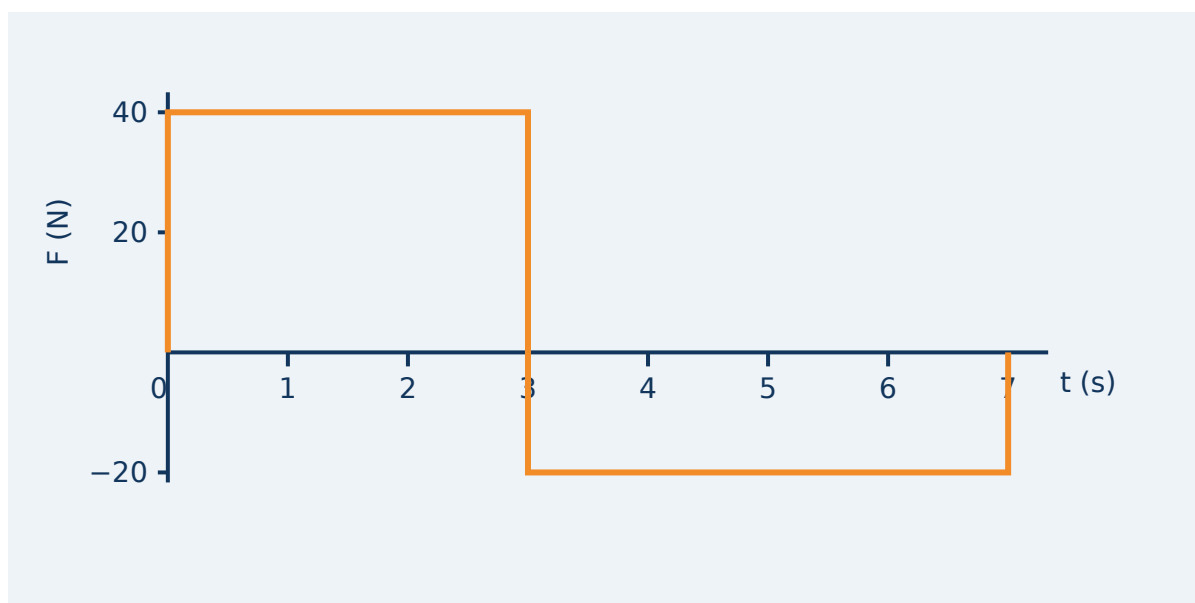
A 0.20 kg ball falls freely for 1.5 s from rest.

1. Calculate the impulse of the weight during this time.
2. Use the impulse to find the speed gained, and check it using $v = gt$.

Problem 11 Force that reverses (medium)

A 10 kg trolley moving at +2.0 m/s is pushed by a force that varies as shown.

1. Calculate the impulse in the first 3.0 s.
2. Calculate the impulse from 3.0 s to 7.0 s.
3. Calculate the total impulse and the final velocity.



A force acts first forward and then backward on a trolley.

Problem 12 Clay and rubber (medium)

Two 0.30 kg balls hit a wall at 6.0 m/s. The clay ball sticks to the wall. The rubber ball rebounds at 6.0 m/s. Take the initial direction as positive.

1. Calculate the change in momentum for each ball.
2. Explain which ball receives the larger impulse from the wall, and why.

Problem 13 Volleyball bump (medium)

A 0.27 kg volleyball arriving at 12 m/s is brought to rest by a player's forearms.

1. Calculate the change in momentum.
2. Calculate the average force if the stop takes 0.050 s.
3. Calculate the average force if the player moves the arms back so the stop takes 0.15 s.

Problem 14 Accelerating car (medium)

A 1200 kg car speeds up from 10 m/s to 25 m/s under a constant net force of 3000 N.

1. Calculate its change in momentum.
2. Calculate the time the force acts.

Problem 15 Bouncing tennis ball (hard)

Emma in Leeds drops a 0.060 kg tennis ball from 1.8 m onto a hard floor. It rebounds to 1.0 m. The contact lasts 0.012 s. Ignore air resistance.

1. Calculate the speed just before and just after impact.
2. Calculate the impulse on the ball.
3. Calculate the average force from the floor on the ball.

Problem 16 Hose against a wall (hard)

Water leaves a hose at 8.0 m/s at a rate of 3.0 kg per second and strikes a vertical wall.

1. Calculate the average force on the wall if the water stops dead and runs down the wall.
2. Calculate the average force if the water bounces straight back at 8.0 m/s.
3. Explain why the second force is larger.

Problem 17 Jumping from the floor (hard)

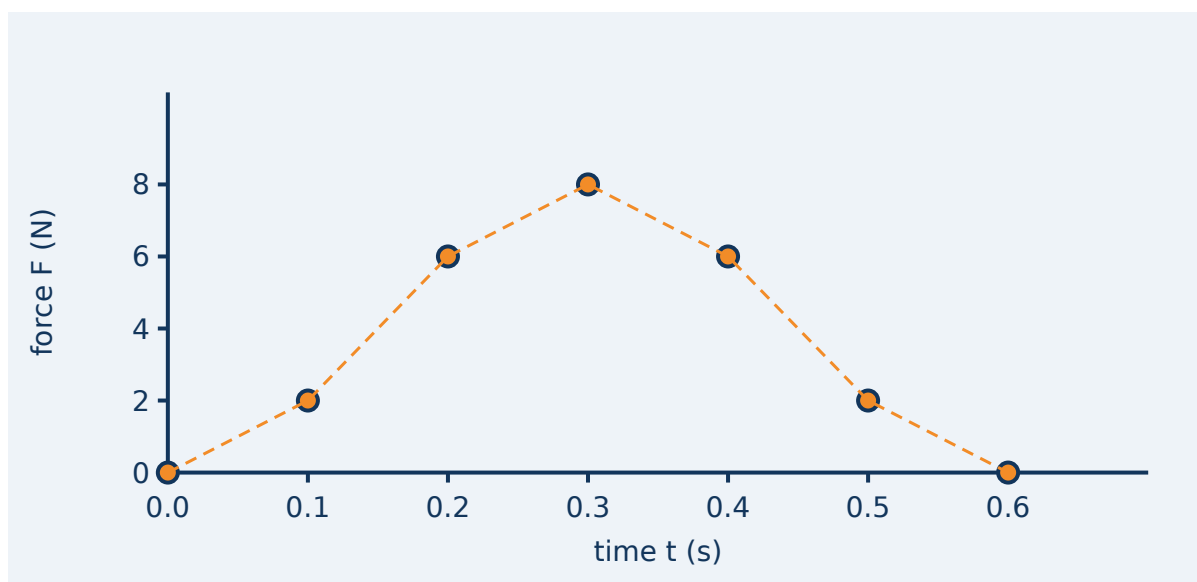
Kofi in Accra, mass 60 kg, jumps straight up and leaves the floor at 2.8 m/s. The push lasts 0.30 s.

1. Calculate the impulse that gives him this speed.
2. Calculate the average net force during the push.
3. Calculate the average force exerted by the floor.
4. Calculate how high he rises after leaving the floor.

Problem 18 Trolley data table (hard)

A force sensor records the force on a 0.80 kg trolley, initially moving at 0.50 m/s, every 0.1 s. The graph shows the readings.

1. Estimate the impulse by joining the points with straight lines and finding the area.
2. Calculate the final speed of the trolley.
3. Suggest one reason why the straight-line method slightly underestimates the true area for a smooth curve.



Force sensor readings on a trolley every 0.1 s.

Problem 19 Spot the error (hard)

Bilal in Lahore says: "A 0.20 kg ball moves at 4.0 m/s towards a wall and returns at 4.0 m/s, so its momentum has not changed and the impulse is zero."

1. Identify the mistake.
2. Calculate the correct impulse on the ball.
3. Calculate the average force if the contact lasts 0.025 s.

Problem 20 Comparing two ways to find impulse (hard)

A 0.50 kg dynamics cart travels towards a force sensor at 0.60 m/s and rebounds at 0.40 m/s. The sensor records a force-time area of 0.48 N s.

1. Calculate the impulse from the change in momentum.
2. Calculate the percentage difference between the two values, using the momentum value as the reference.
3. Suggest one reason for the difference and one way to reduce it.