

Free-body diagrams and net force problems

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems train you to draw free-body diagrams, find the net force, and apply $\Sigma F = ma$ along each axis. You will also identify third-law pairs, solve elevator and hanging-mass problems, and explain results in words.

The level matches AP Physics 1 unit 2. Use $g = 9.81 \text{ m/s}^2$, define up or right as positive, and give each answer with a unit.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 2

Problem 1 Forces on a book (easy)

A book rests on a table.

1. List the forces acting on the book and state their directions.
2. State the net force.
3. Name the third-law partner of the normal force on the book.

Problem 2 Net force and acceleration (easy)

A 1200 kg car has a net forward force of 3000 N.

1. Calculate its acceleration.
2. Calculate the speed after 6.0 s from rest.

Problem 3 Weight on two worlds (easy)

An astronaut has a mass of 70 kg. On the Moon the gravitational field strength is 1.62 N/kg.

1. Calculate the astronaut's weight on Earth.
2. Calculate the weight on the Moon.
3. State the mass on the Moon.

Problem 4 Forces in a line (easy)

The figure shows three horizontal forces on a 5.0 kg block.

1. Calculate the net force and its direction.
2. Calculate the acceleration.



Horizontal forces on a block.

Problem 5 Bus brakes suddenly (easy)

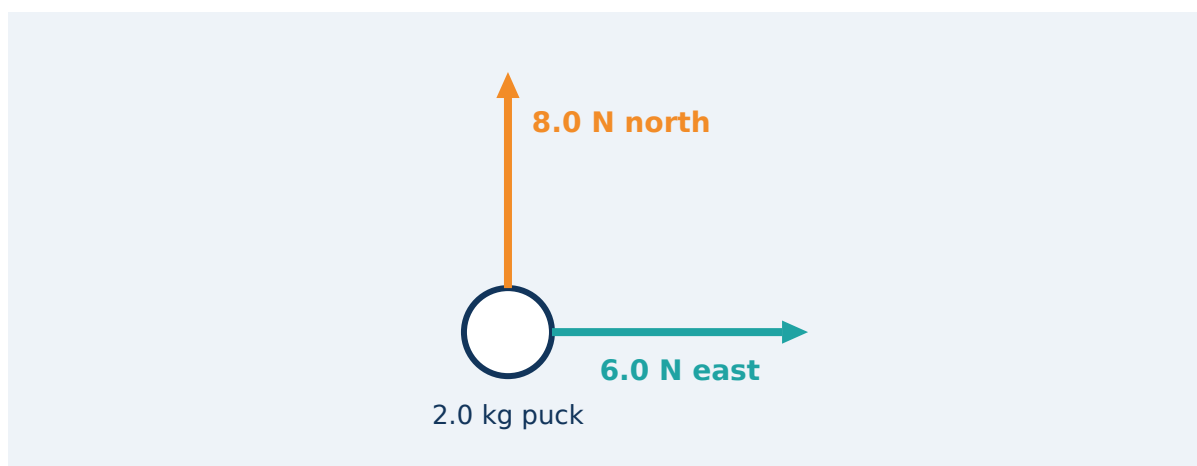
A bus brakes hard and standing passengers lurch forward.

1. Use Newton's first law to explain what happens.
2. State which force slows the bus and what acts on the passengers.

Problem 6 Perpendicular forces (medium)

A 2.0 kg puck on frictionless ice is pulled by two perpendicular forces (see the figure).

1. Calculate the magnitude of the net force.
2. Calculate the magnitude of the acceleration.
3. Calculate the direction of the acceleration, measured north of east.



Top view of a puck; the forces are perpendicular.

Problem 7 Hanging mass (medium)

A 4.0 kg mass hangs from a rope.

1. Calculate the tension when the mass is at rest.
2. Calculate the tension when it accelerates upward at 2.0 m/s^2 .
3. Calculate the tension when it accelerates downward at 2.0 m/s^2 .

Problem 8 Reading a bathroom scale (medium)

Aarav has a mass of 50 kg. In an elevator a scale under him reads 560 N.

1. Calculate his weight.
2. Calculate the acceleration of the elevator and state its direction.
3. State two possible motions of the elevator that fit this reading.

Problem 9 Third-law partners (medium)

For each situation, state the partner force (its object, direction and type).

1. The wall pushes on Diego's hand as he leans on it.
2. A rocket's exhaust gas is pushed downward by the rocket.
3. Earth pulls a falling apple downward.

Problem 10 Braking distance and force (medium)

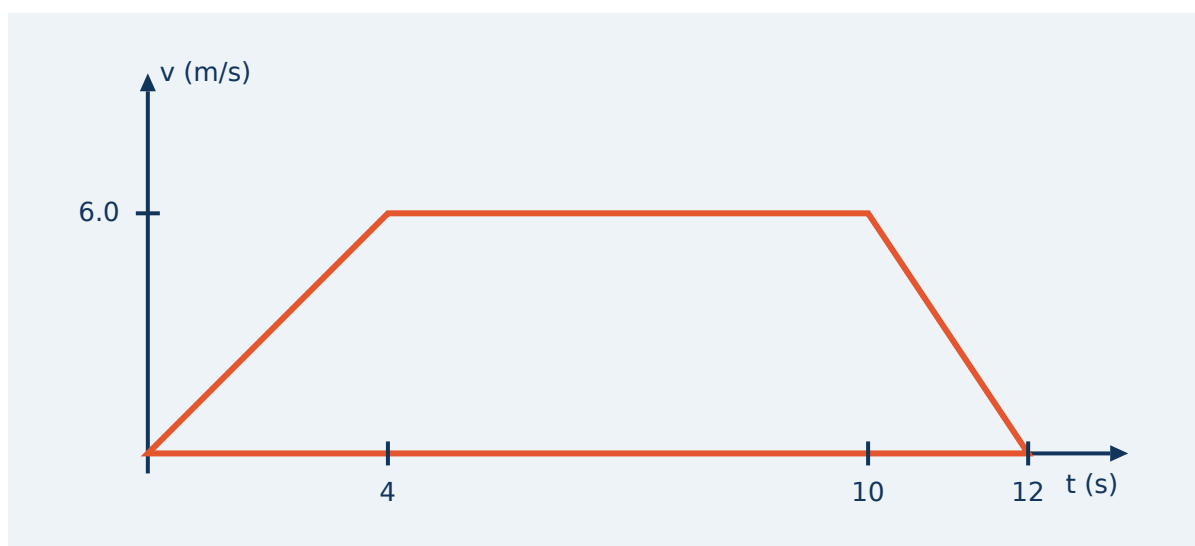
A 1000 kg van moving at 20 m/s stops uniformly in 40 m.

1. Calculate the acceleration.
2. Calculate the braking force.

Problem 11 Dynamics from a graph (medium)

The figure shows the velocity of a 2.0 kg trolley.

1. Calculate the net force from 0 to 4 s.
2. State the net force from 4 s to 10 s.
3. Calculate the net force from 10 s to 12 s and state its direction.



Straight-line segments: 0 to 4 s, 4 s to 10 s and 10 s to 12 s.

Problem 12 Skydiver speeds up (medium)

A skydiver of mass 80 kg falls with an upward drag force of 500 N.

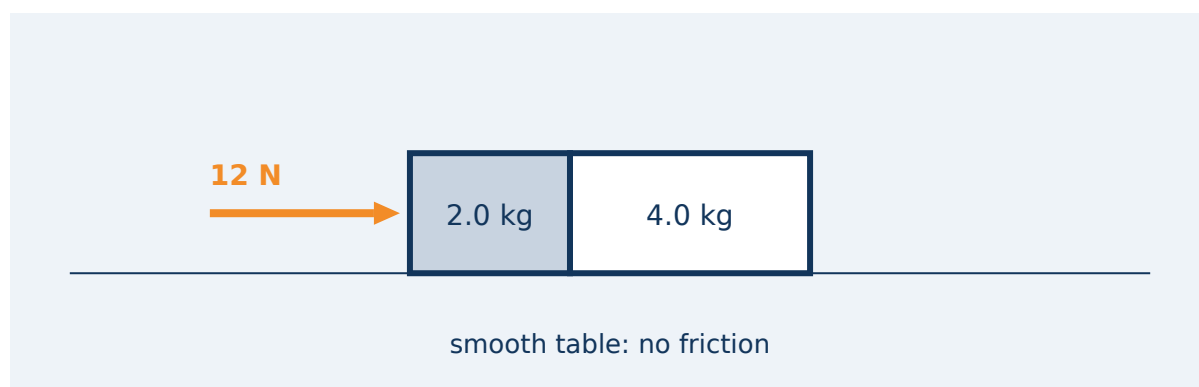
1. Calculate the acceleration.

2. State the drag force at terminal speed and justify your answer.

Problem 13 Two blocks pushed together (medium)

The figure shows a 12 N force pushing a 2.0 kg block that touches a 4.0 kg block on a smooth table.

1. Calculate the acceleration of the pair.
2. Calculate the force the 2.0 kg block exerts on the 4.0 kg block.



Two blocks in contact are pushed together.

Problem 14 Spot the error (medium)

A student says: the weight of a book and the normal force from the table are equal and opposite, so they are Newton's third-law pair.

1. State what is wrong with this claim.
2. Give the correct third-law partner of the weight.

Problem 15 Pulling a crate (hard)

A 25 kg crate on a smooth floor is pulled by a 120 N rope at 35° above the horizontal.

1. Calculate the horizontal acceleration.
2. Calculate the normal force on the crate.

Problem 16 Truck and trailer (hard)

A 2000 kg truck pulls a 800 kg trailer along a smooth road. The road pushes the truck forward with 5600 N.

1. Calculate the acceleration.
2. Calculate the tension in the coupling.
3. Explain why the tension is smaller than 5600 N.

Problem 17 Loaded lift cable (hard)

A lift of mass 1200 kg carries 300 kg of cargo.

1. Calculate the cable tension when it accelerates upward at 0.80 m/s^2 .

2. Calculate the tension when it moves upward and slows down at 1.5 m/s^2 .
3. Calculate the tension at constant velocity.

Problem 18 Bob in an accelerating van (hard)

A 0.20 kg bob hangs from the ceiling of a van that accelerates forward at 2.5 m/s^2 . The string makes an angle θ with the vertical.

1. Draw and describe the free-body diagram of the bob.
2. Calculate θ .
3. Calculate the tension in the string.

Problem 19 Finding the mass from data (hard)

A student pulls a trolley along a track with a force sensor and records:

$F \text{ (N)}$: 1.0, 2.0, 3.0, 4.0

$a \text{ (m/s}^2\text{)}$: 0.51, 1.00, 1.52, 2.01

1. Calculate the gradient of a against F .
2. Use it to find the mass of the trolley.
3. A second experiment gives a line with a negative a -intercept at $F = 0$. Suggest what this means.

Problem 20 Truck against mosquito (hard)

Write a short paragraph answering: a 5000 kg truck hits a $2.0 \times 10^{-6} \text{ kg}$ mosquito. Compare the forces on the two during the collision, and then compare their accelerations. Include the ratio of the accelerations.