

Friction, slopes, pulleys and springs

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems train you to calculate friction forces, resolve weight on a slope, solve Atwood machines and connected blocks, and use Hooke's law. They begin with definitions and one-step calculations and finish with multi-step and experiment-design tasks.

The level matches AP Physics 1 unit 2. Use $g = 9.81 \text{ m/s}^2$, choose a positive direction for each object, and write every result with its unit.

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

Problem 1 Static or kinetic (easy)

State whether each situation involves static or kinetic friction.

1. A book rests on a tilted desk.
2. A skier glides down a slope.
3. A car's tyres grip the road as it accelerates without wheelspin.
4. A sofa is being dragged across a floor.

Problem 2 Friction on a crate (easy)

A 20 kg crate slides on a floor with $\mu_k = 0.30$.

1. Calculate the normal force.
2. Calculate the kinetic friction force.

Problem 3 Stretching a spring (easy)

A spring has a spring constant of 250 N/m.

1. Calculate the force needed to stretch it by 0.12 m.
2. Calculate the stretch produced by a force of 50 N.

Problem 4 Weight components (easy)

A 5.0 kg block rests on a frictionless slope at 40° to the horizontal.

1. Calculate the component of the weight along the slope.
2. Calculate the component perpendicular to the slope.

Problem 5 Harder to start than to keep going (easy)

It takes a larger push to start moving a heavy trolley than to keep it moving at constant

speed.

1. Explain this using static and kinetic friction.
2. State the relationship between μ_s and μ_k for most surfaces.

Problem 6 Pushing a box (medium)

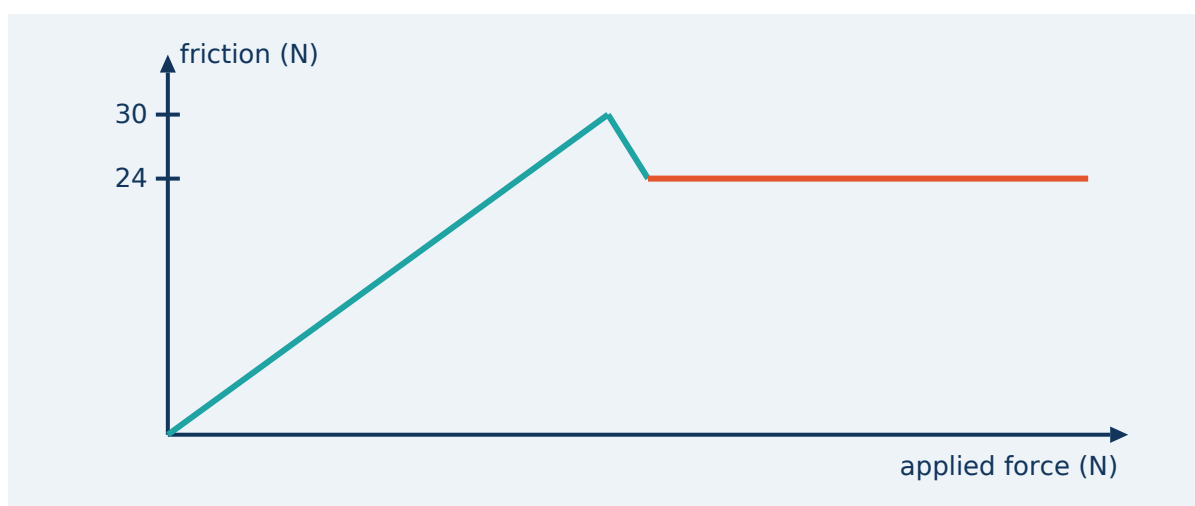
Chiamaka pushes a 12 kg box on a floor with $\mu_s = 0.45$ and $\mu_k = 0.35$.

1. Calculate the maximum static friction force.
2. State the friction force when she pushes with 40 N.
3. Calculate the acceleration when she pushes with 60 N.

Problem 7 Reading a friction graph (medium)

The figure shows friction against applied force for a block weighing 60 N.

1. State the maximum static friction.
2. State the kinetic friction.
3. Calculate μ_s and μ_k .



Friction measured while a force sensor pulls a block with increasing force.

Problem 8 Sliding down a ramp (medium)

A 10 kg block slides down a ramp inclined at 25° with $\mu_k = 0.15$.

1. Calculate the normal force.
2. Calculate the friction force.
3. Calculate the acceleration.

Problem 9 Braking distance (medium)

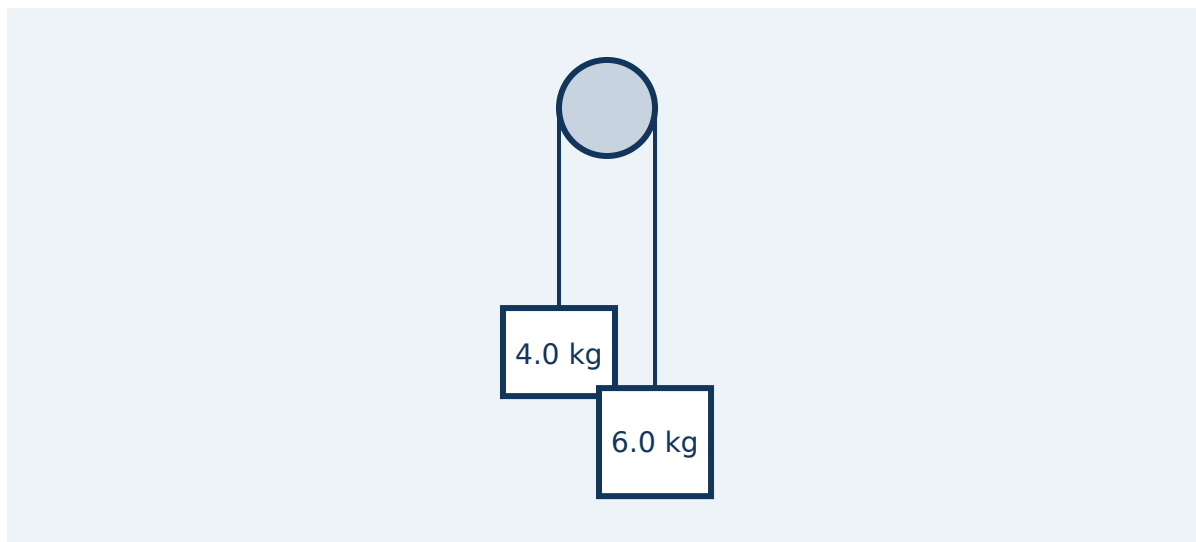
A car with locked wheels slides from 25 m/s to rest on a flat road.

1. Calculate the deceleration if $\mu_k = 0.80$ (dry).
2. Calculate the stopping distance.
3. Calculate the stopping distance if $\mu_k = 0.40$ (wet).

Problem 10 Atwood machine (medium)

The figure shows masses of 4.0 kg and 6.0 kg over a frictionless pulley.

1. Calculate the acceleration.
2. Calculate the tension in the string.



Light string, frictionless pulley.

Problem 11 Spring with a hanging mass (medium)

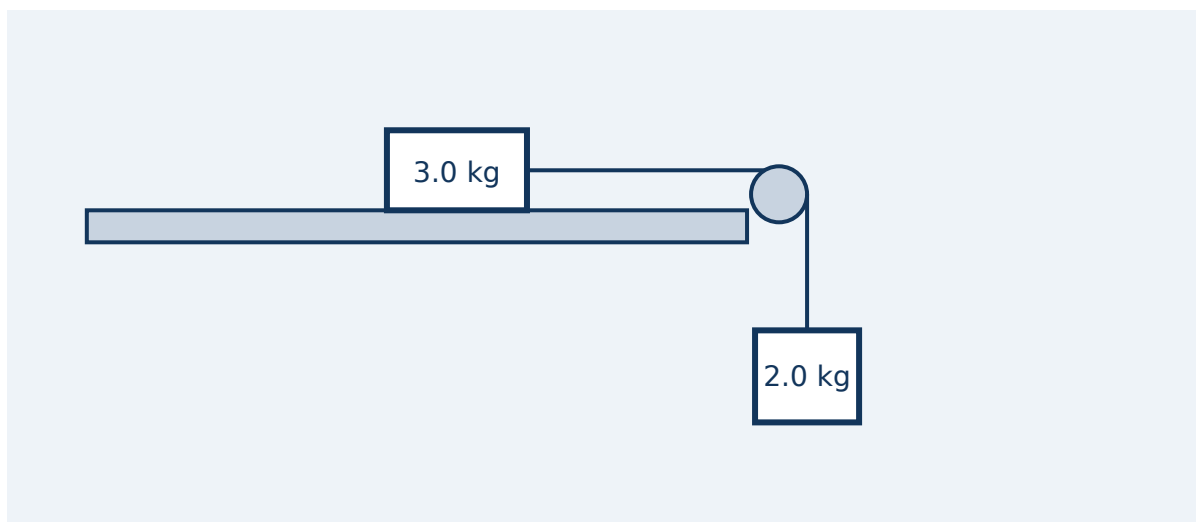
A 0.30 kg mass hangs at rest from a spring and stretches it by 6.0 cm.

1. Calculate the spring constant.
2. Calculate the stretch when 0.50 kg hangs from it.

Problem 12 Table and hanging mass (medium)

The figure shows a 3.0 kg block on a smooth table joined to a 2.0 kg hanging mass.

1. Calculate the acceleration.
2. Calculate the tension in the string.



The hanging mass pulls both masses.

Problem 13 Table with friction (medium)

Repeat the previous situation, but now the table has $\mu_k = 0.20$ for the 3.0 kg block.

1. Calculate the friction force on the block.
2. Calculate the acceleration.
3. Calculate the tension in the string.

Problem 14 Spot the error (medium)

A student says that for an 8.0 kg block sliding down a 30° slope with $\mu_k = 0.30$ the friction force is $\mu mg = 23.5$ N.

1. Identify the mistake.
2. Calculate the correct friction force.

Problem 15 When does it start to slide? (hard)

A block rests on a board that is slowly tilted. It begins to slide at 28° .

1. Show that $\mu_s = \tan \theta$ at that moment.
2. Calculate μ_s .
3. Calculate the angle at which another block with $\mu_s = 0.60$ starts to slide.

Problem 16 Pushing a crate uphill (hard)

A 20 kg crate is pushed up a 30° slope at constant speed by a force parallel to the slope. $\mu_k = 0.25$.

1. Draw and describe the forces on the crate.
2. Calculate the push needed.
3. Calculate the crate's acceleration down the slope if the push stops and it slides down.

Problem 17 Block on a slope and hanging mass (hard)

A 5.0 kg block on a frictionless 30° slope is joined by a string over a pulley at the top to a 4.0 kg mass hanging vertically. The hanging mass moves down.

1. Calculate the acceleration.
2. Calculate the tension.
3. State what happens if the hanging mass is reduced to 2.0 kg.

Problem 18 Spring pulling a block (hard)

A horizontal spring ($k = 80$ N/m) pulls a 0.50 kg block over a surface with $\mu_s = 0.50$ and $\mu_k = 0.30$.

1. Calculate the extension at which the block starts to move.
2. Calculate the extension needed to keep it moving at constant velocity.
3. Explain why the extension decreases after the block starts.

Problem 19 Friction data (hard)

A student drags a block over a table with a force sensor at constant speed after adding masses.

Normal force N (N): 4.9, 9.8, 14.7, 19.6

Pulling force F (N): 1.9, 3.8, 5.8, 7.7

1. Calculate $F \div N$ for each row.
2. Calculate the gradient of F against N and state what it represents.
3. Explain why the line should pass through the origin.

Problem 20 Design a test for μ_s (hard)

Write a short paragraph describing how to find μ_s for a wooden block on a board using only a protractor and a ruler. Explain the physics, name two sources of error and say how you would reduce each.