

Forces, friction and motion on slopes

Physics grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to draw free-body diagrams, apply $F = ma$ with friction, resolve weight on a slope and handle connected bodies and lifts. They move from simple resultant forces to tension, friction coefficients from data and towing problems.

They are written for A Level, IB Physics and CBSE Class 11-12 students. Work from level 1 to level 3, sketch the forces each time and use $g = 9.81 \text{ N/kg}$.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB A.2

Problem 1 Static and kinetic (easy)

Compare the two main kinds of friction.

1. State which one acts when a heavy cupboard is pushed but does not move.
2. State which of the two is usually larger at its maximum, and give the symbol for the coefficient of each.

Problem 2 Net force and acceleration (easy)

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

1. Calculate its acceleration.
2. Calculate the resultant force needed for an acceleration of 4.0 m/s^2 .

Problem 3 Weight and reaction (easy)

Bilal in Lahore places a 12 kg box on a level table.

1. Calculate the weight of the box.
2. State the normal reaction on the box.

Problem 4 Sliding crate (easy)

A 25 kg crate slides on a concrete floor in Accra. The coefficient of kinetic friction is 0.30.

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

Problem 5 Pulled box (easy)

A box of mass 8.0 kg is pulled to the right with a force of 60 N. A friction force of 22 N acts to the left.



The two horizontal forces.

1. Calculate the resultant force.
2. Calculate the acceleration.

Problem 6 Weight components (easy)

A 4.0 kg block rests on a slope inclined at 25° .

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

Problem 7 Pushing a crate (medium)

Kofi pushes a 40 kg crate with 180 N across a floor. The coefficient of kinetic friction is 0.35.

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

Problem 8 Moving a bookcase (medium)

Wanjiru's family in Nairobi move a 15 kg bookcase. $\mu_s = 0.45$ and $\mu_k = 0.32$.

1. Calculate the force needed to start it moving.
2. Calculate the friction force once it is sliding.
3. Calculate the acceleration if the push stays at the force in part 1.

Problem 9 Skidding car (medium)

A car skids to a halt from 25 m/s with all wheels locked. Compare dry and wet roads, assuming that the mass of the car does not matter.

1. Calculate the deceleration on a dry road with $\mu_k = 0.80$.
2. Calculate the skid distance on the dry road.
3. Calculate the skid distance on a wet road with $\mu_k = 0.40$.

Problem 10 Frictionless sledge (medium)

Mei and a friend slide on a sledge down a smooth icy slope of angle 15° in Canada.

1. Calculate the acceleration.
2. Calculate the speed after the sledge has moved 20 m from rest.

Problem 11 Ramp for a crate (medium)

A 12 kg crate slides down a ramp inclined at 20° with $\mu_k = 0.15$.

1. Calculate the component of weight down the slope.
2. Calculate the friction force.
3. Calculate the acceleration.

Problem 12 Angle of slipping (medium)

A wooden block begins to slide on a board when the board is tilted to 27° .

1. Show that $\mu_s = \tan \theta$ at the point of slipping.
2. Calculate μ_s .

Problem 13 Two blocks pulled (medium)

Diego pulls a 3.0 kg block with a horizontal force of 25 N. It is joined by a rope to a 2.0 kg block behind it. Both rest on a table with $\mu_k = 0.20$.

1. Calculate the total friction force.
2. Calculate the acceleration of the blocks.
3. Calculate the tension in the rope.

Problem 14 Lift scale reading (medium)

Emma, mass 70 kg, stands on a weighing scale in a lift.

1. Calculate the scale reading when the lift accelerates upwards at 1.2 m/s^2 .
2. Calculate the reading when it accelerates downwards at 1.2 m/s^2 .
3. Calculate the reading at constant velocity.

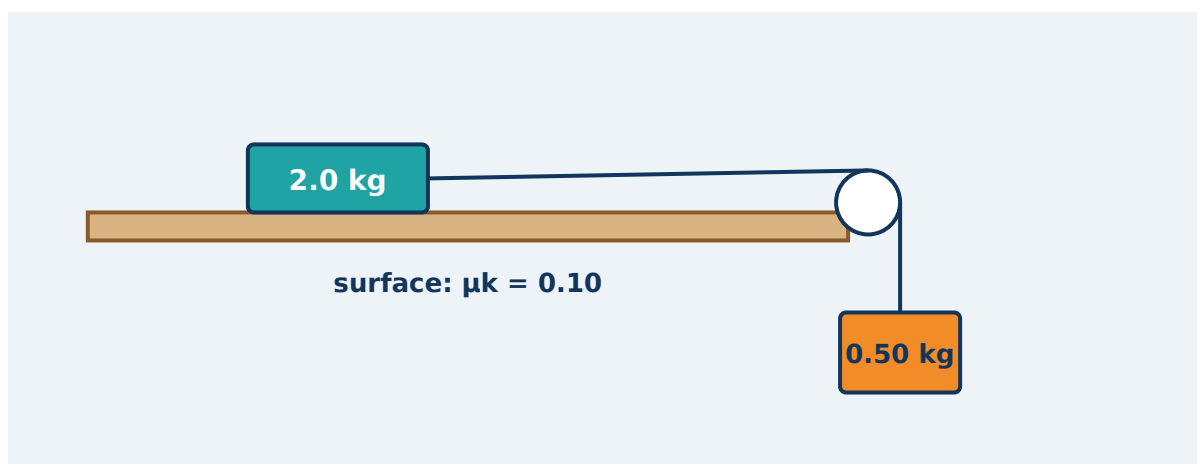
Problem 15 Spot the slope error (medium)

A student finds the acceleration of an 8.0 kg block sliding down a 35° slope with $\mu_k = 0.25$. She writes friction $f = 0.25 \times 8.0 \times 9.81 = 19.6 \text{ N}$.

1. Explain her mistake.
2. Calculate the correct friction force and the acceleration.

Problem 16 Trolley and hanging mass (hard)

A 2.0 kg trolley on a rough table ($\mu_k = 0.10$) is joined by a string over a pulley to a hanging 0.50 kg mass. The system is released from rest.



Trolley and hanging mass.

1. Calculate the friction force on the trolley.
2. Calculate the acceleration of the system.
3. Calculate the tension in the string.

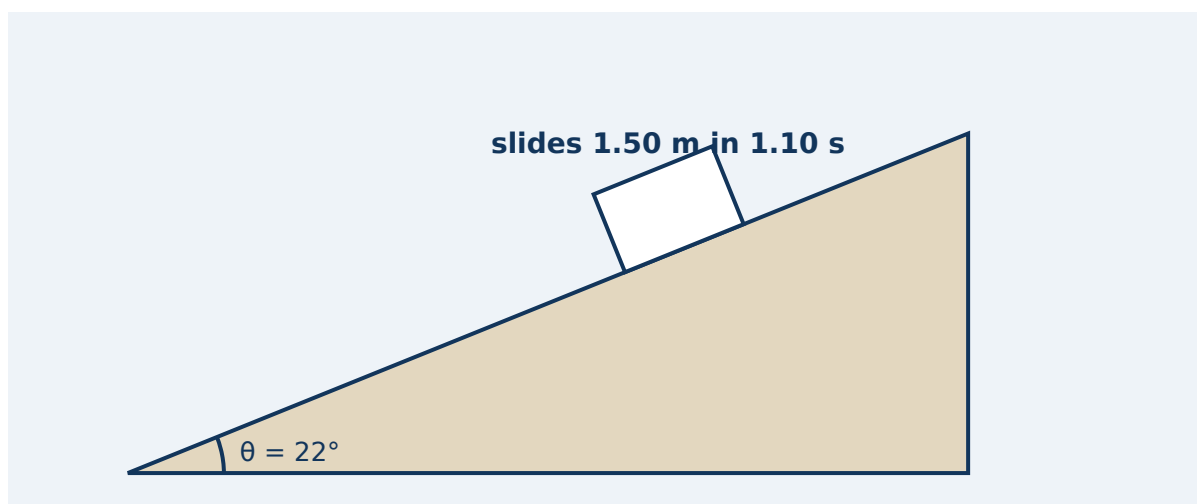
Problem 17 Pushing up a ramp (hard)

Workers push a 20 kg crate up a ramp inclined at 25° with a force parallel to the ramp. $\mu_k = 0.30$.

1. Calculate the force needed for constant speed.
2. Calculate the acceleration if the push is 180 N.

Problem 18 Friction coefficient from data (hard)

A block is released from rest on a slope inclined at 22° . It slides 1.50 m in 1.10 s.



Block on a 22° slope.

1. Calculate the acceleration of the block.
2. Show that $a = g(\sin \theta - \mu \cos \theta)$.
3. Calculate μ_k .

Problem 19 Car and caravan (hard)

A car of mass 1200 kg tows a caravan of mass 800 kg. The driving force is 3500 N. The resistances are 400 N on the car and 300 N on the caravan.

1. Calculate the acceleration.
2. Calculate the tension in the tow bar.

Problem 20 Crate on a truck (hard)

A 50 kg crate sits on the flat bed of a truck. $\mu_s = 0.40$ and $\mu_k = 0.30$ between crate and bed.

1. Calculate the greatest acceleration of the truck for which the crate does not slide.
2. The truck accelerates at 4.5 m/s^2 . Calculate the acceleration of the crate.
3. Calculate how far the crate slides back relative to the bed in 2.0 s.