

Friction, slopes, pulleys and springs

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

A block is dragged over a board and later placed on a tilting ramp. By measuring the pulling force for different loads and the slipping angle, you find the coefficients of kinetic and static friction and test that friction is proportional to the normal force.

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

Aim

To find the coefficients of kinetic and static friction for a wooden block on a wooden board, and to show that friction is proportional to the normal force.

Equipment

- wooden block (0.40 kg) with a hook
- set of slotted masses (0.20 kg each)
- spring balance (0 to 10 N) and string
- wooden board about 1 m long, protractor or ruler
- balance

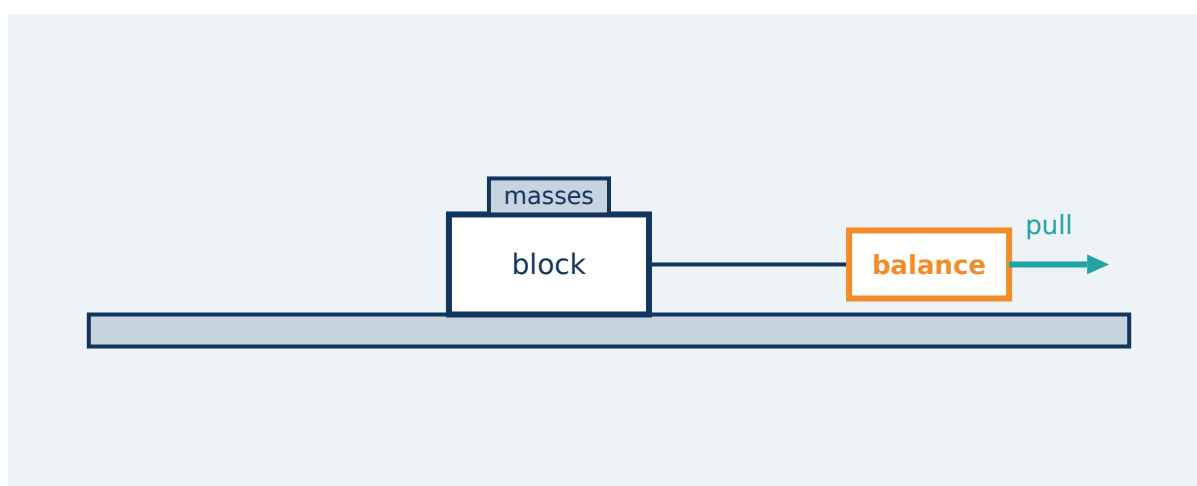
Safety

Safety

Keep feet away from the path of the block and masses, and hold the board firmly while tilting it so it cannot slip off the bench.

Method

1. Weigh the block and add masses so the total mass m is 0.40, 0.60, 0.80, 1.00 and 1.20 kg.
2. For each mass, pull the block along the level board at constant speed with the spring balance and read the force F_k in the middle of the run.
3. Calculate $N = mg$ for each mass ($g = 9.81 \text{ N/kg}$).
4. Tilt the board slowly with the 0.40 kg block alone on it, and measure the angle at which the block starts to slide. Repeat five times.



Pull the block at constant speed so the balance reading equals the kinetic friction force.

Results

Part 1: kinetic friction.

m (kg)	N (N)	F_k (N)
0.40	3.92	1.30
0.60	5.89	1.98
0.80	7.85	2.60
1.00	9.81	3.35
1.20	11.77	3.85

Part 2: angle at which the block starts to slide.

Trial	1	2	3	4	5
θ (°)	19.0	20.0	18.5	19.5	20.5

Analysis questions

Question 1 Normal force

Calculate the normal force and the friction ratio $F_k \div N$ for the 1.00 kg row.

Question 2 Graph of F against N

Calculate the gradient of F_k against N using the first and last data points and state its meaning.

Question 3 Best value of kinetic friction

Calculate $F_k \div N$ for all five rows and give the mean μ_k to two significant figures.

Question 4 Angle method

Show that the block starts to slide when $\tan \theta = \mu_s$, and calculate μ_s from the mean angle.

Question 5 Uncertainty in μ_s

Use the smallest and largest angles to estimate the uncertainty in μ_s .

Question 6 Comparing coefficients

Compare μ_s and μ_k and explain the difference.

Question 7 Improvements

Explain why the block must move at constant speed, and suggest two improvements.