

Free-body diagrams and net force problems

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

A hanging mass pulls a trolley along a bench. By timing a one-metre run for different pulling forces while the total mass stays constant, you test Newton's second law and measure the mass of the system and the friction force.

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

Aim

To show that the acceleration of a system is proportional to the net force on it when the total mass is kept constant, and to find the mass of the system from a graph.

Equipment

- dynamics trolley with a track or smooth bench
- pulley with clamp and string
- mass hanger with 10 g slotted masses
- metre rule and stopwatch (or a phone video with a frame counter)
- balance

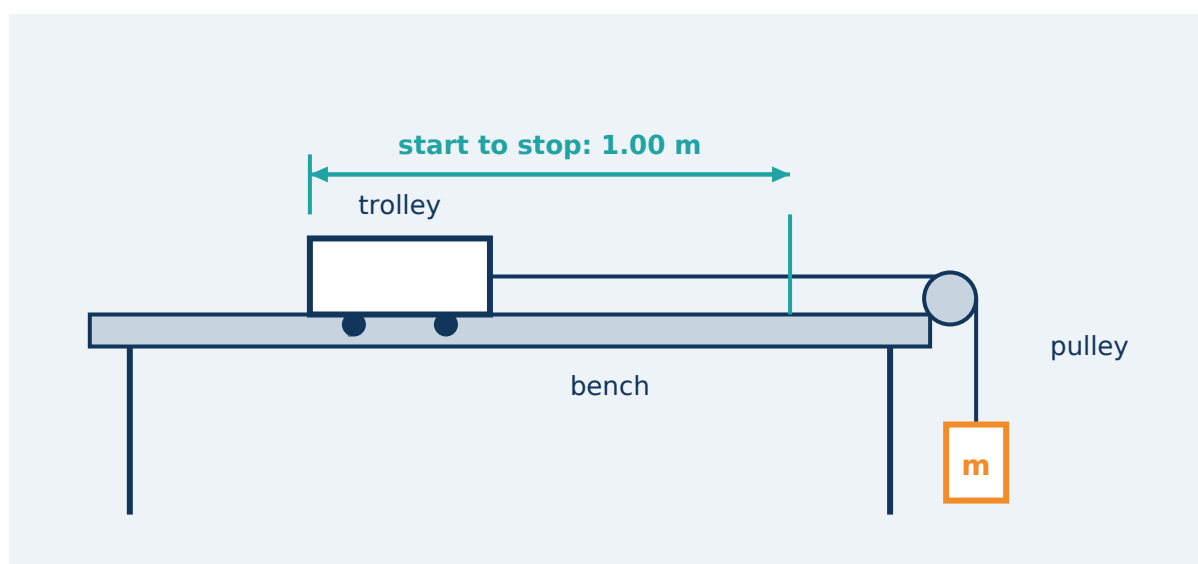
Safety

Safety

Place a cushion on the floor under the hanging masses and a block at the end of the track so the trolley cannot fall off the bench.

Method

1. Use the balance to set the total moving mass (trolley, extra masses and hanger) to $M = 0.600 \text{ kg}$.
2. Mark start and stop lines 1.00 m apart.
3. Put $m = 0.020 \text{ kg}$ on the hanger and the remaining slotted masses on the trolley, so the total stays 0.600 kg.
4. Release the trolley from rest and time the motion from start to stop. Repeat three times and take the mean.
5. Move 0.020 kg from the trolley to the hanger and repeat, up to 0.100 kg.



The hanging mass accelerates the whole system of trolley, string and hanger.

Results

Mean times for the 1.00 m trip. Calculate a using $a = 2d \div t^2$.

m (kg)	$F = mg$ (N)	t (s)	a (m/s^2)
0.020	0.196	2.77	0.26
0.040	0.392	1.85	0.58
0.060	0.589	1.48	0.91
0.080	0.785	1.27	1.24
0.100	0.981	1.13	1.57

Analysis questions

Question 1 Acceleration

Show that $a = 2d \div t^2$ follows from constant acceleration starting from rest, and check the value for $m = 0.060$ kg.

Question 2 The graph

Calculate the gradient of the a against F graph using the first and last points.

Question 3 System mass

Use the gradient to find the mass of the system and compare with 0.600 kg.

Question 4 The intercept

Find the force at which the line crosses the F axis and interpret it.

Question 5 Constant total mass

Explain why masses were moved from the trolley to the hanger instead of simply adding masses to the hanger.

Question 6 String tension

Calculate the tension in the string for $m = 0.100$ kg and compare it with the weight of the hanging mass.

Question 7 Improvement

Suggest two ways to reduce the effect of friction and of timing error.