

Newton's three laws of motion

Grade 8 science (Year 9 · Class 8) · Lab

Name: _____ Date: _____ Class: _____

How does the acceleration of a trolley change when you add mass but keep the pulling force the same? In this lab you time a trolley over 1.00 m with different loads, calculate its acceleration and test the relationship between force, mass and acceleration.

Level: Grade 8 science (Year 9 · Class 8) · **Curriculum:** MS-PS2-1, MS-PS2-2

Aim

To investigate how the acceleration of a trolley depends on its mass when the pulling force stays the same.

Equipment

- Trolley with smooth wheels and a flat table or runway
- String, pulley and 100 g hanger
- Slotted masses (0.5 kg each)
- Metre rule and stopwatch
- Soft stop block (a cushion)

The pulling force is the weight of the hanger: $0.100 \text{ kg} \times 9.8 \text{ N/kg} = 0.98 \text{ N}$. The acceleration is found from the time taken to travel a distance d from rest using $a = 2d \div t^2$.

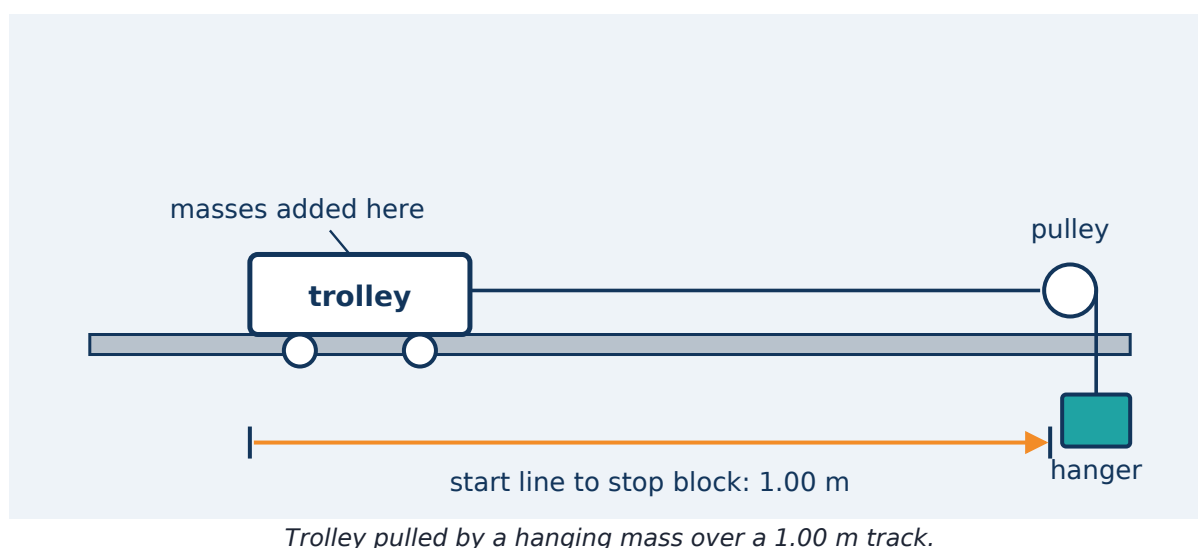
Safety

Safety

Place a cushion at the end of the track so the trolley and falling masses do not hit your feet. Do not let masses fall from height. Keep fingers clear of the pulley.

Method

1. Set up the apparatus as shown, with the hanger at 100 g and the start line 1.00 m from the stop block.
2. Put 0.50 kg of slotted masses on the trolley, hold the trolley at the start line and release it.
3. Time the trolley over the 1.00 m. Repeat three times and record the mean time.
4. Add 0.50 kg more to the trolley and repeat the timing.
5. Continue until you have used four loads: 0.50, 1.00, 1.50 and 2.00 kg on the trolley.



Results

The total mass moving is the trolley load plus the 0.10 kg hanger. Sample mean times for 1.00 m:

Load on trolley (kg)	Total mass moving (kg)	Mean time for 1.00 m (s)
0.50	0.60	1.18
1.00	1.10	1.58
1.50	1.60	1.93
2.00	2.10	2.22

Analysis questions

Question 1 Acceleration values

Calculate the acceleration for each load using $a = 2d \div t^2$, with $d = 1.00$ m.

Question 2 Mass multiplied by acceleration

Calculate total mass $\times$ acceleration for each row and say what you notice.

Question 3 Graph

Plot acceleration (y-axis) against total mass (x-axis). Describe the shape. Suggest a graph that would give a straight line.

Question 4 Compare with the weight

The weight of the hanger is 0.98 N. Compare it with your value of $m \times a$ and calculate the percentage difference.

Question 5 Control variables

State the independent variable, the dependent variable and two variables that must be kept the same.

Question 6 Timing uncertainty

The stopwatch reaction time introduces an uncertainty of about ± 0.1 s. Find the percentage uncertainty in the time for the first row and in its acceleration.

Question 7 Improvements

Suggest two ways to improve the accuracy.