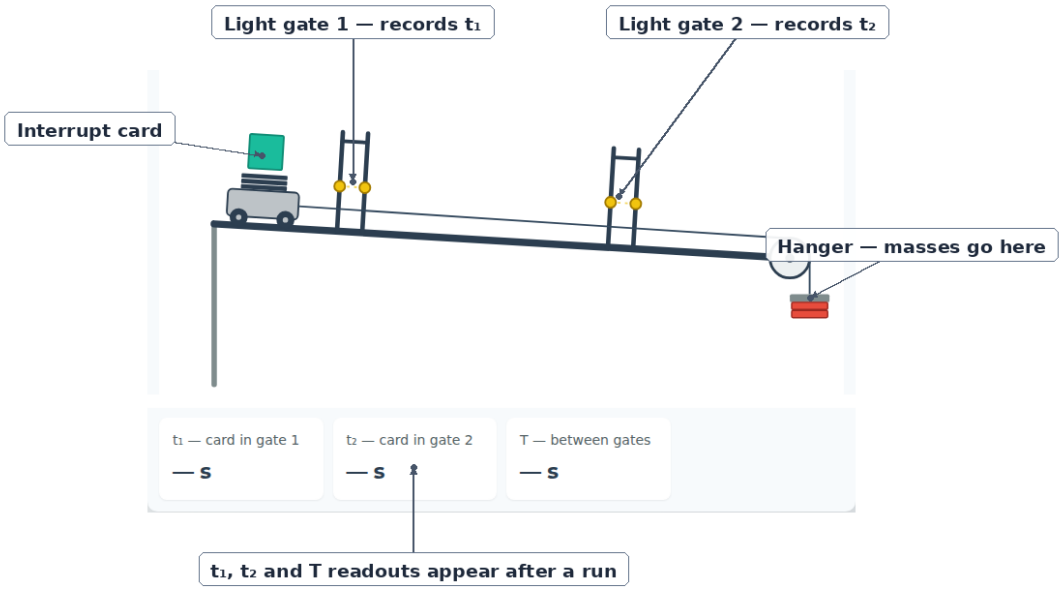
Verifying Newton's Second Law

Trolley, Hanger Mass and Light-Gate Timing

Aim:

You are investigating how the force applied to a trolley affects its acceleration, while keeping the total mass of the system constant.



Method:

1. The trolley mass *M* (= 0.500 kg) and card length *L* (= 0.050 m) are pre-set. Stack all five 20 g masses onto the trolley to begin — the total system mass is fixed at M + 5 × 20 g = 0.600 kg for the whole practical.
2. Select 1 · Compensate friction. With no masses on the hanger, use the Ramp angle slider and Give a small push until the trolley crosses both light gates at a steady velocity ($t_1 \approx t_2$). Keep this ramp angle fixed for the rest of the practical.
3. Select 2 · Run experiment.
4. Use the → button to transfer one 20 g mass from the trolley to the hanger.
5. Press Release trolley, then press Record result once the run finishes. The values of m, t_1, t_2 and T are filled in for you.
6. Calculate $\mathbf{u = L / t_1}$, $\mathbf{v = L / t_2}$ and $\mathbf{\Delta v = v - u}$ for this run and enter them in your table.
7. Repeat steps 4–6 for a second run at the same hanger mass, then transfer another mass across and repeat again — until you have two runs recorded at each of the 5 possible hanger masses (10 runs in total).

Prediction:

With the ramp still at your friction-compensation angle from step 2, transfer all five masses back onto the trolley so the hanger mass is zero. What do you predict will happen if you press Release trolley now — will the trolley accelerate away, or stay still?

My prediction: .....

Test your prediction, then transfer the masses back onto the hanger before continuing.

Results:

#	m (kg)	t_1 (s)	t_2 (s)	T (s)	u (m/s)	v (m/s)	Δv (m/s)

Analysis:

For each run, calculate the force provided by the hanger, **weight (N) = mass transferred (kg) × 9.81 m/s²**, and the acceleration **a = Δv / T**.

Compare your two repeat runs at each hanger mass. How closely do the Δv and T values agree with each other, and which run shows the most scatter between its two repeats?

Plot force (N) on the vertical axis against acceleration (m/s²) on the horizontal axis, using the mean of your two repeats at each hanger mass. Describe the shape of your graph — does a straight line fit your points well, and does it pass close to the origin?

Measure the gradient of your line of best fit, including units. How does this compare with the total system mass M + Σm = 0.600 kg? Calculate a percentage difference between the two.

Why is it important that the total system mass stays constant as you transfer masses between the trolley and the hanger, rather than simply adding extra masses to the hanger each time?