Resultant force and acceleration: constant system mass

Student activity • investigation and reasoning

YEAR 10 / LESSON 5 / PHYSICS + SCIENCE (DOUBLE AWARD)

The question

How does acceleration change when the driving force increases but total system mass stays constant?

Transfer small masses from a sensor trolley to a hanging holder. Measure acceleration from the wheel-derived velocity graph, keeping all transferred masses in the system.

Equipment

- Sensor trolley, level track, pulley, string and padded stop
- Compatible device, balance and small slotted masses with holder
- Padded collection tray, booklet, calculator and graph paper

Secure the track and pulley. Keep feet and fingers away from falling masses and moving trolleys; catch the holder in a padded tray. Use only staff-approved small loads and short drops. Keep string clear of walkways; stop the trolley safely without reaching into its path.

Course coverage: Shared Physics / Double Award: 1.17, 1.21. Force, acceleration and terminal motion.

Plan, model or apparatus sketch

Draw a labelled setup or force diagram; include the measured quantities.

Method and reasoning

Read the whole sequence before starting

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1. Staff secure a level track, low-friction pulley, sensor trolley, string and padded end stop. The hanging holder falls into a tray before the trolley can reach the track end; analyse only motion before the holder lands.

2. Measure the trolley plus all transferable masses plus hanger as total system mass M. Begin with the smallest staff-piloted hanging mass. Keep the remaining transferable masses on the trolley.

3. Release from rest without a push. Record wheel-derived velocity versus time and fit a straight line to the clear moving interval before the hanger lands or trolley stops. Its gradient estimates acceleration.

4. Repeat three runs at the same hanging mass. Transfer one small mass from trolley to hanger, keeping total M unchanged. Repeat for five approved hanging masses.

5. Calculate the approximate external driving force as hanging mass × g, using g = 9.8 N kg^{-1}. Plot mean acceleration against this force and compare with a = F/M.

6. Explain deviations using track friction and pulley effects. Separately sketch weight and drag for a falling object approaching terminal speed: constant speed occurs when those forces balance, not when gravity stops.

Cleanup

- Support the hanger before removing masses; disconnect the string and return masses, trolley and sensors to storage.

Record your evidence

Blank spaces are for your own work

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Reference and task data

For the combined trolley-and-hanger system, string tension is internal. Hanging weight is an approximate net driving force only when friction and pulley effects are small. Do not set the tension equal to the hanger's weight while it accelerates. The sensor cart's wheel-derived velocity slope is used; a raw accelerometer channel is a different measurement. Practice example: a resultant 0.40 N acting on a 0.80 kg system gives 0.50 m s^{-2}.

Hanging mass / kg	a1 / m s^{-2}	a2 / m s^{-2}	a3 / m s^{-2}

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Why transfer masses rather than add new ones?

2. Calculate a for 0.40 N and 0.80 kg.

3. Why use the slope of velocity–time data?

4. Why stop the fit before the hanger lands?

5. Is hanging weight exactly the net system force?

6. What is the resultant force at terminal velocity?