The relationship between force and momentum

Q1: Research Question

- This project investigates the relationship between the initial push force and thus initial momentum of a small object and the distance it travels before stopping due to friction.
- The goal is to show that increasing the applied force leads to greater momentum and a longer travel distance.

Q2: Methodology

- Place the object on a flat surface with a consistent friction coefficient.
- Use the mechanism to push the object for exactly 3.00 seconds.
- Measure the distance from start to the point the object stops.
- Repeat for three different force levels. Record averages (sample values used here: 50 cm, 70 cm, 80 cm).
- Calculate acceleration, force, velocity and momentum using the formulas provided.

Q3: Analysis & Result

Distance(cm)	a (m/s^2)	F (N)	v (m/s)	p (kgm/s)
50	0.1111	0.01111	0.3333	0.033
70	0.1556	0.01556	0.4668	0.046
80	0.1778	0.01778	0.5334	0.05334

Q4: Interpretation & Conclusion

- The force needs to be measured, and multiple trials should be conducted to estimate the uncertainty.
- Mass Variation (Future Direction) : Repeat the experiment by fixing the Applied Force and time, but varying the mass of the object to validate the effect of m on P and d
  - m is mass
  - P is momentum
  - d is distance

Introduction: Background Research

Momentum p is defined as $p = m \cdot v$, where m is mass and v is velocity. When a constant force acts on an object, the object experiences acceleration a and reaches velocity after time t as $v = a \cdot t$. The goal is to show that increasing the applied force (and therefore a and v) leads to greater momentum and a longer travel distance.

THEORETICAL BACKGROUND

Newton's Second Law

$$F = m \cdot a$$

Kinematic relation

$$s = 1/2 \cdot a \cdot t^2$$

Final speed

$$v = a \cdot t$$

Momentum

$$p = m \cdot v$$

Problem

How does the initial momentum of a 100g object affect the maximum distance it travels on a flat surface?

HYPOTHESIS

If the push force increases, the final velocity after the force ends will increase, leading to larger momentum. Larger momentum becomes larger kinetic energy, therefore the object requires a longer distance for friction to dissipate that energy and stop the object.

Investigative methods: variables

independent variable

Momentum of 100g object

Dependent varialbe

Distance object travels

controls

flat surface

Consistent friction

controls

Mechanism

pushing objects

Investigative methods: Material

1	- Test object: mass 100 g (0.1 kg)
2	- Force application time: 3.0 s (fixed)
3	- Controlled pushing mechanism
4	- Ruler or measuring tape (cm)
5	- Tape, stopwatch (for verification)

Investigative methods: Procedure

- Place the object on a flat surface with a consistent friction coefficient.
- Use the mechanism to push the object for exactly 3.00 seconds.
- Measure the distance from start to the point the object stops.
- Repeat for three different force levels. Record averages (sample values used here: 50 cm, 70 cm, 80 cm).
- Calculate acceleration, force, velocity and momentum using the formulas provided.

RESULTS

Distance(cm)	a (m/s^2)	F (N)	v (m/s)	p (kgm/s)
50	0.1111	0.01111	0.3333	0.03333
70	0.1556	0.01556	0.4668	0.04668
80	0.1778	0.01778	0.5334	0.05334

Discussion & interpretations

The calculation results show that with a larger distance (corresponding to a larger applied force), the acceleration, velocity, and momentum all increase, which supports the hypothesis.

The force needs to be measured, and multiple trials should be conducted to estimate the uncertainty.

Possible improvements

Using a track or slide (if available) for easier control and performing multiple repetitions for more accurate calculations.

FUTURE DIRECTIONS/Implications

Mass Variation: Repeat the experiment by fixing the Applied Force and time, but varying the mass of the object to validate the effect of m on P and d

- m is mass
- P is momentum
- d is distance

Abstract

This project investigates the relationship between the initial push force and thus initial momentum of a small object and the distance it travels before stopping due to friction. The experiment pushes a 100 g object for a fixed time of 3 seconds at three different force levels, measures the travel distances, and calculates related physical quantities.