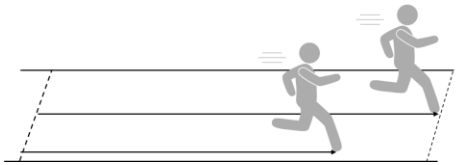
8.03: Forces and Motion

Speed

- the rate of change of distance



uniform speed = unchanging speed

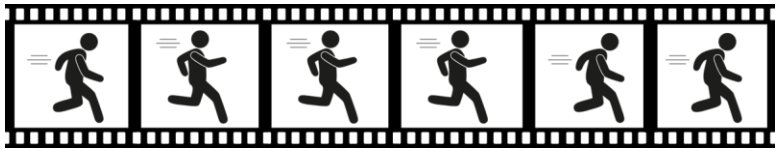
Higher speed:

- greater distance in same time interval
- same distance, shorter time interval

$$\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

Instantaneous Speed

Speed at a particular moment in time.

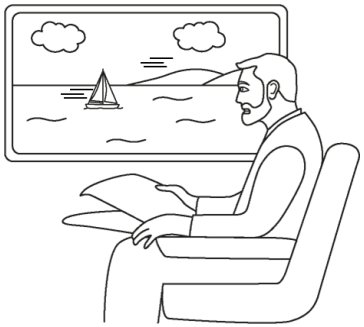


Average Speed

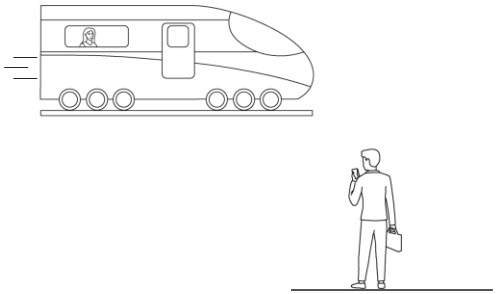
Speed for distance travelled, measured over a longer time interval.

Relative Motion

- movement of one moving object relative to another object
- depends on the frame of reference

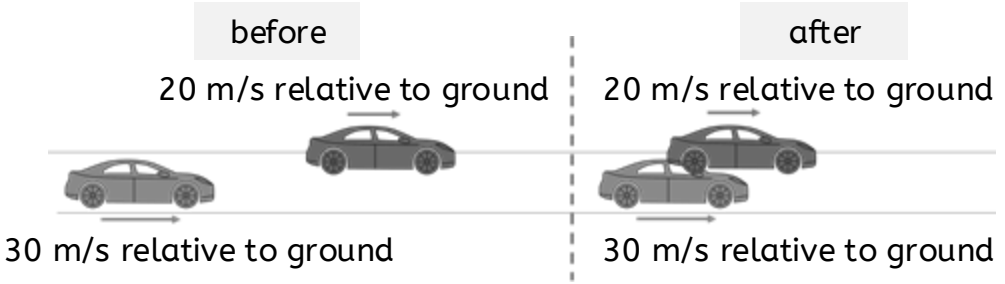


frame of reference: train



frame of reference: ground

Two moving objects relative to the ground

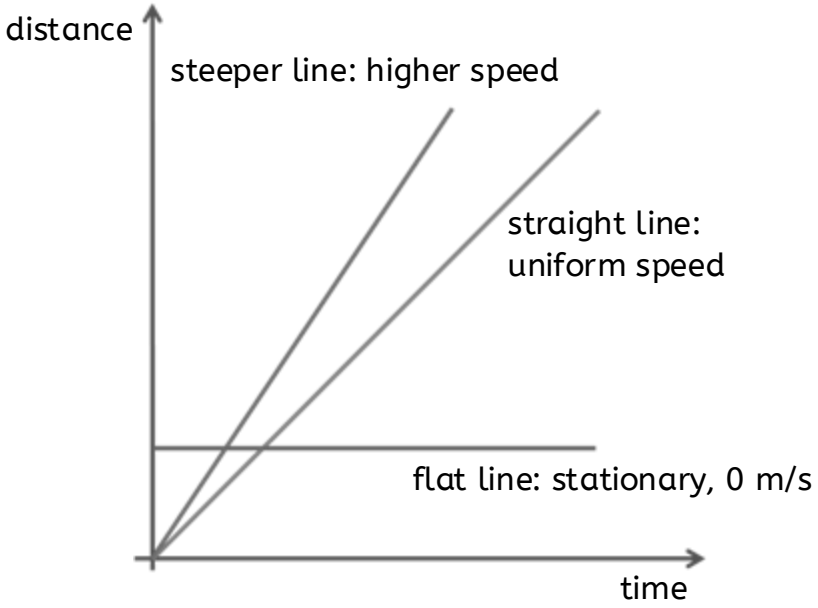


Every second: relative distance changes by 10 m.

Relative speed = 10 m/s

8.03: Forces and Motion

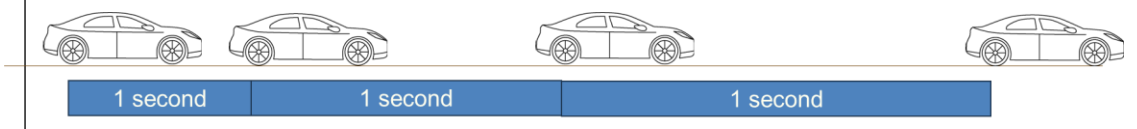
Distance-time Graphs



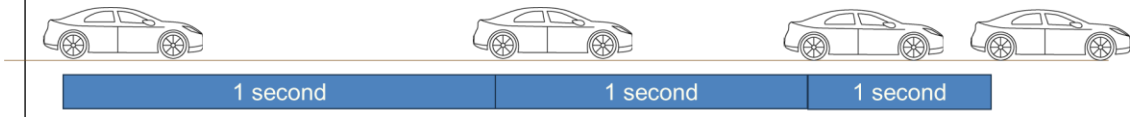
- Measurement results are plotted on a d-t graph.
- Lines-of-best-fit average out an object's position over time.
- Lines indicate general trends of motion.
- Values read off from the line to interpret specific parts of motion.

Acceleration

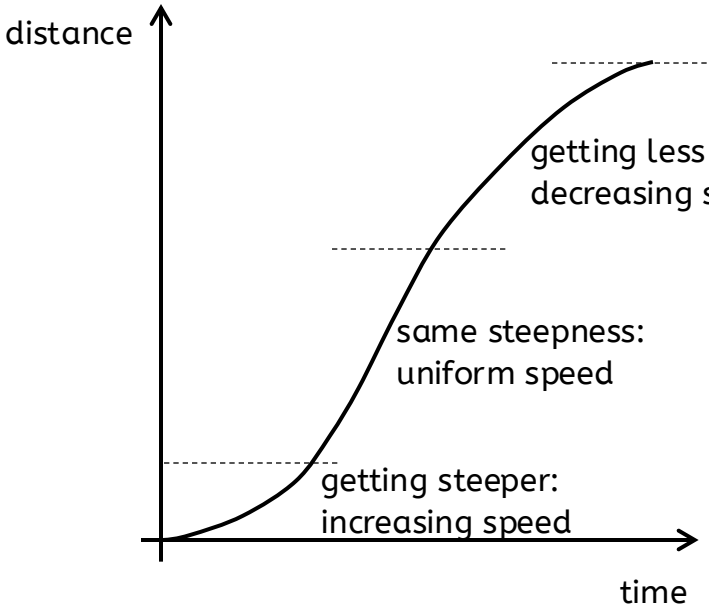
- the change of speed (or direction) over a time interval



increasing speed



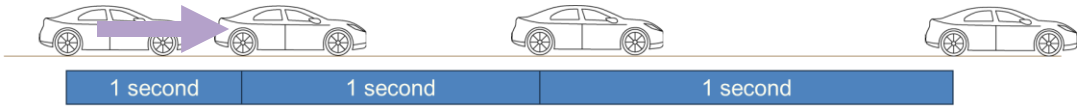
decreasing speed (decelerating)



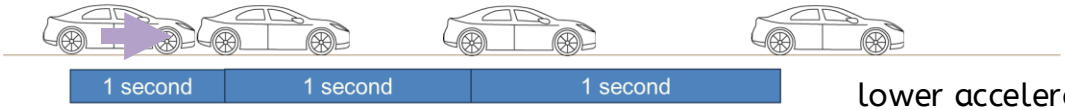
8.03: Forces and Motion

Affects on Acceleration

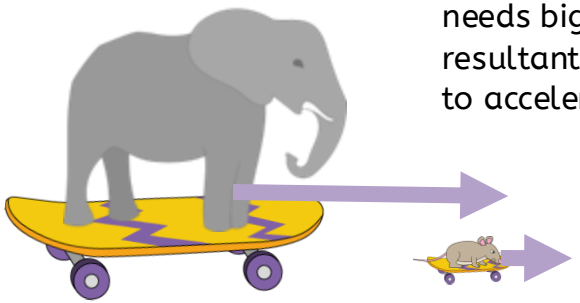
Greater resultant force causes higher acceleration.



higher acceleration

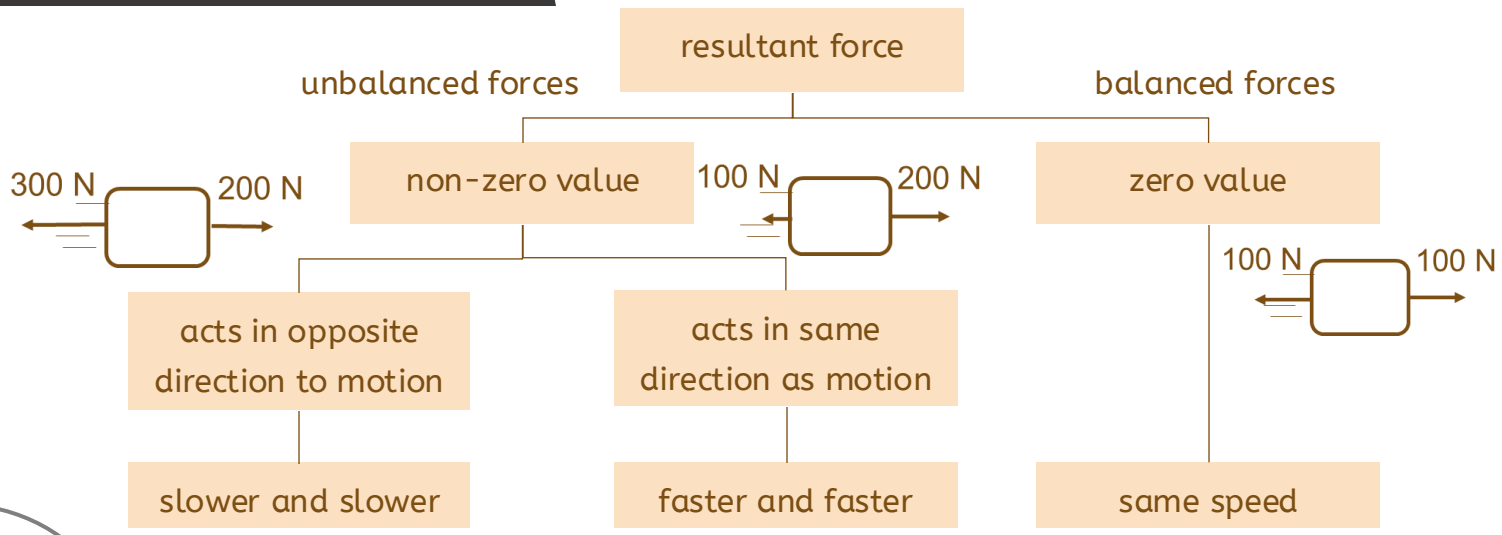


lower acceleration



Greater mass needs bigger resultant force to accelerate.

Resultant Force and Acceleration

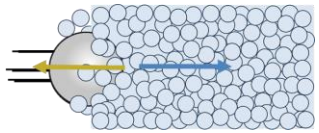


8.03: Forces and Motion

Motion in Fluids

Frictional forces act to **resist motion**

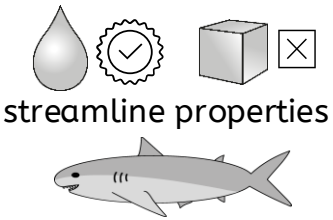
- friction force
- **drag** forces
  - air resistance
  - water resistance



- Relative motion between fluid and object.
- Object pushes forwards on particles of fluid.
- Particles push backwards on object = drag force.

Drag force depends on:

- Material of fluid
- Speed of relative motion
- Shape of object
- Size of front surface
- Smoothness of surface

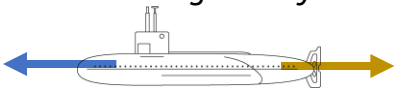


Propelled or Not

Propelled: has driving force

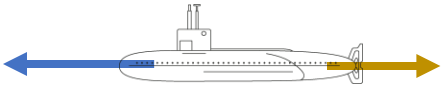
Moving: has drag force

moving slowly



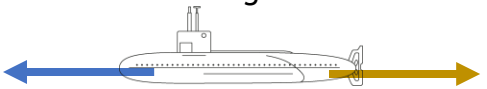
- Resultant force is 0 N: uniform speed, no change to forces

increases thrust



Resultant force ← increasing speed, drag will increase

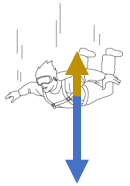
moving fast



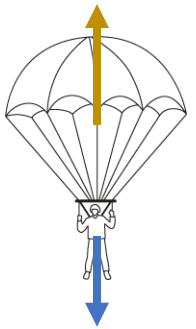
- Resultant force is 0 N: uniform speed, no change to forces

remove propulsion

→ Resultant force decreasing speed, drag will decrease



Accelerates until drag equals size of weight.



Parachute released, increases drag, resultant force acts upwards, decreases speed, drag decreases etc.

8.03: Forces and Motion

High-Quality Data

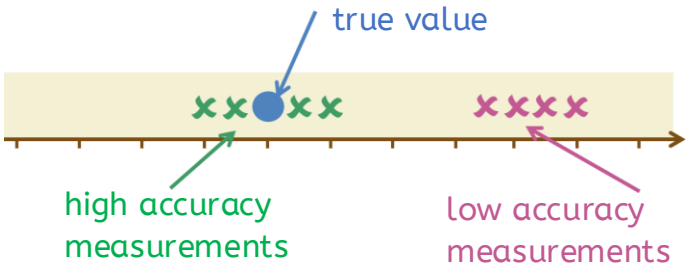
valid data

- with low measurement error
- that is accurate
- that is repeatable
- that is reproducible

- represents the real situation and is trustworthy

accurate data

- closeness of a measurement to the true or agreed value.



Developing a Method

Researchers

- select apparatus and techniques known to give accurate data,
- measure over appropriate range, with systematic intervals.

Line of enquiry → Plan data collection → Type of scientific method → Apparatus / techniques → Valid data

Plan data collection:
- to answer question
- systematic

Apparatus / techniques:
- resolution
- measurement error
  - impact random error
  - likelihood systematic error

Researchers

- often **trial** experiments to finalise the method.

Safe Practicals

Researchers

- may redesign experiments to reduce risk to acceptable levels.

Hazard	Risk	Control Measure
Falling	• Damage to bones on impact with floor or other fixed objects	• Do not stand on tables, stools etc. • Reduce maximum height to one students can reach.

8.03: Forces and Motion

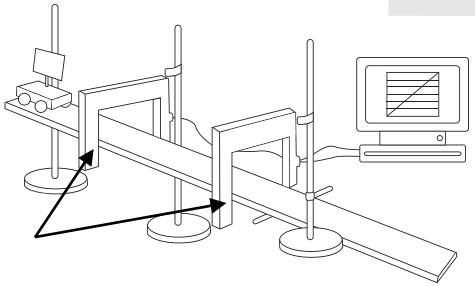
Selecting Apparatus and Techniques

Datalogging

- a process where sensors measure the physical properties of a system

Researcher sets up the constraints on the computer to record data, e.g. time intervals and the logging period.

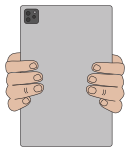
sensor → data → processor



Each light gate is set up to measure time for card to pass; processor calculates speed at each gate.

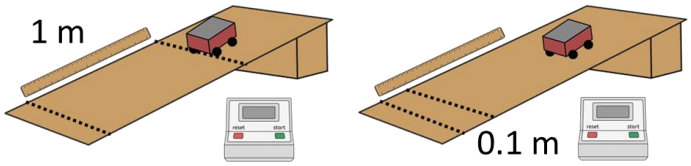
Digital Filming

- multiple images recorded (frames); each frame is over a strict time interval



Recorded against a measurement background, any change can be observed.

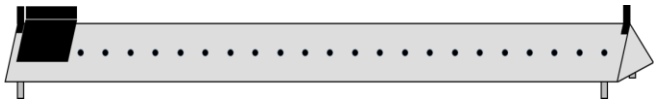
Measuring Speeds (time and distance)



Ramp is 'banked up' to reduce effect of friction.

uniform speed – select greater distance

changing speed – select small distances



Air track removes almost all friction.

Apparatus	Advantages
Datalogging	• over very short intervals • consistent and not subjective • high resolution • removes reaction time (timing)
Digital filming	• not subjective • removes reaction time (timing) • removes measurement error while object moving (distance)

8.03: Forces and Motion

Recording Data

Collected data is generally recorded in a table.

Column headings (describe quantities and units).

IV far left column

Raw data processed, e.g. speed = d ÷ t

Data processed: mean = sum ÷ number

All raw data included

DV furthest right-hand column: processed DV

Repeated measurements with anomalies identified

Rows' values change systematically

CV included

Situation	Distance travelled (m)	Time taken (s)	Average Speed (m/s)	Average Speed (m/s)
Parachute	2.00	1.49	1.34	1.19
	2.00	1.78	1.12	
	2.00	1.78	1.12	
No parachute	2.00	0.17		2.43
	2.00	0.86	2.33	
	2.00	0.79	2.53	

Constant mass

Quantitative values recorded with appropriate significant figures and consistent

Processed values rounded:
Formulae
s.f. same as measurement
Mean
s.f. same as worst measurement

8.03: Forces and Motion

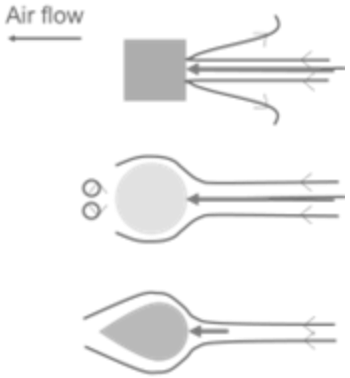
Applications of Technology on Science

Researchers select apparatus that:

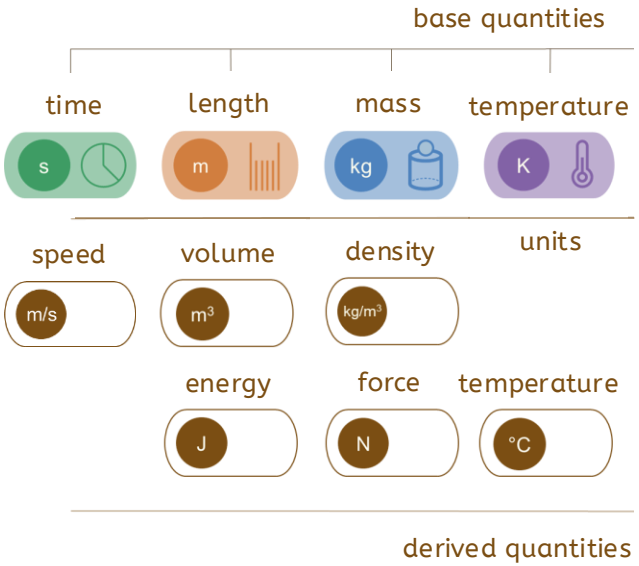
- Restricts control variables.
- Has higher resolution.
- Automates measurement (more often, longer duration).
- Removes random error related to human judgement (subjectivity).

Applications of Science on Industry

Knowledge of fluid flow around objects allows engineers to produce better designs, e.g. more efficient cars.



Measurement Values



Quantities and their units:

Base quantities: length, mass, time, temperature (K).

Derived quantities also include: